LONGLEAF PINE (PINUS PALUSTRIS).

BULLETIN NO. 13.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF FORESTRY.

THE
TIMBER PINES OF THE SOUTHERN UNITED STATES.

By CHARLES MOHR, Ph. D.

TOGETHER WITH

A DISCUSSION OF THE STRUCTURE OF THEIR WOOD.

By FILIBERT ROTH.

PREPARED UNDER THE DIRECTION OF B. E. FERNOW, CHIEF OF THE DIVISION OF FORESTRY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1896.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
Washington, D. C., May 26, 1896.

SIR: I have the honor to submit herewith for publication a series of monographs on the five pines of economic importance in the Southern United States, a result of many years' study by Dr. Charles Mohr, the well-known authority on the botany of the Southern States and agent of the Division of Forestry.

The first draft of these monographs was prepared several years ago, but it was then found that in order to make them fully satisfactory and useful to the practitioner much additional information was needed, especially regarding the rate of growth and other sylvicultural as well as technological questions. This information has been gradually accumulated as our facilities have permitted. The extended investigations carried on in this division may be considered quite exhaustive, especially in regard to the mechanical properties of the wood of these pines. An interesting chapter on the wood structure by Mr. Filibert Roth has been added, and a comparative study of the economic, sylvicultural, and technical characteristics and value of the pines under consideration—a résumé, as it were, of the contents of the monographs—is to be found in the introduction by the writer.

The pineries of the South furnish now, or will in the near future, the most important staples of our lumber industry. According as they are treated, carefully or wastefully, they will continue for a longer or shorter time to be a wealth-producing resource of the South. To aid in securing a true conception of the extent, condition, and value of this resource, and of the nature, development, characteristics (botanical, sylvicultural, and technological) of these pines, these monographs have been written, with the hope of inducing rational forestry methods in their use and reproduction.

Respectfully,

B. E. FERNOW,
Chief of Division.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

FIGURES.

INTRODUCTION.

In ignorance of the nature and without appreciation of the economic value of their resources, pioneers squander and destroy without regard to the future the riches they find. We have done so in the United States and are continuing to do so although the pioneering stage should have been passed, especially with our forest resources. We have exploited them as if they were mines, instead of crops which can be harvested and reproduced continuously, and we have done so in a most wasteful manner; nay, we have by irrational methods of exploitation, no doubt due in part to the necessities of a rapidly developing country, in many cases destroyed the conditions for natural reproduction of the more valuable timber species. Fire and indiscriminate pasturing have also assisted in the process of deterioration.

We are just beginning to realize that our timber supplies are not unlimited; that our magnificent forest resources have been despoiled and need at least more consideration; that sooner or later forestry will become, nay, is now, a necessity.

Forestry is the art of producing, managing, and harvesting wood crops. To be successful in this art it is of course necessary to understand the nature of the crop—to be acquainted with the life history, the conditions of development required by each species of tree composing the crop. Such knowledge can be in part, at least, derived from observations made in the natural forests, and from these observations the manner in which the different species should be treated and rules of management may be determined.

The time for the application of forestry—that is, rational methods of treating the wood crop—has not, as many seem to suppose, come only when the natural forest growths have been despoiled and deteriorated. On the contrary, when the ax is for the first time applied, then is the time for the application of forestry, for it is possible so to cut the original natural forest crop that it can reproduce itself in a superior manner. The judicious and systematic use of the ax alone, in the hands of the forester, will secure this result.

Hence these monographs on the life history of the Southern pines have been written primarily to enable the owners of Southern pineries, who are now engaged in exploiting them, to so modify their treatment of the same as to insure continued reproduction instead of complete exhaustion, which is threatened under present methods.

The pines are the most important timber trees of the world. They attain this importance from a combination of properties. In the first place, they possess such qualities of strength and elasticity, combined with comparatively light weight and ease of working, as to fit them specially for use in construction which requires the largest amount of wood; next, they occur as forests in the temperate zones, often to the exclusion of every other species, so that their exploitation is made easy and profitable; thirdly, they are readily reproduced and tolerably quick growers; and, lastly, they occupy the poorest soils, producing valuable crops from the dry sands, and hence are of the greatest value from the standpoint of national economy.

The Southern States abound in those sandy soils which are the home of the pine tribes and were once covered with seemingly boundless forests of the same. There are still large areas untouched, yet the greater portion of the primeval forest has not only been culled of its best timber, but the repeated conflagrations which follow the lumbering, and, still more disastrously, the turpentine gatherers' operations have destroyed not only the remainder of the original growth, but the vegetable mold and the young aftergrowth, leaving thousands of square miles as blackened wastes, devoid of usefulness, and reducing by so much the potential wealth of the South.

There are, in general, four belts of pine forest of different types recognizable, their boundaries running in general direction somewhat parallel to the coast line: (1) The coast plain, or pine-barren flats, within the tidewater region, 10 to 30 miles wide, once occupied mainly by the most valuable of Southern timbers, the Longleaf Pine, now being replaced by Cuban and Loblolly Pines; (2) the rolling pine hills, or pine barrens proper, with a width of 50 to 120 miles, the true home of the Longleaf Pine, which occupies it almost by itself; (3) the belt of mixed growth of 20 to 60 miles in width, in which the Longleaf Pine loses its predominance, the Shortleaf, the Loblolly, and the hard woods associating and disputing territory with it; and (4) the Shortleaf Pine belt, where the species predominates on the sandy soils, the Longleaf being entirely absent and the Loblolly only a feeble competitor, hard woods being interspersed or occupying the better sites. Within the territory the species that occur occupy different situations. Thus the Cuban, which accompanies the Longleaf, usually occupies the less well-drained situations, together with the Loblolly, which, although it can accommodate itself to all soils, reaches its best development in the rich lowlands and is specially well developed in the flat woods which border the coast marshes of eastern Texas, where it associates with the Shortleaf Pine it also seeks the moister situation.

The Longleaf and Shortleaf pines are, in quantity and quality combined, the most important, while the Loblolly or Oldfield Pine, as yet not fully appreciated, comes next, occupying large areas. The Cuban Pine, usually known as Slash Pine—always cut and sold without distinction with the Longleaf Pine—a tree of as fine quality and of more rapid growth than the Longleaf Pine, is associated with the latter in the coast pine belt, scattered in single individuals or groups, but appears to increase in greater proportion in the young growth, being by its manner of development in early life better fitted to escape the dangers to which the aftergrowth is exposed.

Besides these four most important pines, there are a number of others of less significance. The White Pine (*Pinus strobus*) of the North extends its reign along the higher mountain regions of North Carolina into Georgia, forming a valuable timber tree, but of small extent. The Spruce Pine, to which a short chapter is devoted in this bulletin, develops into timber size, but is found only in small quantities and mostly scattered, and has therefore as yet not received attention in lumber markets; but its qualities, and especially its forestal value, being a pine which endures shade, will probably be appreciated in the future. The other four species of pine found in the South, which appear in the table below, which gives their botanical distinctions, do not develop into timber trees of value, excepting that the Scrub Pine, occupying large areas of abandoned fields in Virginia, furnishes a considerable amount of firewood.

BOTANICAL DIAGNOSIS OF THE FOUR PRINCIPAL PINES OCCURRING IN THE SOUTHERN STATES.

Species.	*Pinus palustris* Miller.	*Pinus heterophylla* (Ell.) Sudw.
Leaves	Three in a bundle, 9 to 12 (exceptionally 14 to 15) inches long.	Two and three in a bundle; 7 to 12 (usually 9 to 10) inches long.
Cones (open)	6 to 9 inches long, 4½ to 5 inches in diameter.	4 to 6½ (usually 4 to 5) inches long; 3 to 4¾ inches in diameter.
Scales	Seven-eighths to 1 inch broad; tips much wrinkled; light chestnut brown; gray with age.	Eleven-sixteenths to seven-eighths inch broad; tips, wrinkled; deep russet brown; shiny.
Prickles	Very short, delicate, incurved.	Very short; straight; declined.
Buds	Three-fourths inch long, one-half inch in diameter, silver white.	About one-half inch long; one-fourth inch in diameter; brownish.

Species.	*Pinus echinata* Miller.	*Pinus tæda* Linn.
Leaves	Two and three in a bundle; 1⅜ to 4 inches long; commonly 2½ to 4 inches.	Three in a bundle; 5 to 8 inches long.
Cones (open)	1½ to 2 inches long; 1⅛ to 1¾ inches in diameter.	2½ to 4½ inches long; 1¾ to 3 inches in diameter.
Scales	Five-sixteenths to three-eighths (exceptionally about one-half) inch broad; tips light yellow-brown.	Three-eighths to three-fourths inch broad; tips smooth; dull yellow-brown.
Prickles	Exceedingly short (one-tenth inch); delicate; straight; declined.	Short; stout at base.
Buds	Three eighths to one-half inch long; about one-eigthth inch in diameter; brownish.	One-half to three-fourths inch long; one-fourth inch in diameter; brownish.

The greatest confusion exists with regard to the vernacular names of these pines, in consequence of which information regarding them, given by the native population, must always be carefully scrutinized to determine exactly to what species it refers. Even in the lumber market and among wood consumers, engineers, architects, and carpenters the same confusion exists; Longleaf and Cuban pines are never distinguished; Shortleaf and Loblolly pines are mixed indiscriminately, and often "Southern Pine," or "Yellow Southern Pine," satisfies the specification of the architect and may come from any of the four species.

To assist in clearing this confusion the following synopsis of botanical and vernacular names is here inserted:

NOMENCLATURE OF SOUTHERN PINES.

Botanical names	*Pinus palustris* Miller. Syn.: *P. australis* Michx.	*Pinus echinata* Miller. Syn.: *Pinus mitis* Michx. *P. virginiana* var. *echinata* Du Roi. *P. tæda* var. *variabilis* Aiton. *P. variabilis* Lamb. *P. rigida* Porcher.	*Pinus tæda* Linn. Syn.: *Pinus tæda* var. *tenuifolia* Aiton.	*Pinus heterophylla* (Ell.) Sudw. Syn.: *Pinus tæda* var. *heterophylla* Ell. *P. elliotii* Engelm. *P. cubensis* var. *terthrocarpa* Wright.
Best common names	LONGLEAF PINE.	SHORTLEAF PINE.	LOBLOLLY PINE.	CUBAN PINE.
Local, market, and lumbermen's names	Southern Yellow Pine. Southern Hard Pine. Southern Heart Pine. Southern Pitch Pine. Hard Pine (Miss., La.). Heart Pine (N. C. and South Atlantic). Pitch Pine (Atlantic). Longleaved Yellow Pine (Atlantic). Longleaved Pine (Atlantic). Longleaved Pitch Pine (Atlantic). Longstraw Pine (Atlantic). North Carolina Pitch Pine. Georgia Yellow Pine. Georgia Pine. Georgia Heart Pine. Georgia Longleaved Pine. Georgia Pitch Pine. Florida Yellow Pine. Florida Pine. Florida Longleaved Pine. Texas Yellow Pine. Texas Longleaved Pine.	Yellow Pine (N. C., Va.). Shortleaved Yellow Pine. Shortleaved Pine. Virginia Yellow Pine (in part). North Carolina Yellow Pine (in part). North Carolina Pine (in part). Carolina Pine (in part). Slash Pine (N. C., Va.), in part. Oldfield Pine (Ala., Miss.). Bull Pine (?). Spruce Pine.	Slash Pine (Va., N. C.), in part. Loblolly Pine (Gulf region). Oldfield Pine (Gulf region). Rosemary Pine (N. C., Va.). Shortleaved Pine (Va., N. C., S. C.). Bull Pine (Texas and Gulf region). Virginia Pine. Sap Pine (Va., N. C.). Meadow Pine (Fla.). Cornstalk Pine (Va.). Black Pine (Va.). Foxtail Pine (Va., Md.). Indian Pine (Va., N. C.). Spruce Pine (Va.), in part. Bastard Pine (Va., N. C.). Yellow Pine (No. Ala., N. C.). Swamp Pine (Va., N. C.). Longstraw Pine (Va., N. C., Ark.), in part.	Slash Pine (Ga., Fla.). Swamp Pine (Fla. and Ala.), in part. Bastard Pine (Fla., Ala.). Meadow Pine (Fla., E. Miss), in part. She Pitch Pine (Ga.).

While it is easy enough to recognize the species in the field by their botanical characters, it is difficult and often impossible to distinguish them in the wood by mere macroscopic inspection or examination with the magnifier and without the aid of the microscope, nor are the miscroscopic features so far recognized sufficient for specific distinction.

A long-continued study of these woods by Mr. Filibert Roth, of the Division of Forestry, has not developed any characteristics which would be always reliable in distinguishing the species. The best that can be done is to give a synopsis of characters, by which they differ generally when larger quantities, as in the log or lumber pile, are under inspection.

CHARACTERISTICS OF THE WOOD OF SOUTHERN PINES.

Diagnostic features of the wood.

Name of species.	Longleaf Pine (*Pinus palustris* Miller).	Cuban Pine (*Pinus heterophylla* (Ell.) Sudw.).
Specific gravity of kiln-dried wood. Possible range	.50 to .90	.50 to .90
Specific gravity of kiln-dried wood. Most frequent range	.55 to .65	.55 to .70
Weight, pounds per cubic foot, kiln-dried wood, average.	36	37
Character of grain seen in cross section	Fine and even; annual rings quite uniformly narrow on large logs, averaging generally 20 to 25 rings to the inch.	Variable and coarse; rings mostly wide, averaging on larger logs 10 to 20 rings to the inch.
Color, general appearance	Even dark reddish-yellow to reddish-brown	Dark straw color, with tinge of flesh color.
Sapwood, proportion	Little; rarely over 2 to 3 inches of radius	Broad, 3 to 6 inches.
Resin	Very abundant; parts often turning into "light wood;" pitchy throughout.	Abundant, sometimes yielding more pitch than Longleaf; "bleeds" freely, yielding little scrape.

Name of species.	Shortleaf Pine (*Pinus echinata* Miller).	Lobolly Pine (*Pinus tæda* Linn.).
Specific gravity of kiln-dried wood. Possible range	.40 to .80	.40 to .80
Specific gravity of kiln-dried wood. Most frequent range	.45 to .55	.45 to .55
Weight, pounds per cubic foot, kiln-dried wood, average.	30	31
Character of grain seen in cross section	Very variable; medium, coarse; rings wide near heart, followed by zone of narrow rings; not less than 4 (mostly about 10 to 15) rings to the inch, but often very fine-grained.	Variable, mostly very coarse; 3 to 12 rings to the inch, generally wider than in shortleaf.
Color, general appearance	Whitish to reddish-brown	Yellowish to reddish and orange brown.
Sapwood, proportion	Commonly 2 to 4 inches of radius	Very variable, 3 to 6 inches of the radius.
Resin	Moderately abundant, least pitchy, only near stumps, knots, and limbs.	Abundant; more than Shortleaf, less than Longleaf and Cuban, but does not "bleed" if tapped.

It is clear from the above diagnosis that Longleaf Pine may be distinguished from Cuban Pine by its finer grain and small amount of sapwood; also that both of these differ from the Shortleaf and Loblolly in their greater weight and the more resinous character of their wood, but that the wood of the two last-named species is rarely distinguishable beyond doubt.

Technically the wood of the pines differs about as follows: The wood of the Longleaf and Cuban pines are about equal in strength, Longleaf excelling by its finer grain and smaller amount of sapwood. The same comparison may be made with regard to Loblolly and Shortleaf Pine. Being much more variable, however, in weight and grain, exceptions to the general rule here are very numerous. Of the last-named species it may be said that the wood derived from more southern localities is generally heavier and stronger than northern grown—a fact especially apparent in the case of the Shortleaf Pine.

The extensive investigations carried on by the Division of Forestry during the last three to four years mainly on these pines permit us to give the following résumé of their mechanical properties derived from not less than 20,000 tests and as many measurements and weighings. We quote this information from Circular 12 of the division:

MECHANICAL PROPERTIES.

In general the wood of all these pines is heavy for pine (31 to 40 pounds per cubic foot, when dry), soft to moderately hard (hard for pine), requiring about 1,000 pounds per square inch to indent one-twentieth inch; stiff, the modulus of elasticity being from 1,500,000 upward; strong, requiring from 7,000 pounds per square inch and upward to break in bending and over 5,000 pounds in compression when yard-dry.

The values given in this circular are averages based on a large number of tests from which only defective pieces are excluded.

In all cases where the contrary is not stated the weight of the wood refers to kiln-dried material and the strength to wood containing 15 per cent moisture, which may be conceived as just on the border of air-dried condition. The first table gives fairly well the range of strength of commercial timber.

Average strength of Southern Pine.

[Air-dry material (about 15 per cent moisture).]

Name.	Compression strength. With grain. Average of all valid tests. Absolute, per square inch.	Relative.	Average for the weakest one-tenth of all the tests. Absolute, per square inch.	Relative.	Across grain (3 per cent indentation), per square inch.	Bending strength. At rupture modulus $\frac{3\,Wl}{2\,bh^2}$. Average of all valid tests. Absolute, per square inch.	Relative.	Average for the weakest one-tenth of all the tests. Absolute, per square inch.	Relative.	At elastic limit modulus $\frac{3\,W_1l}{2\,bh^2}$ per square inch.	Elasticity (stiffness) modulus $\frac{3\,Wl^3}{4\Delta\,bh^3}$ per square inch.	Relative elastic resilience, per cubic inch.	Tensile strength per square inch.	Shearing strength per square inch.
	Pounds.		*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*	*Lbs.*	*Lbs.*
Cuban Pine.....	7,850	100	6,500	100	1,050	11,950	100	8,750	100	9,450	2,305,000	2.5	14,300	680
Longleaf Pine ..	6,850	87	5,650	87	1,060	10,900	91	8,800	101	8,500	1,890,000	2.3	15,200	706
Loblolly Pine...	6,500	83	5,350	82	990	10,100	84	8,100	92	8,150	1,950,000	2.25	14,400	690
Shortleaf Pine..	5,900	75	4,800	74	940	9,230	77	7,000	80	7,200	1,600,000	2.05	13,400	688

RELATION OF STRENGTH TO WEIGHT.

The intimate relation of strength and specific weight has been well established by the experiments. The average results obtained in connection with the tests themselves were as follows:

	Cuban.	Longleaf.	Loblolly.	Shortleaf.
Transverse strength..................................	100	91	84	77
Specific weight of test pieces........................	100	94	82	77

Since, in the determination of the specific gravity above given, wood of the same per cent of moisture (as is the case of the values of strength) was not always involved, and also since the test pieces, owing to size and shape, can not perfectly represent the wood of the entire stem, the following results of a special inquiry into the weight of the wood represents probably more accurately the weight and with it the strength relations of the four species.

WEIGHT RELATIONS.

[These data refer to the average specific weight for all the wood of each tree, only trees of approximately the same age being involved.]

	Cuban.	Longleaf.	Loblolly.	Shortleaf.
Average age of trees .... years..	171	127	137	131
Number of trees involved........	6	22	14	10
Specific gravity of dry wood........	0.63	0.61	0.53	0.51
Weight per cubic foot .... pounds..	39	38	33	32
Relative weight	100	97	84	81
(Transverse strength *)........	(100)	(91)	(84)	(77)

* The values of strength refer to all tests, and therefore involve trees of wide range of age and consequently of quality, especially those of Longleaf; involve much wood of old trees, hence the relation of weight and strength appears less distinct.

From these results, although slightly at variance, we are justified in concluding that Cuban and Longleaf Pine are nearly alike in strength and weight and excel Loblolly and Shortleaf by about 20 per cent. Of these latter, contrary to common belief, the Loblolly is the heavier and stronger.

The weakest material would differ from the average material in transverse strength by about 20 per cent, and in compression strength by about 30 to 35 per cent, except Cuban Pine, for which the difference appears greater in transverse and smaller in compression strength. It must, of course, not be overlooked that these figures are obtained from full-grown trees of the virgin forest, that strength varies with physical conditions of the material, and that therefore an intelligent inspection of the stick is always necessary before applying the values in practice. They can only represent the average conditions for a large amount of material.

DISTRIBUTION OF WEIGHT AND STRENGTH THROUGHOUT THE TREE.

Weight and strength of wood at different heights in the tree.

	Strength of Longleaf Pine (pounds per square inch).		Specific weight.			Mean of all three species (relative weight).	Relative strength of Longleaf Pine (mean of compression and bending).
	Bending strength.	Compression endwise (with grain).	Longleaf.	Loblolly.	Shortleaf.		
Number trees used........	56		22	14	12	48	56
Average age of trees........	150 (over)		127	113	131	....	....
Number of feet from stump:							
0	....	....	.751	.629	.614	....	....
			106	*106*	*105*	*106*	....
6	12,100	7,350	.705	.595	.585		
	100	*100*	*100*	*100*	*100*	*100*	*100*
10	11,650	7,200	.674	.578	.565		
	96	*98*	*96*	*97*	*97*	*97*	*97*
20	10,700	6,800	.624	.534	.523		
	88	*93*	*89*	*90*	*90*	*90*	*90*
30	10,100	6,500	.590	.508	.496		
	84	*89*	*84*	*86*	*85*	*85*	*86*
40	9,500	6,300	.560	.491	.472		
	79	*86*	*80*	*83*	*81*	*81*	82
50	9,000	6,150	.539	.476	.455		
	75	*83*	*77*	*80*	*78*	*78*	*79*
60	8,600	6,050	.528	.470	.454		
	71	*82*	*75*	*79*	*78*	*77*	*76*

NOTE.—Relative values are indicated by italic figures.

In any one tree the wood is lighter and weaker as we pass from the base to the top. This is true of every tree and of all four species. The decrease in weight and strength is most pronounced in the first 20 feet from the stump and grows smaller upward. (See fig. 1.)

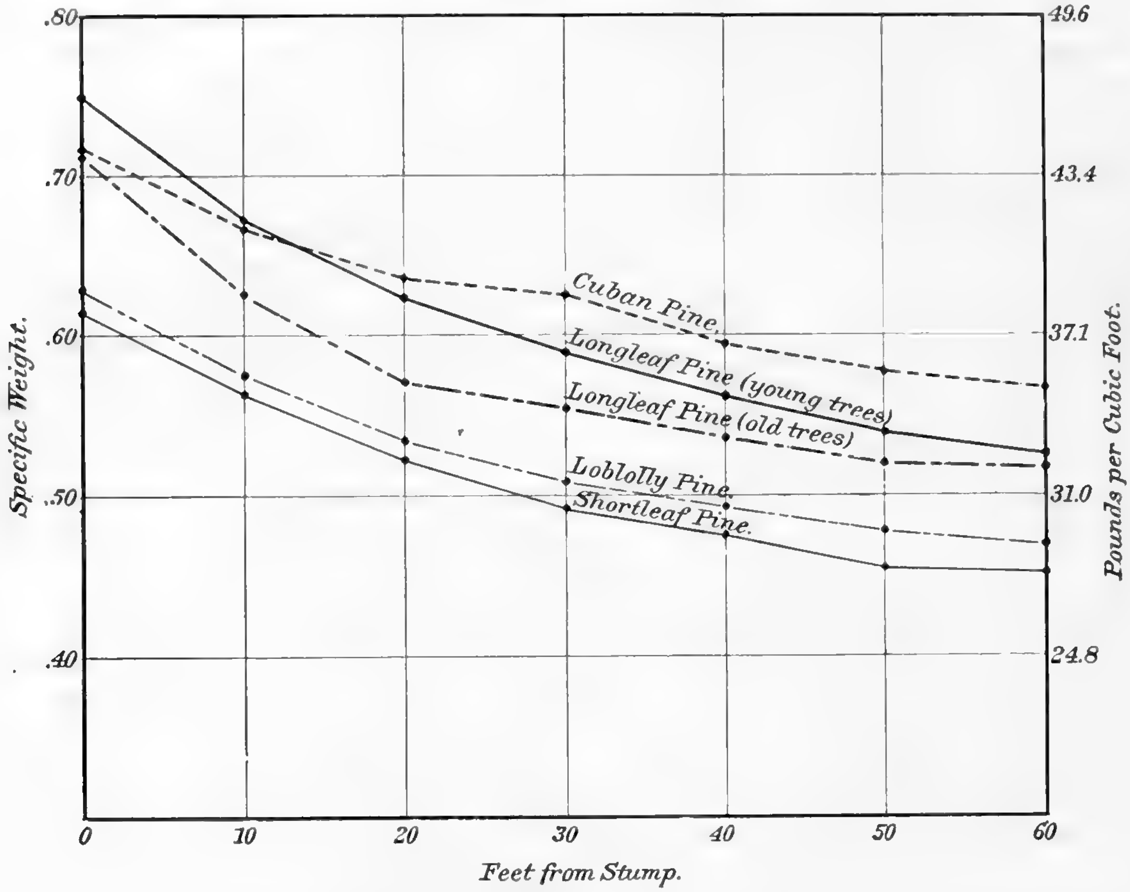


FIG. 1.—Diagram showing variation of weight with height of tree.

This great difference in weight and strength between butt and top finds explanation in the relative width of the summerwood. Since the specific weight of the dark summerwood band in each ring is in thrifty growth from 0.90 to 1, while that of the springwood is only about 0.40, the relative amount of summerwood furnishes altogether the most delicate and accurate measure of these differences of weight as well as strength, and hence is the surest criterion for ocular inspection of quality, especially since this relation is free from the disturbing influence of both resin and moisture contents of the wood, so conspicuous in weight determinations.

The following figures show the distribution of the summerwood in a single tree of Longleaf Pine, as an example of this relation:

	In the 10 rings next to the bark.	In the 10 rings Nos. 100 to 110 from bark.	Average for entire disk.	Specific weight.
	Per cent.	*Per cent.*	*Per cent.*	
At the stump	37	52	50	0.73
32 feet from stump	25	38	33	.59
87 feet from stump	15	37	26	.55

Logs from the top can usually be recognized by the larger percentage of sapwood and the smaller proportion and more regular outlines of the bands of summerwood, which are more or less wavy in the butt logs.

Both weight and strength vary in the different parts of the same cross section from center to periphery, and though the variations appear frequently irregular in single individuals, a definite law of relation is nevertheless discernible in large averages, and once determined is readily observable in every tree.

A separate inquiry, avoiding the many variables which enter into the mechanical tests, permits the following deductions for the wood of these pines, and especially for Longleaf; the data referring to weight, but by inference also to strength:

1. The variation is greatest in the butt log (the heaviest part) and least in the top logs.

2. The variation in weight, hence also in strength, from center to periphery depends on the rate of growth, the heavier, stronger wood being formed during the period of most rapid growth, lighter and weaker wood in old age.

3. Aberrations from the normal growth, due to unusual seasons and other disturbing causes, cloud the uniformity of the law of variation, thus occasionally leading to the formation of heavier, broad-ringed wood in old, and lighter narrow-ringed wood in young trees.

4. Slow-growing trees (with narrow rings) do not make less heavy, nor heavier wood than thriftily grown trees (with wide rings) of the same age. (See fig. 2.)

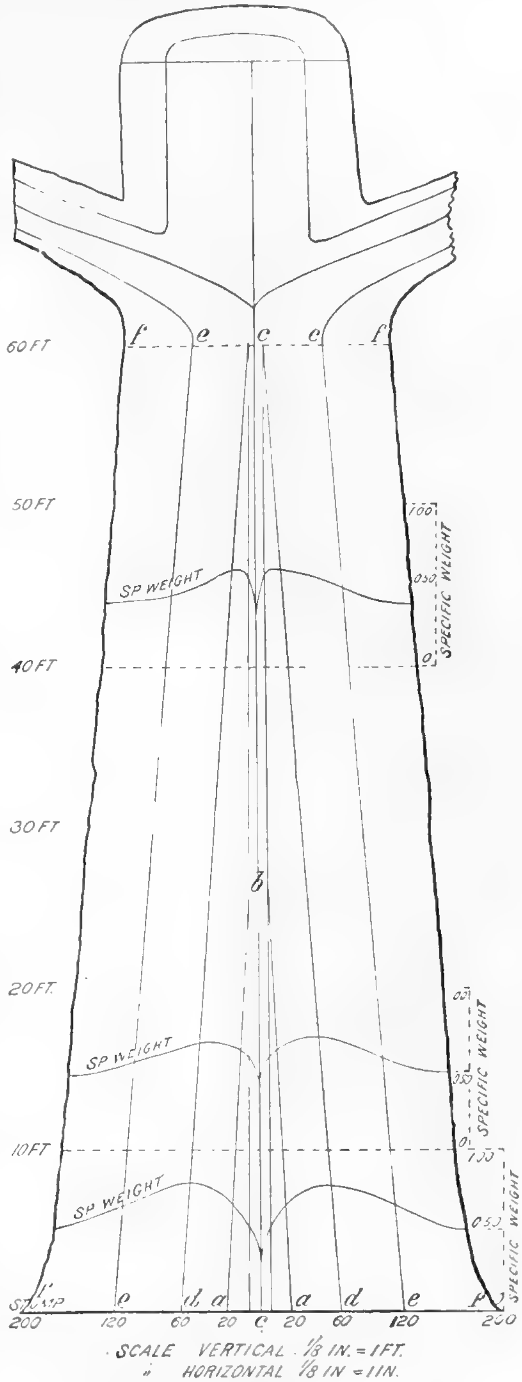


FIG. 2.—Schematic section through stem of Longleaf Pine, showing variation of specific weight with height, diameter, and age at twenty (*aba*), sixty (*dcd*), one hundred and twenty (*cece*), and two hundred (*ffff*) years.

EFFECT OF AGE.

The interior of the butt log, representing the young sapling of less than fifteen or twenty years of age, and the central portion of all logs containing the pith and two to five rings adjoining, is always light and weak.

The heaviest wood in Longleaf and Cuban Pine is formed between the ages of fifteen and one hundred and twenty years, with a specific weight of over 0.60 and a maximum of 0.66 to 0.68, between the ages of forty and sixty years. The wood formed at the age of about one hundred years will have a specific weight of 0.62 to 0.63, which is also the average weight for the entire wood of old trees; the wood formed after this age is lighter but does not fall below 0.50 up to the two hundredth year; the strength varies in the same ratio.

In the shorter-lived Loblolly and Shortleaf the period for the formation of the heaviest wood is between the ages of fifteen and eighty, the average weight being then over 0.50, with a maximum of 0.57 at the age of thirty to forty. The average weight for old trees (0.51 to 0.52) lies about the seventy-fifth year, the weight then falling off to about 0.45 at the age of one hundred and forty, and continuing to decrease to below 0.38, as the trees grow older.

That these statements refer only to the clear portions of each log, and are variably affected at each whorl of knots (every 10 to 30 inches) according to their size, and also by the variable amounts of resin (up to 20 per cent of the dry weight), must be self-evident.

Sapwood is not necessarily weaker than heartwood, only usually the sapwood of the large-sized trees we are now using is represented by the narrow-ringed outer part, which was formed during the old-age period of growth, when naturally lighter and weaker wood is made; but the wood formed during the more thrifty diameter growth of the first eighty to one hundred years—sapwood at the time, changed into heartwood later—was even as sapwood the heaviest and strongest.

RANGE OF VALUES FOR WEIGHT AND STRENGTH.

Although the range of values for the individual tree of any given species varies from butt to top, and from center to periphery by 15 to 25 per cent, and occasionally more, the deviation from average values from one individual to another is not usually as great as has been believed; thus, of 56 trees of Longleaf Pine, 42 trees varied in their average strength by less than 10 per cent from the average of all 56.

The following table of weight (which is a direct and fair indication of strength), representing all the wood of the stem and excluding knots and other defects, gives a more perfect idea of the range of these values:

Range of specific weight with age (kiln-dried wood).

[To avoid fractions the values are multiplied by 100.]

	Cuban.	Longleaf.	Loblolly.	Shortleaf.
Number of trees involved	24	96	60	56
Trees over two hundred years old	61	57	....	....
Trees one hundred and fifty to two hundred years old	63	59	50	....
Trees one hundred to one hundred and fifty years old	....	60.5	53	51
Trees fifty to one hundred years old	61	62	53.4	55
Trees twenty-five to fifty years old	55	61	53	57
Trees under twenty-five years old	51	55	48	53

Though occas onally some very exceptional trees occur, especially in Loblolly and Shortleaf, the range on the whole is generally within remarkably narrow limits, as appears from the following table:

Range of specific weight in trees of the same age approximately; averages for whole trees.

[Specific gravity multiplied by 100 to avoid fractions.]

Name.	Number of trees.	Age, years.	Single trees.													Average.
Cuban Pine	4	150–200	56	68	62	65	....	....	....	....	....	....	....	....	....	62.5
Cuban Pine	5	50–100	60	58	60	59	67	....	....	....	....	....	....	....	....	60.9
Longleaf Pine	13	100–150	59	66	57	62	66	58	59	57	57	66	59	62	57	60.5
Loblolly Pine	10	125–150	51	51	53	51	55	53	54	55	55	52	....	....	....	52.8
Shortleaf Pine	12	100–150	45	47	53	47	50	51	55	55	53	51	50	53	....	50.8

From this table it would appear that single individuals of one species would approximate single individuals of another species so closely that the weight distinction seems to fail, but in large numbers, for instance carloads of material, the averages above given will prevail.

INFLUENCE OF LOCALITY.

In both the Cuban and Longleaf Pine the locality where grown appears to have but little influence on weight or strength, and there is no reason to believe that the Longleaf Pine from one State is better than that from any other, since such variations as are claimed can be found on any 40-acre lot of timber in any State. But with Loblolly, and still more with Shortleaf, this seems not to be the case. Being widely distributed over many localities different in soil and climate, the growth of the Shortleaf Pine seems materially influenced by location. The wood from the Southern Coast and Gulf region and even Arkansas is generally heavier than the wood from localities farther north. Very light and fine-grained wood is seldom met near the southern limit of the range, while it is almost the rule in Missouri, where forms resembling the Norway Pine are by no means rare. The Loblolly, occupying both wet and dry soils, varies accordingly.

INFLUENCE OF MOISTURE.

This influence is among the most important, hence all tests have been made with due regard to moisture contents. Seasoned wood is stronger than green and moist wood; the difference between green and seasoned wood may amount to 50 and even 100 per cent. The influence of seasoning consists in (1) bringing by means of shrinkage about 10 per cent more fibers into the same square inch of cross section than are contained in the wet wood; (2) shrinking the cell wall itself by about 50 per cent of its cross section and thus hardening it, just as a cowskin becomes thinner and harder by drying.

In the following tables and diagram this is fully illustrated; the values presented in these tables and diagrams are based on large numbers of tests and are fairly safe for ordinary use. They still require further revision, since the relations to density, etc., have had to be neglected in this study.

Influence of moisture on strength.

	Per cent of moisture.	Average of all valid tests.				Relative values.				
		Cuban.	Long-leaf.	Lob-lolly.	Short-leaf.	Cuban.	Long-leaf.	Lob-lolly.	Short-leaf.	Average.
Bending strength:										
Green	33+	8,450	7,660	7,370	6,900	100	100	100	100	100
Half dry	20	10,050	8,900	8,650	8,170	118	116	117	118	117
Yard dry	15	11,950	10,900	10,100	9,230	142	142	138	134	139
Room dry	10	15,300	14,000	12,400	11,000	181	182	168	160	173
Crushing endwise:										
Green	33+	5,000	4,450	4,170	4,160	100	100	100	100	100
Half dry	20	6,600	5,450	5,350	5,100	132	122	128	122	126
Yard dry	15	7,850	6,850	6,500	5,900	157	154	156	142	152
Room dry	10	9,200	9,200	8,650	7,000	184	206	206	168	191
Mean of both bending and crushing strength:										
Green	33+	....	....	....	....	100	100	100	100	100
Half dry	20	....	....	....	....	125	119	122	120	122
Yard dry	15	....	....	....	....	149	148	147	138	146
Room dry	10	....	....	....	....	182	194	187	164	182

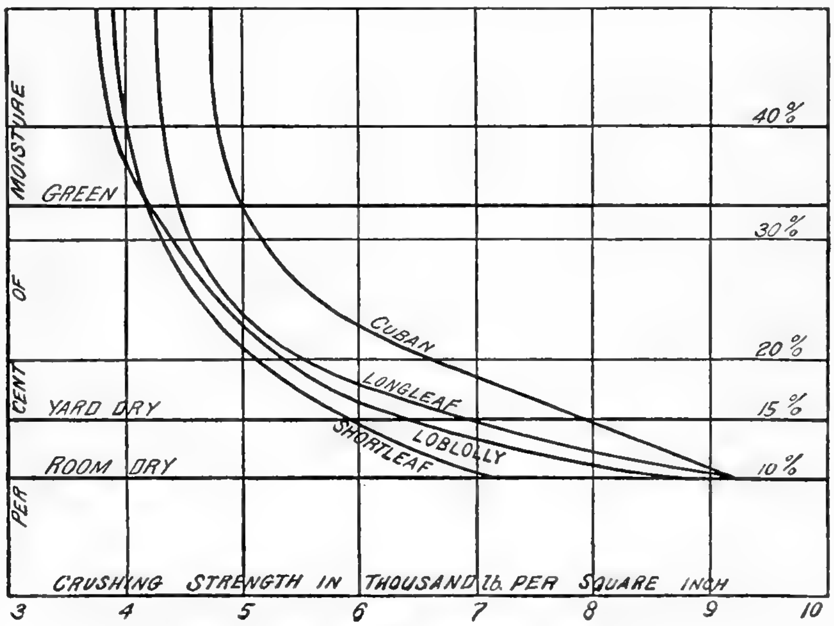


FIG. 3.—Diagram showing variation of compression strength with moisture.

It will be observed that the strength increases by about 50 per cent in ordinary good yard seasoning, and that it can be increased about 30 per cent more by complete seasoning in kiln or house.

Large timbers require several years before even the yard-seasoned condition is attained, but 2-inch and lighter material is generally not used with more than 15 per cent of moisture.

WEIGHT AND MOISTURE.

So far the weight of only the kiln-dry wood has been considered. In fresh as well as all yard and air dried material there is contained a variable amount of water. The amount of water contained in fresh wood of these pines forms more than half the weight of the fresh sapwood, and about one-fifth to one-fourth of the heartwood. In yard-dry wood it falls to about 12 to 18 per cent, while in wood kept in well-ventilated, and especially in heated rooms it is about 5 to 10 per cent, varying with size of piece, part of tree, species, temperature, and humidity of air. Heated to 150° F. (65° C.), the wood loses all but about 1½ to 2 per cent of its moisture, and if the temperature is raised to 175° F. there remains less than 1 per cent, the wood dried at 212° F. being assumed to be (though it is not really) perfectly dry. Of course, large pieces are in practice never left long enough exposed to become truly kiln dry, though in factories this state is often approached.

As long as the water in the wood amounts to about 30 per cent or more of the dry weight of the wood there is no shrinkage[1] (the water coming from the cell lumen), and the density or specific gravity changes simply in direct proportion to the loss of water. When the moisture per cent falls below about 30, the water comes from the cell wall, and the loss of water and weight is accompanied by a loss of volume, so that both factors of the fraction

$$\text{Specific gravity} = \frac{\text{weight}}{\text{volume}}$$

are affected, and the change in the specific gravity no longer is simply proportional to the loss of water or weight. The loss of weight and volume, however, being unequal and disproportionate, a marked reduction of the specific gravity takes place, amounting in these pines to about 8 to 10 per cent of the specific weight of the dry wood.

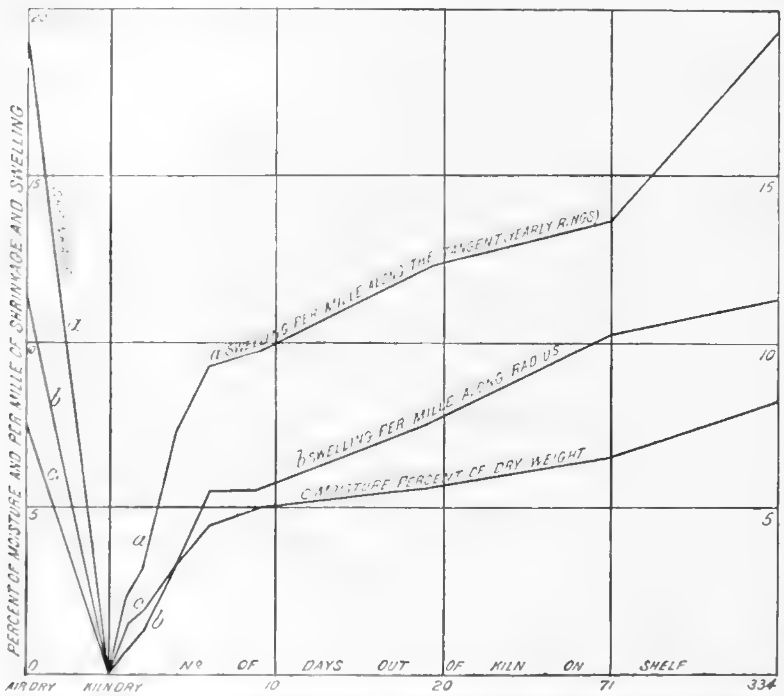


FIG. 4.—Diagram showing loss of water in kiln drying and reabsorption in air, shrinking and swelling.

SHRINKAGE.

The behavior of the wood of the Southern pines in shrinkage does not differ materially. Generally the heavier wood shrinks the most, and sapwood shrinks about one-fourth more than heartwood of the same specific weight. Very resinous pieces ("light wood") shrink much less than other wood. In keeping with these general facts, the shrinkage of the wood of the upper logs is usually 15 to 20 per cent less than that of the butt pieces and the shrinkage of the heavy heartwood of old trees is greater than that of the lighter peripheral parts of the same, while the shrinkage of the heavy wood of saplings is greatest of all. On the whole, the wood of these pines shrinks about 10 per cent in its volume—3 to 4 per cent along the radius, and 6 to 7 per cent along the tangent or along the yearly rings.

After leaving the kiln the wood at once begins to absorb moisture and to swell. In an experiment with short pieces of loblolly and shortleaf, representing ordinary flooring or siding

[1] In ordinary lumber and all large size material the exterior parts commonly dry so much sooner than the bulk of the stick that checking often occurs though the moisture per cent of the whole stick is still far above 30.

sizes, these regained more than half the water and underwent over half the total swelling during the first ten days after leaving the kiln (see fig. 4). Even in this less than air-dry wood the changes in weight far excel the changes in volume (sum of radial and tangential swelling), and, therefore, the specific gravity even at this low per cent of moisture was decreased by drying and increased by subsequent absorption of moisture. Immersion and, still more readily, boiling cause the wood to return to its original size, but temperatures even above the boiling point do not prevent the wood from "working," or shrinking and swelling.

In fig. 4 are represented the results of experiments on the rate of loss of water in the dry kiln and the reabsorption of water in the air. The wood used was of Loblolly and Shortleaf Pine kept on a shelf in an ordinary room before and after kiln drying. The measurements were made with caliper.

EFFECT OF "BOXING," OR "BLEEDING."

"Bleeding" pine trees for their resin, to which only the Longleaf and Cuban Pine are subjected, has generally been regarded as injurious to the timber. Both durability and strength, it was claimed, were impaired by this process, and in the specifications of many architects and large consumers, such as railway companies, "bled" timber was excluded. Since the utilization of resin is one of the leading industries of the South, and since the process affects several millions of dollars' worth of timber every year, a special investigation involving mechanical tests, physical and chemical analyses of the wood of bled and unbled trees from the same locality were carried out by this division. The results prove conclusively (1) that bled timber is as strong as unbled if of the same weight; (2) that the weight and shrinkage of the wood is not affected by bleeding; (3) that bled trees contain practically neither more nor less resin than unbled trees, the loss of resin referring only to the sapwood, and therefore the durability is not affected by the bleeding process.

The following table shows the remarkable numerical similarity between the average results for three groups of trees, the higher values of the bled material being readily explained by the difference in weight:

Longleaf Pine.	Number of tests.	Specific weight of test pieces.	Bending strength per square inch.	Compression strength per square inch.
		Per cent.	*Pounds.*	*Pounds.*
Unboxed trees	400	0.74	12,358	7,166
Boxed and recently abandoned	390	.79	12,961	7,813
Boxed and abandoned five years	535	.76	12,586	7,575

The amount of resin in the wood varies greatly, and trees growing side by side differ within very wide limits. Sapwood contains but little resin (1 to 4 per cent), even in those trees in which the heartwood contains abundance. In the heartwood the resin forms from 5 to 24 per cent of the dry weight (of which about one-sixth is turpentine), and can not be removed by bleeding, so that its quantity remains unaffected by the process.

Bled timber, then, is as useful for all purposes as unbled.

USE OF THE WOOD.

In its use the wood of all four species is much alike. The coarse grained, heavy, resinous forms are especially suited for timbers and dimension stuff; while the fine-grained wood, whatever species it may belong to, is used for a great variety of purposes.

At present distinction is but rarely made in the species and in their use; all four species are used much alike, although differentiation is very desirable on account of the difference in quality. Formerly these pines, except for local use, were mostly cut or hewn into timbers, but especially since the use of dry kilns has become general and the simple oil finish has displaced the unsightly painting and "graining" of wood, Southern pine is cut into every form and grade of lumber. Nevertheless, a large proportion of the total cut is still being sawed to order in sizes above 6 by 6 inches and lengths above 20 feet for timbers, for which the Longleaf and Cuban Pine furnish ideal material. The resinous condition of these two pines make them also desirable for railway ties of lasting quality.

Since the custom of painting and graining woodwork has given way to natural grain with oil finish, the wood of these hard pines is becoming very popular for inside finish.

Kiln-drying is successfully practiced with all four species, but especially with the Shortleaf and Loblolly pines which, if not artificially seasoned, are liable to "blue." The wood can be dried without great injury at high temperatures.

RATE OF GROWTH.

The species naturally develop somewhat differently, according to the soil conditions in which they occur. Without going into a detailed discussion, which will be found in the body of this work under each species, a comparison of the rate of growth of the four species, based on a large number of measurements, gave, for average trees and average conditions, the results shown in the accompanying diagrams (figs. 5 to 7), which permit the determination of the rate of growth at different periods of their life.

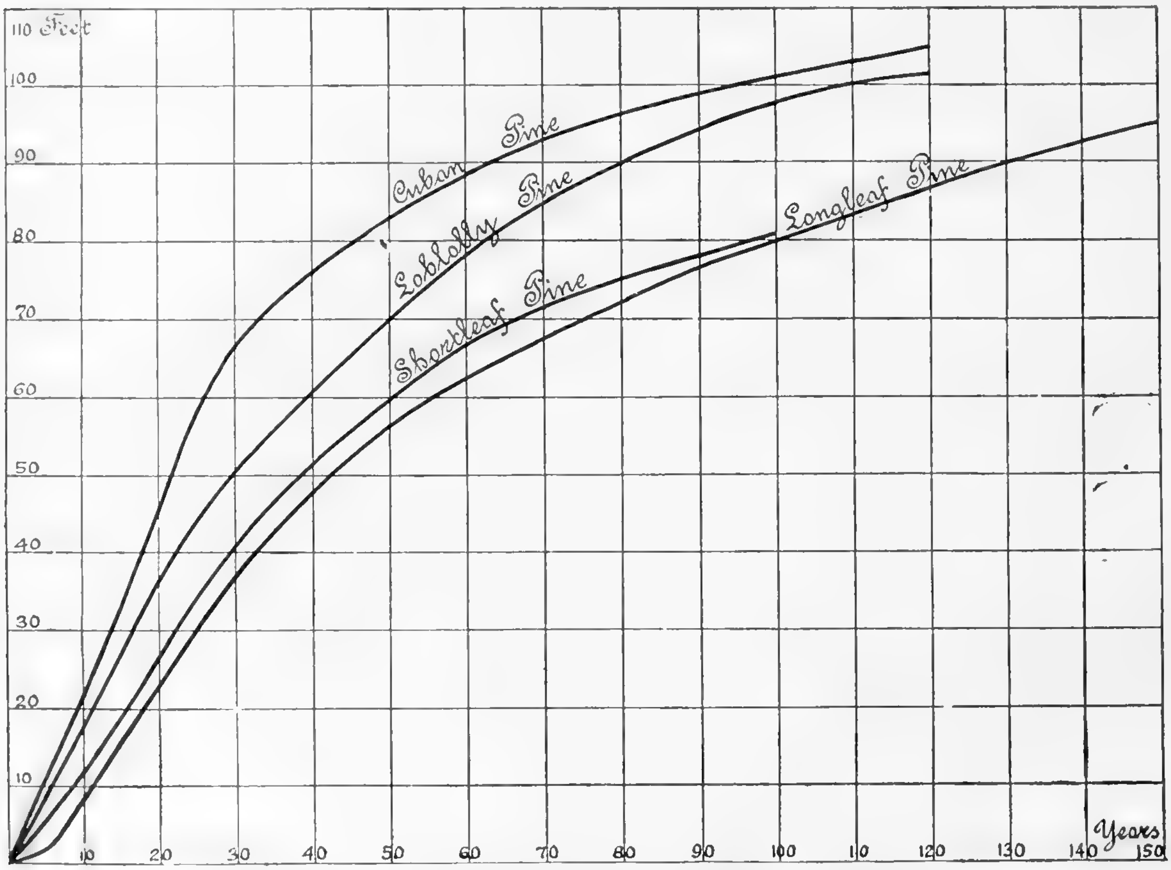


FIG. 5.—Diagram showing comparative progress of height growth in average trees.

From these it appears that the Cuban Pine is by far the most rapid grower, while the Longleaf Pine, which usually grows associated with the former, is the slowest, Loblolly and Shortleaf occupying a position between the two.

The Longleaf shows for the first five to seven years hardly any development in height and begins then to grow rapidly and evenly to the fiftieth or seventieth year, and even after that period, though the rate is somewhat diminished, progresses evenly and steadily, giving to the height curve a smooth and persistent character.

The diameter growth shows the same even and persistent progress from the start, and the volume growth also progresses evenly after the rapid height-growth rate is passed at seventy years.

The Cuban Pine ceases in its maximum rate of height growth at thirty years, starts with its diameter growth at about the rate of the Loblolly, but after the twenty-fifth year leaves the latter behind for the next twenty-five to thirty years, then proceeds at about the same rate, but persisting longer than the Loblolly. At the age of fifty years the Cuban Pine with 46 cubic feet has made nearly twice the amount of the Loblolly and more than four times that of the Longleaf, but at one hundred years the difference is reduced, being then 115, 90, and 55 cubic feet, respectively, for the three species.

Both Loblolly and Shortleaf Pine reach their maximum growth sooner than the other two species. While these still show a persistently ascending line at one hundred and twenty to one hundred and forty years, the rate of growth in the Loblolly shows a decline after the one hundredth year, and the Shortleaf has done its best by the eightieth year. These facts give indications as to the rotation under which these various species may be managed.

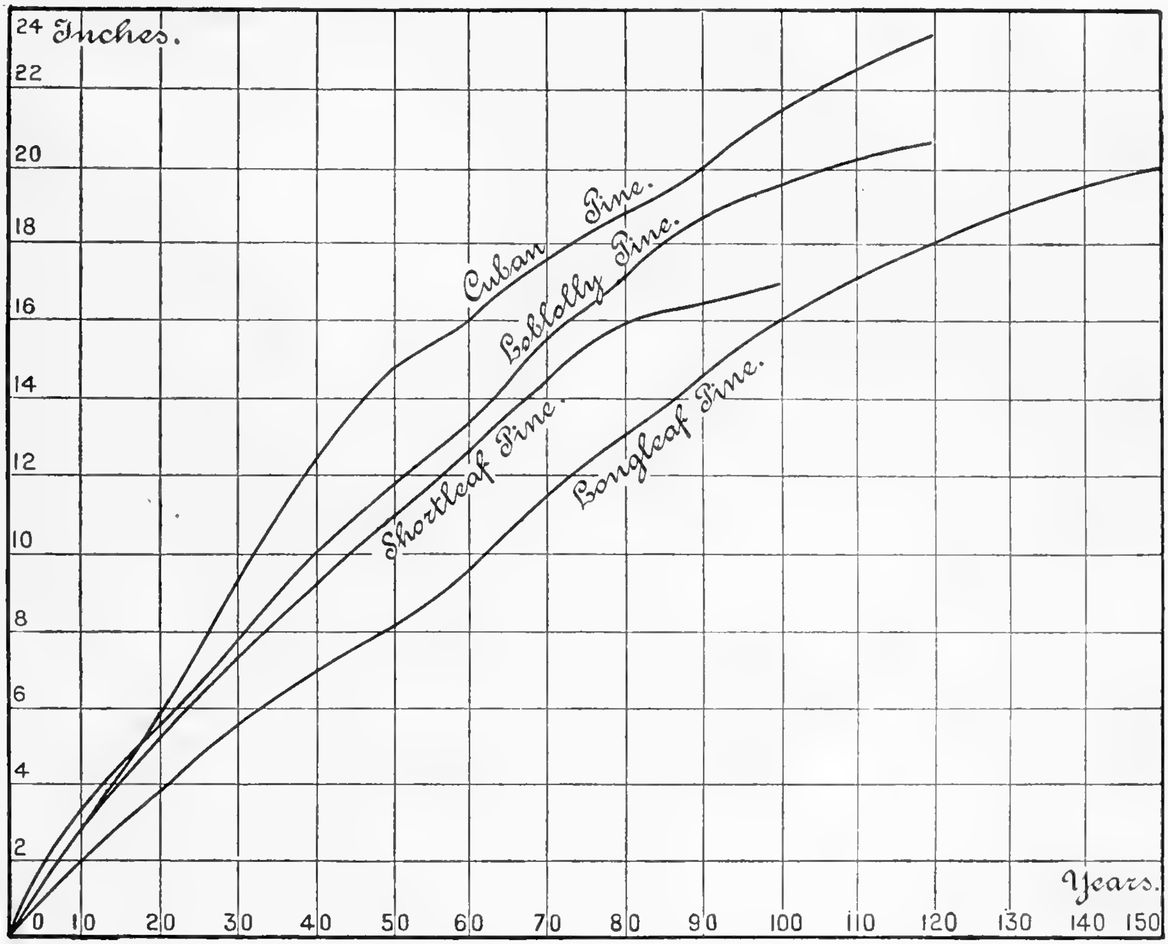


FIG. 6.—Diagram showing comparative progress of diameter growth in average trees.

As stated before, the growth of trees, especially in the virgin forest, is quite variable even for the same species and same soil conditions; an average, therefore, like the one presented in the diagrams, however perfect, could apply only when large numbers are considered. Thus there are fast-growing trees of Longleaf and slow-growing of Cuban or Loblolly Pine. Yet the diagrams will fairly well represent the average growth, with the possible exception of the Cuban Pine, for which the number of measurements was too small to furnish reliable data.

STATISTICS AND CONCLUSIONS.

The greatest difficulty Dr. Mohr has found is in the statistical portions of his work. To determine the amounts of remaining timber supplies of the various species is almost an impossibility without a very elaborate and laborious canvass, which, to be sure, it would appear our duty to undertake, but for which the means at the disposal of the Division of Forestry have never been sufficient. Even the amount of annual consumption can only be approximated, partly because the species are not always kept separate and partly because information is not always readily given by the operators or shippers.

The statistics for Longleaf Pine can be more nearly approximated, for the majority of the mills engaged in its exploitation cut hardly any other timber; moreover, its geographical limits are more clearly defined, so that even the area of remaining supplies is not entirely beyond our ken.

When it comes to using such statistics for a prognostication as regards available supplies, another difficulty arises in the change of standards of material recognized as marketable and the change of demand or use, and hence consumption, of any of the varieties. But we can now safely assume that the standard of size and quality, which was high when the census figures of 1880 were

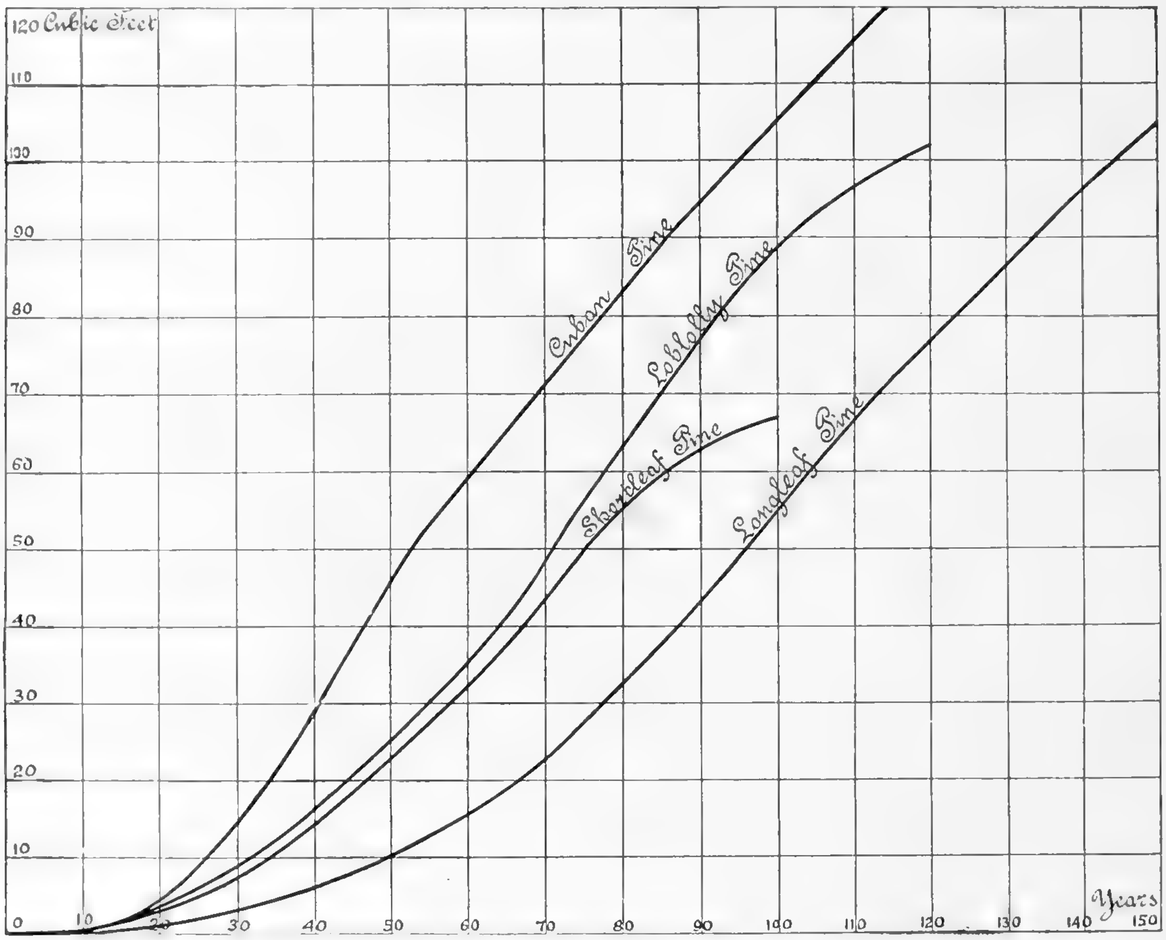


FIG. 7.—Diagram showing comparative progress of volume growth in average trees.

estimated and hence made them appear below the truth, has now sunk nearly to the lowest level, any stick that can be placed on the mill down to 10-inch and 8-inch being fit material. There is also no danger of any reduction in the cut for any reason except a temporary one due to such general business depression as that experienced throughout the last two years. Increase of consumption of Southern timber is bound to follow the imminent exhaustion of the pine supplies of the North. And with the exception of Pacific Coast timbers, which, owing to their great distance, have so far made but little competition in Eastern markets, no new undiscovered timber resource will influence the cut of Southern pine.

Venturing on the basis of the meager data furnished in this publication to make a guess at the probable supply and demand, we may with due reserve state that the amount of pine timber ready for lumber manufacture standing in the South can not be above 250,000,000,000 feet, and more likely will fall far below 200,000,000,000 feet, while the figure for present and lowest future annual consumption may be approximated at near 7,000,000,000 feet, board measure.[1]

There is nobody who knows or can know the actual condition of supplies, and whoever has an opinion on the subject will have to bring at least as good a basis or a better one for such opinion than the data furnished in the following monographs.

There is no attempt to predict from the foregoing figures the absolute exhaustion of the pine supplies of the South within forty or fifty years, although such a result would appear not unlikely. Competition of other timbers, and substitutes for the use of wood (which, to be sure, never in the history of the world have reduced wood consumption), and especially changes in present methods of exploitation, may lengthen out supplies for a short time; or, if we begin rational forestry now, these forests may be kept a source of continuous supplies, even though reduced.

Those who rely upon the spontaneous natural reproduction of these pines to fill the gaps made in the virgin timber will do well to read the chapters on natural reproduction and the incidental remarks regarding the conditions for renewal and the appearance of the aftergrowth; or, better, tramp through the vast region of culled pine woods and observe what the basis of their reliance is, as the writer of these monographs has done through forty years of his life. If, in addition, they study the chapters on conditions of development, they will realize that the Longleaf Pine is bound to disappear largely even in the regions where it reigned supreme; that the Cuban Pine, no despicable substitute, will take its place in the lower pine belt, if allowed to propagate at all; but on large burnt areas the growth of scrubby oaks and brush will forever exclude this species which eminently needs light. Loblolly and Shortleaf, better fitted for warfare with other species, will do much in their respective habitats to recuperate, except in the mixed forest, where they are culled and the hard woods are left to shade out the aftergrowth; or where the continuous conflagrations have destroyed the mold and aftergrowth and given over the soil to scrubby brushgrowth, which for ages will either prevent the gradual return of the pines or impede their renewal and growth. Considering that the timber on which we now rely and on which we base our standards comes from trees usually from one hundred and fifty to two hundred years or more old, and that none of these pines makes respectable timber in less than from sixty to one hundred and twenty-five years, the necessity of timely attention to their renewal is further emphasized.

The owners of timber land and the operators of mills are the only people who can improve these conditions, and this by a more rational treatment of their property. If they can be made to realize now that what they own and hold as a temporary speculation will, in a short time, when supplies have visibly decreased, become a first-class investment, and, by its revenues, become a greater source of wealth under competent management with a view to reproduction than that which they have derived from it by the mere robbing of the old timber, they might take steps at least against the unnecessary damage done to it by fire and cattle. Permanency and continuity of ownership appear to be the first condition to insure such results, and therefore corporations which are not of an ephemeral character and men of large wealth are most desirable forest owners.

The monographs here presented will, it is hoped, aid in this realization, and the information regarding the conditions of development of the different species will furnish suggestions as to the forest management which, modified according to local conditions and economic considerations, may be employed to secure the perpetuity of the Southern pineries.

B. E. Fernow.

Washington, D. C., *June 5, 1896.*

[1] The entire region within which these pines occur in merchantable condition comprises about 230,000 square miles or, in round numbers, 147,000,000 acres; for land in farms, etc., 10,000,000 acres must be deducted, and allowing as much as two-thirds of the remainder as representing pine lands (the other to hardwoods), we would have about 90,000,000 acres on which pine may occur. An average growth of 3,000 feet per acre, an extravagant figure when referred to such an area, would make the possible stand, 270,000,000,000 feet, provided it was in virgin condition and not mostly culled or cut.

Fig. 1.—Longleaf Pine Forest in Louisiana Flats, Virgin, Scorched by Fire as Usual.

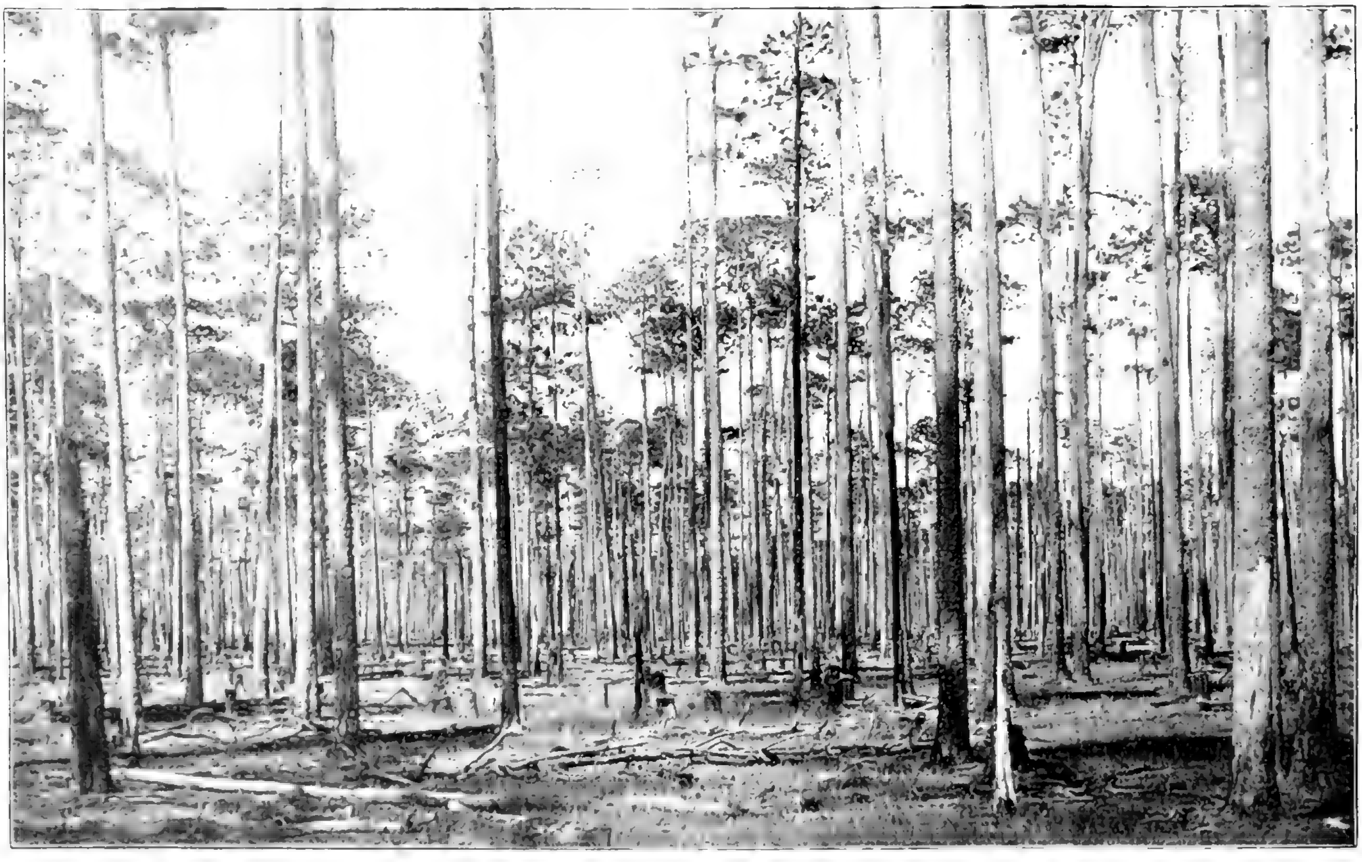


Fig. 2.—Longleaf Pine Forest after Removal of Merchantable Timber.

THE LONGLEAF PINE.

(PINUS PALUSTRIS Miller.)

GEOGRAPHICAL DISTRIBUTION.
PRODUCTS AND USES.
BOTANICAL DESCRIPTION.
DESCRIPTION OF WOOD.
PROGRESS OF DEVELOPMENT.
CONDITIONS OF DEVELOPMENT.
FOREST MANAGEMENT.
APPENDIX: THE NAVAL STORE INDUSTRY.

THE LONGLEAF PINE.

(*Pinus palustris* Miller.)

Synonyms: *Pinus palustris* Miller, Gard. Dict. ed. 8, No. 14 (1768).
Pinus lutea Walter, Fl. Car. 237 (1788).
Pinus australis Michaux f., Hist. Arb. Am. i. 64, t. 6 (1803).
Pinus serotina Hort. Cf. Bon Jard. 976 (1837) ex Antoine, Conif. 23 (1840–'47), not Michx. (1803).
Pinus Palmiensis Fr. Gard. ex Gordon, Pinetum ed. 1, Suppl. 63 (1862).
Pinus Palmieri Manetti ex Gord., l. c. (1862).

LOCAL OR COMMON NAMES.

Longleaved Pine (Del., N. C., S. C., Ga., Ala., Fla., Miss., La., Tex.).
Southern Pine (N. C., Ala., Miss., La.).
Yellow Pine (Del., N. C., S. C., Ala., Fla., La., Tex.).
Turpentine Pine (N. C.).
Rosemary Pine (N. C.).
Brown Pine (Tenn.).
Hard Pine (Ala., Miss., La.).
Georgia Pine (Del.).
Fat Pine (Southern States).
Southern Yellow Pine (general).
Southern Hard Pine (general).
Southern Heart Pine (general).
Southern Pitch Pine (general).
Heart Pine (N. C. and Southern Atlantic region).
Pitch Pine (Atlantic region).
Longleaved Yellow Pine (Atlantic region.)
Longleaved Pitch Pine (Atlantic region).
Long-straw Pine (Atlantic region).
North Carolina Pitch Pine (Va., N. C.).
Georgia Yellow Pine (Atlantic region).
Georgia Pine (general).
Georgia Heart Pine (general).
Georgia Longleaved Pine (Atlantic region).
Georgia Pitch Pine (Atlantic region).
Florida Yellow Pine (Atlantic region).
Florida Pine (Atlantic region).
Florida Longleaved Pine (Atlantic region).
Texas Yellow Pine (Atlantic region).
Texas Longleaved Pine (Atlantic region).

THE LONGLEAF PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

The Longleaf Pine is the tree of widest distribution and of greatest commercial importance in the Southern Atlantic forest region of eastern North America, covering, with scarcely any interruption, areas to be measured by tens of thousands of square miles and furnishing useful material.

The timber wealth of the forests of Longleaf Pine, much of which is still untouched, has given rise to industries which involve the outlay of vast capital and an extensive employment of labor, thus closely affecting the prosperity of a large part of the Southern States as well as the industrial and commercial interests of the whole country.

With the impending exhaustion of the pine forests of the North, the lumber interests of the country are steadily tending to center in the South, attracted chiefly by the forests of Longleaf Pine.

The Old World, which has heretofore depended almost entirely upon the pine forests of Canada and of the Northern United States for timber for heavy construction, is already importing a large amount of hewn and sawn square timber and of lumber from the Southern pine forests. Most of the lumber used for ordinary building purposes in the West Indies, on the coast of Mexico, and in many of the States of South America is furnished by the mills situated in the Longleaf Pine region. The unprecedented increase, during the last quarter of a century, of the population in the timberless regions of the far West, as well as in the country at large, enormously augment the drafts made upon these forests, threatening their eventual exhaustion and ultimate destruction unless measures are taken by which these supplies may be perpetuated. The solution of the difficult problem of devising such measures can come only as a result of a study of the life history of the Longleaf Pine, of the conditions required for its growth and best development, of the laws regulating its distribution, and of the possibilities for its natural or artificial restoration.

HISTORICAL.

The economic importance of the Longleaf Pine was well recognized in early times. Bartram,[1] in the year 1777, in his wanderings along the western shore of Mobile Bay, had his attention attracted by three very large iron pots, or kettles, each with a capacity of several hundred gallons, near the remains of an old fort or settlement, which he was informed were used for the purpose of boiling down the tar to pitch, there being vast forests of pine in the vicinity of this place. "In Carolina," this writer proceeds, "the inhabitants pursue a different method. When they are going to make pitch they dig large holes in the ground, which they line with a thick coat of good clay, into which they conduct a sufficient quantity of tar and set it on fire, suffering it to burn and evaporate for some time, in order to convert it into pitch, and when cool, put it into barrels until they have consumed all the tar and made a sufficient quantity of pitch for their purposes."

Humphrey Marshall, one of the earliest writers on North American forest trees,[2] mentions the Longleaf Pine under the name of the "largest three-leaved marsh pine, as accounted equal to any for its resinous products." In North Carolina crude resin, tar, and pitch figured as important and valuable exports during the later colonial times. During the period from 1766 to 1769, $130,000

[1] Bartram's Travels through North and South Carolina. Philadelphia, 1790.

[2] Humphrey Marshall: Arbustum Americanum, or the American Grove. Philadelphia, 1785.

worth of these stores were exported yearly; among them were 88,111 barrels of crude resin, valued at $11,244.85. F. A. Michaux, in his travels west of the Alleghany Mountains, speaking of the low country of the Carolinas, says:[1] "Seven-tenths is covered with pine of one species, *Pinus palustris*, which, as the soil is drier and lighter, grows loftier; these pines, encumbered with very few branches and which split even, are preferred to other trees for building fences on plantations." In his subsequent work Michaux gives for the first time an accurate and detailed account of the products of this tree and their industrial and commercial importance, as well as of its distribution and a description of its specific characters.[2]

NOTE.—In sketching the topographical features of those regions of the Longleaf Pine forests, which did not come under the personal observation of the writer, the physiographical descriptions of the Cotton States on the Atlantic Coast and the Gulf region published in Professor Hilgard's report on cotton production in the fifth and sixth volumes of the Census of 1880 were freely drawn upon, and these reports were also consulted, together with Table VII in the statistics published in the census report on productions of agriculture in the computation of forest areas.

In the statements of the amount of Longleaf Pine standing in the several States in 1880 and of the cut during the same year, the figures given in Prof. Charles S. Sargent's report, Vol. IX of the Tenth Census, were introduced, and for those which relate to Alabama and Mississippi the writer is mostly responsible. No efforts have been spared to arrive at a correct estimate of the total amount and value of square timber, lumber, and naval stores produced during the decade ending with the year 1890 and during the business year 1893, in order to place in a proper light the economic importance of the tree and its bearings upon the industrial and commercial interests of the country, and also to show the rapid increase of the industries depending directly upon the resources of this tree. The statements given are, however, of necessity only approximations falling below the limits of truth, as it was impossible to ascertain with any degree of accuracy the quantities entering into home consumption. Thus a factor of no little importance had to be neglected.

The thanks of the writer are due to the gentlemen who kindly assisted him by their prompt replies to his inquiries in his search for information, and who in other ways have afforded him aid.

GEOGRAPHICAL DISTRIBUTION.

The Longleaf Pine is principally confined to a belt about 125 miles in width in the lower parts of the Southern States which border upon the Atlantic and the Gulf shores. The northern limit of the tree is found on the coast near the southern boundary of Virginia below Norfolk, north latitude 36° 30′. From here the forests of the Longleaf Pine extend southward along the coast region to Cape Canaveral, across the peninsula of Florida a short distance south of Tampa Bay, westward along the Gulf Coast to the uplands which border upon the alluvial deposits of the Mississippi. West of that river forests of this species continue to the Trinity River in Texas; in that State its northern limit is found to reach hardly 32° north latitude, while in Louisiana and Mississippi it extends hardly more than half a degree farther north, and in Alabama under 34° 30′ the tree is found to ascend the extreme southern spurs of the Appalachian chain to an altitude of between 900 and 1,000 feet. Thus the area of the distribution of the Longleaf Pine extends from 76° to 96° west longitude and from 28° 30′ to 36° 30′ north latitude. (See Pl. III.)

With reference to the distribution of this species as depending upon geological formation, it may be said that its forests are chiefly confined to the sandy and gravelly deposits designated by Professor Hilgard as the orange sand, or Lafayette strata of Post-Tertiary formation, which of late is regarded as the most recent member of the Tertiary formation. These siliceous sands and pebbles, which to such vast extent cover the lower part of the Southern States and form also more or less the covering of the surface throughout the older Tertiary region, offer the physical conditions most suitable to the growth of this tree.

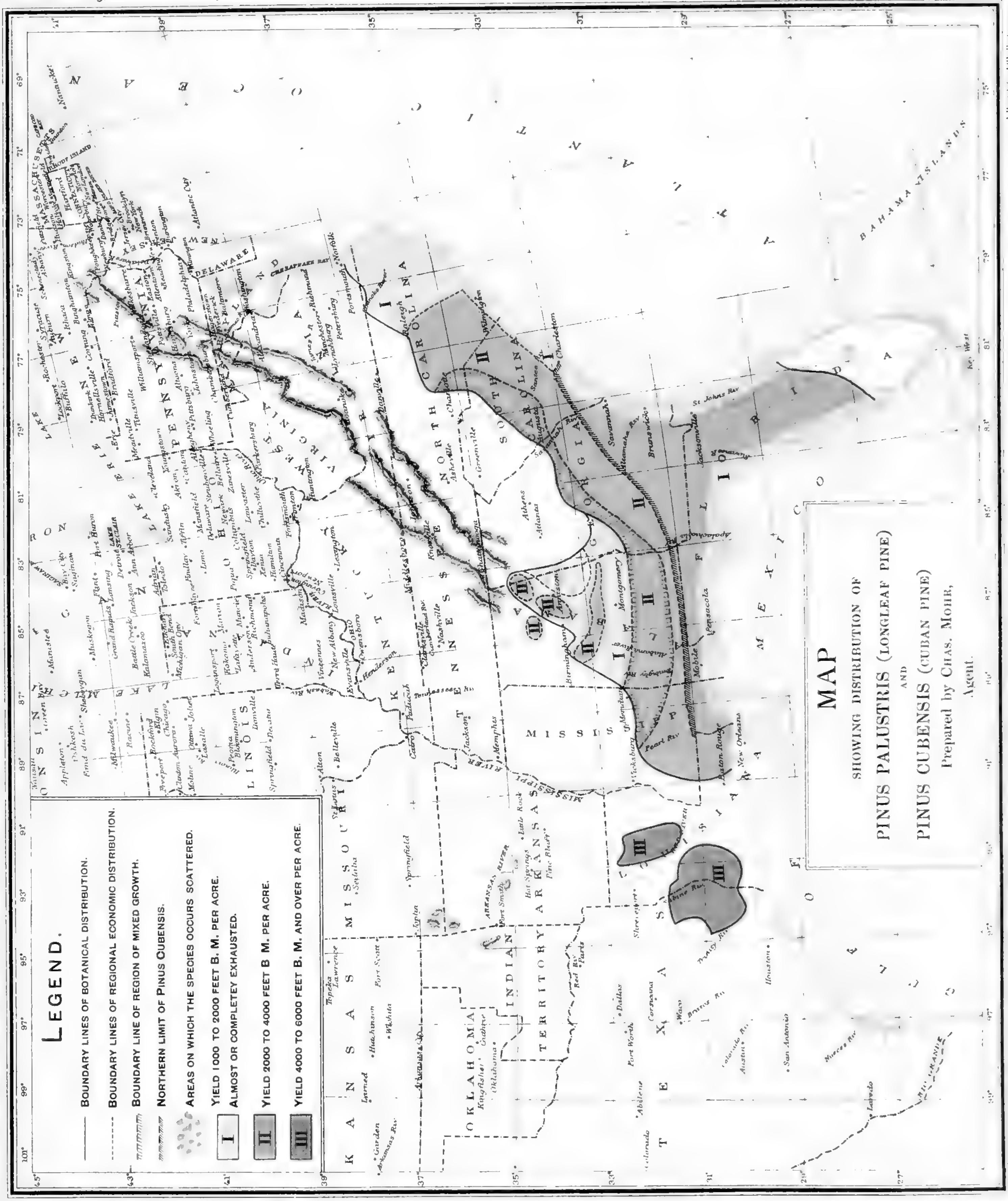
CHARACTERISTICS OF DISTRIBUTION IN DIFFERENT REGIONS.

This great maritime pine belt east of the Mississippi River presents such differences in topographical features and such diversity of physical and mechanical conditions of the soil as to permit a distinction of three divisions going from the coast to the interior:

1. The coastal plain, or low pine barrens within the tide-water region, extends from the seashore inland for a distance of from 10 to 30 miles and over. The forests of the Longleaf Pine which

[1] Travels West of the Alleghanies, by F. A. Michaux. Paris, 1803.

[2] F. A. Michaux, Histoire des Arbres forestiers de l'Amer., Sept. Paris, 1811. Philadelphia Edition, 1852, Vol. III, p. 106 et seq.


LEGEND.
BOUNDARY LINES OF BOTANICAL DISTRIBUTION.
BOUNDARY LINES OF REGIONAL ECONOMIC DISTRIBUTION.
BOUNDARY LINE OF REGION OF MIXED GROWTH.
NORTHERN LIMIT OF PINUS CUBENSIS.
AREAS ON WHICH THE SPECIES OCCURS SCATTERED.
I YIELD 1000 TO 2000 FEET B. M. PER ACRE. ALMOST OR COMPLETEY EXHAUSTED.
II YIELD 2000 TO 4000 FEET B M. PER ACRE.
III YIELD 4000 TO 6000 FEET B. M. AND OVER PER ACRE.
MAP
SHOWING DISTRIBUTION OF
PINUS PALUSTRIS (LONGLEAF PINE)
AND
PINUS CUBENSIS (CUBAN PINE)
Prepared by CHAS. MOHR,
Agent.
Scale

occupy the poorly drained grassy flats of the plain are very open, intersected by numerous inlets of the sea and by brackish marshes. They are also interrupted by swamps densely covered with Cypress White Cedar, White and Red Bay, Water Oak, Live Oak, Magnolia, Tupelo Gum, and Black Gum and again by grassy savannas of greater or less extent. On the higher level, or what might be called the first terrace, with its better drained and more loamy soil, the Longleaf Pine once prevailed, but almost everywhere in the coastal plain the original timber has been removed by man and replaced by the Loblolly Pine and the Cuban Pine.

2. The rolling pine lands, pine hills, or pine barrens proper are the true home of the Long-Leaf Pine. On the Atlantic Coast these uplands rise to hills over 600 feet in height, while in the Gulf region they form broad, gentle undulations rarely exceeding an elevation of 300 feet. Thus spreading out in extensive table-lands, these hills are covered exclusively with the forests of this tree for many hundreds of square miles without interruption. Here it reigns supreme. The monotony of the pine forests on these table-lands is unbroken.

3. The upper division, or region of mixed growth. With the appearance of the strata of the Tertiary formation in the upper part of the pine belt, the pure forests of the Longleaf Pine are confined to the ridges capped by the drifted sands and pebbles and to the rocky heights of siliceous chert, alternating with open woods of oak (principally Post Oak), which occupy the richer lands of the calcareous loams and marls. However, where these loams and marls, rich in plant food, mingle with the drifted soils, we find again the Longleaf Pine, but associated with broad-leaved trees and with the Loblolly and Shortleaf Pine. Here the Longleaf Pine attains a larger size and the number of trees of maximum growth per acre is found almost double that on the lower division.

TIMBER REGIONS—SUPPLY AND PRODUCTION.

The forests of Longleaf Pine can be conveniently discussed by referring to the following geographical and limited areas:

The Atlantic pine region;
The maritime pine belt of the eastern Gulf States;
The central pine belt of Alabama;
The forests of Longleaf Pine of north Alabama (Coosa basin, etc.);
The regions of Longleaf Pine west of the Mississippi River.

THE ATLANTIC PINE REGION.

The Atlantic pine region in its extent from the southern frontier of eastern Virginia to the peninsula of Florida embraces the oldest and most populous States of the Longleaf Pine district, and here the forests have suffered most severely by lumbering, the production of naval stores, and clearing for purposes of agriculture.

Virginia.—The forests of the Longleaf Pine on the southeastern border of Virginia have almost entirely disappeared, and are, to a great extent, replaced by a second growth of Loblolly Pine.

North Carolina.—In North Carolina the area over which this tree once prevailed may be estimated at from 14,000 to 15,000 square miles, leaving out of calculation the coastal plain with its extensive swamps, wide estuaries, and numerous inlets. From the northern frontier of the State southward, some distance beyond the Neuse River, in the agricultural district, the forest growth on the level or but slightly undulating pine land is of a mixed character, the Longleaf species being largely superseded by the Loblolly Pine, together with widely scattered Shortleaf Pine and deciduous trees—White Oak, Red Oak, Post Oak, Black Oak, and more rarely Mockernut and Pignut Hickory, and Dogwood. In this section the lumbering interests are chiefly dependent upon the Loblolly Pine (*Pinus tæda*), better known to the inhabitants as the Shortstraw, or Shortleaf Pine (not to be confounded with the true Shortleaf Pine). The forests of Longleaf Pine begin at Bogue Inlet, extend along the coast to the southern boundary of the State, and inland for a distance varying between 50 and 135 miles.

The highly siliceous soil of these pine barrens offers but little inducement for its cultivation; the inhabitants, therefore, from the earliest time of the settlement of the State have chiefly been engaged in pursuits based on the products of the pine forests. Here the production of naval stores was first carried on; rosin, tar, and pitch figured in early colonial times among the most important articles of export. In consequence, the forests of the Longleaf Pine have been, with but slight exceptions, invaded by turpentine orcharding, and at the present time by far the greater part of the timber standing has been tapped for its resin. The forests of the Longleaf Pine in this State cover the largest area in the basin of Cape Fear River, with Wilmington the main port of export for their products. The export from this port had increased from 21,000,000 feet of lumber in 1880, to nearly 40,000,000 annually, on the average, for the years 1887 to 1891.

The forests of the Longleaf Pine on the banks of the Neuse River, in Johnston County and in Wayne County, are almost exhausted; about 40 to 50 per cent of the timber sawn at Goldsboro and Dover is Longleaf Pine timber from that section, and is invariably bled. A considerable number of the trees from the old turpentine orchards, with the excoriated surface of the trunk ("chip") over 25 feet in length and bled again after a lapse of years, show that they have been worked for their resin for twenty to twenty-four years in succession, and after a longer or shorter period of rest have been subjected to the same treatment continually for the same number of years. Such old martyrs of the turpentine orchard are unfit for lumber, but, impregnated as they are with resin, are used for piling and for posts of great durability.

East of the Neuse River, from the upper part of Johnston County, in an almost southern direction to Newbern, no Longleaf Pine has been observed. Single trees of the Shortleaf Pine (*Pinus echinata*) have been found scattered among the growth of deciduous trees which cover the ridges between the Trent and Neuse rivers, and isolated tracts of a few acres of the Longleaf species are met with in the low flats of the same section, which were in 1894 almost exclusively occupied by the Loblolly Pine.

As reported for the Tenth Census, the amount of Longleaf Pine standing in North Carolina at the beginning of the census year was estimated to be 5,229,000,000 feet, board measure. No reliable information could be obtained as to the amount of timber cut since 1880, consequently no data are at hand from which to compute the amount now standing. The cut for the year 1880 is given in the census report at 108,400,000 feet, board measure. In 1890, eighteen mills were enumerated as engaged in sawing exclusively Longleaf Pine timber, almost all situated in the basin of Cape Fear River, with a daily aggregate capacity of 475,000 feet, board measure. Such capacity would point to an annual cut of at least 65,000,000 feet, board measure.

Statement of the shipments of naval stores from Wilmington, N. C.

[From J. L. Cantwell, secretary Wilmington Produce Exchange.]

Year.	Spirits of turpentine.	Rosin.	Crude resin or turpentine.	Tar.
	Casks.	*Barrels.*	*Barrels.*	*Barrels.*
1880	125, 585	663, 967		
1881	90, 000	450, 000	2, 323	
1882	98, 376	425, 925	3, 188	56, 113
1883	87, 050	483, 432	31, 966	75, 544
1884	78, 978	434, 376	45, 966	85, 230
1885	71, 145	310, 808	35, 290	70, 530
1886	63, 580	324, 942	25, 662	61, 195
1887	71, 912	381, 335	21, 572	68, 143
1888	63, 437	246, 516	18, 171	63, 163
1889	69, 668	351, 827	19, 082	68, 856
1890	70, 289	385, 523		71, 949
1891	67, 480	349, 500	16, 900	63, 700
1892	59, 283	287, 200	15, 500	67, 900
1893	58, 336	274, 800	15, 500	70, 500
1894	46, 036	189, 900	9, 900	45, 500
Total	1, 111, 155	5, 560, 051	261, 026	868, 323
Value	$19, 000, 000	$10, 000, 000	$391, 500	$1, 100, 000

Total value, $30,500,000.

Statement of shipments of lumber to foreign and domestic ports from Wilmington, N. C.

Year.	Feet, board measure.	Year.	Feet, board measure.	Year.	Feet, board measure.
1880	21, 000, 000	1885	36, 000, 000	1890	40, 066, 000
1881	45, 498, 480	1886	39, 500, 000	1891	29, 580, 160
1882	40, 291, 146	1887	41, 000, 000	1892	25, 874, 331
1883	35, 465, 000	1888	36, 680, 000	1893	30, 595, 930
1884	30, 000, 000	1889	40, 289, 000	1894	35, 353, 412

South Carolina.—The forests of Longleaf Pine in this State follow more closely the coast line, with an extension inland averaging 100 miles. The lower parts of the pine belt, or the Savannah region, is low and flat, rising but slowly above the brackish marshes and alluvial lands bordering the sea. Traversed by eight large rivers with wide estuaries and bordered by extensive swamps of Cypress, Magnolia, Red and White Bay, Laurel Oak, etc., its area has been estimated to be 7,000 square miles, 4,500 square miles of which are occupied by swamp lands, including the grassy marshes on the coast. In the low, perfectly level pine barrens, with a soil of fine, compacted, almost impervious sand, covered with the Saw Palmetto, the Pond Pine, and a stunted growth of the Cuban and Loblolly Pine, the Longleaf Pine is rarely seen, and always of dwarfed growth. In the flat woods bordering the alluvial swamps, heavily timbered with Loblolly and Cuban Pine, the Longleaf Pine makes its appearance more frequently, and finally prevails almost exclusively on the broad, dry, sandy ridges, associated with the Barren or Turkey Oak (*Quercus catesbæi*), stunted Spanish Oak, and Upland Willow Oak (*Quercus cinerea*), trees of smaller size forming the undergrowth. The timber growth on these ridges is rather open and of good quality. As has been observed near Ridgeland, in the counties of Beaufort and Hampton, the forests have to a large extent given way to the plow, and along the railroads they have been destroyed by turpentine orcharding. Upon 1 acre, representing fairly the original timber growth of the forests on these ridges, 48 trees of a diameter of from 12 to 24 inches at breast high, with a height of from 50 to 110 feet, were found. Of these, 4 yielded sticks of clear timber averaging 45 feet in length with mean diameter of 18 inches, equal to 2,000 feet, board measure, of first-class lumber. These trees varied in age from 136 to 145 years; 8 trees yielded sticks of timber free from limbs 40 feet in length with mean diameter of 17 inches, equal to 3,200 feet, board measure, age on the average 140 years; 12 trees yielded 35 feet length of clear timber with mean diameter of 16 inches, equal to 3,600 feet of merchantable lumber, age from 130 to 136 years; 8 trees averaged 12 inches mean diameter, length of timber 30 feet, equal to 950 feet, board measure, age from 110 to 118 years; 4 trees averaged 10 inches mean diameter, length of clear timber 24 feet, wood sappy throughout, yielding 200 feet of lumber, age from 80 to 85 years.

The total yield of merchantable lumber of this acre would be 9,950 feet, board measure, representing the average of the better quality of these timber lands. As in the adjoining States, the forests along the railroad lines for a wide distance have been subjected to turpentine orcharding, and but a small percentage of the timber standing has escaped the ax of the "box" cutter. The receipts of naval stores at Charleston during the ten years from 1880 to 1890 averaged annually 57,570 casks (50 gallons to a cask) of spirits of turpentine and 225,920 barrels of rosin, with the largest receipts in 1880 of 60,000 casks of spirits of turpentine and 259,940 barrels of rosin, and the smallest of 40,253 casks of spirits in 1888, and 170,066 barrels of rosin in 1886.

Tabular statement of the shipments of naval stores at Charleston, S. C., from the beginning of 1880 to the close of the year 1894.

[From the annual statements of the commerce of Charleston, S. C., published in the Charleston Courier.*]

Year.	Spirits of turpentine.	Rosin.	Year.	Spirits of turpentine.	Rosin.
	Casks.	*Barrels.*		*Casks.*	*Barrels.*
1880	60,000	259,940	1889	43,127	149,348
1881	51,386	231,417	1890	49,232	217,865
1882	69,027	258,446	1891	35,414	163,816
1883	65,914	285,446	1892	25,969	127,262
1884	64,207	264,049	1893	22,543	121,624
1885	44,126	218,971	1894	14,415	71,329
1886	40,375	170,066			
1887	52,549	171,154	Total	678,537	2,892,619
1888	40,253	181,886	Value	$11,874,397	$5,206,714

* The annual receipts on the average equal the exports.

The rolling pine hills bordering upon the flat woods, or swamps, reach elevations of 130 to 250 feet above the sea, with a width of from 20 to 40 miles, and, as on the pine ridges of the low pine barrens mentioned before, the upland oaks form the sparse undergrowth in the forests of Longleaf Pine. Nearly one-third of the area (estimated at about 4,500 square miles) has been opened to cultivation. These rolling pine lands rise on their northern borders abruptly to a range of steep hills over 600 feet above sea level, covered with a rather scanty growth of Longleaf

Pine among the Shortleaf Pine and fine upland oaks, the latter largely prevailing. On the south and west these hills merge into an elevated plateau with a loose soil of coarse white sand. Here the Longleaf Pine is found in its full perfection and furnishes timber of excellent quality.[1] About 12 per cent of these pine-clad table-lands are under cultivation, and about 22 per cent of the hills, with their generous red soil, are covered with a mixed growth of pine and oak; both of these divisions cover an area of not less than 4,000 square miles.[2]

The Longleaf Pine timber standing in South Carolina in the census year 1880 was estimated at 5,316,000,000 feet, board measure,[3] with an annual cut of 124,000,000 feet.

In 1890 forty mills sawing exclusively Longleaf Pine timber have been reported[4] with an aggregate daily capacity of about 510,000 feet, taken at the lowest figure. This would indicate for that year a cut of 68,000,000 feet, board measure, which may also be considered the average annual cut for the last fifteen years.

The exports of lumber from Charleston, the chief port, have since the year 1880 steadily increased, the excess in 1890 over the amount in 1880 reaching over 400 per cent, as is exhibited in the following statement:

Statement of lumber exported from Charleston, S. C., to foreign and domestic ports from the beginning of 1880 to the close of 1894.

[Includes considerable Loblolly and Shortleaf Pine.]

Year.	Feet, board measure.	Year.	Feet, board measure.
1879-80	15,437,000	1887-88	45,270,000
1880-81	18,500,000	1888-89	50,532,000
1881-82	43,000,000	1889-90	68,400,000
1882-83	40,000,000	1890-91	61,226,827
1883-84	35,589,000	1891-92	53,286,608
1884-85	30,034,000	1882-93	61,093,344
1885-86	26,800,000	1893-94	69,940,453
1886-87	32,672,000		

Georgia.—The great pine State of the South, which has given to the Longleaf Pine the name of Georgia Pine, by which this lumber is known the world over, embraces the largest of the Atlantic pine forests. At a rough estimate, these cover over 19,000 square miles, including the narrow strip of live-oak lands bordering the seashore. The flat woods and savannas of the coast plain are from 10 to 15 miles wide. They are almost entirely stripped of their growth of Longleaf Pine.

The upland pine forests, the pine barrens proper, or wire-grass region,[5] embrace over 17,000 square miles. This region forms a vast plain, nearly level except on the north, covered exclusively with Longleaf Pine. About 20 per cent of these lands have been cleared for cultivation.

Formerly the principal sites of the lumber industry were Darien, Brunswick, and Savannah The logs were rafted hundreds of miles down the Savannah, the Ogeechee, the Altamaha and its large tributaries, the Oconee and Ocmulgee. A limited quantity is carried down the Flint and Chattahoochee rivers to Apalachicola. The railroads, however, supply the mills now to the largest extent.

The forests of these pine uplands are in quality, and originally in quantity, of their timber resources equal to any found east of the Mississippi River. The soil is a loose sand, underlaid by a more or less sandy buff-colored or reddish loam. The almost level or gently undulating plain becomes slightly broken along the water courses, and the forests of Longleaf Pine are interrupted by wide, swampy bottoms which inclose the streams and are heavily timbered with the Loblolly Pine, Cuban Pine, Laurel Oak, Water Oak, Magnolia, White and Red Bay, and Cypress. On the better class of the pine-timber lands the amount of marketable timber found varies between 3,000 and 10,000 feet to the acre. The trees yielding lumber and square-sawn timber of the highest

[1] Kirk Hammond, Census Report, Vol. VI, Cotton production of South Carolina.

[2] Hammond, 1 c.

[3] Report of Tenth Census, Vol. IX.

[4] Lumber Trade Directory, Northwestern Lumberman, Chicago, July, 1890.

[5] From the so-called wire-grass *Aristida stricta*, the most characteristic plant of the dry, sandy, pine barrens from western Alabama to the Atlantic coast.

grade were found to make sticks of from 40 to 45 feet long, perfectly clear of limb knots, and 18 to 22 inches mean diameter, giving from 450 to 750 feet of lumber, with the sapwood from 1½ to 2 inches wide.

The following measurements of trees from a small tract of forest untouched by the ax serve as a fair average sample of its timber growth:

Number of tree.	Diameter, breast high.	Mean diameter.	Length of timber.	Total height.	Number of rings.
	Inches.	*Inches.*	*Feet.*	*Feet.*	
1	28	22	45	93	250
2	22	18	40	106	240
3	19	15	40	96	150
4	18	15	40	93	138
Average	21¾	17½	41¼	97	194

Along the numerous railroad lines and the navigable streams and their tributaries admitting of the driving of logs, the forests have been completely stripped of their merchantable timber, and the denuded areas to a considerable extent are at present under cultivation. The magnificent forests on the Altahama River and between its tributaries, the Ocmulgee and Oconee rivers, and also on the Ogeechee River, have been practically exhausted and are utterly devastated by the tapping of the trees for turpentine. In fact, more than two-thirds of all the timber sawn at present has been bled. The timber from the turpentine orchards, abandoned for years past, is being rapidly removed to the mills, and the vast areas occupied by them will, within a short time, be almost completely denuded of the Longleaf Pine, its place being taken by scrubby oaks, dwarf hickories, and Persimmon. The timber is transferred to the mills mostly by steam-equipped tramroads, and the products of the turpentine distilleries in the remoter districts are hauled to the highways of commerce by ox teams for distances of 12 miles and over.

Considering the removal for their timber of trees far below medium size and during the best period of their growth, the destruction of still younger trees by turpentine orcharding, and of the young seedlings by fire, the prospect for the future of the lumber industry and the renewal of the forests of Longleaf Pine in this region are gloomy. Many of the intelligent men practically interested in the timber lands of this State aver that the exhaustion of the forests of the Longleaf Pine is a question of but a short space of time, to be accomplished before another generation has passed.

The amount of timber standing at the end of the census year 1880 had been computed at 16,778,000,000 feet, board measure, and the cut at 272,743,000 feet.

From the publication quoted, it appears that in the year 1890 there were 88 sawmills in operation in the great pine belt of Georgia, sawing exclusively Longleaf Pine timber. On the basis of lowest figures cited, the daily cut at these establishments during that year would not fall short of 1,667,000 feet.

No statistical returns of the lumber trade previous to 1884 could be obtained at Savannah, Darien, or Brunswick. The export from the first of these ports averaged about 73,000,000 feet, board measure, a year, showing but slight fluctuation during the period beginning with 1884 to the close of 1889, when in the subsequent two years the annual average increased to 118,000,000 feet, board measure. The exports from Darien and Brunswick, averaging 82,000,000 and 85,000,000 feet, respectively, for a similar period of time, show also but small differences from one year to another. About 30,000,000 to 33,000,000 feet are rafted down the Flint and Chattahoochee rivers, to be sawn at Apalachicola. With the spread of the sawmills along the railroad lines in the upper part of the pine region, the shipments of lumber by rail to distant Northern markets increased steadily, until in 1892 it was found that the production of Longleaf Pine lumber shipped by rail to Northern markets exceeded 60,000,000 feet.

Tabular statement of exports of lumber from Savannah, Darien, Brunswick, and St. Marys to foreign and domestic ports and shipments by railroad to inland markets from 1883–84 to 1893–94.

Year.	Savannah.	Darien.	Brunswick.	St. Marys.	Savannah Railroad.	Otherwise by rail.	Flint River.	Total.
	Feet, B. M.	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*
1883–84	82,100,000	90,100,000	84,700,000	8,500,000				
1884–85	69,100,000	72,900,000	87,500,000	8,500,000				
1885–86	68,000,000	83,000,000	80,000,000					
1886–87	68,400,000	90,000,000	88,000,000					
1887–88	70,400,000	90,000,000	88,000,000					
1888–89	78,100,000	85,000,000	82,000,000					
1889–90	128,600,000	70,000,000	81,000,000					
1890–91	107,300,000	80,000,000	80,000,000					
1891–92	138,300,000	85,000,000	80,000,000		50,000,000	16,900,000	33,000,000	403,200,000
1892–93	116,100,000	85,000,000	80,000,000		50,000,000	16,000,000		347,000,000
1893–94	77,400,000	85,000,000	80,000,000		50,000,000			292,000,000
Total	935,800,000	833,000,000	834,200,000	17,000,000	150,000,000	32,900,000	33,000,000	

This makes a grand total for the ten years ended 1894 of 2,836,000,000 feet, board measure, with an aggregate value, at present export rates ($11 per 1,000 feet), of at least $31,196,000.

In the production of naval stores Georgia takes the lead. By the statements of the census of 1870, only 3,208 casks of spirits of turpentine and 13,840 barrels of rosin, valued at $95,970, were produced during that year in the State. In the course of the following ten years this industry progressed steadily and rapidly. In 1888 exports from Savannah, at present the greatest market in the world for these products, had increased to 168,000 casks of spirits of turpentine and 654,000 barrels of rosin, of a total value of $3,880,000.

Statement of exports of naval stores from Savannah during the years 1880–1894.

Year.	Spirits of turpentine.	Rosin.	Year.	Spirits of turpentine.	Rosin.
	Casks.	*Barrels.*		*Casks.*	*Barrels.*
1879–80	46,321	221,421	1888–89	159,931	577,990
1880–81	54,703	282,386	1889–90	181,542	716,658
1881–82	77,059	309,834	1890–91	196,227	770,311
1882–83	116,127	430,548	1891	196,166	758,448
1883–84	129,835	559,625	1892	234,986	873,678
1884–85	121,028	401,998	1893	277,617	1,032,198
1885–86	106,925	424,490	1894	261,081	957,027
1886–87	146,925	566,932			
1887–88	168,834	654,286	Total	2,475,297	9,637,830

Valued at $49,401,031.

The highest prices for these stores in Savannah were obtained in 1880, with $19.50 per cask of 50 gallons for spirits of turpentine and $2.25 per barrel of rosin of 280 pounds gross; and the lowest in 1887–88, with the price of spirits of turpentine at $14.25 per cask and $1.40 per barrel of rosin. On close scrutiny of the prices ruling at Wilmington, for the eleven years after 1880 the price of a cask of spirits of turpentine averaged $18 and of a barrel of rosin $1.90, lowest grades of the latter excluded.

Florida.—That part of the State between the Suwanee River and the Atlantic Coast, as far south as St. Augustine, can be considered as part of the Atlantic pine region, and covers an area of about 4,700 square miles. In the basin of the St. Johns River a large part of the land has been devoted to the cultivation of the citrus fruits. The principal sites of the manufacture of lumber in this section of the State are Ellaville, in Madison County, on the Suwanee River, and Jacksonville. The supplies once existing along the Cedar Keys and Fernandina Railroad are at present well-nigh exhausted. South of St. Augustine the Longleaf Pine is less common and in general inferior in size. The timber on the extensive flat woods to the Everglades, covered with the Saw Palmetto, is stunted and the forests are very open, and in the more fertile soils Longleaf Pine is largely replaced by Cuban Pine. In the central section of the peninsula, with its numerous lakes, the Longleaf Pine is largely associated with the Sand Pine (*Pinus clausa*), and hard woods prevail on the upland hummock lands.

THE MARITIME PINE BELT OF THE EASTERN GULF REGION.

From the banks of the Suwanee River to the uplands bordering the alluvial lands of the Mississippi this pine belt, varying from 90 to 125 miles in width, covers an area roughly estimated at a little over 40,000 square miles. It presents no material differences from the Atlantic region, of which it is a direct continuation, being similar to it in both soil and climate.

This eastern Gulf region is unsurpassed in the advantages it offers for the development of the industries based on the products of the pine forests. Its genial climate throughout the year permits the uninterrupted exploitation of its abundant resources of resinous products and of timber of the best quality. The fine harbors and safe roadsteads on the Gulf Coast are reached by navigable rivers, which, with their tributaries, cross the lower division in every direction, and give ready and cheap transportation to its ports, while great railway lines afford easy communication with inland markets. This region thus presents inducements scarcely found elsewhere for the investment of capital and labor in the development of the resources of its forests.

It is impossible to arrive at anything like an accurate estimate of the amount of timber standing at present, or of the rate of its consumption, since in the returns of the annual lumber product that needed for home consumption has not been included.

Western Florida.—Placing the eastern limit of that part of Florida to be considered as belonging to the Gulf pine region at the lower course of the Suwanee River, the area included comprises about 7,200 square miles, exclusive of the swamps and marshes of the coast. The forests of Longleaf Pine form a narrow strip along the course of the Suwanee River and along the coast to the Appalachicola River, covering about 1,280,000 acres. At their northern limit they merge into the oak and hickory uplands of middle Florida. Along the coast they are surrounded by marshes and swamps, rendering them difficult of access, consequently they have remained untouched. The same may be said of the pine forests between the Appalachicola and the Choctawhatchee rivers. These have been invaded to some extent along the banks of the latter river to supply the small mills situated on the bay of the same name.

The pine lands of western Florida rise slowly above the coastal plain and form a vast expanse of slightly undulating surface. Those surrounding Perdido, Pensacola, Blackwater, and Mary St. Galves Bay, the oldest sites of active lumber industry in the Gulf region, were stripped of their valuable timber more than thirty years ago, and since that time have been cut over again.

The largest tracts of finely timbered virgin forests of Longleaf Pine are found in the undulating uplands from the Perdido and Escambia rivers along the Alabama State line to the banks of the Choctawhatchee River. East of this river, in the same direction, where the younger Tertiary strata make their appearance, Longleaf Pine becomes associated with hard woods, with southern Spruce Pine added in the valleys. Since the opening of the Pensacola and Atlantic Railroad considerable quantities of sawn square timber find their way to Pensacola from these remoter forests.

A large portion of the timber supplied to the mills along the coast having been derived from Alabama, it is impossible to arrive at an exact estimate of the products of the forest of western Florida.

Statement of export of hewn square timber, sawn square timber, and lumber to foreign and domestic ports from Pensacola, Fla., from 1879–80 to 1892–93.

[From Hyer & Bro.'s annual circulars.]

Year.	Square hewn timber.	Square sawn timber and lumber.	Total.
	Cubic feet.	*Feet, B. M.*	*Feet, B. M.*
1879–80	2,180,000	176,000,000	202,000,000
1880–81	4,603,000	209,998,000	264,000,000
1881–82	5,479,650	161,305,000	230,600,000
1882–83	2,169,000	188,100,000	211,386,000
1883–84	2,031,000	194,890,000	219,286,000
1884–85	1,627,000	195,576,000	211,131,000
1885–86	1,700,100	215,750,600	228,590,000
1886–87	1,036,000	231,884,600	245,221,000
1887–88	1,283,000	238,299,400	253,699,000
1888–89	1,574,000	310,255,000	329,153,000
1889–90	1,367,000	276,587,000	292,991,000
1890–91	1,550,133	254,125,000	271,728,800
1891–92	1,488,272	325,081,000	294,958,700
1892–93	1,449,910	252,808,000	270,208,000
Total			3,534,352,300

In the shipment of these products in 1885, valued at $2,305,500, there were 471 vessels engaged, of 294,595 tons, of which 370 of 95,922 tons cleared for foreign ports.

During these fourteen years the price of square timber and lumber taken in the aggregate averaged about $12.50 per 1,000 feet, board measure. On this basis the value of the mill products for these parts of the forests of Longleaf Pine amounted to $3,155,670 a year.

For the past forty years, during which the lands of the peninsula part and in middle Florida have passed mostly into possession of small proprietors, no naval stores have been produced in this section. In western Florida, however, in proximity to the Louisville and Nashville and Pensacola railroads, large areas have been subjected to the tapping of the trees, and the forests close to these railroads having been exhausted, the products of the turpentine stills are hauled for a distance often exceeding 10 miles and find their market mostly at Mobile.

Alabama.—Owing to the diversity in geological conditions and in topographical features prevailing in this State, the distribution of the Longleaf Pine presents within its borders peculiarities not found elsewhere. It appears in three separate regions—the maritime pine belt, the central pine belt, and the pine forests of the Coosa Basin and other outlying forests in north Alabama.

The coast pine belt extends from the Gulf shore inland for a distance of from 90 to 100 miles, and has been estimated to cover about 13,750 square miles, or 8,800,000 acres, outside of the swamps and flatwoods of the coast plain. The latter, perfectly level or rising in gentle swells above the tidewater marshes, is almost completely stripped of its original timber growth. After its removal the Longleaf Pine has largely been replaced by Cuban Pine.

The rolling pine uplands rise to a height of from 200 to 350 feet above the lowlands of the coast. In the lower part of this pine belt, where the sandy and gravelly deposits of the latest tertiary strata prevail, the Longleaf Pine forms pure forests, with the exception of the narrow strips of hardwood timber bordering the water courses. This lower division covers about 4,250,000 acres. In the extent and quality of their timber resources these Longleaf Pine forests can be considered equal to those found in the adjoining parts of Florida and in Mississippi, and unsurpassed by those of the most favored sections of the Atlantic pine forest.

The following measurements of trees felled near Wallace, Escambia County, in collecting the material for the United States timber tests, will serve to represent fairly the quality of the merchantable timber in conformity with the standard in vogue at the mills in 1880, and the relation of age to growth:

Measurements of five trees.

Number of tree.	Diameter, breast high.	Total height.	Rings on stump.	Diameter below crown.	Mean diameter of timber.	Length of timber free of limb-knots.
	Inches.	*Feet.*		*Inches.*	*Inches.*	*Feet.*
1	26	106	216	18	22	50
2	19	111	189	14	16	60
3	16	111	183	12	14	45
4	18	113	196	15	17	50
5	19	113	182	13	16	50
Average	19.6	111	193	14.5	17	51

At a lumber camp near Lumberton, in Washington County, 9 timber trees were measured showing on the average a mean diameter of 17 inches, the clear sticks averaging 40 feet in length.

Upon 1 acre, selected at random in the untouched forests north of Springhill, Mobile County, very open and free from smaller trees or undergrowth, 16 trees were counted above 16 inches in diameter at breast high, namely, 2 trees 23 inches in diameter at breast high, estimated length of timber, 40 feet; 2 trees 20 inches in diameter at breast high, estimated length of timber, 40 feet; 12 trees 16 to 18 inches in diameter at breast high, estimated length of timber, 35 feet; which in the aggregate would yield about 5,000 feet, board measure.

Upon another acre plat of the same quarter section 64 trees above 12 inches in diameter at breast high were found; of these 2 trees measured 20 inches in diameter at breast high, estimated length of timber, 40 feet; 26 trees measured 17 inches in diameter at breast high, estimated length of timber, 36 feet; 36 trees measured 13 inches in diameter at breast high, estimated length of timber, 24 feet.

Upon a third plat exceptionally heavily timbered, 45 trees were counted, of which 5 trees were 25 inches in diameter at breast high, the clear timber averaging 50 feet in length; 12 trees 22 inches in diameter at breast high, length of timber 50 feet, and 28 trees 16 to 18 inches in diameter, average length of timber estimated at 30 feet. Such a stand would indicate a yield of merchantable timber of at least 15,000 feet, board measure, to the acre. All over this lower division boggy tracts are frequently met with, in which the sour, black soil is covered with sphagnum, or bog moss; these support only a few scattered pines. On many of the steeper ridges the soil is pure sand and the pine growth is small and inferior, being largely replaced by Barren Oak, Sparkleberry, and the evergreen heather-like shrub *Ceratiola ericoides*.

In this lower division of the maritime pine belt the manufacture of lumber and the production of naval stores is carried on most actively. These products find their outlet chiefly at Mobile, while more than one-third of the lumber exported from Pensacola (to the amount of at least 100,000,000 feet annually for the past few years) is also derived from this division. In the upper half of the maritime pine belt, with the appearance of the outcrops of limestones and limy marls of the Lower Tertiary (Eocene) formation, the country becomes more broken, with steeper hills and wider valleys, and a change in the character of the flora takes place, particularly manifest in the nature and distribution of the tree growth. In the fertile valleys and on the lower flanks of the hills broad-leaved trees, mostly Post Oak, Black Oak, Mockernut, Bitternut, Pignut, and Magnolia prevail, interspersed with Shortleaf Pine, Loblolly Pine, and Red Cedar—the Longleaf Pine occupying sporadic patches of drifted sands and pebbles. On the steep and frequently wide ridges capped by these deposits, and on the rugged hills of the buhrstone and flinty cherts this tree forms the principal growth, and is in the openings more or less associated with broad-leaved trees. From this commingling of cone-bearing and deciduous trees and the alternations of pine forest and oak woods, this upper division has been designated as the region of mixed growth, which at a rough estimate can be said to cover about 5,000 square miles.

In the deep soil of light loam and strong loamy sands the Longleaf Pine attains a splendid growth and the number of large trees on a given area is greater than found in the lower division. The following measurements of 5 trees felled for test logs fairly represent the average dimensions of the timber from these hills in the vicinity of Thomasville, Clarke County:

Measurements of five trees.

Number of tree.	Rings in stump.	Diameter breast high.	Diameter below crown, or top end of timber.	Mean diameter of timber.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*
16	202	20	15	18	45	108
17	163	21	14	17	40	115
18	210	22	16	19	40	110
19	160	26	19	22	40	111
20	110	17	13	15	30	92
Average	171	21.2	15.4	18.2	39	106.2

Many of the trees of larger size were found affected by wind-shake in the direction of the rings of growth (ring-shake), in many instances impairing greatly the quality of the timber. The forests on these hills are open, with a comparatively small number of young trees. Upon 1 acre selected at random 46 trees were counted; of this number were found 4 trees of a diameter of 25 inches breast high, and the length of timber about 40 feet; 10 trees of a diameter of 22 inches breast high, and the length of timber about 36 feet; 26 trees of a diameter of 18 inches breast high, and the length of timber about 30 feet; 6 trees of a diameter of 15 inches breast high, and the length of timber about 25 feet.

On the average each one of these trees would yield about 400 to 450 feet, board measure. On another acre 44 trees were found differing in their average dimension but slightly from the above, and indicating a yield between 18,000 and 19,000 feet of lumber to the acre. In this upper part of the coast pine belt lumbering and turpentine orcharding have not developed to any great extent, owing to its inaccessibility. However, where railroads traverse the section, the manufacture of lumber is carried on extensively, the output going to Northern markets. Much of the heavy hewn timber that is exported from Mobile and Pensacola is furnished by this section.

In collecting the statistics on the lumbering interests in the maritime pine belt of Alabama the information kindly furnished by firms engaged in the sawmill business or the lumber trade has chiefly been relied upon. The annual production was arrived at by multiplying the average daily output reported by 200, the assumed number of working days of the year. From these data it appears that during the year 1893 the daily output of the 25 points reported from amounted in the aggregate to about 768,000 feet, or to 192,000,000 feet, board measure, for the year. This figure can be said to represent the average of the annual production for the past three years. To this amount, at a low estimate, 85,000,000 feet of round timber are to be added, cut in Alabama and sawn in western Florida, including the hewn square timber shipped from the State to Pensacola, thus swelling the present annual production of lumber and square timber in the maritime pine belt of Alabama to a total of about 277,000,000 feet, board measure. The statement of the annual exports of these products from Mobile by water and by rail for the past fourteen years will aptly illustrate the steady increase of the lumbering interests during this period.

Statement of exports of square timber, hewn and sawn, and of lumber shipped from Mobile to foreign and domestic ports from the year 1879–80 to the end of the year 1894.

Year.	Square timber, hewn and sawn.	Lumber.	Total lumber and square timber.	Value.
	Cubic feet.	*Feet, B. M.*	*Feet, B. M.*	
1879-80	745,000	13,572,000	22,525,000	$280,825
1880-81	1,725,000	18,161,000	38,872,000	400,348
1881-82	1,674,000	32,236,000	53,350,000	710,012
1882-83	1,652,804	26,753,843	46,588,000	582,000
1883-84	3,810,714	22,251,000	67,978,000	801,699
1884-85	3,121,794	22,256,000	59,945,000	636,953
1885-86	2,973,206	21,435,500	56,580,000	588,148
1886-87	1,863,259	29,346,000	60,723,000	641,215
1887-88	2,450,257	29,257,000	59,740,000	677,804
1888-89	3,049,440	48,284,000	100,000,000	1,081,828
1889-90	3,814,987	52,879,000	111,659,810	1,201,934
1890-91	3,592,924	50,892,000	122,000,000	1,415,000
1891-92	5,072,088	61,865,895	141,793,700	1,695,000
1892-93	5,377,009	79,304,565	162,666,700	1,590,900
1893-94	4,147,825	67,209,745	126,684,500	1,270,000

The first statement of the production of naval stores in Alabama is that reported to the census of 1850, mentioned in that year as of a value of $17,800. In 1870 the production had increased to 8,200 casks of spirits of turpentine and 53,175 barrels of rosin, valued at $280,203. In 1873 the receipts in the market of Mobile had fully doubled, amounting to nearly 20,000 casks of spirits of turpentine and to from 75,000 to 100,000 barrels of rosin, besides 1,000 barrels of tar and pitch, of a total value of $750,000. The largest production was reached in 1875, when the receipts reached a value of $1,200,000, up to the present only approximated in 1883 with 43,870 casks of spirits of turpentine and 200,025 barrels of rosin, valued at $1,109,760. Since 1888 a steady decline in the receipts of these products has taken place, due to the exhaustion of the supplies near the commercial highways.

Table of exports of naval stores from Mobile during the period of 1880–1894.

Year.	Spirits turpentine.	Rosin.	Total value.	Year.	Spirits turpentine.	Rosin.	Total value.
	Casks.	*Barrels.*			*Casks.*	*Barrels.*	
1879-80	25,209	158,482	....	1887-88	28,725	132,055	....
1880-81	25,224	170,616	....	1888-89	23,927	106,129	....
1881-82	30,937	172,438	....	1889-90	21,029	93,906	....
1882-83	43,870	200,125	....	1890-91	21,686	89,872	$535,690
1883-84	41,804	210,572	....	1891-92	22,172	87,926	458,002
1884-85	41,713	200,688	....	1892-93	18,060	69,120	355,180
1885-86	38,733	175,817	....	1893-94	24,091	85,619	453,656
1886-87	40,149	182,955	....				

THE CENTRAL PINE BELT OF ALABAMA.

The middle portion of the State is crossed from its eastern boundary nearly to its western, with a decided northern trend along the western border, by a belt of drifted loamy sands, pebbles, and light loams covered in the eastern and central parts with an almost continuous forest of Longleaf Pine, interrupted only by strips of hard-wood which occupy the bottom lands. In its eastern extent the Longleaf Pine becomes associated with upland oaks, hickories, and Shortleaf Pine, the Longleaf Pine being entirely replaced in the northern extension of this belt by the latter species.

This region of gravelly hills, as it is designated in the agricultural reports,[1] is 200 miles in length, 5 to 35 miles in width, and extends over about 2,000 square miles. In the sections where the forest consists almost exclusively of Longleaf Pine the stand of timber is heavy and of fine quality. Operators claim for these timber lands a yield of from 5,000 to 6,000 feet of merchantable timber to the acre, excluding all trees under 12 inches diameter.

Ever since the opening of the great railroad lines leading to Northern markets the manufacture of lumber in this central pine belt has been carried on with unabated activity. In 1880 not less than 80,000,000 feet, board measure, were transported by the Louisville and Nashville Railroad alone, mostly to the great Northwestern centers of commerce. In 1886 the production declined to 50,000,000 feet. At present most of the older mill sites have been abandoned and a few new ones established in other localities. Colonel Wadsworth reports 12 mills in operation located along the Louisville and Nashville Railroad, with an output of a little over 40,000,000 feet a year on the average of the past few years. To this is to be added the production of the few mills on the Mobile and Birmingham Railroad, which will increase the present production in the central pine belt to about 50,000,000 feet a year.

THE FORESTS OF LONGLEAF PINE IN NORTH ALABAMA.

Forests of Longleaf Pine prevail with more or less interruption in the basin of the Coosa River, principally on the beds of flinty pebbles and light, sandy loam which follow the upper course of the river from the base of the Lookout Mountain range near Gadsden to a short distance beyond the State line in Floyd County, Ga., where the Longleaf Pine finds its northern limit in about 34° north latitude, at an elevation above the sea of about 600 feet. With the reappearance of the above deposits south of Calhoun County the pine forests extend on the eastern side of the valley south to Childersburg. On the isolated ridges of old Silurian sandstone (Potsdam), and the metamorphic region adjoining, the Longleaf Pine is scattered and stunted and is not found at a greater height than 1,000 feet above the sea. In proximity to the mineral region the rugged hills and mountain sides have been completely denuded, the pine having been cut for charcoal to supply the blast furnaces. In the valleys the forests of Longleaf Pine are of average density and the timber is considered of excellent quality, particularly in the northern part of the valley in Etowah and Cherokee counties. On the lower hills the timber is less abundant and somewhat inferior in size. The measurements of five trees felled in the hills near Renfroe, Talladega County, can be said to fairly represent the average quality of this pine timber. The undergrowth in the open forest covering the low ridges and the narrow valleys is dense, consisting of Blackjack, Spanish Oak, Pignut, and Bitternut Hickory.

Measurements of five trees.

Number of tree.	Rings on stump.	Diameter breast high.	Mean diameter.	Length of timber.	Total height of trees.
		Inches.	*Inches.*	*Feet.*	*Feet.*
237	135	17	12	50	95
238	165	21	17	35	95
239	170	21	18	45	108
240	215	21	18	45	112
241	206	20	15	50	109
Average	178	20	16	45	104

[1] E. A. Smith: Agricultural Resources of Alabama, Vol. V. Reports of Geological Survey of Alabama.

The extinction of Longleaf Pine in the forests of north Alabama, as far as economic value is concerned, appears to be certain. The dense undergrowth of deciduous trees suppresses completely the second growth of the Longleaf Pine in the closed forest as well as in the openings. On the mountain slopes a young pine is rarely seen, no tree being left to serve for the future dissemination of the species, and the few seedlings sporadically springing up are invariably destroyed by the firing of the herbage one year after another.

The output of the mills at Gadsden and the mills in Talladega County along the Birmingham and Atlantic Railroad combined appears scarcely to exceed 50,000,000 feet, board measure, on the average per year. A fine forest of Longleaf Pine is found in Walker County, strictly confined within an isolated patch of silicious pebbles and sands, said to cover about 60,000 acres. Distant about 10 miles from the nearest railroad this forest has been but slightly invaded, and that to serve a small local demand.

Summary statement of shipments of lumber and square timber from chief centers of production in Alabama during the year 1892.

	Feet, B. M.
Mobile exports to foreign ports, coastwise, and shipments by rail [1]	143,800,000
Estimated cut in Alabama and sawn in western Florida	85,000,000
Transported by rail, mostly to northern markets [2]	95,200,000
Central pine belt [3]	51,000,000
Coosa basin [4]	50,000,000
Total	425,000,000

Mississippi.—What has been said of the forests of the maritime pine belt in Alabama applies in general to the same region in Mississippi. The coastal plain above the extensive grassy marshes lining the seashore and the wide estuaries of the streams covers a larger area, being from 10 to 20 miles in width and embracing, at a rough estimate, about 728,000 acres of the 16,410 square miles within the limits of the pine belt. The broad, scarcely perceptible swells, with a soil of sandy loam and loamy sand, were originally well timbered, the widely spreading depressions with soil of fine, compacted sand, poorly drained, bearing a sparse and inferior timber growth. The timber produced on these flat woods, or "pine meadows," as they are aptly called in the adjoining section of Alabama, being of slow growth, is hard and of fine grain, frequently with the fibers of the younger wood contorted and of varied tints of color. This so-called curled pine is susceptible of high finish and is much appreciated for fine cabinet work. There is comparatively little valuable timber left in this coastal plain. The remainder serves largely for the making of charcoal and cord wood for the New Orleans market.

The rolling pine lands, rising suddenly above the plain, almost exclusively covered by the Longleaf Pine, cover (roughly estimated) about 7,712,000 acres. The western limits of these forests are difficult to define, numerous outlying tracts being found to extend into or even beyond the region of the loamy hills. The region of mixed growth, characterizing the upper division of the maritime pine belt in Alabama, enters the State in the shape of a triangle, with the base along the Alabama State line from Bucatunna to Lauderdale and its apex near Brandon, in Rankin County. The generous soil of the arable lands in this region is mostly under cultivation. The forests of Longleaf Pine covering the steep hills, rather remote from the high roads of commerce, have been as yet but little exploited. About 12,000,000 feet, board measure, of lumber are shipped annually by the way of the Mobile and Ohio Railroad, mostly to Mobile, from this region of mixed growth.

From the information that could be obtained, it appears that the cut of Longleaf Pine timber in this State on the average for the past three years reached between 422,000,000 and 425,000,000 feet. The chief center of the lumbering industry is located above the Pascagoula River, at Scranton and Mosspoint, where it has made great progress during the past thirteen or fourteen years. In 1880, 60,000,000 feet, board measure, were shipped to foreign and domestic ports, which in the

[1] Annual statement of commerce of Mobile. Mobile Register, September 1, 1892. Compiled from returns made to the Mobile Board of Trade.

[2] Production of mills south of Montgomery, etc.

[3] Production of mills on Louisville and Nashville Railroad, north of Montgomery to Calera, by Colonel Wadsworth.

[4] Production of mills on Southern Railway, north of Selma to Stanton, by M. Hanson.

year 1892 had increased to 127,000,000. Comparatively much larger increase is noticeable in the shipments by rail to inland markets. By the reports courteously furnished by the auditor of the Illinois Central Railroad in Chicago, in 1880, 12,000,000 feet, board measure, reached Northern markets by this line, which in 1888 had risen to 62,000,000, with a falling off in the succeeding year to 52,000,000. In 1892 the shipments increased again to 78,240,000, and reached in 1893 181,424,000 feet, board measure.

With the opening of the New Orleans and Northeastern Railroad, in 1883, the lumbering industry took an active start in the virgin pineries. In 1892 fourteen mills are on record, with a daily capacity of not less than 400,000 feet; this amount corresponding fully to the actual output for 1891 as well as 1892. According to Mr. Rich, of Richburg, in consequence of the depression during the year 1893, the output was reduced about one-half.

The following table of partial data regarding annual shipments, made during the thirteen years ending with 1893, from the chief centers of production shows clearly the constant increase of the lumbering industry since the close of the year 1880:

Tabular statement of lumber shipped annually by water and by rail from the centers of production in Mississippi, 1879–80, 1883–93.

Year.	Pascagoula River.	Pearl River Basin.	New Orleans and Northeastern Railroad.	Illinois Central Railroad.
	Feet, B. M.	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*
1879–80	60,000,000	35,000,000	....	12,000,000
1883–84	67,308,000	35,000,000	....	28,000,000
1884–85	67,839,000	....	....	36,000,000
1885–86	....	....	....	30,000,000
1886–87	70,000,000	....	....	40,000,000
1887–88	....	....	....	62,000,000
1888–89	107,000,000	36,000,000	55,000,000	52,000,000
1889–90	119,255,000	....	(*a*)	64,000,000
1890–91	170,000,000	35,000,000	....	....
1891–92	127,002,000	36,000,000	....	78,240,000
1892–93	....	....	....	181,424,000

a From 60,000,000 to 90,000,000.

RECAPITULATION FOR 1891–92.

Pascagoula River	127,000,000
Pearl River Basin	36,000,000
Illinois Central Railroad	78,000,000
New Orleans and Northeastern Railroad	60,000,000
Mobile and Ohio Railroad	12,000,000
Other points	20,000,000
Total	333,000,000

From this amount are to be deducted about 18,000,000 feet of lumber received from Mobile to complete cargoes, and 12,000,000 feet of timber cut on the western frontier of Alabama and finding an outlet at Pascagoula by the Escatawpa River, leaving a round 300,000,000 feet, board measure, for the cut in Mississippi in 1892, against 108,000,000, the cut reported to the census in 1880.

With the exhaustion of the forests along the Pascagoula and Escatawpa rivers and a few points between these streams and the Pearl River, which had been accomplished before the beginning of 1880, the naval-store industry remained almost dormant in the State until it began to receive a new start by the opening of the New Orleans and Northeastern Railroad. The production of the distilleries along this road can be said to average about 15,000 casks of spirits of turpentine and 75,000 barrels of rosin annually since 1890, which are mostly disposed of in the New Orleans market.

Eastern Louisiana.—Forests of Longleaf Pine cover the upper part of eastern Louisiana to the extent of about 3,880 square miles. Their western limit might be said to follow the Amite River, but can not be clearly defined, since these forests toward the west pass gradually into the mixed growth of Shortleaf Pine, oaks, and hickories on the uplands which border the bottom lands of the Mississippi River. Slightly undulating flat woods cover fully one-fifth of the area, and, with a somewhat loamy, porous soil, support a better timber growth than is generally found in the flat pine barrens of the plain. Owing to their proximity to the coast, these forests have been extensively invaded. The pine hills embrace about 1,619,200 acres. Their forests have remained almost intact, their resources having been drawn upon only along the Illinois Central Railroad line and the tributaries of the Pearl River.

In 1890 seven sawmills were reported, with a daily capacity, in the aggregate, of about 120,000 feet, board measure. It can safely be assumed that their annual output would not exceed 15,000,000 feet, board measure. The products of these mills find their market chiefly at New Orleans. In former years a considerable quantity of naval stores was produced in St. Tammany Parish, while at present only a few turpentine orchards are worked in the upper districts.

THE REGION OF LONGLEAF PINE WEST OF THE MISSISSIPPI.

The importance of the pine forests in the western Gulf region can not be overestimated, considering the development of the immense timberless area beyond their western limit. The rapidly increasing population of the Western plains depends chiefly upon them for the supply of the material needed to build up the homes of civilization.

The forests of the Longleaf Pine west of the Mississippi River, as in regions so far considered, are geographically limited to the sands and gravels of the latest Tertiary formation. They make their first appearance in Louisiana above the great alluvial plain in the uplands bordering the valley of the Ouachita and follow its course for 50 miles, then extend west, skirting Lake Catahoula and the alluvial lands of the Red River. These pine forests to the north of this river cover an area estimated at 1,625,000 acres, extending northward for a distance averaging 55 miles. Toward their northern limit the forests pass gradually into a mixed growth of deciduous trees and Shortleaf Pine. In the center of this region the pine ridges alternate with tracts of White Oak and Hickory. Tending toward the Red River, the pure forest of Longleaf Pine which covers the undulating uplands is unbroken and has up to the present been but slightly invaded by the ax. On the low hills of this northern division of the pine belt of northwestern Louisiana the forests are somewhat open, and are composed of trees of the first order as regards their dimensions, the well-drained, warm, and deep soil of sandy loam being highly favorable to their development. This fact is clearly shown in the following statement of the ages and dimensions of six trees felled for test logs:

Measurements of six trees.

Number of tree.	Rings on stump.	Diameter breast high.	Diameter below crown.	Mean diameter.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*
175	270	32	22	26	48	123
176	158	27	20	22	50	127
177	155	22	18	19	50	122
178	170	20	15	16	40	117
179	165	17	13	14	35	118
180	112	16	....	....	40	97
Average	171	22	17.6	19	44	117

Upon 1 acre of the same plat, with the timber standing rather above the average, 38 trees were found. Of these there were 14 of 24 inches diameter at breast high, estimated length of timber, 45 feet; 6 of 19 inches diameter at breast high, estimated length of timber, 40 feet; 9 of 17 inches diameter at breast high, estimated length of timber, 35 feet; 9 of 13 inches diameter at breast high, estimated length of timber, 30 feet.

In the opinion of experts, the average yield of 1 acre of these pine lands at a fair estimate is not less than 6,000 feet, board measure.

According to the statements of Mr. Sues, at Levins Station, 56,000,000 feet, board measure, were shipped, in 1892, from the mills of this section.

South of the Red River bottom the forests of Longleaf Pine continue unbroken to the Sabine River and south to the treeless savannas of the coast in Calcasieu Parish, their eastern boundary parallel with the eastern boundary of that parish. Roughly estimated, these forests cover an area of about 2,668,000 acres. From the marshy lowlands of the coast to the upper tributaries of the Calcasieu River, up to Hickory and Beckwith creeks, the country is poorly drained, almost perfectly level, with a highly retentive and somewhat impervious clay subsoil. In consequence, these pine flats are, for the greater part of the year, more or less covered with water. These low, wet pine forests were stripped some years ago of all their merchantable timber, and only a comparatively small number of trees of less than 12 inches in diameter were left standing. On these abandoned timber lands a young pine is rarely seen, the seeds shed in the fall being apt to rot in the water-soaked soil, or, if they happen to germinate, the seedlings are drowned during the winter rains. On the lands rising gently above the flat woods, with the ridges still low and wide and often more or less imperfectly drained, Longleaf Pine is found of an exceedingly fine growth. The trees in the dense forest are tall and slender, and their timber is equaled only by the timber of the same class growing in the valley of the Neches River, in Texas.

The following measurements of five trees felled for test logs in the forests in the upper part of Calcasieu Parish, between Hickory and Beckwith creeks, will serve as a fair representation of the timber growth on these low, broad ridges:

Measurements of five trees.

Number of tree.	Rings on stump.	Diameter breast high.	Diameter below crown.	Mean diameter.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*
201	196	28	23	24	50	119
202	195	23	16	19	50	127
203	190	21	14	17	40	117
204	180	19	15	17	40	102
205	167	16	13	14	37	127
Average	185	21	16	18	43	118

Upon 1 acre, selected on the back of a low swell which might be said to represent the average of the timber standing, 44 trees in all were counted. Of these, 3 trees measured 25 inches diameter at breast high, with a length of clear timber estimated at 50 feet; 6 trees measured 23 inches diameter at breast high, with a length of clear timber estimated at 50 feet; 19 trees measured 18 inches diameter at breast high, with a length of clear timber estimated at 40 feet; 14 trees measured 14 inches diameter at breast high, with a length of clear timber estimated at 36 feet, corresponding in the aggregate to somewhat over 15,000 feet, board measure.

On another acre considered first class, rather level land, the soil fresh to wet throughout the year, 72 trees were counted. Of this number, 14 were found 27 inches diameter at breast-high, with an estimated length of timber of 50 feet; 5 were found 24 inches diameter at breast high, with an estimated length of timber of 50 feet; 13 were found 23 inches diameter at breast high, with an estimated length of timber of 50 feet; 8 were found 21 inches diameter at breast high, with an estimated length of timber of 40 feet; 10 were found 20 inches diameter at breast high, with an estimated length of timber of 40 feet; 11 were found 18 inches diameter at breast high, with an estimated length of timber of 40 feet; 11 were found 18 inches diameter at breast high, with an estimated length of timber of 36 feet.

According to these figures the timber standing on this acre would amount to not less than 35,000 feet, board measure.

The chief site of the lumber industry of western Louisiana is at Lake Charles. According to the information furnished by Mr. George Lock, of Lockport, La., the annual output of the sawmills in the vicinity of Lake Charles for the years 1892 and 1893 averaged about 154,000,000 feet, board measure, all shipped West and Northwest. It can be assumed that over one-half of the lumber sawn at Orange, in Texas, is cut on the eastern banks of the Sabine River, which amount has to be credited to the cut of Louisiana.

Summary of the production of Longleaf Pine lumber in the State of Louisiana in 1892.

	Feet, B. M.
Parishes east of the Mississippi, about	25,000,000
Parishes north of the Red River	56,000,000
To the Sabine River, sawn at Lake Charles	154,000,000
Sawn at Orange, Tex., estimated	40,000,000
Total cut in Louisiana	275,000,000

Texas.—The forests of Longleaf Pine extend from the Sabine west to the Trinity River and from the grassy savannas of the coast region north to the center of Sabine, San Augustine, and

Angelina counties, and include an area of about 2,890,000 acres. In amount and quality of the timber these forests are unsurpassed and are only equaled by the forest of the adjoining region in Louisiana. Toward their southern borders the country, like the pine flats of southwestern Louisiana, is perfectly level and poorly drained, with the soil water-soaked for a greater part of the year. These flats have been almost completely stripped of their merchantable timber. North of Nona the surface rises gradually above the water level in broad, low swells, and, being underlaid by strata of stiff loams, is more or less deficient in drainage. The intervening wide flats are frequently covered with a dense growth of large shrubs and small-sized trees, consisting of various species of hawthorn (*Cratægus crus-galli*, *C. viridis*, *C. mollis*, *C. berberidifolia*), the Deciduous Holly (*Ilex decidua*), Dahoon Holly (*Ilex caroliniana*), Privet (*Adelia acuminata*), plane trees, and magnolias. These impenetrable thickets are common, and often cover many square miles, like the so-called Big Thicket in the lower part of Hardin County, said to be from 10 to 15 miles wide, either way. The growth of Longleaf Pine which covers the gentle, wide swells, is dense, of fine proportions, and of remarkably rapid development. The average age of five trees felled northwest of Nona, 15 to 25 inches in diameter, is but little over one hundred and fifty years, as the following measurements show:

Measurements of five trees.

Number of tree.	Rings on stump.	Diameter breast high.	Mean diameter.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Feet.*	*Feet.*
188	240	26	20	40	110
189	208	22	19	50	101
190	105	18	16	50	113
191	113	21	18	45	110
192	94	15	12	40	107
Average	152	20	17	45	104

In this region, owing to the direct communication of several railroad lines with the great centers of trade in the North and with the treeless plains of the far West, the manufacture of lumber has made a wonderful progress during the past twelve years. In 1880 the cut of Longleaf Pine in this State has been estimated at 66,450,000 feet. From information received from parties engaged in the lumber business, the cut during the year 1892 can safely be estimated at 440,000,000 feet. The centers of lumber production are Orange and Beaumont, but a great amount is cut at the mills along the several lines of railway passing through this region.

Output of Longleaf Pine lumber in Texas during the year 1892.

	Feet, B. M.
Orange (inclusive of 40,000,000 of feet derived from Calcasieu)	45, 000, 000
Beaumont	75, 000, 000
Sabine Valley, Texas and Northern Railroad	157, 000, 000
Missouri, Kansas and Texas Railroad	143, 000, 000
Houston, Kansas and Texas Railroad	20, 000, 000
Total	440, 000, 000

For the renewal of the forests of Longleaf Pine in this region there is as little hope under their present management as in the adjoining region in Louisiana. In this cold, wet soil the seeds find but a poor chance for germination, and the surviving plantlets soon succumb to the same cause. In the pine flats seedlings are rarely observed among the tall broom sedge grasses (*Andropogon*) which, under the influence of light and a damp soil, thrive luxuriantly in the flat woods denuded of their timber growth, imparting to them the aspect of waving meadows or savannas.

PRODUCTS.

VALUE AND USES OF THE WOOD.

The wood of the Longleaf Pine is hardly surpassed by any of our timber trees of economic importance, and is practically unsurpassed by any member of its own order in the qualities which are required for purposes of construction, thus taking the first place among its congeners.

The timber from the damp flat woods of the coastal plain east of the Mississippi River, with a soil of almost pure, fine, closely compacted sand, is of slow growth and generally of the finest grain, often exhibiting in the sapwood that irregularity known as "curly pine." In the perpetually damp to wet soil of the pine flats in southwestern Louisiana and in Texas, with a deep retentive subsoil richer in nutritive elements, causing a better and quicker development of the tree, the wood is of a more open grain. Owing to the excellent qualities of the wood of Longleaf Pine, its use in the various mechanical arts and industries is as extensive as it is manifold. Its greatest value rests in its adaptability for heavy constructions—in naval architecture, for masts and spars; in civil engineering, for the building of bridges, viaducts, trestlework, and for supports in the construction of buildings. Large quantities of long and heavy sticks of square timber sawn or hewn for such purposes are shipped to the British ports and to the dockyards of the European continent, with a constantly increasing demand.

In the building of railroad cars, where great strength and elasticity is needed, the timber of Longleaf Pine is preferred to any other. For this purpose sticks from 36 to 42 feet, 10 by 12 inches, are required, free from blemish.

Enormous quantities of the younger timber of this tree are cut every year to serve for cross-ties, used by the railroads not only in the pine regions, but in other parts of the country. The demand for these ties forms a constant and increasing draft upon the forest. The ties delivered are, on the average, 8½ feet long, 9 inches wide, and 7 inches thick, and must be all heartwood and free from blemish. The trees selected for this purpose are from 15 to 16 inches in diameter, and preferably only the butt cuts are accepted. On an average 10 cross-ties are cut from 1 acre, each tie representing a log which would make at least 75 superficial feet of lumber. Since such a tie, ready for the roadbed, contains not more than 50 feet, board measure, it will be readily seen what an enormous waste results from this practice.

On the damp, sandy tracts of the lower South, such ties will last five or six years, and 3,000 ties are needed for 1 mile of road. Hence, for the construction of the 3,240 miles of railroad traversing the forest of Longleaf Pine east of the Mississippi River, nearly 10,000,000 ties have been required, which being renewed every six years involves an annual cut of 116,000,000 feet, board measure, to which must be added the amount exported to other regions.

In the Southern States, the West Indies, many places on the coast of Mexico, and Central and South America the lumber of the Longleaf Pine forms the chief, if not the only, material in the construction of houses. For similar purposes considerable quantities are of late years shipped to Northern markets, East and West, replacing in many cases, at least in parts of the buildings, the lumber of the White Pine, on account of its increasing scarcity. The fine-grained and "curly" varieties of Longleaf Pine lumber, by their beauty and the high polish of which they are susceptible, begin, of late years, to take a place among the higher-priced kinds of wood for ornamental inside work.

The importance and value of Longleaf Pine lumber as a material for constructions can not be better evidenced than by the fact that little less than 1,500,000,000 feet, board measure, or about one-third of all the lumber manufactured in the South, is being exported from Southern ports annually to domestic and foreign ports, besides furnishing almost the only material used at home in the construction of dwellings and all kinds of buildings. It also supplies material for furniture, as well as fuel, both in the form of firewood and charcoal, and its exploitation affords the means of subsistence to thousands.

Lightwood.—Whenever the sapwood of the tree is laid bare copious exudation of resin takes place and the surrounding wood becomes charged with it. Thus the wood of the trunks of the trees tapped for the extraction of their resin soon becomes charged with this along the scarified surface, and, as with the evaporation of water from the dead wood, the resinification proceeds and the wood increases in weight and durability. In low, damp places particularly this process takes place more extensively. This resin-charged wood is termed lightwood. The lightwood timber, considered very durable when exposed to alternating conditions of moisture and dryness, is much preferred for posts, etc. Being highly inflammable, it serves for torches and kindling, and hence its name. Of late years a profitable industry has been started to utilize the resinous stumps of abandoned orchards as kindling material by cutting the same close to the ground and then, veneer fashion, into long, narrow strips three-fourths of an inch thick, which are subsequently steamed and rolled in small bundles to make a convenient package for shipment. The knots, limbs, roots—particularly "fat," i. e., highly charged with resin—are used in the making of tar.

Charcoal burning.—Where a market is found the trees left standing, after the removal of the larger timber fit for sawlogs, are burned for charcoal. This industry is carried on to a greater or less extent in the mineral regions to supply the blast furnaces operated for the manufacture of charcoal iron. Large areas of the forests of the Longleaf, covering the hills in north Alabama, have been entirely denuded of their tree covering to meet the demands for such purpose.

Fuel value.—The air-dry wood of the Longleaf Pine is much esteemed for fuel; containing but a small percentage of ash—not over 0.25 per cent—with a small amount of water, and a dense and close fiber, as indicated by its high specific gravity, its fuel value is necessarily high. Being also easily inflammable, it is preferred where quick and intense heat is required, as, for instance, in bakeries, brick kilns, potteries, etc., and in the raising of steam for stationary engines on steamboats and railroad locomotives throughout the pine region, where mineral coal can not be cheaply obtained.

RESINOUS PRODUCTS OF THE LONGLEAF PINE.

It can safely be asserted that among the trees of the same order there is found no other equally rich in resin. The manufacture of naval stores from the resin of the Longleaf Pine forms one of the most widely developed industries in the pine forests of the coast pine belt of the Southern States, and is scarcely less important than the manufacture of its lumber. A full account of these industries will be found in the accompanying appendix. Concerning the manufacture of tar, pitch, tar oils, and other products of destructive distillation of the wood and of rosin oil, see the Report of the Chief of Forestry, 1892, page 356, etc.

PRODUCTS OBTAINED FROM THE LEAVES OF LONGLEAF PINE.

The green leaves of the tree furnish by distillation an essential oil of balsamic odor closely resembling spirits of turpentine. The so-called pine wool is made from their cellular tissue, being treated with a strong alkaline solution at boiling heat, the remaining fiber being cleaned and carded. This pine wool is used in upholstery, and is said to be of value as an antiseptic dressing for wounds. Of late years it is manufactured into various kinds of textile fabrics. One fabric is a carpet which resembles cocoa matting somewhat, but is closely woven and is naturally of a rich-brown color and very durable. This industry, only recently established, has already met such success that the manufacturers have added twenty nine looms to their work.

NOMENCLATURE AND CLASSIFICATION.

This tree was first described by Miller in the year 1768 under the name of *Pinus palustris.* The younger Michaux substituted for it the more appropriate one of *Pinus australis*, under which name it was described by succeeding writers and generally known to botanists of recent date. To satisfy the law of priority, the name given by Michaux has recently been dropped and the old one reinstated, in the Catalogue of North American Forest Trees,[1] published in the ninth volume of the census reports of 1880. (See vernacular nomenclature in introduction.)

BOTANICAL DESCRIPTION AND MORPHOLOGY.

Leaves three, in a long light-colored sheath; commonly from 9 to 13 (sometimes 14 to 15) inches long; of a bright green color and closely set in brush-like clusters at the ends of the stout branches. Cones large, dark tan colored, 6 to sometimes 8 inches long and 2 to 2½ inches in diameter when closed, 5 to 6 inches when open; scales about 2 inches long and one-half to 1 inch wide—rather uniform in width—somewhat thickened at the ends, and bearing a rather delicate incurved prickle; seed large, slightly triangular, three-eighths to seven sixteenths of an inch long and one-fourth of an inch wide; often with two or three longitudinal ridges on one face; whitish, with few or abundant brown specks; wing 1½ to 2 inches long and of a glossy brownish to deep purple-brown color.

The most conspicuous and distinguishing feature of this species is the silvery thick terminal bud, or rather the bud-like clusters of the young leaves inclosed in their finely fringed subtending scales. Its branches are rough, covered with the bases of the imbricated leaf scales, the elongated silvery fringes having fallen off.

[1] A catalogue of North American Forest Trees, exclusive of Mexico, by C. S. Sargent.

ROOT, STEM, AND BRANCH SYSTEM.

The Longleaf Pine attains a height averaging 100 feet, rarely exceeding 110 feet, with a diameter breast high, when fully grown, varying between 20 and 36 inches, rarely more. The tall, straight, very gradually tapering trunk arises from a massive taproot which, in favorable situations, penetrates the soil to a depth of from 12 to 15 feet, and sometimes much more. It has several stout, comparatively short lateral roots, which assist the tree in its hold by slanting deeply into the ground, and some of greater length are placed more or less near the surface. Its crown is open and elongated, of irregular shape, about one half to one-third of its height. The stout limbs are rarely over 20 feet in length, twisted and gnarled and sparingly branched. The trunk is covered with a reddish-brown bark, one-fourth to three-fourths of an inch thick, furrowed throughout its full length, crossed horizontally by deep fissures, and scaling off in thin, bluish, almost transparent rhombic flakes.

LEAVES AND THEIR MODIFICATIONS.

Like all the pines, this species produces during various stages of its growth seven different modifications of leaves as recognized by botanists, all more or less specific in character:

(1) Cotyledonary, or seed leaves (first leaves of the embryo), which soon wither and disappear (Pl. VII, *a*, *b*). (2) Primary leaves succeeding the former immediately on the main axis (Pl. VII, *c*), which either wither or later on are transformed into, or succeeded by, more or less permanent bracts or scales covering the branches (Pl. V, *a*). (3) The secondary or foliage leaves rising from the buds produced in the axils of the primary leaves or of the bud scales by which they are represented (Pl. VII, *d*), permanent foliage of the tree, with three leaves in one sheath. (4) The bud scales forming the sheaths of the foliage leaves (Pl. IV, *b*, *c*, *d*) at base. (5) Involucral bracts of the male flower (Pl. V, *f*). (6) Involucral scales of the female inflorescence (ament) (Pl. V, *c*). (7) The bracts which support the carpellary scale bearing the seed (Pl. V, *h*).[1]

The primary leaves, which succeed the cotyledons on the primary axis, are in form and structure true leaves. They are softer than the final foliage leaves, have a broad base, are rounded on the dorsal side and not channeled, the whitish transparent margins being finely but distinctly denticulate. It is rare that secondary leaves proceed from the axils of these chlorophyll-bearing primary leaves. With the more frequent appearance of the ordinary leaves, these primary leaves wither and henceforth appear as triangular scale-like coriaceous persistent bracts, with broad, hyaline, long-fringed edges, in the axils of which the undeveloped branchlets are produced bearing the secondary or foliage leaves.

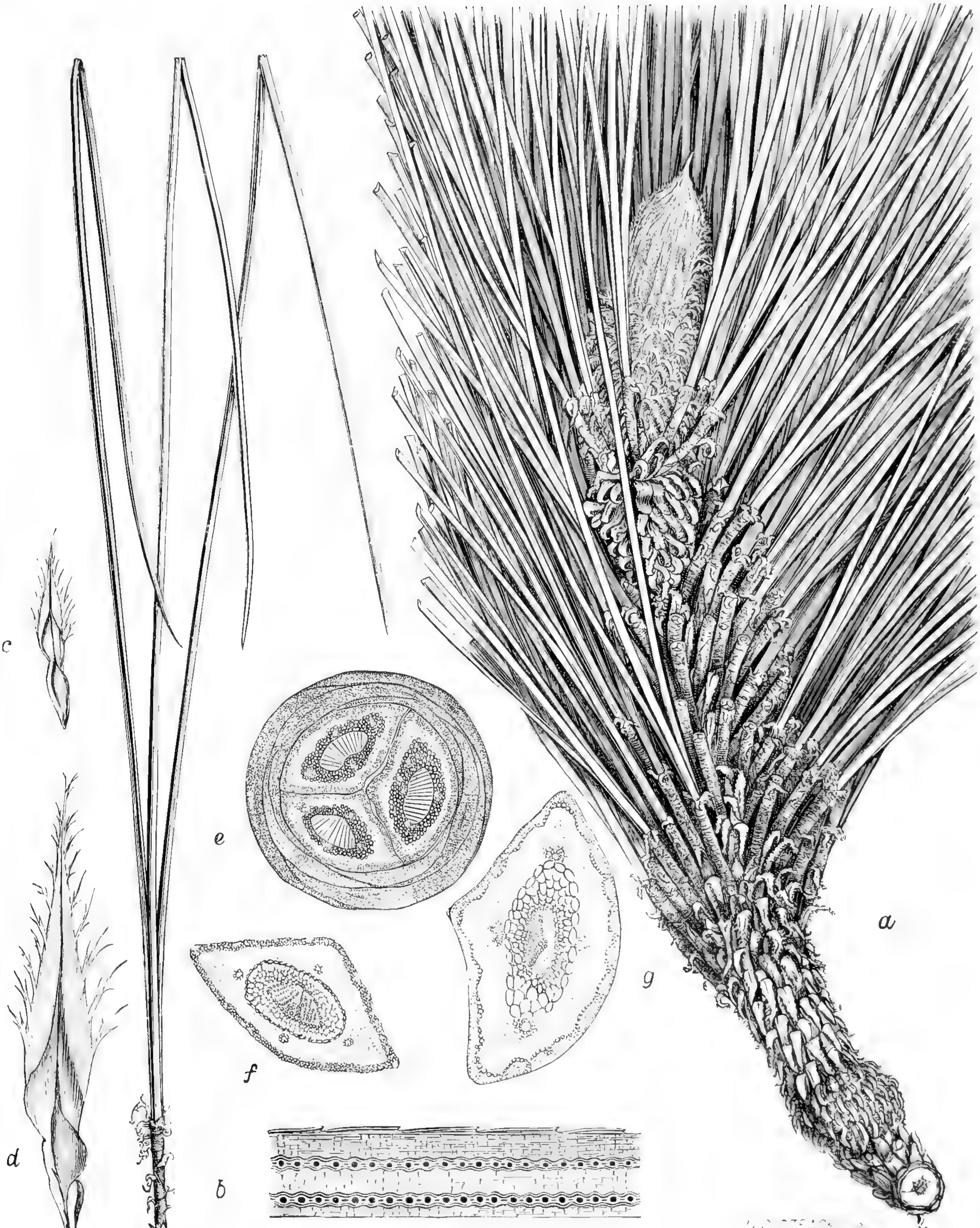
The chlorophyll-bearing primary leaves exhibit a simple structure. The fibro-vascular bundle is single, embedded in a wider ring of large cells free from chlorophyll, and the resinous ducts fewer in number, one, or rarely more than two, being irregularly situated in the chlorophyll-bearing parenchymatous tissues, and mostly external, i. e., close to the thick epidermis. But few of these leaves are formed after the appearance of the foliage leaves, and a few of them persist throughout the first season.[2] The cataphyllary leaves forming the sheath of the foliage leaves are in this species composed of eight successive pairs of bud scales; those of the first pair are blunt, flat, deeply concave and coriaceous, with sharp edges; the others are more membranaceous and with fringed edges, the closely interwoven edges entwining the base of the fascicle. In the secondary leaves the very numerous stomata form, on both sides, regular longitudinal rows. Parallel with these, at regular distances between them and embedded in the parenchymatous tissue, are found bundles of numerous, elongated, thick-walled cells, the so-called hypodermal or strengthening cells. The resin ducts, not over five in number, described by Engelmann as internal, have been found in the specimen examined rather parenchymatous, invariably so on the dorsal side.

Three of the secondary or true foliage leaves are united into one bundle, inclosed at the base by a persistent sheath from one-half inch to an inch in length, formed by the bud scales or cataphyllary leaves. On the older trees the leaves are rarely over 8 inches in length, but during the periods of most active growth they are found 12 to 18 inches long. They are finely serrulate, rounded on the back, channeled, and obtusely triangular in cross section.

[1] George Engelmann: Revision of the Genus Pinus. Transactions of the St. Louis Academy of Science, 1882.
[2] Engelmann: Revision of Genus Pinus. Trans. St. Louis Academy of Science, 1882, p. 5.

EXPLANATION OF PLATE IV.

Fig. *a*, branch showing the terminal spring shoot of the season with characteristic, large silvery white winter bud; the bundles of leaves arise from the axils of the leaf-bracts of the last two seasons, the first leaves of the second year already shed; *b*, detached bundle of mature leaves with sheath; *c*, *d*, scales of the sheath, magnified three and nine times; *e*, transverse section through base of leaf bundle showing imbrication of sheath scales, magnified 30 diameters; *f*, transverse section of an immature leaf, magnified 30 diameters; *g*, transverse section of a mature leaf, magnified 45 diameters, showing the microscopic structure (as pointed out for *P. echinata*, *f*, *f*); *h*, longitudinal section of the dorsal side of a mature leaf showing two rows of stomata and the serrated edge, magnified 45 diameters.



PINUS PALUSTRIS: BUD AND LEAF.

Owing to the shedding of the older leaves at the end of the second year and to the short annual growth of the axis, the leaves on the older trees are conspicuously crowded into dense tufts or tassels on the tips of the branchlets.

The high development of the organs of transpiration, as shown by the immense number of breathing cells, clearly indicates that forests of the Longleaf Pine, and in fact of most evergreens, are not less important than forests of deciduous trees in influencing atmospheric conditions, particularly when it is considered that in the former, clothed with perpetual foliage, this function suffers but little interruption of its activity.

FLORAL ORGANS.

The male and female flowers are sometimes found on the same branch; they are, however, more frequently situated on different branches, the male flowers mostly on the lower (Pl. V, *b*). The male flowers consist of a slender axis, the staminodial column, around which the numerous naked anthers are densely crowded, forming a cylindrical catkin-like flower from 2 to 2½ inches and over in length, surrounded at the base by a calyx-like involucre consisting of twelve ovate somewhat leathery bracts, of which the lowest pair or exterior ones are laterally compressed, strongly keeled, and much smaller. The connective of the dark-rose purple anthers spreads out in a semiorbicular denticulate crest; a number of these male flowers are crowded around the base of this year's shoot, forming a dense whorl. After the discharge of the pollen the withered flowers remain for several months on the tree. The pollen remaining for a long time suspended in the air is often wafted to widely distant localities. In the latitude of Mobile its discharge takes place during or shortly after the second week of March.

The female flowers (see Pl. V, *a*) are united in a subterminal oval, erect, short-stalked catkin, which is also surrounded by an involucre, the bracts being more numerous, longer, more acuminate, and membranaceous than those of the male flower.

The carpellary scales bearing ovules are oblong oval, tipped with a strong reflexed point, and are almost hidden by the thin flat scales by which they are subtended, which, however, they soon surpass in size. During the first year the young cones make but slow progress in their growth. On the opening of the second season they are scarcely over an inch long; during the summer they increase rapidly and reach their full size during the latter part of the fall. The cones are placed horizontally on the branches below the terminal bud (subterminal), sessile, slender, conical with a slight curve and from 6 to 8 inches long; of a dull tan color; the thick scales are light to dark chestnut brown on the inside, 2 inches or slightly over in length, and bear on their exposed end, or apophysis, a small but prominent tubercle armed with a short recurved prickle (see Pl. VI). Plate VI exhibits truly and fully the open cone and especially the fine markings on the apophysis of the scale. The cones are shed in the latter part of the winter of the second year, rarely remaining to the following spring. On breaking from the branches they leave the lowest rows of the scales behind.

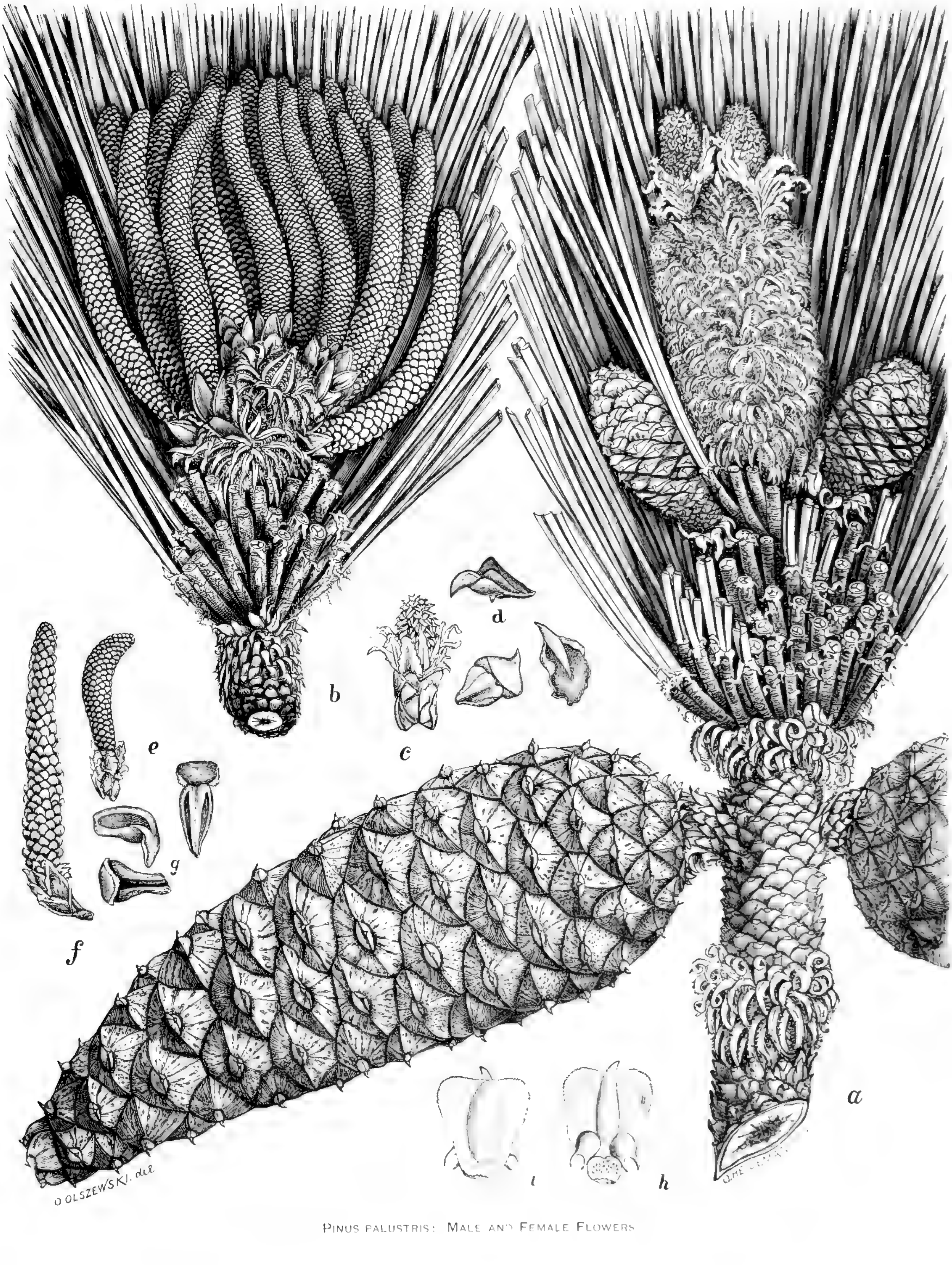
SEEDS.

The seeds are strongly convex, oblong, oval, less than a half inch long, and surrounded by the long oblique wing (see Pl. VI). The shell is whitish, at the front face marked by three prominent ridges, flat, smooth, and darkly spotted on the posterior side. It incloses an oily kernel, covered by a white seed coat; rich in nutritious matter and palatable, the seeds furnish in fruitful years an abundance of mast. They are shed before the fall of the cone during the dry weather, most abundantly during the latter part of the fall (end of October or November the best time for their collection) and in a lesser degree during the winter. They germinate easily after reaching maturity, and it often happens, in wet, sultry weather, that they begin to sprout before leaving the cone, in which event the whole crop is destroyed. This, together with the killing of the flowers by late frosts, seems to be one of the main causes of failure of the seed crop so frequently observed. From the behavior of the seed just mentioned and from its oleaginous character it is to be inferred that the period of time during which the seeds retain the power of germination under ordinary circumstances is but a short one, but as a matter of fact seeds a little over a year old have been known to germinate.

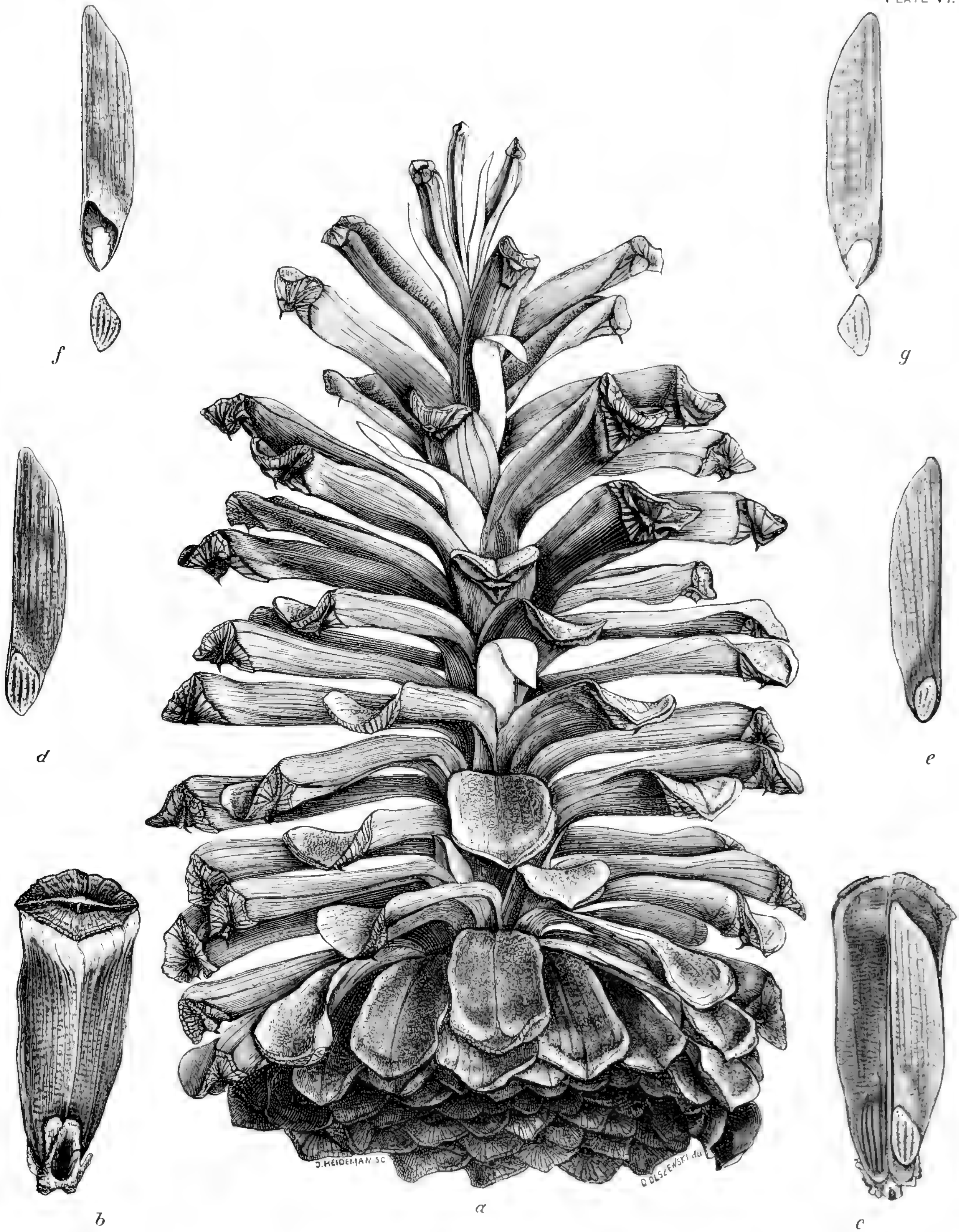
EXPLANATION OF PLATES V AND VI.

PLATE V. Fig. *a*, branch with two female aments (second week of March), at the end of terminal young shoot of the season densely covered with fimbriate silvery bract subtending the leaf buds which are still hidden in their axils; below are two immature cones of one season's growth and mature closed cone of two seasons' growth (October); *b*, branch with the male inflorescence, the leaves cut away to show the dense cluster of male flowers which closely surround the apex of the young shoot; *c*, female ament with basal scales forming the calyx-like involucre; *d*, *d*, *d*, carpellary or seed-bearing scales of female flowers more advanced, lateral, ventral, and dorsal views—magnified 5 diameters; *e*, detached male flower with basal involucral scales, before opening (dehiscence); *f*, male flower, after discharge of the pollen; *g*, three detached anthers, lower sides showing longitudinal slits of the pollen sacs just opening; lateral view of an effete anther; another seen from upper side showing the transverse semilunar crest—all magnified 5 diameters; *h*, detached female flower seen from above; the cuspidate carpellary, or seed scale, bears two strongly bifid naked ovules at its base; *i*, female flower viewed from below, dorsal side; the bract almost covers the carpellary scale, leaving only the tip of the latter and the cusps of the ovules visible; magnified 5 diameters.

PLATE VI. Fig. *a*, mature open cone, after shedding seed; *b*, cone scale seen from lower or dorsal side showing the apophysis with low umbo and small, weak prickle; *c*, cone scale seen from upper or ventral side with seed in place; *d*, seed, upper side; *e*, seed detached from *c*, lower side; *f*, seed detached from wing, upper side, and *g* the same seen from lower side.



PINUS PALUSTRIS: MALE AND FEMALE FLOWERS



PINUS PALUSTRIS: CONE AND SEED.

THE WOOD.[1]

The wood of the Longleaf Pine is heavier and stronger than that of any other pine offered in the market. The average weight of the kiln-dry wood is about 38 pounds, that of the lumber where the outer lighter portion of the log is largely cut away about 40 pounds, per cubic foot. The kiln-dry wood of the butt weighs about 45 pounds per cubic foot; that of a log 50 to 60 feet from the ground only about 33 pounds, a decrease of weight (and with it of strength) of about 25 per cent. Similarly the wood of inner portions of a log are 15 to 20 per cent heavier than those of the outer portions; or, in other words, the wood laid on when the tree is young is heavier than that laid on when it is old, quite contrary to the common belief which seems to associate the light sapwood color of the young sapling with inferior material. The wood shrinks about 10 per cent of its volume in drying, about 6 to 7 per cent along the rings (tangentially) and 3 to 4 per cent along the radius; seasons easily and without great injury. As in other pines, the greatest amount of water is contained in the sapwood, varying from 30 to 50 per cent of the weight of the fresh wood, while the heartwood contains but about 20 per cent.

In its stiffness and strength the wood is remarkable. The average of a great number of tests indicates for the dry wood of Longleaf Pine an elasticity of 1,540,000 pounds per square inch; strength in cross breaking, 10,900 pounds per square inch; strength in compression, 6,850 pounds per square inch; strength in tension, 15,200 pounds per square inch; strength in shearing, 706 pounds per square inch.

In its structure the wood of the Longleaf Pine resembles that of the other Southern pines. Sapwood and heartwood are well defined; on the fresh cross section the former is light yellowish white, the latter a yellowish brown; drops of limpid resin ooze from every resin duct in the sapwood, the surface of the heartwood remains dry (exceptions only in "lightwood"). The sapwood contains much more water, but is far less resinous than the heartwood. This latter contains 5 to 10 per cent of resin (1 part turpentine to 15 to 20 parts resin), while in the former the resin rarely exceeds 2 per cent. If not kiln-dried, fresh sapwood rapidly "blues" on exposure; heartwood does not, and in general excels the sapwood in durability. On drying, the sapwood shrinks more than the heartwood of the same weight. Contrary to common belief, the wood substance, or cell wall, is not increased in the change from sapwood to heartwood, the walls do not grow thicker, the cavities of the cells do not fill up with foreign matter, nor does the strength of the wood seem to be increased by the change. In general the width of the sapwood is greatest in young and thrifty trees, grows smaller in old and stunted trees, is greatest in the lower parts of the stem and smaller in the top and branches. In old logs the sapwood is made up of from 70 to 100 rings, showing that the wood of any one ring remains in older trees seventy to one hundred years in the sapwood condition before it changes to heartwood. In young trees this period is much shorter, twenty-five to forty years commonly sufficing for thrifty trees at the age of sixty to seventy years, but in stunted individuals it is materially prolonged. The share of the sapwood in the total volume of the stem is always considerable; even in typical old trees of this species it forms 40 per cent and more, while thrifty stems under one hundred years are practically all sapwood.

The annual, or yearly, rings are clearly defined; they are widest near the pith and grow rather uniformly narrower toward the bark. In the inner part a width of one-twelfth of an inch is quite common; the rings near the bark of old logs usually measure less than one twenty-fifth of an inch, often scarcely one-fiftieth of an inch. For old trees the average width for the entire stem may be set at about one-twentieth to one-twenty fifth of an inch. Each ring consists of two well-marked parts, an inner, softer, whiter part, the springwood, and an outer, harder, and darker portion, the summerwood, so called because formed during the latter part of the growing season.

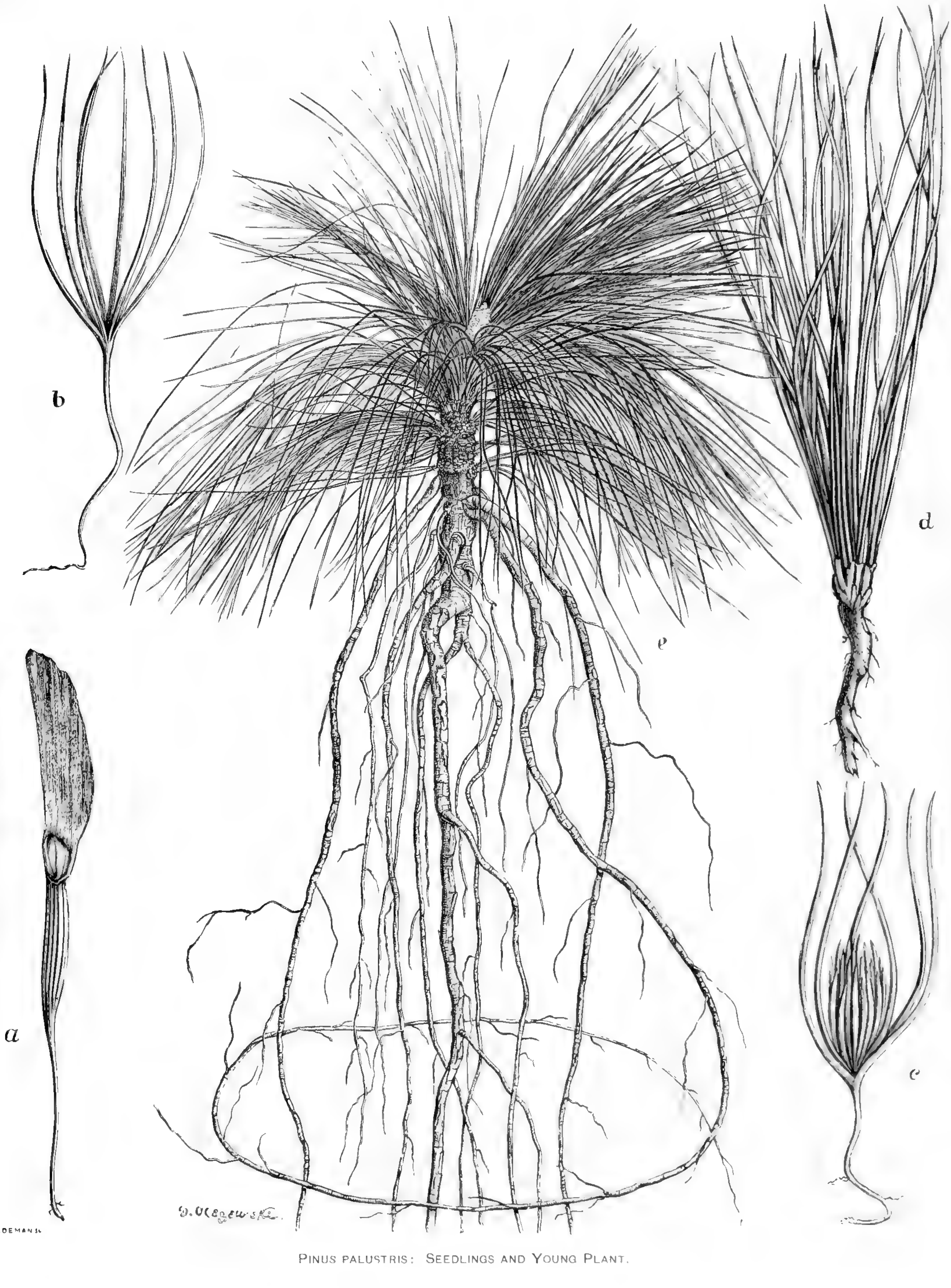
The amount of the summerwood in each ring differs in different parts of the tree. It forms about 45 per cent of the volume of all the wood of the stump, and only about 24 per cent of the wood 60 feet from the butt. It is greater in the heavy inner part of an old log than in the lighter outer portions, and being of a darker color furnishes a convenient means of distinguishing heavy wood. In its finer anatomy (histology) the wood resembles that of the other pines of the *tæda* group. (For the details of structure see the comparative study by Mr. Roth appended to these monographs.)

[1]This statement is furnished by Mr. Filibert Roth, in charge of timber investigations in the Division of Forestry.

EXPLANATION OF PLATE VII.

[Figures natural size, except where otherwise noted.]

Fig. *a*, germinating seed; *b*, young seedling (early spring) with the 8 cotyledons just unfolded; *c*, seedling a few weeks older, showing central cluster of primary leaves just unfolding; *d*, seedling at the end of the first or beginning of the second season, showing bundles of true foliage (secondary) leaves succeeding the primary leaves which have disappeared; *e*, young tree, 3 to 4 years old, with characteristic large root system; one-third natural size.



PINUS PALUSTRIS: SEEDLINGS AND YOUNG PLANT.

GROWTH AND DEVELOPMENT.

In a fruitful year, before the close of the season, with the advent of spring, a dry and sunny state of the atmosphere favoring the fall of the seed, the seedlings are found to come up abundantly in every opening of the forest where the rays of the sun strike the dry ground. The lower (hypocotyledonary) part of the axis of the plantlet is close to the ground, with eight to ten erect colyledons from 1 to 1½ inches in length, their tips inclosed in the shell of the seed, with the long wing persistent and borne banner-like at the top of the plantlet (Pl. VII, *a*). The elongation of the ascending axis proceeds slowly, growth in length being retarded until a certain thickness has been attained, resembling in this respect the growth of the stem of endogenous trees.

Upon examination of a seedling in the latter part of April the cotyledons had disappeared and the caulicle was found to be from one-eighth to one-fourth of an inch long, its length not exceeding its diameter, hidden by a dense tuft of the needle-shaped primary leaves, which closely invest the terminal bud. At this stage a few fascicles of secondary leaves are already showing themselves, still inclosed in their sheaths.

During the first three or four years its energy of growth is mainly expended upon the development of its powerful root system (see Pl. VII, *e*). Before the first spring season has passed, the stout spindle-shaped taproot of the seedling is found to be over 3 inches in length and provided with several fine lateral rootlets, sometimes nearly as long as the main root.

With the opening of June the primary leaves covering the axis are nearly all withered, only a few remaining to the end of the season. With the development of the suppressed secondary axes from which the foliage leaves proceed, the primary leaves are reduced to chaffy fimbriate bracts. Only few of these primary leaves retain the needle-shaped form and green color, namely, those from which no leaf-bearing branchlets were developed. During the first season many of the fascicles of the foliage leaves contain only two leaves, and sheaths inclosing only one leaf are frequently observed.

By the end of the first year the stem of the plantlet is rarely over three-fourths of an inch in length, the main root having attained a length of from 8 to 10 inches.

Having reached the end of the second year the taproot is found from 2 to 3 feet in length, the stem scarcely 1½ inches long, with an increase of diameter hardly perceptible. The conical termination of the spring shoot is now densely covered with the delicately fringed bracts inclosing the buds of the foliage leaves, which impart to it the appearance of a silvery white tuft, by which this species is recognized at first sight.

During the following two years the growth proceeds but slowly, the length by the end of the fourth year averaging not more than 5 inches with a thickness of three-fourths to seven-eighths of an inch. During the same time the taproot is found to gain constantly both in thickness and length (see Pl. VII, *e*). A few single branches now make their appearance on the main axis. The increase of growth from one season to another up to the seventh or eighth year is difficult to follow, since the difference in the appearance of the spring and summer wood cells in the spongy wood of young trees is hardly perceptible, and the rings of annual growth, even as seen in cross sections prepared for microscopical examination, are mostly too indistinct to afford a safe criterion of their age. As far as could be observed the growth proceeds equally slowly during the fifth and sixth years, the plant at the end of that period being from 5 to 7 or 7½ inches in length.

Stage of rapid growth.—With its seventh year the tree may be said to enter on its most vigorous growth. Henceforth the stem (primary axis) increases rapidly in length, and the development of branches (lateral axes) proceeds at an equal rate in regular whorls, to which the symmetry of the tree in that stage of its development is due. During the seventh year, generally, the tree doubles its length, and during a number of successive years the rate of growth in that direction varies between 10 and 20 inches annually, as is clearly shown by the length of the internodes separating the whorls. As the branches increase in length they produce, in the same order mostly, two opposite secondary branches. With the rapid expansion of the leaf surface, the formation of wood keeps pace. The rate of growth in diameter, as well as in height, during this period, is of course variable according to differences in the physical condition of the soil as well as in the available amount of plant food and moisture it contains, and no less upon differences in temperature and of exposure to light and air. These variations are clearly shown in the annexed tables, exhibiting the rate of growth of the tree during its most active stage. With the increasing accretion of wood the annual rings become sharply defined, leaving no doubt as to the age of the tree.

To make sure as to the relation between the annual rings and the age of the tree, the age of second growth was ascertained by close inquiries directed to settlers who knew the time that had elapsed since this second growth made its appearance in the abandoned fields or in the forest. In every instance it was found that the number of rings accorded closely with the information elicited.

To ascertain the difference in rate of growth and quality of wood between trees grown upon ground once turned by the plow and those sprung up in the original forest on the same soil, several trees of nearly the same size were felled in what clearly appeared to be the remnant of virgin forest, and in a grove grown up in a field abandoned years ago.[1] It was made evident that trees in the original forest required almost double the length of time to attain the same dimension.

A field covered with saplings quite uniform in growth and known to have been thrown out of cultivation during the years 1863 and 1864 afforded a good opportunity for these investigations. A number of trees, varying in diameter between 10½ and 11 inches, and in height between 45 and 50 feet, showed from 30 to 35 rings of growth. The length of the spring shoots on the main stem of these trees was found (June 8) to be from 21 to 24 inches.

In another fine grove, covering a field which was known to have been cultivated for the last time during the years 1835 and 1836, a number of trees were cut down for measurement. The number of rings was found not to exceed 48. These trees also showed great uniformity in size, measuring near the base 11½ to 12 inches in diameter and from 68 to 72 feet in height. The wood was sappy throughout and useless, except for fuel and for making charcoal. For this purpose the land is rented at $4 to $5 per acre. In this grove, ranking as best pine-woods land, the soil of which was nearly level, well drained, and with a light, loamy subsoil, 110 trees of the above dimensions were counted on 1 acre.

Among the trees taken from the forest for determining the difference between forest growth and field trees, one measuring 12 inches in diameter and 76 feet in height showed 85 rings of annual growth, with 9½ inches of heartwood. Two others, 14 and 15 inches in diameter and 70 and 71 feet high, showed 96 rings each. The shoots of the year (June 8) on the primary and lateral axes of these trees were found to be but little over 1 inch in length.

In a third grove, upon poor, sandy, undulating ground, a number of trees below medium size were found cut down to serve for posts and logs. In 25 of these trees the diameter varied between 7¾ and 8 inches, with a nearly uniform height of 60 to 62 feet, the first limb being 18 to 20 feet above the ground. The number of rings varied between 48 and 50. The forests in the same vicinity were stripped of their more valuable timber a number of years before. The largest trees of the original forest growth remaining were from 12 to 15 inches in diameter. Several were brought down for measurement and found to be 73 feet in height by 14 inches in diameter, with 126 rings and 9 inches of heartwood; 73 feet in height by 13 inches in diameter, with 94 rings and 6 inches of heartwood; and 89 feet in height by 14 inches in diameter, with 107 rings and 8 inches of heartwood.

When the tree has reached its second decade it begins to produce flowers and fruit. Having during the course of the following ten to fifteen years reached a length of from 40 to 45 feet, with the main stem clear of limbs, the growth of branches does not proceed with the same regularity; consequently, they are no longer arranged in regular whorls, but appear irregularly, and thus the symmetry of the tree is lost.

[1] On the rolling pine uplands near Spring Hill, Mobile County.

TABLE I.—*Measurements of young trees of Longleaf Pine.*

Number of trees.	Number of rings.	Diameter breast high.	Height. To crown.	Height. Total.	Locality.	Remarks.
		Inches.	*Feet.*	*Feet.*		
1	8	$1\frac{3}{4}$	....	$5\frac{8}{12}$	Springhill, Ala	Opening in forest; pasture protected from fire.
2	9	$1\frac{7}{8}$	....	$5\frac{4}{12}$	.....do	Do.
3	10	$4\frac{1}{2}$	....	22	.....do	Old field; last time plowed in 1874.
4	10	2	....	$8\frac{6}{12}$	.....do	In the midst of forest.
18	10	2	5	10	Levins Station, La	Opening in forest.
5	11	$2\frac{3}{4}$	....	11	Springhill, Ala	Deep forest.
6	11	5	....	23	.....do	Old field.
319	11	2	6	17	Ridgeland, S. C	Open forest.
7	12	$2\frac{1}{4}$	....	16	.....do	Pasture in forest; ground never turned.
19	12	4	9	22	Levins Station, La	Old clearing; turned ground.
8	13	$2\frac{1}{4}$	....	15	.....do	Do.
320	12	2	9	14	Ridgeland, S. C	Opening in forest; sandy uplands.
318	13	4	8	24	.....do	Do.
9	13	$2\frac{3}{4}$	....	15	Springhill, Ala	Wood pasture.
10	13	$3\frac{1}{4}$	....	19	.....do	Old field.
248	13	4	8	20	Thomasville, Ala	Opening in forest; hills.
317	14	4	7	24	Ridgeland, S. C	Opening in forest; dry uplands.
11	15	$5\frac{1}{2}$	....	35	Springhill, Ala	Field abandoned in 1872.
260	16	2	8	16	Thomasville, Ala	Inclosed forest; hills; under cover.
199	18	2	16	23	Nona, Tex	Flat, damp; opening in forest; exposure free.
198	19	2	12	20	.....do	Do.
194	20	6	18	47	.....do	Light swell in open forest; exposure free.
12	20	10	....	49	Springhill, Ala	Old field; deep soil; abandoned in 1864; from one open grove.
13	21	10	....	45	.....do	Do.
14	21	10	....	50	.....do	Do.
15	25	11	....	50	.....do	Old field; poor, broken ground.
259	22	2	11	21	Thomasville, Ala	Virgin forest; under cover.
246	20	4	14	29	.....do	Virgin forest; in opening; free.
316	21	6	10	28	Ridgeland, S. C	Open forest; sandy uplands; free.
195	25	7	24	47	Nona, Tex	Flat, damp, dense forest in opening; exposure free.
194	25	4	20	44	.....do	Do.
196	26	6	17	44	.....do	Do.
209	36	4	15	35	Ryansville, Calcasieu Parish, La.	Flat, damp; open forest.
210	39	4	17	35	.....do	Do.
208	40	6	21	50	.....do	Do.
315	40	8	17	60	Ridgeland, S. C	Boundary field; open.
207	43	6	33	55	Ryansville, La	Flat, damp; open forest.
256	43	6	28	47	Thomasville, Ala	Dense oak opening; oppressed.
258	43	4	34	56	.....do	In open forest.
16	48	8	....	60	Springhill, Ala	Old pasture, on poor broken ground.
17-21	52	8	....	61	.....do	6 trees from grove of old pasture; yield, sticks and posts for fencing and building; averaging 20 feet in length.
22-25	48	11	....	73	.....do	Grove with 115 to 120 trees to the acre; on field abandoned in 1835, and rented to charcoal burners.
22*a*	55	8	....	58	.....do	Old pasture.
723	71	5	....	40	Chunchula, Ala	Old turpentine orchard; bled; exposed for over 20 years, one season after another, to fire.
255	78	6	47	62	Thomasville, Ala	Under cover of forest.
23*a*	80	6	....	52	Chunchula, Ala	Old turpentine orchard; bled and scorched, exhibiting the effect of bleeding and repeated burning of the woods by their retarded growth.
24*a*	87	8	....	59	.....do	Do.
25*a*	95	7	....	58	.....do	Do.
26	105	8	....	56	.....do	Do.
27	105	8	....	59	.....do	Do.

Stage of slow growth.—Rapid as is the increase in length of the primary axis or trunk, amounting during the first half century, in the average, to 14 or 15 inches annually, the rate is subsequently greatly diminished, averaging from the fiftieth to about the one hundred and fifteenth year but from 4 to 5 inches, and from this time to the age of two hundred and fifty years only $1\frac{1}{2}$ inches—that is, at a relative rate of 10, 3, and 1 in the three successive periods. The decrease in the accretion of wood corresponds with the reduction in the growth of the branches and consequent reduction of foliage. From what has been said, it is seen that the Longleaf Pine attains maturity of growth, with the best qualities of its timber, at an age of from one hundred and eighty to two hundred years. After having passed the second century the trees are found frequently to be wind shaken and otherwise defective. The deterioration of the weather-beaten crown lessens the vitality of the tree, and the soil, under prevailing conditions, becomes less and less favorable. In consequence, the trees become liable to disease and mostly fall prey to the attacks of parasitic fungi (red heart). Instances of trees which have reached the maximum age of two hundred and seventy-five or three hundred years are exceptional.

In order to ascertain the age required to furnish merchantable timber of first quality, measurements were made of a number of logs in a log camp in the rolling pine uplands of the lower division of the coastal pine belt near Lumberton, Washington County, Ala. From the results obtained it appears that in this section of the eastern Gulf region, at the lowest figure, two hundred years are requisite to produce logs of the dimensions at present cut at the sawmills.

TABLE II.—*Measurements of Longleaf Pine—period of slower growth from one hundred to two hundred years.*

Number of tree.	Number of rings.	Diameter, clear wood.	Height. Of timber to first limb.	Height. Total.	Diameter below crown.	Sap on radius.	Increase in diameter for each successive half century, in inches. 1	2	3	4	5	Number of years required for every inch of wood for each successive half century. 1	2	3	4	5	Locality.	Remarks.
		In.	*Ft.*	*Ft.*	*In.*	*In.*												
190	105	19	62	113	11	4											Nona, Tex	Flat; soil, deep sandy loam, damp; virgin forest close; exposure free.
20	110	17	36	92													Wallace, Ala	Gently rolling, pine upland, close; virgin forest; slightly under cover and oppressed.
70	105	9	38	85													Wilson, Ala	Bored timber; abandoned for five years; dry pine, rolling pine forest; exposure free.
	105	14	40	85								5½	6¼				Chunchula, Ala	Open forest; exposure free.
13	110	14	45	78			4½	5½				11.1	9.5				do	Do.
180	112	15	50	97	11												Levins Station, La.	Do.
191	113	20	53	110	15	4½											Nona, Tex	Flat woods; closed forest; damp, etc.
313	114	12	30	83													Ridgeland, S. C	Clearing in forest; soil dry, sandy.
9	115	12	38	83		3	5½	4½				9.1	11.1				Chunchula, Ala	Rolling pine lands; dry, sandy.
200	115	17	70	96													Nona, Tex	Flat woods; soil damp; crown oppressed.
	116	12½	46	81			5½	5				9.7	10				Chunchula, Ala	Rolling pine woods; dry, sandy.
67	116	13	48	87													Wilson, Ala	Bored; dry uplands; open forest; partially free.
253	118	15	45	84	11	2½											Eastman, Ga	Gently rolling uplands, dry; open forest; exposure free.
21	123	17	40	84		2½	6¼	6¾				7.7	7.8				Chunchula, Ala	Do.
23	125	18	61	102			9	5½				5.5	9.1				Springhill, Ala	Exposed slope; open forest; soil, loamy sand; exposure free.
251	133	18	44	93	13												Eastman, Ga	Open forest; dry, sandy; exposure free.
237	135	17	54	95	10	2½											Renfroe, Ala	Rocky hillside; dry subsoil, loam; exposure free.
252	145	19	49	96	14												do	Rocky hillside; dry subsoil, loam; partially free.
309	145	22	62	102		5											Ridgeland, S. C	Gently undulating open forest; loamy sand; exposure free.
312	140	20	63	99		2½											do	Open pine forest; sandy loam, dry; exposure free.
177	155	23	63	122	16												Levins Station, La.	Do.
24	155	18	65	98			6	5¼	5½			8.3	8.7	9.1			Springhill, Ala	Open pine forest; loamy sand, dry; exposure free.
19	160	24	43	111													Wallace, Ala	Close forest; deep sandy loam; exposure free.
238	165	21	35	97	15												Renfroe, Ala	Rocky hillside; forest open; dry; exposure free.
205	167	16	84	125	8	2											Ryansville, Calcasieu Parish, La.	Flat woods, damp; close forest; exposure free.
239	170	21	50	108	14												do	Do.
178	170	21	62	117	13												Levins Station, Rapides Parish, La.	Rolling open forest; sandy loam; exposure free.
204	180	19	56	102	11												Wallace, Ala	Rolling pine woods; deep sandy loam; partially free.
4	182	19	70	113													do	Rolling pine woods; deep sandy loam; slightly oppressed.
5	183	16	53	111													do	Rolling pine woods; deep sandy loam; partially free.
6	189	19	57	111													do	Rolling pine woods; deep sandy loam; partially under cover.
203	190	21	58	117	11												Ryansville, Calcasieu Parish, La.	Flat woods; loamy, damp; free.

TABLE III.—*Measurements of Longleaf Pine—period of slowest growth from two hundred to two hundred and sixty-six years.*

Number of tree.	Number of rings.	Diameter, clear wood.	Height. Length of timber.	Height. Total.	Diameter below crown.	Sap on radius.	Increase in diameter for every half century, in inches. 1	2	3	4	5	Number of years required for every inch of wood for each successive half century. 1	2	3	4	5	Locality.	Remarks.
		In.	*Ft.*	*Ft.*	*In.*	*In.*												
202	200	23	60	127	14	3½	....	....	....	....	....	....	....	....	....	....	Ryansville, Calcasieu Parish, La.	Flat woods; damp soil; sandy, cold loam; exposure free.
5	216	26	55	106	....	....	....	....	....	....	....	....	....	....	....	....	Wallace, Ala.	Gently undulating; forest dense; exposure free.
16	202	29	56	108	....	....	....	....	....	....	....	....	....	....	....	....	do	Gently undulating; dense forest; loamy sand; exposure free.
241	206	21	54	109	14	3	....	....	....	....	....	....	....	....	....	....	Renfroe, Ala.	Rocky hills; open forest; exposure free.
189	209	22	61	101	12	1¾	....	....	....	....	....	....	....	....	....	....	Nona, Tex	Level, dense forest; damp; exposure free.
18	210	22	50	110	....	....	....	....	....	....	....	....	....	....	....	....	Renfroe, Ala.	Rocky hills; forest open; undergrowth dense; exposure free.
240	215	21	50	112	14½	....	....	....	....	....	....	....	....	....	....	....	Wallace, Ala.	Undulating table-land; forest dense; loamy sand; exposure somewhat oppressed.
5	216	26	55	106	....	....	....	....	....	....	....	....	....	....	....	....	do	Undulating table-land; dense forest; exposure free.
61	215	26	64	120	....	....	....	....	....	....	....	....	....	....	....	....	Wilson, Ala.	Undulating table land; open forest; exposure free; timber bled.
60	220	23	45	117	....	....	....	....	....	....	....	....	....	....	....	....	do	Do.
249	235	22	41	108	15	3¼	....	....	....	....	....	....	....	....	....	....	Eastman, Ga.	Undulating table-land; open forest; loamy sand; exposure free.
250	245	27	49	106	21	3¾	....	....	....	....	....	....	....	....	....	....	do	Do.
188	240	25	52	110	17	2½	....	....	....	....	....	....	....	....	....	....	Nona, Tex	Level, damp; forest dense; somewhat oppressed.
	250	23	46	102	16	1¼	8	5¼	3¾	2¾	2	6.3	9.5	13.3	18	25	Lumberton, Ala.	Rolling uplands; forest open; free.
	248	24	40	101	15	2	8¾	6	4½	3½	1½	5.7	8.3	11.1	14.3	33	do	Do.
	263	26	50	103	....	2	....	....	....	....	....	....	....	....	....	....	do	Do.
	264	28	45	102	20	....	7½	8¾	4¾	3¼	3	6.6	5.7	12.6	15.5	16.6	do	Do.
	264	28	52	103	18	....	7½	8¾	4¾	3	3¼	6.6	5.7	12.6	16.6	12.6	do	Do.
	266	26	....	....	....	....	8	5¾	5¾	3¼	2	6.3	8.7	8.7	15.5	25	do	Do.

The following table and diagram (fig. 8) present the average results of a detailed study of over sixty trees collected in different localities. Since only the part of the stem from stump upward is represented, the seedling period of slow growth finds no expression. It will be observed that the growth in height is a maximum between the age of ten and thirty years, amounting to 14 feet for each decade; that it is but half of this at sixty and little over one-third at the age of one hundred years. As plainly indicated in the fine, uniform grain of the wood, the growth in diameter is remarkably uniform until the tree reaches the age of about one hundred years. From this on it decreases rapidly and is scarcely more than one-fourth as great at one hundred and eighty as it is at one hundred. The rate of growth in volume increases steadily up to the one hundredth year, reaching a maximum of over 1.2 cubic feet per year, but decreases, though very slowly, from that time forward, being only about one-half cubic foot per year when the tree reaches the age of one hundred and eighty years.

Rate of growth of Longleaf Pine.

Age.	Diameter with bark (breast high).	Length of timber, with upper diameter of 5 inches.	Height of tree.	Volume. Tree.	Volume. Log.	Periodical accretion. Decade.	Periodical accretion. Diameter.	Periodical accretion. Height.	Periodical accretion. Area of cross sections.	Periodical accretion. Volume.	Average annual accretion.	Current accretion.
	Inches.	*Feet.*	*Feet.*	*Cu. feet.*	*Cu. feet.*		*Inches.*	*Feet.*	*Sq. foot.*	*Cu. feet.*	*Cu. feet.*	*Cu. feet.*
10	2.0	....	9	0.12	....	First	1.4	9	0.01	0.12	0.01	0.01
20	3.8	....	23	1.20	....	Second	1.8	14	.04	1.08	.06	.11
30	5.5	....	37	3.35	....	Third	1.6	14	.07	2.15	.11	.21
40	7.0	16	48	7.06	5.61	Fourth	1.2	11	.08	3.71	.18	.37
50	8.1	24	56	10.75	9.30	Fifth	1.2	8	.08	3.69	.21	.37
60	9.6	34	62	15.26	13.99	Sixth	1.4	6	.12	4.51	.25	.45
70	11.5	44	67	24.16	23.11	Seventh	1.6	5	.17	8.90	.35	.89
80	13.0	52	72	33.18	32.27	Eighth	1.6	5	.19	9.02	.41	.90
90	14.5	56	76	43.57	42.66	Ninth	1.2	4	.16	10.39	.48	1.04
100	16.0	60	80	55.85	54.94	Tenth	1.1	4	.17	12.28	.56	1.23
120	18.0	65	87	76.87	75.87	Eleventh and twelfth	1.8	7	.30	21.02	.64	1.05
140	19.5	72	93	96.44	95.49	Thirteenth and fourteenth	1.6	6	.29	19.62	.69	.98
160	20.5	80	98	112.30	111.50	Fifteenth and sixteenth	.8	5	.16	15.86	.70	.79
180	21.3	85	103	122.00	121.20	Seventeenth and eighteenth	.75	5	.12	10.76	.67	.53

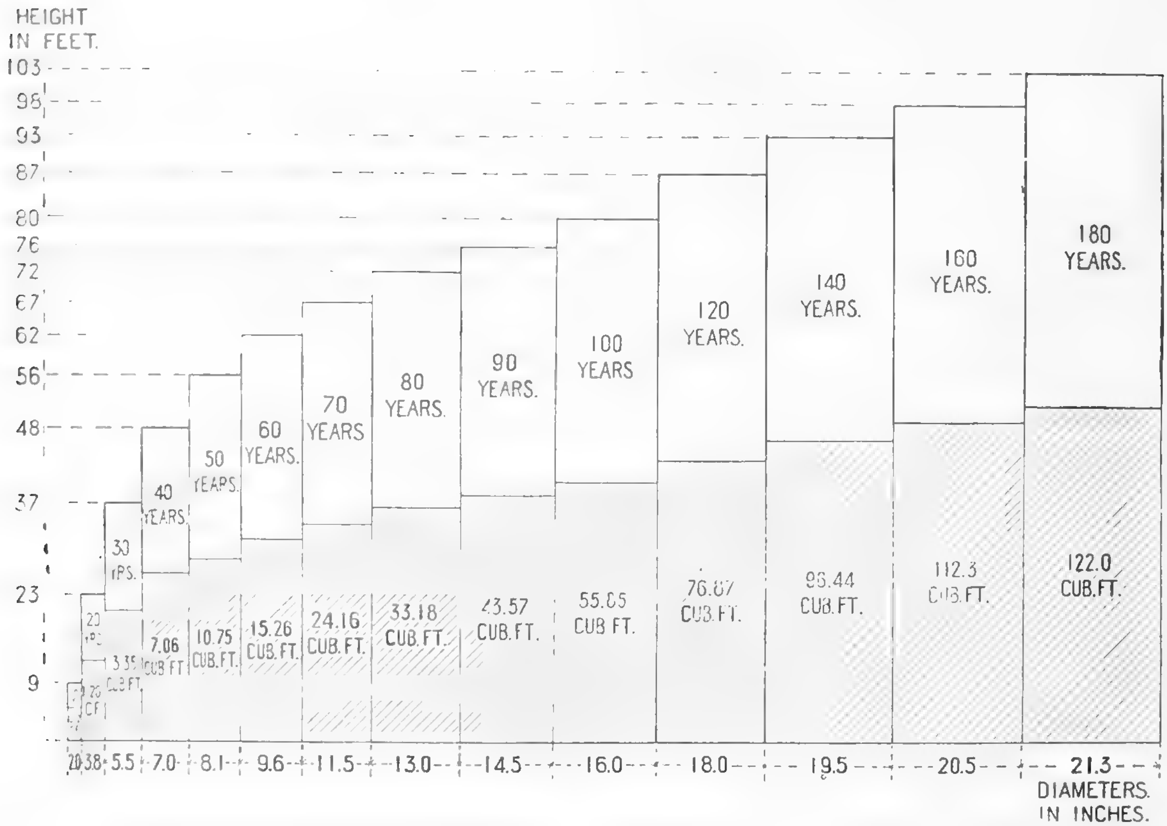


Fig. 8.—Growth of Longleaf Pine: Height, diameter, and cubic contents of average trees at 10, 20, etc., years of age.

CONDITIONS OF DEVELOPMENT.

Demands upon soil and climate.—In its demands upon the soil this pine is to be counted among the most frugal as far as mineral constituents, which are considered as plant food, are concerned, if only the mechanical conditions which influence favorable soil moisture are not wanting. It thrives best on a light siliceous soil, loamy sand or pebbles or light sandy loam, with a slightly clayey subsoil sufficiently porous to insure at least a partial underdrainage and to permit unimpeded development of the long taproot. Whenever the tree meets an obstacle to the development of this root it remains more or less stunted.

The luxuriance of the growth and increase in size of the timber, however, is greatly influenced by the quantity of clay present, particularly in the deep subsoil, which improves mechanical and moisture conditions. This is strikingly exhibited in the timber of the level pine flats west of the Mississippi River, although the surface drainage is almost wanting and the underdrainage through the loamy strata slow, so that the surface of the soil remains damp or water-soaked for the greater part of the year; the stand of timber of first-class dimensions exceeds considerably that of the rolling pine uplands on the Atlantic slope and the lower part of the pine belt in the Eastern Gulf region, which are poorer in clay. Evidently, although the underdrainage is less perfect, the moisture conditions during the dry season of the year, the time of most active growth, must be most favorable. The same fact is apparent in the upper part of the coast pine belt in Alabama and Mississippi, where upon the same area, with a smaller number of trees, the crop of timber may be considered almost twice as heavy as that found on the pine barrens proper farther south. On the soil of fine, closely compacted sand, entirely deficient in drainage as found in the so-called pine meadows along the coast of western Florida, Alabama, and Mississippi, as well as on the siliceous rocky ridges of central and northern Alabama, the tree is so stunted as to be of little or no value for its timber.

"It is neither temperature alone, nor rainfall and moisture conditions of the atmosphere alone, that influence tree growth, but the relation of these two climatic factors, which determines the amount of transpiration to be performed by the foliage, and again with most species we must place this transpiration movement into relation with available soil moisture, in order to determine what the requirements and the most suitable habitat of the species are" (B. E. Fernow). Hence we find that east of the Mississippi River the Longleaf Pine occurs in greatest frequency along the isotherm of 60° F. ranging to the 34° north latitude, while west of the Mississippi it follows a line between the isotherms of 63° and 64° F. and is scarcely found north of the thirty-second parallel of north latitude. Within this area of its distribution it is exposed to wide variation of temperature and moisture conditions.

Under the influence of the vapor-laden breezes from the Mexican Gulf and an evenly distributed rainfall ranging from 42 to 63 inches during the year, the Longleaf Pine appears of the same thrift and vigor of growth in the interior of Alabama under 34° to 35° north latitude, with the thermometer falling as low as 4° F. (16° C.) and a range of temperature of 93° (at Tuscaloosa), as it is found in the subtropical belt of the coast with a maximum temperature of 105° F. (40° C.) and a range of temperature of 94° west of the Mississippi River, although the temperature reaches rarely a minimum of 15° and 12°, respectively, at the northern limit of the tree in these States, the diminished humidity of the atmosphere and lesser rainfall, particularly during the warmer season, account for its absence. There can be no doubt that the greater exposure to the violence of the sudden gusts of dry and cold wind known in Texas as "dry northers" exercises also no small influence in limiting the Longleaf Pine.

ASSOCIATED SPECIES.

The Longleaf Pine is eminently a gregarious tree, covering areas of wide extent, to the almost complete exclusion of any other species. In the flat woods of the coastal plain, particularly near its northern limit on the Atlantic Slope, it is not infrequently associated with the Loblolly Pine; farther south and along the Gulf Coast to the Mississippi River, more or less frequently with this tree and the Cuban Pine. In the upper part of the maritime pine belt it not rarely occurs together with the Shortleaf Pine and the Loblolly Pine intermixed with the deciduous trees of the uplands, viz, the Black Oak, Spanish Oak, Black-jack, Bitternut, Mockernut Hickories, and Black Gum.

It will be apparent, from what has been said regarding the demands for light, that the associated species must be either slower growers or later comers, if the Longleaf Pine is to survive in the mixture. As has been pointed out elsewhere, with the culling of the Longleaf Pine from the mixed growths it must soon cease to play a part in them, since its renewal under the shade of the remaining associates is impossible.

ENEMIES.

The greatest danger threatening the existence of the forests of Longleaf Pine must be ascribed to the agency of man, since their destruction is caused chiefly by the reckless manner in which they are depleted without heed to recuperation. The right of ownership has been generally acquired on such low terms that since no value has been attached to the land without the timber, despoliation has been carried on with no other object than the quickest return of momentary profits.

EXPLOITATION.

Such management could not but entail tremendous waste, a large percentage of the body of the trees felled being left on the ground to rot or to serve as fuel for the conflagrations which scour these woods almost every year. Infinitely greater than the injuries inflicted upon the forest by the logger and by getting out cross-ties and hewn square timber, which consist chiefly in the accumulation of combustible waste, are those caused by the production of naval stores. When the fact is considered that the production of the 40,000 barrels of spirits of turpentine, which on an average during the latter half of this decade annually reached the market of Mobile alone, implies the devastation of about 70,000 acres of virgin forest, the destruction caused by this industry appears in its full enormity. Under the management of the turpentine orchards prevailing at present, trees of such small size are tapped that they are unable to resist the force of the winds, and in a few years are inevitably prostrated, while the larger trees, weakened by the severe gashes on almost every side, become largely wind-shaken and the timber after a few years almost worthless.

While a judicious tapping is not only justified, but demanded, by an economic system of exploitation, the prevailing methods of orcharding are unnecessarily destructive.

The tapping of sappling timber not yet ripe for the saw, and the destructive fires started in connection with this industry, annihilating all young growth, prevent any renewal of the forest, while the working of large bodies of timber years before milling facilities are available leads often to 20 per cent and more of loss in both quality and quantity of the merchantable product.

FIRES.

The greatest injury to which the pine forests are subject in consequence of turpentine orcharding arises from the fires which are started every spring for the purpose of getting rid of the combustible matter raked from around the tapped trees in order to protect them from accidental conflagrations while they are worked. These forest fires, spreading far beyond their intended limits, destroy entirely the youngest progeny of the pines, stunt the growth of the more advanced trees, and cause the ruin of a large number of older ones in the abandoned turpentine orchards. Burning deeply into the gashes and other exposed surfaces of the tapped trees, these fires hasten their prostration by the gales. Moreover, the fire causes cracks in the surfaces laid bare by the ax and the puller occasions greater exposure to atmospheric action, thus inducing more or less rapid decay. A test, made by sawing through twenty-two logs taken at random from a turpentine orchard after it had been abandoned for a period of sixteen to eighteen years, showed that about one-half of the timber was partially decayed and shaky.

Besides the production of naval stores as a cause of forest fires, there is another scarcely less potent. This is the practice prevailing among the settlers of burning the woods upon the approach of every spring in order to hasten the growth of grass for their famished stock. Fires are also frequently started through the carelessness of loggers and hunters, in the preparation of the ground for tillage, and by sparks from locomotives. These fires, occurring at least once during every year, cause the total destruction of the young growth of the Longleaf Pine. The danger to this species is much greater than to any other Southern wood, because of the greater length of time it requires to reach a size at which it can offer some resistance to fire. In the open forests of Longleaf Pine the fires are not so destructive to the larger timber as in the dense forests of coniferous trees farther north, trees of larger size being, with some exceptions, but slightly, if at all, directly damaged.

Another serious damage, however, resulting from the frequent recurrence of fires is the destruction of all vegetable matter in the soil. Deprived of the mulching needed for the retention of moisture, the naturally porous and dry soil, now rendered absolutely arid and barren, is no longer capable of supporting any larger tree growth or other useful vegetation.

LIVE STOCK.

Of no less danger to the existence of the forests of Longleaf Pine is the injury caused by live stock. This agency, slow in its action, is sure to lead to their destruction unless restricted to some extent. Besides the damage due to the trampling down and mutilation of the young growth by herds of cattle roaming through the woods, the smaller domestic animals—goats and sheep—eat the tufts of the tender foliage of the seedlings, while hogs are seen digging up and chewing the spongy and tender roots of the young plants. As a further agency in the way of the renewal of this species, the destruction of the mature cones might be mentioned, caused principally by the squirrels, which peel off the scales clean to the core in search of the sweet, nutritious seed.

STORMS.

Full-grown trees are frequently uprooted by the hurricanes which from time to time pass through the pine belt. Those having the taproot shortened by impenetrable layers of indurated clay interposed in the subsoil at varying depths are invariably the first victims of the high winds. In trees grown in such places the taproot is found with a tumid and round base as smooth as if polished.

FUNGI.

Frequently full-grown trees are found to show signs of rapid decay. These are recognized by the gradually dying of the smaller limbs and their falling off, in consequence of the rotting of the wood surrounding their base; and after having been cast off a hole or diseased spot remains in the trunk, which is infested by a large fungus of the genus *Polyporus* (punk holes, punk stools). The heartwood of such trees is of a reddish color, soft, sappy, and full of small channels, caused by the breaking down of the walls of the wood cells, filled with the mycelium, the so-called spawn of the fungus, the threads of which also penetrate the medullary rays. Such punky or red-heart timber is found mostly on the ridges in the poorest soil. Apparently superannuated trees are most frequently found afflicted with this rot.

INSECTS.

The Longleaf Pine, throughout its existence, is exposed to the danger of destruction by the ravages of insects, hosts of which, belonging to various orders, are found to infest it from the earliest stages of its development. Upon the tufts of the tender primary leaves of the seedling are often found feeding large numbers of a yellow, black-striped caterpillar, the larvæ of a species of sawfly (*Lophyrus*).

The cambium of trees felled in the latter part of the summer is soon found swarming with the larval brood of bark beetles, which after a short time infest the trees growing near by, causing, as has been again and again observed, the death particularly of the trees of younger growth over extensive areas. Hence the necessity of stopping the practice of felling trees during the summer season. According to information kindly furnished by Mr. Schwarz, of the Entomological Division of the United States Department of Agriculture, most if not all the species of the bark beetles, the family *Tomicidæ* have more than one annual generation, and in the Southern States they have, in all probability, three. The summer generation develops in a very short time, possibly within four or five weeks, and the perfect beetles issuing from the trees felled in August will in September attack the healthy trees near by for want of more suitable food. The ravages spoken of by Michaux refer, no doubt, to these species of *Tomicidæ* beetles which enter the solid wood of trees, e. g., *Gnathotrichus materiarius* and *Xyleborus pubescens*. The galleries of these timber beetles or allied species are found to penetrate the wood to the heart. The grating noise made by the larvæ of the large ceramboid beetle, the *Monohammus*, while engaged in its work of destruction frequently strikes the ear in the forest. That there is a large number of species belonging to different orders preying on the Longleaf Pine and more or less destructive to the life of this tree is apparent from the following communication from Mr. Schwarz:

The number of insects to be found on the Longleaf Pine is very large and comprises species of most orders, but a complete list of them has never been published and the habits of most of them have never been carefully studied. Only those which are really injurious to the tree need to be considered.

Order *Hymenoptera:* Several species of sawflies (*Tenthredinidæ*), occasionally very injurious to the younger tress, the larvæ defoliating the branches. The species thus far observed are *Lophyrus Abbotii*, Leach; *Lophyrus Lecontei*, Fitch, and three or four less common species.

Order *Coleoptera*, slip B: Round-headed borers (larvæ of *Cerambycidæ*) affect the trees similarly to the *Buprestidæ*, but their burrows are always cylindrical, and some species bore only under the bark. The most abundant and destructive is *Monohammus titillator*, Fabr., but there are many other species, of which the following is a partial list: *Scaphinus sohæricollis*, Lec.; *Asemum moestum*, Hald.; *Criocephalus nubilus*, Lec.; *Eupogonius tomentosus*, Hald.; *Acanthocinus nodosus*, Fabr. In the family *Curculionidæ*, the worst enemy of the pine tree in the more Northern States, *Pissodes strobi* is rare in the region of the Longleaf Pine, but another species, *Pachylobius picivorus*, Germ., the larvæ of which bore under the bark, is quite common and greatly injurious to the Longleaf Pine. Of its more dangerous enemies the Scolytid beetles, which mostly bore their galleries under the bark, only a few species entering the solid wood, the following are known to infest *Pinus palustris: Pityophthorus pulcarius*, Zim.; *P. annectens*, Lec.; *Tomicus calligraphus*, Ger.; *T. avulsus*, Eich.; *T. cacographus*, Lec.; *Crypturgus atomus*, Lec.; *Dendroctonus terebrans*, Oliv.; *D. frontalis*, Zim.; *Hylastes porculus*, Er.; *H. exilis*, Chap.

The few species entering the solid wood are *Platypus quadridentatus*, Oliv.; *Gnathotrichus materiarius*, Fitch, and *Xyloborus pubescens*, Zim. Most of these Scolytidæ are extremely numerous in specimens, and although they usually infest injured or diseased trees, yet in cases of excessive multiplication or for want of proper food they often attack healthy trees, which within one or two years succumb to their attacks.

NATURAL REPRODUCTION.

Certain peculiarities inherent to this species form a series of obstacles in the way of its spontaneous reproduction. These are, first, the rare occurrence of seasons of abundant crops of seed, and, second, its slow growth during the earliest part of its development, rendering the young offspring of this pine liable to be suppressed by competing species of quicker growth. To these causes is to be further added its dependence upon the influence of direct sunlight, which is required for its germination as well as during the subsequent stages of its growth to maturity, and the sensitiveness of the seeds and seedlings to moisture; placed in a wet, undrained soil, the germinating power of the first is destroyed and the latter will perish on exposure to the same conditions. A study of the young growth of the Longleaf Pine over the different regions of its habitat leads unavoidably to the conclusion that the chances for the reproduction of its forests, left to the ordinary course of nature, are quite limited, even if the adverse conditions arising from human agencies are left out of consideration. On the lowlands of the Atlantic Coast toward its northern limit this pine is almost invariably replaced by the Loblolly Pine, while farther south and in the coastal plain of the Gulf States east of the Mississippi River, after its removal, it is replaced partly by the Loblolly Pine and largely by the Cuban Pine. On the wide expanse of uplands rising above the coastal plain with their broad ridges of a soil of sandy loam, the young trees of the Longleaf Pine are met with in every stage of growth. Attaining, however, during the first five or six years scarcely a greater height than the surrounding herbage, the seedlings are irredeemably ruined by the various destructive agencies to which they are exposed. On land liable to repeated conflagrations, a scrubby growth, chiefly of barren oak and other upland oaks already mentioned, takes possession and excludes by its shade the pine. If upon the rolling pine lands or dry pine barrens the removal of most of the original tree covering is followed by a succession of barren years, the ground will surely be invaded by the hard-wood trees mentioned, which will retain possession. Under the shade of these trees the Longleaf Pine can never again find a home. In the stronger soil of the upper division of the maritime pine belt, the region of mixed growth, where the seedlings of the Longleaf Pine spring up simultaneously with the hard wood trees and the seedlings of the Shortleaf Pine, these latter will eventually gain the supremacy and suppress those of the Longleaf Pine; consequently the latter is seldom observed in mixed forests of second growth. In the flat woods, particularly in the pine flats of southwestern Louisiana and Texas, with a soil water-soaked during the winter and spring, the offspring of the Longleaf Pine is still more rarely met with for the reasons stated. From these facts it is evident that, owing to natural causes, combined with the unrestricted sway of the influences leading to its destruction by human agency, the offspring of the Longleaf Pine is rarely seen to occupy the place of the parent tree, even in the region most favorable to its natural renewal, and that final extinction of the forests of the Longleaf Pine is inevitable unless proper forest management is applied.

FOREST MANAGEMENT.

The time for the acquisition of timber lands or of the right of working them for their products at prices far below what could be considered as an adequate return for their instrinsic value has well-nigh passed away. The opportunities which existed during the last twenty-five years for acquiring Longleaf Pine lands, which were open to purchase by the hundreds of thousands of acres have now in a great measure ceased to exist. The greater part of this kind of property has passed into the possession of capitalists, and the rest will soon be similarly controlled. Under this new order of things the price of these timber lands is gradually approaching figures more in proportion to their true value. The depredations committed unblushingly on the public lands, and on the lands of railroad corporations and private owners, are rendered less easy every year under a mutual protection of interest. Reckless waste and devastation, heedless of the interests in the future, are giving way to a more economical management of the timber resources in the logging camp and in the mill. No measures have been attempted to maintain these resources by sparing the younger timber in its best stage of growth from the ax, or to provide in any other way for the protection and preservation of the younger growth.

What has been said of the geographical distribution of this tree and its demands upon climate, soil, and exposure, demonstrates that east of the Mississippi River it can be successfully grown all over the maritime plain of the Southern States (Austro-riparian zone) and in the interior of Alabama, through a large region of the Carolinian and the extreme southern extension of the Appalachian zone to an elevation above the sea falling little short of 1,000 feet. And the sandy soils of this region, largely too poor for agricultural use, are par excellence Longleaf pinelands. In the renewal of the forests of Longleaf Pine, upon areas denuded, the fact must be borne in mind that to produce timber which is under present conditions considered of fair merchantable quality a period of not less than one hundred and fifty years is required, and that to produce timber of the strength, clearness, and durability for which it is held in such high esteem the slow growth under the severe and hardening conditions involved in the struggle for light in the crowded forests is necessary. Hence, economic reasons would point to the maintenance and conservative management of the existing forests of Longleaf Pine and their renewal by natural reproduction, and perhaps best the method of selection which under the present conditions appears the most practicable, involving chiefly methods of protection.

By this method all or most of the mature trees, corresponding in their proportions to the most desirable quality of timber, are cut and the rest left to grow till they reach similar dimensions, to be in their turn replaced by the second growth, which in the openings from time to time springs up. In fact, this method was followed in the earlier days of the timber industry in the several regions of the Longleaf Pine, where the forests were being culled for the best sizes at intervals of from fifteen to thirty years. But owing to the exhaustion of the mature pine from forests within distance of railroad lines and water courses, which necessitates great outlays of capital for constructing tramroads or waterways, the original practice of selection has been abandoned, no tree being spared at present that will make a stick of timber, however small, as long as it finds a sale in the market. Care should of course be taken to leave always enough seed trees evenly distributed, and the chief care is to be directed to the protection of the seedlings and other young growth from the destructive agencies mentioned—fire, cattle, and the encroachment of invading species. A forest under such management would necessarily present a great diversity in the growth of the trees, and the length of time between one cutting and the next would be equally variable. It must be remarked that the demand of this species for the unhindered access of direct sunlight during the time of germination and successive stages of growth might prove a serious obstacle to the continued success of this method of selection; and the "group method," as described in the report of the chief of the Division of Forestry for 1894, might be substituted with advantage. Where it is desired to reestablish the growth of Longleaf Pine upon denuded areas, the ground must be cleared of every obstacle in the way of free access of the rays of the sun before the sowing. Owing to the ease with which the seeds germinate and the seedlings take root in the ground, but slight preparation of the same would be required, and there would be no difficulty in procuring a good stand. If transplanting is to be resorted to, the seedlings should be taken up during the fall or winter succeeding the first season of their growth, before the further development of the rapidly growing taproot, the precaution always being taken to prevent any injury to the rootlets and their drying out before their transfer to the ground. Since the trees clear themselves easily of branches, the stand in the plantation in the earlier stages does not need to be as dense as with other species. In order to secure improvement and permanency of favorable soil conditions, the litter from the shedding of the leaves and gradual decay of herbage should be left undisturbed on the ground.

There can be hardly any doubt that the introduction of other shady species would greatly assist in improving soil conditions and producing more rapid development of the pine. Care would have to be taken to bring in these species later, say between fifteen and twenty years, when the pine has begun to make its rapid height growth and can escape the shade of its neighbors.

For the present, however, the economic conditions are hardly yet ripe for any artificial reforestation, but the great importance of this valuable forest resource to the industrial and commercial development and prosperity of the people living within its limits should be apparent enough to keep them at least from preventing its natural reproduction. The growth of the young timber after the first few years is rapid enough, as may be seen from the table on page 57, and after fifteen or twenty years, when the trees have reached a diameter of 12 inches, they can be tapped for resin and will give a continuous revenue. Under careful management, and by tapping only the trees which should be removed in thinnings to make light for the rest, this revenue can be obtained without in any way impairing the final harvest value.

CONCLUSION.

From the southern frontier of Virginia, throughout the lower part of the Southern States, to the limits of high and compact forest growth west of the Mississippi River, spread over an area of from 90,000 to 100,000 square miles, the forests of the Longleaf Pine present yet a stupendous timber wealth. Yet, if we deduct the farm lands, and consider that large areas have been culled or entirely denuded of the original growth, we may estimate that the amount of timber standing can at best not exceed 100,000,000,000 feet, and is probably much less, while the cut, which at present does not fall short of 3,700,000,000 feet, board measure, is bound, as the Northern pine is giving out, to increase at even greater rate than in the past. Under such a strain, outstripping by far the possibilities of their reproduction, the exhaustion of the resources of these forests within the near future is inevitable, and if the devastation under present management by the naval store industry and the destruction caused by fire and domestic animals is continued their extermination as far as practical purposes are concerned must be regarded as equally certain.

APPENDIX.

THE NAVAL STORE INDUSTRY.

The resinous product of the Longleaf Pine furnishes the raw material for the production of naval stores, one of the most important industries in connection with the resources of the American forests. At present the bulk of these stores used in the world is derived from the forests of Longleaf Pine, and hence this industry is almost entirely confined to the coast pine belt of the Southern States, the proportion contributed by France, Austria, and other countries being insignificant.

For the year 1892 the foreign export of spirits of turpentine alone amounted to over 260,000 casks and the total production exceeded 350,000 casks. To produce this amount of spirits at least 2,500,000 acres must have been in orchard, and since over one-third of the total production is furnished by orchards being worked for the first year, over 800,000 acres of virgin forest must be attacked annually to supply present demands.

Under the name of naval stores are comprised the products derived directly or indirectly from the resinous exudation of cone-bearing trees, mostly pines, including tar, the product of the destructive distillation of the wood of pines highly charged with resinous matter. The name is undoubtedly derived from their extensive consumption in the shipyards and on board of vessels. These products are:

RESIN, OR CRUDE TURPENTINE.

The resin of the Longleaf Pine recently exuded is almost colorless, or of a pale straw color, of the consistency of honey, having a terebinthinous odor and taste, and like all substances of the same class is insoluble in water, but soluble in alcohol, ether, and spirits of turpentine. It consists of a volatile oil and a solid resin held in solution partially suspended in the former. The best quality is obtained during the first year the tree is worked, known as "virgin dip" or "soft white gum," which is almost colorless and contains the largest quantity of volatile oil. In the following year it is of a deeper yellowish color, the "yellow dip," which with each succeeding year becomes darker in color, more viscid, and poorer in volatile oil.[1]

The resin toward the close of the season produced on the tree under the influence of a cooler temperature is called hard gum, or scrape. This solidified resin of whitish to yellowish color contains only half of the quantity of the spirits of turpentine obtained from the dip or soft gum. By the distillation of the crude turpentine the naval stores of most importance to trade are obtained.

SPIRITS OF TURPENTINE, OR OIL OF TURPENTINE.

Spirits of turpentine, or oil of turpentine, is the volatile constituent of the resin. This liquid when freshly prepared is colorless, of a peculiar odor and taste, of a density varying between 0.85 and 0.87, volatile at ordinary temperatures, boiling between 304° and 320° F. It turns polarized light to the right, a characteristic feature of the American spirits of turpentine, most of the spirits from other sources polarizing the light to the left. In its pure state this volatile oil is free from oxygen, being a hydrocarbon of the composition of $C_{10}H_{16}$. It is highly inflammable and

[1] It is still an open question whether this deterioration is necessary or only owing to faulty manipulation. Experiments to settle this question are now in progress in the Forestry Division.

burns with a sooty flame. It is a good solvent for many resins, wax, fats, caoutchouc, sulphur, and phosphorus, and is used in the arts and industries for the preparation of varnishes, in paints, the rubber industry, etc. Before the introduction of kerosene oil it was used extensively for an illuminator; it is also used in medicine internally and externally and often as an adulterant of various essential oils.

ROSIN, OR COLOPHONY.

The solid constituent of the crude turpentine which forms the residue remaining after its distillation. It is of different degrees of heaviness, according to the quantities of volatile oil retained after distillation, is brittle, easily powdered, of a glassy luster, and of the specific gravity of 1.07, almost without taste, of a faint terebinthinous odor. It becomes soft at about 176° F., melts between 194° and 212° F., and is soluble in the same solvents as crude resin. According to the nature of the crude turpentine, depending upon the number of seasons the trees have been worked, it shows different properties in regard to the transmission of light, and in color. It is either perfectly transparent, translucent, or almost opaque and almost colorless, or a pale straw color to golden yellow, reddish yellow, through all shades to dark brown and almost black. The market value of this article is entirely regulated by these properties. In the American market the following grades are distinguished: WW (Water White) and WG (Window Glass), the lightest and highest-priced grades, obtained from the "virgin dip;" N (Extra Pale), M (Pale), K (Low Pale), I (Good No. 1), H (No. 1), F (Good No. 2), E (No. 2), D (Good Strain), C (Strain), B (Common Strain), and A (Black).

PINE TAR.

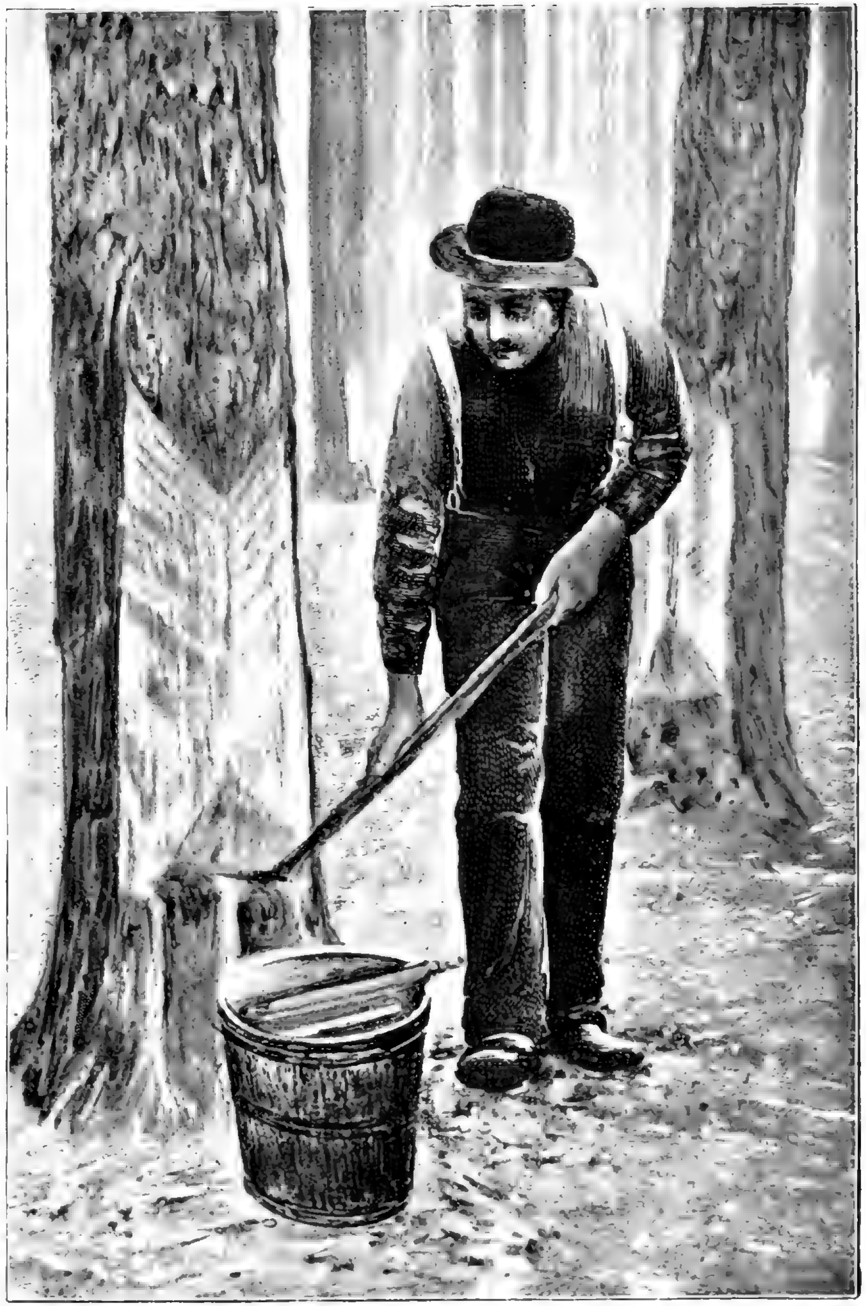
This is not exactly a by-product of the turpentine orchard, but is produced by the destructive distillation of the wood itself. It is chiefly produced in North Carolina, where this industry has been carried on since the earliest colonial times. Small quantities are produced in other sections of the Southern pine belt, mostly for home consumption. Perfectly dry wood of the Longleaf Pine, dead limbs and trunks seasoned on the stump, from which the sapwood has rotted, are cut in suitable billets, piled into a conical stack, in a circular pit, lined with clay, the center communicating by a depressed channel with a receptacle—a hole in the ground—at a distance of 3 to 4 feet from the pile. The pile is covered with sod and earth, and otherwise treated and managed like a charcoal pit, being fired from apertures at the base, giving only enough draft to maintain slow smoldering combustion. After the ninth day the tar begins to flow and continues for several weeks. It is dipped from the pit into barrels of 320 pounds, the standard weight. One cord of dry "fat" or "lightwood" furnishes from 40 to 50 gallons of tar. The price of pine tar is quoted as low as $1.05 a barrel. Since considerable quantities of tar are produced incidentally in the destructive distillation of wood in iron retorts for charcoal and other products, the price has been greatly depressed.

COMMON PITCH.

The best quality is obtained by boiling down tar until it has lost about one-third or more of its weight. The naval pitch of commerce has more or less rosin of the lowest grade added to it. Pitch is also obtained as the residue remaining from the dry distillation of rosin for rosin oil.

HISTORICAL REMARKS.

The tapping of the trees for the crude turpentine and the manufacture of tar and pitch was first resorted to by the earliest settlers of North Carolina, and in later colonial times these products furnished the largest part of the exports of the colony. In the three years from 1768 to 1770 the exports of crude turpentine, tar, and pitch represented on the average for each year a value of $215,000 of our present currency. Most of the crude turpentine was shipped to England. Later the distillation of spirits of turpentine was carried on in clumsy iron retorts in North Carolina and in Northern cities. The introduction of the copper still in 1834 resulted in a largely increased yield of spirits of turpentine, and the industry received a great impetus. With the new demand for spirits of turpentine in the manufacture of rubber goods, and its increased use as an illuminator, the number of stills increased greatly, and turpentine orcharding was rapidly extended south and west beyond its original limit. The large consumption of spirits of turpentine



TURPENTINE ORCHARDING IN LOUISIANA

caused such an increase in its production that the residuary product, rosin, became largely in excess of the demand, and, in consequence, much depreciated. This reduction of profits in the business caused the transfer of the stills from the leading markets to the source of the raw material, the forest. From that time, 1844, dates the great progress made in the extension of this industry. Up to that time more than half of the crude turpentine was distilled in North Carolina, but thenceforth the industry spread into the States of South Carolina, Georgia, Florida, and the Gulf States to the Mississippi River.

At the close of the war the demand for spirits of turpentine was not so great as before, petroleum products of several kinds having been found to take its place not only for illuminating, but also for other purposes. With the general extension of arts and manufactures all over the world, there has since been an increasing demand for spirits of turpentine and rosin. The exports of these articles in the year 1890 amounted to $8,135,339 in value.

TURPENTINE ORCHARDING IN THE FORESTS OF LONGLEAF PINE.

In the establishment of a turpentine orchard and a still, two points must be considered, namely, proper facilities of transportation to shipping points and a sufficient supply of water for the condenser connected with the still. The copper stills generally in use have a capacity of about 800 gallons, or a charge of 20 to 25 barrels of crude turpentine. For such a still to be charged twice in twenty-four hours during the working season, 4,000 acres of pine land of a good average stand of timber are required. This area is divided into twenty parcels each of 10,000 boxes, as the receptacles are called, which are cut into the tree to receive the exuding resin. Such a parcel is termed a crop, constituting the allotment to one laborer for the task of chipping. The work in a turpentine orchard is started in the earlier part of the winter with the cutting of the boxes. Until some years past no trees were boxed of a diameter less than 14 inches; of late, however, saplings under 10 inches in diameter are boxed. Trees of full growth, according to their circumference, receive from two to four boxes, so that the 10,000 boxes are distributed among 4,000 to 5,000 trees on an area of 200 acres.

The boxes are cut (see Pl. VIII) from 8 to 12 inches above the base of the tree, 7 inches deep and slanting from the outside to the interior, with an angle of about 35°. In the adult trees they are 14 inches in greatest diameter and 4 inches in greatest width, of a capacity of about 3 pints. The cut above this reservoir forms a gash of the same depth and about 7 inches of greatest height. In the meantime the ground is laid bare around the tree for a distance of 2½ to 3 feet, and all combustible material loose on the ground is raked in heaps to be burned, in order to protect the trees against danger of catching fire during the conflagrations which are frequently started in the pine forests by design or carelessness. The employment of fire for the protection of the turpentine orchard against the same destructive agency necessarily involves the total destruction of the smaller tree growth, and if left to spread without control beyond the proper limit, often carries ruin to the adjoining forests.

During the first days of spring the turpentine begins to flow and chipping is begun, as the work of scarification is termed, by which the surface of the tree above the box is laid bare beyond the youngest layers of the wood to a depth of about an inch from the outside of the bark. The removal of the bark and of the outermost layers of the wood—the "chipping" or "hacking"—is done with a peculiar tool, the "hacker" (fig. 9, *e*, *f*), a strong knife with a curved edge, fastened to the end of a handle bearing on its lower end an iron ball about 4 pounds in weight, to give increased force to the stroke inflicted on the tree, and thus to lighten the labor of chipping. As soon as the scarified surface ceases to discharge turpentine freely, fresh incisions are made with the hacker. The chipping is repeated every week from March to October or November, extending generally over thirty-two weeks, and the height of the chip is increased about 1½ to 2 inches every month. The resin accumulated in the boxes is dipped into a pail by a flat trowel-shaped dipper (fig. 9, *a*) and then transferred to a barrel for transportation to the still. In the first season from six to eight dippings are made. The 10,000 boxes yield at each dip 40 barrels of "dip" or "soft gum," as it is reckoned in Alabama, to be of 240 pounds net weight. The flow is most copious during the height of the summer (July and August), diminishes with the advent of the cooler season, and ceases in October or November. As soon as the exudation of the resin is arrested and the resin begins to harden under the influence of a lower temperature it is carefully scraped from the scarified surface and the boxes with a narrow, keen-edged knife attached to a long wooden handle (fig. 9, *b*, *c*). In the first season the average yield of dip amounts to 280 barrels and of the hard gum or scrape to 70 barrels. The first yields 6½ gallons spirits of turpentine to the barrel of 240 pounds net, and the latter 31 pounds to the barrel, resulting in the production of 2,100 gallons spirits of turpentine and 260 pounds of rosin of higher and highest grades. The dippings of the first season are called "virgin dip," from which the finest quality of rosin is obtained, graded in the market as Water White (WW) and Window Glass (WG). In the second year from five to six dippings are made, the crop averaging 225 barrels of soft turpentine and 120 barrels of scrape, making altogether about 1,900 gallons spirits of turpentine.

The rosin, of which about 200 barrels are produced, is of a lighter or deeper amber color, and perfectly transparent, of medium quality graded as I, H, and G. In the third and fourth years the number of dippings is reduced to three. With the flow over a more extended surface, the turpentine thickens under prolonged exposure to the air and loses some of its volatile oil, partly by evaporation and partly by oxidation. In the third season the dip amounts to about 120

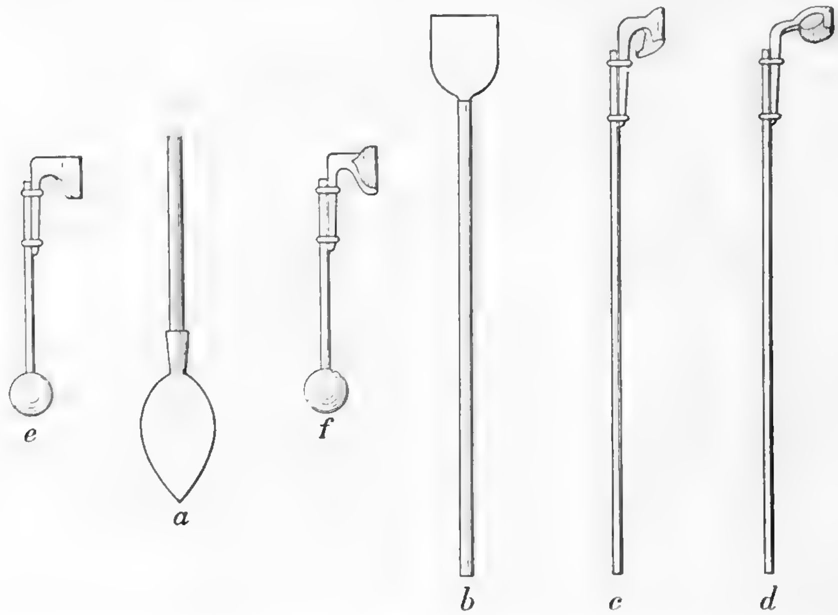


FIG. 9.—Tools used in turpentine orcharding: *a*, dipper; *b*, pusher; *c*, open puller; *d*, closed puller; *e*, *f*, hacker (front and rear view).

barrels and the scrape to about 100 barrels, yielding about 1,100 gallons spirits of turpentine and 100 barrels of rosin of a more or less dark color, less transparent, and graded as F, E, and D. In the fourth and last year three dippings of a somewhat smaller quantity of soft turpentine than that obtained the season before and 100 barrels of scrape are obtained, with a yield scarcely realizing 300 gallons of spirits of turpentine and 100 barrels of rosin of lowest quality, classed as C, B, and A. After the fourth year the turpentine orchard is generally abandoned. Owing to the reduction in quantity and quality of the raw product, it is not considered profitable by the larger operators to work the trees for a longer time. It is only in North Carolina that the smaller landowners work their trees for ten or more successive seasons, protect the trees against fire, and after giving them rest for a series of years, apply new boxes on spaces left between the old chips—"reboxing."

DISTILLATION.

The process of distillation is carried on in the ordinary way, and requires care and experience to obtain largest quantities of rosin of highest grade and to guard against overheating. After heating the still, somewhat above the melting of the crude turpentine, a small stream of tepid water from the top of the condenser is conducted into the still and allowed to run until the end of the process. A large quantity of water runs over with the spirits of turpentine, which is collected in a barrel, where it separates from the water and is then immediately transferred into barrels. After the oil has ceased to run freely the heating of the still and the influx of water has to be carefully regulated. After all the spirits of turpentine has been distilled over, the fire is removed and the contents of the still are drawn off by a tap connected with the bottom. This residuum, molten rosin, is at first allowed to run through a wire cloth and is immediately strained again through coarse cotton cloth or cotton batting, made for the purpose, into a large trough, from which it is ladled into barrels. The legal standard weight of the commercial package is 280 pounds gross. A turpentine distillery on the basis of twenty crops produces on the average during the four years that the boxes are worked 2,400 casks or 120,000 gallons of spirits of turpentine and about 12,000 barrels of rosin or 2,800,000 pounds, the lowest grades, B and A, excluded, a total value of about $60,000 at average prices. The prices of spirits vary at present from 28 to 40 cents a gallon, even through the same season, according to supply and demand in the market. The average quotations on December 30, 1892, at Wilmington were 28 cents for spirits and $1.91 for a barrel of rosin down to grade C.

COST OF ESTABLISHING A PLANT AND WORKING THE CROPS.

Timber lands with the privilege of boxing the timber for a term of four years are rented at the rate of $50 per crop of 10,000 boxes, or 200 acres. The establishment of a plant for the working of twenty crops, or 4,000 acres of timber land, requires an investment of about $5,000, including the buildings, stills, machinery for pumping water, tools, and teams. According to the statements of an experienced operator, the cost of working the trees of one crop during the four years, which is mostly done by the job—that is, the making and cornering of the boxes, inspecting the same, raking around the trees, chipping, dipping, scraping, hauling the crude turpentine to the still, including cost of barrels for spirits of turpentine, and for the rosin and superintending the crop—amounts to about $2,300 per crop, or $46,000 for the twenty crops. If to this amount the interest, 6 per cent per annum, on the capital invested and the depreciation in the value of the plant during the four years is added, with s me other incidental expenses (taxes, etc.), the cost of the production of the 120,000 gallons of spirits of turpentine and 12,000 barrels of merchantable rosin' foots up to not less than $50,000.

FIG. 10.—Improved method of turpentine orcharding.

A method of improving on the present practice by employing an earthen pot instead of the injurious "box" has been patented and practically introduced by J. C. Schuler, of West Lake, La. The arrangement is represented in fig. 10, its main feature being an earthen pot which can be moved as the scar is lengthened, thus reducing the distance over which the resin has to flow, and with this the amount of volatilization and loss of spirits of turpentine. The method resembles that employed in France (see Report of Chief of Forestry, United States Department of Agriculture, 1892, page 347), and, though its general application in this country is not yet secured, it is certainly a step in the right direction.

Mr. Schuler admits that the first cost for providing the cups, putting them up, and removing them the second season raises the expense of working a crop of 10,000 cups for two seasons to $460, against $190 for cutting 10,000 boxes expended under the old system in working one crop for two seasons, all other expenses connected with the work being considered equal. On the other hand, Schuler claims that the difference is vastly overbalanced by the increased yield of crude turpentine obtained by his cup methods, amounting for one crop worked two years to 195 barrels, at $3.50 per barrel; after deducting the extra expense involved by his method, this would leave a net balance of $410 per crop in favor of the cup system. He also claims that this amount is still further augmented if the larger quantity of spirits of turpentine and the higher quality of resin obtained from the dippings under his system are taken into account. On the first point he says that fully one-eighth of the crude turpentine brought to the still from the boxes consists of chips, sand, and other foreign matter, contaminations from which the product of the cups is entirely free. On the second point he refers to the high grades of rosin resulting from the distillation of the crude turpentine from the cups, which almost entirely classes with the highest and higher grades.

EFFECTS OF THE PRODUCTION OF NAVAL STORES UPON THE TIMBER, THE LIFE OF THE TREE, AND THE CONDITIONS OF THE FOREST.

In the present management of the turpentine orchards in the Southern pine forests a great deal of crude turpentine is wasted, much of the valuable spirits of turpentine is lost by volatilization in passing over the long chip face on its way to the box, and much of the resin is lowered in its grade and value by oxidation consequent to exposure and by admixture of foreign substances—bark, coal, dust, etc.

Concerning the effect of the tapping of the trees upon the timber, there exists no reason on physiological or anatomical grounds for considering it injurious, and the opinion held by many, that the qualities of timber are impaired by bleeding, finds no support when it is considered that the heartwood remains unaffected. The resinous contents of the heartwood being solidified and the formation of the resin taking place only in the newly formed wood, the heartwood can not participate in the flow of the resin, the discharge being necessarily confined to the sapwood. This fact has been fully substantiated by the work of the Division of Forestry, by which it has not only been shown that the strength of the heartwood, the most important if not the only part of the tree used for lumber, has in no wise been diminished, but also that the durability of the timber, as far as it depends upon its resinous contents, can not be impaired by bleeding. It is only in that part of the butt log around the chip that the quality of the timber becomes somewhat impaired—the wood becoming highly charged with resin is rendered more brittle and harder to work, with a tendency to gum up the tools. Indirectly, however, a considerable proportion of the boxed timber becomes damaged if not utilized shortly after having been bled. It is often left standing for a number of years, exposed to various destructive agencies, such as insects and fire, followed by parasitic fungoid growth. Large capricorn beetles bore their way through the callus surrounding the chip and through and beyond the sapwood. Through the innumerable fissures which are caused by fires, air and water charged with the spores of parasitic fungi find entrance to the body of the tree, causing disease and decay. The damage from these causes increases every year, so that from them alone the timber from a turpentine orchard abandoned for a dozen years was found damaged to the extent of fully 20 per cent. Although the loss of its resin by bleeding results physiologically in no direct injury to the tree, the wound inflicted by tapping, like any other wound, interferes with its healthy growth and, particularly in the case of trees of smaller size, causes their early decay. While the exuded resin covering the excoriated surface of the tree acts as an efficient antiseptic, affording a firm protection against the access of the spores of fungi, it endangers the life of the tree, if exposed to fire, by its greater inflammability, the heat produced by its flame being capable of killing the trees outright. Under the crude and inconsiderate manner of cutting the boxes, all of the trees of smaller size and many of the larger trees are blown down, and a considerable number of those remaining with their excoriated surfaces out of proportion to the recuperative power of the trees are doomed to perish sooner or later in consequence of such treatment.

These injuries inflicted upon the individual trees, in connection with the fires started with the opening of the season one year after another, cause such damage to the forests as to effect finally their total destruction. Fire being allowed to sweep over large areas, its force increased in the turpentine orchards by the exposed resinous surfaces of the trees, and by trees blown down and the débris covering the ground, an immense amount of timber is destroyed. Trees which have not been killed outright by the fire, or have altogether escaped the danger, are doomed to speedy destruction by bark beetles and pine borers, which find a breeding place in the living trees prostrated by the winds during the summer, the broods of which rapidly infest the standing trees, which invariably succumb to the pest the same season. In consequence, the forests invaded by turpentine orcharding present, in five or six years after they have been abandoned, a picture of ruin and desolation painful to behold, and in view of the destruction of the seedlings and the younger growth all hope of the restoration of these magnificent forests is excluded.

CUBAN PINE FLATWOODS OF FLORIDA.

THE CUBAN PINE.

(PINUS HETEROPHYLLA (ELL.) Sudw.)

GEOGRAPHICAL DISTRIBUTION.
PRODUCTS.
CLASSIFICATION AND NOMENCLATURE.
DESCRIPTION AND MORPHOLOGICAL CHARACTERS.
PROGRESS OF DEVELOPMENT.
REQUIREMENTS FOR DEVELOPMENT.

THE CUBAN PINE.

(*Pinus heterophylla* (Ell.) Sudw.)

Synonyms: *Pinus tæda* var. *heterophylla* Elliott, Sk. ii, 636 (1824).
Pinus cubensis Grisebach in Mem. Am. Acad., viii, pt. 2, 530 (1863), not Hort. ex Gord. (1858).
Pinus cubensis var. *terthrocarpa* Wright in Grisebach, Cat. Pl. Cuben., 217 (1866).
Pinus elliottii Engelmann ex Vassey, Cat. Forest Trees, 30; in Rep. Com. Ag. 1875, 178 (1876).
Pinus elliottii Engelmann in Trans. St. Louis Acad., iv, 186, t. 1, 2, 3 (1879).
Pinus heterophylla (Ell.) Sudworth in Bull. Torr. Bot. Cl. XX, 45 (1893).

COMMON OR LOCAL NAMES.

Slash Pine (Ala., Miss., Ga., Fla.).
Swamp Pine (Fla., Miss., Ala.), in part.
Bastard Pine (Ala. lumbermen, Fla.).
Meadow Pine (Cal., Fla., E. Miss.), in part.
Pitch Pine (Fla.).
She Pitch Pine (Ga.).
She Pine (Ga. and Fla.).
Spruce Pine (So. Ala.).

THE CUBAN PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

Confined within narrow limits along the coast of the extreme Southern States east of the Mississippi River, little known and mostly confounded with its allied species, the value of the Cuban Pine has been scarcely recognized. A closer investigation of the properties of its wood, of its life history, and of the part it plays among the forest growth soon discloses its economic importance. Convinced that to meet proper appreciation the merits possessed by this pine need only to be made more generally known, their consideration in this place among the biological investigations of the more important timber trees of the coniferous order will explain itself.

This tree was not known to the earlier American botanists. Elliott first[1] took notice of it as a distinct form, and he regarded it as a variety of the Loblolly Pine. It remained still practically unknown as a separate species for another half century, until near the beginning of the past decade, when it was again brought to notice of botanists by Dr. Millishamp, of Bluffton, S. C.; Dr. Engelmann exhibited clearly its specific characters, and for the first time directed attention to the economic value of this pine by discussing the development of the tree and the qualities of its timber.[2] On account of the coarser grain of its wood and the large amount of sapwood, this timber was held to be of little value, and the tree received little or no attention by the lumberman. It is only very lately, especially since kiln-drying has become more general, that its value is being recognized and appreciated, and under the name of "Slash Pine" it is cut and sold without discrimination with the Longleaf Pine, with which it is usually associated.

GEOGRAPHICAL DISTRIBUTION.

The Cuban Pine is a tree of the coast region in the subtropical region of North America east of the Mississippi River, and also of the neighboring tropics, being found in Honduras and Cuba (see Pl. III). In the United States the tree is confined to the eastern belt of the Austro-riparian or Louisianian life zone of American biologists, from 33° north latitude in South Carolina along the coast to the extremity of the peninsula of Florida. Toward the west the tree extends along the coast of the Gulf to the Pearl River Valley. It is principally restricted to the coast plain, but on the Gulf Coast and along the water courses it extends inland to a distance of fully 60 miles from the sea. On the Atlantic Coast it penetrates the interior nearly to the limit of the coast pine belt, as has been observed in Georgia in the valley of the Ocmulgee River, over 100 miles distant from tide water. Groves of the Cuban pine skirt the low shores of the numerous inlets and estuaries of these coasts, and cover the outlying islands. More or less associated with the Loblolly and the Longleaf Pine, it forms a part of the timber growth of the open pine forests which in unbroken monotony cover the flats for long distances. It is only in the lower part of Florida, where the tree extends from the Atlantic across to the Gulf of Mexico, south of Cape Canaveral and Biscayne Bay, that, as the only pine there, the Cuban pine forms forests by itself. Toward the interior it occurs scattered among the varied growth of broad-leafed evergreens and cone-bearing trees which cover the swamps along the streams. Since it is invariably cut and sold

[1] Elliott, sketch 2, page 263.

[2] Engelmann: Revision of the genus *Pinus* and description of *Pinus elliottii*. Transactions St. Louis Acad. Sci., vol. 4, 1880.

without distinction, no figures can be given of its annual consumption, nor is it possible to form even an approximate estimate of the standing supplies. The old timber goes, of course, as fast as that of the Longleaf Pine, but in its reproduction it outstrips the latter. Wherever in the coast plain the original growth of the Longleaf Pine has been removed, the Cuban Pine takes, in a great measure, possession of the ground, in some localities associated with the Loblolly Pine. Young forests in every stage of growth are seen covering tracts of greater or lesser extent, promising important supplies of resinous products, timber, and fuel.

PRODUCTS.

As a timber tree the Cuban Pine is little inferior to the Longleaf Pine. It furnishes sticks of large dimensions free from blemish, rivaling in that respect that superior variety of the Loblolly Pine called Rosemary Pine, and there is no doubt that it was often confounded with this tree in the shipments of masts and long spars made in former years from the southern Atlantic and eastern Gulf ports. In the lumber mills on the Atlantic Coast the timber of this tree is indiscriminately sawn and shipped with that of the Longleaf Pine.

It remains yet to be proved whether the coarser structure of the wood of the Cuban Pine would render it less durable. It is certain, however, that this very cause, which might interfere with its resistance to atmospheric influences or to contact with the soil, will be found an advantage if the preservation of the timber is to be secured by its impregnation with antiseptic solutions, more open structure permitting readier infiltration.

Resinous products.—This pine abounds in resinous matter. The oleoresin, resin, or crude turpentine, when freshly exuded, is perfectly limpid, of honey-yellow color, less viscid than the resinous product of the Longleaf Pine, and to all appearances richer in volatile oil or spirits of turpentine, judging by the smaller amount of hard gum or scrape formed on the tree. A sample of the dip of the first year from South Carolina was to all appearance exposed for a short time in the box to atmospheric influences. Examined by Prof. E. Kremers, University of Wisconsin, the resin showed an emulsion-like appearance and separated upon standing into heavier granules and into a lighter, transparent, yellowish liquid. Its specific gravity at 20° C. was found 1.0253. D=32.423° (determined in 16.26 per cent alcoholic solution). Distilled with water, the sample yielded 16 per cent of oil of the specific gravity 0.865 (20° C.). D=9.620.

In view of the rapid destruction of the forests of Longleaf Pine, the principal source of resin, the future importance of the Cuban Pine in the production of naval stores becomes at once apparent, especially when it is considered that it reproduces itself so much more readily. Even now, on the coast of South Carolina and Georgia, a large proportion of resinous products is derived from the young growth of this pine, which, after the removal of the original timber growth, took possession of the ground. It is claimed by the turpentine gatherers in these States that at an age of from thirty to forty years the trees are sufficiently large for tapping with advantage, and that protected against fire a spontaneous renewal takes place, and after a period of forty years the new crop is ready for profitable exploitation.

In Washington County, Ala., on the more or less extensive flats that intervene between the low ridges covered with Longleaf Pine, the Cuban Pine furnishes considerable supplies of crude turpentine of superior quality. In this section the tree is known under the name of Spruce Pine, a misnomer, leading to its confusion with an entirely different tree, the true Southern Spruce Pine (*Pinus glabra*).

CLASSIFICATION AND NOMENCLATURE.

Pinus heterophylla is closely allied to the Longleaf Pine, forming with this and two other species inhabiting the nearest tropical regions—Cuba and Mexico—under the subgenus pinaster, a natural group of trees with heavy resinous wood, rigid long leaves from two to five in a sheath, and subterminal or lateral, horizontal or reflexed cones, designated by Englemann as the group of the Euaustrales, or longleaf pines. First distinguished by Elliott as *Pinus tæda* var. *heterophylla* and remaining subsequently unknown for more than fifty years, the specific characters of this pine were first recognized and fully described by Dr. Engelmann, who in honor of its discoverer distinguished the tree under the name of *Pinus elliottii*, finding himself soon afterwards convinced of the identity of his species with *Pinus cubensis* of Grisebach. Recently these various forms were found to be the same as Elliott's, to which they have been referred with his varietal name *heterophylla* raised to specific rank. The tree is little known among the inhabitants of the region of its growth; it is generally regarded as a mere variety or bastard form of the Longleaf or the Loblolly Pine. In Florida, where best known, it is distinguished as the Slash Pine, or Swamp Pine; and in the flat woods along the seashore in Alabama and Mississippi as Meadow Pine. In a few localities in Alabama it is generally called Spruce Pine.

DESCRIPTION AND MORPHOLOGICAL CHARACTERS.

The leaves, two or three in a bundle, are surrounded by a smooth sheath from one-half to nearly an inch in length, which, close and smooth during the first season, become loose and shriveled in the second year (Pl. X, *d*). The leaves are from 8 to 12, mostly 9 inches in length and three-fourths of a line wide, glossy, of a deep-green color and closely serrulate with a short, rigid point, rounded on the back, the binary leaves deeply concave and the ternate bluntly keeled. They arise from the axils of fringed deciduous bracts, are densely crowded toward the end of the branches, and are shed by the close of the second season. Bundles with two leaves are most frequently observed in younger trees and almost invariably on the fertile branchlets.

The resin ducts are internal, variable in size, and in number from four to six and over, close to the thin-walled bundle sheaths, which inclose two closely approximate fibrovascular bundles, often coalescing. The fibrovascular region, like the ducts, shows no hypodermal or strengthening cells. The hypodermal cells underlying the epidermis are as large as the epidermal cells, in the angles of one or several layers.

Flowers.—The catkin-like male flowers (Pl. X, *a*, *b*), from 1½ to 2 inches long, are of dark purple (royal purple) color, supported on a short stalk and surrounded by about a dozen involucral coriaceous bracts, of which the lowest pair is strongly keeled (Pl. X, *b*, slightly magnified), the others being oblong with fringed edges. From ten to twenty of these cylindrical flowers are crowded in dense clusters below the apex of the youngest shoots, and are shed almost immediately after the discharge of their abundant pollen. The anthers are crowned with a purplish crescent-shaped denticulate crest. The female flowers form an oval, pink-colored ament borne on a stalk, from one-half to 1 inch in length, which singly, more frequently several in number, are produced close to the terminal bud of the shoot of the season (Pl. X, *d*). First erect, they are, at the lapse of a month, horizontally reflected, the shoot bearing them increasing rapidly in length during the same time, long before the unfolding of its leaf buds. The involucral scales or bracts which surround the female catkin are more numerous, narrower, longer, and more membranaceous than those forming the involucra of the male flowers. The carpellary scales are round with a slender, erect tip, their lower half covered by the broad retuse bract.

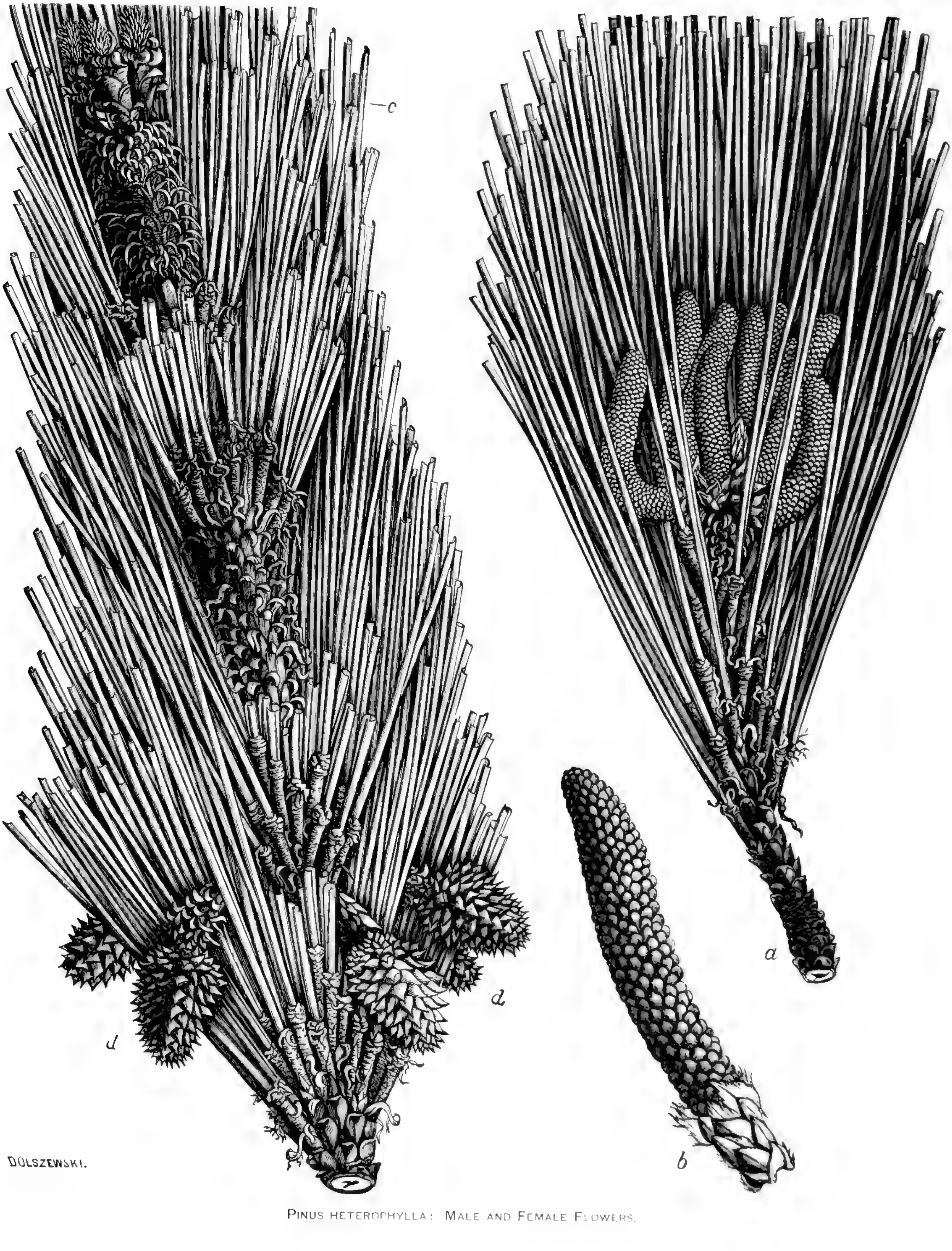
A tree discovered by Dr. Mellichamps near Bluffton, S. C., showed the remarkable anomaly of producing androgynous flowers regularly every season. In most of the specimens examined every one of the male flowers clustering around the base of the terminal bud of the very young shoot had the upper part of the floral axis covered with female flowers, appearing like a distinct inflorescence superimposed upon the staminodial column, occupying generally one-third of its height. In one of the flowers they were seen to extend near to its base. In a single instance it was observed that the female flowers extended on one side of the staminodial column in a narrow streak among the stamens.

In a specimen from the same locality the terminal shoot of the season, exceeding in length the male flowers by which its base was surrounded, was bearing a normal subterminal female ament. The short-stalked cones are ovate or conical, rather obtuse, horizontally reflexed, from 4 to 5 inches long, about 2½ inches greatest width, of glossy leather-brown or hazel color (Pl. XI, *a* and *b*); scales about 2 inches long averaging five-eighths of an inch in width, somewhat flexible, the prominent ridge of the pyramidal striated umbo with a short, mostly straight, strong prickle (Pl. XI, *c* and *d*). By the end of the first season the conelets are scarcely an inch long (Pl. X, *d*). Before the close of the summer of the succeeding year, the cones have reached their full size, maturing during the month of October. In the ripe cones, already described, the apophyses of the scales in the lower rows are almost pointless, becoming on the upper strongly mucronate. The cones remain on the tree until the approach of the next summer, leaving on their separation the lowest rows of the scales behind.

EXPLANATION OF PLATE X.

[Figures natural size, except where otherwise noted.]

Fig. *a*, branch with young shoot of the season bearing a cluster of male flowers; *b*, male flower detached showing basal involucral bracts, magnified three diameters; *c*, branch bearing three subterminal female flowers; *d*, *d*, characteristically reflexed immature cones of one season's growth.



D OLSZEWSKI.

PINUS HETEROPHYLLA: MALE AND FEMALE FLOWERS.

The triangular black roughish seeds $2\frac{1}{2}$ to a little over 3 lines long, with a few faint ridges; the brown, obtuse, and somewhat oblique wing (Pl. XI, *e*, *f*, *g*) about 1 inch in length is deciduous in germination. This species at all stages of growth can be distinguished from the Loblolly Pine by the deep-green foliage, the glaucous hue of the young, tender shoots, and varying number of leaves in a bundle—from the Longleaf Pine by the thinner, almost smooth, terminal buds, and in the adult state, from both of these species, with which it is found frequently associated, by its cones.

THE WOOD.

As in the Loblolly, the sapwood is wide in the young trees, measuring usually about 4 inches and forming in thrifty trees fifty to seventy years old about 80 per cent of the total volume. As the trees grow older, however, this preponderance of sapwood ceases, and in trees one hundred and fifty to two hundred years old only 35 to 50 per cent of the total volume of the trunk was found to be composed of sapwood. As in the case of the pines already mentioned, the change from sapwood to heartwood begins when the tree (or disk) is about twenty-five to thirty years old, and the process is retarded as the tree (or disk) grows older, so that when any one disk is sixty years old the sapwood contains about forty rings, and reaches eighty rings or more by the time the tree (or disk) is two hundred years of age. As a consequence the sapwood of the disks of the main part of the trunk in old trees is formed of nearly the same number of rings, and only near the top a marked diminution appears, while in a tree sixty years old the sapwood of the stump may have forty rings and that of a disk 40 feet from the ground only twenty-five rings. As in other pines, the width of the sapwood is quite variable and is always greatest in young and thrifty trees.

When green the wood of this species is too heavy to float well; its weight varies chiefly with the amount of sapwood, and is therefore greatest in sapling timber. The sapwood itself is frequently heavier than water, and where the water in the sapwood and a large amount of resin in the heartwood combine, the weight of the entire disk frequently approaches 60 pounds to the cubic foot.

Kiln-dried, the wood of trees one hundred to one hundred and fifty years old was found on an average to weigh about 39 pounds per cubic foot, thus excelling in weight even the valuable Longleaf Pine. The wood of very young trees is decidedly lighter, as is also that of very old trees, the heaviest wood being formed during the age of thriftiest growth or between the twentieth and eightieth year. The presence of resin in the heartwood, as conspicuous in this species as in Longleaf Pine, materially adds to the weight of the wood, so that the heartwood of old trees is invariably heavier than the same wood had been while in a sapwood condition. As in other pines, the butt is heaviest and the toplog lightest; thus in trees over one hundred and fifty years of age the wood at the butt weighs 44 pounds per cubic foot, 37 pounds at 38 feet, and only 32 pounds at 60 feet from the stump, a difference amounting to over 25 per cent. This difference is greatest in the young sapling and is remarkably uniform for all adult trees examined.

In strength, as in weight, the wood of Cuban Pine excels. The following figures represent the general average of a long series of experiments on wood especially collected:

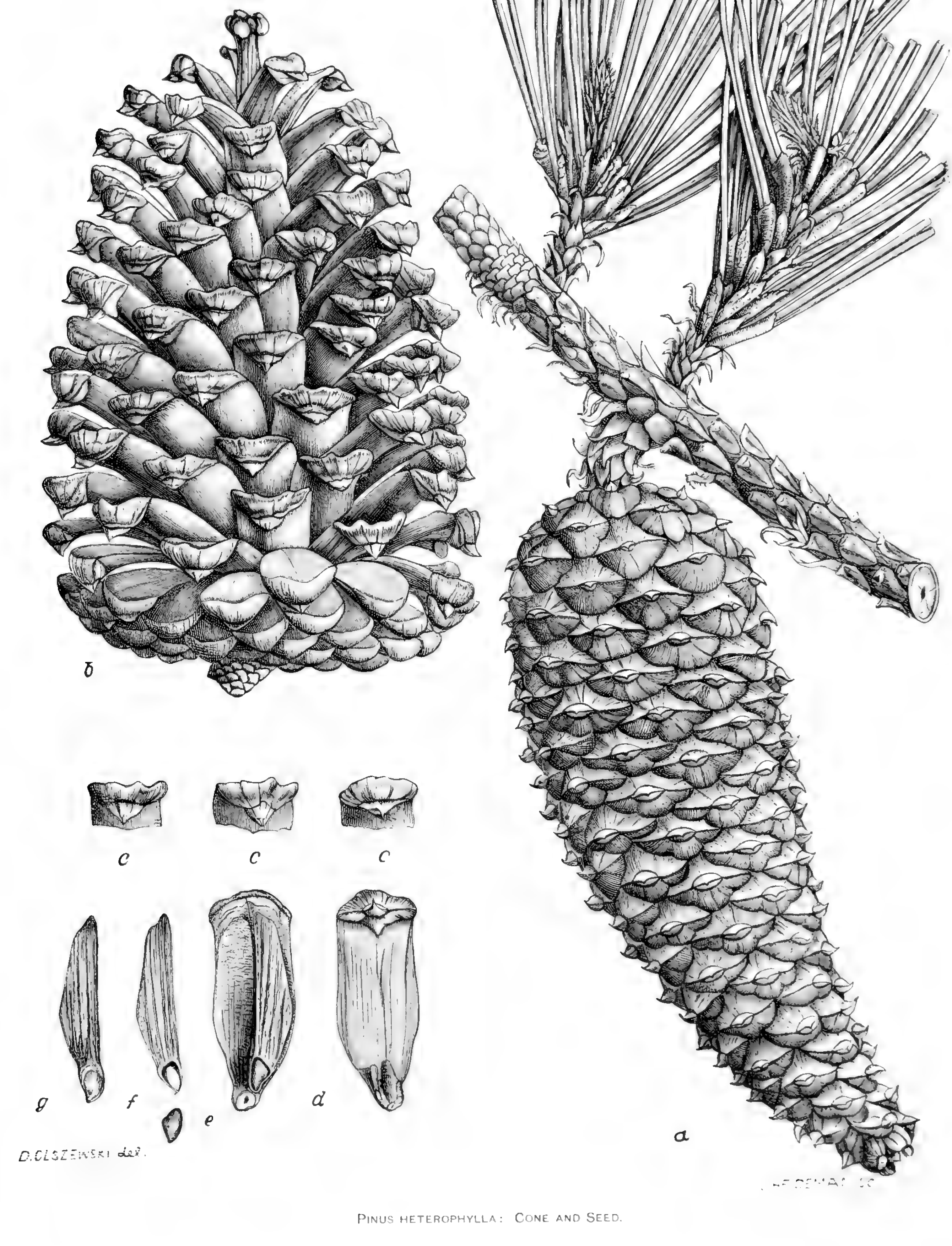
	Lbs. per sq. inch.
Modulus of elasticity	2,300,000
Transverse strength	11,900
Compression endwise	7,850
Shearing	680
Tension	11,300

The average weight of the pieces tested was 49 pounds per cubic foot, the outer lighter part of the old trees having largely been cut away in shaping the pieces, so that only heavy wood had been tested. The above figures require, therefore, a reduction of about 20 per cent to represent the true average strength of all the wood of entire trees.

The amount of water contained in the fresh wood depends on the proportion of sapwood. In this latter it forms about 60 per cent of the weight of fresh wood; in the heartwood only about 20 per cent. Accordingly, fresh logs of sapling timber seventy years old have about 45 per cent, logs of trees over one hundred and fifty years old only about 30 per cent of water. The wood dries easily and without great injury, even if seasoned in the dry kiln.

EXPLANATION OF PLATE XI

Fig. *a*, section of a branch bearing a mature closed cone (October); *b*, mature open cone after shedding seed; *c*, *c*, *c*, tips of cone scales showing variation in form of apophysis and stout prickle; *d*, cone scale, outer or dorsal side; *e*, inner or ventral side of cone scale with seed in place; *f*, seed with wing detached; *g*, seed and wing intact.



PINUS HETEROPHYLLA: CONE AND SEED.

The shrinkage during drying is very considerable for sapwood, and therefore all young timber, but is not as great for old timber as might be expected on account of the great weight of the wood. Young timber shrinks from 12 to 13 per cent of its volume, the wood of old trees (over one hundred and fifty years) only about 11 per cent, and in all trees the amount of shrinkage is greatest in the heaviest disk of the butt and decreases upward very much in proportion of the decrease in weight.

In its structure the wood resembles that of the Loblolly in every respect. Summerwood and springwood are sharply defined, giving rise to alternating bands of light-colored, soft and dark-colored hard bands of wood conspicuous in every section. For details of structure see the comparative study by Mr. Roth appended to these monographs.

PROGRESS OF DEVELOPMENT.

This is the earliest flowering of the Southern pines. The buds of the male flowers make their appearance in the early part of December, and the flowers open during the last days of January and during the first week of February. This species produces abundant crops of cones every year, almost without failure; they ripen in the fall of the second year; the seeds are discharged through the winter of the second year until spring. Germinating easily, their seedlings are found to come up copiously from early in the spring to the beginning of the summer in old fields and on every opening in the vicinity of the parent trees, wherever the rays of the sun reach the ground. The plantlets bear six to seven seed-leaves (cotyledons). As soon as these have fairly expanded the terminal bud develops rapidly, and the first interno 'e of the stem, increasing quickly in length, is densely covered with the soft, narrow, linear, pointed, primary leaves, which are fully an inch long. Before the end of the second month, in the axils of some of the leaves, the undeveloped branchlets, bearing the fascicle of the foliage leaves, make their appearance. With the further development of the foliage leaves, increasing in number during the growing season, the primary leaves wither away. By the close of the first season the plantlets are from 8 to 9 inches high, with a very slender taproot and many lateral rootlets near its upper end. After the beginning of the second season but few of the primary leaves are found to support the buds of the foliage leaves. The tendency to the production of secondary axes becomes manifest by the appearance of a single branchlet; on having reached the end of their second year the plants are from 12 to 15 inches high, with a taproot not more than 4 inches long; at the end of their third year they average little less than 2 feet in height, with the taproot 6 inches long—the laterals being much longer. The crown from this period develops in regular whorls for a long succession of years.

The Cuban Pine, in its rate of growth and when fully grown, exceeds in its dimensions the Longleaf Pine. The taproot, less powerful than in its allies, is assisted by mighty lateral roots running near the surface of the ground to support the tall, sturdy trunk, rising to a height of 110 or 115 feet, with a diameter of 2½, not unfrequently exceeding 3, feet, clear of limbs for a height of from 60 to 70 feet above the ground. The heavy limbs are horizontally spreading, from 22 to 24 feet at their greatest length, somewhat irregularly disposed; they form in the trees of full growth a rather dense crown of rounded outline. Trees of the dimensions mentioned, having passed the fullness of their growth, are found to be from one hundred to one hundred and forty years old, according to the surrounding conditions. The thick bark is of a clear, reddish color, laminated, and exfoliating in thin, broad, purplish flakes.

Seedlings of the Longleaf Pine, which those of the Cuban Pine somewhat resemble, can be readily distinguished at this period by the disproportion of height and diameter and absence of branch growth in the former. The rate of growth differs, of course, according to the conditions of soil and exposure.

Saplings showing five rings of annual growth were found from 4½ to nearly 6 feet in height, with a diameter of from three-fourths to seven-eighths of an inch; between the age of from ten to twelve years the trees measure from 10 to 18 feet in height, with the stem clear for over half its length—even when grown in the open—and from 2 up to 4 inches in diameter. From this stage on the rate of growth proceeds most rapidly. At eighteen and twenty years heights of 40 to 50 feet and over, and diameters from 9 to 10 inches across the stump, cut close to the ground, are attained.

The trees of the extensive groves of Cuban Pine in the vicinity of Mobile upon the loamy lands of the coast plain, which have sprung up since 1864, when these lands were completely stripped of all arboreal growth, average at present between 50 and 60 feet in height by a diameter of from 14 to 16 inches breast high. Trees of second growth, forming open groves on lands of similar character, and also more or less deficient in drainage, forty-five to sixty-five years old, measure from 65 to 85 feet in height and from 15 to 20 inches in diameter breast high.

At the edge of a heavily wooded swamp, in a perpetually wet, sandy, and mucky soil and skirted by large Longleaf Pines occupying the steep slope rising from the bottom, a tree measuring 114 feet in height, with a diameter of 24 inches breast high, the trunk clear of limbs for a length of fully 60 feet, showed one hundred and thirty-five rings of annual growth. Another tree felled deeper in the same swamp, of lank growth, with a poorly developed crown, rising to a height of 88 feet and towering above the dense growth of black gums, swamp maples, and white bays, was found to measure only 15½ inches in diameter, with almost the same number of annual rings. Trees of second growth which have sprung up in clearings with a drier surface soil underlaid by a clayey substratum, with free exposure to sunlight and air, reach in little over half the time the full size of those produced in the forest-covered swamps.

TABLE I.—*Growth of Cuban Pine during first stages of life, from four to twenty years.*

No. of tree.	Rings in stump.	Diameter.		Height.			Locality.	Remarks.
		Breast high.	Across stump.	Total.	To first limb.	Crown.		
		Inches.	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
1	4	½	....	3½	....	....	....	
2	5	1¼	....	4½	....	....	....	Nos. 1 to 5, near Whistler, Ala.
3	5	1½	....	6¼	....	....	....	Wet, sandy, flat soil very poor; open thickets in the clearing of the forest.
4	6	1½	....	8¼	....	....	....	
5	8	1⅞	....	8⅓	....	....	....	
236	9	2	2¼	17	10	7	Whistler, Ala	Exposure partially free; suppressed soil; slushy.
296	9	2	2⅛	19	10	9	Ridgeland, S. C	Old field; soil fresh; from midst of dense grove.
295	9	....	....	18	8	10	do	
235	10	2	....	18	7	11	Whistler, Ala	Open edge of swamp, somewhat suppressed.
223	11	3¾	4	26	13	13	do	Partially free; edge of swamp.
294	11	4	4½	28	14	14	Ridgeland, S. C	Open grove of saplings; soil fresh; old field.
6	12	3¾	....	19	....	....	Mobile, Ala	Grove of young trees; crown covered partially by large pines; soil conditions, best.
291	13	6	....	29	13	16	Ridgeland, S. C	
292	14	4	4½	27	....	....	do	Old field.
7	15	8½	....	37	....	....	Mobile, Ala	Midst of dense thicket; in the shade; suppressed; soil conditions, best.
8	15	9	....	31	....	....	do	Do.
262	16	6	7	36	18	26	Ridgeland, S. C	Exposure free; old field; soil black, mucky.
9	16	8	....	46	27	19	Mobile, Ala	In the shade of large pines.
10	17	8¼	....	46	....	....	do	Do.
232	17	6½	6½	38	15	13	Ridgeland, S. C	Swamp soil; slushy; suppressed.
231	18	6	6½	50	20	....	do	Exposure free; soil fresh, good.
11	18	8	....	47	....	....	Mobile, Ala	Under cover of large pines; soil conditions, good.
12	18	9	....	37	14	23	do	Do.
13	21	10½	....	53	27	26	do	Free exposure.

TABLE II.—*Growth of Cuban Pine during middle and last stages of life, from forty to one hundred and forty-five years.*

No. of tree.	Rings in stump.	Diameter. Breast high.	Diameter. Across stump.	Diameter. Below crown.	Diameter. Mean.	Height. Total height.	Height. Length to crown, clear.	Height. Length of crown.	Locality.	Remarks.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
1	40	14½	....	....	....	60	39	24	Mobile, Ala	Midst of grove, crowded; damp, sandy loam; clay subsoil; surface flat.
290	43	12	....	....	....	66	34	32	Ridgeland, S. C	Exposure free; edge of swamp; soil perpetually damp.
230	51	12½	....	....	....	87	51	....	Whistler, Ala	Edge swamp; soil fresh to damp; growth lank; sap, 5 inches.
2	52	17	17½	....	....	83	50	36	Mobile, Ala	Edge of grove.
3	55	19	....	....	....	74	40	....	Stockton, Baldwin County, Ala.	Exposure free; springy hillside; soil coarse, sandy, and gravelly.
4	55	20	25	13½	....	82	50	32	Mobile, Ala	Exposure free; open grove.
5	56	20	24	19	....	79	47	32	....do	Do.
289	60	16	....	....	....	90	59	31	Ridgeland, S.C	Low pine flat, open; soil moist and black, sour.
288	70	21	....	....	....	83	41	42	....do	Exposure free; soil moist and black, sour.
6	87	20	....	....	....	85	....	....	....	Springhill edge of swamp; damp, sandy.
286	101	24	....	....	....	98	48	50	Ridgeland, S.C	Exposure free; near border of swamp; pine flat, badly drained.
7	110	22	....	....	....	90	60	30	....	Springhill rich hummock, perpetually damp; magnolia, red bay, spruce gum; Census 1880.
227	110	20	....	....	....	113	71	42	Whistler, Ala	Exposure free; edge of swamp; soil fresh; stick perfectly clear for 52 feet; sap, 2½ inches.
225	126	26	....	....	....	130	78	52	....do	Timber perfect for 60 feet.
8	133	24	25	14½	21½	118	60	58	....do	Exposure free; somewhat suppressed by longleaf pine; edge of swamp.
226	127	20	....	....	....	104	80	24	....do	Exposure free; lank, tall; red heart above 54 feet.
228	132	22	....	....	....	119	73	....	....do	Base of hill; a fine-looking tree; timber clear for 50 feet.
229	145	26	....	....	....	116	73	....	....do	Swamp always slushy; free from knots for over 65 feet.
9	145	12½	....	7½	....	67	21	....	....do	Of suppressed growth; in middle of swamp; soil pure sand, mostly covered with water.

From Table III the rapid growth of this species is quite apparent. It will be observed that good trees are about 20 feet high at ten, 45 feet at twenty, and over 80 feet high at fifty years of age, when the rapid rate of upward growth comes to a stop. It appears, also, that the greatest mass of wood for any decade is found at the early age of fifty, the growth in volume being nearly 15 cubic feet for these ten years, and that at ninety the growth in volume is only about two-thirds of the maximum; that at one hundred years the average annual growth nearly equals the current growth, thus indicating that the age of proper exploitation has been reached, i. e., that now the tree is ripe for the ax, as far as profitable growth, represented in volume accretion, is concerned.

TABLE III.—*Growth of Cuban Pine.*

Age.	Diameter with bark (breast high).	Length of log with upper diameter of 5 inches.	Height of tree.	Volume. Tree.	Volume. Log up to 5 inches diameter.	Periodical growth for each decade. Decade.	Diameter.	Height.	Area of cross section.	Volume.	Average annual accretion.	Current accretion.
	Inches.	*Feet.*	*Feet.*	*Cubic feet.*	*Cubic feet.*		*Inches.*	*Feet.*	*Sq. feet.*	*Cubic feet.*	*Cub. feet.*	*Cub. feet.*
10	2.9	....	20	0.50	....	First	2.1	20	0.02	0.50	0.05	0.05
20	5.9	5	45	4.24	2.44	Second	2.6	25	.10	3.74	.21	.37
30	9.3	24	66	14.95	13.06	Third	3.0	21	.20	10.71	.50	1.07
40	12.3	40	75	29.70	29.23	Fourth	2.6	9	.26	14.75	.74	1.47
50	14.8	50	83	47.01	45.53	Fifth	2.5	8	.31	17.31	.94	1.73
60	16.0	60	89	59.65	58.35	Sixth	1.2	6	.18	12.64	.99	1.26
70	17.6	69	93	72.25	71.17	Seventh	1.2	4	.19	12.60	1.03	1.26
80	18.8	76	96	84.05	83.15	Eighth	1.2	3	.21	11.80	1.05	1.18
90	20.0	83	99	95.03	94.31	Ninth	1.2	3	.22	10.98	1.05	1.10
100	21.4	90	101	105.97	105.48	Tenth	1.0	2	.20	10.94	1.06	1.09
110	22.4	96	103	115.58	115.27	Eleventh	1.0	2	.20	9.61	1.05	.96
120	23.4	100	105	125.18	124.96	Twelfth	1.0	2	.25	9.60	1.04	.96

REQUIREMENTS FOR DEVELOPMENT.

Soil.—For its best development the Cuban Pine requires a light, sandy, but constantly damp soil, which is attained where the sandy surface is underlaid by a loamy subsoil retentive of moisture but sufficiently loose to give the roots unhindered access. Such conditions are found on the lands rising above the perpetually wet swamps. On the flats, with a soil of fine, compact sand, devoid of all drainage and underlaid by a hardpan, where nothing but the Saw Palmetto appears to thrive, the tree remains of low, stunted growth, scarcely ever reaching medium size. In the depth of the swamp, with the soil wet and slushy throughout the year, where the tree is commonly met with, closely surrounded by White Bay, Red Bay, Black Gum, Titi, and White Cedar towering high above it, it is of slow growth and frequently affected by red heart or red rot, particularly near its northern limit. It is never found in alluvial bottoms, and eschews the dry, pine-barren hills, requiring a moderate but sure and even supply of soil moisture.

Climate.—The range of its distribution coincides with the area of greatest rainfall in the Southern States, which, evenly distributed through all seasons, amounts for the year, in the mean, to 60 and 64 inches.

The Cuban Pine demands a warm climate, free from excesses in the range of temperature, as is afforded by the vicinity of the sea. It is found in greatest abundance and most perfect within the isothermal lines of 64° and 68° F., with a minimum of but a few degrees below the freezing point. The tree, as observed at Mobile, has escaped uninjured the severe and unprecedented long spell of ice and snow during the latter part of January and first week of February, 1895, when the thermometer fell as low as 11° F., the flowers unfolding unimpaired by frost during the succeeding first days of milder weather.

In its dependence on light it is less exacting than either the Longleaf Pine or the Loblolly Pine. It appears to thrive, from the earliest stage of its development, as well when partially shaded as in the open, in this respect resembling the Southern Spruce Pine. It is due to these facts, combined with the rapid progress of its growth from the earliest stage, that the Cuban Pine is gaining the upper hand over the offspring of the light-requiring Longleaf Pine, which, on the damp soil of the coast plain, is soon outstripped and finally almost completely suppressed by the seedlings of this tree.

In the inherent capacity for natural reproduction, or in the advantages for the renewal of its forests by man, the Cuban Pine is not surpassed by any other of the species with which it is found associated. This tree commends itself strongly to the tree planter in the coast plain of the lower South. Producing seeds in abundance regularly and with certainty, being less exacting in its demands for direct sunlight, and hence successfully resisting the encroachment of competing species, being less liable to succumb to the destructive agencies of fire on account of its more rapid development in early life, it has greater promise of success than the others. If to this is added the rapid rate of growth, the great value of its timber, being equal to the Longleaf, if not superior, and the abundant yield of its valuable resinous product, it becomes evident that in the reforestation of the low pine lands of the Southern coast region the Cuban pine is to be preferred to any other, not only within its original boundaries, but as far beyond its range of natural distribution as the climatic requirements of the tree will permit.

SHORTLEAF PINE (PINUS ECHINATA), FOREST-GROWN SPECIMENS IN MISSOURI.

THE SHORTLEAF PINE.

(PINUS ECHINATA Miller.)

ECONOMIC HISTORY AND DISTRIBUTION.
BOTANICAL DESCRIPTION.
DESCRIPTION OF WOOD.
PROGRESS OF DEVELOPMENT.
CONDITIONS OF DEVELOPMENT.
FOREST MANAGEMENT.

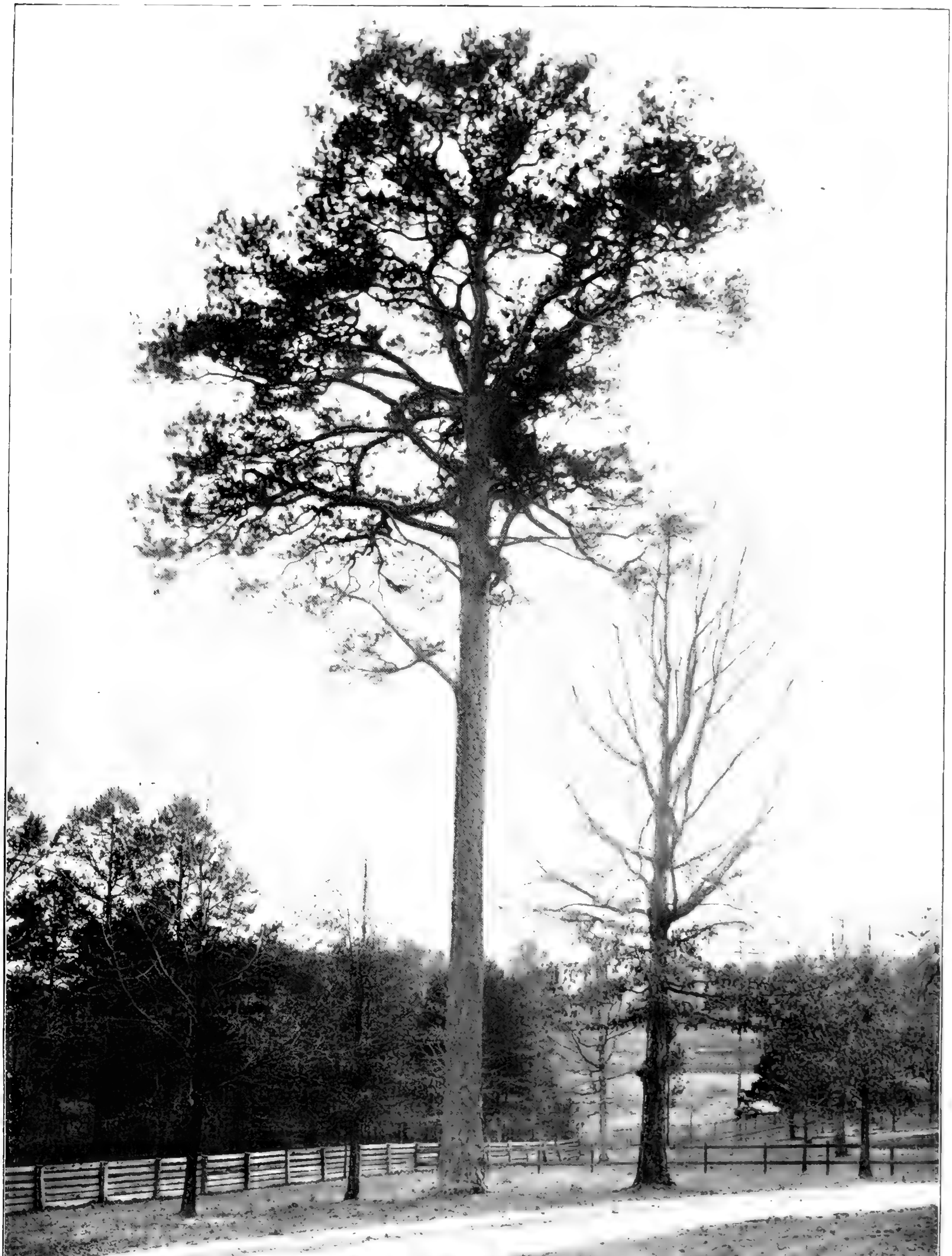
THE SHORTLEAF PINE.

(*Pinus echinata* Miller.)

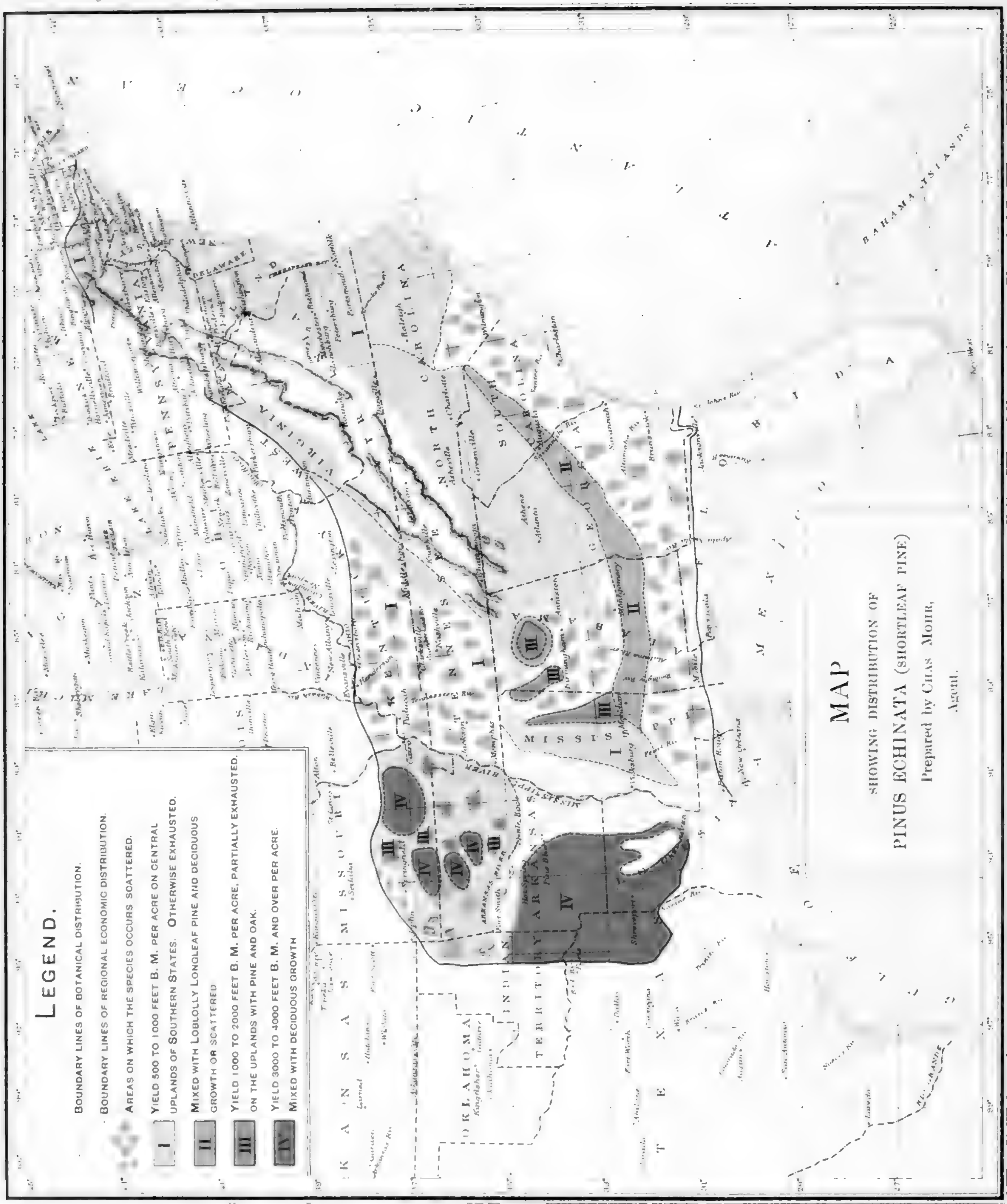
Synonyms: *Pinus echinata* Miller, Gard. Dict., ed. 8, No. 12 (1768).
Pinus virginiana var. *echinata* Du Roi, Harbk., ii, 38 (1772).
Pinus tæda γ variabilis Aiton, Hort. Kew., ed. 1, iii, 368 (1789).
Pinus mitis Michaux, Fl. Bor. Am., ii, 204 (1803).
Pinus variabilis Lambert, Pinus, ed. 1, i, 22, t. 15 (1803).
Pinus royleana Jamieson ex Lindley, in Journ. Hort. Soc., ix, 52 (1855).
Pinus intermedia Fischer ex Gordon, Pinetum, ed. 1, 170 (1858), not Du Roi (1772).
Pinus rigida Porcher, Resources S. States, 504 (1863), not Miller (1768).
Pinus lutea Loddiges ex Gordon, Pinetum, ed. 1, 170 (1858), not Walter (1788).
Pinus roylei Lindley ex Gord., l. c.

COMMON OR LOCAL NAMES.

Yellow Pine (N. Y., N. J., Pa., Del., Va., N. C., Ala., Miss., La., Ark., Mo., Ill., Ind., Kans. (scarce), Ohio).
Shortleaved Pine (N. C., S. C., Ga., Ala., Miss., Fla., La., Tex., Ark.).
Spruce Pine (Del., Miss., Ark.).
Bull Pine (Va.).
Short Schat Pine (Del.).
Pitch Pine (Mo.).
Poor Pine (Fla.).
Shortleaved Yellow Pine.
Yellow Pine (N. C., Va.; Eng. lit.)
Virginia Yellow Pine (Va.) in part.
North Carolina Yellow Pine (N. C., Va.) in part.
North Carolina Pine (N. C., Va.) in part.
Carolina Pine (N. C., Va.) in part.
Slash Pine (N. C., Va.) in part.
Oldfield Pine (Ala., Miss.).



SHORTLEAF PINE (PINUS ECHINATA), A ROADSIDE SPECIMEN IN NORTH CAROLINA


LEGEND.
Boundary lines of botanical distribution.
Boundary lines of regional economic distribution.
Areas on which the species occurs scattered.
I Yield 500 to 1000 feet B. M. per acre on central uplands of Southern States. Otherwise exhausted.
II Mixed with Loblolly Longleaf pine and deciduous growth or scattered
III Yield 1000 to 2000 feet B. M. per acre, partially exhausted. On the uplands with pine and oak.
IV Yield 3000 to 4000 feet B. M. and over per acre. Mixed with deciduous growth
MAP
SHOWING DISTRIBUTION OF
PINUS ECHINATA (SHORTLEAF PINE)
Prepared by Chas. Mohr,
Agent.
Scale
Miles

THE SHORTLEAF PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

Among the timber trees of the Atlantic forest region the Shortleaf Pine ranks with the first of those noted for their economic importance. Equally abundant, distributed over a wider area, and in the quality of its wood but little inferior, it takes its place next to the Longleaf Pine. When maintenance of forest and production of timber under a rational system of forestry is to become the rule, this species above all others of southerly distribution will claim attention, for it can be safely asserted that of the coniferous trees adapted to the climatic conditions of the Southern Atlantic forest, no other can be found of better promise for the production of valuable timber in the shortest time.

HISTORICAL.

The Shortleaf Pine, besides furnishing to the colonists the supplies of pine timber required for the construction of their dwellings, formed in early colonial times an article of export to the mother country and the West Indies. Michaux, the younger, writing in the first years of this century, speaks of this timber tree as becoming scarce near the ports. It seems that the specific characters of this tree were but imperfectly understood by the earlier investigators of our sylva. They were first accurately defined by Michaux, the father, who described this tree in his Flora Americana Borealis II, 204 (1803), under the name of *Pinus mitis*. A still more detailed description was soon afterwards given by Michaux, the son, in his work on American forest trees (Hist. Arb. Amer., 1, 52, t. 3, 1810), with a full account of its value as a timber tree, the qualities and uses of its wood, and all that was known in those days of its place in the forest. Besides the account given of the tree by the Rev. M. A. Curtis, of North Carolina, in his "Trees of North Carolina," little has been added to our knowledge of this pine until the publication in Professor Sargent's report on the Forests of North America,[1] of the results of the investigation which the writer had carried on in the Gulf States,[2] and Professor Harvey in Arkansas.[3]

For valuable information on the occurrence of this pine on the Atlantic Coast and west of the Alleghany Mountains, the writer is indebted to the kindness of correspondents active in the field of botany. In regard to the area over which this species is found distributed in the Southern States, the information contained in the physiographic descriptions of the several counties of the cotton States, in Professor Hilgard's report on cotton production,[4] were chiefly relied upon.

GEOGRAPHICAL DISTRIBUTION.

The Shortleaf Pine is widely distributed from the Atlantic Seaboard to the treeless plains of the Indian Territory under 95° west longitude over 23½° from east to west and 10° from south to north, namely, from 31° north latitude to Long Island, New York, or 41° north latitude along the Atlantic Coast, while in the interior it only reaches to 39° in western Virginia. According to F. A. Michaux, the Shortleaf Pine extended originally as far north as Albany, N. Y. The tree is at present not known in New York outside of Long Island, and its existence even in Pennsylvania is considered

---

[1] Forest of North America, Volume IX of Tenth Census. (C. S. Sargent, 1880.)

[2] C. Mohr: "Forest Trees of the Gulf Region" (Am. Jour. Forestry, Vol. I, 1883).

[3] "Forest Trees of Arkansas." (Harvey: Am. Jour. of For., Vol. I.)

[4] Hilgard: Tenth Census Report, Vols. V and VI.

at present doubtful. Its northern limit west of the Alleghanies can be described by a line drawn from the lower part of Wood County, in West Virginia, to Menifee County, eastern Kentucky. Beyond the wide gap covered by the deciduous forests of the lower Ohio Valley and the flood plain of the Mississippi the tree appears on the southeastern spur of the Ozark Hills in Cape Girardeau County, Mo., latitude 37° 30′, and on the opposite side of the river on the bluffs in Union and Jackson counties, Ill., the line dropping gradually half a degree southward to the western limit of its range. (Pl. XIV.)

The Shortleaf Pine is a tree of the plain and the foothills, in the South rarely ascending to an elevation over 2,300 feet, and at its northern confines not over 1,000 feet (in the Ozark Hills). East of the Mississippi River the tree appears sparsely scattered among the hard-wood trees; along the border of the Carolinian and within the Austro-riparian zone it becomes more frequent, and often the predominating tree. West of the Mississippi River the Shortleaf Pine finds its region of greatest profusion, forming forests of vast extent on the uplands of the undulating plain and the table-lands of the hill country, which in their timber wealth and economic importance rival the great lumbering regions farther south.

CHARACTERISTICS OF DISTRIBUTION IN DIFFERENT REGIONS.

On the Atlantic Coast, from southern New York to Virginia, judging from the statements of earlier writers, this tree must have formed originally a considerable part of the forests of coniferous evergreens covering the belt of light silicious soils of the Tertiary strata. A. Michaux mentions this species "as not found beyond certain districts in Connecticut, it being multiplied in the lower part of New Jersey, and still more on the eastern shore of Maryland and the lower part of Virginia." From the remarks of this writer on the extensive use of the timber of the Yellow Pine (Shortleaf) it appears that at the time of his writing—the beginning of this century—it must have been quite abundant in those parts.

This appears clearly by his statement that "in the Northern and Middle States (of the Atlantic Seaboard) and in Virginia, where, to a distance of 150 miles from the sea, all houses are built of wood, the floors, casings of doors, wainscots, and sashes are made of this species, as being more solid and lasting than any other indigenous wood. In the upper part of the Carolinas the houses are constructed wholly of Yellow Pine, and are covered with it." Further on we learn that immense quantities were used in the dockyards of New York, Philadelphia, and Baltimore, and that Yellow Pine lumber formed a considerable part of the exports to Great Britain and the West Indies. Since that time this tree has in the region mentioned not only long ceased to be a source of timber, but has generally become quite scarce. According to the information of Dr. N. L. Britton, "it grows on the coast of New York naturally only on Staten Island, and only about twenty-five trees are to be found in Richmond County. It is fairly abundant in the portion of New Jersey from the Raritan River to Delaware Bay, forming forests, on a tract not more than 8 miles, and it is also found in Delaware on the same formation outcrop of Green Sand."

With the appearance of the Longleaf Pine south of Virginia the Shortleaf Pine recedes from the coast and is found chiefly in the upper (interior) part of the Southern coast pine belt, scattered among the mixed growth of coniferous and deciduous trees. Above the upper limit of the Longleaf Pine belt the Shortleaf Pine extends, in the Southern Atlantic States, throughout the interior to the lower ranges of the mountain region.

West of the Alleghany Mountains, in western Virginia and eastern Tennessee, it occurs only widely scattered, and hence is practically of no importance to the lumbering industry.

In North Carolina the Shortleaf Pine is found from the coast to the mountains, though in the lower districts enters more rarely into the composition of the upland forests. According to Hale's report on the woods of North Carolina the tree is found in the majority of counties of the State, but is most abundant in the middle district, where, with upland oaks and hickories, it is the prevailing tree. It is found about Asheville, at an altitude of 2,500 feet. The Shortleaf Pine used to form 25 per cent or more of the forest growth in many places, but such areas are not now frequent anywhere. In the latest report on the forests of North Carolina[1] it is stated that there

[1] W. W. Ashe: The Forests, Forest Lands, and Forest Resources of Eastern North Carolina. Bulletin 5, Geol. Survey, N. C., 1894, page 41.

are possibly 300,000,000 feet, board measure, Shortleaf Pine standing in the counties bordering the oak uplands in the eastern part of the State.

In South Carolina this pine is similarly distributed sparingly in the coast region and more frequent in the midland country to the lower mountain ranges.

In Georgia, in the lower part of the coast pine belt, the Shortleaf Pine is rarely met with. On the sandhills in the center of the State, forming the northern border of the pine belt, it occurs mixed with the Longleaf Pine among the inferior hard-wood timber. In the region of crystalline rocks, which embraces the more or less mountainous upper half of the State, covering over 19,000 square miles, at an average elevation of about 2,500 feet, this tree is most frequent, in many parts predominating.

In the three States last named the Shortleaf Pine was originally most abundant in the regions now most densely populated, and hence their supplies of timber are more or less exhausted, much of the so-called North Carolina Pine sent to market being Loblolly Pine. Young forests, however, of this tree are seen everywhere on the hills and mountain slopes, where the original timber growth has been removed, and on the worn-out lands abandoned by the cultivator.

In Florida the Shortleaf Pine is confined to the uplands along the northern border of the State, scattered among the Longleaf Pine and hard-wood trees. In the northwestern part, it approaches the seashore within a distance of from 25 to 30 miles on the isolated patches of red loam lands, where, together with the Longleaf Pine, it is associated with the Southern Spruce Pine (*Pinus glabra*).

In Alabama and Mississippi the Shortleaf Pine is rarely seen in the lower part of the coast pine belt, but forms a more or less conspicuous part of the forest covering of the uplands in the central and upper sections, and sometimes predominates to such an extent over the hard woods as to impart to the woodlands the somber aspect of a pure pine forest. In the region of crystalline rocks, with its arid ranges in Alabama, covering an area a little over 3,000 square miles, between the Coosa River and the southern tributaries of the Tallapoosa, the tree is less frequent than in the region of the same formation in Georgia, the Longleaf here taking its place. In the northern part of Alabama, on the table-land of the Warrior coal field over an area of fully 5,000 square miles, mostly in forest, the Shortleaf Pine forms a more prominent feature of the growth. This is the case particularly in the eastern part of this area, where the tree occupies mostly the summits and steep declines with a thin, dry soil, while in the deeper and moister soils the Loblolly Pine takes its place. In Cullman County, altitude 800 feet, where numerous acre measurements have been made, rarely over 2,000 feet, board measure, of this timber have been found upon one acre, and it can safely be said that in the localities where it is more frequently met with the average stand does not exceed 1,500 feet to the acre on this table-land. The supplies of Shortleaf Pine timber are rapidly diminishing before the demands of a rapidly increasing population and of the adjacent centers of the mining industry, and their total exhaustion is sure to be effected within a short time.

Wherever the original timber growth has been removed on these uplands the young growth of the Shortleaf Pine is rapidly spreading and predominates over the deciduous trees. The timber trees of full growth average on these table-lands about 22 inches in diameter breast high and 95 feet in height, furnishing clear sticks of from 35 to 45 feet in length. Such trees have been found with from 90 to 135 rings of annual growth on the stump.

Four trees felled in the vicinity of Cullman showed the following dimensions:

Measurements of four trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings on stump.
Inches.	*Feet.*	*Feet.*	
22	42	101	109
21	41	75	111
20	40	87	132
24	45	92	120

On the gravelly hills of the northern extension of the central pine belt in Alabama the Shortleaf Pine becomes frequently the predominating tree in the forest of oak and hickory. In Lamar County, Ala., and in northeastern Mississippi it forms forests which in the latter State give rise to a considerable lumbering industry. These forests are, however, rapidly decimated along the Memphis and Charleston Railroad, where the products of the mill find ready market throughout north Mississippi and at Memphis. Through the northern half of Mississippi, on the divide which separates the waters flowing into the Mississippi River from those of the Tombigbee, extends a region of undulating uplands of oak, hickory, and Shortleaf Pine over an area little short of 5,000 square miles; on this long, narrow belt the Shortleaf Pine can be said to form 12 to 15 per cent of the tree covering. These forests furnish an ample supply of pine lumber for local demands. It appears, however, that in the eastern Gulf States generally the existing supplies of Shortleaf Pine are scarcely sufficient to cover home demand. On these uplands the Shortleaf Pine takes rapid possession of the openings in the forest and the old fields. Here, as has been elsewhere observed in the central and northern parts of these States, this tree can truly be considered the timber tree of the future. Since it is rarely found in compact bodies, but associated with other trees widely scattered, any attempt at an estimate of the amount of the timber standing in these States must appear futile. The amount of timber cut can also hardly be approximated, since it forms only a part of the cut of the mills in these States.

West of the Mississippi River, north of the region of the Longleaf Pine, the Shortleaf Pine is found most abundant and in fullest perfection. It is in these Western forests that the Shortleaf Pine finds its best development, and forms pure forests, extending over many hundreds of square miles with but little interruption. The forests of Shortleaf Pine in northwestern Louisiana, Arkansas, southern Missouri, and northeastern Texas are scarcely surpassed in their timber wealth. The Tenth Census estimates the amount of merchantable timber of Shortleaf Pine standing in 1880 in these Western forests at 87,000,000,000 feet, board measure, exclusive of the forests in southern Missouri and the Indian Territory.

In Louisiana the Shortleaf Pine is unequally distributed over the uplands north of the Longleaf Pine region between the Ouachita River and the eastern boundary of Texas, embracing an area of a little over 8,000 square miles. Along the northern extent of the Louisiana and Texas State line this pine forms pure forests, and also prevails in many localities on the upland along the border of Arkansas. The resources of pine timber in these mixed forests of oaks, hickories, and Shortleaf Pine, removed as they are from the highways of traffic, have been but slightly drawn upon.

In Arkansas, in the hilly and mountainous region on both sides of the Arkansas River, over 19,000 square miles in extent, the Shortleaf Pine forms a large part of the tree covering of the siliceous rocky soil and frequently extensive forests on the wide table-lands. On the uplands of yellow loam south of the hills the tree predominates, especially on the low ridges of gravel and, loam, the hard woods encroaching where the soil conditions become more favorable.

The low ridges rising above the Loblolly Pine forests of the flood plain of the Ouachita and Little Missouri rivers are covered with open forests almost exclusively of Shortleaf Pine, interspersed with a few White Oaks, Post and Spanish Oaks, rarely above medium size. In the vicinity of Gurdon, in Clark County, upon one acre representing average conditions, 22 Shortleaf Pines have been counted from 12 to 25 inches in diameter, with no pines of smaller growth among the scattered undergrowth of dogwood, huckleberries, scrubby oaks, Black Gum, and hickories. Of this number, 8 trees measured from 21 to 25 inches; 6 trees from 18 to 20 inches; 6 trees from 15 to 17 inches and 2 trees 12 to 14 inches in diameter breast high, indicating a stand per acre of about 6,000 feet, board measure.

Five trees, representing the average timber growth of the forest selected for timber tests, were found of the following dimensions:

Measurements of five trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings on stump.	Sapwood.
Inches.	*Feet.*	*Feet.*		*Inches.*
20	60	110	120	2½
24	47	106	132	2½
19	40	109	102	3
18	36	95	120	3
25	45	717	143	3

On the arid hills of flinty sandstone the trees are of inferior growth, as observed in Hot Springs County, in the vicinity of Malvern. On their steep slopes the pines are rarely found to exceed 18 inches in diameter breast high and 75 feet in height, clear of limb for the length of about 35 feet. In a number of trees from 120 to 125 rings were counted on the stump. The wood produced on these hills is of a lighter color, less resinous, and of a fine grain. Specimens of finished lumber from such timber resemble somewhat that of the White Pine. The hard-wood trees, mostly Spanish Oak and Post Oak, scattered beneath the pines, are scrubby and of no value for their timber.

Along the railroad lines the forests have become exhausted for a distance of from 5 to 10 miles on either side, and the timber from the virgin forests is conveyed to the mills on steam tramroads. It appears that of late years about 550,000,000 to 560,000,000 feet, board measure, of pine timber are sawn annually in Arkansas south of the Arkansas River. In this amount the Loblolly Pine lumber is included, which is indiscriminately sawn and put with the Shortleaf Pine on the market as Arkansas Yellow Pine. The bulk of the product of the sawmills in this section is shipped by rail to the markets of the Northwest.

In the northern part of Texas, east of the prairie region, from the Red River Valley to the northern border of the Longleaf Pine region (under latitude 32° N.), extends an area of oak, hickory, and Shortleaf Pine uplands, stated in the agricultural report as covering 35,000 square miles. In the southern extent of this area the districts where the Shortleaf Pine prevails are popularly known as the "Pineries." North of the Sabine River, from Longview through Cass and Bowie counties, the Shortleaf Pine forms compact forests over many hundreds of square miles. Near Bevins, in Cass County, where the pine forests were more closely investigated, the moderately dense timber growth covers the undulating country down to the lowlands of the Red River in Louisiana. The sandy gray loam forming the rather compact soil of the surface is underlaid by laminated stiff clayey marls, which at the depth of about 4 feet become quite impervious to water. Blackjack, Spanish Oak, and Post Oak of stunted growth are scattered beneath the pine. The pine appears to be of slower growth; trees of full size—that is, from 20 to 24 inches in diameter—were found to have reached an age of from 195 to 210 years. The upper part of the timber of such old trees is frequently affected by rot, a defect undoubtedly to be ascribed to the cold, impervious subsoil.

From 6,000 to 7,000 feet of merchantable timber are claimed as an average stand for these timber lands. Every tree above 10 inches in diameter at breast height is cut for the mills. After the removal of the pine the hard woods gain rapidly in the rate of their growth, soon shading the ground completely. Young pines are rarely seen in the natural openings, the seedlings being too frequently destroyed by fire. In the clearings, where the original tree growth has been completely removed and the pine takes quick possession of the ground, the second growth, if not killed outright by the fires which again and again devour the surrounding tall weeds and broom grasses, becomes too severely injured to be of any promise.

Four trees, selected as representing fairly the average merchantable timber of the Shortleaf Pine forests of northeastern Texas, showed the following record:

Measurements of four trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings in stump.	Sapwood on stump.
Inches.	*Feet.*	*Feet.*		*Inches.*
24	36	120	195	3
23	40	109	205	3
18	45	95	102	5½
17	42	94	102	5½

The forests of Shortleaf Pine near Longview, which was in 1880 the site of a most active lumber industry, have been nearly exhausted, and with diminished supplies along the New Orleans and Pacific Railway the business has greatly declined. The annual output of the 30 mills situated along this road, and its branch from Carthage to Panola, does not at present in the aggregate exceed 70,000,000 feet, board measure. From the information obtained in 1892 it appears that in 1891-92, 200,000,000 feet, board measure, were handled in Texarkana, the product of the mills at that place and immediate vicinity, and also that the shipments of the mills south of the Red River in the same year reached about 105,000,000 feet, board measure.

In Missouri the rugged hills and table-lands of the southern slope of the Ozark Mountains, rising to an elevation of from 800 to 1,000 feet, are covered with forests of Shortleaf Pine, which, roughly estimated, extend over little more than 3,000,000 acres. In the counties bordering on the Arkansas State line (Terry, Ozark, and Douglas counties) the pine is said to yield on the average not over 2,000 feet of timber to the acre. The forests in the basin of the Current and Black rivers are heavily timbered, as observed at Grandin. The density of the timber growth varies, however, on these broken lands with the soil conditions, a fact demonstrated by actual measurements on several plats, upon which the amount per acre varied from 3,000 to 15,000 feet of timber. After years of experience, the average yield of the timber lands of the Grandin Lumber and Mining Company is estimated at 6,000 feet of merchantable timber to the acre, including trees of 10 inches in diameter.

The trees felled to serve as material for the United States timber tests, and fairly representing the average timber growth, showed the following record:

Measurements of five trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings on stump.*a*
Inches.	*Feet.*	*Feet.*	
31	40	103	174
20	50	99	150
17	35	92	140
22	40	88	180
24	50	109	218

a Sapwood on radius of stump averaging 2¾ inches.

The timber from these most northern of the forests of Shortleaf Pine is remarkably free from resin, of a fine, close grain, almost white, and claimed to be lighter and softer than the timber grown farther south, and like the timber occasionally found on the dry, rocky hills in Hot Spring County, Ark., resembling the wood of the White Pine. In these forests the fine tall pines tower high above the stunted Scarlet, Black, and White Oaks and hickories, but the growth of these hard woods almost completely overpowers the second growth of pine.

In close connection with the great markets of the North, and nearest to the timberless region of the Northwest, the manufacture of lumber in this region is fully developed. According to information received at Grandin, the output of the mills located along the Current River Valley Railroad, the Iron Mountain Railway, the Kansas City, Fort Scott and Memphis Railroad, and the Cape Girardeau and Southwestern road amounted for the year 1891–92 to fully 300,000,000 feet, board measure. At such rates the depletion of the timber wealth of this forest is to be expected before another generation has passed away.

Under the existing method of exploitation, which involves the almost total destruction of the smaller timber growth, nothing remains to be depended upon for the future. Considering the difficulties in the way of their natural renewal, there is no hope left for their restoration on these knolls. The dense undergrowth and brush of deciduous trees and shrubs which completely shade the soil, the rocky surface being hidden by an abundant and inflammable leaf covering, deprives the pine of every possibility of reproduction by natural seeding, even if the seedlings could escape destruction by fire.

According to the census of 1880,[1] extensive bodies of Shortleaf Pine timber exist in the eastern part of the Indian Territory. It occurs mixed among the hard woods on the higher ridges of the timber belt in the Choctaw Nation, 60 miles in length, and considerable bodies of Shortleaf Pine timber in belts of from 10 to 30 miles in length and 2 to 4 miles wide are found on the tributaries of Grand River in the Cherokee Nation, and in a large body of timber extending for 25 miles west of Ream this tree appears to reach its western limit.

The great importance of the forests of Shortleaf Pine to the industrial and commercial interests of the country west of the Mississippi River, and to the development of the adjacent timberless States and Territories, is forcibly exhibited by the enormous production of lumber for the past ten years. During the year 1891–92 at a low estimate not less than 1,270,000,000 feet, board measure,

[1] Report of Tenth Census, vol. 9, 1884.

have been shipped from points in Texas, Arkansas, and southern Missouri to Northern markets. This amount may be swelled by the production east of the Mississippi to round numbers of 1,500,000,000 feet, board measure.

As stated before, an estimate of the timber of this species standing is impossible on account of its scattered distribution and prevalent occurrence in mixed growths. But considering the extent of the areas within which it occurs and the average cut on the same, or comparing with the amounts of Longleaf Pine, which on account of the compact bodies in which it occurs, can be more readily approximated, it is safe to assume that very much less than 100,000,000,000 feet remain available, while the cut can be roughly estimated at 1,500,000,000 feet, board measure.

PRODUCTS.

Among the coniferous trees of eastern North America the Shortleaf Pine stands next to the Longleaf Pine in importance to the lumber industry and in the value of its timber. Freer from resinous matter, softer, more easily worked, not less susceptible of a good finish, the lumber of the Shortleaf Pine is often preferred by the cabinetmaker and the house carpenter to that of the Longleaf Pine. Less tenacious, and of less power of resistance under strain, it is principally used for the lighter framework in buildings, for weatherboarding, flooring, ceiling, wainscoting, cases for windows and doors, for frames and sashes of all kinds, and for shingles. Most of the dwellings located within the districts where this tree prevails are built almost entirely of Shortleaf Pine lumber, which bears ample testimony to its wide usefulness. It is also extensively employed in car building, for cross-ties, and in the manufacture of furniture.

NOMENCLATURE AND CLASSIFICATION.

This species, like all of the same genus of a decidedly Southern distribution in the Atlantic forest, belongs to the section *Pinaster* as defined by Engelmann, with cones of tough, woody scales their exposed ends thickened by an umbonate swelling (apophysis), which is armed with a weaker or stronger deciduous or persistent prickle or mucro. It was first described by Miller in the year 1768 as *Pinus echinata*,[1] and under that name recognized by the earliest writers on North American forest trees;[2] it was subsequently named by an obscure writer *Pinus virginiana*, var. *echinata*, Du Roi.[3] Michaux described this tree in his North American Flora[4] under the name of *Pinus, mitis*, which received general recognition and by which it is known to botanists to the present day. *Pinus variabilis*, the name under which it was described at about the same time by Lambert,[5] was adopted by Wildenow, and following that author by Pursh, Nuttall, Elliott, and a few others of the writers on the botany of this country. In following strictly the rule of priority, at present most strongly advocated as the only measure to avoid further the confusion arising from an endless number of synonyms, *Pinus mitis*, the name under which it is generally known, will have to be abandoned, and the more obscure one, *Pinus echinata*, under which this species was first published, restored.

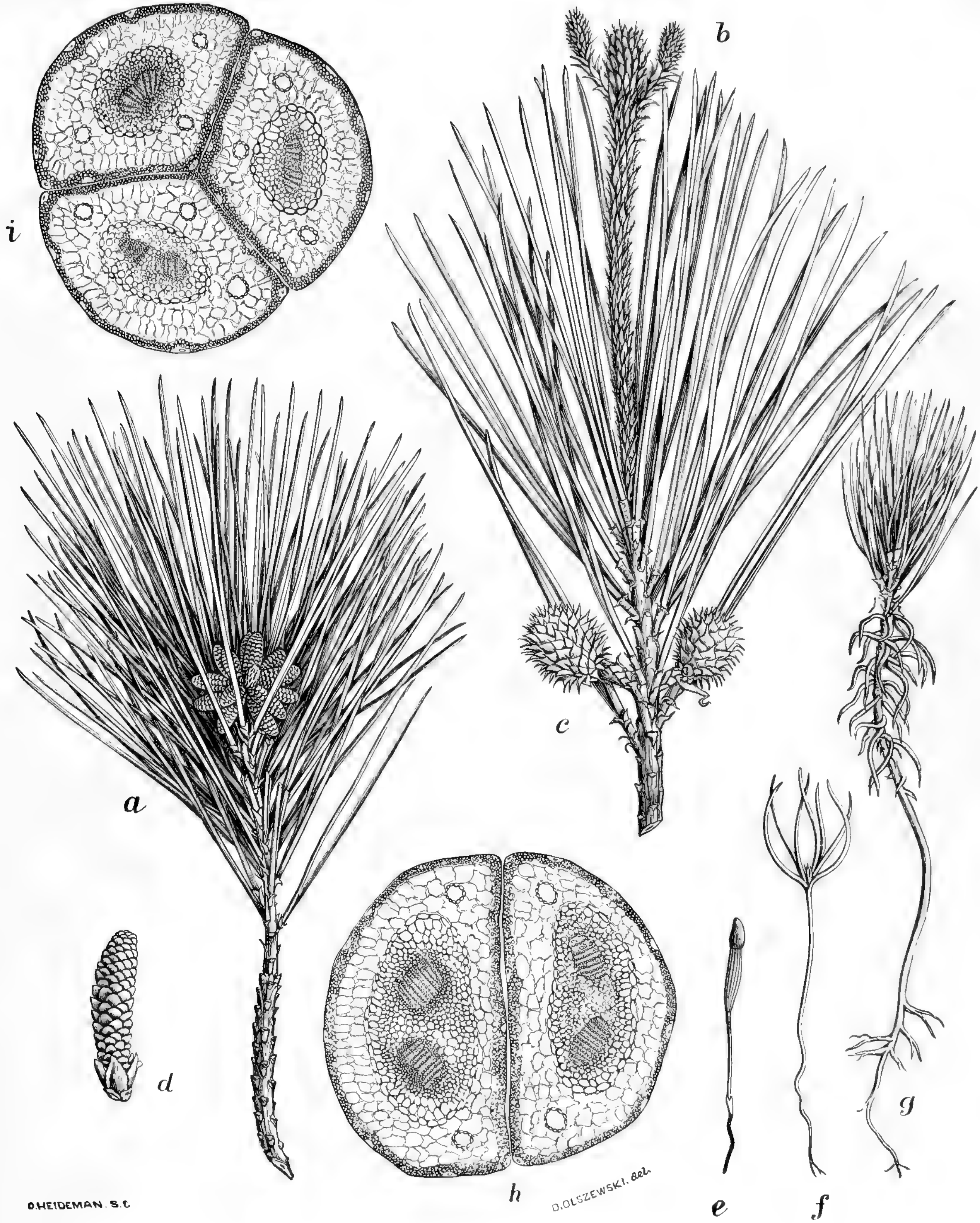
Great confusion is caused by the various appellations this tree has received in the English vernacular, being indiscriminately called Shortleaf Pine, Yellow Pine, and Spruce Pine, although most widely known under the first of these names, and in the markets it is now somewhat doubtfully established under the name of North Carolina Pine. In the States of the lower South it is frequently confounded with the Loblolly Pine, as the timber of the two is often, if not mostly, mixed. M. A. Curtis, in his "Trees of North Carolina," selected for this tree the name of Yellow Pine, strongly recommending its general adoption in order to introduce greater uniformity in the designations of our forest trees. Unfortunately the same name is in many of the Southern lumbering districts bestowed upon the Longleaf Pine, particularly when the timber is spoken of. It is often quite impossible to determine to which of the two species the timber is to be referred when under that name it is quoted in the reports of the lumber markets.

[1] Miller's Dictionary, 8th ed., 1768: London.
[2] Marshall's Arboretum Americanum: Philadelphia, 1785.
[3] Du Roi Hb.
[4] A. Michaux's Flora Amer. boreal., Paris, 1803.
[5] Description of the Genus Pinus: A. B. Lambert, 1803 and 1824.

EXPLANATION OF PLATE XV.

[Figures natural size, except where otherwise noted.]

Fig. *a*, branch from a lower limb bearing male inflorescence with flowers in a dense cluster (first week of April, southern Alabama); *b*, *c*, branch with two subterminal aments of female flowers below which are two immature cones of one season's growth; *d*, detached male flower showing basal involucral scales, magnified 3 diameters; *e*, germinating seed (February); *f*, same seedling one month later (March) with 7 cotyledons in the midst of which the terminal bud shows the primary leaves appearing; *g*, seedling about the close of the first season with terminal cluster of true (secondary) leaves, below which are seen the withered primary leaves; *h*, *i*, transverse section through base of two and three leafed leaf bundle, magnified 50 diameters, showing outer small hypodermal cells, the stomata appearing as marginal white spots; next a broad band of large in-walled parenchymatous cells bearing chlorophyll, within which, at the angles of the leaf, resin ducts appear as large openings; the dark areas in the center are fibro-vascular bundles surrounded by a single row of thin-walled cells (bundle sheath).



PINUS ECHINATA: SEEDLING, MALE AND FEMALE FLOWER, AND LEAF SECTIONS.

Under the name of Spruce Pine, in the extreme Southern districts, it is invariably confounded with the true Southern Spruce Pine (*Pinus glabra*), the species which in several points it closely resembles and to which it is most closely related.

BOTANICAL DESCRIPTION.

Leaves mostly 2 (sometimes 3) in a short sheath, 3 to 5 inches long; cones 1½ to 2 inches long, oval or somewhat conical; scales with a short, tender, straight, and finally incurved prickle, light brown. Seeds rather small, two-fifths of an inch long, by one-tenth to one-eighth of an inch wide, with dark, scattered or confluent specks; the wings are reddish brown and about one-half of an inch long. The young shoots are of a glaucous violet color. The bark of mature trees is rather thick and broken up in squarish plates. The different general appearance of the tree will almost always serve to quickly distinguish it from the closely related Scrub Pine (*Pinus virginiana*) which is distinguished by its shorter and more rigid leaves. Any doubt can be removed by trying the twigs; those of the Scrub Pine are tough while those of the Shortleaf Pine snap off readily. The bark is of a light reddish brown color, and on the lower part of the trunk in full-grown trees three-fourths to fully one inch thick crossed by deep furrows, and flaky.

The limbs are arranged in more or less regular whorls, under full exposure, forming a crown with the outline of a truncated pyramid, by which the tree can be recognized from a distance and distinguished from kindred species with which it happens to be associated. The oldest and stoutest limbs are rarely over 20 to 25 feet in length, and are somewhat drooping.

It is indeed a beautiful tree, with its stately, gently tapering trunk and its finely shaped full crown clothed in an abundance of foliage, bearing the stamp of thrifty and vigorous growth.

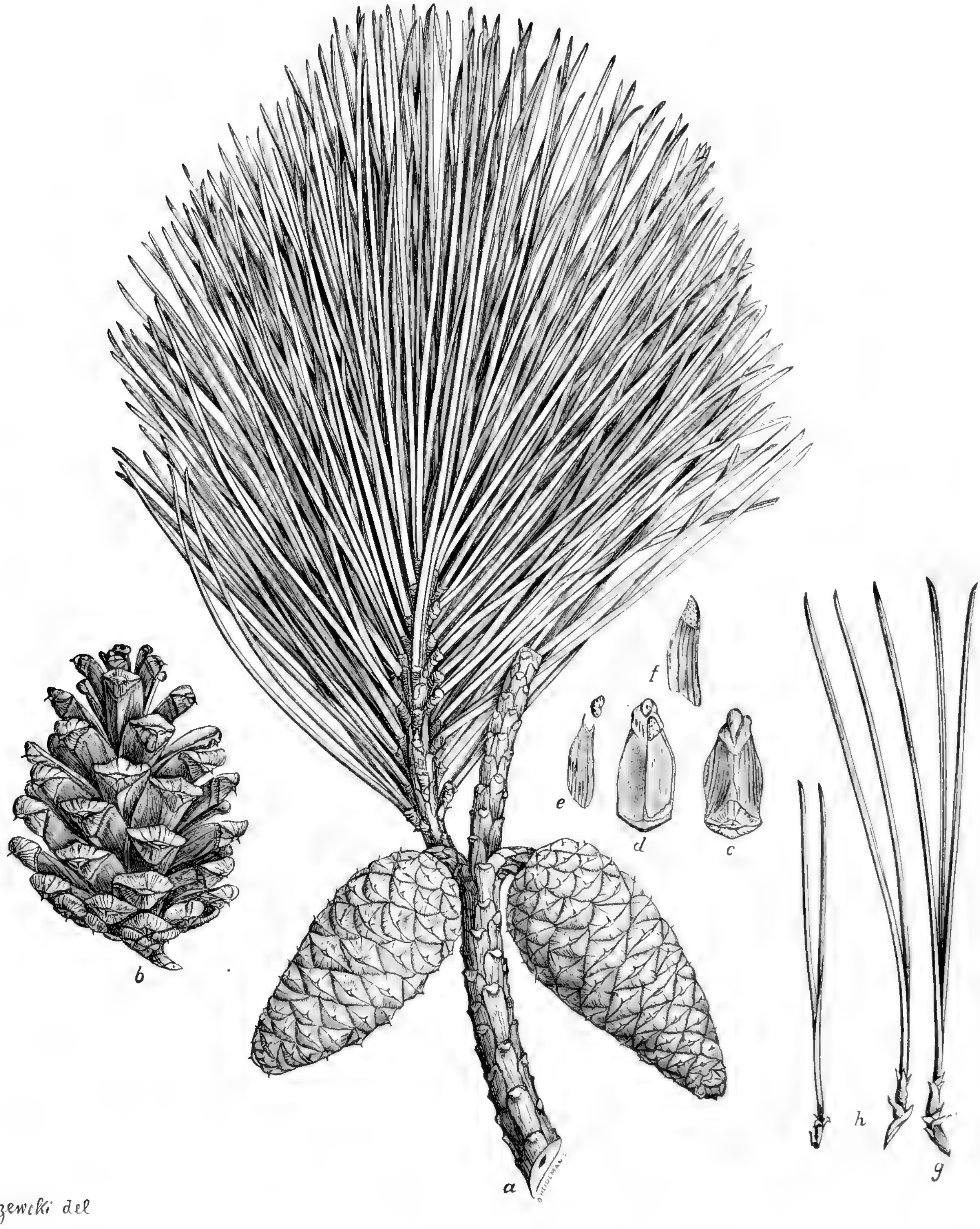
Leaves.—The secondary or foliage leaves are found mostly 2 in a sheath, and on shoots of vigorous growth often 3 are found in a bundle; occasionally whole trees are seen with 3 leaves in a sheath and in some rare instances on young trees even 4 have been counted (Pl. XVI, *g*, *h*). The leaves vary from 3 to 4 inches and a little over in length; they are slender, about one-eighteenth of an inch wide, strongly concave, slightly twisted, faintly serrulate, and abruptly sharp pointed, while young of a yellowish and later on of a deeper green color. In the cross section (Pl. XV, *h*, *i*) they present a semicircular outline; examined under the microscope they show on both sides about ten rows of minute stomata (breathing pores) the small epidermal cells underlaid by a single layer of rather thin-walled hypodermal or strengthening cells; in the specimens examined from 3 to 4 peripheral resin ducts were found, the bundle sheath consisting of a single row of cells. The sheath invests the leaves closely and rarely exceeds at any stages of growth three-sixteenths of an inch; the leaves are shed during the latter part of their second year.

The bract-like scales (Pl. XV, *b. c.*), modified primary leaves, which densely cover the young shoots and in the axils of which the foliage leaves are produced, are while young of a grayish color, closely appressed, lanceolate, acuminate, and fringed; with the subsequent development of the foliage leaves and the increase of the shoot in length, their tips become dried and are cast off. As the tender shoots become hardened they assume a glaucous purplish color.

Flowers.—The flower buds make their appearance during the latter part of the winter and begin, in stations of southern latitudes, to open near the end of March (Baldwin County, Ala., March 26), and farther north from three to four weeks later (Cullman, Ala., April 28). The staminate flowers are closely sessile, to the number of fifteen to twenty surrounding the terminal bud (Pl. XV, *a*), which at the time has scarcely grown to the length of an eighth of an inch. The staminal column, of a pale purplish color, does not exceed three-fourths of an inch in length, is less than one-eighth of an inch in thickness, and is surrounded by eight or nine decussate scales, those of the first pair being strongly keeled and scarcely half the size of the others (Pl. XV, *d*). The crest of the anthers is nearly circular and slightly denticulate. The male flowers are shed immediately after the discharge of the pollen. The female flowers are united in an oblong, obtuse, short-stalked catkin of a delicate rose-pink color, about one-fourth of an inch in length. They are rarely single, but mostly from two to four, produced closely below the apex of the youngest shoot (Pl. XV, *b*). The stipe of the catkin, not over three-eighths of an inch in length, is invested by twenty to twenty-four hyaline lanceolate, pointed, involucral scales, those immediately surrounding the flowers being widely spreading. The bracts subtending the carpellary scales cover the latter to the base of their long, subulate, erect tips.

EXPLANATION OF PLATE XVI.

Fig. *a*, branch with mature closed cones (October of second season); *b*, mature cone; *c*, cone scale, outer or dorsal view showing apophysis; *d*, ventral view of the same with seed in place; *e*, seed detached from wing; *f*, seed with wing intact; *g*, leaf forms, two and three leafed bundles.



D. Olszewski del

PINUS ECHINATA: CONE, SEED, AND LEAVES.

After fertilization has taken place the shoots bearing the fertile flowers increase rapidly in length. Fertile catkins are frequently found on the older branches, produced on branchlets from adventitious buds. The tree begins to produce flowers when from ten to twelve years old, according to exposure; male flowers have been observed one or two seasons earlier.

Cones.—Every season cones are produced in great abundance. The conelets of the first year, borne on a short, horizontal stalk, are oval in shape, scarcely one-half an inch in length, the squarrose tips of the scales giving them the echinate appearance from which the botanical name first given to this species was undoubtedly derived (Pl. XV, *c*).

Fully matured by the end of the second year, the cones are nearly sessile, oval, of dull or leather brown color, 1½ to rarely 2 inches long, and when open, nearly as wide; they are frequently smooth (Pl. XVI, *a*, *b*). The scales are hard, with a slightly swelled apophysis, devoid of or armed with the weak, more or less deciduous prickle (Pl. XVI *c*, *d*). The cones open early in the fall, and remain, after the discharge of their seeds, for several years on the branches. In consequence, the older trees are covered with them through all seasons.

Seed.—The Shortleaf Pine produces seeds in greatest abundance; its crops seem never to fail. The seeds are small, triangular, three-sixteenths of an inch long by one-eighth of an inch wide, the hard, roughish testa marked with three indistinct ridges and more or less with confluent specks; the wing is of a light, reddish brown, half an inch in length and deciduous during germination (Pl. XV, *e*, *f*). The seeds retain their vitality for several years; fresh, they will germinate in from ten to fifteen days. The number of seeds to the ounce is about 5,000; wafted by the wind over wide distances and germinating early during the first days of spring, their offspring are found to take possession of every opening in the forest and of the old fields in localities favorable to their growth.

THE WOOD.

The wood of Shortleaf Pine resembles that of the Loblolly in almost every respect. The sapwood is clearly defined, being quite broad, and even in very old trees forms fully one-half of the total volume of the trunk. In thirteen trees one hundred to one hundred and fifty years old, the average width of sapwood was found to be about 4 inches, while even in trees over one hundred and fifty years old its average width was 3 inches. In the former case, the sapwood formed 65 to 70 per cent of the volume of the logs; in the latter, 50 to 55 per cent, while in a set of trees fifty to one hundred years old it formed fully 80 per cent of all the wood. The change from sapwood to hardwood proceeds much as in Loblolly Pine. It begins when the tree (or any disk) is about twenty-five to thirty years old, and is retarded more and more with age, so that in old trees as many as eighty or even one hundred rings are counted in the sapwood, while in young and thrifty trees not more than thirty to forty may occur.

In keeping with the large amount of sapwood, the weight of green Shortleaf Pine is rather great, varying, for entire logs, from 45 to 55 pounds per cubic foot, commonly approaching 60 pounds in the largely water-filled outer portions of the sapwood.

When kiln-dried, the wood of trees one hundred to one hundred and fifty years old weighs on the average about 32 pounds per cubic foot. As in other pines, the butt is 15 to 20 per cent heavier than the top, and the wood of the inner forty to fifty rings excels in weight and strength the wood of the outer parts of old logs. As was stated for Loblolly, the sapwood may be light, heavy, weak, or strong, according to the age of the tree from which it is obtained. As might be expected from the great range of distribution of this tree, its wood, like that of Loblolly, varies within very wide limits. Specimens from Missouri (near its northern limits) are generally lighter and less resinous than those from farther south, and frequently resemble the wood of the Norway Pine, while many select specimens from the Gulf and South Atlantic States rival in weight and strength the best grades of Longleaf Pine. In its strength, as in its weight, the Shortleaf follows Loblolly Pine.

The average of a large series of tests furnishes the following average values for dry pieces of this species:

	Lbs. per sq. inch.
Modulus of elasticity	1,600,000
Transverse strength	9,230
Compression endwise	5,900
Shearing along the fiber	688

As the average weight of this series was 38 pounds per cubic foot, or about 16 per cent heavier than the average weight involving all parts of all the trees, these figures should be reduced by that per cent to represent the true average for the wood of the species.

In drying, 100 pounds of wood lose from 40 to 50 pounds of water, the bulk of which comes from the sapwood, which contains 60 per cent and more, while the heartwood, like that of most pines, contains about 25 per cent.

The shrinkage in volume consequent on drying amounts to about 11 per cent. It is about 13 per cent in the wood of the butt and about 10 per cent in that of the upper logs, varying in this respect directly as the weight of the dry wood. Of the 11 per cent, about 8 per cent fall to the tangent or occur along the rings and 3 to 5 per cent along the radius.

The structure of the wood of Shortleaf Pine is essentially the same as that of Loblolly. Summerwood and springwood are sharply defined. The proportion of the former to the wood on the whole varies, as in Loblolly, in the same manner as the weight of the wood, being greater in the butt than top, greater in the wood of the inner rings than in the wood farther out, and greatly reduced in all cases where the growth of the tree is suddenly retarded by unfavorable seasons, but is otherwise quite independent of the width of the rings.

For details of structure, consult the comparative study of Mr. Roth, appended to these monographs.

PROGRESS OF DEVELOPMENT.

The seeds begin to swell and to germinate in the early days of spring. In Mobile County, on the end of the first week of March, the plantlets had their cotyledons fully unfolded, which were found to vary from six to seven in number, with the lower (hypocotyledonary) part of the axis from 1½ to 2 inches long, the rootlets being somewhat less in length (Pl. XV, *e*, *g*). The development of the upper part of the axis (caulicle) from the terminal budlet and of the primary acerose leaves proceeds now rapidly. These primary leaves succeeding the cotyledons are stiff and spreading, about three-fourths of an inch long and covering the stem densely (Pl. XV, *g*), remain during the first season, withering from below during the warmer part of the season. By the close of the first season the caulicle or first shoot has attained a length of from 3 to 4 inches. On the shoot of the second season (rarely before) the secondary leaves, which constitute the foliage, make their appearance from the undeveloped branchlets in the axis of the primary leaves (Pl. XV, *g*). At the end of the second year the plants are 7 to 8 inches high, with a taproot 2 to 3 inches long. During this season adventitious buds appear at the collar of the stem, which bring forth vigorous sprouts, particularly if the stem has sustained the slightest injury. These shoots are covered with primary leaves, which are retained for one season. They are apt to form strong branches before the tree has reached its fourth or fifth year; such branches, which are produced profusely from the stumps of larger trees, scarcely survive another season. It is rarely that branches are produced in the second year, the first branches appearing generally in the third season in whorls of three to four. In the third year foliage leaves alone are produced in the axils of scales with their bases close to the stem. At the close of the third year the plants are from 12 to 18 inches high. Now the development of the root system advances rapidly, the taproot being by this time about 8 or 10 inches long, with strong lateral roots often double that length. Both taproot and lateral roots are finally vigorously developed, penetrating deep into the ground, so that trees of this species are rarely blown down by winds. At the end of the fourth year the plants are from 2 to 3 feet high, with the stem at best from five-eighths to seven-eighths of an inch thick.

The branches of the whorls begin now in their turn to develop branchlets in whorls of secondary order. The development of the primary axis and its branch system proceeds henceforth in the regular acropetal order. As in all pines, the shoot of the main axis takes the lead in rapidity and vigor of growth. By a number of measurements made at Cullman, north Alabama, of trees from the openings in the forest, as well as from clearings, it was found that by the end of the fifth year they had attained a height varying between 3 and 5 feet, rarely over, the stem being from five-eighths to seven-eighths of an inch in thickness; by the end of the sixth year, from 6 to 9 feet high and from one-half to 2 inches in diameter; and at the tenth year, from 10 to 16 feet high and from 2 to 2½ inches in diameter. At the age of fifteen to twenty years, with a total height of from 20 to 30 feet and a diameter breast high of 4 to 5 inches, the crown of the tree occupies from one-half to five-eighths of its height. Henceforth throughout the period of quickest growth its rate is greatly influenced by conditions of light and soil. At the age of fifty years the height of the trees varies between 40 and 60 feet and the diameter breast high between 10 and 14 inches. About this age, or perhaps a short time before, the height growth begins to decline and the branches become somewhat reclining below and spreading toward the top, and consequently the head of the tree becomes more rounded in outline. Between the ages of sixty and seventy years the trees are from 50 to 70 feet high and from 12 to 15 inches in diameter, with the trunk clear of limbs for 30 to rarely over 40 feet. From this period on the growth proceeds at a slower rate. On reaching its one hundredth year the tree has attained a height between 90 and 95 feet and a diameter of from 16 to 19 inches at most. Having now passed its period of vigorous life, the growth is henceforth insignificant. Between the ages of one hundred and twenty and one hundred and thirty years trees were found 90 to 110 feet high and from 18 to 24 inches in diameter. The oldest tree encountered in the measurements, with two hundred and eight rings of annual growth in the stump, scarcely exceeded 109 feet in height and measured 24 inches in diameter. The largest tree felled was 117 feet high and 25 inches in diameter, with one hundred and forty-three rings in the stump. Occasionally trees are found of a diameter exceeding 3 feet, but such are exceptional.

TABLE I.—*Growth of Shortleaf Pine* (*Pinus echinata*), *from eight to fifty years.*

Number of tree.	Rings in stump.	Diameter at breast high.	Height to first limb.	Total height.	Locality.	Remarks.
		Inches.	*Feet.*	*Feet.*		
1	8	2	6	11	Cullman, Ala	Clearing made in 1879 for pasture in dense pine thicket.
2	8	2	....	11	do	Do.
3	9	1¾	....	11	do	Do.
4	10	2¾	....	17	do	Rocky hillside, border of thicket.
5	10	2½	....	11	do	Rocky hillside in dense thicket of vigorous growth; youngest shoot, 19 inches.
173	12	2¼	7	11	Bivins, Tex	Exposure free in opening of forest.
138	11	2	7	11	Grandin, Mo	Rocky table-land; opening in forest.
9	12	3	....	20	Cullman, Ala	Border of thicket; freely exposed.
137	12	2	....	16	Grandin, Mo	Rocky table-land; partially exposed; in forest.
6	12	2	10	19	Cullman, Ala	Exposed; border of woods.
5	13	2½	6	16	do	Do.
7	13	2½	....	17	do	In midst of thicket; old clearing.
10	13	3	....	20	do	Old pasture, cleared in 1879; most vigorous growth; young shoot 19 inches.
8	15	4	12	24	do	Do.
136	15	4	10	20	Grandin, Mo	Rocky hills; open forest.
171	18	4	15	36	Bivins, Tex	Open forest.
159	19	4	22	37	Gurdon, Ark	Exposure free; open grove of second growth.
135	19	4	10	20	Grandin, Mo	Oppressed in forest opening by oak scrub.
134	20	6	14	26	do	Rocky; open woods.
161	19	2½	8½	25⅓	Gurdon, Ark	Open grove; closely oppressed.
160	22	3	12	25	do	Open grove of second growth.
157	27	6½	12½	25½	do	Do.
138	24	3½	22	33	do	Do.
170	25	4	15	34	Bivins, Tex	Partially free; in forest.
155	41	11	51	70	Gurdon, Ark	Free; old field.

TABLE II.—*Growth of Shortleaf Pine during stage of rigorous growth, from fifty to one hundred and twenty years.*

Number of tree.	Rings in stump.	Diameter— At breast high.	Diameter— Below crown.	Height to first limb or crown.	Total height.	Length of timber.	Locality.	Remarks.
		Inches.	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
169	52	6½	....	22	46	....	Bivins, Tex..........	In forest; soil cold, underdrainage deficient; exposure free.
168	58	6¼	....	20	50	....	....do	Exposure free; opening in forest.
	60	15	....	45	81	......	Baldwin County, Ala., near Tensaw River.	Coastline; loamy sand, with Cuban Pine; exposure free.
167	73	12	....	38	80	32	Bivins, Tex	Opening in forest; exposure partially free.
165	102	16½	....	62	94	....	....do	Oppressed.
164	102	18	....	45	95	....	....do	
152	102	19	....	38	109	38	Gurdon, Ark	Exposure free; open forest.
	105	15	....	32	64½	30	Cullman, Ala	Partially free on gravelly ridge.
	109	22	....	42	101	40	....do	Exposure partially free; open forest; dry hill; sandy, gravelly loam.
1	111	21	....	41	74		....do	Exposure free; gravelly loam.
166	114	17	....	46	93	46	Bivins, Tex	Oppressed on all sides; red heart above 36 feet.
1	116	22	19½	45	93	42	Cullman, Ala	Exposure free; open forest; rocky, and sandy loam.

TABLE III.—*Growth of Shortleaf Pine during stage of slow growth, latest stage of life.*

Number of of tree.	Rings in stump.	Diameter— At breast high.	Diameter— Below crown.	Height to first limb or crown.	Total height.	Length of merchantable timber.	Locality.	Remarks.
		Inches.	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
	120	24	....	45	92	42	Cullman, Ala.....	Open forest; hills; soil, sandy clay; exposure free.
150	120	20	13	73	110	60	Gurdon, Ark......	Open forest; gentle declivity; gravelly clay.
153	120	20	....	47	95	45	.....do	Do.
150*a*	132	24	19	47	106	43	.....do	Do.
	132	20	....	42	87	40	Cullman, Ala.....	Open forest; clay hill; exposure free.
129	140	17	12	39	92	38	Grandin, Mo......	Exposure free; rocky table-land.
154	143	25	20½	46	117	45	Gurdon, Ark	Exposure free; gravelly hillside.
128	150	20	....	50	100	50	Grandin, Mo......	Rocky table-land; exposure free.
127	174	31	....	46	102	40	.....do	Do.
130	180	22	....	42	91	40	.....do	Rocky table-land; exposure partially free; slightly suppressed.
162	195	24	....	37	119	37	Bivins, Tex.......	Cold soil; exposure free.
163	204	23	....	61	108	40	.....do	Cold soil; exposure free; affected above 40 feet with red heart.
131	218	25	22	55	110	50	Grandin, Mo......	Exposure free; soil loamy; deep.

From the general table (No. IV) and the corresponding diagram it seems that in the average the tree at twenty is about 30 feet high, reaches 50 feet at the age of forty, and that its growth in height is in the main finished at the early age of 70. In keeping with this, the growth in diameter is quite rapid during the first fifty years, continues at a moderate pace up to 80, when the age of extreme slow growth is entered.

TABLE IV.—*Rate of growth of Shortleaf Pine.*

Age.	Diameter with bark (breast high).	Length of log with upper diameter of 5 inches.	Total height of tree.	Volume.		Periodical growth by decades.						
				Tree.	Log up to 5 inches diameter.	Decade.	Diameter.	Height.	Area of cross section.	Volume.	Average annual accretion.	Current accretion.
	Inches.	*Feet.*	*Feet.*	*Cu. ft.*	*Cu. ft.*		*Inches.*	*Feet.*	*Sq. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
10	3.0	....	11	0.32	....	First	2.2	11	0.03	0.32	0.03	0.03
20	5.2	....	27	2.21	....	Second	2.3	16	.07	1.89	.11	.19
30	7.4	15	41	7.55	6.37	Third	2.2	14	.14	5.34	.25	.53
40	9.3	26	51	14.06	12.98	Fourth	1.6	10	.13	6.51	.35	.65
50	11.0	38	60	22.18	21.18	Fifth	1.6	9	.17	8.12	.44	.81
60	12.7	48	67	31.97	31.10	Sixth	1.6	7	.21	9.79	.53	.98
70	14.5	56	71	43.96	43.32	Seventh	1.6	4	.21	11.19	.62	1.20
80	16.0	61	75	56.54	55.91	Eighth	1.5	4	.23	12.58	.70	1.26
90	16.5	64	78	62.53	61.89	Ninth	.6	3	.10	5.99	.69	.60
100	17.0	67	81	67.68	67.05	Tenth	.5	3	.07	5.15	.68	.51

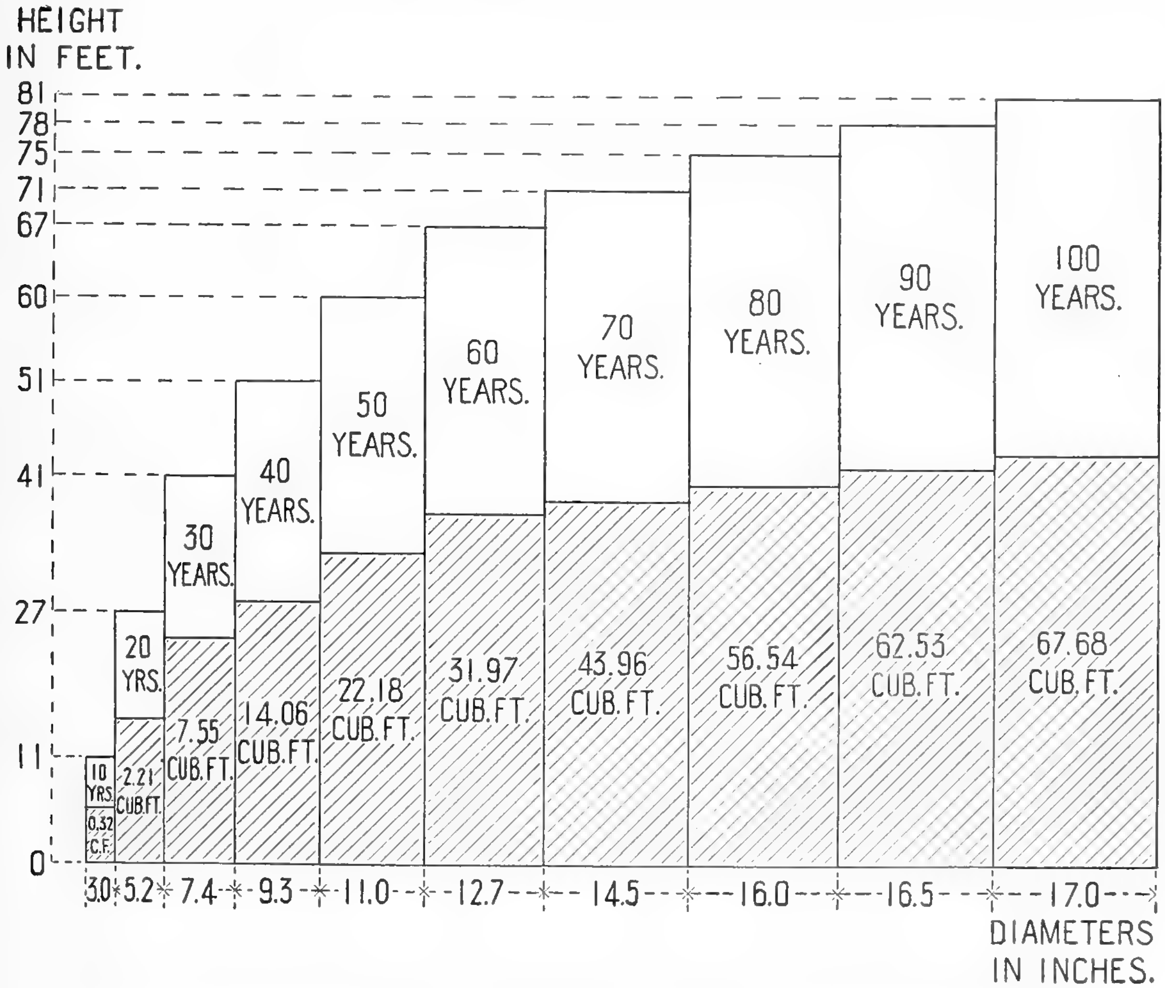


FIG. 11.—Growth of Shortleaf Pine: Height, diameter, and cubic contents of average trees at 10, 20, etc., years of age.

CONDITIONS OF DEVELOPMENT.

Soil and climate.—The Shortleaf Pine prefers a well-drained, light sandy or gravelly clay soil or warm loam, even if deficient in the elements of plant food. Soils of this character which are found widely prevailing over the undulating or broken uplands, if only of sufficient depth, will produce this tree in greatest perfection. It avoids the strongly calcareous and the rich alluvial soils, as well as purely silicious, being dependent on the presence of a certain amount of clay by which the mechanical condition of the soil is improved, rendering it more compact and more retentive of moisture. That a purely sandy and highly porous soil is not favorable to this tree is shown by the stunted growth of the waifs sometimes found in the openings of the forests of Longleaf Pine on the sandy, arid uplands in the lower part of the coast pine belt.

Distributed in its range over 10 degrees of latitude and exposed to wide differences of temperature, it shows almost the same thrift of growth near its northern limits under the isotherm of 50° F., and in regions where the thermometer falls to near 20° below zero, as in lower latitudes with a mean annual temperature of 64° F. It can, therefore, endure a considerable range of temperature.

The conditions of atmospheric moisture evidently exercise a much more decided influence over its distribution, and, without doubt, upon its individual development. The tree is found in greatest abundance and of best growth where, within the limits of its distribution, the annual rainfall varies between 48 to 52 inches, it is less frequent in the districts where the precipitation exceeds 56 inches, still scarcer where the annual rainfall averages below 44 inches, and entirely wanting where this is less than 40 inches. Hence it is found best developed in the upper part of the Gulf States and west of the Mississippi River in adjacent northern districts from the interior of Georgia to northeastern Texas, where the most favorable conditions in regard to atmospheric precipitation prevail. The tree seems to avoid the humid air of the coast along the Gulf, as well as along the seashore of the Southern Atlantic States, nor does it ascend the mountains in these States above an altitude of 2,500 feet.

RELATION TO LIGHT AND ASSOCIATED SPECIES.

The Shortleaf Pine, like most pines, is a light needing species, being, however, less sensitive to a deficiency in this direction than the Longleaf and Cuban pines, which latter succumb in competition with the Shortleaf Pine. Originally the Shortleaf Pine is found more or less associated with various oaks (Spanish Oak, Blackjack, Scarlet Oak, Post Oak, and Black Oak), the Mockernut and the Pignut Hickory, and more rarely with the Chestnut, the Mountain Oak, and the Scrub Pine. All of these species prefer the warm, lighter soils of the uplands. These companions of the Shortleaf Pine are joined in the lower Southern States by the Loblolly and Longleaf Pine. Wherever in these upland forests an opening is made the Shortleaf Pine gains over its associates, finding its only successful rival in the Loblolly Pine. It is in the Southern States proverbial that in the upland forests "the pine is crowding out the hard-wood timber," a fact early observed. The displacement is effected either gradually in the course of time, or instantly when the removal of the original timber growth has been sudden. In the upper part of the maritime pine belt, where it is associated with the Longleaf Pine, the latter is sure to be replaced by the Shortleaf species, often joined in the course of such invasion by the Loblolly Pine.

ENEMIES.

Little is known of the fungoid parasites and of the insects endangering the life of the Shortleaf Pine. From my own observation, it seems that this tree is less affected by the former than the other pines of the same region. In the lumbering districts of Alabama a disease called redheart or redrot, caused by the mycelium of a large species of Polyporus, which is so highly destructive to the Longleaf Pine, is in this species almost unknown. In northeastern Texas this disease was found to affect the superannuated timber trees, which were over two hundred years old. According to A. S. Packard[1] the hosts of insects affecting this pine seriously are scarcely less in number than those infesting the Longleaf Pine; its enemies belong to the same or very nearly related kinds. Among the borers the *Monohamnus confusor* and other species of the same genus dig burrows in the timber to the heart; the larvæ of numerous *Buprestidæ*, *Cerambicidæ*, and *Curculionidæ* burrow under the bark, and the *Tomicus calligraphus*, *cacographus*, *cicelatus*, and other species of *Scolytidæ*, at certain seasons are in immense numbers carrying on their work of destruction in the cambium layer, leaving in wonderful delineation on the inside of the bark the marks of their pernicious activity and causing the speedy death of the tree.

Mr. E. A. Schwarz, of the Division of Entomology, Department of Agriculture, remarks in this connection that of more than usual interest is the remarkable and disastrous invasion of one of

[1] A. S. Packard: Insects injurious to forest and shade trees.

these bark-boring Scolytid beetles (*Dendroctonus frontalis*), which in former years was universally considered a rare species. This invasion started in 1888 from the mountainous regions of West Virginia and within four years spread throughout the Alleghany Mountains and adjacent lowlands from Pennsylvania to the Carolinas. The amount of damage caused by this beetle within that time to the Shortleaf Pine and other pine trees has been enormous. A contagious disease, probably of a fungoid character, terminated in 1892 this invasion just as suddenly as it had commenced, and in 1893 not a single living beetle could be found throughout the infested region. The white froth hiding the larva of a tree jumper (*Aphrophora parallela*) is very common on the summits of the twigs, the larvæ of the sawflies are seen at the same season to feed on the tender, young foliage, which is also infested by a small white Gelechia depositing its eggs on the leaves, the larvæ boring into them to provide shelter for their pupæ; and according to Mr. Schwarz the leaves of the Shortleaf Pine are frequently found completely covered by a scale insect (*Mytilaspis pinifoliæ*), causing what is termed in New England the "white malady" of the pine. Of the flat-headed borers, larvæ of the *Buprestidæ*, the most injurious species are *Chrysobothris dentipes* (Germ.), *Calcophora virginiensis* (Drury); less common, *Calcophora georgiana* (Lec.) and *Buprestis lineata* Fab. (Schwarz).

Exposed to the same dangers of destruction by forest fires and by live stock of every kind, which threaten the Longleaf species with extermination, the chances of this pine to resist them and to escape such eventually are more favorable in consequence of the greater facilities for its reproduction and of its rapidity of growth during the earliest stages of its existence.

The pernicious influences of the first of these agencies is, however, painfully visible near the settlements where the forest is exposed to its effects one season after another. In such localities the pines are of stunted growth; in the middle stage—their very prime of life—they exhibit signs of decay and early death. But few of the younger trees exposed to fire were found on close examination to be free from defects and marks of impending disease.

Confined to the gentle slopes of the low hill country, to rolling uplands, and to broad table-lands, this tree is scarcely exposed to destruction by torrents and floods. Unsought for its resinous juices, it is not subjected to the wholesale destruction caused by the prevalent methods employed in the manufacture of naval stores. No other timber tree found in the southern portion of the Atlantic forest region is more easy of natural reproduction than this species throughout the wide range of its distribution. This is readily accounted for by its great fecundity, the seeds produced in great abundance almost without failure every year being profusely spread far and wide, and germinating easily wherever the proper soil and a chance is offered for their reception. By their thrifty growth the seedlings soon gain the upper hand over the contemporary growth of other species.

Throughout the interior of the Atlantic and the Gulf States tracts of upland, originally covered with fine oak forests, which had been cleared for cultivation and but little over half a century ago abandoned, are found at present occupied by the Shortleaf Pine, forming dense groves of trees 65 feet and over in height, with a diameter of 10 to 12 inches, standing 18 to 20 feet apart, with no undergrowth whatever.[1] Such young forests, met with in every stage of growth, afford highly instructive lessons of the ways taken by nature in the spontaneous restoration of the forest. In such spontaneous growths of the Shortleaf Pine the saplings form from the first mostly dense thickets. Before having arrived at their tenth year the work of thinning has actively begun by the death and speedy decay of the weakest. Thus favored by the access of light and air, the surviving trees shoot rapidly upward, the most aspiring individuals spreading out their crown, overshadowing those lagging behind, which being thus cut off from the influences above all others required for their existence, one after another die. Before the trees have reached the middle stage of their growth the stand of timber in the young forest appears to be firmly established, and during the following period, embracing less than half a century, they have attained the fullness of their growth, furnishing timber fully matured and of the dimensions and quality required by the present standard. Unchecked by destructive influences the rotation of a crop of timber of the Shortleaf Pine produced without the interference or assistance of man, can be said to be accomplished within a period of from eighty-five to ninety-five years.

[1] Charles Mohr: Proceedings of the Fourth Annual Meeting of the American Forestry Congress, Boston, September, 1885.

FOREST MANAGEMENT.

From the place this species is taking among the second growth it can be safely predicted that it is destined to be the timber tree of the future, as far as the Southern States of the Atlantic forest region north of the Longleaf Pine belt are concerned. It is upon this tree that in this section succeeding generations will have to depend for their supplies of pine timber of superior quality, and in which the nearest substitute is to be found for the supplies furnished at present by the Longleaf Pine. That the resources of the latter under the increasing strain to which it is subjected will be completely exhausted before its restoration can be effected is too evident to admit of any doubt.

Among the timber trees of the coniferous order found in the Atlantic forests, there is, then, scarcely a species presenting stronger claims to the attention of the forester than the Shortleaf Pine. As far as its demands upon climate and soil are concerned, it is capable of successfully establishing itself over the immense territory reaching from 30° to 38° north latitude and from the Atlantic Slope to the treeless plains of the West, embracing within these limits areas of wide extent, with all the conditions required for the best development of this species, and in great measure adapted to nothing better than the growth of timber. Of not less importance than its value as a timber tree are its facilities for natural renewal, resulting from the abundant crops of seed produced almost without failure every year and its aggressive behavior toward competing species in the successful struggle for the possession of the soil.

From a closer observation of the young forests of spontaneous growth at different stages, it is apparent that in the establishment and rearing of a forest of Shortleaf Pine, where mother trees exist, nature requires comparatively little assistance from the hands of the forester, and that the efforts of the latter will be chiefly confined to measures of protection against destruction by fire and against the injuries caused by inroads of live stock during the earlier stages of growth. That by thinning out, practiced after the first to the middle or end of the third decade, the forest growth would be benefited, there can be but little doubt. To what extent, by such interference, the production of merchantable timber can be promoted and in quantity and quality improved at the least cost remains a matter of future experiment. In the total absence of facts, based on experiment, no suggestions can be offered on these points other than such as can be deduced from the natural requirements of this species, as already discussed.

In conclusion, it can be safely asserted that the Shortleaf Pine is destined to take a prominent place in the forest management of the future throughout the regions favorable to its growth, not only on account of its economic value in the natural forest, but also in holding out better prospects to the forest planter for the production of timber of higher quality in the shortest time than any tree of the same order in the Southern Atlantic forest region. That the methods of a rational forest management will have to be resorted to at no distant time can with certainty be predicted, although the timber wealth existing at present in the vast territory of its growth may appear enormous.

Of great importance in the reforestation of large areas, this tree is of no less significance to the farmer who is aware of the advantages resulting from the restoration of the tree-covering on his denuded uplands, either originally unfit for profitable tillage or thrown out of cultivation after their exhaustion. By the facility of its natural renewal the Shortleaf Pine affords within a short time a firm protection to the light soil, preventing it from being carried away by wind and rain, providing a shelter for the crops and for insectivorous birds, a lasting income of increasing supplies of timber and fuel on lands that yield no other profit whatever, and to the lands abandoned after their exhaustion a chance for their recuperation while resting under the cover of its shade.

LOBLOLLY PINE PINUS TÆDA.

THE LOBLOLLY PINE.

(PINUS TÆDA Linn.)

HISTORY AND DISTRIBUTION.
PRODUCTS.
DESCRIPTION, BOTANICAL.
DESCRIPTION OF WOOD.
PROGRESS OF DEVELOPMENT.
CONDITIONS OF DEVELOPMENT.
REPRODUCTION.

THE LOBLOLLY PINE.

(*Pinus tæda* Linn.)

Synonyms: *Pinus tæda* Linnæus, Spec. Pl. ed. 1, ii, 1000, excl. habitat "*Canadæ paludosis*" (1753).
Pinus tæda var. tenuifolia Aiton, Hort. Kew. ed. 1, iii, 368 (1789).
Pinus tæda Rafinesque, Flor. Ludovic. 162 (1817), *nomen nudum*.

COMMON OR LOCAL NAMES.

Loblolly Pine (Del., Va., N. C., S. C., Ga., Ala., Fla., Miss., La., Tex., Ark.).
Oldfield Pine (Del., Va., N. C., S. C., Ga., Ala., Fla., Miss., La., Tex., Ark.).
Torch Pine (Eng. lit.).
Shortleaf Pine (La.).
Rosemary Pine (Va., N. C.).
Slash Pine (Va., N. C.), in part.
Long Schat Pine (Del.).
Long Shucks (Md., Va.).
Black Slash Pine (S. C.).
Frankincense Pine (lit.).
Shortleaf Pine (Va., N. C., S. C.).
Bull Pine (Tex. and Gulf region).
Virginia Pine.
Sap Pine (Va., N. C.).
Meadow Pine (Fla.).
Cornstalk Pine (Va.).
Black Pine (Va.).
Foxtail Pine (Va., Md.).
Indian Pine (Va., N. C.).
Spruce Pine (Va.), in part.
Bastard Pine (Va., N. C.).
Yellow Pine (N. Ala., N. C.).
Swamp Pine (Va., N. C).
Longstraw Pine (Va., N. C.), in part.

THE LOBLOLLY PINE.

By Charles Mohr, Ph. D.

INTRODUCTION.

Among the trees remarkable for the part they take in the spontaneous renewal of the forests in the Southern Atlantic region after the destructive interference by man, the Loblolly Pine is most prominent. This readiness to occupy the ground lends to it a special economic significance in forest growth, aside from its value as a source of timber and as an abundant source of fuel. There can be no doubt that in the future management of the forests of the lower Southern States the Loblolly Pine will be assigned a highly important place. This view is confirmed by the fact that in the older of the States within the limits of its distribution, where the original timber growth has suffered greatest reduction, as in North Carolina, the second growth of this tree is largely depended upon to furnish the timber supply for the existing lumbering industry.

Although known to have contributed to the necessities of the earliest settlers of these coasts, and forming at present a large part of the lumber supplies reaching the markets east and west of the Mississippi River, the merits of the Loblolly Pine and its economic bearings are generally but little understood, wide differences of opinion about its value as a timber tree prevailing. Such diversity of opinion is in itself a sufficient reason for a fuller investigation of its life history.

In the preparation of this monograph the writings of F. A. Michaux[1] and Rev. M. A. Curtis[2] and the report of the Tenth Census[3] have been consulted. To Prof. Lester Ward and Mr. Canby thanks are due for valuable information on the distribution of the Loblolly Pine toward its northern limits. Much information of practical value was elicited by the Division of Forestry from numerous manufacturers of and dealers in lumber in the lower part of Virginia and in North Carolina, which has been largely quoted.

HISTORICAL.

The Loblolly Pine was recognized as a timber tree of value by the earliest settlers of lower Virginia and North Carolina. Its timber was largely used in the construction of their dwellings. Michaux states that three-fourths of the houses in lower Virginia were built of Loblolly Pine, and that its mighty trunks, furnishing shafts of clear timber of largest size, were in early days held in high esteem for masts by the navies of the world. The distinctive characters of the tree were clearly understood by the earliest writers on North American botany. F. A. Michaux defined the northern limits of the tree and its distribution in the southern Atlantic States, and first pointed to its economic value. The Rev. M. A. Curtis gives an account of its distribution in North Carolina and recognized the form distinguished in that State as Slash Pine or Rosemary Pine. Investigations of the forest growth by the writer, under the direction of Prof. Charles S. Sargent, for the Tenth Census, and later investigations made in the transmississippi region, under the direction of the Division of Forestry, have led to a more accurate knowledge of the

[1] Michaux, F. A. The North American Silva. Philadelphia, 1856.

[2] Curtis, M. A. The Timber Trees of North Carolina. Geol. and Natural History Survey of North Carolina. Part III, Botany. Raleigh, 1860.

[3] Volume 9 of the Tenth Census. Charles S. Sargent.

distribution of this tree in the Southwestern States, to the establishment of its western and northern boundary lines, and to a more general appreciation of its economic importance in its eastern and western range.

GEOGRAPHICAL DISTRIBUTION AND ECONOMIC HISTORY.

The Loblolly Pine extends from the Delaware and Maryland peninsula through lower Virginia to Cape Malabar, in Florida, and all over the Gulf States and southern Arkansas to the Colorado River in Texas (see Pl. XVIII). The northern limit of the Loblolly Pine can be described by a line drawn from the lower part of Newcastle County, Del., through the District of Columbia, to Petersburg, Va., thence toward middle North Carolina, following in its western course nearly the thirty-fifth degree of north latitude to the southern boundary of Tennessee, through southern Arkansas to the southeastern confines of the Indian Territory. Its most western station is an isolated tract of small extent near Bastrop, Tex., the sole and last representative of the Atlantic pines in the Southwest.

Michaux the younger established the northern limit of the Loblolly Pine near Fredericksburg, Va., between the Rappahannock and Potomac rivers; M. A. Curtis placed it in or close to the District of Columbia. Its occurrence in the District was, however, considered doubtful, or merely accidental, until in 1888 it was confirmed by Dr. George Vasey, who discovered a group of fullgrown trees in the woods near the Reform School. Mr. William Canby states that he "found in the lower part of Newcastle County, Del., a good many Loblolly Pines, and from the point mentioned it becomes more and more plentiful and widespread in the Delaware-Maryland peninsula."

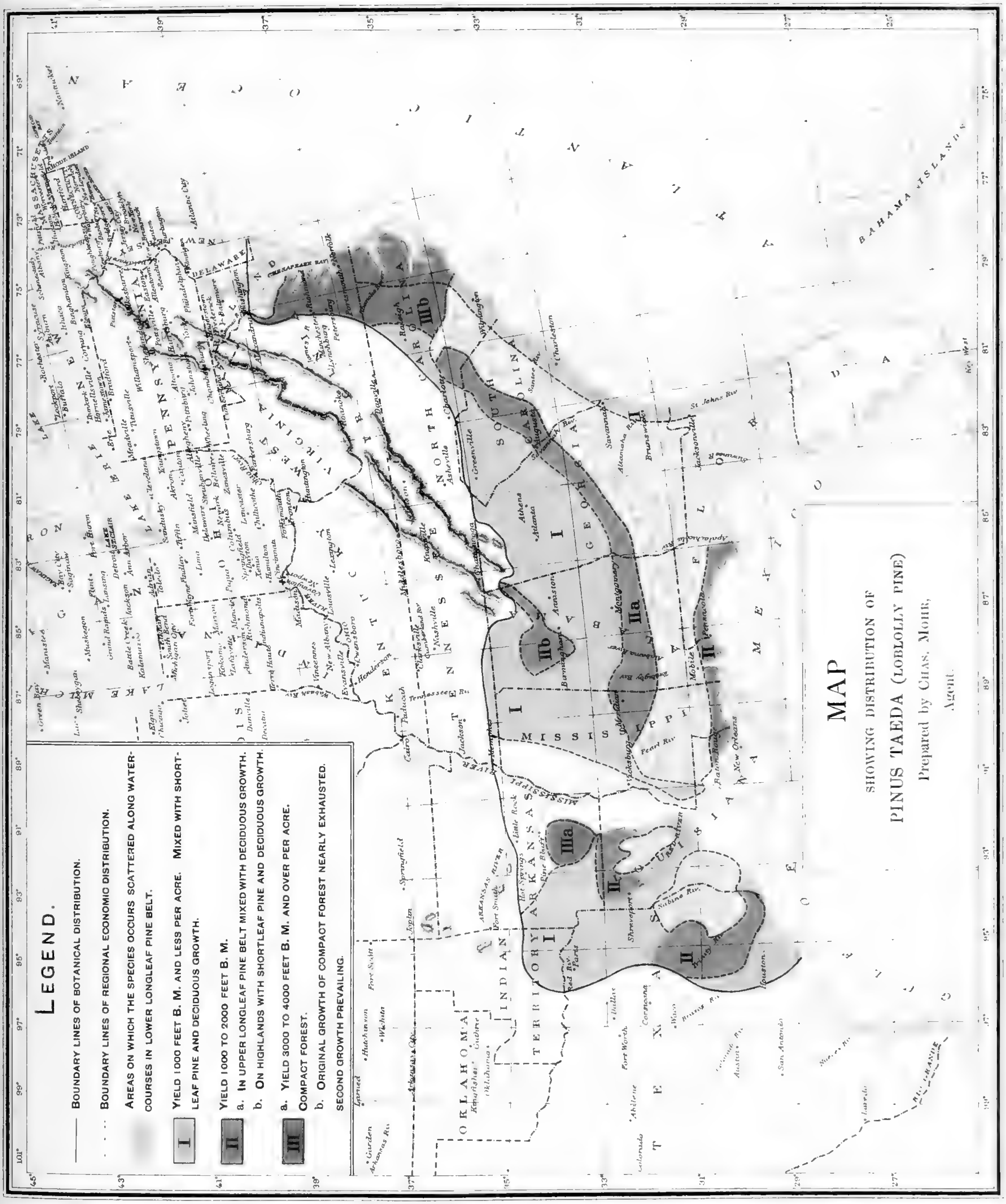
On the Atlantic Slope, near its northern limit, the Loblolly Pine occurs most frequently in the flat lands of the tidewater districts, forming rarely continuous forests, more frequently less compact bodies of timber, associated with the Shortleaf Pine, oaks, and other hard-wood trees.

In Virginia this tree is not found beyond the northern limit of the Tertiary strata of the coast region, and is not met with west of Petersburg and Richmond.

In the lower part of this State, as in North Carolina, the Loblolly Pine was formerly found in great perfection and abundance—broad forest belts of Loblolly alternating with forests of Shortleaf in Michaux's time. The original forests have, however, in a great measure disappeared, and their progeny, of second or third growth, is now depended upon as the principal source of lumber. On the lands exhausted by the earlier planters, and which have been abandoned for several generations, the timber of this Sap Pine, or Oldfield Pine, has in many localities attained dimensions and a degree of maturity fitting it for all purposes for which timber of the original growth is employed. This important fact is confirmed by parties engaged in the lumber business in southeastern Virginia and in eastern North Carolina.

From information received it is evident that in these parts the second growth of Loblolly Pine is chiefly depended upon for the manufacture of lumber. It is, however, to be presumed that the Shortleaf Pine contributes not a small part of the timber supply. Both of these trees are known by the inhabitants as Shortleaf, or Shortstraw, Pine, and their timber is sawn indiscriminately; the proportions of the lumber of either reaching the markets can therefore not be determined. Mr. Joseph Allard, jr., of Richmond, reports that most of the Virginia Pine is Loblolly Pine, and that every fifty years will produce trees large enough for sawlogs, three to each tree, averaging 16 feet in length. Mr. Sparrow, of Brooke, Stafford County, states that the pine of this county, and in Caroline County, is almost entirely of the Oldfield Pine (Loblolly Pine), and that in the latter from thirty to forty sawmills are cutting this pine. Messrs. J. E. and Edward Rogers, from Suffolk County, each remark that "large quantities of lumber are manufactured from Oldfield Pine, which is fast taking the place of Yellow Pine (*Pinus echinata*), the latter having been used up by the sawmills in this section." The young timber is, according to the same accounts, cut into joists, uprights, and other square stuff for framing; the best quality is selected for flooring, ceiling, and other inside finish, the lumber being sold under the name of Virginia Pine in the markets of Washington, Baltimore, and Philadelphia.

On the coast of southern Virginia the Loblolly Pine forms about 75 per cent of the timber standing. According to all accounts the original growth is rapidly disappearing, but the exceed-


LEGEND.
BOUNDARY LINES OF BOTANICAL DISTRIBUTION.
BOUNDARY LINES OF REGIONAL ECONOMIC DISTRIBUTION.
AREAS ON WHICH THE SPECIES OCCURS SCATTERED ALONG WATER-COURSES IN LOWER LONGLEAF PINE BELT.
I YIELD 1000 FEET B. M. AND LESS PER ACRE. MIXED WITH SHORT-LEAF PINE AND DECIDUOUS GROWTH.
II YIELD 1000 TO 2000 FEET B. M.
a. IN UPPER LONGLEAF PINE BELT MIXED WITH DECIDUOUS GROWTH.
b. ON HIGHLANDS WITH SHORTLEAF PINE AND DECIDUOUS GROWTH.
III a. YIELD 3000 TO 4000 FEET B. M. AND OVER PER ACRE. COMPACT FOREST.
b. ORIGINAL GROWTH OF COMPACT FOREST NEARLY EXHAUSTED. SECOND GROWTH PREVAILING.
MAP
SHOWING DISTRIBUTION OF
PINUS TAEDA (LOBLOLLY PINE)
Prepared by Chas. Mohr, Agent.
Scale
600 Miles

ingly large area of exhausted lands abandoned in that section by the cultivators during a long period of time has been taken entire possession of by this tree.

In North Carolina the Loblolly is the predominating tree throughout the eastern coast plain and in the lower part of the State, where it forms extensive forests, more or less frequently interspersed with Longleaf Pine. South of Cape Fear River, however, the latter prevails almost exclusively. In the extensive region watered by numerous streams flowing into Albemarle and Pamlico sounds, in the rich, moist soil of the wide swamps above tide water, the Loblolly reaches its best development, attaining dimensions which place this tree among the timber trees of first order. The primeval forests of this pine have, however, almost completely disappeared in this region, and with them the gigantic trees of this species known by the people as Rosemary Pine, once so highly prized and eagerly sought in shipbuilding. Farther south, in the low pine barrens, this tree is largely superseded by the Longleaf Pine, and is principally confined to the borders of the swamps and to the bottoms along the water courses. Throughout the lower part of the coast pine belt, after the removal of the original timber growth, the progeny of the Loblolly Pine immediately takes possession of every opening, and particularly of the fields thrown out of cultivation.

"The principal kinds of Loblolly recognized by the lumbermen under distinct names are:

"1. Rosemary Pine, the best kind from the trees of best development, of a fine grain but heavy, hard, durable, with but a small proportion of sapwood. At present scarcely known by name at the mills in the section where half a century ago it abounded.

"2. Swamp or Slash Pine, of a coarser grain, with about one-half of the diameter of the tree in sapwood. This kind comprises most of the timber of original growth, and the oldest and best matured second growth.

"3. Oldfield Pine, by the rapidity of its growth, is very coarse-grained and for the greater part sap, scarcely one-fourth of the diameter being heart. At present the principal source of the timber supplies in the coast region."[1]

At the sawmills at Goldsboro, close to the border of the Longleaf Pine region, over 50 per cent of the lumber sawn is Loblolly Pine. On a trip through the forests between the Neuse and Trent rivers it was observed that the Loblolly Pine forms over two-thirds of the tree covering, almost entirely of second growth, of dimensions to furnish sawlogs of from 10 to 18 inches mean diameter by a length of from 15 to 30 feet. The sandy swells and knolls rising above the flats originally covered with the Longleaf Pine are not infrequently occupied by a young growth of Loblolly. The mills at Newbern and vicinity are almost solely depending for their lumber supplies upon these forests of second growth. The same conditions are prevailing in Duplin and in Pender County, by the reports of operators. Mr. C. C. Williams, at Teacheys, in Duplin County, states that 66 per cent of the timber sawn is Loblolly Pine, mostly of second growth, furnishing timber for creosoting and lumber for building purposes.

Mr. Bauman, at Burgaw, reports that the Oldfield Pine (Loblolly of second growth) is coming more and more into use every year, and the demand for this kind of lumber is greatly increasing. In a number of the Newbern journals of 1891 it is stated that over 60,000,000 feet of lumber, board measure, were produced in 1891 by the mills of that place and the vicinity. In the bulletin quoted the output of the nine mills in operation during 1893 is given at 38,000,000 feet, board measure. The timber delivered at the mills sells for about $5 per 1,000 feet, and the price of rough lumber averages $12.

In the latest report on the forests of North Carolina the acreage of the Loblolly Pine, including the land covered with the second growth, and where the Loblolly Pine is taking the place of the Longleaf Pine, is stated as exceeding 4,000,000 acres. The standing merchantable timber can be said to cover 1,150,000 acres. Allowing 4,000 feet, board measure, to the acre, this will make 4,600,000,000 feet of standing Loblolly Pine in 1893. The total cut of Loblolly Pine for the same year has been reported at 290,000,000 feet, board measure.[2]

In South Carolina and Georgia the Loblolly Pine is confined all over the coast pine belt to the more or less swampy borders of the pine barrens scattered among the broad-leaf evergreens and

[1] The Forests, Forest Lands, and Forest Products of Eastern North Carolina. W. W. Ashe, p. 41, Bull. 5, N. C. Geol. Survey.

[2] W. W. Ashe, Bulletin No. 5, North Carolina Geol. Survey, Raleigh, 1894, p. 41.

deciduous trees peculiar to these latitudes—the Magnolia, Sweet and Red Bay, Black Gum, and Titi, associated with the Cuban Pine. The timber of the Loblolly Pine produced in these swamps is of inferior quality, with the sapwood from 4 to 5 inches on a radius of from 8 to 12 inches. It has been noticed that among the original tree-covering Loblolly Pines above 2 feet in diameter were frequently found affected with dry or red rot.

On the dry rolling pine uplands of these States to the foot of the mountain ranges, rising to an elevation of 800 to 1,000 feet above sea level, as well as of the Gulf States east of the Mississippi, this pine is found more or less dispersed among the hard-wood timber, but is considered of no value except for fuel; the trees branch a short distance above the ground and the timber is too knotty to be fit for lumber.

Five trees from the damp, flat pine barrens bordering upon the swamps, felled for test logs in Hampton County, S. C., showed the following dimensions:

Measurements of five trees.

Number of rings on stump.	Diameter at breast high.	Height of tree.	Length of timber.	Diameter below crown.	Sapwood on radius of butt.
	Inches.	*Feet.*	*Feet.*	*Inches.*	*Inches.*
103	26	118	55	17	5½
103	22	118	70	14	4½
80	17	103	66	13	3½
95	19	112	53	14	....
63	14	90	54	9	3

In peninsular Florida the Loblolly Pine is more rarely found, its place in the old fields being taken either by Cuban Pine or the Florida Oldfield Pine (*Pinus clausa*).

In the eastern Gulf States throughout the coast pine belt the Loblolly Pine is scattered along the swamps bordering the water courses. Until of late years it has been cut only on special orders for low-priced stuff intended for temporary purposes. As an instance, the fact may be cited that the millions of feet of square sawn timber and of lumber required for the buildings of the New Orleans World's Exposition were mostly Loblolly Pine, sawn at Pearlington, Miss. Since the introduction of the dry-kiln it is extensively used for flooring and inside finish. In the fresh, deep soil of light loam of the coast plain and the valleys in the upper part of the pine belt—the region of mixed growth—this tree is found in great perfection. In these districts it furnishes clear sticks of from 50 to 60 feet and over in length. A considerable proportion of the long and heavy sticks of hewn timber reaching the Mobile market for export as "pitch pine" coming from the upper division of the coast pine belt in Alabama are Loblolly Pine. The timber of the Loblolly Pine from the table-lands of north Alabama is of excellent quality, with but a small proportion of sapwood from 2 to 3 inches on a radius of from 10 to 12 inches, heavy, of a fine close grain and hence of greater durability and strength. The lumber from that region finds a ready market, being used for all the purposes of the house carpenter, and is indiscriminately sold with the product of the Shortleaf Pine.

On the table-lands of the Warrior coal field the Loblolly Pine is better developed than in any other part of this or the adjoining State of Mississippi. If not found in compact forests of any considerable expanse, it forms bodies of heavy timber covering the flat and badly drained tracts, from a few to many acres in extent, associated with the hard wood growth peculiar to a moist soil. It might be said that about one-half of the pine timber growth of these highlands consists of the Loblolly Pine.

The following measurements have been taken of trees felled in Cullman County, Ala., from heavily timbered land several acres in extent:

Measurements of four trees.

Rings on stump.	Diameter breast high.	Height of tree.	Length of timber.
	Inches.	*Feet.*	*Feet.*
78	21	101	41
156	24	103	40
100	22	101	45
137	19	106	57

In Louisiana, west of the Mississippi bottom, the Loblolly Pine is found frequently scattered in the level woods bordering upon the grassy marshes of the coast. North of the region of the Longleaf Pine on the pine flats with a poor, sandy, undrained soil, between Lake Beaudeau and Bayou Dauchitt, extending to the Arkansas State line, this species forms the principal tree covering. The tree is cut only for local consumption in the absence of means of transportation.

In Arkansas heavily timbered forests of Loblolly Pine cover the flat woods in the southeastern part of the State and the region of the Tertiary and Post-Tertiary formation. The lower levels in the rolling uplands are covered with heavily timbered forests of the Loblolly Pine. It forms in this State an important factor in the manufacture of lumber. From observations made in the logging camps in connection with the principal points of production along the St. Louis and Iron Mountain Railroad south of Gurdon and on the St. Louis and Southwestern Railroad it can be safely assumed that about one-half of the lumber cut and shipped as "Yellow Pine" to Northern markets from southwestern Arkansas is Loblolly Pine, the other half being Shortleaf. The flood plain of the Little Missouri River and the Ouachita River is covered with extensive forests of this tree. The deep soil, a stiff sandy loam, flooded after every rainfall, produces a heavy and finely developed timber growth. Upon one acre, representing fairly the average of the merchantable timber standing, 30 trees were counted of from 12 to 48 inches in diameter at breast high; of this number were found: One tree 48 inches in diameter at breast high, length of timber estimated at 40 feet; one tree 36 inches in diameter at breast high, length of timber estimated at 35 feet; three trees 30 inches in diameter at breast high, length of timber estimated at 35 feet; seven trees 23 inches in diameter at breast high, length of timber estimated at 35 feet; three trees 15 inches in diameter at breast high, length of timber estimated at 35 feet; fifteen trees 12 to 15 inches in diameter at breast high, length of timber estimated at 24 feet.

Measurements of four trees.

Rings on stump.	Diameter at breast high.	Height of tree.	Diameter below crown.	Length of timber.
	Inches.	*Feet.*	*Inches.*	*Feet.*
85	17	85	12	47
150	21	105	14	58
83	20	96	12	37
110	22	109	12	68

The timber of these trees was almost free of any defects; sap from 3 to 4 inches on radius.

In Texas this species is distributed in greater or less abundance to the south and southwest of the Shortleaf Pine region over an area exceeding 6,800 square miles. There is even less basis for statistical statements regarding timber standing at present and consumption than for the Shortleaf Pine, since it is not even recognized as a particular species, and always cut together with the latter, especially between the Trinity and the Brazos rivers. No data have lately been obtained of the annual production of lumber derived from the Loblolly Pine forests in this State, but in the light of the statements of the Tenth Census[1] it must contribute largely to the timber supplies of this State. According to this authority, the merchantable timber of Loblolly standing in 1880 was estimated at 20,907,000,000 feet, board measure, and the cut for the same year at 61,500,000 feet, board measure.

PRODUCTS.

VALUE AND USES OF THE WOOD.

Considered solely as the source of furnishing an abundant and cheap material for purposes where strength and durability are not the first considerations, the Loblolly Pine would be entitled to take its place among the timber trees of greater importance. The average tree of full growth, as it is generally found in the original forest on a poorer soil, furnishes timber with a fair proportion of heartwood, with sticks of from 30 to 50 feet and over in length, free from blemish and in some points scarcely inferior to the timber of the Shortleaf and sometimes even of the Longleaf Pine. In fact, the selected lumber of Loblolly classes with the latter in many of the markets for the same

[1] Charles S. Sargent, report of Tenth Census, Vol. IX, p. 511, 1884.

uses by the house carpenter, while the inferior grades are largely consumed for secondary purposes. Of late years the value of the lumber even of lower grades has been much enhanced by the process of kiln-drying, now universally introduced into the mills. After the removal of the water from the sapwood by exposure to a current of heated air, the lumber loses its proneness to get discolored or to "blue" by the rapid development of the mycelium of a fungus and greatly gains in its capability of a good finish, as well as in durability, and is thus rendered suitable for many purposes for which, without such treatment, it would be rejected.

The consumption of Loblolly Pine lumber is constantly on the increase in the markets of the North, as the lumber of the White Pine becomes scarce and more expensive. The sappy timber of second growth is every year coming more in demand, especially in foreign markets, where this cheap timber is rendered durable by creosoting. In the highest state of perfection, which is only attained in the regions most favorable to its development, no other pine was deemed of higher value or was more eagerly sought after for masts and other heavy spars of ships. Before the use of iron in naval construction for these purposes, the Loblolly Pine timber of largest size was eagerly contracted for in all the Southern ports by every one of the maritime powers of Europe. In consequence, the trees which could furnish timber of the dimensions and qualities required for such purposes have become exceedingly scarce, and can be said to have almost entirely disappeared.

The Rev. M. A. Curtis, in his account of the Loblolly Pine,[1] quotes the following statement on the habitat and the dimensions of this tree, from the pen of Mr. E. Ruffin, of Virginia, which, illustrating a feature of the life of the Southern forest forever past, I can not refrain from introducing here:

> This (Slash Pine) tree grows only on low, moist lands, and is the better for timber and grows larger in proportion to the richness of the land. Among other gigantic forest trees on the rich and wet Roanoke swamps, mostly of oak, poplar, gum, etc., the few pines which yet remain tower above all others; I have visited several standing trees and stumps of others which have been cut down and which measured 5 feet in diameter, and were supposed to have been from 150 to 170 feet high.

In evidence of the dimensions of the trees, the writer gives the sizes of the squared sticks cut in Bertie County, made into a raft, and shipped in 1856 by way of the Dismal Swamp Canal to New York. These sticks varied from 50 to 86 feet in length by a mean diameter of from 26 to 31 inches, containing from 347 to 537 cubic feet each. Remarking further:

> All of these sticks are nearly all heartwood; thence it follows that the proportion of heartwood must have been very large, the timber must have been resinous or it would not be good, and it must be durable or it would not serve for masts and other long spars for ships exposed to the alternations of wetting and drying, and for which only the best materials are permitted to be used.

The inferior growth of the Loblolly Pine furnishes vast supplies of cordwood. Immense quantities are shipped from the coast of Virginia and North Carolina to the large cities on the Atlantic seaboard. It is chiefly used where a brisk flame with a quick heat is required, viz, in bakeries, brickkilns, and the kilns of potteries. In its fuel value, the wood of this tree ranks with the better class of resinous trees. Large quantities of the wood are also used for the burning of charcoal.

RESINOUS PRODUCTS.

Regarding the production of resinous products from this pine there has existed a wide divergence of statements. A. F. Michaux states that this tree affords turpentine in abundance, but of a less fluidity than that of the Longleaf Pine, and suggests that as it contains more sapwood a deeper incision would yield a larger product. Rev. M. A. Curtis follows Michaux in this statement, and the writer, relying upon the information from operators in south Alabama, was also led into the error of supposing this tree to yield an abundance of resin for distilling, similar to the free-flowing resin of the Cuban Pine, and published a statement to the effect that this tree was tapped wherever found. A trial box made at the request of the writer seemed to confirm the opinion as to the character of the resin. It appears now, however, that the tree boxed (not inspected by the writer) could not have been a Loblolly, for lately a number of true Loblolly Pines, tapped accidentally in a turpentine orchard, were found in Washington County, Ala., and showed that the resin

[1] M. A. Curtis: Trees and Shrubs of North Carolina, Raleigh, 1860, p. 23.

of this pine does not flow freely and hardens so rapidly on exposure that it can not be profitably worked. An experienced operator at the place confirmed this to be the experience everywhere with this kind of pine. The statements regarding the use of this tree for its resinous product can therefore only be explained by a confusion of names applied to the different pines, and it was most likely the Cuban Pine to which the operators referred.

In a report lately published by the State geologist of North Carolina the remark is made: "It is said that the crude turpentine of the Loblolly Pine has so much water in it that it yields only a poor spirits of turpentine."[1] This, to be sure, is a misconception; but the statement confirms the fact that this species is not tapped for its resin, which had also been observed by the writer a short time previously in the Loblolly Pine forests of North Carolina as well as South Carolina and Georgia.

From an extensive series of analyses of the resin of fresh specimens of both Longleaf and Loblolly Pine collected in Georgia and South Carolina, it appears that the wood of Loblolly contains but little less resin than that of Longleaf; that the distribution of resin in the log is practically the same, and, what seems most remarkable, that the composition of the resin, as far as the relation of spirits of turpentine and rosin is concerned, is nearly the same (being quite variable in both), so that the absence of free "bleeding" or abundant resin exudation can not be due to a lack of liquid oil, but must be caused by other physiological peculiarities.

NOMENCLATURE AND CLASSIFICATION.

The Loblolly and half a dozen other species, mostly Pacific and Mexican,[2] form a natural group of timber trees included in Englemann's *Eutadæ*, which might fitly be designated as the group "torch pines," and can be characterized as embracing trees, mostly of larger size, with more or less resinous, coarse grained wood, long leaves by threes in a fascicle, and with lateral cones provided with thick, woody scales bearing a stout, sharp prickle. The distinctive characters of this species have been early recognized by Pluckenet, one of the earliest writers on American plants[3] and Linnæus described the tree under the name of *Pinus tæda*[4] which was adopted subsequently by all botanists. The name given to this pine by Linnæus in 1753 has never been changed. In 1789 Aitan established a variety, *P. Tæda* var. *tenuifolia* (Hort. Kew., III, 368), which, however, has not received recognition.

BOTANICAL DESCRIPTION AND MORPHOLOGY.

Leaves three in the close, elongated sheath, 6 to 9 inches long, slender, stiff, rigidly pointed, channeled, and strongly keeled on the upper side, of a pale green color; cones nearly sessile, single, in twos or threes, roundish-ovate or ovate-oblong, about 3 inches long, with the scales hard and woody, the pyramidal apophysis with a strong, recurved prickle; seeds small, their wing an inch or over long.

This species is easily distinguished from its most frequent associates—the Longleaf and Shortleaf Pine—by its slightly glaucous foliage at all seasons, and by its more slender and almost smooth terminal buds; from the former and from the latter by the more robust shoots and buds; and from both the species named, and also from the Cuban Pine, by its characteristic cones.

ROOT, STEM, AND BRANCH SYSTEM.

The stout taproot of this pine is assisted by powerful laterals which divide into numerous branches and descend into the soil, usually at a short distance from the trunk; but where a hard, compact subsoil is encountered they are often seen to run for a greater or less distance near the surface. In the localities most favorable to its growth, the massive trunk of the Loblolly Pine is in its dimensions not surpassed by any other pine of the Atlantic forest region. In such cases the tree attains a height of 120 to 150 feet and over, with a diameter of from 4 to 5 feet breast high, and with the trunk clear of limbs for a length of from 60 to 80 feet.

[1] The Forests, Forest Lands, and Forest Products of Eastern North Carolina, by W. W. Ashe. Bulletin 5 of the Geological Survey of North Carolina, 1895.

[2] Engelmann's revision of the genus Pinus. Transactions of the St. Louis Academy of Sciences, vol. iv, p. 177.

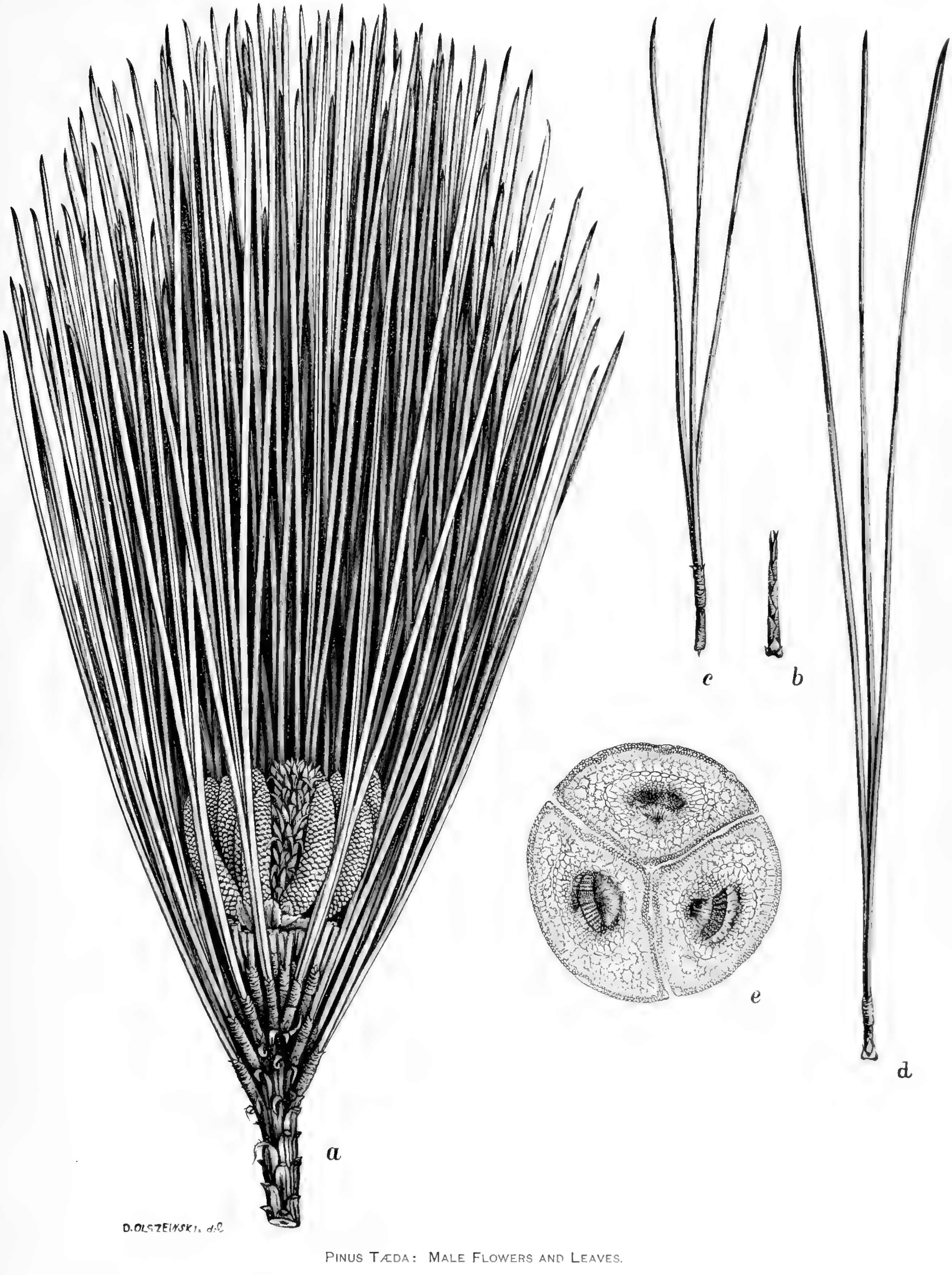
[3] Pluckenet: Amalges tum botanicum. London, 1696.

[4] Linnæus: Species plantarum, 1000, 1753.

EXPLANATION OF PLATE XIX.

[Figures natural size, except when otherwise noted.]

Fig. *a*, branch bearing male inflorescence; *b*, young fascicle of leaves (spring); *c*, *d*, forms of mature leaves; *e*, transverse section of leaf bundle showing structural characters of the leaf (as explained for *Pinus echinata*, *f*, *f*); magnified 20 diameters.



PINUS TÆDA: MALE FLOWERS AND LEAVES.

Such trees, however, have at no time been plentiful and at present are rarely met. In its average growth the diameter of the trunk, breast high, measures from 20 to 24 inches, and the height from 95 to 110 feet. In wet places, somewhat distended at its base, the trunk tapers very gradually to the crown, which covers from one-third to one-half of its height. The lowest limbs are horizontally spreading, and toward the upper part of the tree they become gradually more erect. The largest limbs are rarely found over 20 feet in length. The primary branches dividing in a regular order of ramification into numerous branches and branchlets, the crown becomes full and compact toward the top. The bark of the full-grown tree is, in the lower part of trunk, from 1 to 1½ inches thick, generally rough, of a grayish color, becoming smoother, flaky, and reddish brown as the tree grows older.

LEAVES.

The leaves are united, to the number of three, in a smooth, close sheath, which in the young foliage is about 1 inch long and in the next season scarcely half that length. (Pl. XIX, *c*, *b*, *d*.)

In the bushy growth of less than ten years the leaves are scarcely 5 inches in length, resembling closely the foliage of the Shortleaf Pine of equal age. Prof. L. Ward notes this resemblance as a singular fact, which, as he very pointedly remarks, has the effect of obscuring the gradual appearance of this species among the young growth of the Shortleaf Pine.[1] In the following years the leaves are from 7 to 9 inches long, less densely crowded on the slender branches than in the Longleaf and Cuban Pine, and persisting to the third year; the foliage is of a more open spray. The leaves are stiff, slightly twisted, roughish on the finely serrulated edges and the prominent midrib, channeled on the upper side, abruptly tipped by a rigid, sharp point (Pl. XIX, *c*, *d*), and of a pale green color. They are scarcely one-sixteenth of an inch wide, about half as thick, and present in the cross section on the dorsal side a convex and on the ventral side a strongly triangular outline. Examined under the microscope they show on both surfaces from 10 to 12 rows of rather large breathing pores (stomata), alternating with rows of numerous hypodermal or strengthening cells, in several layers. The cells of the bundle sheath are thin walled; the fibrovascular bundles are, on their ventral side, surrounded by a single row of small strengthening cells. The rather large resinous ducts, from 3 to 5 in number, are peripheral, and placed irregularly mostly about the angles (Pl. XIX, *e*); sometimes smaller ducts are observed close to the bundle sheath.

FLORAL ORGANS.

The staminate flowers are crowded, from 18 to 20 in number, below the apex of the youngest shoot. (Pl. XIX, *a*.) They are from three-fourths to one inch long, of sulphur-yellow color, and surrounded at the base by from 8 to 10 ovate to lanceolate, leathery, involucral scales; the lowest pair is much shorter than the others and strongly keeled; those of the uppermost row are longest, narrow, lanceolate, and reflexed. The anthers are crowned with an erect orbicular crest. After the discharge of the pollen the flowers are gradually shed. The pistillate flowers form an oblong, erect catkin, borne on a short stalk, singly, in pairs, sometimes 3 to 4, below the apex of the shoot (Pl. XX, *a*) of the season, which by the time of blooming has already reached a length of several inches and is covered with the well-advanced leaf buds. Including their stipe, the female aments are about one-half to three-fourths of an inch long, surrounded by from 15 to 20 involucral scales similar to those of the staminate flower. The carpellary scales are ovate, lanceolate, tapering to a sharp, erect, and somewhat reflexed and twisted point. The small bracts subtending the scales are orbicular, scarcely covering their base.

The flowers open, in the coast region of the lower Southern States, about the second week of March (Mobile, Ala., March 15 to 20), and in the interior from four to five weeks later (Cullman, Ala., April 25).

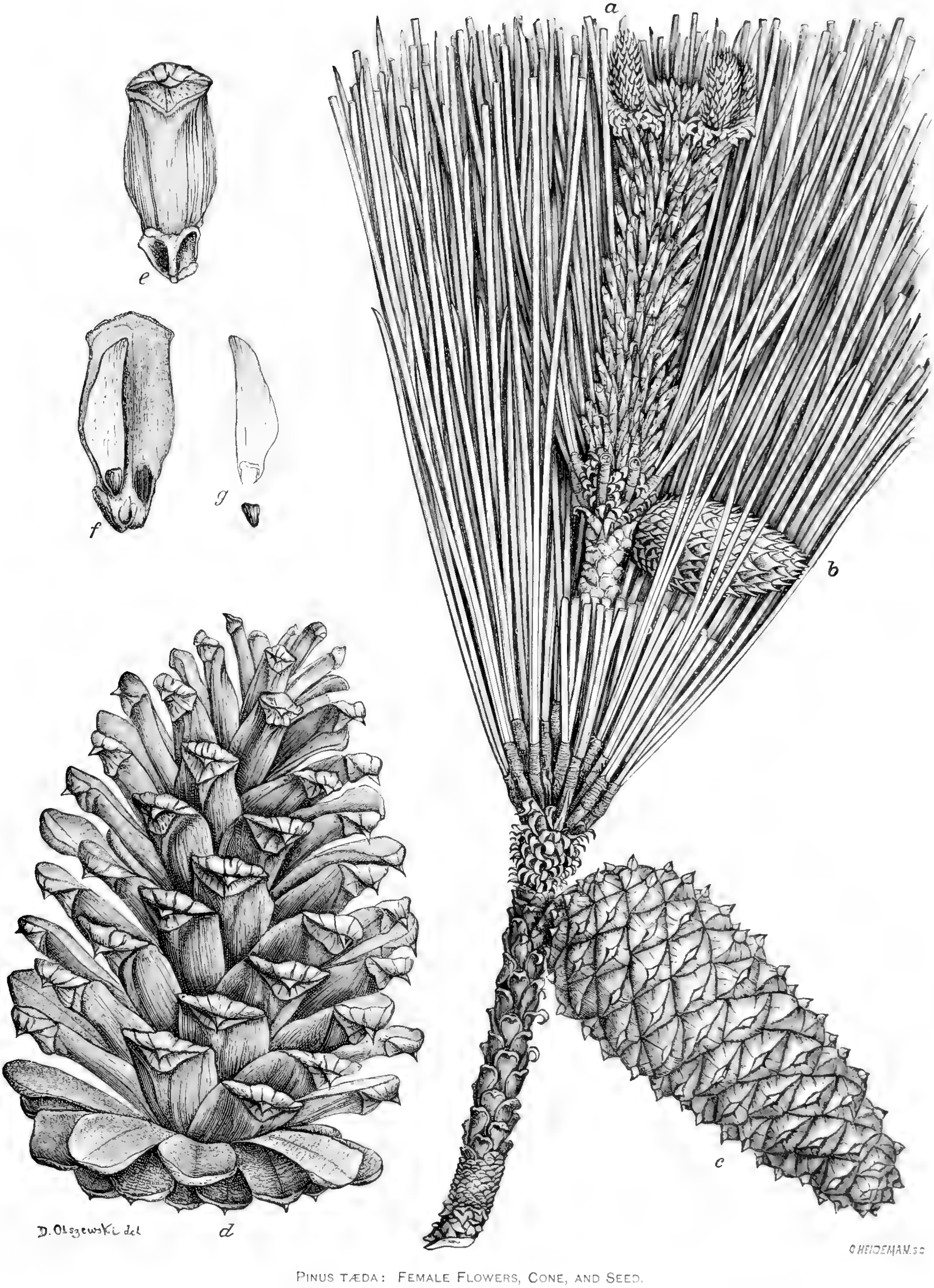
Immediately after pollination the female catkins increase rapidly in size; before ten days have passed the carpellary scales have doubled in size, and their tips become stiffly erect, the bracts having remained stationary in their growth, and the fertile shoots having grown to the length of 8 inches and over. This period passed, the growth of the conelets during the rest of the season proceeds very slowly.

---

[1] L. Ward: Botanical Gazette, February, 1886.

EXPLANATION OF PLATE XX.

Fig. *a*, branch bearing two subterminal aments of female flowers at end of shoot of the season; *b*, immature cone of one season's growth; *c*, mature closed cone of two seasons' growth; *d*, mature open cone after shedding seed; *e*, cone scale, outer or dorsal side, showing the broad umbonate apophysis end with its sharp transverse ridges and the stout reflexed prickle; *f*, inner or ventral view of the same with the seed in place; *g*, seed and wing detached.



D. Olszewski del.
C. HEIDEMAN, sc.

PINUS TÆDA: FEMALE FLOWERS, CONE, AND SEED.

At the beginning of the second season the immature cones are scarcely one-half inch wide and less than an inch long (Pl. XX, *b*), and from that time on increase in size and by the following October have reached their maturity. The ripe cones are lateral, almost sessile, broadly conical or ovate in shape, rarely over 3 inches in length (Pl. XX, *c*, *d*), when fully opened 1½ to 2 inches wide, and of a light wood-brown color. The pyramidal, swelled, exposed ends (apophyses) of the hard, woody scales with a sharp transversal ridge are armed with a stout, straight, or slightly reflexed prickle. (Pl. XX, *e*.) Having reached their maturity, the cones open slowly, the seeds being gradually discharged during the fall and winter seasons. The cones are apt to remain on the tree till the end of another year, and when they finally separate from the branch by the breaking loose of their very short stalk, leave none of their basal scales behind. The seeds are irregularly truncate or rhomboid in outline, inflated, sharp-edged, with two to three more or less distinct ridges, roughish, dark brown to almost black, and surrounded to the base by the narrow border of their delicate wing (Pl. XX, *g*, *f*), which is over an inch long and from one-fourth to one-eighth of an inch wide.

THE WOOD.

Among the pines of the southern Atlantic forests noted for their economic importance the Loblolly is held least in value as a timber tree. This opinion is chiefly founded on the lesser durability of its wood, being more speedily given to decay under the combined influences of dampness and air, and also on the supposition of its being of less strength than the other pine timbers. There is scarcely a timber tree existing that shows wider differences in the quality and value of the timber. This is strikingly demonstrated when the timber of a tree of full average growth, grown on land broken by the plow, is compared with the timber of a tree in its highest perfection taken from the primeval forest. In the former case the wood is crossgrained, sappy, and quick to decay. In the latter it is finer grained, resinous, has less sapwood, and approaches the timber of the Longleaf Pine.

In general, the well-marked, lighter-colored sapwood is quite broad, and usually about 4 inches, frequently 6 inches and more. It is wider in young, thrifty trees, narrower in old and stunted or slow-grown timber; forms about 60 to 70 per cent of the total volume of stems over one hundred years of age, and 80 to 90 per cent of trees sixty to one hundred years old. The formation of heartwood does not begin before the age of twenty-five, the process being retarded as the tree, or better the particular part of the stem, grows older, so that while the innermost sapwood in a log or disk with twenty-six rings is twenty-five years old, the innermost sap ring is thirty-five years old when the log attains the age of forty-five; it is forty-five years old when the log is sixty-five, and about seventy or even more years old when the log reaches the age of one hundred and fifty or two hundred. It follows that the sapwood is formed of fewer rings in young trees and in the upper part of older stems, but owing to the greater rapidity of growth in these parts the width of the sapwood does not always follow this same law. Since neither width of the ring, nor that of the denser summerwood, the thickness of the cell walls, nor any other important structural feature is changed when the wood of any ring changes from sap to heart wood, the prevalent notions of sapwood being necessarily either coarse or fine grained, light, and weak, are erroneous. The sapwood of a young, well-grown tree is coarse-grained, heavy, and strong; that of an old tree is fine-grained, light, and weak. Since durability on exposure is not to be expected of the sapwood of any pine, the prejudices against the sapwood, and therefore all young timber of this particular kind, are unwarranted. With proper treatment, it will serve all purposes for which any pine wood of its grain and weight can be employed.

Owing to the great amount of water-soaked sapwood the weight of green Loblolly timber is very great, varying chiefly between 50 and 55 pounds to the cubic foot, with the sapwood commonly approaching 60 pounds to the cubic foot. Kiln-dried, the wood of the entire trunk of trees one hundred to one hundred and fifty years old weighs about 33 pounds per cubic foot. In such trees the wood of the log 50 feet from the ground is about 20 per cent lighter (and weaker) than that of the butt log, and the wood next to the bark in the butt log is 15 to 20 per cent lighter than the wood of the inner fifty to sixty rings.

In strength the wood of the Loblolly varies chiefly with weight (the same degree of seasoning always presumed), and keeping this in mind, compares favorably with that of any other conifer.

For well-seasoned wood, the following figures represent the average of hundreds of tests on specimens specially collected for this purpose:

	Lbs. per sq. inch.
Modulus of elasticity	1,950,000
Transverse strength	10,100
Compression endwise	6,500
Shearing with the fiber	690

Since the average weight of the test pieces was 40 pounds per cubic foot, being heavier than the average weight of the wood, these figures must be taken about one-sixth lower than given above to represent the true average for the wood of the species.

Like the wood of most conifers, that of Loblolly dries easily and rapidly. In doing so the green lumber loses a large amount of water, dependent chiefly on the proportion of sapwood. Though quite variable, the water in fresh sapwood commonly forms 50 to 60 per cent of the weight, while in heartwood it little exceeds 25 per cent.

The shrinkage consequent on drying amounts to 11 to 12 per cent of the volume; is greater in the lumber of the butt than in that from the top logs, varying in this respect from 13 per cent at the butt to about 10 per cent in the top, a difference which appears due to the difference in the weight of the wood of the different sections. As in other pine, about two-thirds or seven-eights per cent of this shrinkage falls to the tangent (i. e., is along the rings) and about 4 to 5 per cent to the radius.

In kiln-drying, the wood may be taken fresh from the saw and behaves extremely well, suffering no great injury, a fact which has greatly enhanced its value by facilitating its exploitation.

For the details of wood structure, consult the comparative study by Mr. Roth appended to these monographs.

PROGRESS OF DEVELOPMENT.

The crops of seed are produced quite abundantly every year and copiously dispersed over the vicinity of the mother trees by the wind, the offspring quickly taking possession of old fields and clearings in the forest.

The seeds germinate in the early spring. The ends of the cotyledons remain for a short time after germination inclosed in the endosperm. The number of the germinal leaves (cotyledons) is mostly six, rarely seven. At the time of the unfolding of the cotyledons the lower (hypocotyledonary) part of the axis of the plant is about 1 inch in length. The rootlets are half that length, and are provided with several acropetal secondary rootlets. The caulicle grows rapidly, and is soon covered with the stiff, needle-shaped, and strongly serrulated primary leaves. Before the spring season has passed the bundles of secondary or foliage leaves make their appearance in the axils of the former. At the close of the summer season the plantlet has attained a height of from 6 to 8 inches, the upper part of the stem covered with foliage leaves, the acerose primary leaves of the lower part having completely withered. In examining a large number of young plants never less than three leaves in a bundle have been found during this or any subsequent stage of the growth. With the second year the primary leaves have all become reduced to the ordinary form of the leaf bract—lanceolate, acuminate, with fimbriate white hyaline edges and tips.

In all the specimens examined it was found that the growth of the main axis proceeded less rapidly during the second session, but produced a regular whorl of from three to four lateral axes. At the close of the second year the main stem rarely exceeds 10 inches in height.

At the end of their third year the plants are from 18 to 20 inches high, the stem being from one-fourth to five-sixteenths of an inch in thickness. The branches, forming regular whorls, are erect and produce in their turn whorls of secondary order. The root system shows a corresponding increase, the taproot being from 6 to 8 inches long, with numerous stout lateral roots.

RATE OF GROWTH.

With the fourth year the Loblolly Pine enters seemingly upon the period of quickest growth. As ascertained by many measurements, the trees at the end of their fourth year average 3 feet in height and from one-half to seven-eighths of an inch in diameter, and at the end of the fifth year measure nearly 5 feet and from 1 to 1¼ inches in diameter. At the beginning of the seventh year the tree attains a height of 10 feet, and with the close of the first decade trees are found 12 to 16 feet high and from 2¾ to 3 inches in diameter. Some trees begin to mature their first cones by the tenth year.

The above measurements were made in 1890 in the vicinity of Cullman, Ala., on trees taken indiscriminately from the midst and near the border of a dense pine thicket covering a field plowed for the last time in 1882, and from an adjoining opening in the forest protected from fire and but rarely used for pasture.

According to a number of measurements made of trees in the southern Atlantic States, the Gulf region, and southern Arkansas, the Loblolly Pine reaches at the tenth year, on the average, a height of 20 feet, doubling this height during the succeeding decade. During this period of quickest growth the increase in height proceeds at the rate of 2 feet per annum, and trees twenty years old average 4½ inches in diameter breast high. At the age of fifty years the trees are from 65 to 75 feet in height (average about 70 feet) and 15 inches in diameter breast high. The annual increase for this period of thirty years is about 1 foot in height and 0.35 inch in diameter. From numerous observations it appears that the Loblolly Pine attains the fullness of its growth at the age of one hundred years, with a height, on the average, of 110 feet and a diameter breast high of 2 feet, the length of merchantable timber varying between 50 and 60 feet. The annual rate of height growth during the second half century is about eight-tenths of a foot, and the diameter growth eighteen one-hundredths of an inch. Henceforth the growth in height remains almost stationary. A dozen trees from one hundred to one hundred and fifty years old were found to vary from 99 to 125 feet in height, with a length of trunk free from limbs of from 60 to 68 feet and from 19 to 27 inches in diameter at breast height.

From the annexed tabulated records of growth it becomes evident that under similar conditions of soil and exposure the rate of increase for the various stages of growth show but slight differences in localities widely distant from each other.

TABLE I.—*Growth from five to fifty years.*

No. of tree.	No. of rings.	Diameter (breast high).	Height to first limb.	Total height.	Locality.	Remarks.
		Inches.	*Feet.*	*Feet.*		
1	5	1	....	$5\frac{6}{12}$	Cullman, Ala	Clearing made for pasture in 1879; dense pine thicket.
2	5	1	....	4	....do	Do.
3	6	2	....	10	....do	Do.
4	6	1½	....	7	....do	Do.
5	6	1½	....	$8\frac{3}{12}$	Whistler, Ala	Edge of swampy hummock.
6	7	2¾	....	10	Cullman, Ala	Clearing, dense pine thicket.
7	7	3⅛	....	12	....do	Do.
8	9	2½	....	$13\frac{6}{12}$	....do	Do.
9	9	2¼	....	$12\frac{6}{12}$	....do	Do.
10	10	2¾	....	18	....do	Do.
224	11	2	8	23	....do	Do.
12	12	3⅜	....	20	....do	Do.
13	12	3¼	$7\frac{2}{12}$	24	....do	Do.
223	12	2⅓	10	21	Whistler, Ala	Edge of hummock.
189	13	2	13	19	Gurdon, Ark	Open forest; exposure free.
271	13	2½	13	20	Eastman, Ga	Do.
222	14	3	10	25	Whistler, Ala	Edge of hummock; slightly oppressed; partially covered.
148	14	2¼	8	21	Eastman, Ga	Opening in forest; under cover; fresh soil.
272	14	2	7	21	Gurdon, Ark	Opening in forest; exposure free; damp soil.
221	15	4	12	35	Whistler, Ala	On gentle decline; opening in forest; soil fresh.
222	16	6	13	30	....do	Do.
219	17	6	16	39	....do	Natural opening near swamp; soil damp.
220	18	6	17	43	....do	Do.
221	20	4	28	33	....do	Oppressed.
270	21	4	22	45	Eastman, Ga	Natural opening in forest; under cover.
146	26	4½	28	33	Gurdon, Ark	Natural opening in forest; exposure free.
269	22	4½	32	43	Eastman, Ga	Natural opening in forest; suppressed.
267	22	8	25	55	....do	Old field; fresh, deep loam; free.
268	24	6	17	39	....do	Old field; oppressed.
187	24	4¼	30	47	Gurdon, Ark	In open forest; exposure free.
144	32	6	38	55	....do	Open forest; exposure free.
145	32	6	36	56	....do	Do.
266	35	12	51	77	Eastman, Ga	Old field; deep, rich loam; fresh, young forest trees of similar size.
143	48	16	30	66	Gurdon, Ark	Open forest; soil damp.
14	44	15	33	68	Stockton, Ala	Flat near banks of Tensas River; open forest; exposure free; March 16, 1888, just past flowering.

TABLE II.—*Growth of Loblolly Pine (Pinus tæda) from fifty to one hundred and fifty-six years.*

No. of tree.	Rings in stump.	Diameter. Breast high.	Diameter. Across stump.	Diameter. Below crown.	Height to first limb (length of timber).	Total height.	Locality.	Habitat, and other remarks.
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*		
301	63	14	13½	9½	54	90	Ridgeland, S. C.	Low pine barrens, edge of hummock, soil damp, exposure free.
265	70	16	16½	9½	57	86	Eastman, Ga.	Old field, abandoned one hundred years ago; typical for oldest second growth.
261	73	22	....	....	50	94	....do	Close to edge of swamp; open forest; soil wet; exposure free; sapwood 4½ inches.
302	71	12	10¾	6¼	35	80	Ridgeland, S. C.	Close to edge of swamp; somewhat suppressed.
24	80	21	18¾	....	41	101	Cullman, Ala.	Swampy swale; open forest; exposure free.
299	80	18	16¾	9⅜	66	103	Ridgeland, S. C.	Swampy hummock; exposure partially free.
141	83	20	20	15¾	37	96	Gurdon, Ark.	Low, wet, piny woods; exposure partially free.
139	85	17	15½	12	47	88	....do	Low, wet, piny woods; exposure free.
217	87	21	....	....	40	105	Whistler, Ala.	Low, open forest; soil damp; exposure free.
20	90	22	....	....	46	104	Cullman, Ala.	Wet swale; sandy loam; open forest; free.
300	95	19	19½	12	53	112	Ridgeland, S. C.	Edge of swamp; slightly oppressed; sapwood 5 inches.
297	100	27	26½	18¼	56	118	....do	Low, pine barrens; soil damp; near swamp; exposure free; sapwood 5½ inches.
216	101	23	24	18	51	111	Whistler, Ala.	Open forest, on slight decline; soil drained; fresh; exposure free; sapwood 4½ inches.
142	110	22	22	12	68	109	Gurdon, Ark.	Low, rather dense forest; wet; exposure free.
262	117	22	21½	....	69	116	Eastman, Ga.	Edge of swamp; soil damp; partially suppressed.
215	118	19	18¾	....	53	125	Whistler, Ala.	Slight declivity; soil well drained; suppressed.
263	120	22	22½	....	68	99	Eastman, Ga.	Near border of swamp; soil damp; exposure free.
214	128	23	22½	....	59	109	Whistler, Ala.	Open forest; soil fresh; exposure free.
27	137	19	....	....	57	115	Cullman, Ala.	Open forest; damp swale; exposure free.
213	142	27	286	....	54	103	....do	Edge of swamp, damp to wet; exposure almost free.
140	150	21	23	15¾	58	108	Gurdon, Ark.	Flat, wet, rather dense forest; exposure free; slightly oppressed on the sides.
25	156	24	25½	....	39	103	Cullman, Ala.	Wet swale; sandy loam; exposure free.

From Table III and the corresponding diagram, based upon a considerable number of trees, it appears that the Loblolly Pine is nearly 40 feet high when twenty years old; that the length of the merchantable timber (60 feet) is attained at the age of forty; that this shaft has a basal diameter of 20 inches at the age of one hundred years, and that the age of thrifty growth is practically at an end when the tree is one hundred and ten years old. Comparing this table with those for Longleaf and Shortleaf pines, the excellence of the Loblolly becomes apparent.

TABLE III.—*Rate of growth of Loblolly Pine.*

Age.	Diameter with bark (breast high).	Length of log with upper diameter of 5 inches.	Total height of tree.	Volume.		Periodical accretion or growth per decade.					Average annual accretion.	Current accretion.
				Tree.	Log up to 5 inches diameter.	Decade.	Diameter.	Height.	Area of cross section.	Volume.		
Yrs.	*Inches.*	*Feet.*	*Feet.*	*Cu. ft.*	*Cu. ft.*		*Inches.*	*Feet.*	*Sq. feet.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
10	3.4	....	18	0.60	....	First	2.4	18	0.03	0.60	0.06	0.06
20	5.6	....	37	3.05	....	Second	2.3	19	.08	2.45	.14	.24
30	7.8	23	50	8.72	7.49	Third..............	2.2	13	.14	5.67	.29	.57
40	10.0	35	61	16.63	15.45	Fourth	2.0	11	.17	7.91	.41	.79
50	11.8	44	70	25.30	24.12	Fifth	1.8	9	.19	8.67	.57	.87
60	13.3	52	78	35.65	34.47	Sixth	1.6	8	.19	10.35	.59	1.03
70	15.5	60	85	49.02	47.88	Seventh	1.5	7	.21	13.37	.70	1.33
80	17.1	68	90	62.44	61.44	Eighth	1.4	5	.21	13.42	.78	1.34
90	18.7	76	95	78.02	77.16	Ninth..............	1.1	5	.19	15.58	.87	1.56
100	19.5	80	98	89.41	88.59	Tenth	.9	3	.16	11.39	.89	1.14
110	20.2	83	100	96.00	95.23	Eleventh	.8	2	.13	6.59	.87	.66
120	20.7	85	102	102.00	101.23	Twelfth	.5	2	.10	6.00	.85	.60

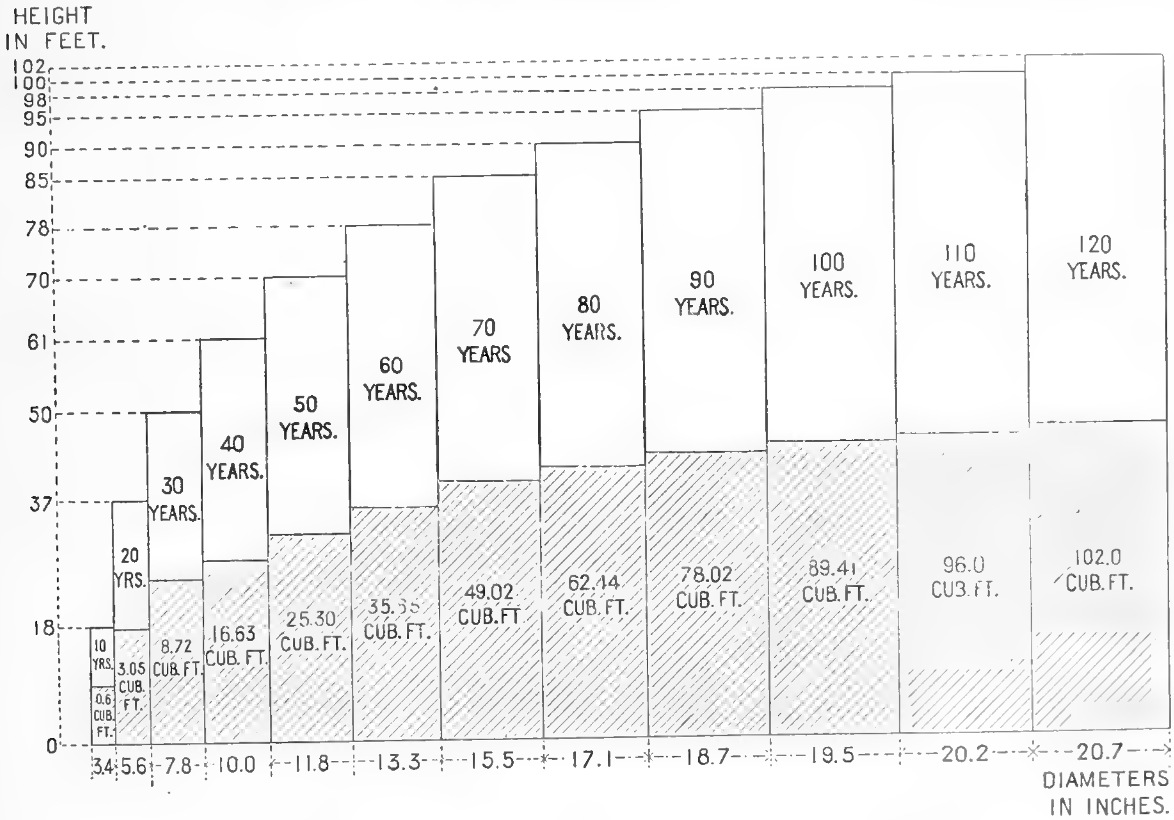


FIG. 12.—Growth of Loblolly Pine: Height, diameter, and cubic contents of average trees at 10, 20, etc., years of age.

CONDITIONS OF DEVELOPMENT.

SOIL AND CLIMATE.

The Loblolly Pine prefers a moist, cool, sandy or light loamy soil, which, if not always moist, should have a greater retentiveness for moisture than is required by most of the other upland pines. It reaches its greatest perfection in the perpetually moist or fresh forest lands, with a soil of a sandy loam, rich in vegetable mold—the accumulation of ages—which border the swamps of the coast region. The tree is not found on the porous, highly siliceous soils of the more elevated uplands, where the Longleaf Pine almost exclusively prevails; it also avoids heavy clay and calcareous soils of the uplands and the alluvial lands.

The Loblolly Pine is a tree of austral regions confined to the humid belt of the Austro-riparian or Louisiana zone and the lower border of the Carolinian life zone, which, on the Atlantic Coast, follows quite closely the isothermal line of 56° F.; westward, in the direction of the Gulf Coast, the isothermal line of 60°. The mean temperature of the winter along the northern limit is about 45°, with the lowest temperature only occasionally falling below 10° F. This tree approaches the Appalachian zone only under the influence of a peninsular clime between the Delaware and Chesapeake bays.

The Loblolly appears to be indifferent to the wide differences in the amount of atmospheric precipitation existing within the vast range of its distribution. Extending from Florida (isotherm, 71°) to the 39° of north latitude on the Atlantic Coast (isotherm, 56°), it is found of equal thrift on the Gulf shore, with its damp air and annual rainfall exceeding 64 inches, and in the flat woods of Texas, where the mean annual precipitation is only one-half that amount, with a mean of 6 inches during the winter months. In fact, the Loblolly Pine is found most frequently and is more widely distributed in the districts of lesser precipitation. It is certainly more dependent on the supplies of soil moisture than upon atmospheric humidity.

RELATION TO LIGHT AND ASSOCIATED SPECIES.

This species is less exacting in its demands for direct sunlight than the kindred species within its range. To this relation may be ascribed the success which it achieves in the struggle for the possession of the soil with the Shortleaf Pine. Observing this contest as it is going on between the competing species in the forest, the conditions of the soil being equally favorable, the Loblolly Pine, under the cover of shade, outstrips the Shortleaf Pine under the same conditions; and, on the other hand, where the sunlight has had unhindered access, it gives way to its competitor, being then subjected to the disadvantage resulting from a speedier desiccation of the soil. Through such influences it is that, under conditions seemingly equally favorable to either one of these pines, now the one and now the other is found to predominate.

In the deep forests covering the rich swampy lands of the coast regions, the Loblolly Pine forms comparatively a small part of the rich and varied growth consisting chiefly of deciduous trees, Black Gum, Sweet or Red Gum, Water Oak, and Mockernut, to which in the lower South the Magnolia, Sweet Bay, Red Bay, and Cuban Pine are to be added. Although requiring less sunlight than most pines, in the gloomy impenetrable shade of these dense forests the progeny of the Loblolly Pine has no future, especially as these lands once cleared are devoted to tillage, being of great agricultural value.

On the lands of a poorer, more exposed soil in the maritime plain of the southern Atlantic States, in Virginia and North Carolina, and in southwestern Texas, this pine forms more or less compact forests. In these forests the tree is always succeeded by its own progeny, either in the course of nature or after the artificial removal of the original forest growth. On the coast of Georgia, in Florida, and in the coast plain of the eastern Gulf States, the Loblolly Pine is scattered among the Cuban and the Longleaf Pine; there its second growth meets a formidable competitor in the first named of these species. In the flat woods, deprived of drainage, the Cuban Pine is always found to vastly outnumber the Loblolly among the young forest growth. In the upper part of the great maritime pine belt the Loblolly Pine is frequently found among the mixed growth of Magnolia, Spanish, Red, Post, and Blackjack oaks, Mockernut and Pignut Hickory, Shortleaf Pine, and Southern Spruce Pine. Throughout this region the tree takes almost undisputed possession of the old fields.

In the interior, on the uplands of oaks and Shortleaf Pine, the Loblolly is sure to gain the upper hand and to retain its hold among the young forest growth, giving way to its most aggressive competitor, the Shortleaf Pine, only when under the disadvantage of a greater exposure and a greater lack of moisture in the soil.

ENEMIES.

Principally confined to low, damp localities, not easily liable to invasion by the frequent conflagrations which scour the Southern pine forests, the Loblolly Pine suffers less from destruction by fire than any other species. In virtue of the inherent facilities for its natural renewal resulting from its fecundity and from the rapidity of its development from the earliest stages of growth, any damages inflicted by that agency are more easily repaired. The same causes afford it also greater protection against incursions of live stock. As also observed in the Shortleaf Pine, the rapidly growing seedlings form, after a few years, thickets of such density as to be avoided by the larger quadrupeds, and by the time such thickets, in the course of natural thinning out have become more open, the trees have reached dimensions which place them beyond the danger of being tramped down or otherwise injured by live stock. The rapid spread and thrift of the second growth, unprotected and uncared for, observed everywhere within the range of the distribution of this pine, are witnesses to its greater immunity from such dangers.

Owing to the large amount of sapwood, the timber of the Loblolly is more liable to the attacks of fungi and to the ravages of insects. The mycelium (spawn) of large polyporous fungi is found frequently infesting the woody tissue of the living tree, the hyphæ (filaments) of the spawn destroying the walls of the wood cells, causing the wood to assume a reddish color and rendering it brittle in the same way as is observed in the living Longleaf Pine timber affected with the disease called "red heart." It seems that the destruction caused by this disease in the Loblolly Pine is from the start more rapid in consequence of the larger proportions of sapwood, and perhaps also on account of the broader bands of soft springwood naturally accompanying wood of rapid growth.

In a piece of wood examined in north Alabama, the filaments of the spawn of one of these fungi crossing each other in every direction were found to form a dense film interposed between the spring and summer wood, causing its easy separation in the direction of the concentric rings, and, as the destruction of the wood proceeds, forming finally a compact layer of the nature of amadou, or tinder. In the longitudinal section the rays were found full of cavities, caused by the breaking down of the cell walls, and these cavities were filled with the white film of these filaments, which similarly affected the adjoining tracheids of the resinous summerwood.

The felled timber left on the ground is soon infested by a host of fungi of the genera *Agaricus*, *Tramites*, *Lentinus*, *Polyporus*, and others, the nearer identification of which has not been undertaken.

From the very limited observations that have been made it clearly appears that this pine suffers equally as much, if not more than the other pines of Southern growth from insect enemies of various kinds. The larvæ of the same capricorn beetles (*Cerambicidæ*) burrow in the body of the timber. Those of the round-headed borers (*Caleophora*) dig their channels in the sapwood, as is indicated by the occurrence of several species of jumping beetles (*Buprestidæ*) which are found clinging to the leaves and branches of this tree. The most fatal injury it sustains is caused by the bark borers (*Tomicidæ*); this pest particularly affecting the trees during the formation of the last cambium layer in the later summer months. Trees felled in August are immediately infested by multitudes of these destroyers. Favored by a high temperature and an abundance of nourishment, several generations of them succeed each other before the close of the season, the countless broods soon infesting every tree in the vicinity and carrying their work of destruction over the full expanse of the young forest growth. Under this affliction the forests often present, by their drooping rusty-colored foliage, a sad picture of disease and decay. Weevils (*Curculionidæa*) deposit their eggs in the youngest tender shoots; the larvæ which hatch from them eat their way into these shoots, causing their decay, and thus destroy the symmetry of the tree and impair the usefulness of the resulting timber. Other species of the same family puncture the older branches, lay their eggs in the exuded resin, their larvæ injuring the tree in a similar way. The larvæ of spittle insects injure the terminal buds, which are also found infested by the larvæ of Pitch-moths (*Retiniæ*), causing them to wither. The foliage seems to be less frequently attacked by sawflies (*Lophyrus*) than the tender young leaves of the Longleaf Pine, as by the rapidity of their growth the young leaves sooner harden, and are therefore less relished by these depredators. The evidences of the work of the pine-leaf miners (caterpillar of *Gelechia*) have been freequently observed in Alabama, and everywhere are seen the deformities caused by gall flies and scale insects.

NATURAL REPRODUCTION.

If the Shortleaf Pine has been spoken of emphatically as the future timber tree of the light rolling uplands of the interior, the Loblolly Pine might be fitly designated as the timber tree of greatest promise in a large part of the coast plain from the middle Atlantic States to the limits of compact forest growth beyond the Mississippi River. The promptness with which it colonizes the old fields and other clearings, and the tenacity with which it retains from one generation to another the ground once taken possession of, clearly point to the important part this tree is to take when the ruthless stripping of timber lands practiced at present gives place to the management of the forests under a system of fostering care, tending to their future maintenance and to the disposal of their resources on the principle of true economy with an eye to the future welfare of the country. No timber tree will be found better adapted for forest planting in the southern part of the Atlantic forest division. It is only in the narrow belt of flat woods along the shores of Florida, Georgia, and the eastern Gulf region that it is likely to find its superior in the Cuban Pine (*Pinus heterophylla*).

Besides the advantages of adaptability to varied soil and climate, it excels in rapidity of growth during the earliest stages, and the copious production of seeds, which, almost without fail, are plentifully distributed every year over the vicinity of the parent trees. As an evidence of the facility with which the reproduction of a compact forest by this pine is effected, it is only necessary to point out the spontaneous groves near the settlements, representing, as they do, every stage of development.

In the coast region the second growth, if not interfered with under proper soil conditions, yields in fifty to sixty years timber of dimensions rendering it fit to be sawn into lumber well adapted for various uses, as already mentioned.

CONCLUSION.

In this attempt at a sketch of the life history of this tree, the object was constantly kept in view of placing its value among the products of the Southern forests in the proper light. From the consideration of the structure of the wood and its physical properties it clearly appears that although inferior to the wood of the Longleaf and Cuban pines, the timber of this species fully equals that of Shortleaf Pine, and that the present practice of treating them as equivalent seems therefore justified.

As an abundant and cheap source of timber of inferior grades, and especially when the rapidity of its growth is considered, the Loblolly Pine is of no less economic importance than the other timber trees of the same section. At present held in low esteem in the great lumbering districts of the lower South, where the supplies of the superior timber of the Longleaf Pine still abound and receive the preference, the value of the timber of the Loblolly Pine is quickly recognized in other districts which, but a short while ago boasting of similar resources, are now stripped of them. Its physiological peculiarities make it an important factor in the future forestry of this section. Its propagation is successful over a vast expanse in the southern section of the Atlantic forest region, and by its productive capacities, mode of development, and behavior toward competing species in the struggle for existence, the Loblolly Pine possesses great advantages for its natural and artificial renewal, adapting it particularly for the restoration of the forests on the lowlands of the maritime region.

THE SPRUCE PINE.

(PINUS GLABRA Walt.)

HISTORICAL.
DISTRIBUTION.
ECONOMIC IMPORTANCE.
BOTANICAL DESCRIPTION.
PROGRESS AND DEVELOPMENT.
ENEMIES.
REQUIREMENTS OF DEVELOPMENT.

THE SPRUCE PINE.

(*Pinus glabra* Walt.)

Synonyms: *Pinus glabra* Walter, Fl. Caroliniana, 237 (1788).
Pinus mitis β (?) *paupera* Wood, Cl. Book, ed. 41, 660 (1855).

COMMON OR LOCAL NAMES.

Spruce Pine (S. C., Ala., Fla.).
Cedar Pine (Miss.).
White Pine (Fla.).
Walter's Pine (S. C.).
Lowland Spruce Pine (Fla.).
Poor Pine (Fla.).

THE SPRUCE PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

The Spruce Pine is the least common of the pines found in the lower Southern States. The tree is frequently confounded by the inhabitants with the Shortleaf Pine, to which it is closely related. Its vernacular names are, in different sections of its range, applied to several other pines; in Florida to the Sand Pine (*Pinus clausa*), in north Alabama to the Scrub Pine (*Pinus virginiana*), and in the southern part of this State even to the Cuban Pine. Although never forming extensive bodies of timber, being for the most part widely scattered among the broadleaf evergreens and deciduous trees with which it is associated, and in the quality of its wood of low rank, this little known tree has been given a place here among the monographs of the timber pines of the South Atlantic forest region in order to dispel for the future its confusion with some of these trees, and at the same time to attract the attention of the tree planter to it as the only one of its kind which thrives and propagates in the shade, keeping its ground closely surrounded by the luxuriant and varied tree growth with which it is associated, and soon outstripping the same by the rapidity of its growth. Considering that among all others of its kind in the same region it attains the fullness of its growth in the shortest time, with dimensions which render it valuable for many of the purposes for which the softer and lighter kinds of timber are used, its economic importance can not be ignored.

HISTORICAL.

The Spruce Pine was first recognized as a distinct species and described as *Pinus glabra* by Walter, in his Flora Carolinensis in 1788, having since that time been known under this name by the botanists. Hidden in the remote semiswampy dense forests, it escaped the attention of later botanists. Neither the Michauxs, father and son, nor Nuttall were aware of its existence. It was unknown for fully three-fourths of a century until rediscovered by Professor Ravenel in the swamps of Berkeley County, S. C. Ten years later the tree was described in Chapman's Flora, 1860. It was recognized by Professor Hilgard in the Pearl River Valley, Mississippi. In 1880 its distribution was traced by the writer through the Gulf region to its western limit in the eastern parishes of Louisiana.

DISTRIBUTION.

The Spruce Pine is a tree of the southeastern Atlantic forest, confined to the subtropical region or the Louisianian zone of American botanists, within that part of the coastal plain of the southern Atlantic and the Gulf States embraced between the thirty-first and thirty-third degrees of north latitude; from South Carolina through middle and northwestern Florida to Louisiana, with its western limit between the Pearl and Mississippi rivers. This tree is mostly found single or in groups on the low terraces with a fresh or damp soil rich in humus, rising above the swamps subject to frequent overflow. It is seldom seen to form compact bodies of timber; such have only been observed between the Chattahoochee and Choctawhatchee rivers, in northwestern Florida, where, to all appearances, this tree finds its best development on isolated tracts of fertile red loam lands.

ECONOMIC IMPORTANCE.

Nowhere forming pure forests of any extent, this pine is of little importance to the lumbering interests of the present, and its timber has never become an article of commerce. Although the timber is of inferior quality, it furnishes lumber of dimensions equaling the best of our timber pines. It is light, soft, easily worked, and capable of good finish, and is without doubt fit for many uses of the house carpenter and cabinetmaker in the manufacture of furniture and other purposes. Owing to the large percentage of ash and smaller quantity of resinous matter, the actual fuel value of the wood of the Spruce Pine is lower than that of the other Southern pines: for its resinous product the tree is considered of no value, since the resin does not run when it is tapped.[1]

In its wood the Spruce Pine resembles Loblolly. The sapwood is wide, and even in trees seventy-five to eighty years old it forms more than three-fourths of all the wood. The change from sap to heart wood begins as early as in the pines mentioned, and as in these is retarded with age and also with any suppression of growth, so that in stunted young trees the change begins later, and the sapwood of these, as well as old trees, is always composed of a greater number of rings. While green, the wood is very heavy, weighing 45 to 50 pounds per cubic foot, varying in this respect chiefly with the proportion of sapwood. When kiln-dried, the wood weighs about 27 pounds to the cubic foot; it is heavier at the butt, weighing about 31 pounds to the cubic foot, and lightest near the top, where its weight falls as low as 25 pounds to the cubic foot. As in other pines, the heaviest wood is produced by young trees. The amount of water contained in the fresh wood is quite variable—very great in the sapwood, and consequently in young timber—but falls little below 50 per cent of the weight of green timber on the whole. Its behavior in drying is the same as in light grades of Loblolly; it dries rapidly and without much injury, shrinking, during this process, by about 10 per cent of its volume.

The strength of this wood is, as in other conifers, closely related to its weight. Accordingly, the Spruce Pine is inferior to both Shortleaf and Loblolly.

From careful experiment it appears that its—

	Lbs. per sq. inch.
Modulus of elasticity is about	900,000
Transverse strength	6,000
Compression endwise	4,000

In its structure the wood resembles too closely that of the Loblolly to enable as yet any identification on this feature, and the description for the wood of the Loblolly answers perfectly for the product of this species. As in Loblolly and other hard pines, summerwood and springwood are always well defined, the summerwood forming from 15 up to 40 per cent of the total volume, differing in this respect from the White Pine which it has been claimed to resemble. Thus while decidedly softer on the whole than Loblolly it is by no means to be expected that the Spruce Pine can hope to serve as a general substitute for the true White Pine.

BOTANICAL DESCRIPTION.

Leaves invariably in pairs, with short and close sheath; soft, slender, 1½ to 3 inches long, twisted; cones short-stalked, horizontal or reflexed, the cone scales with a flat apophysis, the depressed umbo unarmed or with a minute weak erect prickle.

The Spruce Pine is readily distinguished by the close bark of its trunk which in the crown and the limbs is perfectly smooth and of a light gray color; in foliage and in cones it resembles most closely the Sand Pine (*Pinus clausa*) of the coast region of Florida and the eastern Gulf States, which however is distinguished by the more prominent apophysis of the cone scales, armed with a short, stout, reflexed prickle. The Shortleaf Pine, to which it is next related, is distinguished by the same characters and further by the fascicles of two and three leaves and the rigid young shoots of the season covered with slender, long, loosely fimbriated bud scales.

The leaves are concave, faintly serrulate, short pointed, and are shed during the latter part of the second season or the beginning of the third.

In the details of their structure they differ little from the leaves of the Shortleaf Pine; the rows of breathing pores (stomata) are numerous on both surfaces; the strengthening cells of the cortical tissue are smaller and less numerous; the resin ducts, two or three, are parenchymatous, the cells of the bundle sheath thin walled. The two fibro-vascular bundles distant and without strengthening cells.

[1] Ravenel: Proceed. of Elliott Society, Charleston, I, 52.

The male flowers are lateral, sessile, and about one-half to three-fourths of an inch long, slender, surrounded by five to six pairs of short ovate, rather obtuse stiff scales, with a narrow, membranaceous lacerated border. The crest of the anther is elliptical, with fine denticulations. The small female aments are mostly single, short stalked, the carpellary scales lance-shaped with slender tips and subtended by the short infertile bract.

The cones are mostly single with a short stalk and of various shapes on the same tree, from round to oblong ovate or more or less cone-shaped, from 1¼ to 2 inches long, and, on the opening of the scales from three-fourths to one inch wide, of a light tawny color. The scales are softer and more flexible than in the Shortleaf Pine, the apophysis broader, with the umbo depressed, unarmed, or with a minute, weak, erect, and deciduous prickle, the ridge faint, hazel-brown on the inside. The somewhat triangular roughish seeds, black with brown specks, about three-sixteenths of an inch long and one-eighth inch wide, separating easily from the wing which is little over one-half inch long and surrounds the seed to the base.

PROGRESS OF DEVELOPMENT.

The Spruce Pine begins to flower and to produce perfect seeds at an age of twelve to fifteen years, in greatest abundance between twenty and forty years; the flowers appear during the earliest part of March; shortly after pollination the female aments assume a horizontal position, and finally become more or less reflected. At the end of the first season the conelets are of the size of a large pea. The cones mature in the second year in the month of September; the seeds are freely shed early in the fall. They germinate during the fall and early in the coming spring; the plantlets, with eight to ten slender, soft cotyledons, are over an inch long. The terminal bud develops rapidly, densely covered with the slender, soft primary leaves which are sharp pointed and frequently over an inch in length. Early in April seedlings are found over one-half foot long, later in the season fascicles of the foliage leaves appear in the axils of the upper primary leaves, when the lower wither and disappear near the end of the season. At this stage the seedlings are generally a foot high with the root system less developed than in its kindred species at the same age; the taproot scarcely 2 inches in length with a few short lateral roots.

With the twentieth year the trees are generally from 30 to 35 feet high and 4 to 4½ inches in diameter, the stem clear of limbs for the length of about 12 feet. They attain their full growth at an age of from sixty to seventy-five years.

The trees for the United States timber tests from the border of the swamps on the banks of the Tensaw River in Baldwin County, Ala., showed the following dimensions and age:

Measurements of five trees.

No. of tree.	Rings on stump.	Diameter breast high.	Length of timber.	Height of tree.	Sap on radius.
		Inches.	*Feet.*	*Feet.*	
458	78	22	45	120	5½
459	53	17	56	96	5⅛
....	46	15	40	65	All sap.
460	75	22	57	99	5
461	83	23	60	116	5

From these figures it appears that the two trees forty-six and fifty-three (average forty-nine) years old have an average volume of 63 cubic feet and grew at the rate of about 1.3 cubic feet, while the three trees seventy-five to eighty-three (average seventy-eight) years old have an average volume of about 152 cubic feet and an average yearly growth of about 2 cubic feet. The following represents a typical case:

Growth of Spruce Pine.

Rings on stump. a	Height of tree.	Diameter without bark.	Volume of wood.	Average yearly growth in—		
				Height.	Diameter.	Volume.
	Feet.	*Inches.*	*Cubic ft.*	*Feet.*	*Inches.*	*Cubic ft.*
10	37	5	2.5	3.7	0.5	0.2
20	51	8.5	9.5	1.4	.3	.7
30	67	12	26	1.6	.3	1.6
45	84	15	51	1.1	.2	1.6

a For age of tree add about three years.

The Spruce Pine attains a height of from 85 to 110 feet and over; the trunk is clear of limbs for a length of from 45 to 60 feet, and it is from 2 to 2½ feet in diameter breast high, seldom exceeding 3 feet. The largest trees observed were about 120 feet in height by a girth of fully 10 feet breast high.

The taproot appears to be less strongly developed than in the Shortleaf, the lower lateral roots run for a short distance close to the surface before penetrating the ground; the bark is close, with deep, narrow furrows, separating in narrow thin scales and of a reddish-brown color. The limbs are horizontal, dividing in rectangular spreading branches and branchlets. The leaves also become in the latter part of the season widely spreading, the density of the foliage being reenforced by the leaves of the short branchlets produced on the older branches from adventitious buds. To this spreading habit of the ultimate division of the branches and of the leaves is due the peculiar spray of the foliage, similar to that of the true cedars.

ENEMIES.

No observations have been made of the injuries inflicted upon this tree by insects. Trees, after having passed the period of full growth, at the age of about 100 years are very frequently affected with decay in the stump and with redheart in the top. In the damp hummock lands the tree is rarely touched by fire. Where the underbrush and the vegetable matter of the soil covering has been destroyed by repeated conflagrations, however, the trees begin to sicken and soon die.

REQUIREMENTS OF DEVELOPMENT.

The Spruce Pine requires the warm climate of the subtropical zone, with a mean annual temperature of about 66° F. and a mean temperature of 49° F. in the winter months (in central Alabama the thermometer falls sometimes to an extreme of 5° F.), and the humid atmosphere of the coastal plain, with a mean annual rainfall of 54 inches, evenly distributed throughout the year. This tree will endure, during the early stages of its growth, more shade than any other of the pines of the Atlantic forest region, perhaps the White Pine (*Pinus strobus*) excepted. Retarded in its growth under severe oppression, it will finally force its way through its close surroundings, and having gained a freer access to light, it pushes its crown rapidly above the broad-leaved evergreens and deciduous trees which luxuriate on the same ground. It demands a loose soil, rich in humus, fresh to moist but not wet, with a deep porous subsoil, which in these lands is frequently a light, sandy loam.

The Spruce Pine is never found in the forest of the alluvial bottoms with their heavy soil, subject to frequent overflow, nor in the dry, sandy pine forests. Where it finds the soil conditions most favorable to its growth, Magnolias, Cucumber trees, Sweet Gum, Mockernut Hickory, and Beech are found of greatest thrift, not infrequently associated with the Shortleaf and the Loblolly pines. The undergrowth on such lands is luxuriant, consisting of Dogwood, Holly, Summer Haw, and a variety of shrubs, Bush Huckleberries (*Vaccinium virgatum*), Farkleberries (*V. arboreum*), Storax Bushes (*Styrax grandifolium*), Cornals (*Cornus sericea*), and Blue Palmetto, forming dense brush interlaced by numerous woody climbers (*Vitis*, *Ampelopsis*, *Wistaria*).

As has been observed in northwestern Florida, where it finds the proper soil conditions, the second growth of this pine soon occupies the clearings made in the original forest. Tracts of young forests of much promise have been met with between the Choctawhatchee and Chattahoochee rivers. The hummock land, forming the home of the Spruce Pine, being with the increase of the population rapidly claimed for cultivation, this beautiful pine will soon be solely confined to the most remote and inaccessible localities. Being the only really soft pine of the Southern States, and having by its shade endurance a peculiar forest value, this tree will probably form an important part in the future, when forestry has become an established business.

NOTES ON THE STRUCTURE OF THE WOOD OF THE FIVE SOUTHERN PINES.

(*Pinus palustris, tæda, echinata, heterophylla, glabra.*)

Sap and Heartwood.
Annual Rings.
Spring and Summer Wood.
Grain of the Wood.
Minute Anatomy.

NOTES ON THE STRUCTURE OF THE WOOD OF THE FIVE SOUTHERN PINES.

(*Pinus palustris, heterophylla, echinata, tæda, glabra.*)

By Filibert Roth,
In charge of Timber Physics, Division of Forestry.

The wood of these pines is so much alike in appearance and even in minute structure that it can be discussed largely without distinction of species. The distinctions, as far as there are any, have been pointed out in the introduction. Here it is proposed to give in more detail the characteristics of the wood structure.

SAP AND HEART WOOD.

All five species have a distinct sap and heartwood, the sap being light yellow to whitish, the heart yellowish to reddish or orange brown. The line of demarcation between the two is well defined, without any visible transition stage. The location of this line does not as a rule coincide with the line of any annual ring, so that the wood of the same year's growth may be sap on one side of the tree and heart on the other. The difference in this condition may amount to ten or twenty rings, which on one side of the same section will be heart, on the other side sap.

There is considerable variation in the relative width of the two zones as well as the number of rings involved in either and also in the age at which the transition from sap to heartwood begins. This age was rarely found to be below twenty years; as a rule the transformation begins in young trees when the particular section of the tree is between twenty and twenty-five years old, but the progress of heart formation does not keep pace with the annual growth, being more and more retarded as the tree grows older, so that while in a section twenty-five years old twenty-two rings may be sapwood, at thirty-five years the sapwood will comprise only thirty rings; at forty-five years, forty rings; at eighty years, fifty rings; and in sections two hundred years old the outer eighty to one hundred rings will still be sap. A young tree of Longleaf Pine (No. 22) was, for instance, found to show the following relations:

Section.	Height from stump.	Age of section.	Rings of sap.
	Feet.	*Years.*	*Number.*
III......	6	46	40
IV......	14	38	33
VII......	22	30	27
IX......	30	24	23
XII......	42	18	17

The change from sap to heart wood begins earlier in young trees than in the younger portions of older trees; in these latter, sections thirty-six and forty years old are quite commonly found still entirely made up of sapwood, while in young trees, as stated above, the change begins before the age of thirty years.

The progress of the transformation is somewhat influenced by the rate of growth; it is slower in slow-growing trees and usually also on the slower-growing radius, i. e., there are more rings of sapwood. The width of the sapwood, on the other hand, stands in relation to the rate of growth in an opposite manner; it is wider in young and thrifty than in old and stunted trees, and widest along the greatest radius of any section; similarly, it is wider in the faster-growing Loblolly, Cuban, and Spruce pines than in the slow-growing Longleaf.

Besides being of a lighter color the sapwood differs from the heartwood in several respects. Its resin is limpid and oozes out of the pores or resin ducts of any fresh cut; that of the heartwood does not flow, except in rare cases, from saturated pieces or "light wood." The sapwood contains much less rosin—both rosin and turpentine—than the heart wood. Thus in a section of Longleaf the sapwood contained only 0.2 per cent of turpentine and 1 per cent of rosin, while the heart contained from 2 to 4 per cent of turpentine and 12 to 24 per cent of rosin, and though this is an extreme case the heart generally has three to five times as much resinous matter as the sap. The fresh sapwood contains three to five times as much free water as the heartwood and is, even when seasoned, more hygroscopic and subject to relatively greater shrinkage than the heart. This capacity for taking up water readily is probably one of the reasons why sapwood decays more readily. In addition, the parenchyma cells of the medullary rays and resin ducts (see further on) contain, at least in the outer parts of the sapwood, living protoplasm and reserve food materials which are readily seized upon by fungi which cause "bluing" and decay. Such living tissue does not exist in the heartwood. The heartwood in old logs generally is heavier than the sapwood. This is not due to any later thickening or growth of its cell walls, after their original formation, but is due chiefly to two causes:

1. The heartwood of old logs was formed when the tree was younger, and made, naturally, heavier wood.

2. The accumulation of resin in the heart already referred to increases often very considerably the weight of the heartwood.

In the same way the sapwood of old logs, such as supply the sawmills, is weaker than the heartwood of the same logs, but this is not because the wood is in the sapwood condition, but because it is lighter and its summerwood per cent smaller, being, as stated before, the product of old age when heavy and strong wood is no longer formed. Chemically the wood substance of sapwood is practically like that of heartwood; the coloring substances which permeate the cell walls in heartwood appear to be infiltrations, i. e., deposited in the walls from solutions; they are insignificant in amount, and their true nature, especially the processes leading to their formation, are not yet fully understood. The most modern views which consider these coloring bodies or heartwood substances as products of oxidation of tannin still require confirmation.

ANNUAL RINGS.

The layers of growth, known and appearing on any cross section as annual rings, show very distinctly in the wood of these pines. In a section 8 or 10 feet from the ground the rings are widest at the center, of considerable width for the first thirty to fifty rings, the period of most rapid growth in height; then they grow more and more narrow toward the periphery. In the last sixty to one hundred rings of very old logs the decrease is very small, the rings remaining practically of the same width. The same year's growth is usually wider in the upper part of the stem, both in young and old trees, but the average width of the rings is naturally greater in the upper part only of young trees; in old and also in stunted trees it is smaller, since in these the upper portions do not share in the more rapid growth of the early years.

Rings over half an inch wide are frequently seen in Loblolly and occur in Spruce Pine; rings one-fourth of an inch in width occur in very thrifty saplings of all five species, but the average width of the rings for sapling timber is usually less than one-fourth of an inch, commonly one-eighth. In trees over one hundred years old it drops to one-twelfth of an inch and even below. The average width of the rings is normally smallest in Longleaf Pine, being one-twenty-fifth of an inch and less. (See also tables and diagrams of rate of growth in the introduction, as well as in the several monographs.)

The influence of orientation on the width of the rings is completely obscured by other, more potent influences, so that sometimes the radius on the north side, other times that of some other side, is the greatest; and it is a common observation to see this relation vary within wide limits, even in the trunk of the same tree.

Stunted trees of Longleaf Pine over one hundred years old with an average width of ring of one-fiftieth of an inch are frequently met with in old timber; of the other species no such trees were observed. The decrease of the width of the rings from center to periphery is never perfectly uniform. Not only do consecutive rings differ within considerable limits, but frequently zones of narrower rings, including thirty or more years' growth, disturb the general regularity. Where these zones consist of very narrow rings, one-fiftieth of an inch or less, the wood is of distinctly lighter color and weight. Since the value of this class of wood depends not only on its strength and stiffness but also on the fineness of its rings (grain), in so far as the grain influences both the appearance and the ease of shaping as well as other mechanical properties, the width of the annual ring is of great importance, from a technical point of view, the finer-ringed (grained) wood of the same weight always deserving and mostly receiving preference.

The rings of the limbs are narrower than the corresponding rings of the stem. Moreover, they are usually of different widths on the upper and lower side of the same branch, those of the latter excelling in width those of the former. Frequently the wider lower part of a ring of a branch appears like a "lune" on the cross section, quite wide (one-eighth of an inch and more) in its lower median part, and scarcely visible, often entirely fading out, on the upper side. This difference is commonly accentuated by the appearance of the wood itself. In the upper part the wood of the ring is normal and light colored, owing to a very small summerwood per cent; on the lower wide part, the "lune," the wood is commonly of reddish color, either even throughout the entire width of the ring, or else in several varicolored bands, which give the appearance of two or more separate ill-defined rings. Sometimes the earliest formed springwood is included in this unusual coloration, at other times only the median portion of the ring. This "red wood," as it has been termed by the French and German writers, is composed of very thick walled cells and increases markedly the weight of the wood, so that the wood of the side containing it is usually much the heaviest. It is of interest that the several "lunes" in any cross section occur rarely, if ever, exactly one above the other, but commonly the radius passing through the middle of one "lune" makes an angle of 20 to 40 degrees with the radius passing through the middle of another "lune." Often successive "lunes" show considerable deviation in position and commonly differ in width or degree of development. Accepting the most recent explanation of this phenomenon as expressed by Hartig and Cieslar,[1] it would appear that the formation of these broad "lunes" of especially strong cells is due to pressure-stimulus on the growing cambium, caused by the weight of the limb and its peculiar position, increased at all times by movements of the limb due to the wind. Moreover it seems that the formation of one well-developed "lune" relieves for a time the pressure, and with it the necessity for a repetition of this formation. These "lunes" are most conspicuous in the limbs of these pines near the trunk, and disappear at variable distances from the trunk and with them disappears the eccentricity and the difference in appearance and weight of the wood of the limbs. Immediately at the junction of limb and stem the pressure is constant, and the result is the formation of almost uniformly thick-walled tissue in all parts of the ring, giving to the "knot" its great weight and hardness.

Lunes similar to those of the limb are frequently observed in the stems of small trees; wherever this has been noted it was found on the underside of a leaning or curved portion.[2] Occasionally such a "lune" extends for 12 and more feet up and down.

Quite distinct from this modification of the annual ring is another modification frequently seen, especially in young trees, giving rise to so-called "false" rings. It consists in the appearance of one or more, rarely two, dark-colored lines, which precede the true summerwood band of the ring. These lines, resembling the summerwood in color and composed like it of thick-walled cells, follow the true springwood of the year and are separated from the summerwood and from each other (if there are more than one), by a light-colored line resembling springwood. While occasionally this is somewhat misleading in counting the rings, a moderate magnification usually suffices to

[1] A. Cieslar, "Rotholz d. Fichte," Centralblatt f. d. g. Forstwesen 1896, p. 149, and Robert Hartig "Das Rothholz der Fichte" in Forstlich-naturwissenschaftliche Zeitschrift, 1896, p. 165.

[2] Cieslar produced them at will by bending young spruce saplings.

distinguish the real character of the tissues, as described later on. A more serious difficulty arises in very old, slowly growing trees, where the ring sometimes is represented by only one to three cells (see fig. 18) and occasionally disappears, i. e., is entirely wanting in some parts of the cross section. Generally these cases, due to various causes, are too rare to seriously interfere in the establishment of the age of a tree.

SPRING AND SUMMER WOOD.

The difference between spring and summer wood is strongly marked in these pines, the transition from the former to the latter being normally abrupt and giving to the annual ring the appearance of two sharply defined bands. (See figs. 13 and 18 B.) In wide rings the transition is sometimes gradual. The springwood is light colored, has a specific gravity of about 0.40, and thus weighs somewhat less than half as much as the darker summerwood, with a specific gravity of about 0.90 to 1.05, so that the weight and with it the strength of the wood is greater, the larger the amount of summerwood. (See diagram, fig. 14.)

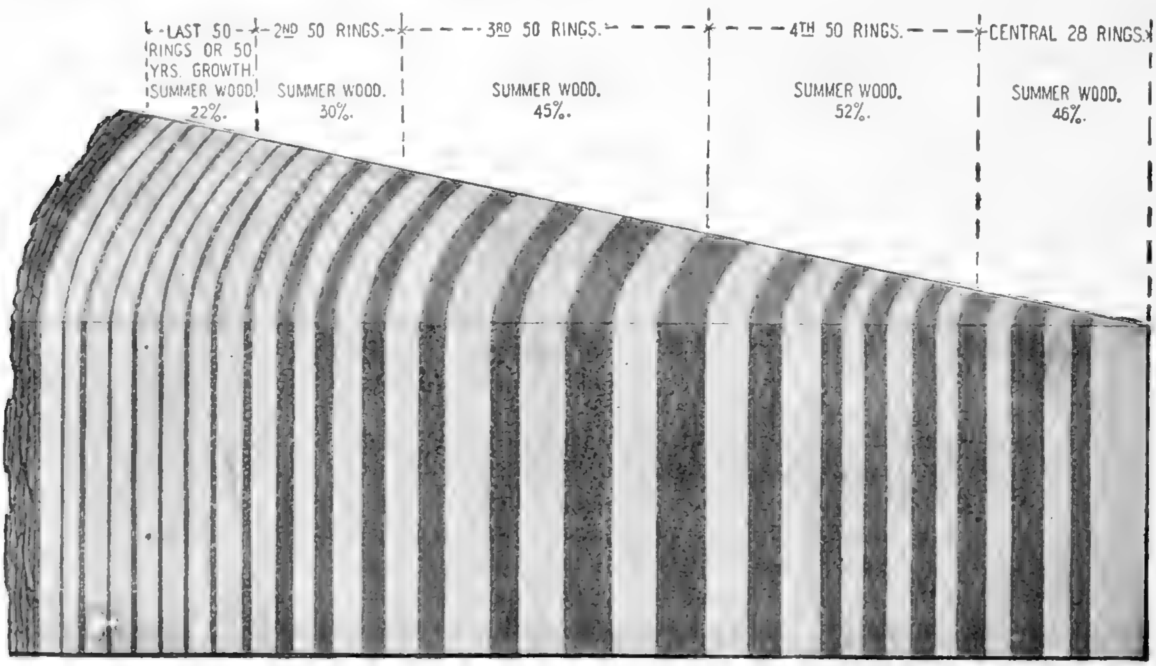


FIG. 13.—Variation of summerwood per cent from pith to bark.

The absolute width of the summerwood varies generally with the width of the ring (see diagram, fig. 15), i. e., the wider the ring the wider the summerwood band. It decreases in a cross section of an old log from near the pith to the periphery, and in the same layer, from the stump to the top of the tree. Where the growth of the stem is very eccentric, the wood along the greater radius has the greatest proportion of summerwood; thus, in a disk of Longleaf, for instance, there is on the north side a radius of 152 mm. with 27 per cent summerwood; on the south side a radius of 98 mm. and a summerwood per cent of only 20 per cent. In the stump section the great irregularity in the contour of the rings is accompanied by a corresponding irregularity in the outline of the summerwood.

The summerwood generally forms less than half of the total volume of the whole log (see fig. 13); it forms a greater part of the coarse-grained wood which was grown while the tree was young than in the fine-ringed outer parts of the log, grown in the old age period. It also forms a greater part in the volume of the butt than of the top log, and thus fully explains the well-known difference in the weight, strength, and value of the various parts of the tree. The following table serves to illustrate this point. The numbers in each line refer to the average values for the same ten annual layers through three sections of the tree at varying height. The figures in *italics* below refer to specific gravity for the same layer. The values for specific gravity were calculated on the basis of allowing a specific gravity of 0.40 for springwood and 0.90 for summerwood, the values for the entire disks as actually observed being given below:

Summerwood per cent and specific gravity in various parts of a tree of Longleaf Pine.

Rings from periphery.	1 to 10	11 to 20	21 to 30	31 to 40	41 to 50	51 to 60	61 to 70	71 to 80	81 to 90	91 to 100	101 to 110	111 to 120
Section I, 3 feet from ground.	39 .59	44 .62	40 .60	42 .61	38 .59	35 .57	45 .62	32 .56	44 .62	66 .73	43 .61	43 .61
Section IV, 35 feet from ground	26 .53	24 .52	25 .52	34 .57	28 .54	24 .52	26 .53	24 .52	35 .57	49 .64	31 .55	33 .56
Section VII, 70 feet from ground	23 .51	16 .48	17 .48	18 .49	18 .49	20 .50	16 .48	20 .50	18 .49	26 .53	21 .50	24 .52

Rings from periphery.	121 to 130	131 to 140	141 to 150	151 to 160	161 to 170	171 to 180	181 to 190	191 to 200	201 to 210	211 to 220	221 to 230	231 to 236	Average for total.
Section I, 3 feet from ground.	52 .66	56 .68	48 .64	46 .63	48 .64	43 .61	47 .63	47 .63	52 .66	45 .62	42 .61	*a*15 .47	45 .625
Section IV, 35 feet from ground	43 .61	34 .57	40 .60	31 .55	34 .57	33 .56	33 .56	31 .55	22 .51	*b* 6 .43	....	....	29 .545
Section VII, 70 feet from ground	19 .49	19 .49	22 .51	16 .48	18 .49	*c* 2 .41	....	....	....	....	....	....	18 .490

a Six rings next to pith. *b* Two rings. *c* One ring.

The observed values of specific gravity for the three sections are 0.700, 0.560, and 0.490, respectively.

It will be noticed that the greatest difference between the calculated and the actual value of specific gravity occurs in the section at the stump. This is fully accounted for by the fact that large amounts of resin, not considered in the values of summerwood per cent, always occur in this portion, adding from 5 to 20 per cent to the weight of the wood.

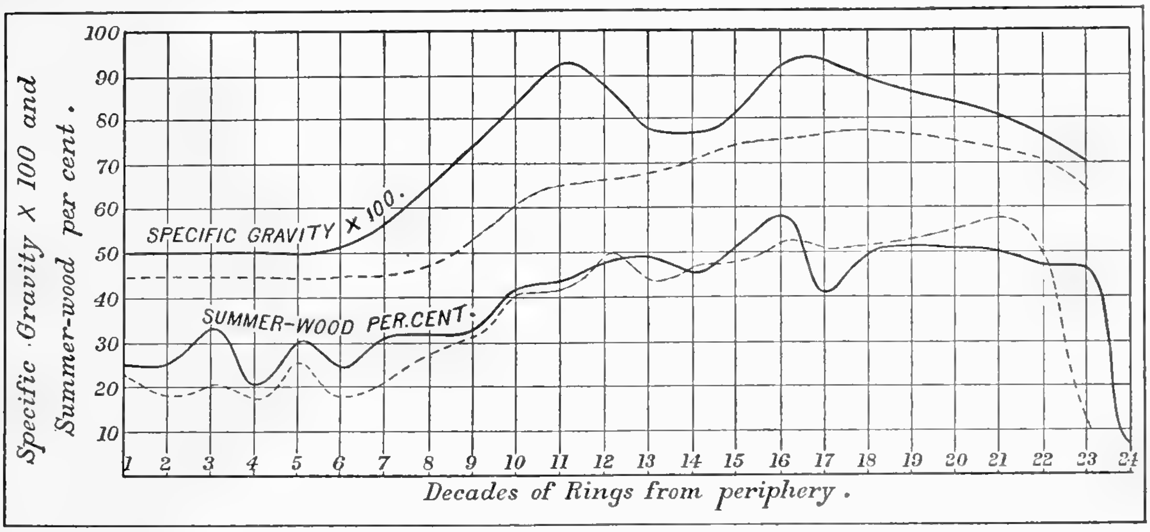


FIG. 14.—Variation of specific gravity with summerwood per cent and age of section in Longleaf Pine, the solid lines referring to a section 3 feet from the ground, the dotted lines to one 14 feet from the ground. (Specific gravity as actually observed on pieces of 1 inch radial extent.)

In stunted trees the summerwood forms nearly as great a per cent of the total volume for the whole tree as in thrifty trees of the same age, but in the stunted growth, or extremely narrow ringed portion of otherwise normal trees, the per cent of summerwood is markedly decreased, a feature which becomes conspicuous in the lighter color of the wood of such portions. (See diagram, fig. 15.) Where, on the other hand, the rate of growth in an old tree is suddenly increased by the accessibility of more light, for instance, the summerwood per cent also is disproportionately increased, but this disproportion appears to be more transient, i. e., a decrease in the summerwood per cent sets in sooner than for the rate of growth or the width of the rings. (See fig. 15.) In some of the rapidly grown Loblolly and Spruce Pine the summerwood forms but a small part of the first ten to twenty years' growth, and in all cases the first few rings about the pith have but little summerwood. In general, the summerwood per cent varies in the several species as well as in the individual with the weight of the wood, which is least in the Spruce Pine, greatest in Cuban and Longleaf Pine, and stands between these in Loblolly and Shortleaf. It furnishes a very useful criterion to distinguish between these groups and especially to select strong timber.

In the limb the summerwood is most abundant in the knot (all wood practically partaking of the character of summerwood, at least as far as the thickness of cell walls is concerned) and in the part next to the stem, decreasing with the distance from the trunk. As might be expected, it also forms a larger per cent of the wood of the underside of limbs and the concave portions of bent trunks.

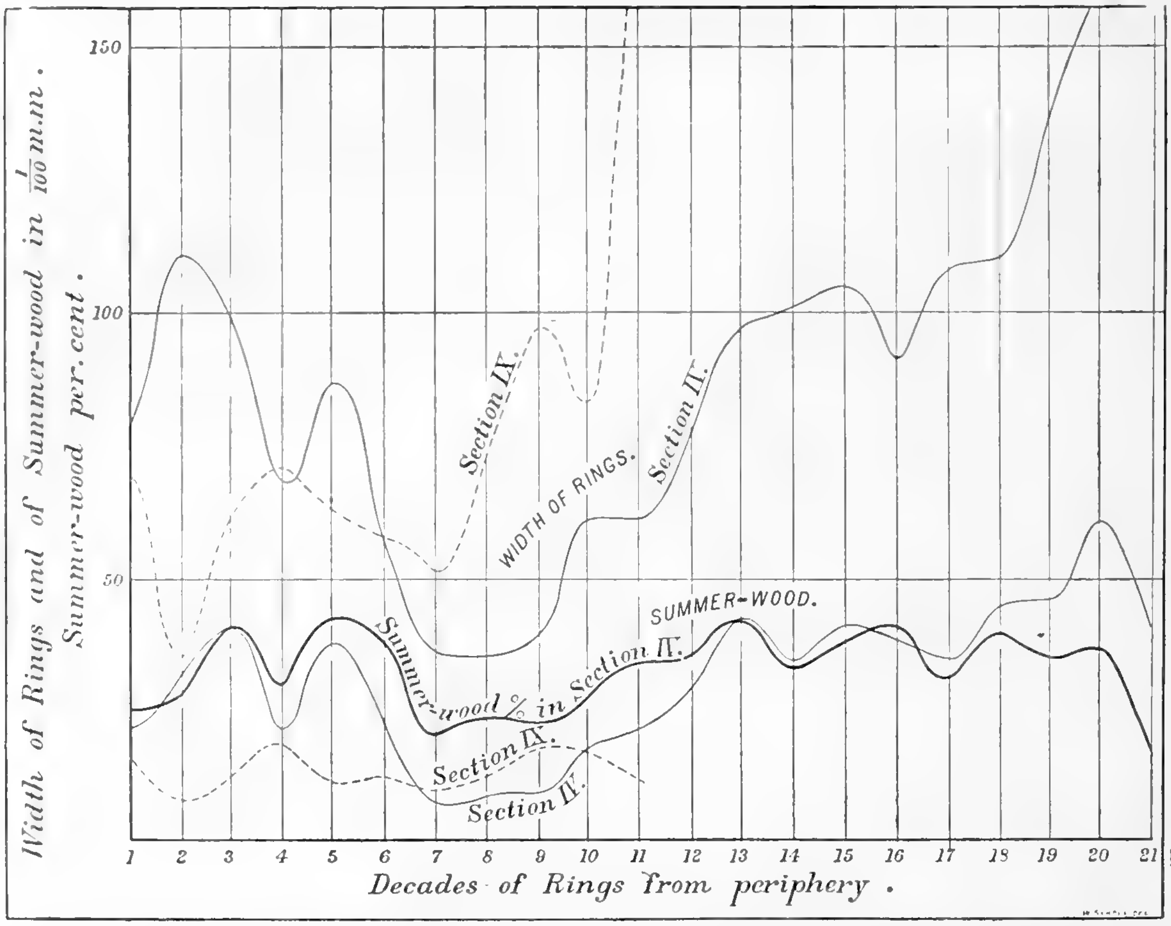


FIG. 15.—Variation of summerwood per cent with rate of growth (width of ring), in tree No. 3, Longleaf Pine.

NOTE.—Only the heavy line represents summerwood per cent; the others indicate the actual width of the rings (upper pair) and of the band of summerwood (lower pair).

GRAIN OF THE WOOD.

Though usually quite straight grained, the wood of these species is by no means always so. Spiral growth leading to "cross-grained" lumber occurs frequently, is usually more pronounced in the basal portions of the tree, and commonly varies from pith to bark in the same log. Wavy grain resembling that of the maple (curly maple) has not been observed, but an irregular wavy grain, due to the fact that the surface of the trunk for many years is covered with small, low eminences, 1 to a few inches across, is frequently seen, especially in Longleaf Pine, and leads to remarkably pretty patterns. Unfortunately the contrast of spring and summer wood being so very pronounced, the figures are somewhat obtrusive and, therefore, not fully appreciated.

MINUTE ANATOMY.

The minute structure or histology of the wood of the five species under consideration is that of a group whose position in a general classification of the wood of pines is indicated in the following scheme, suggested by Dr. J. Schroeder, and more completely by Dr. H. Mayr,[1] in which they appear as part of group 2 of Section I.

[1] Dr. J. Schroeder, Holz der Coniferen, Dresden, 1872, p. 65; Dr. H. Mayr, Waldungen von Nordamerika, München, 1890, p. 426.

Section I. Walls of the tracheids of the pith ray with dentate projections.

a. One to two large, simple pits to each tracheid on the radial walls of the cells of the pith ray.—Group 1. Represented in this country by *P. resinosa*.

b. Three to six simple pits to each tracheid on the walls of the cells of the pith ray.—Group 2. *P. tæda, palustris*, etc., including most of our "hard" and "yellow" pines.

Section II. Walls of tracheids of pith ray smooth, without dentate projections.

a. One or two large pits to each tracheid on the radial walls of each cell of the pith ray.—Group 3. *P. strobus, lambertiana*, and other true white pines.

b. Three to six small pits on the radial walls of each cell of the pith ray.—Group 4. *P. parryana*, and other nut pines, including also *P. balfouriana*.

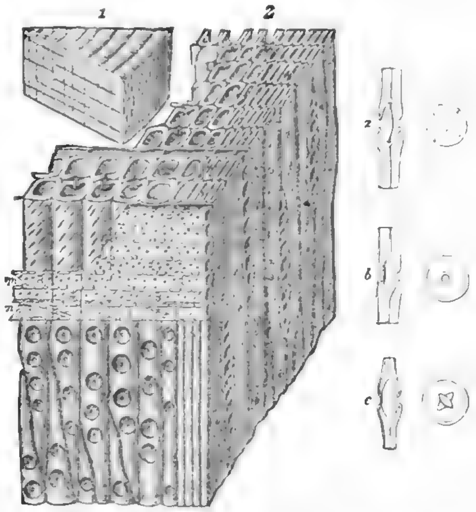


Fig. 16.—Schematic representation of coniferous wood structure: wood of spruce—1, natural size, 2, small part of one ring magnified 100 times. The vertical tubes are wood fibers, in this case all "tracheids." *m*, medullary or pith ray; *n*, transverse tracheids of pith ray; *a*, *b*, and *c*, bordered pits of the tracheids more enlarged.

The general features of structure of coniferous woods are represented in the accompanying cut (fig 16).

The structural elements, as in all pine, are few and simple and consist of (*a*) tracheids, the common wood fibers, forming over 90 per cent of the volume; (*b*) medullary or pith rays, minute cell aggregates composed of two kinds of cells, scarcely visible without magnifier and then only on the radial section, yet forming about 7 to 8 per cent of the volume and weight of the wood in these species; (*c*) resin ducts, small passages of irregular length surrounded by resin-secreting cells, scattered through the wood, but forming two more or less connected systems, one running in the direction of the fibers, the other at right angles to the first, the individual ducts of the latter system always occupying the middle portion of medullary rays (see Pl. XXVII).

The tracheids, or common wood fibers, are alike in all five species, and resemble those of other pines; they are slender tubes, 4.5 to 6 mm. (about one-fourth inch) long, forty to one hundred times as long as thick, usually hexagonal in cross section, with sharp or more or less rounded outlines (see Pl. XXI), flattened in tangential direction at both ends (see Pl. XXI, A *f*), the diameter in radial direction being 45 to 55 μ (about 0.002 inch) in the springwood, and about half that, or 21 to 25 μ, in the summerwood, and in tangential direction about 40 μ on the average in their middle. They are arranged in regular radial rows (see Pl. XXI), which are continuous through an indefinite number of rings, but the number of rows increasing every year to accommodate the increasing circumference of the growing stem. (See Pl. XXI, C *c*.) The fibers of the same row are practically conterminous, i. e., they all have about the same length, though at their ends they are often bent, slightly distorted, and usually separated (see Pl. XXI, B *c*; also fig. 17), their neighbors filling out the interspaces. There is no constant difference in the dimensions of these fibers in the different species here considered. In every tree the fibers are shortest and smallest near the pith of any section, rapidly increasing in size from the pith outward, and reaching their full size in about the tenth to twentieth ring from the pith. To illustrate: In a section of Longleaf Pine, 10 feet from the ground, the diameter of tracheids in radial direction is in μ=0.001 mm:

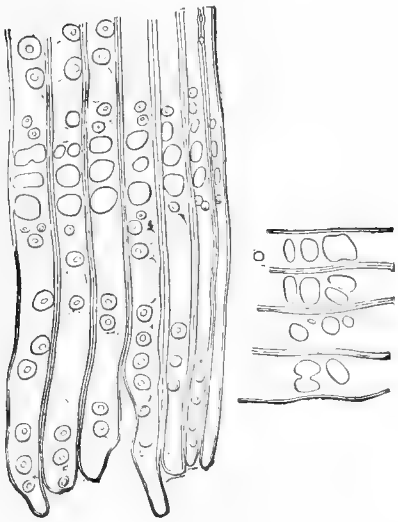


Fig. 17.—Cell endings in pine.

Number of rings from center.	Spring-wood.	Summer-wood.	Average.
	μ	μ	μ
1	24	15	24
2	34	23	32
3	45	24	40
4	43	26	36
7	50	26	38
10	52	28	36
24–33	52	28	36
44–53	52	27	37

As usual in conifers, the tracheids are largest in the roots and smallest in the limbs. In these pines, especially in Longleaf Pine, they are larger in well-grown wood than in that of extremely stunted trees, though very narrow rings in otherwise normal trees do not share this diminutive size of the tracheid. (See fig. 18, A and B, where a few very narrow rings are made up of elements of normal size.)

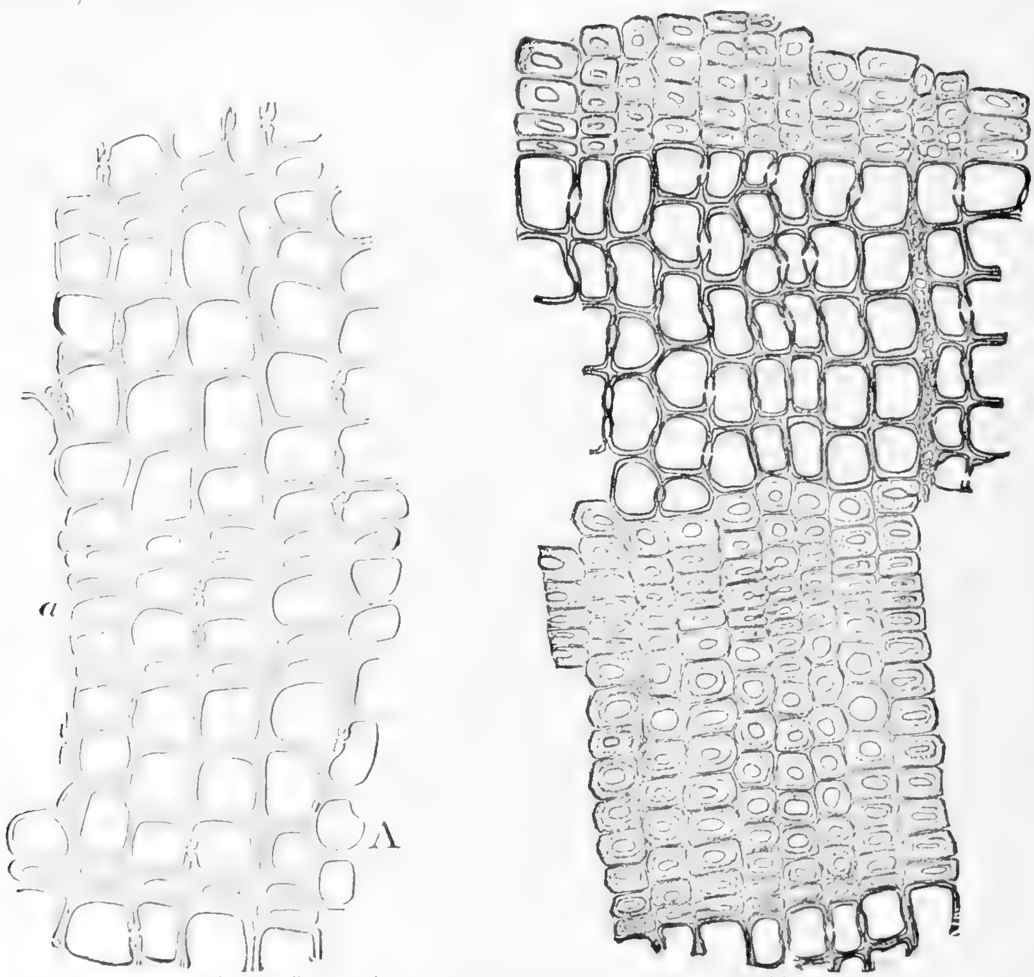


FIG. 18.—Cross section of normal and stunted growth in Longleaf Pine.

The following average figures illustrate the difference between wood from very stunted trees and that of normal trees in Longleaf Pine, of which we give an average from an extensive series examined:

Number of tree.	Age.	Average width of ring.	Radial diameter of tracheids in springwood μ = 0.001 mm.	Character of tree.
		Millimeters.		
4	86	0.4–0.5	31–36	Stunted.
5	60	.4	30–36	Do.
6	70	.4	33–38	Do.
7	68	2.0	52	Normal.

As soon as the average width of the annual rings gets above 0.5 mm. the dimensions of the elements approach the normal. Thus, in trees Nos. 1 and 2, with average width of annual rings 0.5 to 0.6 mm., the average diameter of the tracheids in radial direction is 35 to 48 μ.

Normally, the diameter in radial direction is greatest in the first-formed or inner part of any ring, and decreases even before the summerwood is reached. In narrow rings with an abrupt beginning of the summerwood, so common in these Southern pines, the diameter is quite constant throughout the springwood, but changes, together with the thickness of the wall, quite suddenly with the beginning of the summerwood, thus adding to the sharpness of the outlines of the two parts. (See Pl. XXI; also fig. 18, B.) In nearly all sections there is an additional marked decrease in radial diameter in the last 3 to 5 cells of each row, which helps to emphasize the limits of the ring. In the so-called "false" rings, mentioned before, the cells of the false summerwood part resemble those of the normal summerwood. The recognition of the false ring as such rests upon the difference in shape and dimensions of the last cell rows in comparison with those adjoining. In the true summerwood the last cells are much flattened, with small lumen and somewhat reduced walls making a sharp definition toward the springwood of the next ring, which is still further accentuated by the wide lumen and thin wall of the cells of the latter. In the "false" summerwood, on the contrary, the end cells are not flattened, and the cells of the light-colored adjoining zone of wood have but a moderately wide lumen and comparatively thick walls. The fact that the outline is less regular and commonly incomplete—i. e., it does not extend around the entire section—also aids in recognizing the false rings. In the "lunes" of both limb and stem referred to above the fibers are smaller, more rounded in cross section, and commonly exhibit conspicuous intercellular spaces between them. The walls of these are often much thicker than those of the summerwood of the same ring at this point. Since the radial diameter of the fibers of the summerwood is only about half as great as that of the springwood, it is clear that the number of fibers of the summerwood forms a much greater per cent of the total number of fibers than is indicated in the per cent of summerwood given above and based upon its relative width. Thus, in wood having 50 per cent of summerwood there are, in number, twice as many tracheids in the summerwood as in the springwood.

The walls of the cells are generally about 3 to $3\frac{1}{2}$ μ thick in the springwood, while in the summerwood they are 6 to 7 μ thick on the tangential side and 8 to 11 μ thick on the radial side of the fiber. Generally it may be said that the thickness varies inversely as the extent of the wall, i. e., the greater any diameter the thinner the walls parallel to this diameter, which gives the impression that each cell is furnished an equal quantum of material out of which to construct its house and had the tendency of giving an equal amount to each of its four or six sides.

Generally the absolute width of the ring does not affect the thickness of the cell walls, the fibers of wide rings having no thicker walls than those of narrow rings; but when the growth of a tree is unusually suppressed, so that the rings are less than 0.5 mm. (0.02 inch) wide and each row consists of only a few fibers, the walls of the fibers of the summerwood, like those of the last-formed 2 or 3 fibers of normal rings, are thinner, so that in these cases the wood is lighter in color and weight not only because there is relatively less summerwood, but also because the fibers of this summerwood have thinner walls. (See fig. 18, A and B.) In very stunted trees, where the rings are all very narrow, the reduced thickness of the walls is counterbalanced by the smaller size of the cells.

All tracheids communicate with each other by means of the characteristic "bordered" pits. the structure of which is shown in fig. 16. These pits occur only on the radial walls of the fibers, They are most abundant near the ends of each fiber, fewest in the middle, form broken rows, single or occasionally double. (Pl. XXIII, C.) As in other pines the pits of the summerwood differ in appearance from those of the springwood. In the latter the pit appears in the cell lumen (radial view) as a perforated saucer-like eminence; in the former as a mere cleft, elongated in the direction of the longer axis of the fiber. (See Pl. XXI, B, *d* and *e*; Pl. XXIV, D, *d* and E, *a*.) In both the essential part of the pit is similar, a circular or oval cavity resembling a double convex lens, with a thin membrane dividing it into two equal plano-convex parts. (This membrane is shown only in the drawings, Pl. XXIV, D and E.) In keeping with the small radial diameter of the fibers of the summerwood, these pits are much smaller in the summerwood than springwood, and usually are very much fewer in number.

The simple pits are in sets and occur only at the points where the fiber touches the cells of a medullary ray. (See fig. 17, also Pl. XXIV, E, sp., and other figures of this plate and Pl. XXV.) Above and below these simple pits occur very small bordered pits, communicating with those of the short transverse fibers or tracheids which form part of all medullary rays. (See Pl. XXII, D, *b. p.*)

As in all pines, the medullary or pith rays are of two kinds, the one small, 1 cell wide, and 1 to 10—in large averages 5 to 7—cells high; the other large, and each containing in the middle part a transverse resin duct. (See Pls. XXII, XXIII, XXV, and XXVII.) Of the former there occur about 21 to 27 on each square millimeter (about 15,000 per square inch) of tangential section. The second class are much less abundant and scattered very irregularly, so that sometimes areas of several square millimeters are found without any of these rays. Generally about one of these rays occurs to every 1.5 or 2 square millimeters, or about 300 to 400 per square inch of tangential section. In all rays the cell rows forming the upper and lower edge (see Pl. XXIII) are composed of short fibers or tracheids (transverse tracheids), while the inner rows contain only parenchyma cells. Occasionally small rays occur which are composed of tracheids only. (See Pl. XXII, C.) Frequently the rows of parenchyma are separated by one, rarely by two, series of tracheids (see Pl. XXIV, D, and Pl. XXV, D), giving rise to "double" or "triple" rays.

The number of cell rows in each medullary or pith ray varies from 2 to 10, on an average from 5 to 7, and of these the rows of tracheids or fibers form more than half. (See Pl. XXVI, where the outer cells or tracheids are marked with dots.)

The tracheids of the rays have thick walls covered with point-and bar-like projections, the boldest of which are on the upper and lower walls and surround the bordered pits. (See Pls. XXII and XXIII.) These short tracheids communicate with the common wood fibers, with each other, as well as with the parenchyma cells, by means of small bordered pits, which in this last case are bordered on one side (side of the tracheid) and simple on the other (half-bordered pits). The parenchyma cells occupying the inner rows of each ray communicate in the springwood part of the ring with each neighboring tracheid by 3 to 6, commonly 4 to 5, simple elliptical pits, in the summerwood by a single narrow, elongated slit-like pit (see Pls. XXII and XXIII), and with each other by small, irregular, scattered simple pits.

The walls of these cells are generally smooth, but local thickenings, especially on the upper and lower walls and surrounding the pits, occur quite frequently, though not regularly.

The parenchyma cells of the rays are usually somewhat broader and higher than the fibers, the average height for both being about 21 to 27 μ, the average width about 20 μ, while the length of each cell and fiber, greater in springwood and least in the summerwood, is from two to ten times as great as the height. Assuming 25 μ and 20 μ to represent the average height and width, and allowing 25 rays of 6 cell rows each to each square millimeter of tangential section, then the rays form about 7.5 per cent of the total volume and weight of the wood of these species. An attempt to utilize for purposes of identification the difference in the number, size, and distribution of these rays, or the proportion between the number of rows of tracheids and those of parenchyma cells, as was done by Dr. J. Schroeder,[1] has not been successful, and appears of little promise.

The large rays with transverse resin ducts resemble the smaller rays described. On Pl. XXV at A such a ray is seen both in radial and tangential section. Series of transverse tracheids occupy the upper and lower edge, but the interior, unlike that of common rays, is several cells wide, and contains an open duct in its widest portion. (See Pl. XXVII, *r. d.*) This duct is commonly more or less filled with resin (see Pl. XXVII, E); it is surrounded by thin-walled secreting cells, and, in the heart wood, often divided or filled up by thylosis, i. e., by very thin walled, much puffed out cells, growing out of the surrounding secreting cells before the latter perish.

The walls of the secreting cells are quite thin, those of the remainder of the parenchyma vary to some extent in the different species. In the Longleaf and Loblolly Pines the walls of the parenchyma composing the principal part of the ray are generally quite thick (see Pl. XXVII, A–E),

[1] Dr. Julius Schroeder, Das Holz der Coniferen, Dresden, 1872.

thicker than those of the cells of ordinary rays, and especially thickened near the simple pits by which these cells communicate with each other. In Cuban and Shortleaf this thickening is much less conspicuous, and absent entirely in many cases (see Pl. XXV, A), while in the Spruce Pine it seems wanting altogether.

These ducts exist even in the very first ring (next to the pith), are smaller and more numerous near center, but have essentially the same structure in the wood of the fifth and later years.

The tracheids of the pith rays are wanting next to the pith, but occur in all rays in the outer part of even the first ring. The rays in this ring are generally lower, composed of fewer cell rows, but the cells are larger than in the rest of the wood.

Both shape and size of these medullary rays are very variable; an average of about 0.4 mm. for the height of the ray and 60 μ for the width at the resin duct was observed. An attempt to utilize the shape, especially the appearance of the two edges, as a means of separating the wood of these species has so far failed entirely.

The large resin ducts running lengthwise in the wood or parallel to the common wood fibers are much larger than the transverse ducts, measuring, inclusive of the secretive cells, on an average about 0.2 mm. (0.008 inch) on their smaller radial diameter and about 0.3 mm. on the tangential. (See Pl. XXI, A, *r. d.*) They are usually situated in the summerwood of each ring, often in narrow rings, causing an irregular outline. They are smaller and more numerous near the pith, here usually forming several series in one annual ring, more numerous in wide rings than in narrow ones, but their number per square inch of cross section as well as their dimensions appear to be independent of the width of the rings. In their structure they resemble those of other pines. They are surrounded by thin-walled resin-secreting parenchyma, part of which often appears as if not directly connected with the duct. (See Pl. XXI, A.) In many cases all the tissue between two neighboring ducts is of this parenchyma. Longitudinal and transverse ducts frequently meet and thus form a continuous network of ducts throughout the wood.

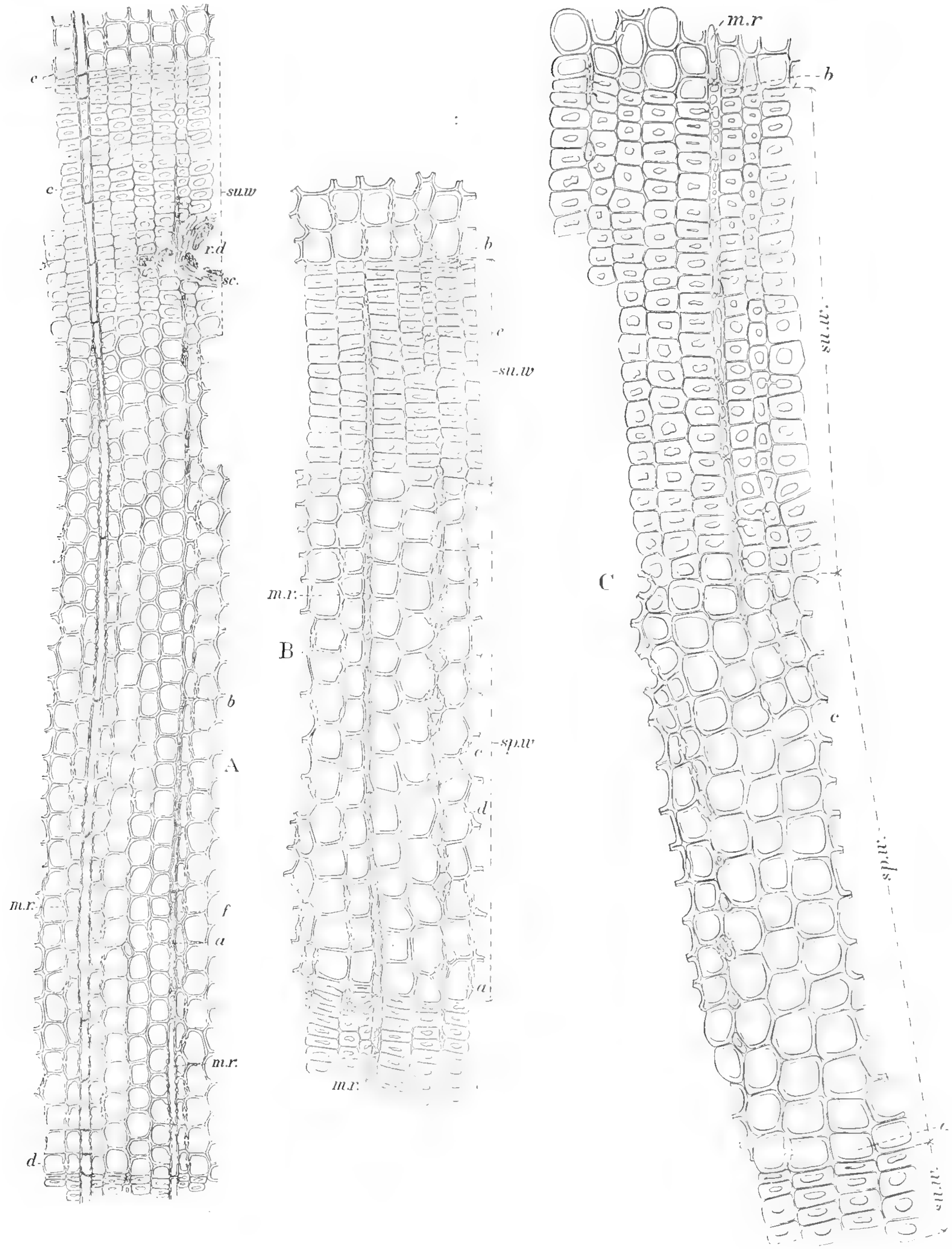
PLATE XXI.—CROSS SECTIONS.

A, PINUS TÆDA, $\frac{75}{1}$. *r. d.*, resin duct; *s. c.*, secreting cells; *m. r.*, medullary rays; *a*, section of transverse tracheid of ray; *b*, the ray leaves the plain of the section at this point, small parts of it reappearing further on; *c*, simple pits connecting parenchyma cells of the ray; *d–e*, part of a row of tracheids formed during one season; *f*, flattened terminal part of a tracheid.

B, PINUS HETEROPHYLLA, $\frac{100}{1}$. *sp. w.*, springwood; *su. w.*, summerwood; *a–b*, part of a row of tracheids formed during one season; *c*, terminal parts of tracheids; *d*, bordered pit in springwood; *e*, same in summerwood; other letters as in *A*.

C, PINUS GLABRA, $\frac{150}{1}$. *c*, row of tracheids doubled; other letters as in *B*.

Originals, all $\frac{300}{1}$.



TYPICAL CROSS SECTIONS OF PINUS TÆDA, HETEROPHYLLA, AND GLABRA.

PLATE XXII.

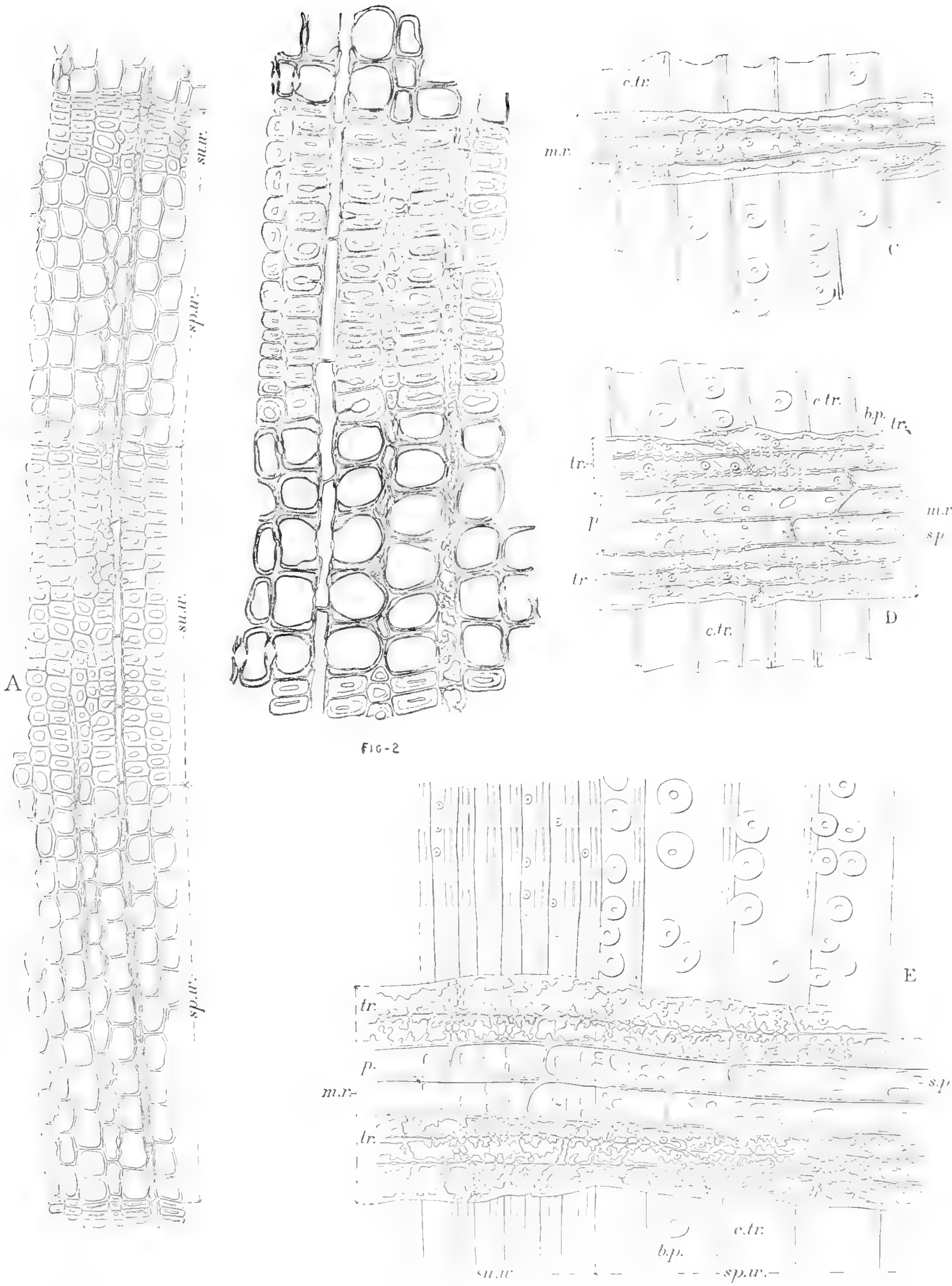
A, Pinus echinata. Cross section of two rings; *sp. w.*, springwood; *su. w.*, summerwood.

B, Pinus palustris. Cross section of a very narrow ring. Of the two medullary rays one is cut through a row of parenchyma, the other through a row of tracheids.

C and *D*, Pinus glabra. Radial sections; *m. r.*, medullary rays; *tr.*, tracheids of the medullary rays; *p.*, parenchyma of the same; *s. p.*, simple pits leading from the parenchyma to the neighboring tracheids or common fibers *c. tr.*; *b. p.*, bordered pit. The ray at *C* is made up of tracheids only.

E, Pinus palustris. Radial section; lettering as in *D*.

Originals magnified: *A*, $\frac{300}{1}$, the rest $\frac{500}{1}$; illustrations: *A*, $\frac{100}{1}$, the rest $\frac{200}{1}$.



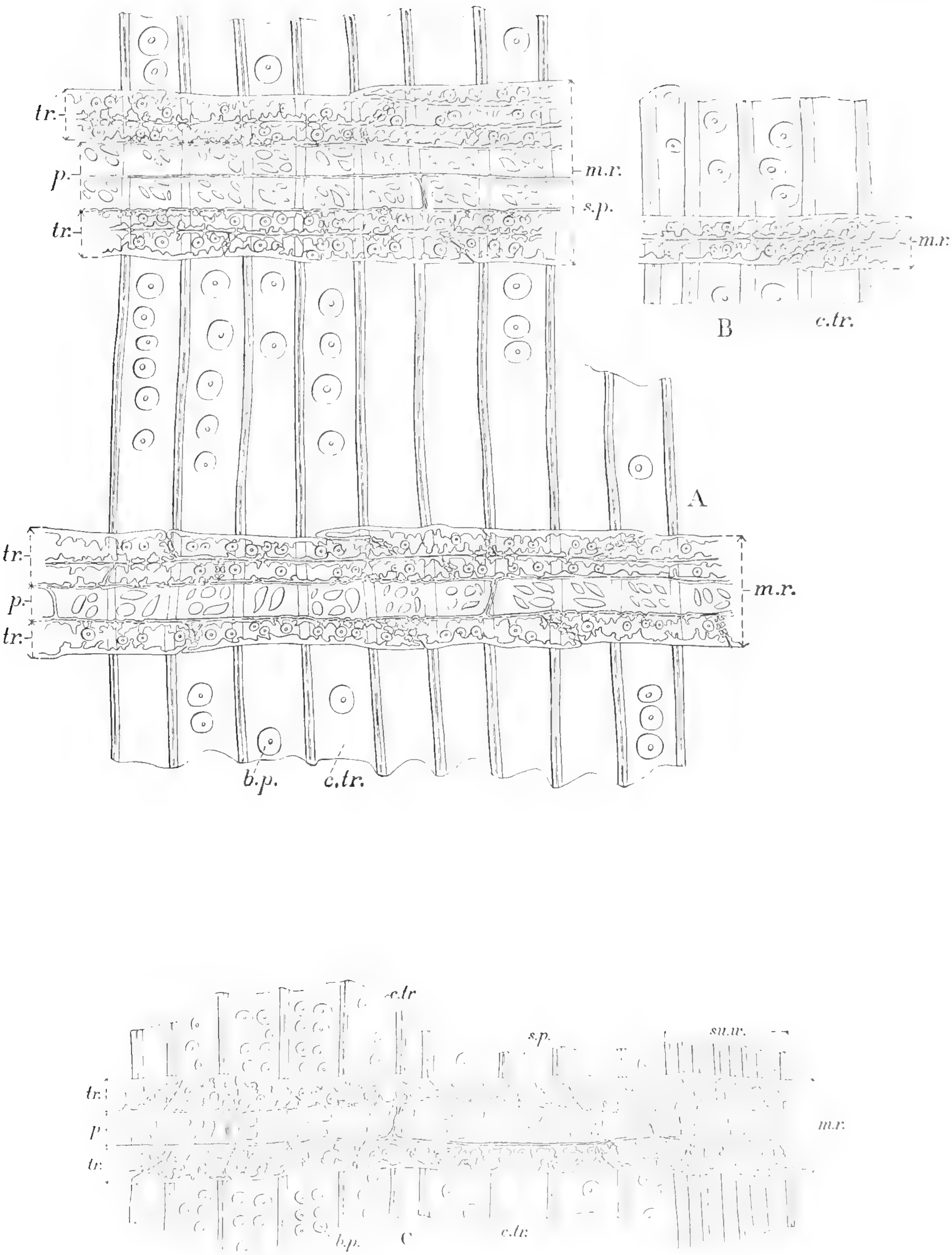
TYPICAL CROSS SECTIONS OF PINUS PALUSTRIS AND ECHINATA, AND RADIAL SECTIONS OF PINUS PALUSTRIS AND GLABRA.

PLATE XXIII.—RADIAL SECTIONS.

A and *B*, PINUS ECHINATA. *m. r.*, medullary rays; *p.*, parenchyma of same; *tr.*, transverse tracheids of rays; *s. p.*, simple pits; *b. p.*, bordered pits; *c. tr.*, common tracheids.

C, PINUS HETEROPHYLLA. *su. w.*, summerwood; other letters as in *A*.

Originals magnified $\frac{500}{1}$; illustrations, $\frac{200}{1}$.



RADIAL SECTIONS OF PINUS ECHINATA AND HETEROPHYLLA.

PLATE XXIV.—RADIAL AND TANGENTIAL SECTIONS.

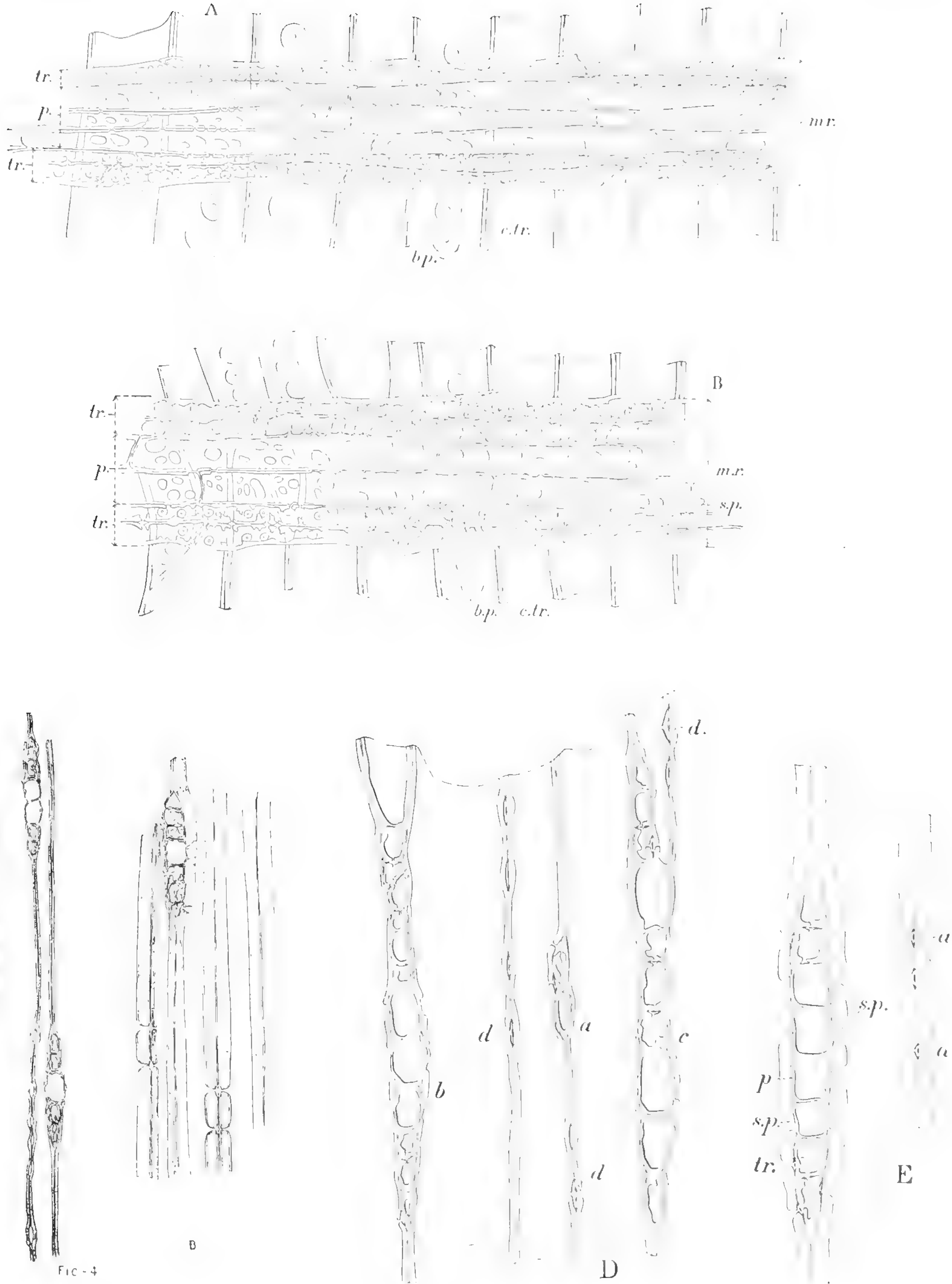
A and *B*, PINUS TÆDA. Radial sections; *m. r.*, medullary rays; *tr.*, tracheids; *p.*, parenchyma of the rays; *s. p.*, simple pit; *b. p.*, bordered pit; *c. tr.*, common tracheids.

C–E, tangential sections.

C, PINUS PALUSTRIS. Left-hand part in springwood, right-hand portion in summerwood.

D–E, PINUS ECHINATA. *D*, Section in springwood; *a–c*, medullary rays; *a*, a small ray composed of tracheids only; *c*, a "triple" ray; *d*, bordered pit showing the membrane in place. *E*, Section in summerwood; *a*, bordered pit, other letters as in *A* and *B*.

Magnification of originals, $\frac{500}{1}$; of illustrations: *A* and *B*, $\frac{200}{1}$; *C–E*, $\frac{300}{1}$.



RADIAL SECTIONS OF PINUS TÆDA AND TANGENTIAL SECTIONS OF PINUS PALUSTRIS AND ECHINATA.

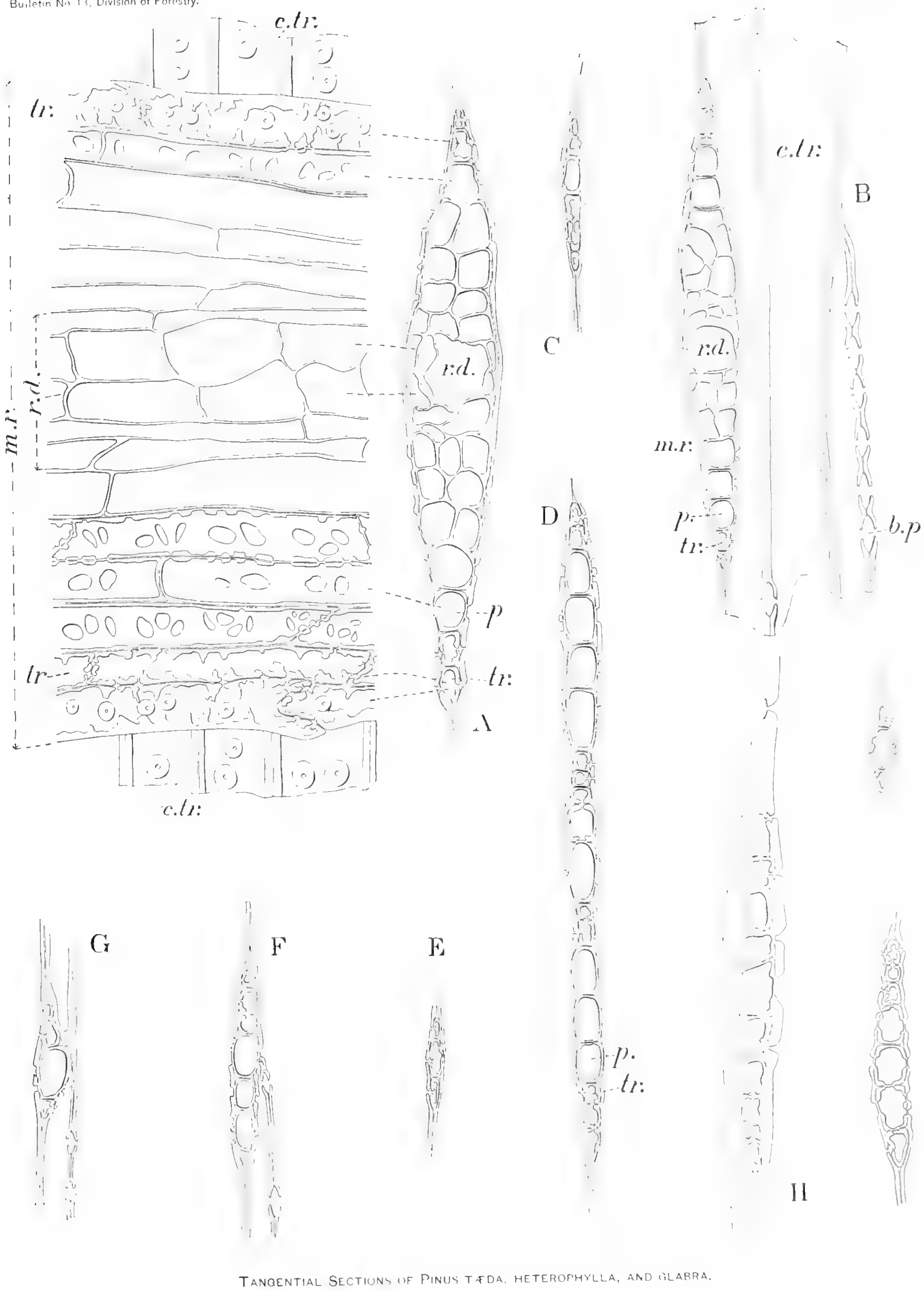
PLATE XXV.

A, Pinus heterophylla. Radial and tangential sections of a transverse resin duct; *r. d.*, resin duct; *m. r.*, medullary ray; *tr.*, tracheids of the medullary ray; *p.*, parenchyma cells of the same; *c. tr.*, common tracheids or wood fibers.

B–G, Pinus glabra. *B*, tangential section of a transverse resin duct and parts of three fibers; *b. p.*, bordered pit; other letters as above; *C–G*, tangential sections of medullary rays, of which *E* is made up of tracheids only, while *D* is a "triple" ray.

H, Pinus tæda. Tangential sections of medullary rays in spring and summer wood.

Original magnified 500 times, illustrations about $\frac{300}{1}$.



TANGENTIAL SECTIONS OF PINUS TÆDA, HETEROPHYLLA, AND GLABRA.

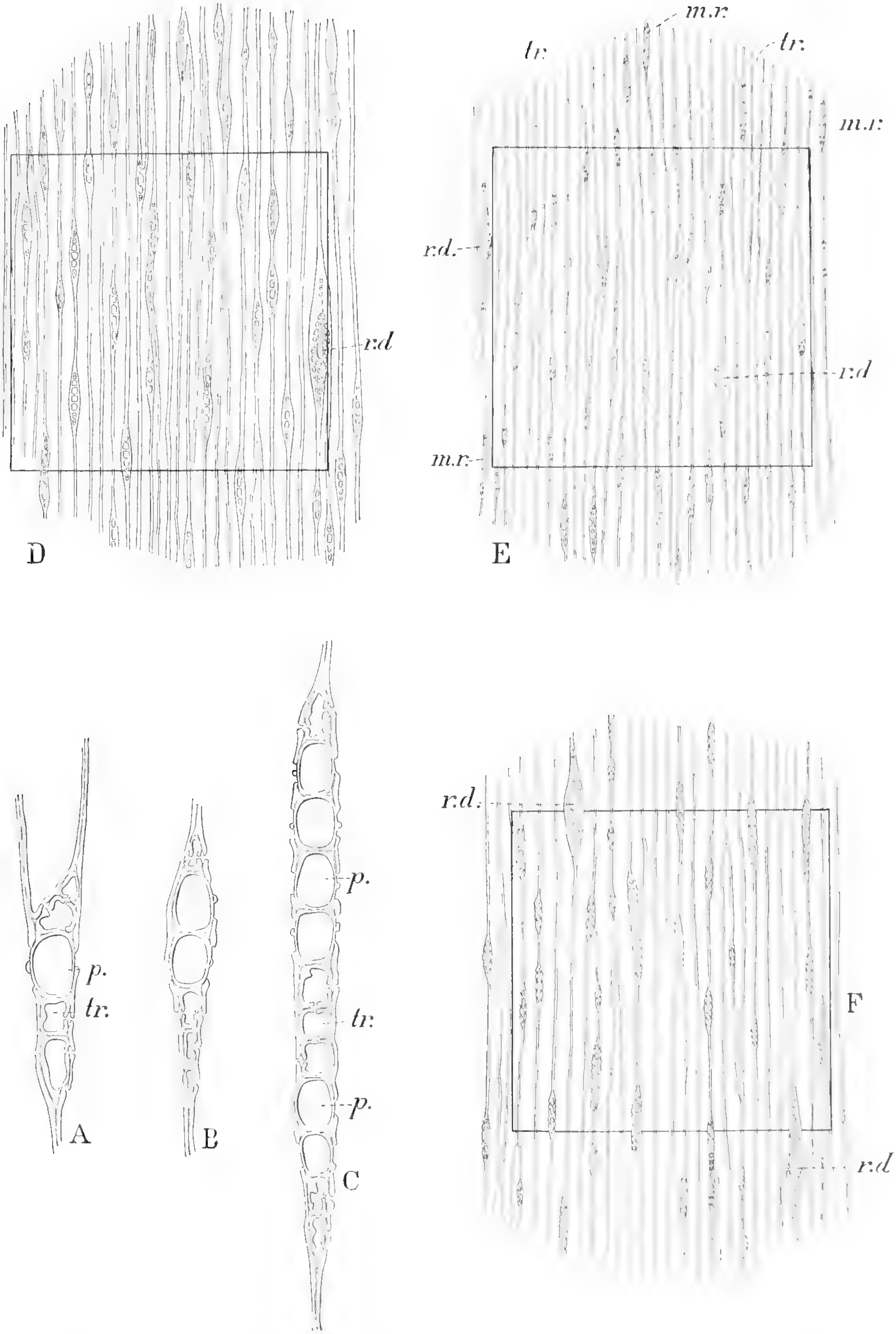
PLATE XXVI.—TANGENTIAL SECTIONS.

A–C and *F*, Pinus heterophylla. *D*, Pinus echinata. *E*, Pinus glabra.

A–C, sections of medullary rays; *tr.*, tracheids; *p.*, parenchyma; *C* is a "double" ray.

In *D–F*, histological details are omitted; they are camera drawings showing number and distribution of medullary rays, and also the proportion of the tracheids to parenchyma in each ray, the former being indicated by dots; *r. d.*, transverse resin ducts; *m. r.*, medullary rays.

Magnification of originals: *A–C*, $\frac{500}{1}$; *D–F*, $\frac{85}{1}$; of illustrations: *A–C*, $\frac{300}{1}$; *D–F*, $\frac{85}{1}$.

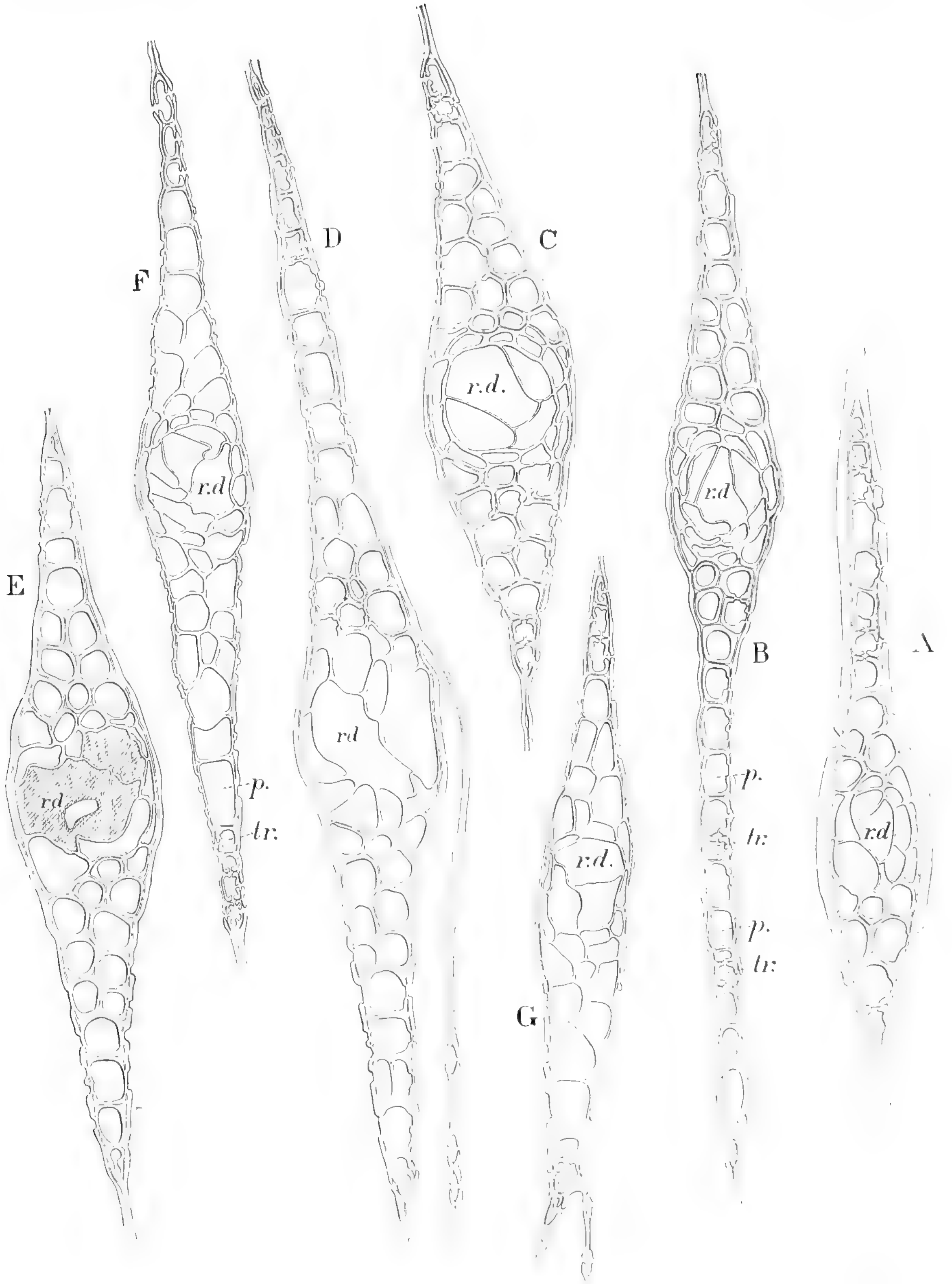


TANGENTIAL SECTIONS OF PINUS ECHINATA, HETEROPHYLLA, AND GLABRA, SHOWING NUMBER AND DISTRIBUTION OF PITH RAYS AND PROPORTION OF PITH-RAY CELLS.

PLATE XXVII.—TANGENTIAL SECTIONS OF TRANSVERSE RESIN DUCTS.

A–C, PINUS TÆDA. *D* and *E*, P. PALUSTRIS. *F*, P. ECHINATA. *G*, P. HETEROPHYLLA. *r. d.*, resin ducts; *tr.*, transverse tracheids; *p.*, parenchyma.

Magnification of originals, $\frac{500}{1}$; of illustrations, $\frac{300}{1}$.



W Schull

TRANSVERSE RESIN DUCTS. TANGENTIAL VIEWS.

INDEX.

WHITE PINE FOREST.

BULLETIN No. 22.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF FORESTRY.

THE WHITE PINE.

(PINUS STROBUS Linnæus.)

BY

V. M. SPALDING,

Professor of Botany in the University of Michigan.

REVISED AND ENLARGED BY

B. E. FERNOW,

Chief of the Division of Forestry.

WITH CONTRIBUTIONS:

INSECT ENEMIES OF THE WHITE PINE . . By F. H. CHITTENDEN, Division of Entomology.

THE WOOD OF THE WHITE PINE . . . . . . By FILIBERT ROTH, Division of Forestry.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1899.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
Washington, D. C., March 15, 1898.

SIR: I have the honor to submit herewith for publication a monograph on the White Pine of the Northern United States.

The first draft of this monograph, like the one on "The Timber Pines of the Southern United States" (Bulletin No. 13, Division of Forestry), by Dr. Charles Mohr, was prepared more than ten years ago by Prof. V. M. Spalding, of Ann Arbor, Mich.; but it was then found that much information of practical value was still lacking, and hence publication was delayed until the deficiencies could be supplied. Professor Spalding, after having made several revisions, under the pressure of other work had to abandon the idea of amplifying and perfecting the monograph itself, and this was left to the undersigned, with the collaboration of the staff of the Division of Forestry.

The undersigned is responsible not only for the plan of the work, but especially for the portions referring to forest conditions, forestal treatment, and for the discussion on the rate of growth, to which Mr. Mlodziansky also contributed.

Mr. Filibert Roth, of the Division, besides furnishing the study on the wood of the species, has also contributed the portions on the history of the lumbering operations, while the discussion on the injurious insects is by Mr. F. H. Chittenden, of the Division of Entomology.

A very comprehensive investigation into the rate of growth of the White Pine has been carried on since 1892 as opportunity afforded and funds permitted. The results of this investigation, comprising the analysis of over seven hundred trees, in the form of tables and notes, will be found in the Appendix. The measurements in the field were mainly executed by Mr. Austin Cary, of Bangor, Me., and by Mr. A. K. Mlodziansky, of the Division. The latter also performed the calculations and tabulations in the Division, and in this work developed a short and satisfactory method of tabulating, analyzing, and using the large mass of data readily for the purpose of summarizing, averaging, and generalization. This method is described in Bulletin No. 20, Division of Forestry.

The situation regarding White-Pine supplies has materially changed since this monograph was first conceived, so that it might almost be charged that this publication comes too late. This would be a misconception both as to the situation and the objects of the monograph. No information of any kind could have arrested the decimation of our White-Pine supplies, which proceeds through the momentum of economic laws; and even now, when it is well known that a few years will see their exhaustion, no change in the methods of milling with a view to lengthening the supplies is contemplated by the manufacturer, who is only concerned in keeping his mill running. The manufacturer is a harvester, not a forest grower.

The object of this monograph is to lay the basis for an intelligent recuperation of the virgin growth by the forest grower of the future, work which will surely be begun presently, but which would not have been undertaken ten years ago.

In the preparation of this monograph use has been made of all available sources of information. Acknowledgments are due to a large number of correspondents, named in the proper connection, who have rendered valuable aid by contributing notes on distribution or have assisted in other ways.

The botanical illustrations showing external characters are by Mr. George B. Sudworth; those of the anatomy of the wood are by Mr. N. B. Pierce and Mr. Filibert Roth, and those of parasitic organisms and disease conditions are from Hartig's "Lehrbuch der Baumkrankheiten" and "Zersetzungserscheinungen des Holzes." The illustrations accompanying the section on injurious insects were furnished by the Division of Entomology. The map of distribution was prepared in the Division of Forestry.

The monograph is believed to be just in time for the use for which it is intended, namely, to prepare for the application of sylviculture to the remnant of our pineries.

Respectfully,

B. E. FERNOW,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

THE WHITE PINE.

(PINUS STROBUS Linnæus.)

SYNONYMS.

Pinus strobus Linnæus, Spec. Pl. ed. 1, 1001 (1731).
Pinus tenuifolia Salisbury, Prodr. 399 (1796).

LOCAL OR COMMON NAMES.

White Pine (Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Virginia, West Virginia, North Carolina, Georgia, Indiana, Illinois, Wisconsin, Michigan, Minnesota, Ohio, Ontario, Nebraska).
Weymouth Pine (Massachusetts, South Carolina, European literature).
Soft Pine (Pennsylvania).
Northern Pine (South Carolina).
Spruce Pine (Tennessee).


MAP
SHOWING THE
ORIGINAL DISTRIBUTION
OF THE
WHITE PINE (Pinus strobus L.)
Prepared under the direction of
B. E. FERNOW
Chief of the Division of Forestry
U. S. Department of Agriculture
LEGEND
PINE FOREST WITH OTHER CONIFERS AND HARDWOODS PINERY PROPER ON SANDY SOILS: BEST DEVELOPMENT IN COMMERCIAL QUANTITIES.
IMPORTANT AS ADMIXTURE TO HARDWOODS.
EXTENSION OF BOTANICAL RANGE: OCCURRING ISOLATED OR IN SMALL BODIES
TERRITORIES
NEW FOUNDLAND
NEW BRUNSWICK
NOVA SCOTIA
MAINE
VERMONT
N. HAMPSHIRE
MASS
CONN
NEW YORK
PENNSYLVANIA
WISCONSIN
IOWA
ILLINOIS
INDIANA
OHIO
MO
KENTUCKY
WEST VIRGINIA
VIRGINIA
MARYLAND
DEL
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA

THE WHITE PINE.

INTRODUCTION.

For two centuries and a half the White Pine has been universally employed for purposes of construction in the Northern United States. Its abundance and the combination of qualities which adapts it to an almost unlimited number of uses have made it the most important and the most highly prized of all the timber trees of the region to which it is indigenous. In several of the Northern States it has been a more constant source of wealth and has yielded larger returns than any other single product. Thus, for instance, in 1879, a fair year for comparison, the natural products of the State of Michigan were estimated by Governor Jerome as follows:[1]

Agricultural products	$88,500,000
Timber	60,000,000
Copper	8,000,000
Iron	10,000,000
Salt	2,000,000
Fish	1,000,000

According to this estimate the value of the timber products, chiefly White Pine, was at that time, in round numbers, six times that of the iron, seven and one-half times that of the copper, and thirty times that of the salt product of the State, and amounted to about 35 per cent of all the products of the State combined; and if the value of the entire White Pine product of the present year (1898), some 7 billion to 8 billion feet B. M., be taken into consideration, it will exceed in value at first points of production the entire gold and silver output of the country, which is not much less than $100,000,000.

Commercial interests of great magnitude, dependent upon the handling and transportation of the White Pine product, have been built up in Chicago and other northern cities, and the diminution or failure of the supply must inevitably result in the transfer of the capital thus employed to other purposes or to other centers of distribution. In fact, such changes have already been and are now being made with great rapidity, and much of the capital formerly invested in the pine lands and mills of the northern lake region has been transferred to those of the Gulf States and the Pacific coast.

A multitude of industries is dependent upon a continued and large production of pine lumber, and its failure, though perhaps not threatening such a collapse of business interests as alarmists have pictured, will nevertheless involve serious if not disastrous consequences to the communities relying upon its continuance. The maintenance of an adequate future supply, especially in view of the well-known fact that the existing forests of White Pine can last but a few years longer, at most, is therefore a matter of great economical importance and can not receive too prompt attention.

GEOGRAPHICAL DISTRIBUTION.

The White Pine is a tree mainly of northern distribution, although it occurs along the mountain ranges as far south as northern Georgia. It occupies in this distribution the Boreal and Transition life zones, as defined by Dr. C. Hart Merriam.

[1] Michigan and its Resources, Lansing, 1881.

The botanical range of the White Pine may be circumscribed as follows: From Newfoundland and the Atlantic coast north of the Gulf of St. Lawrence its northern limit runs in a wavy line between the forty-ninth and fifty-first degree of latitude, its most northern extension occurring near its western limit, when, skirting the southeastern end of Lake Winnipeg, it turns southward, following more or less closely the ninety-sixth meridian of longitude, and in a southeastern direction the line which demarcates the boundary between forest and prairie to the Cedar River at the Iowa line, and along the Mississippi River, crossing it near Rock River, when, following this river for some time, it takes an easterly course to the head of Lake Michigan, then in a northeasterly direction through Michigan to the shores of Lake St. Clair and across Ontario, skirting the southern shores of Lake Erie in the two most northeasterly counties of Ohio, then turns southward through the eastern counties of that State, and following into West Virginia near the 1,000-foot contour line along the foothills of the Alleghenies through Kentucky and Tennessee, gradually withdrawing to higher elevations (1,200 feet) into northeastern Georgia; the line then returning northward along the eastern slope and crossing upper Delaware, reaches the Atlantic coast in southern New Jersey.

The distribution of commercially valuable timber is, to be sure, very different and much more confined. The northern parts of Minnesota, Wisconsin, and Michigan contained probably the largest amount of White Pine, the broad belt of commercial pine of these States continuing eastward through Ontario, northern New York, and the northern New England States to New Brunswick and Newfoundland, and following the New England coast, while the higher elevations of the New England States showed preponderantly spruce with pine intermixed. The northern counties of western Pennsylvania also contained a large amount of White Pine timber mixed with Hemlock and hardwoods. The character of this distribution is exhibited by general outlines and shadings on the accompanying map (Pl. I). The extreme limits of its sporadic occurrence can not be fixed with absolute precision, and from the nature of the case must remain more or less indefinite. Similarly, the limits of greater or less development can only be approximately stated.

The occurrence of the White Pine was generally as a component of the mixed hardwood forest of the Atlantic, even in the best developed portions of its range, and under such conditions, that is, in mixture with other species, it seems to attain its most perfect development.

The finest specimens of the highly esteemed "Cork Pine" of Michigan grew among hardwoods on a better quality of soils than those which produced less valued grades. On the lighter sands true pinery (pure or nearly pure growth of White Pine) occurs. Here its admixtures are most frequently of Red Pine (*Pinus resinosa*) and in its northern limits of Jack Pine (*Pinus divaricata*), while on the better and cooler situations it accompanies the spruces (*Picea mariana* and *P. canadensis*) with Balsam Fir (*Abies balsamea*) and Hemlock (*Tsuga canadensis*).

CHARACTER OF DISTRIBUTION, BY REGIONS.

The character of the occurrence of the White Pine in the forest within its field of distribution will readily appear from the descriptions in the tables of acre yield in the Appendix.

In *Maine*, the lower altitudes, along the coast and some of the river valleys, contained in their hardwood forests the White Pine in fine development, which gave to that State its cognomen of the "Pine Tree State." Reports of trees 6 to 7 feet and over in diameter and up to 250 feet in height testify to the capacity of the species in this region. The original stand of this pine in the State is practically entirely removed, while the young growth furnishes now again small quantities of logging material. The higher altitudes, with their slate and granite soils, are stocked entirely with the spruce and hardwood forest in which the pine occurs only as a scattering mixture and of inferior development.

This same manner of distribution applies more or less to *New Hampshire* and northern *New York*. In the Adirondacks the pine, now almost entirely removed, fringes with the Spruce and Balsam Fir the many lakes and water courses and keeps to the lower altitudes; mixed in with the Maples, Birches, Beech, and Spruce, it towers 50 to 60 feet above the general level of the woods, with diameters of 30 to 40 inches. Its reproduction under the shade of its competitors, however, is prevented, young pine being rarely seen except on old abandoned openings in the forest. (See Pl. II.)

FIG. 1. WHITE PINE MIXED WITH HARDWOODS IN CENTRAL NEW YORK.

FIG. 2.—OLD WHITE PINE TREE IN MIXED FOREST (YOUNG PINE IN THE FOREGROUND) IN NEW YORK STATE.

In western *New York* the White Pine was once quite abundant as a concomitant of the hardwood forest. Young growth is now creeping into every wood lot, while in *Pennsylvania* the White Pine occurred undoubtedly in the lower eastern counties in commercial quantities as well as in the adjoining counties of *New Jersey*, where it begins to be a tree of the mountains, the higher slopes, ridges, and tops becoming its favorite habitat. It is here largely associated with Hemlock, which often becomes the preponderant tree. Pure pine growth is rare, but the mixed hardwood forest is seldom without an admixture of White Pine to the extent, as a rule, of about 30 per cent numerically, the soils within the range of its occurrence being seemingly everywhere quite favorable to its growth.

Besides the Hemlock, the coniferous species with which it is found associated are Pitch Pine (*Pinus rigida*) and Spruce, while Red Pine (*Pinus resinosa*), the most successful rival of the White Pine in the lake region, is here rarely met, and then only in single individuals. The hardwoods most frequently represented are Maple, Beech, and Birch, more rarely Oak and Chestnut, with Basswood, Cucumber, Hickory, Cherry, etc., interspersed in single individuals.

The best development of the White Pine is usually found along the water courses. Thus, in Pennsylvania, in Luzerne County the White Pine is situated along Bear Creek and its tributaries; in Clinton County the pine is found on both branches of Hyner Run and along Youngwomans Creek; in Clearfield County there were 20,000 acres along Sandy Creek and its tributaries heavily timbered with White Pine, of which about 2,000 acres of primeval timber are left, which would cut about 100 million feet B. M. of White Pine. In Jefferson County a tract of Hemlock and White Pine forest of about 90 square miles, known as the Hay's tract, is traversed by the North Fork and its tributaries. In Forest County the areas heavily covered with pine were situated along Hickory and Tionesta creeks. There is as yet standing over 100 million feet B. M. of White Pine along Hickory Creek and its tributaries.

The heavy cut of pine in Elk County came from Medix Run, Dents Run, and their tributaries. The courses of the streams follow the trend of the ridges, the substrata of which are usually of a porous nature, consisting in most cases of slate or laminated shale, a soil very favorable to pine situated on moderately elevated grounds and slopes along the hollows and gorges, which, on account of the pervious substratum, offer most satisfactory soil-moisture conditions.

From *New Jersey* the White Pine has practically vanished long ago as a factor in lumber production, and almost as a tree of common occurrence.

With the extension of the distribution southward, the White Pine becomes less frequent and of inferior development; the climate forces it to higher and higher altitudes. It occurs in quantity only in islands or in small bodies on the crests and along the slopes of the Alleghenies, both east and west, usually accompanying water courses in broader or narrower belts.

Regarding the manner of occurrence of the White Pine in these southern regions, the remarks of Mr. W. W. Ashe on the distribution in North Carolina (Bulletin No. 6, North Carolina geological survey, 1898) are more or less applicable:

> The woodland in which White Pine is the dominant coniferous tree is not extensive, but lies in isolated, small bodies along the crest and southern and eastern slopes of the Blue Ridge, or on the low hills on the west, * * * extensive forests seldom being found above the higher limit (3,000 feet in Macon and Jackson counties), or perfect individual development attained below the lower (2,800 feet). In a few places on the southern slope of the Blue Ridge * * * the White Pine is associated with Yellow Pines as well as with deciduous trees, but the trees are generally short-boled, and neither so large nor tall as those growing at a higher elevation to the west of this range. Single specimens or small groups of trees are locally dispersed in the broad-leaf forests throughout the mountain counties between the limits of altitude given above.

It appears from these statements that in these latitudes below the 2,000-foot level this pine can hardly be expected to be of commercial or forestal value for the future.

The area of greatest quantitative development is found around the Great Lakes and in the basin of the St. Lawrence and its tributaries, in the very places most perfectly adapted to its ready and economical exploitation and easy shipment to markets, the large number of streams that are capable of carrying logs, the accessibility of natural ports of distribution, and favorable climatic conditions inviting the logger and lumberman. Michigan, Wisconsin, and Minnesota have thus become known as the great lumber region of the United States.

In *Michigan* the distribution of the species is entirely controlled by the character of the soil, all sandy areas being pinery proper, with large areas of pure growth of several square miles in extent containing only White Pine. Occasionally, and especially on the driest and poorest sandy gravels, the Red Pine (*Pinus resinosa*) associates and sometimes predominates, the White Pine not representing more than 10 to 20 per cent of the number of trees. In the northern regions Jack Pine (*Pinus divaricata*) takes the place of the Red Pine.

The typical pine forest on fresh sandy soils consists of White Pine (45 to 55 per cent of the dominant growth) mixed with Red Pine (25 to 45 per cent) with scattering Hemlock (10 to 15 per cent) and occasional Fir and hardwoods. The undergrowth, usually moderately dense, consists mainly of small Hemlock, Fir, and young hardwoods.

On moister sand with loam or clay subsoil Hemlock and hardwoods replace the pines, the Red Pine vanishing entirely and the White Pine occurring only in large isolated individuals. Into wet or swampy places the White Pine also penetrates in single individuals among Arborvitæ, Hackmatack, and Spruce.

As the loam in the composition of the soil increases, the hardwoods increase numerically, the White Pine occurring only in single individuals and groups, and Red Pine and Hemlock only occasionally. Finally, the heavy clay soils toward the southern range of the species give absolute preponderance or exclusive possession to the hardwoods, mainly Sugar Maple, Yellow Birch, and Beech, although occasionally White Pine appears scattered, or even in smaller or larger groups.

Lumbering of White Pine in Michigan began about 1835, and was at its best in 1883, but now the virgin pine is nearly cut out. Reproduction is satisfactory on the sandy areas wherever fires are kept out, which is rare; on the clay-loam areas reproduction under the shade of the hardwoods is practically impossible.

In *Wisconsin* the same dependence on soil conditions in the distribution of the species prevails as in Michigan. The accompanying map of the forest areas of Wisconsin, taken from Bulletin No. 16, of the Division of Forestry, will serve to give an idea of the manner in which this distribution appears within the belt of best development. (See Pl. III.) From this map it will be seen that the distribution is to the largest extent dependent on soil conditions, the sandy soils representing the pinery areas, in which merchantable hardwoods and Hemlocks are wanting; the loam and clay areas are stocked with the hardwood forest, in which both Hemlock and Pine occur scattering or in isolated groves, represented almost entirely by mature old timber. Saplings, bushy young trees, and seedlings are comparatively scarce, an active reproduction of the pine evidently not going on. This condition is found especially on the heaviest soils, where the hardwoods crowd out the pine, while on the sandy or gravelly soils the pine holds its own and forms a fair proportion of the sapling timber. In the true pinery of the sandy soils the hardwoods are scantily represented by small White Birch, Aspen, and Maple. The Hemlock is entirely wanting. On the barrens proper the White Pine is replaced by Jack Pine and Red Pine, one, or both together, forming forests of considerable extent, usually with hardly any undergrowth or admixture save some scattering Scrub Oak.

In *Minnesota* climatic conditions again begin to assert themselves in influencing the distribution of the White Pine.

The conifers become preponderant over the hardwoods everywhere. Pines, both Red and White, together with Tamarack (*Larix laricina*) and Arborvitæ (Cedar—*Thuja occidentalis*) and some admixture of Spruce occupy those sites, both swamp and dry lands, which elsewhere would be occupied by hardwoods. With this change in composition goes a decrease in development; the sizes both in diameter and height are reduced.

It is an interesting fact that both in Wisconsin and Minnesota the pine area does not, as in the eastern field of distribution, gradually fade out toward the prairie, but the true pine woods cease abruptly within 30 or 40 miles at most from the demarcation line of the prairie, leaving the intervening ground to Birch and Aspen or Scrubby Oak and Jack Pine openings.

In the Canadian extension of the species pure pinery is very rare. The great bulk of the most productive pine country lies northward and westward from the mouth of the Ottawa River to Georgian Bay in mixed growth, which consists mainly of hardwoods, with Hemlock, Spruce, Arborvitæ (Cedar), and Balsam, while the lower tiers of Ontario are of the same character of hardwoods, with little scattering pine, as in southern Michigan. The eastern extension of the

LEGEND.

- PINERY, ON SANDY LAND, WITHOUT MERCHANTABLE HARDWOODS EXCEPT IN SMALL SCATTERED AREAS.
- + + PINERY WITH CONSIDERABLE MERCHANTABLE TIMBER.
- — — PINERY NEARLY OR ENTIRELY CUT OVER.
- V V PINERY LARGELY STOCKED WITH CONSIDERABLE JACK PINE.
- MIXED FOREST OF HARDWOODS, PINE, AND, IN THE PART EAST AND NORTH OF RED LINE, WITH HEMLOCK. WITH LESS THAN 3,000 FEET OF HARDWOOD AND HEMLOCK PER ACRE OF STOCKED AREA.
- MIXED FOREST WITH 3,000 TO 5,000 FEET OF HARDWOOD AND HEMLOCK PER ACRE OF STOCKED AREA.
- MIXED FOREST WITH OVER 5,000 FEET OF HARDWOOD AND HEMLOCK PER ACRE OF STOCKED AREA.
- + + MIXED FOREST WITH CONSIDERABLE STANDING MERCHANTABLE PINE.
- — — MIXED FOREST FROM WHICH PINE HAS LARGELY BEEN CUT.
- — — MIXED FOREST FROM WHICH HARDWOOD AND HEMLOCK HAVE LARGELY BEEN CUT OR DAMAGED BY FIRES.
- MIXED FOREST, WHERE PINE IS PREDOMINANT, THE FOREST RESEMBLING PINERY.
- MIXED FOREST WHERE PINE FORMERLY PREDOMINATED BUT IS NOW CUT, AND THE APPEARANCE NOW IS THAT OF A PINE SLASHING.
- V V OPENINGS WITH JACK PINE WOODS.
- V V OPENINGS WITH SCRUB OAK WOODS.
- LIMIT OF HEMLOCK (AREA NOT CARRIED OUT IN THE EASTERN PART) TO THE SOUTH AND WEST OF THIS LINE, THE HEMLOCK IS NOT OF COMMERCIAL IMPORTANCE, AND THE BIRCH IS REPLACED BY OAK.

field of commercial pine in Canada followed mainly the St. Lawrence River as far as Quebec. On Newfoundland the species is indigenous to nearly the whole of the island, and in some parts produces considerable quantities of merchantable timber. At its northwestern limit the forest fades out into prairie, the White Pine gradually disappearing, while at the northern limit the change is into Spruce forest.

NOTES ON GENERAL DISTRIBUTION.

Dr. N. L. Britton, for some years connected with the geological survey of New Jersey, writes of the occurrence of White Pine in that State as follows:

Pine Brook Station and sparingly northward along the Southern Railroad of New Jersey (Britton); sparingly 3 miles south of Woodbury, Gloucester County (Canby), and frequent in the middle and northern portions of the State. There are no White Pine forests in New Jersey, and the largest grove known to me is of but a few acres in extent. It evidently prefers a heavier soil than does *P. rigida*, which forms the forests of the pine barrens. On Staten Island, New York, there are a few scattered trees of *P. strobus*.

Mr. William M. Canby, of Wilmington, Del., reports the existence of a grove of White Pine trees in upper Delaware, and Mr. Thomas Meehan, of Germantown, Pa., states that White Pine grows (or did recently) at the Soapstone quarry, on the east side of the Schuylkill, some 8 or 10 miles above Philadelphia. Mr. Canby adds: "It is a very difficult thing to define the limit of a species that is being so rapidly destroyed, and doubtless the southern line is being rapidly effaced."

Prof. Lester F. Ward, of Washington, D. C., is of the opinion that *Pinus strobus* is not indigenous around Washington, and that the few trees met with in wild situations in its vicinity grew from seeds blown from planted trees. He has never met it in his botanical excursions into southeastern Maryland and Virginia.

Mr. F. E. Boynton writes from Highlands, N. C.:

I have seen some very fine specimens growing in Pickens and Oconee counties, S. C., but I have never seen it in this part of the country except in high altitudes, say from 2,500 to 3,000 feet usually. I have never seen or heard of its forming forests here. I have seen groves of a few acres where it might be said to predominate. As a rule, it is found scattered among other forest trees. It nearly always grows in or quite near Rhododendron and Mountain Laurel thickets, which indicate a moist soil. It often grows to be a very large tree here I measured a log in the mill yard near here last night that was 37 inches through. Considerable lumber is cut from White Pine in this mountain region, but, as a rule, the lumber is of inferior quality, being very knotty and often shaky. Cultivated specimens thrive and grow very fast. It is usually found most common on southern exposures. The rock formation is granite, and soil usually a sandy or gravelly loam wherever I have observed the White Pine in this region.

The following has been furnished by Prof. W. R. Lazenby, of the State agricultural experiment station at Columbus, Ohio:

From all the data in my possession, I should say that White Pine is rarely met with in Ohio outside the borders of two of our northeastern counties, viz, Ashtabula and Lake. Occasionally a sporadic patch has been noted along the banks of streams in some of the eastern counties. I have never heard of its spontaneous occurrence anywhere throughout the central or southern portions of the State. It appears to thrive well here at Columbus and submits kindly to change of soil. Wherever I have seen it in Ohio under artificial cultivation it has presented a thrifty appearance, although the young plants do not make a very rapid growth for the first few years.

Concerning the occurrence of White Pine near the head of Lake Michigan, Prof. E. J. Hill, of Normal Park, Ill., writes:

It begins at Whiting Station, on the Michigan Southern Railroad, and extends eastward to Michigan City. I came across a clump of White Pine once, about a mile north of Otis, where the Michigan Southern Railroad crosses the New Albany road. * * * You would be pretty safe in taking the Calumet River as the southern boundary. * * * I do not know of a single native tree in Cook County, Ill.

Mr. M. S. Bebb, of Rockford, Ill., communicates the following concerning the occurrence of White Pine in the northern portion of that State:

In a few localities on Kents Creek and Rays Creek, in Winnebago County, and giving the name to Pine Creek in Ogle, the county immediately north of this, the White Pine is certainly indigenous, but occurring only as a sparse growth, cresting precipitous banks, where it seems to have found a favorable environment.

To this Mr. S. B. Wadsworth, of Oregon, Ill., adds:

The White Pine in Ogle County grows in some cases to a height of 40 or 50 feet. * * * Nearly all the small streams in Pine Rock township have some pines near the mouths of the streams if there are any rocks along the banks. * * * The White Pine prefers the St. Peters sandstone, but in some cases grows on limestone rocks.

Mr. R. Williams, of Streator, Ill., says:

White Pine is without doubt a native of La Salle County. It occurs on the Vermilion and its little tributaries wherever there is an exposure of carboniferous sandstone, and more frequently is seen close to the edge of the highest bluffs, where the soil is largely composed of the disintegrated rock. To find one beyond the influence of the sand rock would be almost phenomenal. The number is very small and their situation does not permit them to attain much size. I think that 40 feet is about the limit of height. Small thrifty plants from one to a few feet in height occur here and there, and are sometimes transplanted to the prairie soil, where they make a vigorous growth, outstripping Norway Spruce, Scotch and Austrian Pine, Hemlock, and White Cedar. Pines planted here in 1854 or 1855 are now (1886) about 40 feet high.

The limiting line of the White Pine beyond the Mississippi northwestward is traced substantially as indicated by Mr. Warren Upham in the Geological and Natural History Survey of Minnesota. Mr. Upham sends the following:

The White Pine, wherever I have seen it in New Hampshire and other parts of New England and in the Northwest, prefers somewhat clayey land. It does not thrive on wholly sandy plains ("modified drift" of glacialists), which are denominated "pine barrens," the congenial dwelling place in the East for the Pitch Pine (*P. rigida*), and in the Northwest for the Banksian or Jack Pine (*P. divaricata*); nor does the White Pine in either region grow plentifully and of largest size on very clayey land, which is the favorite location for Maples, Basswood, Elms, and other deciduous trees. The White Pine in this matter of its choice of soil follows the injunction. *Medio tutissimus ibis.* The Red Pine (*P. resinosa*), so far as I have observed, can thrive better on the very sandy plains and "barrens" than the White Pine, being intermediate in this between the White Pine and the Pitch and Jack pines.

Prof. T. H. Macbride, of the State University of Iowa, says:

I have collected White Pine in the following counties in this State: Mitchell, Howard, Winneshiek, Allamakee, Clayton, Dubuque, Delaware, Jackson, and Muscatine. It is, by others, reported from Scott. It ought to be found also in Fayette, but I have never run across it there.

[This would confine the White Pine in Iowa to the counties bordering the Mississippi River and the Minnesota State line as far west as the Cedar River Valley.]

CONCLUSIONS REGARDING NATURAL DISTRIBUTION.

The leading conclusions to be drawn from what has been stated regarding the natural distribution of White Pine seem to be the following:

(1) Leaving out of consideration all the outlying portions of the region under discussion, there is left an area of not less than 400,000 square miles in the United States and Dominion of Canada within which the White Pine is in its home and surrounded by the conditions of its own choice, throughout which its successful cultivation is fully assured.

(2) A much larger territory than this is included within the limits of extreme distribution as defined above, and there is abundant evidence to show that over nearly the whole of this wide area, and in some directions far beyond it, this species makes under cultivation a healthy and rapid growth. There is apparently no species of equal value indigenous to eastern North America that is at the same time adapted to so wide an area.

(3) The habits of this species near the western limit of its natural occurrence, as well as experimental planting, indicate plainly that its successful growth can not be depended upon much beyond this limit.

THE WHITE PINE LUMBER INDUSTRY.

No species of American timber has been so much used for lumber as the White Pine, and the development of the lumber industry in this country is coincident with the exploitation of the White Pine forests.

The commercial use of White Pine began with the first settlement of New England. The first sawmills were established in the seventeenth century, and numerous small sawmills, which were usually an attachment of the neighborhood gristmill, were in operation early in the eighteenth century. Timber was exchanged for merchandise, and the collections thus made were floated to ports of shipment, whence they were exported. This primitive industry, confined largely to White Pine, was continued well into the third decade of the present century. In 1850, J. S. Springer, of Maine, wrote: "Thirty years ago it was unnecessary to search for a locality for a lumber camp on the Penobscot, for a man could step from his house to his day's work, the pine, that forest king, abounding on every side. Fifty years hence the vast pine forests through which the Penobscot flows will be on the eve of destruction." This prophecy has long since been verified, for the Spruce has practically taken the place of the White Pine in the lumber output of Maine.

This early trade in White Pine, though involving small capital and limited operations on the part of each dealer, was by no means unimportant in the aggregate, lumber being a leading industry in New England from the first. The Bangor Weekly Register of March 2, 1816, noted that between 300 and 400 sleigh loads of lumber, etc., came into Belfast in one day. The Gazette of July 10, 1822, says that 136,086 feet of lumber and 35,000 shingles were hauled in on one Saturday by teams. In 1825 twenty-five vessels were engaged in the lumber trade from Bangor to the West Indies. The mills of those days were all small affairs, generally single-sash saws, driven by water power, with a capacity of 1,000 to 3,000 feet per day. About 1830 the construction of larger mills began, and in 1890 a capital of nearly $12,000,000 was invested in the sawmilling industry in the State of Maine alone.

In general, it may be said that the White Pine of New England was cut by numerous small concerns, and that the bulk of the supplies was cut before modern sawmilling began.

Although the great forests of White Pine in Maine have disappeared, a small amount of this material is still cut in the State every year, so that since 1881, on the Penobscot, for instance, out of a total cut of about 150 million feet per year between 24 and 30 million feet have been pine, the pine thus generally forming 15 to 20 per cent of the entire output.

In Pennsylvania the exploitation of White Pine likewise began quite early. Pittsburg furnished pine lumber to points along the Ohio and even to St. Louis, Mo. As late as 1850 Philadelphia received its 150 million feet of lumber, largely White Pine, from the State, importing but very little from New England and the South. At Williamsport, the center of White Pine lumbering in Pennsylvania, the first large mills were erected about 1838, and the bulk of the pine was cut prior to 1870.

In the forties the White Pine product marketed at Williamsport excelled in quantity all other points of production. The highest production was reached in 1873, with nearly 300 million feet B. M. in logs boomed, which in 1893 had sunk to a little over one-tenth of that amount. While in 1873 the amount of timber standing was estimated as 3,300 million feet B. M., in 1896 the State commissioner of forests places the remainder at 500 million feet B. M.

The only uncut White Pine forests of Pennsylvania now standing are isolated bodies in the more inaccessible parts of Clearfield, Lycoming, and Tioga counties.

In the State of New York, too, which in the Adirondacks and in the western counties contained considerable quantities of White Pine, the species is largely cut out. Hardly more than 5 per cent of the cut is now of White Pine, the output from the Adirondack mills being in the neighborhood of 25 million feet B. M.

The exploitation of White Pine in the Lake region began during the thirties, when small mills were erected at various points, both in Michigan and Wisconsin. The first steam sawmill at Saginaw was built in 1834, and the first mill at Alpena was built two years later. Nevertheless the lumber industry of both Michigan and Wisconsin remained insignificant until toward the close of the fifties, when most of the present sites of manufacture had been established. Ten years later (1870) the annual cut of White Pine in Michigan and Wisconsin amounted to nearly 4 billion feet; Minnesota had scarcely begun to contribute to the output; and in the marketing the railway was fast displacing the older method of rafting. The progress of lumbering is well illustrated in the following figures from the Northwestern Lumberman, representing the annual cut of lumber alone from 1873 to 1897:

Annual cut of lumber (exclusive of shingles and laths) of the three Lake States, Michigan, Wisconsin, and Minnesota, 1873–1897.

	Feet B. M.		Feet B. M.
1873	3,993,780,000	1886	7,425,368,443
1874	3,751,306,000	1887	7,757,916,784
1875	3,968,553,000	1888	8,388,716,460
1876	3,879,046,000	1889	8,305,833,277
1877	5,595,333,496	1890	8,664,504,715
1878	3,699,472,759	1891	7,943,137,012
1879	4,806,943,000	1892	8,903,748,423
1880	5,651,295,006	1893	7,599,748,458
1881	6,768,856,749	1894	6,763,110,649
1882	7,552,150,744	1895	7,093,398,598
1883	7,624,789,786	1896	5,725,763,035
1884	7,935,033,054	1897	6,233,454,000
1885	7,053,094,555		

Or, dividing the time into periods of five years each, the figures are as follows:

Cut of lumber (exclusive of shingles and laths) in Michigan, Wisconsin, and Minnesota, by periods of five years.

	Feet.
1876–1880	21,562,090,361
1881–1885	36,933,924,888
1886–1890	40,542,339,679
1891–1895	38,302,143,140
Total	137,340,498,068

From the figures, to which about 10 per cent must be added for shingles, laths, etc., it appears that the yearly output did not reach 4 billion feet until 1879, and that the greatest increase in the cut occurred between 1876 and 1882, when the 7-billion mark was reached. This enormous cut continued until the general business depression of 1894 called a temporary halt. In Minnesota, pine lumbering began on the St. Croix and did not reach conspicuous dimensions until during the eighties, when the regions along the upper Mississippi, as well as the Duluth district, were opened. This progress westward is well illustrated by the following figures, which show the percentage of the total cut of lumber alone from period to period, by districts:

Percentage of total cut of lumber, 1873 to 1895, by districts.

Districts.	Lumber cut.				
	1873	1880	1885	1890	1895
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Saginaw district and mills along railways in southern peninsula of Michigan	36	31	27	24	16
Ports about Lake Michigan, including those of Green Bay	30	32	28	28	26
District west of Chicago, that is, most of the mills in Wisconsin and Minnesota	34	37	45	48	58

In this connection the White Pine trade of St. Louis presents an interesting illustration. The first pine lumber was received from Pittsburg in 1819, and this point remained the principal source of supplies for years. In 1843 a boom on the St. Croix River broke and the liberated logs were gathered and rafted to St. Louis, where they were sawn. In 1850 the first regular raft of Wisconsin logs was brought to the city. In 1853 Schulenberg and Boeckler built a large sawmill on the St. Croix, and from this time on rafts of sawed White Pine were sent to St. Louis from the northern rivers.

The receipts of White Pine at St. Louis were: In 1853, about 60 million feet; in 1882, about 162 million feet. Similarly the lumber trade of the city of Chicago, the greatest lumber market in the United States, if not in the world, illustrates well the development of the White Pine lumber industry. In 1847 only 32 million feet of White Pine lumber were received. The annual receipts at intervals of ten years since 1855 to 1895 were as follows:

	Feet.
1855	306,000,000
1865	617,145,734
1875	1,153,715,432
1885	1,744,892,000
1895	1,637,389,000

The receipts reached their maximum in 1892 with 2,203,874,000 feet, and the heavy diminution since that date is not greater than would be accounted for by the general business depression throughout the country.

In Canada, as in New England, the exploitation of White Pine began almost with the first settlement. Logs, hewn timbers, and especially ship spars, were exported in early days, and of late years an extensive trade in sawn lumber, as well as saw logs, has sprung up between that country and the United States. Since reliable statistics of the lumber output of this region are wanting, the following figures for the dues on crown timber in Ontario and Quebec must suffice to illustrate the development of the industry:

Average annual dues on crown timber for Ontario and Quebec.

1826–1834	$24,000
1835–1851	82,000
1852–1857	122,000
1858–1866	168,000
1867–1881	450,000

The export into the United States for 1894, the heaviest year, was: Lumber, 1,155 million feet (Pine and Spruce); pine logs, 277,947,000 feet, or less than 1½ billion feet B. M.

Though scattering White Pine occurs in all provinces of eastern Canada, large bodies of merchantable timber are only to be found on the upper waters of the Ottawa, and on the shores of Lake Huron (Georgian Bay district) and Lake Superior, and the White Pine lumbering is practically confined to these districts. The output of White Pine in the Dominion is estimated at 1½ to 2 billion feet per year.

ORIGINAL STAND AND PRESENT SUPPLIES.

What the original stand of White Pine was is difficult even to estimate. The amount of White Pine cut in the New England States, New York, Pennsylvania, and the eastern Provinces of Canada is not known, and the only reliable figures which give an indication of what has been harvested are the figures for the Lake States above mentioned. For the Lake region alone the estimated original stand for Wisconsin may serve as an illustration. For the pine-stocked area of this State, a total stand of about 150 million feet per township (23,000 acres) has been shown to be a fair average. This would indicate a total of about 130 billion feet, of which about 66 billion feet were cut between 1873 and 1897, and about 20 billion feet are supposed to have been cut prior to 1873, making a total of about 86 billion feet as actually harvested, while about 18 billion feet were believed to be still standing in 1897. These figures are based upon a thorough canvass made by Mr. Filibert Roth and published in detail in Bulletin No. 16 of the Division of Forestry. On the same basis, Michigan possessed fully 150 billion feet and Minnesota may be assumed to have had about 70 billion feet, which would make an aggregate of about 350 billion feet of pine for the Lake States. Of this about 170 billion feet were cut between 1873 and 1897, and about 50 billion feet were probably cut prior to this time, accounting for about 220 billion feet out of 350 billion feet. While it must remain mere conjecture, it seems quite fair, nevertheless, to assume that the total supplies of White Pine aggregated probably not less than 700 billion feet of standing timber originally. Of this total, then, not less than 50 per cent was contained in Canada and the Eastern States, the United States portion representing about two-thirds of this heritage, the Canadian portion showing less than 20 per cent of total supplies.

Of this large amount of virgin supplies, a little over 15 per cent, or 100 billion feet, may be estimated as standing. These supplies may be approximately distributed as follows:

Canada is credited by the statistician of its department of agriculture with about 37 billion feet of standing pine, an estimate probably far below the real truth. For the Lake States the following estimates were made in 1897 by the best-informed man of the Lake region: Minnesota, 36 billion feet; Wisconsin, 18 billion feet; Michigan, 10 billion feet. These estimates are considered quite high by many. The standing pine in Michigan is placed by a detail township canvass in 1890 at only about 6 billion feet; the standing White Pine of Minnesota is estimated by the State chief fire warden at only about 12,600 million feet, while an estimate for Wisconsin made in 1895 places the standing pine of that State at only 8 billion feet.

Retaining the larger figures as probably the nearest correct, there exist to-day: In the Lake States, about 64 billion feet; in Canada, over 40 billion feet; in New York and Pennsylvania, not over 2 billion feet; in New England, not over 3 billion feet; in West Virginia and Tennessee, not over 1 billion feet; making a total of about 110 billion feet, or about 22 per cent of what may fairly be believed to have been standing originally. Of this standing supply, about 100 billion feet are so located that the present rate of exploitation (over 6 billion feet per year) can be, and probably will be, continued until over 75 per cent of the present supply is cut, when, of course, a lack of logs will lead to a reduction in output. This condition may be looked for before the end of the next ten or twenty years, and from that time, unless recuperative measures are adopted, White Pine will cease to be the great staple of our lumber markets.

In former years lumbering of all kinds was careless, and even in the White Pine forests the prevailing "inexhaustible supply" notion led to enormous waste. Stumps were left 3 to 4 feet high, all defective trees were left, and top logs burned up with the débris. Many of these old slashings have been logged for the second and even the third time, often yielding a greater profit than when first culled.

At present this is no longer the case. High stumpage prices and a perfect market have led to the closest economy in logging, milling, and shipping of White Pine. The trees are felled with the saw, the stumps are 18 inches and less, care is had in the marking and sawing of logs, and the top is utilized, irrespective of knots, just as far as it will make saw timber. Defective logs are rarely left behind, and "clean cutting" now means the removal of all logs, however defective. In logging, ice roads, improved by nightly sprinkling, enable the transport of enormous loads (5,000 feet and more) by single or double teams. The logging railway is fast finding favor, and in many places the logging is thereby made continuous, being carried on at all seasons. (See Pl. IV.)

The yields in White Pine are, as might be expected, very variable.

A cut of 2 million feet B. M. on a "forty," or 50,000 feet per acre, was not a rare one in the pineries of southern Michigan, and occasionally such cuts are made in Wisconsin and Minnesota. To yield such a result the entire "forty" must be well and evenly stocked. The best acre, then, need not be far above the average, and, in fact, rarely exceeds 75,000 feet.

A stand of 1 million feet on a "forty," or 25,000 feet per acre, is a good one, but was of quite common occurrence in all White Pine districts, and may still be found in many places, while whole townships or counties have averaged 10,000 feet per acre.

These yields depend, of course, on the character of the forest growth, the greater or smaller admixture of other species occasioning the differences. Thus, if any large territory of the pine districts were taken into consideration, a yield of 150 million feet per township would be found a fair statement for most parts of the pineries of Wisconsin and Michigan.

The best yields do not usually come from those tracts which contain the largest trees, but where the pine is least mixed with other species and stands most dense.

Such areas, pineries proper, where no merchantable hardwoods were mixed with the pine, are usually tracts of loamy sand, and occur in extensive bodies in all three of the Lake States. Generally, White Pine cuts more wasteful than Norway or Red Pine, has a thicker bark, more large dead limbs and knots, these latter often coming to within 20 feet of the ground, even on large trees, and is quite given to forking. This latter peculiarity seems natural to the tree, and has been observed abroad as well as here. It seems independent of the character of the soil, as it occurs on clay and sand alike, but it is often localized, so that on a small tract of 10 or 20 acres nearly all trees are forked. Trees with three and four forks are not rare, and five forks occur. In addition, White Pine is extensively defective by decay, so much so that in some localities 15 to 20 per cent must be allowed for the loss from this source.

NATURAL HISTORY.

The oldest description of the White Pine appears to be that of Plukenet, published in 1700. Its scientific name of *Pinus strobus* was given the species by Linnæus in 1753, and unlike most trees but one other scientific name has been applied to it, the synonym being *Pinus tenuifolia* Salisbury, 1796. Besides the generally accepted common name of White Pine, the species is locally known in the United States as Soft Pine, Northern Pine, and Spruce Pine, and to a limited extent by its usual European name of Weymouth Pine.

The species was first introduced in Europe at Badminton, England, and was soon after extensively planted on the estate of Lord Weymouth, whence its common name abroad. It was also extensively planted in Germany at the end of the last century under the same name, Weymuthkiefer.

BOTANICAL DESCRIPTION.

White Pine (*Pinus strobus* L.) in its natural habitat is a tree of large size, 100 feet or more in height (not unfrequently attaining a height of over 150 feet, even trees of 250 feet in height having been reported), with smooth, thin, grayish bark (fig. 1), becoming at the base thick and deeply furrowed with age. The leaves are slender, straight, triangular in section, five in a sheath, $2\frac{1}{2}$ to $4\frac{1}{2}$ inches long; resin ducts, chiefly two near the dorsal face; stomata in three to five rows on the ventral faces; fibro-vascular bundle, one. Cones, single or in groups of two to three, stalked and pendulous, 4 to 6 inches long, cylindrical, slightly tapering and curved, fruit-scales oblong wedge-shaped, the apophysis half pyramidal, with a triangular blunt point. Seeds, one-fifth to one-fourth inch long, grayish-brown, with a thin membranaceous wing. Cotyledons, seven to eleven.

A number of varieties, more or less distinctly marked, are recognized in cultivation. Among these are *nana*, a dwarf, bushy form, cultivated in gardens in the Old World; *nivea*, *viridis*, and *aurea*, named from the color of their leaves; *brevifolia*, and several others (*umbraculifera*, *minima*,

FIG. 1. TRANSPORTING LOGS OVER ICE ROAD IN MICHIGAN.

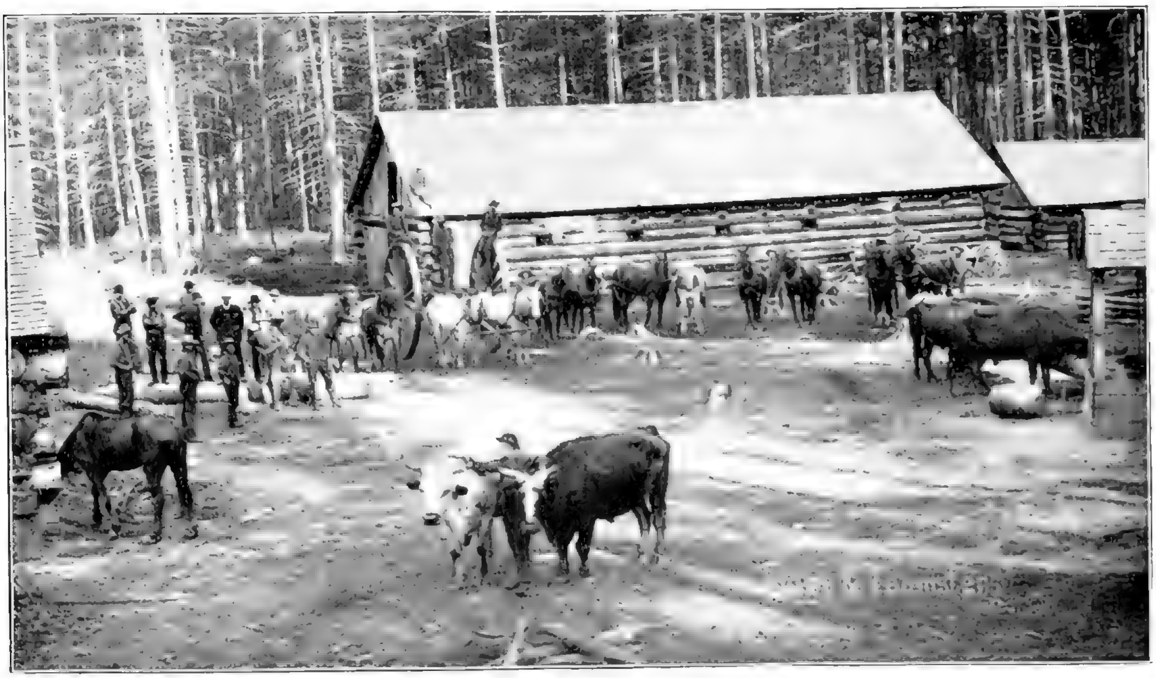


FIG. 2.—LUMBER CAMP IN MICHIGAN.

fastigiata, *gracilifolia*, *variegata*, *zebrina*, and *prostrata*), some of which are propagated and sold as special attractions in nurseries.

RELATIONSHIP.

The White Pine (*Pinus strobus*) is closely related to the Bhotan Pine (*Pinus excelsa*) of India, the Swiss Stone Pine (*Pinus cembra*) of southern Europe, the White Pine (*Pinus flexilis*) of the Rocky Mountains, the Sugar Pine (*Pinus lambertiana*) of the Pacific coast, and a number of others less generally known, of which *Pinus monticola*, *P. albicaulis*, *P. strobiformis*, *P. quadrifolia*, *P. parryana*, and *P. cembroides* are natives of the United States.

Fig. 1.—Bark of old White Pine.

The species belonging to this section of the pine genus are distinguished by their slender, delicate leaves, five in a sheath; by the exceptionally soft and even texture of their wood, and by certain well-defined botanical characters, by which they are marked as a natural and easily recognized group.

The group of species just named shows a preference, generally characteristic of this section of pines, for elevated, mountain regions, and a light rather than a heavy soil, making, as a rule, a healthy growth on sandy and rocky places, and manifestly preferring these to low and heavy soil. All are handsome trees, symmetrical in form, some of them, as the Sugar Pine (*Pinus lambertiana*), of rapid growth, and forming magnificent specimens from 150 to over 200 feet in height, while others are of slow growth, as the Stone Pine of the Alps, which produces, however, a beautiful, fine-grained wood, extensively used by the Swiss peasants for carving. The Bhotan Pine of the Himalayas is the representative of the White Pine in Asia, resembling it very closely in habit, size, structure of wood, and various technical characters.

Admitting the common ancestry of these various species, a more extended comparative study of their preferences and habits would be of much interest in relation to their cultivation beyond their natural range, considering the fact that, whatever their environment, such ancestral traits are certain to manifest themselves.

MORPHOLOGICAL CHARACTERS.

ROOT, STEM, AND BRANCH SYSTEM.

In the natural forest, with a due amount of shade, the White Pine has at maturity a straight columnar trunk, destitute of branches for half to two-thirds of the distance from the ground to the tip of the leader.

The branches are for many years disposed regularly in whorls, and during this early period the tree retains a symmetrical, conical form, and is one of the most graceful of the pines for ornamental cultivation, but, as is the case with other conifers, the lower branches are short lived, and ultimately, by their decay, the tree becomes unsightly. This fact, which renders this species, in common with all other conifers, undesirable during part of their lifetime for ornamental purposes, gives it the greater value as a timber tree.

The crown, at first pyramidal, is finally less regular, although rarely flattening, and, owing to the rapid and persistent growth of the tree, conspicuously overtops the surrounding forest of deciduous trees. The root system is small compared with the size of the tree and spreads near the surface of the ground; its comparatively slight development is in harmony with the less pronounced dependence of this species on the soil and its greater dependence on the atmosphere.

Nursery seedlings produce numerous slender, fibrous roots, the delicate tissues of which are as in most conifers easily dried at the time of transplanting, resulting in very serious injury or loss of plant material. White Pines planted upon the dry sand along the Lake Michigan shore and trimmed of their lower branches have been observed restoring these lower limbs and forming a thick, green covering over the roots before making any height growth, suggesting in a striking manner the necessity of protecting the root system against too rapid evaporation and a too highly heated soil. In the natural forest, and in artificial groves properly planted, the fallen leaves fulfill this function by making a deep, thick coating over the roots.

LEAVES.

The leaves arise from greatly reduced short branchlets and are produced five together, surrounded at the base by a thin deciduous sheath, and are further distinguished by being more slender and delicate than those of our other native pines. (Pl. V, *1, 2, 3, 4.*) The relative position of the five leaves inclosed in their common sheath is shown in Pl. V, *5*, and in Pl. V, *6*, is represented a cross section of a single leaf, magnified sufficiently to show the characteristic arrangement of the tissues.

Without entering into a detailed account of its functions, which would here be irrelevant, it may nevertheless be remarked that the leaf of the White Pine constitutes a highly complicated and delicate piece of apparatus. Like all foliage leaves, the leaf of the White Pine fulfills the important functions of respiration and the manufacture of starchy food, during which processes large amounts of watery vapor are exhaled.

A healthy pine seedling, three years old, in the air of a dry room, lost by evaporation in twenty-four hours 81.1 per cent and in the following twenty-five hours 96.7 per cent of its entire dry weight.[1] The evaporation, chiefly through the leaves, is more rapid in the daytime than in the night, in clear than in cloudy weather, and most rapid of all in a drying wind. It will readily be seen that if a tree is planted on a clear, dry, and windy day, the conditions are the most unfavorable that could possibly be chosen, the rapid evaporation carrying off the water of the plant beyond the capacity of the roots, not yet adapted to their new place, to meet the demand, which results in the drying up of the tissues and often in the death of the tree.

The various forms of modified leaves are characterized by extreme delicacy. Winter buds (Pl. V, *7*), with their thin and small scales, present a striking contrast to those of Longleaf Pine, for example, and other species that produce large buds with relatively thick and coarse scales. The very loose leaf sheaths and scale-like leaves of the young shoots are early deciduous, a fact that contributes to the growth of the smooth, clean bark characteristic of the branches of White Pine, in which it differs in so marked a way from the species of the Yellow Pine group.

In Pl. V, *1*, the modified, scale-like leaves that constitute the loose sheaths are conspicuously shown. Separate fascicles, with their sheaths, are represented in Pl. V at *2* and *3*, while at *4* is an older one as it appears at the end of the summer after the sheath has fallen.

EXPLANATION OF PLATE V.

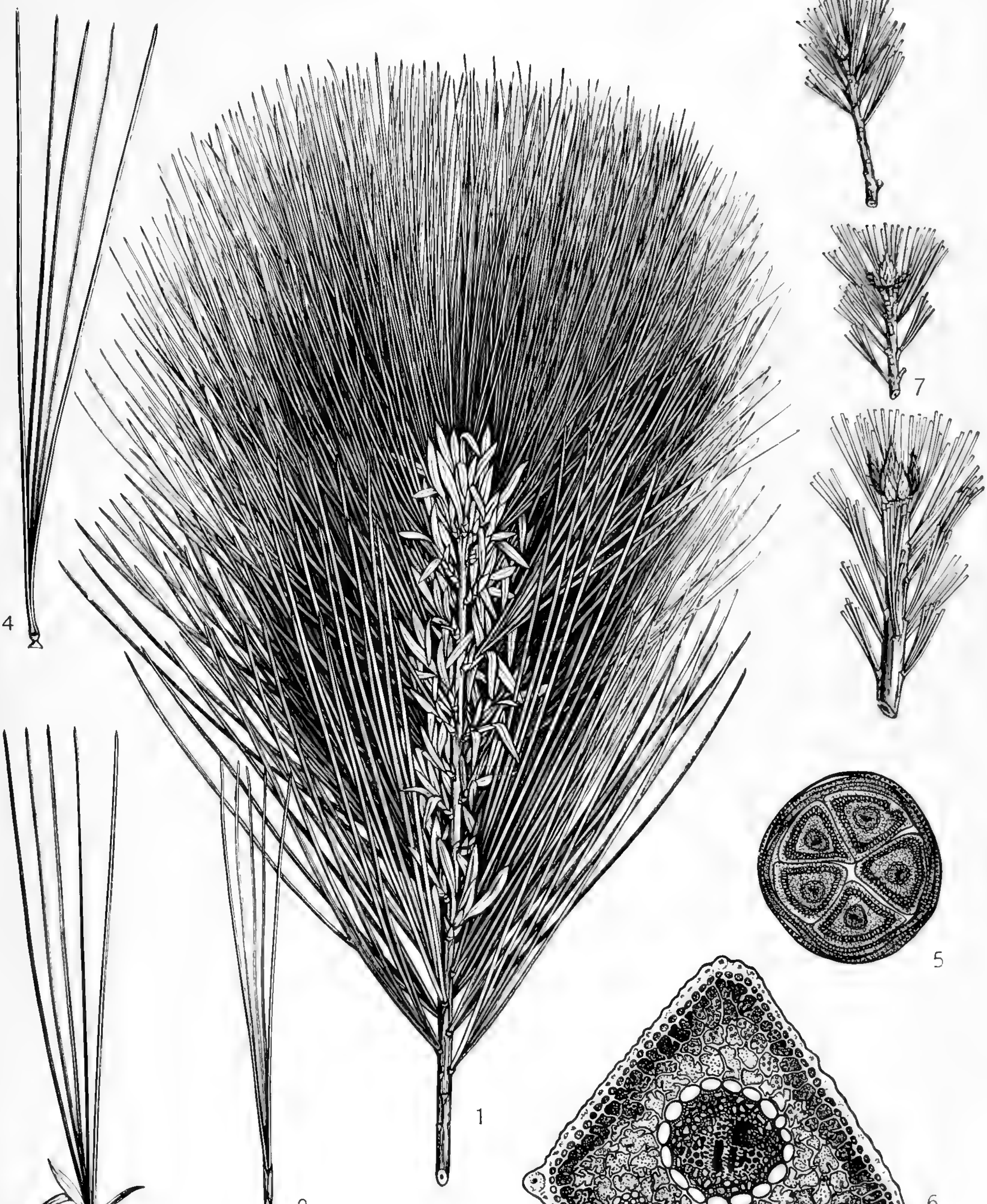
1. Shoot showing foliage and scale leaves of different ages.
2. Young fascicle with sheath.
3. Young fascicle further developed.
4. Still older fascicle from which the deciduous sheath has fallen.
5. Section of fascicle inclosed in sheath.
6. Section of leaf magnified.
7. Winter bud.

FLORAL ORGANS.

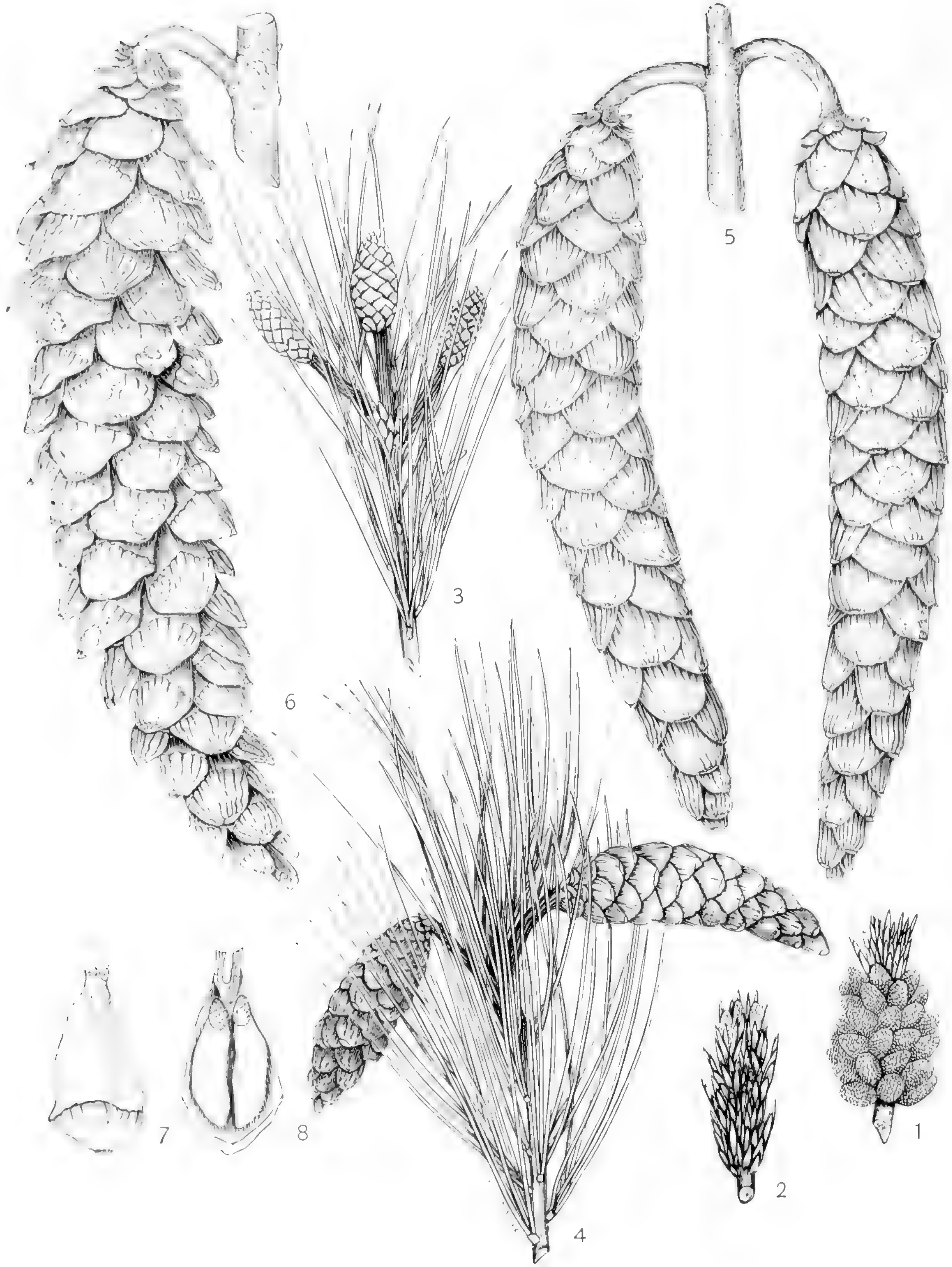
Flowers and fruit are rarely produced to any considerable extent before the tree has attained the age of fifteen or twenty years, though occasionally trees may bear fruit at ten to twelve years of age.

The staminate and pistillate flowers are separate, but produced on the same tree. They appear in May, the pollen ripening and pollination taking place (in the latitude of Ann Arbor,

[1] According to determinations made in the botanical laboratory of the University of Michigan, November 18, 1886.



LEAVES AND BUD OF THE WHITE PINE.



CONES, SEEDS, ETC., OF THE WHITE PINE.

Mich.) between the middle and the end of the month. The staminate flowers are borne laterally on the shoots of the season (Pl. VI, *1*). They are extremely simple in structure, consisting of numerous pollen sacs borne in pairs on the outer face of the scale-like staminal leaves. The pollen is produced in great abundance and is carried by the wind to great distances. Fertilization, however, notwithstanding the profuse production of pollen, often fails to take place. In fact, failure appears to be rather the rule than the exception, if we consider the frequency of "off years," in which little, if any, good seed is produced. But doubtless other causes often combine to prevent the production of a full crop of seeds.

The pistillate flowers occupy the apex of the young shoot (Pl. VI, *2*), finally forming a bunch of cones pendent from the ends of the branches. At the time of pollination they are about one-fourth of an inch in length and have the appearance of minute fleshy cones, which by the end of the first summer's growth have attained the length of three-fourths of an inch to an inch, and have the appearance represented in Pl. VI, *3*. They are not ripe until the fall of the succeeding year, when the cones, having now attained their full size, as shown in Pl. VI, *5* and *6*, open and allow the winged seeds to escape. In order to prevent loss of seeds it is necessary to gather the cones a little before they ripen, which occurs during early September in most localities of the natural range. Afterwards, if kept in a dry place, they will open readily themselves and allow the seeds to fall out. The ripening is signalized by the change of color to a yellow brown and the forming of a resin coat.

SEEDS.

The seeds are one-fourth of an inch in length by about half that measure in breadth, of an oval form, grayish-brown in color, sprinkled with darker spots, and provided with a thin, delicate wing, by means of which they are disseminated through the agency of the wind (Pl. VI, *8*). The seed coats consist of a hard outer shell, or testa, inside of which is a thinner membrane, the endopleura. Inside of the seed coats is the whitish endosperm, constituting the food of the germinating plant, within which, occupying the center of the seed, is the small, straight embryo, the three parts of which, stem, radicle, and cotyledons, are plainly distinguishable.

To get 1 pound of seed from 2 to 2½ bushels of cones are necessary.

Concerning the production of seed, the experience in this country is but fragmentary. The individual tree begins to bear quite early. Isolated specimens, or trees in open groves, bear cones before they are twenty years old, and even trees in the dense forest seem to bear generally before they are forty years of age. The capacity to bear abundantly is retained to old age, the oldest trees seen still bearing heavily, and even mutilation by fire or otherwise does not prevent the trees from bearing.

EXPLANATION OF PLATE VI.

1. Staminate flowers of *Pinus strobus* just before shedding of pollen.
2. Pistillate flowers, terminating young shoot.
3. Young cones in autumn of first year.
4. Young cones early in summer of second year.
5. Cones at close of second year's growth before opening of scales.
6. Mature cone, the scales separated to admit of dissemination of seeds.
7. Single scale, showing outer surface.
8. Single scale, showing inner surface with seeds in place.

SEED SUPPLY.

A full crop of seeds is usually produced by the same tree only at intervals of several years. Cones may be formed year after year, but upon examination it is often found that many of the seeds are abortive. Of a large number of cones gathered at Ann Arbor, Mich., in 1886, not a single one showed a perfect seed. Mr. John E. Hobbs states that the same year (1886) was a good seed year in Maine, and that trees had not produced so largely before since 1879. According to Mr. J. Dawson, of the Arnold Arboretum, a crop of seed may be looked for about once in five years, though others make intervals between seed years shorter. The frequency of seed years has not been sufficiently noted as yet to warrant any general statement, but it is known that during certain seasons the seed production is perfectly general over large areas, while in other years it is not. Thus, in 1897 the White Pine bore heavily in every pine county in northern Wisconsin.

The frequency of seed years varies of course not only on account of more or less favorable seasons, but according to locality and climatic conditions. In Europe the White Pine is regarded as a frequent and heavy seeder, one year out of three being generally productive. A grove of 8 acres near Frankfort on the Main produced during twenty years, on an average, $100 worth of seed, with a maximum yield of $500, and with but three "off" or fail years in the twenty. Similarly an area of about 40 acres in the Palatinate furnishes as high as 1,700 bushels of cones, or about 1,300 pounds of seed, supplying all the nurseries of the Palatinate State forests with seed.

THE WOOD.

The structure and development of the wood of the White Pine may be studied to the best advantage by beginning with a young shoot cut from a vigorous tree in early summer. A cross section of such a shoot in the first season of its growth (Pl. VII, *1*) shows three plainly marked zones—the pith (*m*) surrounded by the wood (*x*) and the inner bark (*ph*), which together form the conspicuous zone crossed by radiating bands, the so-called medullary rays, and outside of the parts just described, a broad zone of cellular tissue, constituting the middle bark, which is bounded externally by the epidermis.

The pith, medullary rays, and middle bark consist of simple cells, originally of an irregularly rounded form. Together they constitute the so-called ground tissue of the stem, as distinguished from the fibro-vascular portion, which includes the wood and inner bark.

Within the cortical portion of the ground tissue numerous large openings (Pl. VII, *1*, *rd*) are seen, of different sizes and apparently without definite arrangement. These are the resin ducts. Each duct runs longitudinally through the stem, and consists of a central cavity filled with resin, around which is a single layer of secreting cells, easily distinguished by the nature of their contents from the surrounding cells of the cortex. At this stage of development the resin ducts are confined to the cortical parenchyma, none having yet been formed in the woody portion of the stem; but later in the season, as may be seen in older sections, a number of ducts are formed, arranged in a circle near the periphery of the wood. These have essentially the same structure as those of the cortex, but are of smaller size and are surrounded by fewer secreting cells. In cross sections of older stems the resin ducts are seen, arranged in an irregular circle, in each annual ring. Their physiological significance is not fully understood, though there can be little doubt that De Vries is correct in assuming that the abundant resin is of service to the growing tree, when wounded, in preventing decay of the wood, and that its preservative influence is continued after the tree has been cut into lumber.

In such a young shoot as has been described the cells are vitally active, and are filled with granular protoplasm, in addition to which several other substances are either produced or stored up in them, particularly in the cells belonging to the ground tissue. Chlorophyll occurs in the pith and medullary rays as well as in the cortical portion. It is most abundant in the cells of the cortical parenchyma, occurring in the form of minute grains, irregular in shape and size. Starch, in rounded granules, occurs abundantly throughout the ground tissue, the cells of the cortex containing a larger proportion than those of the pith. Resin, as already stated, fills the resin ducts and the secreting cells around them, though starch is often found in the latter.

Passing now to the woody portion immediately surrounding the pith, two characteristic features at once attract attention. The elements composing the wood, *x* (Pl. VII, *1* and *3*), have a much narrower lumen than those of the pith, and are regularly disposed in radiating rows. These elements, the tracheids, are elongated thick-walled cells, four to six sided, according to the number of tracheids by which they are surrounded. Their walls are lignified and are marked by the peculiar structures called bordered pits. Their structure, when fully developed, is shown in Pl. VIII, *1*, *2*, and *4*. In the economy of the tree the wood fulfills the function of mechanical support, and serves as the conducting tissue through which the water, evaporated from the leaves, is carried up from the roots.

The medullary rays are composed of cells so flattened by the pressure of the tracheids that on longitudinal sections they appear as represented in Pl. VIII, *3*. They contain a conspicuous nucleus, are closely packed with granular food substances, and serve collectively as a storehouse of reserve materials. Communication between these and the tracheids is effected by means of simple pits on their radial walls.

The inner bark, or phloem, *ph* (Pl. VII, *1* and *3*), closely resembles the young wood on cross section, its elements being arranged in radiating rows and traversed in like manner by the medullary rays. The cells composing it differ, however, in various important particulars from those of the wood. Their walls are of cellulose, and although important as conducting tissue, they contribute comparatively little to the rigidity of the stem.

Between the wood and inner bark is the cambium or formative tissue, represented in Pl. VII, *1*, as a light band of extremely small and delicate cells, and in the same plate as a zone of cells with thin walls and large lumen, contrasting strongly with the wood elements and those of the inner bark between which they lie. It is from the cells of the cambium that those of the wood are formed on the one hand and those of the bark on the other. The process is a gradual one, and no absolute line of demarcation can be drawn between the cambium and the tissues derived from it. The cells of the cambium multiply by tangential division. The essential features of this process, as regards the position of the cell walls, are represented in Pl. VIII, *4*, in which the lightest lines represent the youngest walls and the heavier ones those of greater age, successively. It is by the constant repetition of this process of tangential division and the subsequent thickening of the walls of the cells thus formed that the wood and inner bark make their yearly increase in thickness. In the spring the cells of the cambium are large and vigorous, and a rapid formation of wood elements with relatively thin walls and large cavities takes place, while later in the season much smaller tracheids with thicker walls are formed. This results in the strong contrast between the wood last produced in any given year and that formed at the beginning of the next season's growth, giving rise to the sharp distinction of annual rings so clearly brought out in Pl. VIII, *1*.

The histological characters thus briefly summarized hold true, in a general way, for other conifers as well as the White Pine. This species, however, presents a number of peculiarities that are of both physiological and economical interest.

The resin ducts of the White Pine are larger and more numerous in the cortex than in the wood, an arrangement well adapted to secure the protective action of the resin contained in them without introducing an element of weakness into the wood. Comparisons with other species bring out this fact in a striking manner. Thus, upon comparing the distribution of the resin ducts in stems of the White and Scotch pines, as nearly alike as possible, it was found that in the cortex of White Pine stems of one year's growth the number of resin passages ranged from 20 to 47, the average being about 33. The number in the wood was more uniform and averaged about 13. In the Scotch Pine the average for the wood was found to be 33 and for the cortex 10. Taking the second year's growth in the same way, the average number for cortex of White Pine in the specimens examined was 28 and for wood 27; in Scotch Pine, for cortex 9 and for wood 37.[1] The small size of the resin ducts in the wood contrasts strongly with the very large ones of Scotch Pine, which seriously interfere with the continuity of the wood and tend both to weaken it and to give it an uneven texture.

The extremely small number of thick-walled tracheids constituting the summer wood of the White Pine is in marked contrast with the broad band of summer wood formed in various other species. Comparing the annual rings of White Pine with those of Longleaf Pine, for example, it is seen that while the thick-walled tracheids of the former make hardly more than the mere outer edge of each ring, those of the latter constitute one-third or more of its entire width. Moreover, the gradual, almost imperceptible, transition from spring to summer wood in the White Pine contrasts strongly with the abrupt line of demarcation seen in Longleaf Pine and all other Yellow Pines. It is to this very gradual transition that the uniform texture of the wood of White Pine is chiefly due. The medullary rays of the different groups of pines show certain structural peculiarities that appear to be constant for the group of species in which they occur. The writer is indebted to Mr. Filibert Roth for the following notes in regard to this feature:

In all pines the medullary ray is made up of two kinds of cells which differ in their general form, and still more in the configuration of the cell wall and pits. The one kind occupies the upper and lower rows of each ray,

[1] Etta L. Knowles, in Botanical Gazette, August, 1886.

and are therefore termed the outer cells; the other kind makes up the intermediate rows and are known as the inner cells.

In the appearance of both outer and inner cells there is a marked and constant difference in different groups of pines. While the interior of the wall of the outer cells (transverse tracheids) is smooth in some groups, it is beset with numerous bold projections in others. Similarly the inner cells (parenchyma) of the spring wood of each ray in some groups have but a single large pit communicating with the neighboring tracheid, while in other groups this is brought about by three to six smaller pits.

Based upon these differences, the following classification of the wood of different species of pines is proposed by Dr. J. Schroeder:[1]

SECTION I. Walls of the tracheids of the pith ray with dentate projections.

a. One to two large, simple pits to each tracheid on the radial walls of the cells of the pith ray.—Group 1. Represented in this country only by *P. resinosa*.

b. Three to six simple pits to each tracheid, on the walls of the cells of the pith ray.—Group 2. *P. taeda*, *palustris*, etc., including most of our "hard" and "yellow" pines.

SECTION II. Walls of tracheids of pith ray smooth, without dentate projections.

a. One or two large pits to each tracheid on the radial walls of each cell of the pith ray.—Group 3. *P. strobus*, *lambertiana*, and other true White Pines.

b. Three to six small pits on the radial walls of each cell of the pith ray.—Group 4. *P. parryana*, and other nut pines, including also *P. balfouriana*.

Returning to the medullary ray of the White Pine, it is observed that the walls of the outer cells are thin ($1.5\ \mu$ to $2\ \mu$); the round pits quite variable in number and size, but always as small, and often smaller, than the pits of the tracheids in the summer wood; also that the walls of the inner cells are thin ($1.5\ \mu$ to $3\ \mu$), for the most part very thin, being largely occupied by pits; that the pits are large ovals on the radial walls of the cells in the spring wood, small erect ovals in the summer wood, and small and irregular in outline above and below where the inner cells communicate with each other. The length of these cells varies, even in the same ray, between $50\ \mu$ and $300\ \mu$; the width was found to be about $7\ \mu$ for the outer and $12\ \mu$ for the inner cells; the height, more variable in the outer than in the inner cells, and less variable than either width or length, may be set at about $23\ \mu$ for outer and inner cells. The average number of cell rows in one medullary ray, for the specimens studied, is 7.5, whereof 2.6 fall to the outer cells and 4.9 to the inner cells. The limits of the total number of cell rows were 2 and 16; the height of the ray, therefore, $46\ \mu$ to $368\ \mu$, dimensions scarcely appreciable to the unaided eye. What is lost in size is gained in number; on an average 21.3 medullary rays were counted on 1 square millimeter, or 13,312 to 1 square inch of tangential section.

A study of the wood in its physical and mechanical properties, by Mr. Filibert Roth, will be found further on in this monograph.

EXPLANATION OF PLATE VII.

1. Transverse section of fresh shoot, cut in summer of first year × 25. The zone of small cells surrounding the pith includes the wood and inner bark, both of which are traversed radially by the medullary rays. The thick cortical parenchyma outside of these is marked by the presence of a number of large resin ducts.

2. Portion of epidermis, with appendages. Beneath the epidermis a few cells of the cortical parenchyma containing starch.

3. Highly magnified view of a part of the transverse section, showing the structure of wood and inner bark, with the thin-walled cells composing the cambium lying between them.

[Figs. 2 and 3 were drawn with great care with the camera, but unfortunately no statement of the magnification was preserved with them.]

EXPLANATION OF PLATE VIII.

1. Cross section of wood × 175. The section includes parts of three medullary rays, the middle one of which is cut partly through the inner cells and partly through the cross tracheids. The gradual transition from spring to summer wood is clearly shown. Part of a resin duct is seen on the right.

2. Radial longitudinal section of wood × 200, showing a few of the thick-walled tracheids of the summer wood followed by the large thin-walled ones of the succeeding spring, both crossed by a medullary ray. The bordered pits of the outer cells of the ray, shown both in section and surface view, are in strong contrast with the simple pits of the inner cells.

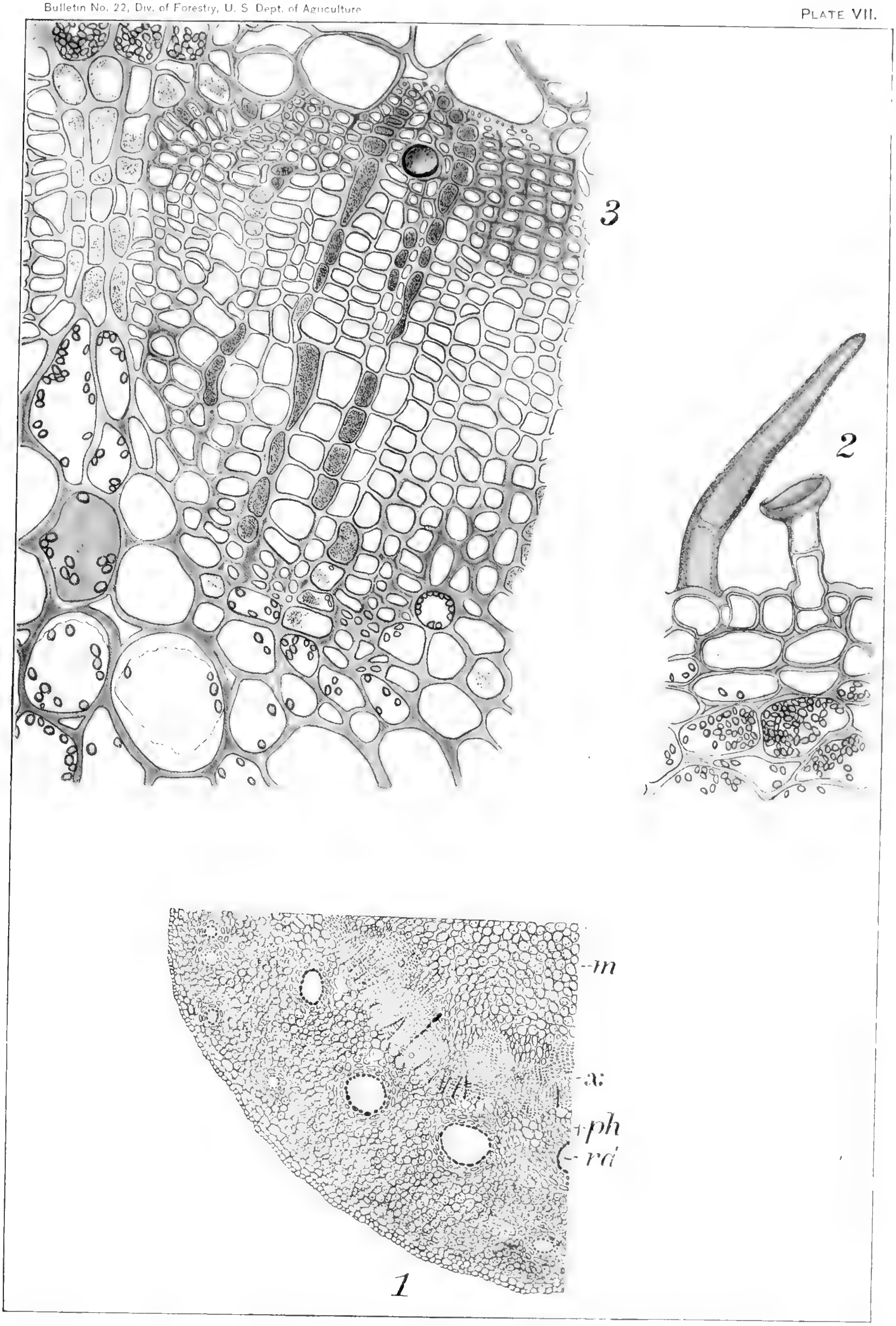
3. Tangential section of wood × 200.

4. Cross section of part of twig collected May 20, 1886, × 175, showing cambium and development of wood and bark. The woody ring is about one-third its final thickness.

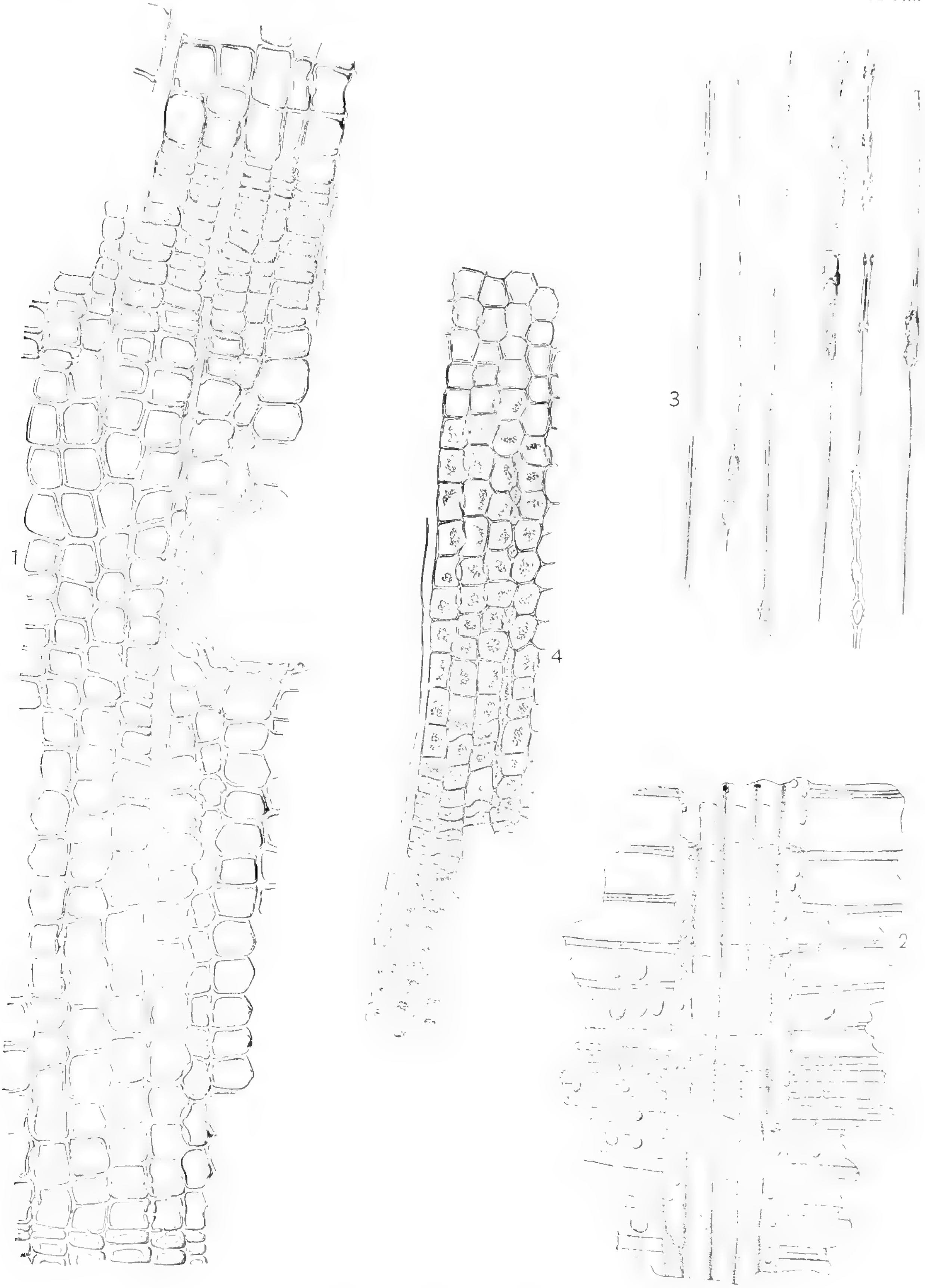
GROWTH AND DEVELOPMENT.

The seeds of the White Pine retain their vitality for a long period. Trustworthy observers state that a fair percentage will grow after being kept five years or more. The conditions of germination and successful growth are, in general, the same as for other pines, namely, a suitable

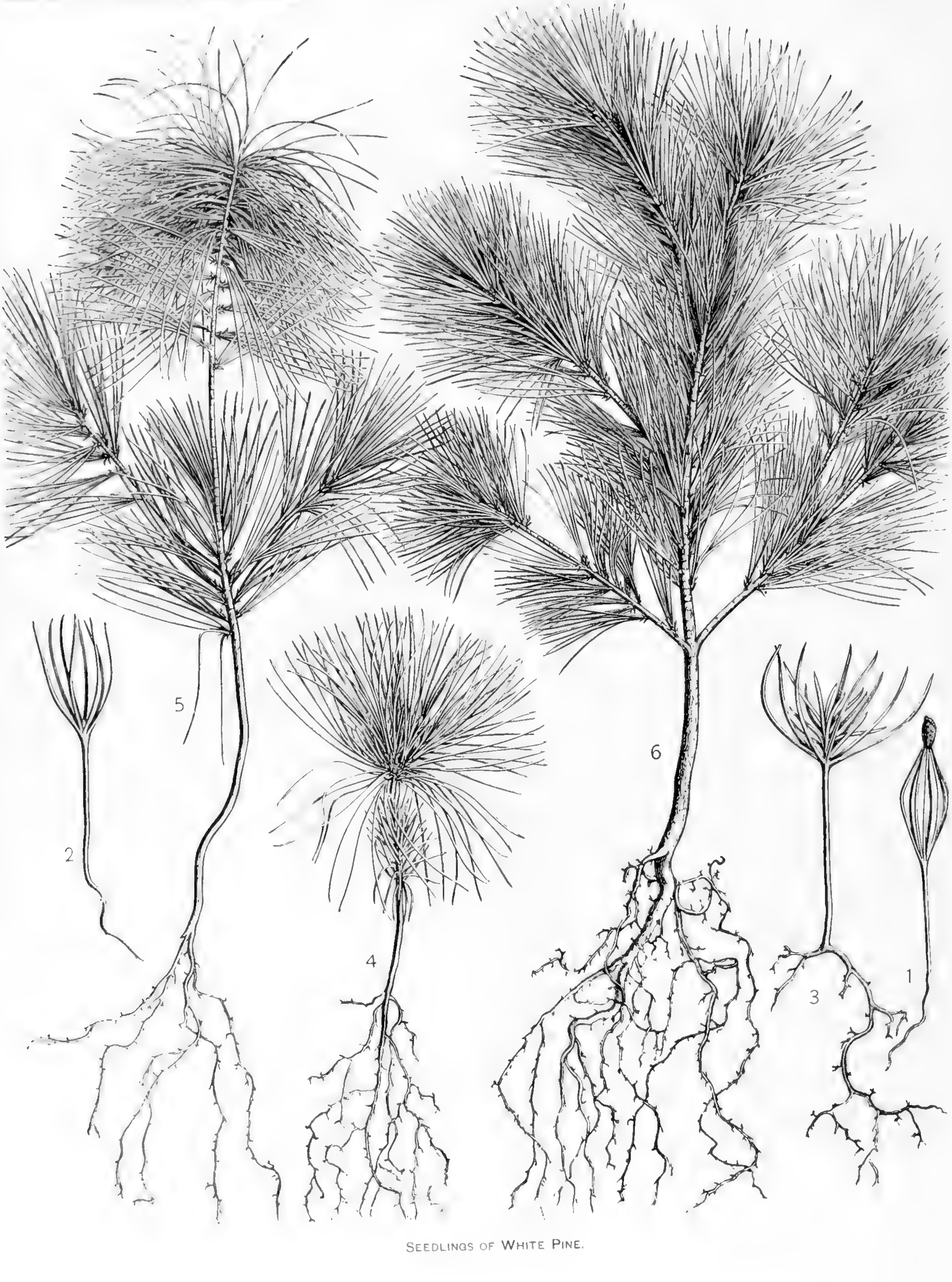
[1] Dr. J. Schroeder, Das Holz der Coniferen, 1872.



SECTIONS OF YOUNG SHOOT OF WHITE PINE.



SECTIONS OF WOOD OF WHITE PINE.



SEEDLINGS OF WHITE PINE.

soil, moderately warm and moist (not wet), in which the seeds are covered at a depth not exceeding twice their own diameter, and, further, protection of the young seedlings against the hot sun and drying winds. Special attention is required in the nursery to avoid undue moisture when the seedlings appear above the ground, as they are often attacked by a destructive disease very common in propagating beds, known as "damping off." If, however, no adverse influences have interfered with its normal development, the young plant presents itself after some months' growth as a slender shoot, crowned by the persistent seed leaves, in the midst of which is the terminal bud, the latter having already formed numerous short foliage leaves. No branches have appeared, and the foliage leaves arise singly instead of in groups of five. The whole plant, as it appears at this time, with its slender stem and long taproot, is represented, natural size, in Pl. IX, drawn from a specimen obtained in the pine woods of Michigan, in September, 1886. Earlier and later stages of development of the seedlings are shown in the same plate (*1*, *2*, *3*, *4*, *5*, *6*) drawn from nursery specimens.

For the first two or three years the growth of the seedling is slow, and is so greatly influenced by its surroundings as to make it impossible to give averages that will fairly represent the yearly increase in height and diameter.

Thus, a healthy seedling, three years old, from the nursery row, measured 4.6 inches, while a self-sown specimen from Maine, four years old, measured only 2.7 inches in height. But, if the circumstances are favorable, after the third year a growth of one to several inches is made each year, and from this time on the yearly increase in height is clearly defined by alternating nodes and internodes, a whorl of branches being formed at each node.

The leading shoot is from the first the most conspicuous and the most important part of the plant, branches being manifestly subordinate, dying off in later years as in other conifers. The rate of growth being of most important practical interest, much space has been devoted to this part of the developmental history.

The tree rarely reaches a height of more than 160 feet and diameters of more than 40 inches, more usually 30 inches. Occasionally these dimensions are exceeded; trees of 200 feet in height and of 60 inches in diameter have been reported. The largest actually measured by the Division of Forestry was 48 inches in diameter breast high and 170 feet in height, with an age of about four hundred and sixty years, containing 738 cubic feet of wood, standing in a group of similarly old and large pines in Michigan. Another tree of this group, with 47 inches diameter and 162 feet in height, contained 855 cubic feet, being less tapered.

EXPLANATION OF PLATE IX.

1. Seedling as it first appears with seed coat attached to seed leaves.
2. Seedling with seed coat detached.
3. Seedling with seed leaves and primary foliage leaves disposed singly on stem; five months old.
4. Seedling in its second year, showing primary leaves and secondary leaves (mature form), the latter in clusters of five.
5 and *6*. Seedlings three to five years old.

RATE OF GROWTH.

The following statements regarding the progress and rate of growth of White Pine are based mainly upon the very comprehensive data collected by the Division of Forestry in Maine, New Hampshire, Massachusetts, Pennsylvania, Michigan, and Wisconsin. These data, involving measurements and detailed analyses of over seven hundred trees grown under varying conditions, together with records of the conditions under which they grew, and the amounts of timber which were produced under such conditions per acre, are presented fully in the tables, with accompanying notes, in the Appendix to this monograph. It appeared, however, desirable to present in the text not only the generalizations and conclusions, but also some typical cases. Some other measurements, made before this comprehensive investigation and recorded by the writer in his original manuscript, are also produced.

HEIGHT GROWTH.

SEEDLING STAGE.

The growth of the seedling is variable, according to the conditions under which it grows. In the forest it is much slower than under cultivation, as would naturally be expected. The common practice of nurserymen is to sow the seed broadcast in carefully prepared beds, where the seedlings stand from two to four years before transplanting. Standing very close, the trees do not make as stocky growth as they otherwise would. Under these conditions the average growth of untransplanted seedlings, according to statements by the well-known nurserymen, Thomas Meehan & Sons, is as follows: One-year seedlings, 2 to 3 inches high; two years, 4 to 6 inches; three years, 12 to 15 inches; four years, 24 to 36 inches.

The late Mr. Robert Douglas, the veteran nurseryman, of Waukegan, Ill., wrote:

White Pine seedlings one year old are 1 to 2 inches high and altogether too small and tender for transplanting. At two years old they are much stronger, from 3 to 5 inches high, with fine fibrous roots and in fine condition for transplanting. At three years old they are 6 to 9 inches high and should not be allowed to stand another year, as they would add about 10 inches to their height during the next year and would not be suitable for planting.

The first season after transplanting, the White Pine (like other trees) will not increase much in height, but will establish itself, extending its roots and forming a strong terminal bud, so that when it is six years old it will exceed in weight and bulk over one hundred times its proportions when transplanted, and thereafter will increase in growth from 18 to 30 inches in height annually in good soil for many years.

Gardner & Sons, whose nursery is about 90 miles west of the Mississippi River, in Iowa, and therefore outside of the natural range of the species, submit the following measurements, coinciding with the above, as representing average growths at their nurseries before and after transplanting: One-year-old seedling, 1½ inches high; two-year-old seedling, 4 inches high; three-year-old seedling, 7 inches high. The trees are transplanted at three years of age and thereafter the average height for the three following seasons are: Four years old, 12 inches high; five years old, 16 inches high; six years old, 33 inches high. Another establishment reports as the average height of two-year-old trees in seed bed, 3½ inches; of three-year seedlings, 7 inches.

Casual observations and measurements of some forty-five seedlings in the forest permit the following as to the height growth of seedlings in the forest:

Height growth of White Pine in the forest for the first six years.

Age of seedlings.	Height of stem.			Current annual accretion.
	From—	To—	Average.	
	Inches.	*Inches.*	*Inches.*	*Inches.*
1 year	1	2	1½	......
2 years	2	4	3	2
3 years	3	7½	5	2
4 years	6	10	8	3
5 years	10	12	11½	3½
6 years	30	34	31½	20

These measurements show that the rapid height growth begins with the sixth year, when the total growth of the first five years is almost doubled in one season. This, to be sure, holds only for seedlings favorably situated. In those less favored the rapid stage of development comes more gradually. This slow progress in younger years is naturally reflected in a retardation of the year of maximum height growth, which in dominant trees occurs about the twentieth year, while in oppressed trees it may not come before the fortieth year.

DEVELOPMENT IN OPEN STAND.

Trees on lawns and in pastures, which grow up in full enjoyment of light, are somewhat different from trees in the forest. The slow seedling stage is followed by a very rapid increase in the rate, which attains its maximum before the twentieth year and then declines gradually.

Table I, on the next page, presents a complete record from year to year of the growth of eight trees planted on a lawn at Ann Arbor, Mich., which were measured in 1886, the annual increase being measured between the whorls of branches. These measurements also exhibit the great variability of growth from season to season and from tree to tree, even under otherwise similar conditions. In some of the trees, evidently, injuries or accidents retarded development. Such apparent deficiencies have been left out of consideration in averaging the data.

TABLE I.—*Height growth of White Pine planted in lawn at Ann Arbor, Mich., by years, in inches.*

Number of tree.	Age.	Diameter breast high.	Height.	Height, by years. 1 to 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Yrs.	*Inches.*	*Feet.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1	17	5.1	30.5	26	15	22	21	23	28	39	37	39	39	39	39	...	...	...	...	...	...	...	...	...	...	...	...	...
2	19	3.8	23.5	20	3	5	11	16	11	19	24	33	32	35	28	24	21	...	...	...	...	...	...	...	...	...	...	...
3	19	6	30.5	25	10	4	14	32	24	23	23	32	35	32	36	26	32	...	...	...	...	...	...	...	...	...	...	...
4	21	6	26.6	41	6	12	24	23	18	26	23	5	29	25	5	19	20	25	19	...	...	...	...	...	...	...	...	...
5	23	8.2	34.5	33	12	14	14	20	40	29	20	37	30	10	32	30	7	26	24	21	15	...	...	...	...	...	...	...
6	29	12.8	44.5	50	7	16	17	24	28	20	30	21	27	21	25	17	34	25	23	22	17	20	12	29	25	17	7	...
Averages	...	...	...	32.5	9	12	17	24	25	26	26	32	32	27	30	32	27	25	22	22	16	...	...	...	...	...	...	...
7	30	15	53	41	22	14	14	9	3	13	18	38	27	40	27	41	36	28	44	36	38	19	24	27	26	14	21	12
8	30	13.5	47.5	39	22	20	24	35	18	15	14	18	24	31	18	22	23	36	29	12	15	24	31	24	22	17	16	20
Average by 6-year periods.	...	...	...	6.3	...	...	...	...	...	18	...	...	...	...	...	27.6	...	...	...	...	...	26	...	...	...	...	...	...

NOTE.—Trees Nos. 1 to 6 stood in shallow soil on gravel subsoil; Nos. 7 and 8 in deep loam.

From this table it appears that these eight trees grew on an average hardly more than 6 inches during the first six years, more than three times as fast during the next six years, and reached a maximum rate of over 27 inches per year during the third period of six years, the decline beginning after the twentieth year and the rate decreasing until it has fallen to about 15 inches near the thirtieth year.

To show how, under less favorable conditions, the progress of self-sown trees is very nearly the same, the following measurements may serve, from which it appears that natural seedlings on pastures, standing more or less crowded, reach at ten years a height of 10 feet; at the age of twenty years about 25 feet, and trees thirty-five to forty years of age, with diameters of 6 to 9 inches, attained and even passed the height of 60 feet, showing an average growth for that period of 15 to 18 inches per year:

TABLE II.—*Measurements of self-sown White Pine on pasture.*

[Furnished by Mr. J. E. Hobbs, of North Berwick, Me.; altitude, 250 feet.]

Number of tree.	Number of rings on stump cut at ground.	Number of rings 1 foot above ground.	Diameter of stump at ground.	Diameter 4 feet high.	Height of tree.	Length of leader at time of measurement.	Length of leader for last five years.
			Inches.	*Inches.*	*Ft. in.*	*Inches.*	*Ft. in.*
1	10	6	2¾	1 1/16	8 10	23	7 11
2	10	...	3¼	2	13 6	32	9 11
3	10	...	2⅝	2	12 9	28	...
4	10	8	2⅝	2	12 9	28	6 3
5	11	8	3¼	1¾	11 3	29½	8 5
6	12	9	5	2⅝	13 9	16	7 2
7	12	...	4	3	...	22	10 10
8	13	10	5½	2⅛	15 9	21	9 7
9	13	11	4	2	13 9	25	9 0
10	14	10	3½	2	13 9	24	8 0
11	14	...	4¼	3	16 6	21	...
12	14	...	5¼	4	21 0	13	7 0
13	14	...	4½	3	16 6	21	6 0
14	15	...	5⅝	4½	25 0	18	...
15	15	...	9½	4¾	20 6	18	...
16	18	...	6½	5½	28 4	33	...
17	18	...	13¼	10¼	...	...	...
18	18	14	5⅝	4¾	25 6	18	6 0
19	20	...	7⅝	4½	25 6	30	6 6
20	22	16	6½	5½	28 10	33	7 0
21	26	22	5	4	29 9	14	6 1
22	36	...	...	7½	61 0	12	...
23	38	...	...	6¼	60 0	15	...
24	39	...	...	9	64 0	15	...
25	39	...	...	6¼	60 0	18	...
26	40	...	...	9¼	60 0	18	...

NOTES TO TABLE II.

No. 1. From old pasture after one year's tillage; 5 feet from No. 6; bore cones.
No. 2. With Nos. 1 and 3, and from similar trees.
No. 3. Old pasture, soil shallow, gravelly loam on compact subsoil of sand; pine mixed with Hemlock, Oak, and Maple.
No. 4. Level ground, soil heavy loam, somewhat shaded.
No. 5. From old pasture after one year's tillage; 5 feet from No. 6; bore cones.
No. 6. From old pasture after one year's tillage; 5 feet from No. 1; bore cones.
No. 7. From old pasture after one year's tillage; 5 feet from No. 6; bore cones; distant from neighbors 8, 34, and 19 inches.
No. 8. From old pasture after one year's tillage; 5 feet from No. 6; bore cones; touched another 4-inch diameter.

No. 9. Level ground, soil heavy loam, somewhat shaded.
No. 10. From old pasture after one year's tillage; 5 feet from No. 6; bore cones.
No. 11. Old pasture, soil shallow, gravelly loam on compact subsoil of sand; pine mixed with Hemlock, Oak, and Maple.
No. 12. On slight incline to north; soil nearly 3 inches from similar tree, with others quite near; crowded.
No. 13. Level ground, soil heavy loam, somewhat shaded.
Nos. 14-16. Old pasture, soil shallow, gravelly loam on compact subsoil of sand; pine mixed with Hemlock, Oak, and Maple.
No. 17. Isolated; lost leader six years previous, apparently through leader worm.
No. 18. Level ground, soil heavy loam, somewhat shaded.
No. 19. With No. 12; lost leader five years previous by leader worm; nearest neighbors 2, 5, and 10 feet, respectively.
No. 20. Level ground, soil heavy loam, somewhat shaded.
Nos. 21-26. Old pasture, soil shallow, gravelly loam on compact subsoil of sand; pine mixed with Hemlock, Oak, and Maple; ground slopes to west; all six trees, besides four others, within circle of 24 feet diameter; crown about 20 feet long.

Concerning trees 1, 2, 5, 6, 7, 8, and 10 (Table II), Mr. Hobbs sent the following interesting communication, under date of January 11, 1887:

All these trees were found in an old pasture adjoining my land on the north and having similar aspect and soil. A fringe of tall White Pine timber surrounds it on three sides, north, east, and south. The distance across this open land from north to south is about 60 rods. This land has been in pasture from fifty to one hundred years. It was formerly thickly covered with moss, sweet fern, and other low-growing bushes, in the shade of which animals found some grass. Although thus surrounded by tall pines their seeds seldom sprung up.

Not many years before these trees started a portion of this land was plowed and planted with potatoes one year, and then turned out to pasture again, whereupon young pines immediately sprung up. These were cut down first, but they continued to come up so abundantly that they were allowed to grow, and now the patch that was planted with potatoes is quite thickly covered, in many places too thickly, with trees like those measured. This fact shows the importance of turning up the soil so that the seeds that fall upon it may have a chance to take root. Only here and there a seed will find lodgment on land that is covered with moss and low-growing bushes, no matter how abundantly seeds may be sown upon it.

How such trees continue to grow is shown in Table III. From the measurements it appears that a steady growth continues, which, by the hundredth year has brought the tree to a height of near 100 feet.

TABLE III.—*Measurements of White Pine, grown on abandoned fields.*

[Furnished by Mr. J. E. Hobbs, of North Berwick, Me.]

Number of tree.	Age.	Diameter breast high.	Diameter below crown.	Length of crown.		Length of leader for last five years.	Total height.		Height at—											
									10 yrs.	20 yrs.	30 yrs.	40 yrs.	50 yrs.	60 yrs.	70 yrs.	80 yrs.	90 yrs.	100 yrs.	110 yrs.	120 yrs.
	Years.	*Inches.*	*Inches.*	*Ft.*	*In.*	*Inches.*	*Ft.*	*In.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1	58	16	13½	50	0	66	80	10	15	28	42	55	69	......	......	......	......	......	......	......
2	59	14½	10¾	30	0	69	67	6	10	20	31	45	57	......	......	......	......	......	......	......
3	61	12¾	7¾	33	0	48	78	3	12	25	37	47	62	77	......	......	......	......	......	......
4	64	15½	10	28	6	56	70	2	11	24	36	47	58	68	......	......	......	......	......	......
5	70	15⅝	11¼	43	6	50	84	6	14½	30	46	60	68	76½	84½	......	......	......	......	......
6	82	11¾	8¼	38	0	72	91	1	Only one log cut; height at fifty-eight years, 64 feet 10 inches.											
7	84	20¼	13	38	8	40	100	8	9	21	39	54	71	82	91	99	......	......	......	......
8	85	23	16¼	45	6	66	91	6	9	19	28	41	52	63	75	86	......	......	......	......
9	85	18	12½	39	4	62	92	7	8	16	26	39	52	64	76	87	......	......	......	......
10	87	25	18	49	10	36	104	10	8	16	28	47	66	77	87	97	......	......	......	......
11	87	19⅜	12½	40	4	72	100	2	9	21	35	48	60	70	81	93	......	......	......	......
12	108	32	21½	52	6	28	112	9	13	25	39	53	66	79	86	92	99	106	......	......
13	109	31	21	61	4	40	112	9	Not cut into sections.											
14	117	29	23	57	0	......	101	10	14	27	40	48	55	62	69	76	83	90	97	......
15	122	23	16	55	0	30	107	5	8	16	25	36	49	62	70	77	84	92	99	106½
16	123	28	19	50	0	24	97	4	10	21	35	52	58	63	69	74	80	85	90	96

NOTES TO TABLE III.

No. 1. North Berwick, Me.; near foot of hill sloping to north; growth, dense; apparently abandoned farm land; shallow, sandy soil.

No. 2. South Berwick, Me.; thrifty second growth, in valley of Great Works River; exhausted farm land on granitic formation, sand over 20 feet deep, well stocked with White Pine.

No. 3. North Berwick, Me.; near foot of hill sloping to north; growth, dense; apparently abandoned farm land; shallow, sandy soil.

No. 4. North Berwick, Me.; near foot of hill sloping to north; growth, dense; apparently abandoned farm land; shallow, sandy soil.

No. 5. South Berwick, Me.; thrifty second growth, in valley of Great Works River; exhausted farm land on granitic formation; sand over 20 feet deep, well stocked with White Pine.

Nos. 6-16. North Berwick, Me.; near foot of hill sloping to north; growth, dense; apparently abandoned farm land; shallow, sandy soil.

DEVELOPMENT IN THE FOREST.

In the dense forest the same general law of development, namely, of slow and rapid stages, prevails for dominant trees as is exemplified by the foregoing measurements of trees grown in the field, although the quantitative progress varies somewhat. According to the relative amount of light at the disposal of the crown the rate of growth differs, and there is found, therefore, in the forest trees, though very nearly the same age, trees of different heights, according to the success of the struggle for light which they have had with their neighbors. At every stage of the development of a forest growth, after its juvenile period, the trees can be classified into dominant, the tallest, which grow with their entire crown in full enjoyment of light and space, overtopping their neighbors; codominant, which, although of same height, have their crowns narrowed in, but still unimpeded at the top; while others (oppressed) are pressed in from sides and top, and finally are entirely suppressed and die. This relationship of individuals changes from time to time, some of the codominant gradually falling into the class of oppressed, and of these a large number become suppressed. Occasionally a codominant becomes dominant, or an oppressed one, by liberation of its oppressors, through storms or accident, finds opportunity to push forward and make up for lost time. Thus, a natural growth may start with a hundred thousand seedlings per acre; by the twentieth year these will have been reduced by death to 6,000, and by the hundredth year hardly 300 may be left, the rest having succumbed under the shade of the survivors.

It is owing to these changes that in analyzing tree growth we find great, often unaccountable, variation in the rate of growth of even the same individual, and hence, in order to recognize the average, a very large number must be measured to even out the deviations from the law.

For the same reason it is desirable to classify the trees as indicated above and ascertain the rate of growth of trees grown under different light conditions. To be sure trees behave also somewhat differently under varying conditions of soil, climate, and exposure; hence, a further classification is necessary if it is desired to establish more than the mere general law of progress and also to ascertain the influence of these variable conditions.

In a general way, we find, as in the trees grown in the open, the slow seedling stage followed by a very rapid increase in the annual rate of growth, beginning with the sixth year and reaching a maximum of 16 inches with the tenth year in dominant trees. With trees which have not enjoyed access to light to the same extent the maximum occurs later; hence, in codominant trees it is reached, with 13 inches, in the twentieth year, while the oppressed trees reach their maximum current accretion still later, namely at forty years, with less than 12 inches for the year. As soon as this highest rate is reached decline takes place gradually in all classes, much faster in the dominant trees than in the less-favored ones, which decline in the rate of annual height growth much more slowly.

By the one hundreth year the annual height growth is reduced to from 6 to 7 inches, the dominant trees showing the lower rate, which continues to decline until about the one hundred and sixtieth to one hundred and seventieth year, when all tree classes have come to a rate of about 2 inches, at which they continue to grow, slowly but evenly, for another century.

This persistence of the height growth, which makes old trees tower 40 to 50 feet above their broad-leafed neighbors, influences also the shape of the crown, which does not flatten, as is the case with most pines. Very old trees, four hundred years and over, rarely exceed a height of 160 feet, although exceptional individuals have been found of the unusual height of 200 feet.

It will thus appear that the principal height growth is made during the first century, the second century noting a persistent but only slow progress.

If we take the average of all the yearly accretions at any one year of the life of the tree (the average annual accretion at that year), the influences which have been at work during the whole lifetime are of course reflected; therefore, since the juvenile period shows a slow growth, the average accretion attains its maximum much later. This culmination of the average annual accretion takes place much earlier in the more favored tree classes, namely, at about the twentieth to fortieth year, after that declining, while in the oppressed it does not occur until the seventieth year, maintaining itself afterwards for a long period.

This difference would also appear if we compared better and poorer sites. In other words, when the annual rate of growth is slow it remains more persistent than when it is rapid. The persistence noted in oppressed trees indicates also the shade endurance of the species. From Table IV, which gives the accretions from decade to decade (periodic accretion), we see the capacity of the species to thrive in spite of the shade, even in later stages of its life. Even after ninety years of oppression, when the tree is given opportunity by increase of light, it is still able to make as good an annual height growth as its more-favored neighbors, and can continue the same to the second century. From the table of heights at various ages it is learned that the success in the juvenile stages after all tells on the total height growth.

TABLE IV.—*Periodic height growth, by decades, of dominant, codominant, and oppressed pine.*

Class.	Decades.																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Ft.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
Dominant	8	12	13	13	11	10	8	7	6	6	5	5	4	3	3	3	3	3	3	3	3	.....	.....	.....	.....
Codominant	4	12	10	10	12	6	8	8	7	6	5	5	4	4	3	3	2½	2½	2	2	2	2	2	2	1
Oppressed	4	8	7	8	9	9	8	8	6	6	6	5	5	4	4	4	3	3	3	2½	.....	.....	.....	.....	.....

Effect of composition of forest upon height growth.

The height development of White Pine seems to progress more rapidly when it grows mixed with other species. A striking instance showing how the height growth of White Pine is benefited by the presence of other species is given in the diagram (fig. 2), which represents the height growth of White Pine taken from two sites (*a* and *b*) in Presque Isle County, Mich. The sites were about 5 or 6 miles distant from each other. The soil and the moisture conditions on both sites were apparently identical (fresh sand), as were the total number of trees to the acre (the sample area on site *a* contained 181 trees and that on site *b* 189 trees) and the age of the trees and their distribution over the ground (density of crown cover). The only difference found between the sample areas staked off on both sites was the composition of the forest. Site *a* consisted of a mixed growth of Norway and White Pine, while site *b* represented practically a pure growth of White Pine save a few small Hemlock and an occasional Norway Pine. The diagram shows that the White Pine on site *a* was exceedingly stimulated in its height growth by the presence of the Norway Pine.

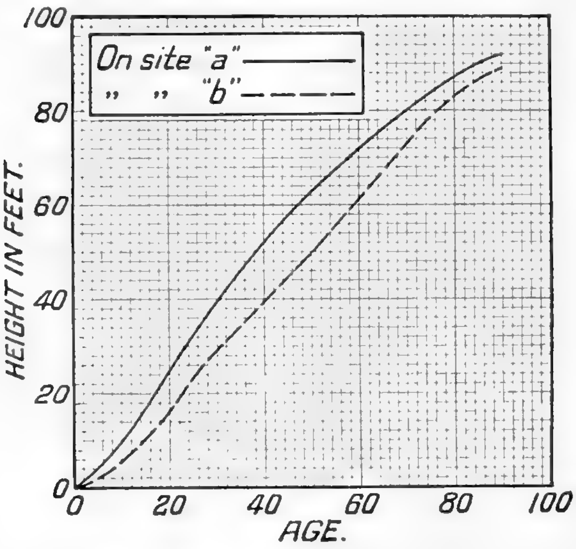


FIG. 2.—Diagram showing height growth of White Pine in Presque Isle County, Mich.: Site *a*, in mixed growth; site *b*, in pure growth.

The associated species entering into the struggle for light with the White Pine naturally affect the progress of the height growth of the pine. The effects of the associated species upon the height growth of White Pine and the period of their influence depend upon the capacity of the associated species to grow in height as well as upon the time when the associated species are either introduced among the pine or received it under their shelter. In case, for instance, hardwoods accompany White Pine from the very start the influence of the hardwood upon the height growth of the pine will last only for the first sixty or seventy years, that is, up to the age at which most of the hardwoods practically reach their maximum height. In case the Norway Pine or the Hemlock starts simultaneously with the White Pine, the height growth of the White Pine will be stimulated to a considerably later age, because the Hemlock or Norway Pine continues to grow in height at a similar rate for a longer time. When the White Pine happens to start on ground already covered with other species in such a manner as not to be interfered with in its growth the associated species, if capable of growing in height to a later age, will stimulate the height growth of the White Pine for a considerably longer period. All this is clearly demonstrated in the accompanying diagram (fig. 3), representing the height growth of White Pine taken from three sites (*f*, *k*, and *i*) of identically the same conditions except as to composition of the forest and the difference in the ages between the pine and associated species. All three sites had a well-drained clayey loam underlaid by a laminated shale of indefinite depth. The White Pine on site *f* (Clearfield County, Pa.) was mixed with Hemlock of a large size; the pine on this site had started among the Hemlock, which stimulated the height growth of the pine during all its lifetime. The White Pine on site k (Jefferson County, Pa.) was mixed with Hemlock of a small unmerchantable size. The pine here had started simultaneously with the Hemlock, which stimulated the height growth of the pine only for a certain period, after which the Hemlock, being overtopped by the pine, was out of the struggle and left in the capacity of an underwood. The White Pine on site i, which merged into site k, was mixed with hardwoods, which stimulated the height growth of the pine for the first sixty years, when the hardwoods reached their maximum height and then withdrew from the competition, leaving the pine to increase the height on its own account.

The influence of climate and soil on height growth will further appear from a study of the tables in the Appendix. This influence on height growth is not very great, if we confine our inquiry to regions of best development, the difference rarely exceeding from 5 to 10 per cent.

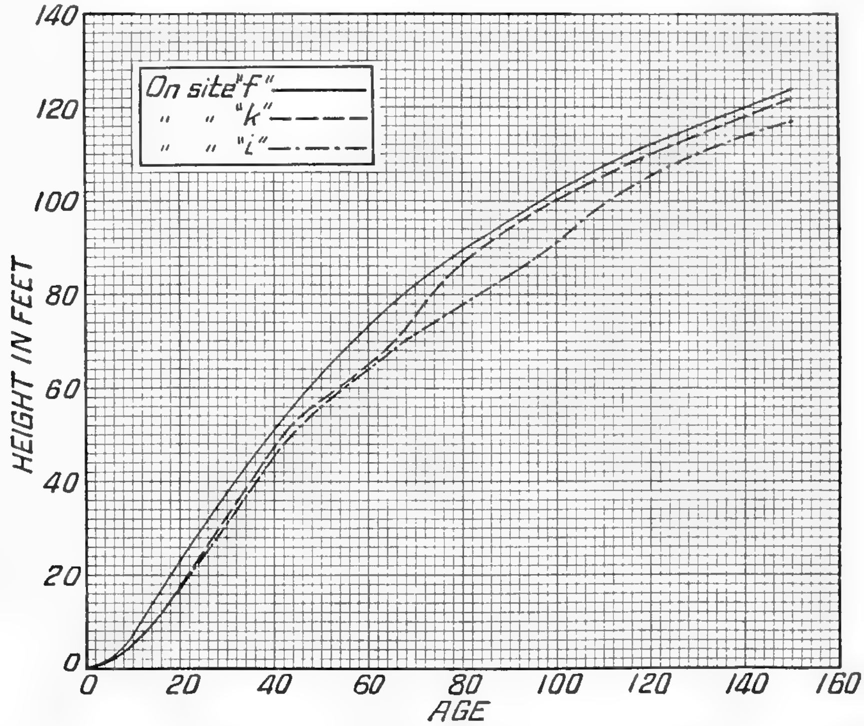


FIG. 3.—Diagram showing height growth of White Pine in forest of varying composition in Pennsylvania: Site f, Clearfield County; sites k and i, Jefferson County.

Effect of locality upon height growth.

Comparing the growth in different localities, it appears that the trees from Pennsylvania started at a lower rate than those in all other localities, but after the twentieth to the twenty-fifth year they surpass all others. If this can be accepted as correct, the deduction of the development in early youth from old trees being subject to errors, it may be explained by the fact that these trees grew in mixture with Hemlock and were kept back by the shade of their neighbors, but when they had outgrown these they felt the stimulus exerted by them.

The trees from Maine and Wisconsin, also starting more vigorously than those from Michigan, decline and sink below the Michigan trees between the eightieth and ninetieth year, which may for Wisconsin be possibly explained by the retarding influence of winds after the pines have outgrown the hardwoods, while in Maine the poorer soil may account for it. Michigan, with its tempered lake climate, presents a most regular and persistent height curve, coming nearest to the average of all locations.

In codominant and oppressed trees these differences do not come to an expression, but since the classification is somewhat doubtful and variations within wide ranges are possible, these data are hardly to be used for comparison as to locality effects.

GROWTH IN THICKNESS.

The growth in thickness, or diameter accretion, although remarkably regular in this species, is much more variable, but it is also more persistent, than the height growth, as will appear from the following comparisons: Thus, in five groups of trees from different sites, ninety-four to one hundred and nine years old, the heights differ only by a little over 8 per cent, varying from 91 to 98½ feet, while the diameters differed by almost 50 per cent, varying from 16 to 23.7 inches. Again the persistence is illustrated by the comparison of the height growth of five groups from two hundred and seven to two hundred and thirty-three years old, which showed an increase over the group just mentioned of somewhat over 20 per cent, while the diameters were by 30 per cent greater; and if the poorest groups of the two sets had been compared the difference would have been still more striking, namely, 15 per cent for the height as against 37 per cent for the diameters.

This is in part explained by the fact that, where the seedling springs up in the virgin forest, it is very apt to be suppressed for a longer or shorter period by the large mother trees and the host of deciduous and other forms which make up the forest cover. While the height growth is by this shade also impeded, this is not so to the same degree as the diameter, which is a direct function of the amount of foliage that is at work.

The sapling may thus remain a slender pole for many years, and not until it is able to lift its head above its crowding neighbors, or until light has been admitted to its branches, does it begin to expand its crown and consequently thicken its stem.

In managed forests, or in tracts where from any cause crowding has been prevented, the growth in diameter progresses somewhat more in the manner of the height growth, namely, slowly at first, then rapidly until the maximum is attained, when a slowly decreasing rate sets in. In the seedling the diameter growth is exceedingly small, very rapid in the young trees, when the annual ring is often one-sixth to one-half of an inch wide, but decreases with the slower rate of height growth. When the tree is sixty to eighty years old, the yearly ring is commonly not more than one-twelfth of an inch wide; it then gradually sinks to one-fifteenth of an inch, which is then maintained throughout life, rarely falling to one twenty-fifth of an inch.

The average annual accretion reaches its maximum about the fiftieth to the sixtieth year with somewhat over one-fifth of an inch on the diameter of dominant trees, which rate is nearly maintained to the one hundred and fiftieth year.

Thrifty trees at forty years of age grown in the forest, measure from 6 to 9 inches in diameter breast high; at fifty years, from 10 to 12 inches; at eighty years, 15 to 17 inches; and they reach a diameter of 18 to 20 inches by the time they are a hundred years old.

To attain a diameter of 30 to 40 inches, which represents the best merchantable material of days now almost passed, more than two hundred years have been required, while trees four hundred to four hundred and fifty years old attain diameters of 50 to 60 inches and over. Trees of 40 inches diameter at three hundred years were by no means rare.

To be sure, there are exceptional individuals which exceed these dimensions, and variation in the rate of growth, due to soil, climate, and surrounding conditions, are naturally as frequent as in height growth.

The progress of diameter development of dominant, codominant, and oppressed tree classes, and in different localities, is exhibited in the tables and diagrams in the Appendix.

The usual method is to determine the diameters at 4½ feet from the ground (breast high), not only because when measuring standing trees the measurement is most conveniently made at this height, but because the lower diameters show much more irregularity. There is also more wood deposited near the base at and above the root collar, giving rise to the so-called root swelling (butt swelling), undoubtedly a provision to strengthen the stability of the tree. Unfortunately for the investigations here recorded, it was not practicable to have the trees cut and measured at breast height, since the measurements were made on trees felled in regular lumbering operations, exposing only the cross sections at the height of the stump, mostly 2½ feet above ground, and at log lengths. Even at that height (2½ feet above ground), a difference in the progress of diameter growth from that on higher cross sections is noticeable and becomes especially pronounced in later life, as is shown in the curves representing the progress of diameter growth on cross sections at various heights.

The diameters here given for the lowest section are, therefore, somewhat larger than those usually employed, namely, breast high, especially in later years.

The higher sections exhibit not only a regular course, but an entirely similar one, from cross section to cross section. There is no reason to assume that the course at breast height would not follow the same law; therefore there can be constructed a curve for this height similar to the curves of higher sections, using for guide points the data obtained from a series of measurements made to establish the yield of pine in which trees were measured at breast height (compiled in tables in the Appendix). This has been done on the diagram in the Appendix, which shows the diameter development of different cross sections for dominant trees. From this can be read the following average dimensions as approximating the diameters of each decade, leaving out the uncertain juvenile stage:

Diameter, breast high, of White Pine (averages approximated), in inches.

Decade: 20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
4.5	5.5	8	11.5	13.5	15	16.5	17.8	19	20.2	21.3	22.2	23	23.8	24.5	25.2	26.4	26.8	27.5

That these figures may be considerably exceeded (even by 50 to 60 per cent) under favorable conditions will appear from the various tables of measurements in the Appendix. Especially is this the case in the second-growth groves of pine.

As will be readily seen in the curves after the juvenile stage, during which the diameter grows very slowly, an acceleration in the rate takes place, which soon reaches a maximum, continuing at that for a short time, and then slowly and persistently declining from about 3 inches per decade between forty and fifty years to 1¼ inches at one hundred years, and half that amount at two hundred years.

DETAIL MEASUREMENTS OF ANNUAL GAIN IN CIRCUMFERENCE.

An interesting set of most accurate observations have been made and reported by Mr. Nathaniel Morton, of Plymouth, Mass., exhibiting 38 young trees of White Pine, which had sprung up among oak and other hardwoods, mixed with White Pine and a few Pitch Pine in an old, rather-neglected piece of woods, and which were measured every year from 1891 up to 1898. The trees stand rather open. The age varied from twenty-eight to forty-two years, most trees being between thirty and thirty-six years old and their average age thirty-six years in 1891.

In 1891 the average cross section 3 feet from ground was 131 square inches; in 1898, 197 square inches; the growth 66 square inches, or about 9 square inches per year, one tree making 15 square inches per year. This growth corresponds to a growth in circumference of about 1.3 inches per year, or a growth in diameter of four-tenths of an inch per year.

The detail measurements are given in the following table:

TABLE V.—*Annual gain in circumference of White Pine trees in Massachusetts.*

Number of tree.	Circumference in 1890.	Gain, in quarter inches. 1891	1892	1893	1894	1895	1896	Total in six years.
	Inches.							
1	55	3	5	5	5	4	5	27
2	26	3	6	5	6	4	5	29
3	26	4	5	6	6	5	6	32
4	50	1	1	2	2	2	2	10
5	28	1	3	4	3	1	3	15
6	38¾	0	1	3	3	2	1	10
7	44	1	3	4	4	4	2	18
8	27	2	3	4	5	4	5	23
9	35	3	3	3	6	3	4	22
10	40½	2	4	6	6	3	4	25
11	34½	1	2	4	3	3	4	17
12	22	3	2	4	5	3	5	22
13	44½	1	4	4	3	2	2	16
14	33¾	4	4	7	5	5	4	29
15	24½	4	4	5	7	4	4	28
16	26¼	5	5	6	6	5	4	31
17	28¼	1	3	3	4	3	3	17
18	39	1	2	4	3	3	3	16
19	48½	1	1	4	2	3	2	13
20	50½	2	4	5	5	4	6	26
21	49¾	5	6	7	6	7	8	39
22	49	4	2	3	6	5	4	24
23	35¼	3	4	5	6	6	5	29
24	33	4	3	5	5	5	6	28
25	51	2	3	6	5	5	7	28
26	37½	3	3	6	5	5	5	27
27	31½	4	6	6	7	7	8	38
28	47	5	7	7	6	7	6	38
29	42	4	4	6	5	5	5	29
30	40½	4	5	6	5	5	5	30
31	57	0	2	5	5	4	4	20
32	44¼	5	4	6	6	4	5	30
33	42½	1	5	5	4	5	5	25
34	44¼	3	5	6	5	4	4	27
35	46¾	4	4	6	4	5	5	28
36	44½	3	3	4	4	3	3	20
37	47	4	4	7	5	4	5	29
38	36½	2	4	6	3	4	4	23
Total		103	139	190	181	157	168	938
Total in inches		25¾	34¾	47½	45¼	39¼	42	234½
Percentage of gain as compared with gain of 1891		100	135	184	176	152	163	......
Average gain per tree (in inches)		$\frac{68}{100}$	$\frac{91}{100}$	$\frac{125}{100}$	$\frac{119}{100}$	$\frac{103}{100}$	$\frac{111}{100}$	......

AREA ACCRETION.

While the diameter accretion decreases in rate continuously after the juvenile stage, the growth of the areas or layer of wood corresponding to the diameter increments follows by no means the same course.

After the juvenile stage, which is determined by the formation of a definite crown, and when the diameter has attained at least 6 inches the cross-section area begins to increase in arithmetical progression; a constantly increasing rate prevails until a maximum is attained, which comes between the sixtieth and one hundred and twentieth year, and then continues remarkably uniform for a long period. No decline is noticeable until after the second century has begun. In codominant and oppressed trees the area as well as the diameter accretion move somewhat differently, the maximum rate coming later and lasting a shorter time, the decline following soon after the maximum.

FORM DEVELOPMENT, OR TAPER.

Since size of crown and light conditions regulate the amount of diameter growth, it is evident that trees with well-developed free crowns form more wood than those crowded, the dominant more than the oppressed, and those on lawns more than those in the dense forest. Moreover, in these latter the wood is differently disposed along the trunk than in the former. Not only do trees grown in the open throw their energy into branch growth, but the accretion on the bole is laid on in layers, increasing in width from top to base. The result is a more rapid taper than in forest-grown trees, in which each annual layer is wider at the top than at the base of the tree, producing thereby a more cylindrical form.

The following table exhibits in the measurements of six trees this variation in the width of the same annual rings at different heights, and also in general the mode of diameter growth in these trees. More elaborate tables, showing the diameter growth of White Pine at various heights from the ground for dominant, codominant, and oppressed trees in various parts of its range, together with diagrams, will be found in the Appendix:

Diameter growth of forest-grown trees at various heights from ground.

Height of section from ground.	Width of rings, in millimeters.																			Age of tree.
	Single groups of ten rings, beginning at periphery.									Accumulative, by groups of ten rings, beginning at periphery.										
	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100	
Feet.																				*Years.*
17	14	19	21	17	17	13	18	22		14	33	54	71	88	101	119	141			115
33	15	21	32	28	34					15	36	68	96	130						
49	19	28	39	27						19	47	86	113							
68	27	58								27	85									
16	9	10	16	20	21	40	39			9	19	35	55	76	116	155				100
34	14	16	23	27	31	52				14	30	53	80	111	163					
50	16	22	25	37	40					16	38	63	100	140						
66	19	19	32							19	38	70								
18	11	13	16	15	15	20	32	48		11	24	40	55	70	90	122	170			105
34	12	15	18	20	22	36	50			12	27	45	65	87	123	173				
50	13	17	23	31	39	39				13	30	53	84	123	162					
66	14	25	24	35	42					14	39	63	98	140						
16	13	26	21	24	24	28				13	39	60	84	108	136	177				102
28	20	24	28	31	39					20	44	72	103	142	170					
42	19	28	31	41						19	47	78	119	155						
58	20	33	45							20	53	98								
76	24	19								24	63									
18	19	25	27	28	26	31	35			19	44	71	99	125	156	191				110
34	23	33	35	44	31					23	56	91	135	166						
50	24	34	34	40						24	58	92	132							
66	25	35								25	60									
18	13	18	21	21	24	25	21	21	18	13	31	52	73	97	122	143	164	182	193	165
42	13	19	20	22	25	27	35	32	23	13	32	52	74	99	126	161	193	216		
58	13	21	22	26	27	32	40	32		13	34	56	82	109	141	181	213			
70	16	25	25	32	35					16	41	66	98	133						
86	11	29	29							11	40	69								

From such tabulations the taper, factor of shape, or form factor, may be derived (see Tables II and V in Appendix), which denotes the deviation of the shape of the tree from a cylinder. This factor varies between 0.40 for the older trees and larger diameters to 0.50 for younger and more slender trees, a factor of 0.45 being about the average for centenarians—that means the volume of a hundred-year-old tree is forty-five one-hundredths of a cylinder of the diameter, measured at breast height and the height of the tree.

This factor varies, of course, according to the ratio between diameter and height, and since in codominant and oppressed trees this ratio is a different one from that of dominant trees, as we have seen, their factor of shape is also different from that for dominant trees, that is, their taper differs, the former being more cylindrical than the latter. This will appear from a comparison of the taper of trees as recorded in Table II of the Appendix, in which small diameters with comparatively long shafts indicate the codominant and suppressed trees. Those with short lengths and large diameters are trees grown in open stand.

From Table II, Appendix, we also see that the taper varies within wide limits from less than 1 inch to 5 inches for every 16 feet, although in the majority of cases it lies between 2 and 3 inches. The tops taper, to be sure, much faster than the middle portion; and, again, in older trees especially, the butt logs much faster than the upper portions, which are outside of the influence of the root swelling.

In young trees which make three log lengths of 16 feet, it will be safe to allow 1½ inches for the first two logs and 2 inches for the last one as the average taper. In medium-sized trees, making four to five log lengths, an allowance of 2 inches on the whole will fairly represent the average taper, or one-eighth of an inch for every foot in length. In old trees which furnish five and six or more logs, an allowance of 4 to 5 and even 7 to 8 inches must be made for the first log and 3 to 4 inches for the two top logs, while the middle portions show a more regular and less variable taper of about 2 inches, or one-eighth of an inch per foot.

GROWTH IN VOLUME.

During the juvenile stages the volume growth of the White Pine, as of most trees, is insignificant, a dominant tree of twenty years measuring not more than 0.5 cubic foot, which means an average accretion of 0.025 cubic foot per year. For the third decade the amount of wood formed is over three times what it was during the first two decades, and at fifty years the bole of a dominant tree may contain from 10 to 14 cubic feet and over, the average annual accretion having come up to one-fourth of a cubic foot, or ten times what it was at twenty years.

Now, after the rapid height-growth period, with fully developed crowns, a rapid rate of volume growth sets in, increasing with each year, in arithmetical progression, until at sixty to seventy years the current accretion has become 1 cubic foot and over, and at one hundred years as much as 1½ cubic feet is attained. After the one hundred and twenty-fifth year the increase in the rate abates, yet before the second century it has become 2 cubic feet, and remains then practically stationary for another century at least.

Some of the oldest trees (four hundred and fifty years and over) measured contained 600 to 800 cubic feet of wood in the stem alone, the largest, with 855 cubic feet, indicating an average annual accretion for this long life of over 1.8 cubic feet.

While the current annual accretion after the fiftieth year is rapidly increasing, the average annual accretion, affected by the earlier stages of slow growth, increases naturally more slowly. For the first one hundred years the average is about two-thirds to three-fourths of a cubic foot for dominant pine, making the volume about 70 cubic feet. It increases to 1 cubic foot at one hundred and fifty years and 1¼ cubic feet at two hundred years, and, as shown above, gains gradually until old age.

The progress in volume growth naturally varies under different soil conditions and with tree classes. In a general way, the oppressed trees and those on poorer sites do not begin the period of rapid volume growth as early as the dominant classes, but just as in the height growth, which is similarly delayed, the rate when once at its maximum persists with great uniformity until about the one hundred and fortieth to one hundred and sixtieth year, when a decrease becomes noticeable.

The tables and diagrams in the Appendix show, by figures and graphically, the progress of diameter, height, and volume accretion for dominant, codominant, and oppressed trees throughout the range of the species. Comparing the growth from the several localities represented, a striking difference is not observed. It would appear that in similar soils the White Pine grows at about the same rate, with similar persistence, and to the same dimensions in all parts of its range.

In Europe, too, as appears from a table on page 69, its growth as well as its general behavior, at least in the forests of Germany, is fully as favorable as at home.

Besides differences as result of soils, an influence of the composition of the forest is noticeable. White Pine mixed with Hemlock (Pennsylvania stations) shows a more rapid growth for the first one hundred and thirty years, while among hardwoods (Wisconsin stations) the next one hundred years seem to produce the thriftiest growth. This is perhaps explained by the fact that in the latter mixture the White Pine has after the first one hundred years its entire crown above the shorter hardwoods, and hence is in full enjoyment of light.

The so-called "second growth" pine develops somewhat differently, because, as a rule, it does not start in a dense growth, enjoying the light conditions of the open stand, the single individuals make a more rapid volume growth, until they have closed up, and forest conditions prevail. This is fully exhibited in the measurements of young groves in Massachusetts and New Hampshire, tabulated in the Appendix.

In managed woods, where the number of trees allowed to grow per acre is under control, the volume accretion may also be accelerated; the growth energy of the site being then exerted on fewer individuals, each one deposits larger amounts. What this increase can be may be inferred from the table on page 69, which records the growth of White Pine in Germany.

CUBIC CONTENTS OF TREES.

Having ascertained by a large number of measurements the diameters, heights, and factors of shape possessed by trees under all sorts of conditions, the cubic contents of such trees can be calculated and recorded in a table for further use, by reference, in measuring contents of trees. Such table for White Pine of different diameters and heights will be found in the Appendix, from which the contents in cubic feet of the bole of a tree whose diameter at breast height has been measured and whose height has been estimated or measured can at once be read off.

LUMBER CONTENTS OF TREES.

The total cubic contents, being based on mathematical considerations alone, is the only rational measure of the volume. By stating contents in board measure we introduce at once a number of uncertain factors, which are variable in the practice, such as the lowest-size diameter to which logs are taken; the size of the lumber that is cut, from one-half-inch boards to square beams; the saw used, which determines the loss in kerf, and the skill of the sawyer, who can waste a large proportion in slabs and inconsiderate use of the logs.[1]

In these losses there is no allowance made for crooks or rot, which would reduce the results still further, so that hardly one-third of the total volume of the tree would seem to reappear in the shape of lumber, provided the log scales used are correct, which anticipate a loss of 44 per cent (Scribner) to 50 per cent (Doyle) in sawdust, slabs, and edgings for 14-inch logs, the average size of logs in the northern pineries.

As a matter of fact, in good modern mill practice, not only does no such waste occur as is indicated in these log scales, even if all logs were cut into inch boards, but in addition small logs are worked into dimension material 2 by 4, 2 by 6, 4 by 4, etc., in which the loss is reduced to a minimum; thus an 8-inch log may be cut to 6 by 6 inches. It then would make, if 16 feet long, not 16 to 25 feet B. M., but 48 feet. Since the bulk of our pine material is now obtained from small logs (over one-half below 14 inches diameter), these differences are of considerable practical importance.

---

[1] A careful examination and measurement of one hundred trees of White Pine was made by Mr. Filibert Roth to ascertain what rational allowance should be made on the cubic contents of trees when converted into lumber. The average diameter of the trees measured was 28 inches, breast high with bark, and the height 100 feet, the factor of shape 0.43, that is to say, they were old trees with a moderate taper. They averaged 4.2 logs of 16 feet per tree, which represented 76 per cent of the total volume of the bole with bark, 24 per cent being lost in the top and stump and in the bark. The lumber contents of these logs, calculated by Scribner's log rule, represented only 39.5 per cent of the total volume of the tree, that is to say, over 60 per cent of the whole tree is supposed *not* to reappear in the lumber, the saw waste representing 48 per cent of the log volume and 36 per cent of the total volume of the tree.

Based upon a proper consideration of these practices, it will appear that an average allowance of 30 per cent in saw waste on the volume of logs of all sizes is more than ample, and that the lumber yield given in the following table and computed on this assumption of waste, although being for same sizes even 100 per cent above the log scales in use, remains still below the practically obtainable results:

Lumber contents in 16-foot logs.

Diameter at small end.	Judson's favorite.	Doyle rule.	Scribner rule.	Computed for 30 per cent waste.	Waste. By Scribner.	Waste. By Doyle.
Inches.	*Feet B. M.*	*Feet B. M.*	*Feet B. M.*	*Feet B. M.*	*Per cent.*	*Per cent.*
8	22	16	25	32 to 48 / 46	61	76
10	37	36	49	60 to 85 / 72	50	65
12	64	64	79	100 to 130 / 105	47	57
14	95	100	114	142	44	51
16	142	144	159	187	41	46
18	197	196	213	237	37	42
20	248	256	280	292	33	39
22	324	324	334	336	34	36
24	392	400	404	420	33	33
26	476	484	500	492	30	32
28	562	576	582	564	29	30

In estimating the cut of lumber that may be obtained from a given area, there must, to be sure, an allowance be made in addition for unserviceable, crooked, knotty, rotten material, which may reach from 15 to 20 per cent, and, furthermore, an allowance for the loggers' risk in breakages and other losses, which may be figured at 10 to 12 per cent.

To give, however, an approximate idea of the lumber contents of trees of various diameters and heights, these have been calculated for a number of trees and recorded in Table II, p. 87, in the Appendix.

From these measurements, which are based upon Doyle's log scale, the following tabulation is made, showing approximately the increase of lumber contents with diameter growth and age. From this it would appear that the greatest per cent of increase occurs during the period from the fortieth to seventieth year, while in the fortieth year the average annual growth in volume has been about one-third of a cubic foot, in the seventieth year it is nearly 2 cubic feet, or six times as great, and by the one hundredth year this rate is doubled, centenarians containing about 400 feet B. M. During the next century the trees make twice as much lumber wood, for now all wood deposited makes lumber:

Increase in lumber contents with size.

Diameter breast high.	Height.	Approximate age.	Lumber.	Average annual accretion.	Periodic accretion.	Per cent of increase per year during preceding period.
Inches.	*Feet.*	*Years.*	*Feet B. M.*	*Cubic feet.*	*Feet B. M.*	*Per cent.*
7 to 9	50 to 70	40	14	0.35	....	....
10 to 12	50 to 80	55	50	.9	36	17
13 to 15	55 to 115	70	130	1.8	80	17
16 to 18	75 to 125	85	260	3	130	7
19 to 21	80 to 135	110	440	4	180	3
22 to 24	85 to 140	140	650	4.6	210	1.7
25 to 27	85 to 150	185	940	5.1	290	1
28 to 30	85 to 150	230	1,200	5	260	.6

CONDITIONS OF DEVELOPMENT.

DEMANDS UPON CLIMATE AND SOIL.

The wide field of its natural distribution and the thriftiness with which the White Pine develops in climates outside of its native home show that it is quite adaptive as far as climatic conditions are concerned. Yet, from the manner of its development within the climatic range of its occurrence, its use for forestal purposes would seem to be circumscribed by conditions of humid and cool atmospheres, such as are found in northern latitudes and high altitudes. Its distribution is manifestly more dependent on humidity than on temperature, or rather, on a low transpiration factor, that is, such a relation of heat and moisture, both at the foot and at the top, that the thin foliage can readily perform its functions; hence, its failure in cultivation in the trans-Missouri States, the contraction of its southern field to the high altitudes, and its best development in quantity if not in quality within the influence of the Great Lakes and to the northward and eastward.

While adapting itself readily to almost any variety of soil, the White Pine manifestly prefers one with a fair admixture of sand, insuring a moderately rapid drainage. The pine tribe in general occupies the sandy soils, to which it is better adapted than most of the deciduous tree species; but the White Pine is capable of disputing possession with its competitors even of the fresh medium-heavy loam and clay soils, making here the best individual growth.

Its shallow root system, in which it resembles, as in many other respects, the spruces, permits it to accompany the latter to the thinner soils of the rocky slopes in the Adirondacks and New England States, although here its development is naturally less thrifty. Its growth on the rocky hills of Massachusetts within the hardwoods of that region is, however, at least for the first sixty to eighty years not much less thrifty than in the better soils in the valleys. It does not shun even the wetter and occasionally overflowed and swampy ground, and is here found, together with the Fir, Arborvitæ, and even Tamarack; yet, on the dry, light sandy, coarse, and gravelly soil the Red Pine and Jack Pine seem to be able to outdo it.

ASSOCIATED SPECIES.

The White Pine is less gregarious than any other pines of the Eastern United States. Although it occurs in pure growths as true pinery on the red clays and moister gravels, it more frequently is an admixture in the hardwoods, sharing with them the compacter, heavier soils from which the other pines are excluded.

Spruce, Hemlock, and Arborvitæ (Cedar) are most frequent concomitants of the White Pine in Canada; various species of Birch and Maple with Beech and Spruce form the composition of the forest in the Adirondacks, overtowered by the pines, and there is hardly any species of the Northern Atlantic forest which in one or the other region of its distribution may not be found in association with the White Pine.

Owing to the fact that the hardwoods as a rule occupy the better soils, the best individual development of the White Pine is also found in these mixtures. In the pinery of the northwest Red Pine and Jack Pine are the associates, while the Pitch Pine (*P. rigida*), and, in the southern field, the Shortleaf Pine (*P. echinata*) are not unfrequently found in its company.

The samples of "acre yields" following will serve to illustrate more in detail the manner of distribution, the associations, and the capacity of White Pine in the native forests in different parts of its range. More extensive tabulation will be found in the Appendix.

Table VI.—*Acre yield of White Pine on sites in Wisconsin, Michigan, Pennsylvania, and Maine.*

WISCONSIN.

Site *a*: Washburn County.

Description of site.	White Pine. Number of trees.	White Pine. Diameter (breast high).	White Pine. Height.	White Pine. Volume. Boles.	White Pine. Volume. Merchantable timber.	Basswood. Number of trees.	Basswood. Diameter (breast high).	Basswood. Height.	Fir. Number of trees.	Fir. Diameter (breast high).	Fir. Height.	Elm. Number of trees.	Elm. Diameter (breast high).	Elm. Height.	Yellow Birch. Number of trees.	Yellow Birch. Diameter (breast high).	Yellow Birch. Height.	Butternut. Number of trees.	Butternut. Diameter (breast high).	Butternut. Height.	Hornbeam. Number of trees.	Hornbeam. Diameter (breast high).	Hornbeam. Height.
		In.	Ft.	Cu. ft.	Ft. B. M.		In.	Ft.		In.	Ft.		In.	Ft.		In.	Ft.		In.	Ft.		In.	Ft.
Sample area, 1 acre, 1,200 feet above sea. Age of pine, 200 to 220 years. Number of trees, 132: White Pine, 52 per cent; hardwoods 48 per cent. Classification for White Pine: Dominant, 75 per cent; oppressed, 22 per cent; suppressed, 3 per cent. Two-story stand, upper story formed by White Pine, the lower story by hardwoods (Yellow Birch mixed with Basswood with scattering Hornbeam and Fir and occasional Elm). Scanty undergrowth of the young hardwoods and Fir. Soil, clay, underlaid by a hardpan of clay and stones, 4-inch mold on top, with a surface cover of leaves.	1	14	80 to 120.	55		9	3 to 6	40	5	3 to 6	40	1	3 to 6	40	12	3 to 10	40	1	3 to 6	40	5	3 to 6	40
	1	16		71		6	6 to 10	60							16	6 to 10	60	1	6 to 10	60	1	6 to 10	60
	3	19		288											2	10 to 14	80						
	2	20		210											3	14 to 18	80						
	1	21		114											1	19	80						
	2	22		280																			
	6	23	120 to 140.	918																			
	9	24		1,440																			
	3	25		534																			
	6	26		1,152																			
	5	27		1,035																			
	5	28		1,155																			
	6	29		1,482																			
	3	30		780																			
	2	31		560																			
	1	33		315																			
	1	34		347																			
	3	35		1,101																			
	3	36		1,161																			
	1	37		408																			
	1	38		429																			
	1	39		485																			
	3	40		1,521																			
	69			15,841	95,040	15			5			1			34			2			6		

Average annual accretion: White Pine, 75 cubic feet.
452 feet B. M.

MICHIGAN.

Site *d*: Montmorency County.

Description of site.	White Pine. Number of trees.	White Pine. Diameter (breast high).	White Pine. Height.	White Pine. Volume. Boles.	White Pine. Volume. Merchantable timber.	Red Pine. Number of trees.	Red Pine. Diameter (breast high).	Red Pine. Height.	Hemlock. Number of trees.	Hemlock. Diameter (breast high).	Hemlock. Height.
		Inches.	Feet.	Cu. ft.	Ft. B. M.		Inches.	Feet.		Inches.	Feet.
Sample area, 1 acre. Age of pine, 250 to 270 years. Number of trees, 113: White Pine, 54 per cent; Red Pine, 35 per cent; Hemlock, 11 per cent. Locality damaged by fire twelve years before; 15 per cent dead trees and 20 per cent injured by fire. White Pine mixed with Red Pine and intermixed with Hemlock. Soil, fresh, loose sand of a gray color, turning brown and red underneath, with a surface cover of brakes, checkerberry. The subsoil is a brown sand, sometimes loamy and in spots clayey. Density of crown cover, 0.5.	2	10	120 to 140.	36		2	13	120 to 140.	2	3 to 6	40
	1	12		38		1	14		1	9	
	3	13		159		3	15		1	11	50 to 80
	1	14		60		1	16		2	12	
	3	15		207		3	17		6	15	
	3	16		231		3	18		1	20	
	1	17		86		6	19				
	1	18		96		5	20				
	3	19		315		4	21				
	2	21		280		8	22				
	6	22		906		1	23				
	5	23		855		1	24				
	9	24		1,611		1	30				
	4	25		800							
	1	26		216							
	3	27		696							
	2	28		498							
	7	29		1,862							
	2	30		560							
	1	31		302							
	1	33		340							
	61			10,154	60,900	39			13		

Total yield: 86,100 feet B. M., of which White Pine 66 per cent.
Volume of Red Pine: Boles, 5,256 cubic feet; merchantable timber, 25,200 feet B. M.
Average annual accretion: White Pine, 59 cubic feet.
331 feet B. M.

TABLE VI.—*Acre yield of White Pine on sites in Wisconsin, Michigan, Pennsylvania, and Maine*—Continued.

PENNSYLVANIA.

SITE *f*: Dubois, Clearfield County.

Description of site.	White Pine. Number of trees.	Diameter (breast high).	Height.	Volume. Boles.	Volume. Merchantable timber.
		In.	*Feet.*	*Cu. ft.*	*Ft. B. M.*
Sample area, 1 acre, 1,200 to 1,500 feet above sea. Age of pine, 240 to 260 years. Number of trees, 132: White Pine, 37; Hemlock, 84; Maple, 5; Beech, 3; Birch, 3. Hemlock mixed with White Pine, with occasional Maple, Beech, and Birch, on a hill sloping towards southwest, where it is bounded by the left-hand branch of the Narrow Creek. The undergrowth, moderately dense, consists of very young Beech, Hemlock, and occasional Birch and Cucumber. Soil, yellow clayey loam of a medium grain (fine shales in it), deep, fresh, well drained, with 2 to 3 inches mold on top, with surface cover of scanty leaves, fern, teaberries, and scattering dogwood (laurel, northeast corner and north side). Subsoil, laminated shale of an indefinite depth. Density of crown cover, 0.7 (in places 0.8).	2	15	120	360	1,360
	2	17	120		
	2	18	130		
	1	19	130		
	1	20	130	1,370	6,420
	4	21	130		
	2	22	130		
	2	23	130	570	3,000
	1	24	130		
	3	25	135	651	3,690
	1	26	135	257	1,390
	2	27	135		
	1	28	135	1,140	6,600
	1	29	135		
	2	30	145	610	3,900
	4	31	145	1,220	7,800
	1	32	145	390	2,300
	2	34	145	800	4,800
	1	40	145	511	3,300
	1	41	145	511	3,300
	1	45	145	638	4,400
	37	......	......	9,028	52,260

Total yield: 90,103 feet B. M.
Average annual accretion: White pine, 36 cubic feet.
209 feet B. M.

MAINE.

SITE *a*: York County.

Description of site.	White Pine. Number of trees.	Diameter (breast high).	Height.	Volume of bole.
		In.	*Feet.*	*Cu. ft.*
Sample area, one-half acre. Age of pine, 90 to 100 years. Number of trees: White Pine, 118; Red Oak, 6; Norway Pine, 2. Classification for White Pine: Dominant, 26 per cent; codominant, 40 per cent; oppressed, 18 per cent; suppressed, 16 per cent. White Pine with scattering Red and White Oak and occasional Norway Pine, on a level site. The undergrowth, moderately dense, consists of small Hemlock and Beech, small Maple and Oaks numerous. Soil, a fine loamy sand, gray or brown in color, deep, fresh, with 2 or 3 inches mold on top, and leafy surface cover; clay lies probably some feet below surface. Density of crown cover, 0.5.	2	10	75	42
	8	11	75	192
	8	12	75	243
	4	12	85	120
	6	13	85	222
	4	14	75	154
	8	14	85	332
	8	15	85	384
	8	16	85	408
	8	17	85	528
	10	18	85	690
	18	19	85	1,323
	2	20	85	152
	4	21	85	320
	6	22	85	534
	6	23	85	660
	2	24	95	250
	2	25	95	280
	4	26	95	560
	118	......	......	7,384

Average annual accretion: White Pine, 77 cubic feet.
Current accretion: White Pine, 160 cubic feet.

MAINE.

SITE *b*: York County.

Description of site.	White Pine. Number of trees.	Diameter (breast high).	Height.	Volume of bole.
		In.	*Feet.*	*Cu. ft.*
Sample area, one-fourth acre. Age of pine, 50 to 60 years. Number of trees: Mature White Pine, 328; young White Pine, 160; mature Hemlock, 20; young Hemlock, 20. Classification for White Pine: Dominant, 9 per cent; codominant, 45 per cent; oppressed, 23 per cent; suppressed, 23 per cent. White Pine, with scattering Hemlock and occasional Spruce and Fir, on a plain and level site. Scanty undergrowth of Hazel and young Hemlock. Soil, a gray sand, sometimes brown or loamy, with a vegetable mold of 3 inches, deep, fresh, with a leafy surface cover. Clayey subsoil, probably 4 or 5 feet below surface. Density of crown cover, 0.7.	4	6	45	20
	32	7	55	256
	60	7	45	330
	84	8	55	840
	8	8	45	72
	36	9	55	414
	8	10	65	144
	52	10	55	780
	8	11	55	144
	12	12	65	306
	12	12	55	240
	4	13	65	116
	8	17	75	408
	328	......	......	4,070

Average annual accretion: White Pine, 74 cubic feet.
Current accretion: White Pine, 133 cubic feet.

MAINE.

SITE *c*: York County.

Description of site.	White Pine. Number of trees.	Diameter (breast high).	Height.	Volume of bole.
		In.	*Feet.*	*Cu. ft.*
Sample area, one-fourth acre. Age of pine, 50 to 60 years. Number of trees: Mature White Pine, 396. Classification for White Pine: Dominant, 18 per cent; codominant, 27 per cent; oppressed, 24 per cent; suppressed, 31 per cent. White Pine, with occasional Norway Pine, on a slope to north 5° to 10°. Scanty undergrowth of Hemlock, Oak, and Fir. Soil, a sandy loam, with little pebbles in it, of a brown color, deep and fresh, with black soil and mold of 3 inches on top and leafy surface cover; clay probably 8 to 12 feet down. Density of crown cover, 0.8.	4	6	65	28
	28	6	55	168
	20	7	65	190
	20	7	55	160
	84	8	65	1,008
	24	8	55	240
	36	9	65	522
	32	10	65	576
	8	10	75	168
	40	11	65	880
	4	11	75	100
	16	12	65	408
	24	12	75	696
	8	13	65	232
	16	13	75	552
	4	14	65	132
	12	14	75	462
	8	15	65	292
	4	16	75	184
	4	17	75	204
	396	......	......	7,202

Average annual accretion: White Pine, 131 cubic feet.

LIGHT REQUIREMENTS.

The capacity of the White Pine to keep its place in mixture with the hardwoods is probably mainly due to its shade endurance. In this respect it excels all pines with which we are acquainted. Pines are, as a rule, rather light-needing species, and are usually at a disadvantage in the mixed forest, unless compensating influences are in their favor. The White Pine is an exception. As a consequence, it is capable of forming dense thickets, supporting a larger number of trees per acre and producing a larger amount of material than the more light-needing species. Also, as a consequence of its shade endurance, it does not clean itself of its branches as readily as other pines; not only do the lower branches remain green for a long period in spite of the shade of the superior tiers of foliage, but they persist after they are dead for many years.

As this shade endurance is, however, only relative, and as many of the associates possess it in greater degree, the additional advantage of rapid height growth alone saves the pine from being after all suppressed by its shadier companions. Yet, these succeed in keeping the young progeny of the pine subdued, and hence the observation that in the dense virgin forest of hardwoods the reproduction of White Pine is scanty.

The difficulty of cleaning itself of dead branches seems to be overcome by association with shadier companions, for, as a rule, the best quality, cleaner boles, and absence of black knots, which denotes earlier cleaning, are found in such association. Yet, in these mixtures the trees are apt to be shorter bodied, since the hardwood companions are shorter bodied and the stimulus to height growth ceases sooner. In the pinery proper the stimulus to height growth exerted by the neighbors continues longer; hence, longer shafts are found here, other conditions being the same, although the boles are less clean and less free of knots.

Its shade endurance is decidedly less than that of the Spruce, which maintains itself, but not thriving under the dense shade of Maple, Birch, and Beech, where White Pine seedlings and saplings are not to be found, although they sustain perfectly the shade of oaks. To be sure, this shade endurance is to some extent dependent on moisture conditions of soil, being less on the drier than on the fresher soils.

This relatively high shade endurance permits ready natural reproduction of the pine, especially where the hardwoods have been thinned out to some extent, or where, after clearing, all species start their race for reoccupation of the soil with equal chance. The pine then appears in the young hardwood growth in single individuals at first, somewhat behind in height, but finally, when it enters upon the period of rapid height growth, it outgrows its competitors and is assured of its place.

More frequently does the reproduction take place in groups, smaller or larger, the many areas of "second growth" of several acres in extent, which are found throughout the hardwood coppice of Massachusetts, showing that tendency toward gregariousness so characteristic of the conifers. A further discussion of the conditions of reproduction and the yield occurs in the portion devoted to the discussion of forest management and of forest yield.

In these natural reproductions the trees grow close together, that is, close for unaided natural reproduction, as is apparent from the following table of acre yields of young growth taken at various places in New England:

TABLE VII.—*Acre yield of young pine groves.*

State.	Soil.	White Pine.						Species intermixed.	
		Age.	Number.	Diameter (breast high).	Length of log.		Volume of logs.	Number.	Name and remarks.
		Years.		*Inches.*	*Max.*	*Min.*	*Cu. feet.*		
Massachusetts	Fresh, well-drained loam and sandy loam.	35	2	14 to 18	40	35	54	147	Oak.
			128	10 to 14	40	20	1,611.2	52	Chestnut.
			284	6 to 10	35	20	348.9	21	Maple.
			75	3 to 6				8	All other.
			1	3					
Total			490				2,014.1	228	All small.
New Hampshire	Dry, well-drained sandy loam.	35	3	18 to 24	30	18	178.9	13	Maple
			13	14 to 18	30	22	372.4	10	Gray Birch.
			79	10 to 14	35	15	1,007	9	Pitch Pine.
			231	6 to 10				6	All other.
			181	3 to 6					
			5	3					
Total			512				1,558.3	38	

TABLE VII.—*Acre yield of young pine groves*—Continued.

State.	Soil.	White Pine. Age.	Number.	Diameter (breast high).	Length of log. Max.	Length of log. Min.	Volume of logs.	Species intermixed. Number.	Name and remarks.
		Years.		*Inches.*	*Max.*	*Min.*	*Cu. feet.*		
Massachusetts	Fresh, well-drained sandy loam.	40	14	14 to 18	40	25	315.9	133	Oak.
			136	10 to 14	40	20	1,870.4	204	Maple.
			177	6 to 10				19	Chestnut.
			32	3 to 6				15	Gray Birch.
			3	3				11	Cherry.
								15	All other.
Total			362				2,186.3	397	All less than 3-inch diameter.
New Hampshire	Dry, well-drained loamy sand.	40	46	14 to 18	35	15	489.3	26	Hemlock.
			65	10 to 14	30	15	51.9	27	Red Pine.
			184	6 to 10				1	Gray Birch.
			615	3 to 6					
			150	3					
Total			1,060				541.2	54	Small.
Massachusetts	Fresh, well-drained sandy loam.	48	11	14 to 18	40	30	258.2		None.
			158	10 to 14	40	15	2,096.9		
			277	6 to 10					
			18	3 to 6					
Total			464				2,355.1		
Massachusetts	Dry, well-drained loamy sand.	50 to 55	1	18 to 24	35		102	19	Representing seven species.
			48	14 to 18	40	20	902		
			126	10 to 14	40	15	1,311.5		
			147	6 to 10	30	18	152.2		
			15	3 to 6					
Total			337				2,467.7	19	

It would be possible to increase the number of trees that could grow per acre and develop satisfactorily by attention of the forester, as will appear from the statements regarding the White Pine forest plantations in Germany, where pure White Pine growths showed at sixty-eight years still over six hundred and seventy trees, and in another place at eighty-two years seven hundred and twenty-three trees, and at one hundred and four years over two hundred and fifty trees per acre. Even in such close stand the crown of living branches remains long, occupying one-third of the bole, and dry branches persist down to over half the length. The stems are straight and cylindrical, in this respect also reminding one of the Norway Spruce, although the tendency to fork seems more frequently developed.

YIELD OF WHITE PINE.

The question as to the amount of material which the White Pine is capable of producing per acre is difficult to answer. It can not, of course, be deduced from a knowledge of the development of the individual tree, since there remains one factor unknown, namely, the number of trees of different classes that can occupy an acre. Nor can the capacity of production, as a rule, be ascertained from the actual production or acre yield of natural virgin growths, for these usually not only do not occur in pure growths, but also are usually not developed under most advantageous conditions, and do not, therefore, represent the possible or normal yield which could be secured. Only by selecting smaller, seemingly normally and favorably developed groups in the forest at different ages and in various localities and measuring the same may we arrive at an approximation of what the species is capable of producing by itself.

Such measurements have not been attempted, but the yield of virgin acres under varying conditions has been ascertained to give at least a forecast of the possibilities, although not representing the normal or possible yield of fully stocked acres of White Pine. In addition we may utilize the results recorded from Germany (page 69) of a number of plantations, which have had the advantage of at least the partial care of forest management.

From these indications, we are justified in the assertion that the White Pine produces per acre as well as any species with which we are acquainted in our northeastern woods, and at a rate which is not excelled by any of the lumber trees within its range.

In this respect, again, it approaches the German Spruce, though it probably excels this species in persistency, as it does in the dimensions which it can produce. We can, therefore, for the first hundred years at least, approximate the capacity of our White Pine by reference to experience tables of the German Spruce.

As with all conifers, the rate of production at first is very slow, not more than 40 to 70 cubic feet in the average per year for the first twenty years. With the better development of crowns and the assertion of individual superiority in the struggle of neighbors, which leads to the establishment of dominant classes, the production increases rapidly, and by the fiftieth year, in fully stocked areas, the average rate of 140 to 160 cubic feet per acre may be attained, so that at that age we may, with five hundred to six hundred trees to the acre, find 7,000 to 8,000 cubic feet of wood stored up in the boles of the trees. The current annual accretion, then, may readily be at the rate of 160 to 180 cubic feet, keeping the average annual accretion of fully stocked acres very nearly to those figures, so that at one hundred years we should find, under favorable conditions, as much as 15,000 cubic feet of wood, of which at least 80,000 to 90,000 feet B. M. is saw material.

The persistency of growth seems to continue beyond that age, and the indications are that the decrease of the current as well as average accretion per acre during the next century takes place so gradually that at one hundred and fifty years it may still be over 100 cubic feet, and not much below at two hundred years, when the burden of the acre may be near 20,000 cubic feet, with over 120,000 feet B. M., and double the amount in the oldest growths of two hundred and fifty or more years, which may possibly be the limit of production.

While these figures, which differ very materially from those proposed in the tables by Messrs. Pinchot and Graves, may stand for the better soils, as ideally possible, practically, perhaps, rarely attainable, especially in older stands, poorer soil sites will vary from them by from 20 to 40 per cent, so that a yield of 9,000 cubic feet at a hundred years, or 50,000 feet of lumber, would still be quite reasonable to expect on the poorest soils on which White Pine can be satisfactorily grown. On the sandy soils of Wisconsin whole forties are found to average 50,000 feet per acre of naturally grown unattended forests of one hundred and fifty years of age.

Table VIII summarizes the measurements of sample areas, which are given in detail in the Appendix. It will serve to show what our native woods, without attention, stocked with partly useless trees and in open stand, exhibiting much wastage in unoccupied ground, are capable of producing.

If we assume that the areas might have been stocked with pine alone, that they would have produced at only the same rate as they have under their present conditions, even though the acres had been fully stocked and not in the fractional manner which is indicated by the decimal giving density of cover (all assumptions), and if in connection with the density factor we consider the number of all trees per acre and the percentage which the pine represents, we may, as a mere matter of judgment not fit for tabulation, arrive at an indication as to what the acre might possibly have produced. Such indication of possibility has been attempted in the last column of the table, and has served in the above discussion in connection with all other data presented. This is all that can be done in the absence of the measurements above indicated. These figures are of no direct practical application except to give a general notion of the productivity of White Pine and the variability of yields.

An inspection of the table of yield in Germany, on page 69, will show that these approximations are not unreasonable. The lumber contents in board feet may be approximated by multiplying these figures by 4 or 5 in the younger growths and by 6 or 7 in the older. Assuming a moderately careful practice of logger and sawyer, by no means mathematically tenable, the above tentative propositions for normal yields might be even increased.

To assume, as is done by certain authorities, that tables of normal yield could be constructed by using the density indicated by a decimal as a mathematical factor, using that factor as a divisor of the actually measured yield in order to arrive at the normal, is to mistake the value of the density factor. Not only would trees and whole acres have developed very differently when grown under different density conditions during their life, but the estimate of the density is such a vague and uncertain one, a mere opinion, that even if the greatest care were exercised, its use as a mathematical factor would not be admissible. It is a mere indication of the present condition of the growth, and its meaning at different periods of life is very different in its physiological effects as expressed in volume accretion.

TABLE VIII.—*Acre yield of White Pine in natural forest.*

[Condensed from fuller tables of measurements in Appendix. Where admixtures are reported as scattered for brevity's sake 1 per cent has been allowed.]

State.	Site.	Age.	Character of—			Number of trees.		Density.	Volume.					Indication of possibility.
			Soil.	Forest.		All.	White Pine.		All species. Cubic feet.	All species. Feet B. M.	White Pine. Cubic feet.	White Pine. Feet B. M.	White Pine. Per cent of total yield.	
		Years.			*Per ct.*									*Cubic feet.*
Massachusetts	*f.*	25 (cultivated.)	Sandy loam	White Pine	73	*a* 779	*a* 560	(?)			1,536			2,000
				Hardwood	23									
				Pitch Pine	4									
Pennsylvania	*g.*	25 to 35	Clay loam	White Pine	71	*b* 183	*a* 131	0.5 to 0.6			1,152			3,000
				Hardwood	29	*a b* 1,301	*a b* 154							
Massachusetts	*h.*	30 to 35	Sandy loam	White Pine	99		*a* 301	Full.			4,520			4,600
				Hardwood	1		90							
Massachusetts	*i.*	35	Sandy loam	White Pine	99		*a* 413	0.8			5,540			6,000
				Hardwood	1		77							
Massachusetts	*j.*	35 to 40	Black loam	White Pine	99		*a* 313	0.8			3,973	*a* 16,000		5,000
				Hardwood	1		89							
New Hampshire	*o.*	35 to 40	Loam	White Pine	99		*a* 435	0.8			5,649	*a* 22,500		6,000
				Red Pine	1									
New Hampshire	*p.*	35 to 40	Sandy loam	White Pine	99		*a* 517	0.7 to 0.8			4,396	*a* 17,500		5,000
				Pitch Pine	1									
New Hampshire	*r.*	35 to 40	Sandy loam	White Pine	100		*a* 794	(?)			3,818	*a* 15,500		
New Hampshire	*s.*	35 to 40	Sandy loam	White Pine	99		*a* 503	0.6 to 0.7			4,674	*a* 18,500		5,000
				Maple	1									
Massachusetts	*a.*	35 to 38	Sandy loam	White Pine	99		*a* 286	0.6			4,822	*a* 20,000		6,000
				Hardwood, Hemlock	1		85							
New Hampshire	*l.*	40	Loamy sand	White Pine	99		*a* 1,077	(?)			2,832	*a* 12,000		
				Red Pine	1									
Massachusetts	*g.*	40	Sandy loam	White Pine	100		*a* 323	0.8 to 0.2			5,378	*a* 22,000		
							35							
New Hampshire	*m.*	40 to 45	Sandy loam	White Pine	99		*a* 410	0.9			5,406	*a* 22,000		6,000
				Hardwood	1		119							
New Hampshire	*g.*	40 to 45	Loam	White Pine	99		*a* 371	(?)			4,503	*a* 18,000		
				Maple, Hemlock	1									
Massachusetts	*e.*	45 (cultivated.)	Loamy sand	White Pine	99		*a* 374	(?)			5,327	*a* 22,000		6,000
				Birch	1		99							
Pennsylvania	*j.*	40 to 50	Clay loam	White Pine	60	*a* 409	*a* 239	0.8			1,826	*a* 8,000		
				Hardwood, Hemlock	40	1,102	144							
Massachusetts	*k.*	48	Clay loam	White Pine	99		*a* 446	0.6			6,775	*a* 33,500		8,000
				Hardwood	1		86							
Massachusetts	*d.*	50	Clay loam	White Pine	99		*a* 235	(?)			4,923	*a* 25,000		
				Hardwood	1		47							
Massachusetts	*b.*	50 to 55	Sandy loam	White Pine	99		*a* 339	Full.			4,859	*a* 25,000		5,500
				Hardwood	1		69							
Massachusetts	*c.*	50 to 55	Sandy loam	White Pine	100		*a* 310	(?)			6,188	*a* 30,000		
							11							
Maine	*e.*	50 to 60	Gray loamy sand.	White Pine	91	*a* 348	*a* 328	0.7			4,070	*a* 20,000		5,500
				Hemlock, Spruce	6	180	160							
Maine		50 to 60	Sandy loam	White Pine	99		*a* 396	0.8			7,200	*a* 36,000		
				Norway Pine, Hemlock	1									
Maine		50 to 60	Sandy loam	White Pine	82	*a* 370	*a* 314	0.8			4,800	*a* 24,000		8,000
				Spruce, Red Pine	18		86							
New Hampshire	*n.*	60 to 65	Sandy loam	White Pine	99		*a* 291	0.8 to 0.9			7,870	*a* 40,000		9,000
				Red Pine	1									
Pennsylvania	*c.*	60 to 80	Loamy sand	White Pine	40	*a* 216	*a* 80	0.5			2,918	*b* 14,000		11,000
				Hemlock	9									
				Hardwood	51									
Pennsylvania		60 to 80	Loamy sand	White Pine	66	*a* 232	*a* 154	0.6			5,036	*b* 24,173		12,000
				Hardwood	27									
				Hemlock	7									

Maine	a.	90 to 100	Loamy sand	White Pine Red Pine Red Oak	93 7	a 126	a 118	0.5	......	......	7,384	......	......	15,000
Michigan	i.	95 to 105	Loamy sand	White Pine Hardwood Hemlock	47 30 23	a 364	a 173	0.7	8,500	33,400	7,165	b 28,650	87 (?)	12,000
Michigan	a.	100 to 150	Deep loose sand	Red Pine White Pine Hardwood	61 36 3	a 181	a 68	0.6	6,800	33,000	2,990	b 14,350	44 (?)	10,000
Michigan	e.	100 to 120	Sandy loam	White Pine Red Pine	41 59	a 110	a 46	0.5	5,686	23,800	2,154	b 9,030	38 (?)	9,000
Michigan	h.	130 to 140	Deep loose sand	White Pine Red Pine Hemlock	68 14 18	a 189	a 129	0.7 to 08.	11,162	55,810	8,200	b 39,300	73 (?)	14,000
Michigan	m.	160 to 200	Fresh loose sand.	Red Pine White Pine Hardwood	53 39 8	a 91	a 36	Open.	10,913	53,250	5,550	b 26,650	50	......
Michigan	......	160 to 200	Fresh loose sand.	Red Pine White Pine	75 25	a 153	a 39	(?)	11,246	49,220	3,332	b 15,980	32 (?)	......
Michigan	n.	160 to 200	Loamy sand	White Pine Hardwood	31 69	a 130	a 40	(?)	(?)	(?)	7,698	b 37,000	......	......
Michigan	......	160 to 200	Fresh loose sand.	White Pine Red Pine Hardwood	39 53 8	a 91	a 36	Open.	10,900	53,000	5,550	b 26,650	50	......
Wisconsin	c.	160 to 200	Clayey loam	White Pine Hardwood Red Pine Fir	65 32 1 2	a 166	a 108	Open.	(?)	(?)	12,290	b 59,000	(?)	......
Wisconsin	e.	160 to 200	Clayey loam	White Pine Hardwood	49 51	a 110	a 54	(?)	(?)	(?)	9,200	b 41,160	(?)	......
Wisconsin	c.	160 to 220	Clayey loam	White Pine Hardwood Fir	59 38 3	a 144	a 85	(?)	(?)	(?)	11,795	b 56,610	(?)	......
Wisconsin	g.	160 to 230	Loamy sand	White Pine Red Pine Hardwood Fir	54 9 24 13	a 143	a 77	(?)	10,150	47,820	8,682	b 41,660	86	......
Wisconsin	a.	200 to 220	Fresh clay	White Pine Hardwood	56 44	a 76	a 43	(?)	(?)	(?)	8,120	b 52,920	(?)	......
Wisconsin	a.	200 to 220	Fresh clay	White Pine Hardwood	52 48	a 32	a 69	(?)	(?)	(?)	15,840	b 95,000	(?)	......
Wisconsin	c.	200 to 220	Light clay	White Pine Hardwood Fir	22 74 4	a 88	a 19	(?)	(?)	(?)	5,414	b 32,480	(?)	......
Wisconsin	c.	200 to 220	Light clay	White Pine Hardwood Fir	44 53 3	a 136	a 60	(?)	(?)	(?)	12,136	b 72,810	(?)	......
Wisconsin	c.	200 to 220	Light clay	White Pine Hardwood Fir	40 47 13	a 123	a 50	(?)	(?)	(?)	12,169	b 73,000	(?)	......
Michigan	k.	230 to 240	Loamy sand	White Pine Red Pine Hemlock	80 (41) 20 (18) (41)	a 110 76	a 76	0.8 to 0.9	20,060	92,000	12,174	b 58,400	61	20,000
Michigan	k.	230 to 240	Loamy sand	White Pine Hemlock	51 49	a 118	a 60	0.5	21,076	115,560	16,586	b 99,400	71	30,000
Pennsylvania	d.	240 to 260	Rock, sandstone	White Pine Hemlock Hardwood	24 60 16	a 96	a 47	0.4 to 0.5	11,148	66,000	6,836	b 39,600	61	40,000
Pennsylvania	f.	240 to 260	Clay loam	White Pine Hemlock Hardwood	28 62 10	a 132	a 37	0.7	15,686	90,103	9,028	b 52,260	57	......
Pennsylvania	h.	240 to 260	Clay loam	White Pine Hemlock Hardwood	30 47 23	a 78	a 23	0.5 to 0.6	11,224	66,900	7,269	b 43,500	65	40,000
Michigan	g.	250 to 260	Loamy sand	White Pine Hemlock Fir Hardwood	50 20 25 5	(?)	a 44	0.7	(?)	(?)	10,385	b 62,300	......	......
Michigan	d.	250 to 270	Fresh loose sand.	White Pine Red Pine Hemlock	54 35 11	a 113	a 61	0.5	15,400	86,000	10,150	b 60,900	66	......

a Lumber contents have been approximated.

b Lumber contents have been calculated by Doyle's log scale.

It may be of interest to record more especially the data of a small clump of young White Pine sprung up naturally on an abandoned field of less than three-fourths of an acre in extent, situated near Farmington, N. H., which its owner (Mr. J. D. Lyman, of Exeter) had from time to time thinned out for the last twenty-two years, with a view of accelerating the growth of the trees. Unfortunately, no record of previous conditions and frequency and extent of operations was attainable, but the present condition (three or four years ago) is exhibited in the following table:

Data of a clump of naturally grown young White Pine.

[Age: Forty-six to fifty-six years; average, fifty-one years. Height: 70 to 80 feet. Area: 108 square rods.]

Number of trees.	Diameter (breast high).	Volume.
	Inches.	*Cubic feet.*
1	22	85
1	21½	84
10	16 to 19	600
27	14 to 16	1,169
25	13 to 14	875
31	11 to 12	806
18	10 to 11	360
6	9 to 10	96
2	7	20
121		4,095

This would indicate a yield per acre of about 6,000 cubic feet, from which, with the dimensions attained under careful mill practice, some 36,000 feet of lumber might be cut. To be sure, with such open stand much of this must be knotty, even though the trees were pruned as far as possible.

By comparison with the measurements of naturally grown unthinned acres, we find that two to three times the number of trees of the age indicated in the above table might stand on an acre and make as much total product (see Massachusetts, site *c*, which, with 324 trees, produced 6,188 cubic feet); and although a few trees in the thinned grove had reached larger dimensions, the total product of trees over 12 inches in diameter is almost the same, the difference in favor of the thinned part being only 100 cubic feet. From this comparison it would appear that the thinning was too severe to secure the most desirable results. Pl. X shows the condition of the grove when the measurements were taken.

Allowance, however, should be made for the amount utilized in thinnings. Whether this inferior material would pay in most cases the cost of its removal is questionable. A very uncertain estimate by the man who performed the thinnings places the amount of wood removed equal to that now standing, among which is 5,000 shingles.

The following table shows the measurements of one of the largest trees in the grove:

Measurements of tree.

[Age: Fifty-six years. Height: 80 feet.]

Height of section, in feet.	Diameter, in inches.	Number of rings on section.
Stump	19½	54
10	14	46
20	12⅞	42
3	12⅛	37
40	10¼	32
50	8½	24
60	5¾	15
70	3	8

This tree, when felled and cut into waney-edged boards, made lumber to the amount of 364 feet.

FIG. 1. A THINNED PINE GROVE IN NEW HAMPSHIRE (TREES 51 YEARS OLD, 186 TO THE ACRE).

FIG. 2.—YOUNG PINE IN NEW HAMPSHIRE (TREES 20 YEARS OLD).

DANGERS AND DISEASES.

The White Pine is subject to a considerable number of destructive influences even when growing spontaneously, but a large proportion of these might be avoided if properly understood and guarded against, since they are in great part due to human agency.

INJURIES BY HUMAN AGENCY.

The subject of forest fires has been so fully discussed that it is unnecessary here to treat it in detail, although the pine forests of the Northern States have suffered more irreparable injury from this than from all other destructive agencies combined. From the numerous suggestions that have been made respecting protection from fire and from unnecessary injuries in general, the most important appear to be:

(1) That a well-digested code of laws, capable of prompt enforcement, based upon the recommendation of a nonpolitical forest commission, is of primary importance

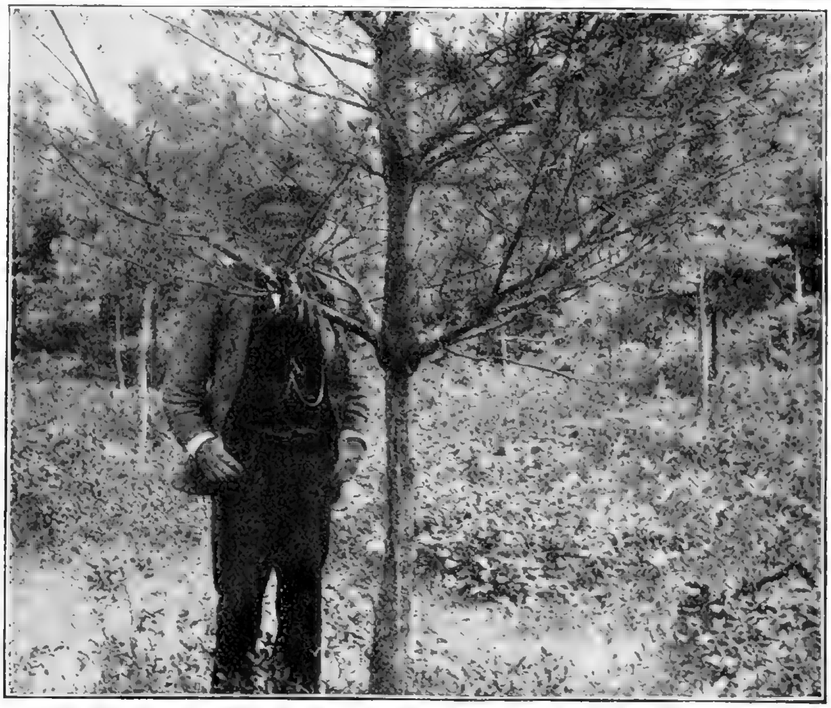


FIG. 4.—Girdled White Pine continuing to grow.

(2) That a correct public sentiment, encouraged by a wider dissemination of information concerning the value of forest products and the time required for their growth, will have more influence than all other means together in preventing unnecessary destruction.

Unlike the Loblolly Pine of the Southern States, or the Red Pine with which it is commonly associated, White Pine has a thin bark during the first thirty to fifty years, which affords but slight protection from fire. Consequently, the species suffers much in young growths from surface fires, which do little or no harm to the thick-barked pines and hardwoods. In the mature trees the growing layer is much better protected, as the bark with age becomes proportionately thicker than that of Red Pine.

Related to the foregoing, and properly placed under the head of injuries to be charged to human responsibility, are wounds occasioned by cattle. A pine forest is less liable to injury from the browsing of cattle than one composed of deciduous trees, and in the Eastern States old pastures commonly grow up to pine, the deciduous species being kept down by the cattle. But in any case, when the growth of timber is the primary object, domestic animals should be rigorously excluded, as they are certain to do more or less injury to the growing trees. A pine forest, or a forest of any kind, is no more properly a "run" for cattle than a field of standing grain, and the damage is likely to be more extensive and less capable of repair in the former than in the latter case.

The White Pine shows considerable recuperative power, which is exhibited in the ready reestablishment of broken leader and the healing of wounds, in which the prolific resin exudations assist by keeping out water and fungi.

The experiences of Mr. Nathaniel Morton, of Plymouth, Mass., in trimming pines, recorded in The Forester (June, 1898), show the absolute safety of pruning live limbs of 3 to 5 inches and more in diameter, which are covered in a few years by new growth (Pl. XI). An interesting case of pertinacity of life and recuperative power, which at the same time throws light on the much-debated question of food and water movement in trees, is also reported from the same source, and represented in fig. 4.

A young pine in the forest was, two years ago, not only girdled, but the bark peeled off for 11 inches all around the tree. The tree has a perfectly healthy appearance, and has continued to grow in length, although apparently about half as fast as before. The measurements of internodes of this tree during the last six years follow. The diameter growth above the wound has continued, while below the wound it has remained stationary, as will appear from the measurements made two years after the removal of the bark.

	Inches.
Circumference near the ground	15
Circumference just below the wound	11
Circumference where bark is stripped	$9\frac{1}{2}$
Circumference just above first row of branches	14
Circumference above second row of branches	11

The wound is entirely covered by pitch. The growth just above the wound has a baggy appearance, showing an accumulation of wood deposit, which shows the arrest of the food materials due to the absence of the cambium layer and bark.

It would appear that the roots could either live without the food supply from above (at least for two years), or else that a sufficient amount can pass through the dead wood of the trunk, and at least the water necessary for the elaboration of food materials in the foliage can be supplied through the old wood. The writer inspected this tree, and can vouch for the truthfulness of the description. A similar case with a southern pine (species undetermined) came to his attention, where the tree was older and had grown over twenty years above the wound; but as only a cut was inspected the possibility of a cambial connection of the upper and lower parts was not absolutely excluded, as in the present case.

INJURIES BY STORMS.

Of injuries not within human control may be mentioned, first, those resulting from storms, snow, and ice. The soft texture of the wood and the short-lived branches of the White Pine would naturally suggest its being more liable to injury by storms than are deciduous trees. This, however, is not the case. The angle which the branches make with the trunk admits of their readily bending, and under such a weight it is found that Maples and other hardwood trees break down much more frequently. Mr. B. F. Hoyt, of Manchester, Iowa, states that "a whole summer's observation among the White Pines of Tennessee failed to reveal a single case in which a tree of that species was injured by the wind," attributing the fact to the mechanical disposition and structure of the trunk and branches.[1] In this respect, then, the White Pine stands at a decided advantage as compared with many deciduous trees with which it is naturally associated.

Like the shallow-rooted Spruce, the White Pine is liable to be uprooted and thrown by storms, although to a less degree.

While, however, the mechanical effects of the wind and of storms of snow and ice are not sufficient to require special consideration, the injurious consequences of drying winds are such as

[1] American Naturalist, December, 1886.

FIG. 1.—YOUNG PINE IN NEED OF PRUNING.

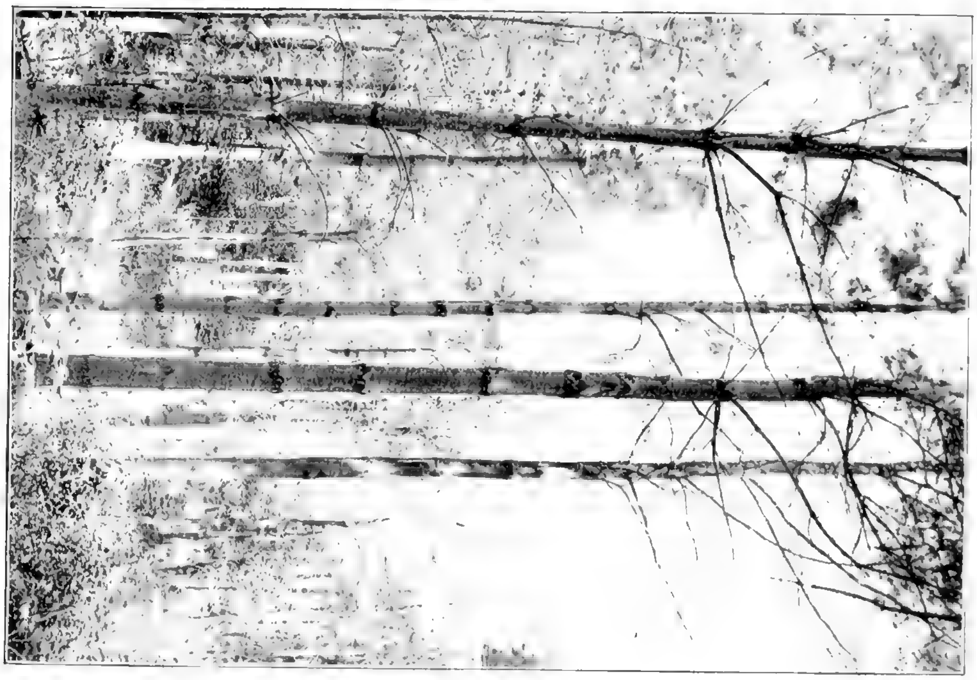


FIG. 2.—YOUNG PINE PRUNED.

to become an important factor in determining the limits of the artificial cultivation of this species. At the time of planting, deciduous trees are not in leaf, and accordingly there is but little evaporation of water, while the leaf surface of conifers is exposed then as much as ever to the drying effects of the atmosphere, often resulting in their death before they are fully established in the soil. It is for this reason and because of the general lack of a sufficient amount of atmospheric moisture that comparatively slight success has attended the cultivation of the White Pine on the plains west of the Mississippi. The raw winds from the Atlantic again have been found to be much more injurious to this species than to the Pitch Pine (*Pinus rigida*), and the latter is therefore decidedly preferable for planting in the immediate vicinity of the coast.

DISEASES.

EFFECT OF HEAT AND DROUGHT.

In Germany, plantations of White Pine thirty-five to forty years old have suffered much injury from a disease which appears to be occasioned by unusual heat and drought, and which was particularly severe after the hot, dry summer of 1876.[1] The disease manifests itself externally by dried-up patches on the trunks, the spots being largest 3 to 6 feet from the ground, gradually running out above and below this, and often reaching a height of 15 to 18 feet. The spots may be only an inch or two wide, but frequently the bark is dead nearly around the entire trunk. As a rule, these dead spots are on the south and west sides of the tree. The wood is often penetrated by larvæ of insects, but these are not the cause of the disease, since in many cases they are not present.

Dr. R. Hartig, from a comparison of specimens and study of the disease in question, concludes that it is due to extreme dryness and that the White Pine can not be trusted to endure such extremes. He further states that it suffers greatly from dry air even in the winter time.

PARASITIC DISEASES.

The White Pine is subject to a number of parasitic diseases, some of which attack it when growing spontaneously in the forest, while others are highly destructive to the tree in cultivation, especially in Europe under changed climatic conditions. A few only of the best known of these, including several due to fungi, will be considered in detail.

(1) *Agaricus melleus* Vahl.—This fungus, of common occurrence in the United States as well as Europe, is exceedingly destructive to coniferous trees, the White Pine in particular suffering greatly from its attacks. It also fastens upon various deciduous species as a parasite, attacking living trees of all ages, but living as well upon dead roots and stumps and on wood that has been cut and worked up, occurring frequently on bridges, railroad ties, and the like, and causing prompt decay wherever it has effected an entrance. The most conspicuous part of the fungus is found frequently in the summer and fall on the diseased parts of the tree or timber infested by it. It is one of the common toadstools, this particular species being recognized by its yellowish color, gills extending downward upon the stem, which is encircled a little lower down by a ring, and by its habit of growing in tufts or little clumps of several or many individuals together (Pl. XII, *1* and *2*). It is also particularly distinguished by the formation of slender, dark-colored strings (Pl. XII, *2* and *3*), consisting of compact mycelium, from which the fruiting parts just described arise. These hard root-like strings (called rhizomorphs) extend along just beneath the surface of the ground, often for a distance of several feet, and penetrate the roots of sound trees. By carefully removing the bark from a root thus invaded the fungus is seen in the form of a dense, nearly white, mass of mycelium (Pl. XII, *3, c*), which, as the parts around decay, gradually produces again the rhizomorphs already described. These rhizomorphs are a characteristic part of the fungus. Occurring both in the decayed wood, from which they spread to the adjacent parts, and extending in the soil from root to root, they constitute a most effective agency in the extension of the disease.

The symptoms of the disease are marked, and, taken together, sufficiently characteristic to admit of its ready recognition. External symptoms, to be observed especially in young specimens

[1] Hartig. Untersuchungen aus dem Forstbotanischen Institut zu München, 1883.

recently attacked, consist in a change of the leaves to a pale sickly color and often the production of short stunted shoots. A still more marked symptom is the formation of great quantities of resin, which flow downward through the injured parts and out into the ground, resulting in the sticking together of the roots and masses of dirt that have been penetrated by the resin. Passing up a little way into the trunk, the cause of this is seen in the active working of the fungus in the medullary rays and around the resin canals, where apparently both cell walls and cell contents undergo degeneration and partial conversion into resin. This flows downward, as already stated, and also works laterally into the cambium, producing great blisters in the younger parts where growth is going on, and also resulting in the formation of abnormally large resin canals.

As the disease advances the fungus continues to attack the tracheids of the sound wood and soon induces marked changes. Under its influence the walls lose their lignified character, become softer, and give the cellulose reaction, while the mycelium of the fungus penetrates and fills the enlarged cavities of the tracheids. (Pl. XII, *4*, *5*, *6*.)

The whole inside of the trunk may finally become hollow for some distance above the stump, its interior being filled with a loose rotting mass, penetrated by rhizomorph strings, and only becoming worse the longer it stands. The disease having once reached this stage, there is of course nothing to be done for the tree but to fell it as soon as possible and save whatever wood remains unaffected.

(2) *Polyporus annosus* Fries (*Trametes radiciperda* R. Hartig).—This is one of the most dangerous parasites of coniferous trees, causing "red rot" and the dying out of plantations both of young and old pines. In Germany it infests various species of pines, including *Pinus strobus* and *Pinus sylvestris;* also *Picea excelsa*, *Juniperus communis*, and others. It is more destructive to the White Pine than to the Scotch Pine.

The disease appears in plantations of various ages, from five to one hundred years old, showing itself by single plants here and there becoming pale, then yellow, and suddenly dying. These external symptoms are altogether similar to those observed in trees infected by *Agaricus melleus*. Other trees are attacked in the neighborhood of the infected ones, and so the disease spreads centrifugally.

The fruiting portion of the fungus (Pl. XIII, *1* to *6*) grows on the roots near the surface of the ground, forming yellowish-white cushions (white on the spore-bearing surface) that may finally, though rarely, become a foot or more in diameter. Between the wood and bark of the affected tree are extremely thin layers of mycelium, distinguished from those of *Agaricus melleus* by their softness and delicacy. The tissue of the roots and the inside of the stem is decayed to a considerable height.

The disease is spread by the spores, which are carried away by mice and other burrowing animals and deposited on the roots of adjacent trees, where they germinate and penetrate the living tissues of the bark, passing thence into the wood elements and growing in them toward the stem. It is also communicated by the roots of infected trees crossing those of sound ones in the ground (Pl. XIII, *7*), the fungus growing directly from one to the other.

A violet discoloration of the wood is the external symptom of beginning decomposition, in which the contents of the parenchyma cells die and turn brown through the action of the mycelium. This color disappears with the loss of the cell contents, and a clear brownish-yellow takes its place, with scattering black spots here and there. These are surrounded at a later period with a white zone (Pl. XII, *8*), and at the same time the wood becomes continually lighter and more spongy. At last numerous openings arise, the wood is separated into its constituent fibers, and becomes watery and of a clear brownish-yellow color. The cell wall undergoes decomposition, giving the cellulose reaction instead of remaining lignified, and finally even the entire middle lamella disappears. The process may go on until the wood elements are isolated, so that they are easily picked apart like threads of asbestos.

The parasite advances rapidly in the wood elements, decomposition sometimes going on in this way to the height of 25 feet. In the bark it proceeds more slowly, but is finally none the less dangerous, since it causes the death of the cortical part of the root in which it originates, and when after reaching the trunk it passes into the other roots, their death finally resulting in the death of the whole tree.

In the Scotch Pine a great amount of resin is produced, and this, accumulating in the lower part of the stem, probably acts as a barrier to the growth of the mycelium upward. In the White Pine the fungus extends much farther in the trunk.

Pl. XII, *7*, represents a stump of White Pine that has been attacked by *Polyporus annosus.* The heart is surrounded by decayed wood and spots filled with masses of resin. Pl. XII, *9*, represents parts of adjacent wood elements of Norway Spruce after they have been acted upon by the fungus; the mycelium hyphæ and spores, highly magnified, are represented in *10* of the same plate.

(3) *Coleosporium senecionis* Pers.—This fungus, under the name of "pine blister," infests various species of pines, growing in the æcidium stage on both leaves and bark, and sometimes proving very destructive. When growing on the leaves it affects but little the vitality of the tree, but is highly injurious when the bark is the place of attack. It penetrates the bark, apparently through wounds occasioned by insects, woodpeckers, or other agencies, and its mycelium spreads through the cortical parenchyma and bast, and into the wood to the depth of several inches, passing through the medullary rays.

Under its influence the starch and other cell contents disappear and a resinous substance collects in their stead, a mass of dead tissue soon taking the place of the living cells. This change of the cell contents results in a great accumulation of resin, which often exudes in large quantities from the diseased parts of the tree.

The mycelium is perennial, extending itself through the stem from year to year, particularly in a longitudinal direction. Where it is present the growth of the stem is prevented and the formative materials are diverted to the opposite side of the stem, causing there a greatly stimulated and abnormal growth. The death of the leader often results, especially in dry summers, for the reason that the wood, thus choked with resin, is unable to supply it with sufficient water.

The researches of Wolf lead to the conclusion that this parasite of the pine lives in the form known as *Coleosporium senecionis* on various species of Senecio, and that it is communicated to pine shoots from them. He proposes the extermination of these hosts as a preventive measure. Later investigations of Kleebahn go to show that a blister rust which he observed badly affecting the bark of *Pinus strobus*, in the neighborhood of Bremen, is caused by a closely related parasite form which he names *Peridermium strobi*, and considers to be the æcidium stage of *Cronartium ribicola.*

All these fungi have probably caused far more destruction of timber than casual observation would indicate, but the limited extent to which artificial cultivation of forests has thus far been carried on in this country gives comparatively few exact data regarding them. The facts, as above stated, have therefore been drawn largely from the works of Hartig and other European authorities. With increasing cultivation of timber and probable increase of such diseases, their investigation and the employment of protective measures must necessarily receive far more attention.

Several diseases attributable to the action of fungi, but as yet imperfectly investigated, are of frequent occurrence in this country. One of these, known as "damping off," characterized by the sudden decay of seedlings at the surface of the ground, is common in nurseries, and attacks young plants of different kinds, the White Pine among them.

The disease is most prevalent in plants growing in a damp soil in a warm, moist atmosphere. As observed in the Ann Arbor (Michigan) greenhouses for several years in various plants propagated from slips, the disease appears a few days after the slips are set, giving the lower part of the stem a wet, unhealthy appearance, which extends to the lower leaves, particularly where these touch the sand in which they are growing. Upon taking up the specimens, the parts affected are found to be in the early stages of decay, and penetrated throughout, even in the interior of the epidermal appendages, by the branching filaments of a fungus. The fungus appears to live in the sand in which the plants are propagated, and to run in it from one to another, resulting often in the rapid destruction of the plants in the bed.

"Damping off" is due to the action of several different parasitic organisms, of which the potting-bed fungus, *Pythium de baryanum* Hesse, is one of the most common, though a number of other species have been shown to be capable of producing the disease. The relief measures recommended by those who have studied the disease are the use of fresh soil free from decaying matter, as much sunlight as the plants will endure without wilting, a fairly low temperature, and an abundant supply of fresh air. Mr. J. Dawson, of the Arnold Arboretum, suggests watering the young plants from below, so as to avoid wilting the leaves, as a means of prevention. Other suggestions will be found in recent literature of the subject, practically in the reports of various agricultural experiment stations.[1]

A disease which attacks the trunk of the tree, at various ages, is very prevalent in pine forests, and occasions the condition known among lumbermen as "punky pine." A diseased tree can frequently be recognized by its having one or more knots with a rough, irregular contour, at a considerable height above the ground, commonly conspicuous by a considerable outflow of resin. These seem to result from the breaking off of branches, followed by gradual decay at the place where they have separated from the tree, in such a way as to admit water into the trunk, the opening being afterwards partially covered by subsequent growth of the tree while decay is going on inside.

Upon examining the wood of such a tree, it is seen to be discolored and in various stages of decay, the diseased condition extending inward from the knot hole, and both upward and downward from it in the trunk. By inspecting logs cut from such trees, it will be noticed that the decayed portion may have filled up the center, making a rotten heart; or it may follow the rings of growth for some distance, midway from the center to the periphery; or it may be still nearer to the surface, its position and extent being very variable and following no recognizable rule. The parts diseased are utterly worthless, though boards containing a greater or less amount of wood thus affected are common in the market. Microscopic examination shows that the wood is penetrated by the filaments of a fungus, and that the elements of which the wood is made up have been greatly altered, and to a considerable extent decomposed by its action.

Continued observation in the pine woods of Michigan, in different years, does not so far justify the reference of this disease to any single species of the various fungi found growing upon the trunks and logs of decaying pine trees. But whatever the species, one or several, concerned in producing or hastening the condition described, the general facts, as stated above, appear to be that the disease finds its way where the separation and decay of a branch presents a favorable place for the entrance of water and the spores of fungi, and that it spreads so extensively in the trunk as to entirely ruin large and valuable trees.

In our natural forests there is, of course, neither remedy nor prevention, but in artificial cultivation careful and seasonable pruning would doubtless be the most effectual preventive, since, if properly performed, the wounds left by the removal of branches would soon be grown over and there would be no further danger from this source.

EXPLANATION OF PLATE XII.

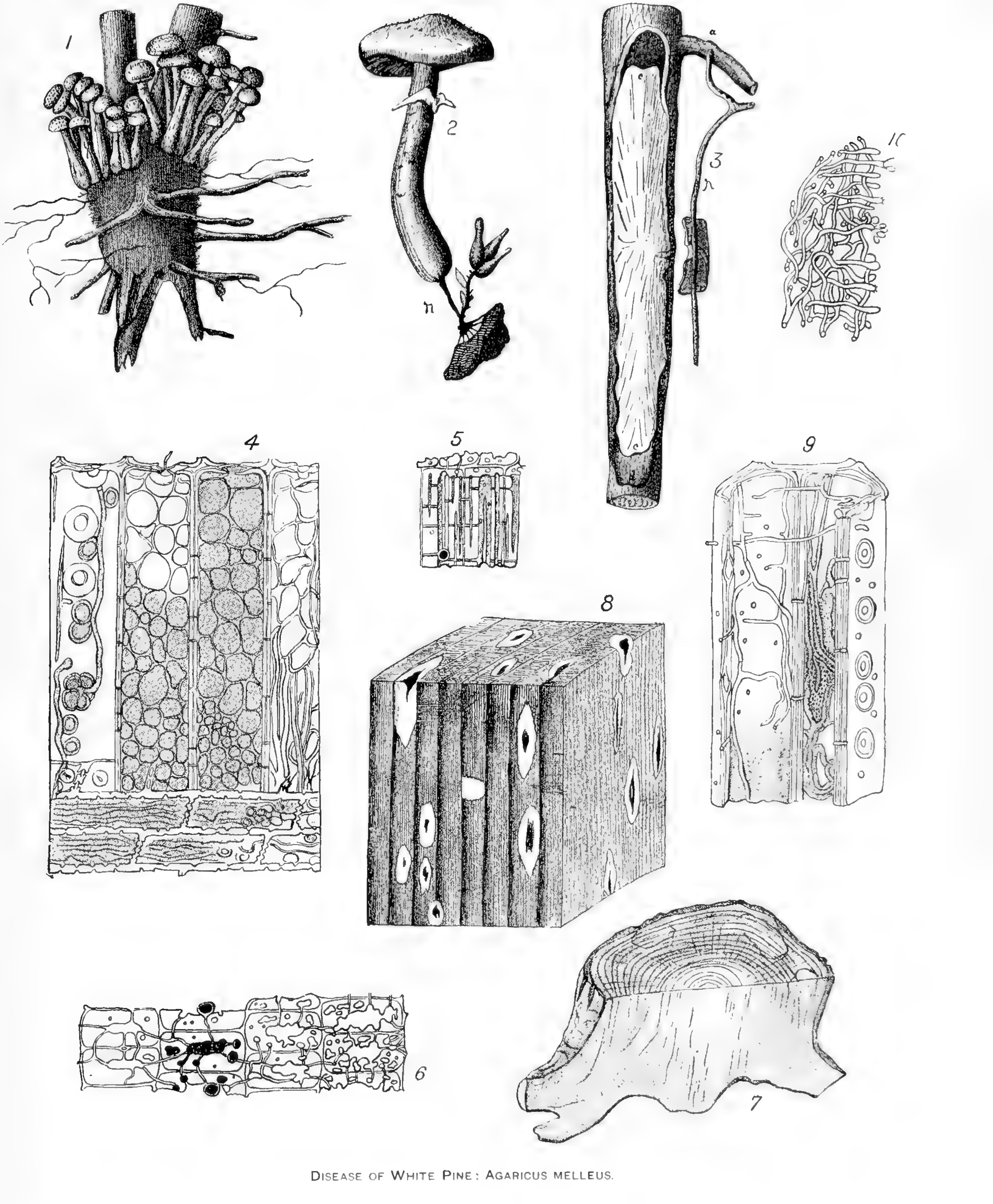
1. *Agaricus melleus,* cluster of young sporophores.
2. *Agaricus melleus,* larger sporophore with root-like organ of attachment.
3. Root of spruce tree invaded by mycelium of *Agaricus melleus;* rhizomorph of same fungus on the right.
4–6. Fragments of pine wood showing the destructive action of *Agaricus melleus.*
7. Stump of White Pine attacked by *Polyporus annosus;* the heart is still sound, but is surrounded by decayed wood and spots filled with masses of resin.
8. Wood of Norway Spruce in early stages of decay occasioned by action of *Polyporus annosus;* the white areas have become delignified, and the wood elements composing them are soft and easily separable.
9. Wood elements of Norway Spruce isolated and showing the mycelium of the *Polyporus annosus.*
10. Fruiting hyphæ and spores of *Polyporus annosus.*

EXPLANATION OF PLATE XIII.

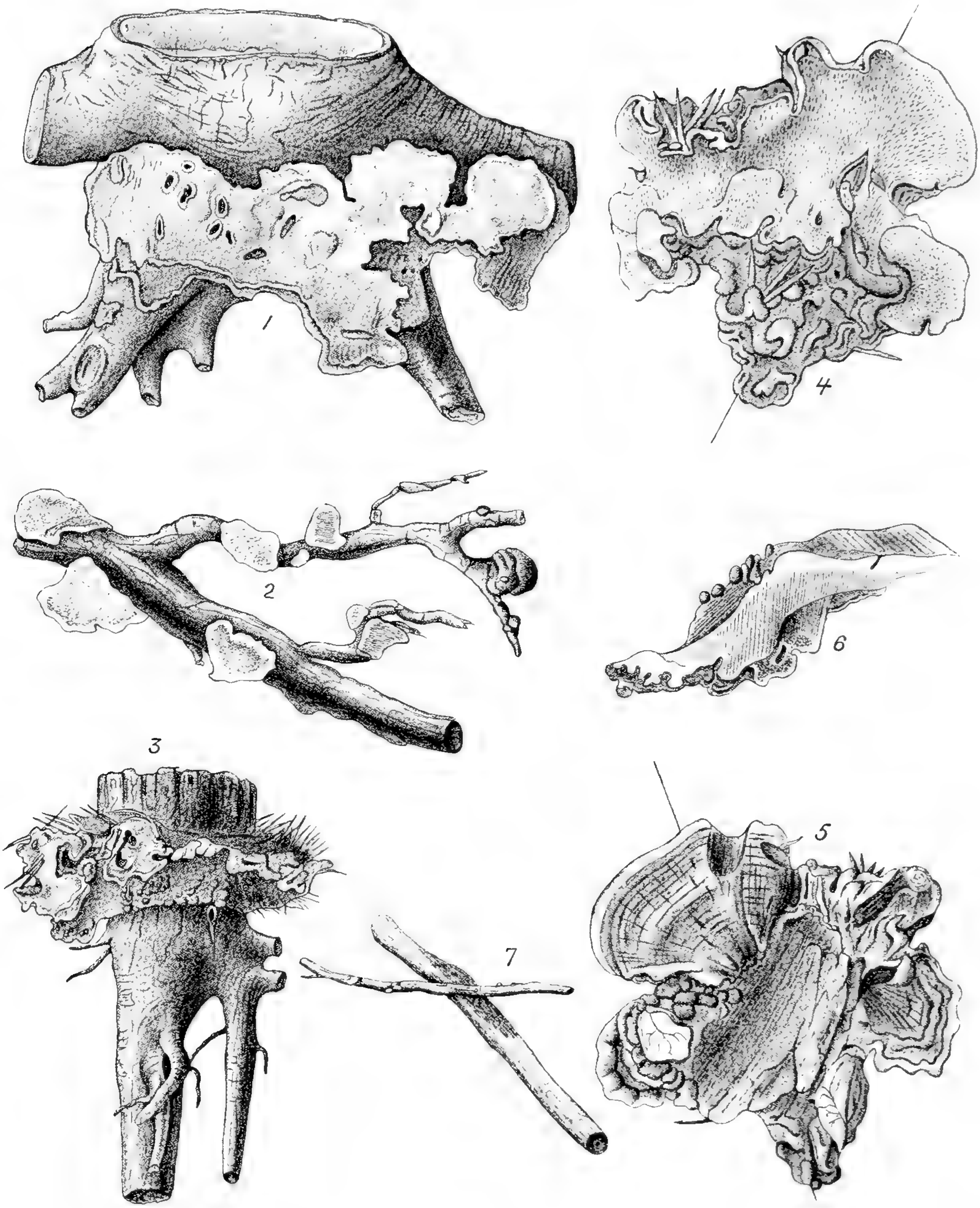
1. Stump of Norway Spruce, with a sporophore of *Polyporus annosus* several years old; the inner portions of the stump wholly decayed.
2. Roots of a diseased spruce tree, with numerous small sporophores of *Polyporus annosus* attached.
3. Stump and part of root system of a young pine tree killed by the action of *Polyporus annosus,* the sporophores of which have grown entirely around the base of the trunk.
4. Mature sporophore of *Polyporus annosus* seen from below, showing the porous spore-bearing surface.
5. Mature sporophore of *Polyporus annosus* from above, showing the velvety upper surface and concentric bands.
6. Mature sporophore of *Polyporus annosus* in section.
7. Mode of infection; where the smaller diseased root crosses the larger one, the mycelium of the *Polyporus annosus* has penetrated the latter and spread in both directions for some distance.

---

[1] Cf. Atkinson, Cornell Univ., Agr. Exp. Sta. Bull. 94, 1895.



DISEASE OF WHITE PINE: AGARICUS MELLEUS.



DISEASE OF WHITE PINE: POLYPORUS ANNOSUS.

INSECT ENEMIES OF THE WHITE PINE

By F. H. CHITTENDEN, *Division of Entomology.*

INTRODUCTION.

Of all coniferous plants, perhaps none are more subject to insect attack than the White Pine. Upward of a hundred species are reported to affect this tree, and a careful compilation of all known species would probably add many more to this list. The more important are found in the order Coleoptera, and of these the cylindrical bark-beetles of the family Scolytidæ hold the highest rank. Most of the Scolytidæ live within the cambium of dead or dying trees, but a few penetrate the solid wood, and several forms, when excessively abundant, do not hesitate to attack healthy growth. Numerous other Coleoptera belonging to the families Cerambycidæ and Buprestidæ similarly infest the White Pine, but are for the most part secondary in the nature of their attack, and will therefore require only passing mention. One species, however, the white-pine weevil (*Pissodes strobi* Peck), is a pest of the most pernicious type. In addition to the bark-boring and wood-boring insects, several species infest the roots, some only the branches or twigs, some the cones, and others injure growing trees by defoliation. The leaf-feeding species comprise the larvæ of several sawflies, the caterpillars of numerous moths, and a number of beetles. Various species of plant-lice and scale insects also occur upon the leaves, and often the limbs and trunks of trees are injured by them.

Most of our injurious forest insects are native to this country, in which respect they differ markedly from those which affect field and garden crops. Only such species as experience has shown to be more or less injurious either to living trees or to cut timber will be considered in this paper. Some few forms that have not been recorded on White Pine are mentioned, as it is more than probable that they are capable of injury to this tree. The majority, however, have been observed on White Pine.

In the preparation of the present paper the writer has drawn freely from the published works of Packard, Fitch, and Hopkins, as well as from personal experience in pine forests, particularly of New York.

THE DESTRUCTIVE PINE BARK-BEETLE.

The last decade witnessed very extensive destruction of pine and spruce forests in portions of the United States east of the Rocky Mountains. The principal injury, which dates from about the year 1888, has been attributed to the so-called destructive pine bark-beetle (*Dendroctonus frontalis* Zimm.), one of a genus of six described species, all of wide distribution and all destructive to the Coniferæ. It is quite possible that some predisposing agency had first caused a weakened condition of the trees in the infested districts, but it is fairly certain that this species of beetle was responsible for much injury. The infested area observed comprised the pine and spruce forests from Maryland in the North to and including North Carolina in the South, an area estimated at upward of 10,000 square miles in extent. In some sections entire forests were killed.

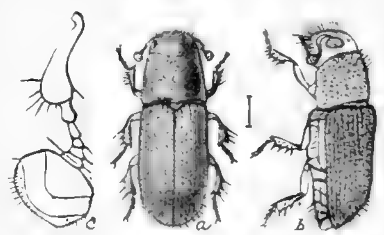


FIG. 5.—*Dendroctonus frontalis*: *a*, dorsal view of beetle; *b*, lateral view—enlarged about six times; *c*, antenna—greatly enlarged (author's illustration).

The accompanying illustration of this species (fig. 5) will enable its recognition. It ranges from reddish to dark brown in color, and measures about one-eighth of an inch in length, being the smallest species of its genus. Its credited distribution includes Lake Superior to Georgia, and it is recorded also from Arizona and California. The adult beetle appears some time in May, the date depending upon season and locality, bores into living trees and its larvæ develop under the green sappy bark. Copious quantities of turpentine exude from the holes made by the beetles and dry in masses upon the bark. The manner of work of the larvæ in great numbers beneath the bark produces about the same effect as that of girdling, thus cutting off the flow of sap, the natural supply of plant food and moisture, greatly weakening and eventually killing the trees. The first outward manifestation of injury is the accumulated masses of pitch, followed by the leaves turning yellow and then red, as though scorched by fire.

A singular feature in connection with the irruption of this species is that it was practically unknown save in the collections of specialists until its sudden appearance in 1888, but still more remarkable is its unaccountable, but almost entire, disappearance in 1893, not, however, before it had done a great amount of damage, which has been estimated at upward of a million dollars. The apparent extermination of this bark-beetle in the district where it was most destructive is believed to have been due to a fungoid disease.

REMEDIES.

After boring insects of this class once gain access to a tree it is practically impossible to eject them, and to save the tree recourse must be had to preventive measures. For this purpose various protective washes are in use. One of these consists of lime, to which has been added a sufficient quantity of Paris green to give it a slight green color and enough glue to cause it to be adhesive. Another wash consists of soft soap reduced to the consistency of a thick paint by the addition of washing soda in water. A thick wash of soap, plaster of Paris, and Paris green is also of value. A carbolated wash, which is in successful use against the peach-tree borer, is prepared by mixing a pint of crude carbolic acid with a gallon of soft soap in eight gallons of soft water. Fish or train oil is valuable as a deterrent, but should not be used except with the greatest caution upon young trees. Whatever wash is employed should be applied to the trees on the first appearance of the beetles in May, and should be renewed if found necessary.

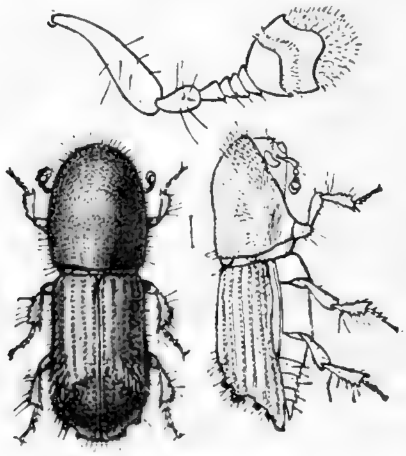


FIG. 6.—*Tomicus cacographus*: beetle, showing dorsal view at left, in profile at right—enlarged about ten times; antenna above, highly magnified (original).

Better than any other measure, however, is the observance of clean cultural methods. Owners of pine forests or groves will do well to cut down all dead and trim all injured trees. For the protection of pines, dead spruces and other coniferous trees, and such as are infested and too much weakened to recuperate, should be cut down and destroyed by burning. A great deal of good can be accomplished merely by removing the bark of dead timber. The progeny of the insects that have deposited their eggs in one season so loosen the bark that it is an easy matter to remove and burn it before the following spring. By pursuing this method millions of the insects will be destroyed before they have an opportunity to issue and lay their eggs for the destruction of other valuable trees. A practice known as "rossing" is in use on borer-infested lumber in Canada. It consists in cutting a strip of bark along the full length of the upper side of a log, which causes the bark to dry up and eventually drop away.

OTHER INJURIOUS BARK-BEETLES.

Of the other species of Dendroctonus, one has recently been reported as ravaging the spruce forests of New Hampshire. It is the species at present known as *D. rufipennis* Kby., and although not known to affect White Pine, it is not impossible that it might attack this tree in case it extends its present depredations. The species of Dendroctonus are peculiarly periodical in their attacks. There is, however, one exception, *D. terebrans* Ol., which is usually common at all times over a very wide area of the United States and Canada, infesting all the pines. According to information received in May, 1898, this or a related species is now ravaging the pine forests of a portion of southern New Jersey.

The genus Tomicus contains perhaps quite as dangerous forms as those which have just been mentioned. The appearance of the beetles is somewhat similar, as is also their method of life. A species that has been associated with the mortality of pines in the region about and south of the District of Columbia is *T. cacographus* Lec., or southern pine bark-beetle, which is illustrated much enlarged at fig. 6. It is reddish in color and may be readily separated from any of the preceding species by the structure of its antennæ and by the toothed apex of the elytra or wing-covers. Its mine is shown as it appears on the under side of the bark of a tree at fig. 7.

Tomicus pini Say, the northern pine bark-beetle, is destructive to pine forests in the North in a very similar manner to the preceding species, which it much resembles in structure as in habit, but is less injurious farther South. *T. calligraphus* Germ., a similar species to the two preceding and about equally destructive, abounds in the pine woods of both the North and South, and *T. cælatus* Zimm. and *T. avulsus* Eich. also infest White Pine.

Among other well-known white-pine bark-beetles may be mentioned *Crypturgus pusillus* Gyll., *Hylurgops glabratus* Zett., and several species of Hylastes and Dryocœtes.

The remedies to be employed against these insects are practically the same as for the destructive pine bark-beetle.

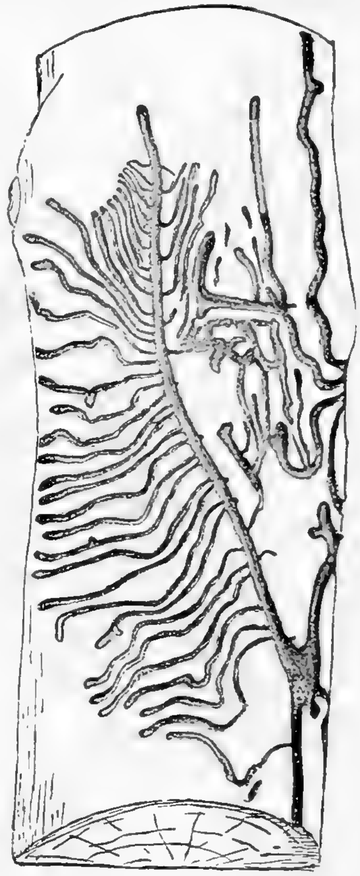


FIG. 7.—Galleries of *Tomicus cacographus* on wood under bark of pine (original).

TIMBER-BEETLES AND OTHER SCOLYTIDÆ.

While the majority of the pine-infesting Scolytidæ breed between the bark and the wood, a considerable number, called timber-beetles, live entirely within the sapwood; others, the twig-beetles in the small twigs and branches, and a third group, represented by *Pityophthorus coniperda* Sz., inhabits the cones.

The chief danger from the bark-beetles, as has been shown, is from their attacks on living trees. They do comparatively little damage to timber, except as they loosen the bark and thus afford ready access to water and mold and to other destructive insects. The timber-beetles, or ambrosia beetles, as they are sometimes called, live almost exclusively in greenwood, preferring that which is slightly injured, of impaired vitality, or such as has been newly felled, but they often attack and kill healthy growth, and in the process of their work in timber cause a staining or "bluing" which entails a still greater loss than results from their direct attack to living trees. The presence of these beetles in a tree is manifested by the little piles of white sawdust which they eject from the "pin-hole" entrance to their galleries. The pine timber-beetles are found in the genera Gnathotrichus, Xyloterus, Xyleborus, and Platypus. *Gnathotrichus materiarius* Fitch is the commonest of three species of the genus, all of which attack pine. This species is shown greatly enlarged at fig. 8, and its characteristic galleries in the wood of pine are well illustrated at fig. 9.

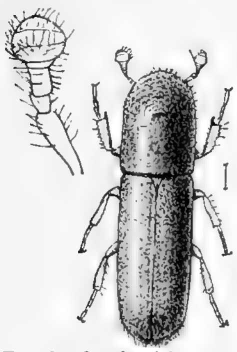


FIG. 8.—*Gnathotrichus materiarius:* beetle, enlarged: antenna, still more enlarged at left (Marx del.).

The same remedies advised against bark-beetles will prove valuable against the timber-beetles. Kerosene emulsion or a carbolated wash would accomplish the destruction of the timber-beetles even after they have attained entrance to a tree, provided the application be made in time.

The twig-beetles are represented by the genera Pityophthorus and Hypothenemus. Of the former genus, *P. sparsus* Lec., *cariniceps* Lec., *pullus* Lec., *lautus* Eich., *plagiatus* Lec., are all well-known pine species. The genus Hypothenemus inhabits alike deciduous and coniferous trees.

Remedies are the same as for bark-beetles. Pruning and burning infested twigs and branches and the clearing away and burning of brush heaps during winter are indicated. For choice ornamental trees in private grounds and in parks plugging the "pin holes" with wire and stimulating the trees with manures and fertilizers to assist them to recuperate from attack are advisable.

PINE SAWYERS AND OTHER BORERS.

Of all the insects that occur in pine timber the Cerambycid, or long-horned beetles, of the genus Monohammus, are the best known, and are credited with being the most destructive. If we except the losses occasioned by the more or less sporadic attacks of certain species of the Scolytidæ already mentioned, probably this opinion is about correct. Five of these species have been described, all pine feeders and beetles of the largest size, with elongate cylindrical bodies and extremely long antennæ, those of the male being two or three times as long as the remainder of the insect. The pine sawyers are most troublesome in the mill yard, and their large white larvæ often do much damage to logs by eating great holes through their solid interior. While burrowing in the wood the larvæ make a peculiar grating sound that may be heard on quiet nights at a considerable distance. This is a familiar sound in the lumber camps of the North, and has probably

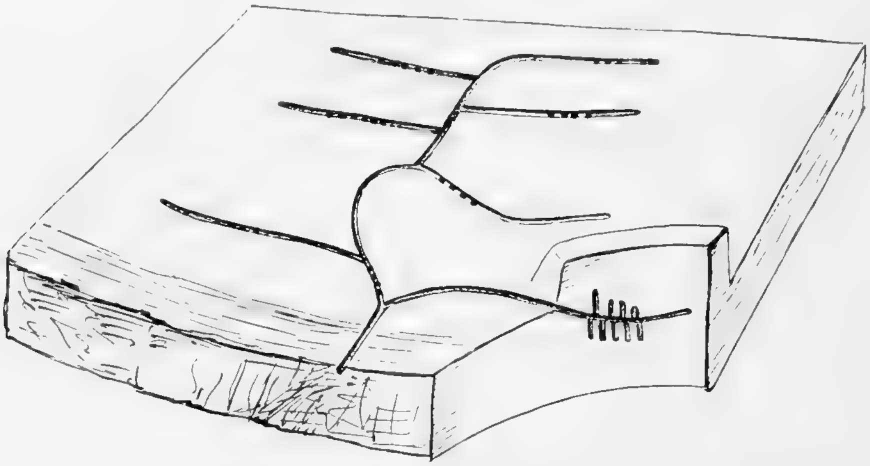


FIG. 9.—Gallery of *Gnathotrichus materiarius* in pine (adapted from a drawing by A. D. Hopkins).

given rise to the name of pine sawyers, by which these insects are known. *Monohammus confusor* Kby. is a large gray species destructive in the lumbering districts of the Northern United States and Canada; *M. titillator* Fab., a mottled brown beetle, replaces the above species in the South, and *M. maculosus* Hald. occurs in the West; *M. scutellatus* Say. is widely distributed and abundant from the Atlantic to the Pacific, and *M. marmorator* Kby. is a rather rare northern form.

Among other borers belonging to the same family as the sawyers, the majority of which infest White Pine, may be mentioned *Criocephalus agrestis* Kby., *C. obsoletus* Rand., *Asemum mæstum* Hald., *Orthosoma brunneum* Forst., *Prionus pocularis* Dalm., *Hylotrupes bajulus* Linn., *Callidium antennatum* Newm., *Rhagium lineatum* Ol., *Graphisurus pusillus* Kby., *Acanthocinus obsoletus* Ol., *A. nodosus* Fab., and *Neoclytus muricatulus* Kby.

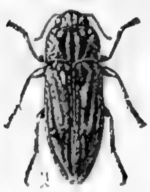


FIG. 10.—*Chalcophora virginiensis*—natural size (Marx del).

In the Coleopterous family Buprestidæ are many borers which infest pine. These include five species of Chalcophora, one of which, *C. virginiensis* Dru., is figured (fig. 10); *Dicerca punctulata* Sch., *D. tenebrosa* Kby., *Buprestis striata* Fab., *Melanophila fulvoguttata* Harr., *M. longipes* Say., *Chrysobothris dentipes* Germ., *C. floricola* Gory, and *C. scabripennis* Lap. and Gory. These beetles are graceful in form, hard of texture, and many are brilliantly metallic. Their larvæ are slender, white grubs with very large, round flat heads. Some of this family attack living trees and do injury to the sapwood and to felled timber in the same manner as the sawyers, but the majority of them prefer devitalized material, and their attacks are usually secondary to some more injurious species.

THE WHITE-PINE WEEVIL.

In the White Pine forests of the Northern States, particularly in those of a second growth, one's attention is often drawn to the great number of deformed trees. They sometimes occur singly, but more often in groups. The insect that is responsible for this damage is the white-pine weevil (*Pissodes strobi* Peck). This beetle is a member of the family Curculionidæ, and is about a fourth of an inch in length, of oval form, red and brown in color, with its elytra marked with white spots, as shown in the accompanying illustration (fig. 11). It is provided with a rather long rostrum or snout to which are attached its elbowed antennæ. The larva, which is white and footless, is illustrated at *a*, and the pupa, also white, is figured at *b*.

This weevil is one of the first spring visitants in the North, occurring as early as March about Washington City and in April or May farther north. Its eggs are deposited on the terminal shoots of pine, particularly of young trees, but sometimes also in the bark of old trees. The larva, when hatched, bores into the pith or mines the sapwood. Toward the end of summer it attains full growth, when it goes into hibernation until the next spring, transforming to pupa and soon afterward to the mature or beetle form. The presence of this insect in a tree is first manifested by the wilting of the leading shoots, which becomes most evident toward the close of summer. The identity of the species at work may be established at once from its peculiar cells beneath the bark. (See fig. 12.) These cells, which are destined for its winter nest and for further transformation, are sunk into the pith and covered over with long fibers of chipped wood. When a terminal shoot of a small tree becomes filled in the summer with these larvæ, to the number sometimes of a score or more, the shoot, with its lateral branches, as well as the stock below, wilt and gradually die, the bark becomes loosened, pitch oozes out, and by autumn the shoot turns black, and the bark is covered with masses of pitch. A tree thus damaged will fail sometimes for several successive seasons to send out a new terminal shoot, with the result that the lateral shoots continue to grow, and the tree becomes more or less distorted.

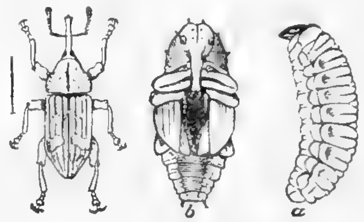


FIG. 11.—*Pissodes strobi:* beetle at left; *a*, larva; *b*, pupa—enlarged about three times (from Packard).

Owners and overseers of pine groves will do well to make a practice of examining the young trees each year, say in August, and when one with a wilting terminal shoot is found to cut or break it off and commit it to the flames. With every blighted twig thus treated from a dozen to fifty or more weevils will be destroyed, and thus the numbers of the insects for the coming year will be greatly lessened. All dead growth or such trees as have from any cause been injured beyond recovery and which might serve as centers of infestation by harboring this weevil or other injurious species should be similarly treated. What is most needed is a preventive, and for this purpose a good thick fish-oil soap mixed with Paris green and carbolic acid, in the proportion of about a pound of the former and a quart of the latter to 100 gallons of the wash, is recommended. It should be sprayed in April and May on the terminal shoots of the trees and repeated at the end of a month if necessary.

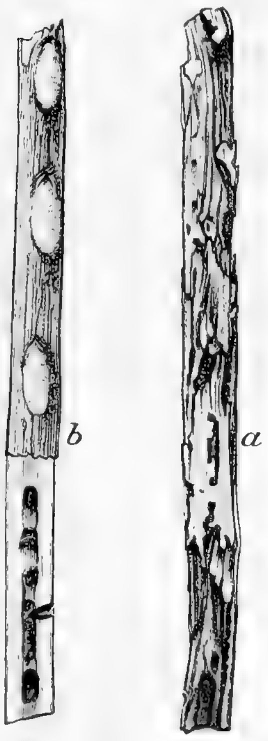


FIG. 12.—*Pissodes strobi: a*, larval mines under bark; *b*, pupal cells—natural size (from Riley).

MOTH CATERPILLARS AND PLANT-LICE ON TRUNKS AND LIMBS.

The trunks and limbs of pine are also subject to the attack of several insects besides those in the order Coleoptera that have been mentioned. Of these are three tortricid moths of the genus Retinia, which affect the pitch and other pines. Two other moths of similar habits to the above occur on White Pine, wounding the trunk below the insertion of the branches and causing the resinous sap to exude. These are the pitch-drop worm (*Pinipestis zimmermanni* Grote) and *Harmonia pini* Kell.

The same remedies advised for other boring species, and particularly those specified to be used against the white-pine weevil, are indicated for the present class of insects.

Several species of plant-lice affect the White Pine. The white-pine aphis (*Lachnus strobi* Fitch) is very abundant in the Northern States, living in colonies on the branches of trees and puncturing and extracting their juices. The so-called "pine blight," *Chermes pinicorticis* Fitch, is sometimes very destructive, its presence being manifested by large patches of a white, flocculent secretion, beneath which covering are concealed myriads of minute lice. *Schizoneura pinicola* Thos., feeds on the tender shoots of young White Pine.

Kerosene emulsion applied as a spray is the appropriate remedy for these plant-lice.

LEAF-FEEDING INSECTS.

The most destructive insects of the foliage of pine are several species of sawflies of the genera Lophyrus and Lyda, one of which is represented in its several stages at fig. 13. It is called

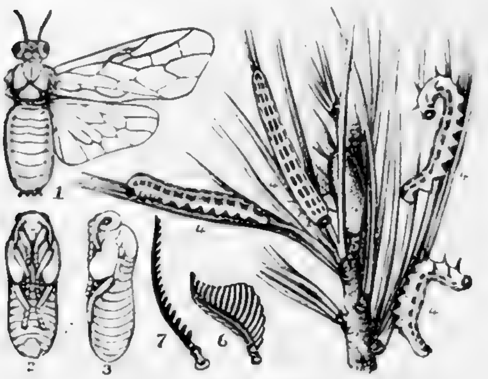


FIG. 13.—*Lophyrus abbotii*: 1 female, enlarged; 2, 3, pupa, enlarged; 4, 4, larvæ, natural size; 5, cocoon, natural size; 6, male antenna, 7, female antenna, enlarged (from Riley).

FIG. 14.—Tubes of pine leaves made by pine tube-builder—natural size (from Packard).

Abbot's white-pine sawfly (*Lophyrus abbotii* Leach.), and is perhaps the most injurious foliage feeder which infests the pine woods of the North.

The caterpillar of a single species of butterfly, *Thecla niphon* Hbn., is known to feed upon the foliage of White Pine, but among the larvæ of moths of different families are innumerable pine-

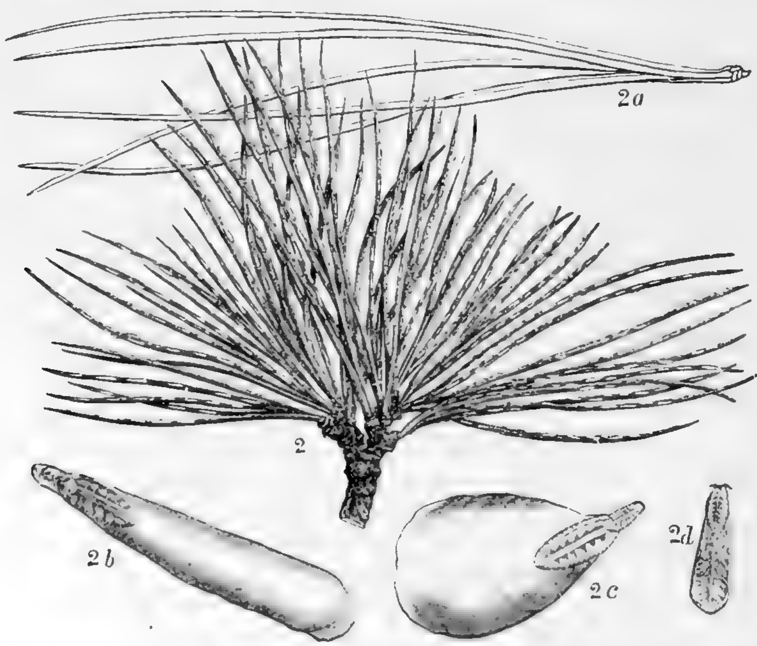


FIG. 15.—*Chionaspis pinifoliæ*: 2, scales on White Pine, leaves stunted; 2*a*, same leaves not stunted by insects; 2*b*, 2*c*, female scale; 2*d*, male scale—2 and 2*a* natural size, 2*b* and 2*c* much enlarged (from Comstock Ann., Rept. Dept. Agr., 1880).

feeding species. Prominent among them is the magnificent sulphur-yellow imperial moth (*Eacles imperialis* Dru.), whose larva attacks the leaves of various forest trees. Of other moths whose caterpillars devour the foliage of White Pine may be mentioned: Harris's pine hawk moth (*Ellema harrisii* Clem.), *E. coniferarum* S. and A., *E. pineum* Lint., *Tolype laricis* Fitch, the white-pine tufted caterpillar (*Platycerura furcilla* Pack.), the redhead inchworm (*Semiothisa bisignata* Walk.), the sulphur leaf-roller moth (*Dichelia sulphureana* Clem.), *Teras ferrugana* S. V., and *Amorbia humerosana* Clem. An interesting species is the pine tube-builder (*Lophoderus politana* Haw.), which, in its larval stage, lives within a tube formed by webbing together a number of pine needles as shown in fig. 14.

A number of species of adult Coleoptera, whose larval habits are imperfectly understood, subsist upon the leaves of White Pine. Of these are the Scarabæid, *Dichelonycha albicollis* Burm., and the Chrysomelid, *Glyptoscelis pubescens* Fab.

The best remedy for the sawfly larvæ, caterpillars, and beetles is a spray of Paris green, applied upon the first appearance of these insects on the trees.

The consideration of the insect enemies of the White Pine may conclude with the mention of the pine-leaf scale insect (*Chionaspis pinifoliæ* Fitch), which forms its scales upon the leaves, exhausting them of their juices and causing them to turn yellow. This species is illustrated at fig. 15.

A strong spray of kerosene emulsion will be found an efficient remedy against these scale insects.

FOREST MANAGEMENT.

As regards forest management, we have, unfortunately, in this country no experiences which would permit us to form very positive opinions based on actual observation regarding this species or any other. The study of the natural history of the species in its native occurrence permits us, nevertheless, to draw conclusions which may at least serve as a basis for its future sylvicultural treatment.

In the first place, it may be declared that the White Pine is the most important and promising species upon which to expend attention in our coming forestry operations within the limits of its natural occurrence. Its adaptation to a variety of soils and situations within these limits, its rapid growth, its excellent form, its remarkable mass development per acre, its shade endurance, its all-round useful wood product, and its propagation, both by natural and artificial reproduction, give it a position among our timber trees hardly approached by any other.

There are certain general principles which are the result of experience in forest management in Europe and elsewhere, applying to this as to most species. The first is, that mixed growth is in every respect superior to pure growth; it will therefore be proper policy to grow White Pine preferably, if not altogether, in mixture with other species. This advice is given in spite of the fact that the White Pine grows rather well in pure stand, and that, owing to its shady crown during a long period of its life and the density of stand in which it can develop, and the large quantity of foliage which it sheds, the soil conditions are not in danger of deteriorating, as would be the case with more light-needing species. But, as has been observed in its natural occurrence, its development is more favorable in companionship, and especially is this the case with regard to the cleaning of the bole of its branches, which are peculiarly persistent. Whether it would pay to substitute an artificial cleaning by pruning the young growths is still doubtful; meanwhile the self-pruning performed by mixture with shady companions will have to be encouraged, especially as thereby other valuable advantages are secured which attach to the mixed forest in general.

Unfortunately, our irrational exploitation has reduced the White Pine in the natural forest areas often to such an extent that its reestablishment is possible only by artificial means. Wherever the culling has not been too severe, and either young growth has developed or seedling trees have been left, the natural reproduction should be encouraged by favoring the young growth and by removing or thinning out other species which interfere with the starting of a young growth. Fortunately, the White Pine, owing to its shade endurance, is specially fitted for natural reproduction from the seed of mother trees, more so than most other pines, and the rapidity of its growth, in which it excels most other shade-enduring species, is also favorable in this respect.

We are not yet prepared to determine the most profitable rotation in which the species is to be managed under varying conditions. The fact that it is not only a very rapid but one of the most persistent growers, trees making wood at the rate of $1\frac{1}{2}$ to 2 cubic feet per year up to the one hundred and fortieth year, permits a wide range of choice for rotations, and since its wood, being rapidly changed into heartwood, becomes serviceable very early, the rotations may be either low or high, varying from fifty to one hundred and fifty years, according to local economic and soil conditions.

NATURAL REPRODUCTION.

The White Pine reproduces itself readily in the virgin forest on all sandy and loamy sand soils where the hardwoods do not interfere. On these areas thickets of young growth, sapling timber, and dense groves of mature trees are scattered without regularity, and there is no indication that this pine forest has undergone material change for centuries. In the hardwood districts of the heavier soils of the Lake region, where the pine is met with chiefly as old, overripe timber, the reproduction of the pine seems, temporarily at least, to be interfered with by the associated growth. Large, old trees occur, thinly scattered or in clusters, but sapling timber and young growth is often entirely wanting over considerable areas. Similar conditions prevail, or have prevailed, in the mountains of Pennsylvania, and also in New England and in the Adirondacks. Where the pine is cut and some seed trees are left the ground soon covers itself with young growth. This, contrary to the common notion, is true even where fire has run over the slashings and the ground for a time is stocked with Poplar and other brush. Such groves or thickets of young pine occur in all parts of the pinery of the Lake region, and in the aggregate cover several hundred thousand acres. Generally, however, the fire returns from time to time, the young seedlings, as well as the mother trees, are finally all destroyed, and thus the reproduction is completely prevented. On such lands, impoverished by fire and exposure to sun and wind, not even the Poplar returns. In the hardwood, Spruce, and Hemlock regions the cutting of the pine in the usual manner simply assists its competitors, and its reproduction is seriously hampered and frequently prevented altogether. Where these clay and loam lands are completely cleared and then abandoned, as has been the case with thousands of acres of New England forests, the White Pine is one of the first to return if any seed trees exist in the vicinity. Hundreds of groves have sprung up in New England in this way.

NOTES ON NATURAL REPRODUCTION.

A case of the kind above referred to was observed in 1886 in York County, Me., and the following notes on the subject will, no doubt, prove of interest:

In company with Mr. John E. Hobbs, who is thoroughly familiar with the history of the various pieces of forest examined, a visit was made to a number of places on which White Pine was growing, others on which young pine seedlings were coming in, and still others in the immediate vicinity where none were to be seen, although the general conditions of soil and situation were practically identical. The soil, much of it, was light and sandy, with a growth of *Comptonia, Pteris, Gaultheria,* and other plants common on pine land.

A large number of trees had a crop of cones, the last year before this visit in which there was a good crop having been 1879, according to Mr. Hobbs. Going first to an open field that was formerly covered with pine trees, it was found to be very thickly covered with young seedlings, from a few inches to 2 feet or more in height, that had sprung up in such abundance that a bare spot was hardly to be seen over the whole tract. This piece was cut over in the winter of 1879-80, the ground was not burned over, and there being a good crop of seeds, these had grown promptly and a young forest was rapidly coming on to take the place of the one removed.

On going to other pieces in the vicinity, from which the pine had been cut at different times since 1879, a most striking contrast was observed. On these pieces that seemed otherwise just like the first, and with the conditions just as favorable for a second growth, only a very few pine seedlings were to be seen. These few may have come from seeds carried by wind from the neighboring forests, but evidently the ground had not been seeded as the first piece had, and it was impossible not to draw the conclusion that the difference was due simply to the fact that the first piece was fully seeded, while the others were not. Repeated observations of similar pieces of land led further to the conclusion that no dependence can be placed upon the springing up of seeds that have lain dormant in the ground for a term of years; or, in other words, although the seeds of the White Pine retain their vitality for a long time if kept in a dry place, there is a lack of evidence to show that this is the case in the natural forest, where they are alternately dry and wet.

Other interesting conditions of growth were noticed in the same region. In the vicinity of standing pine forests, particularly on their leeward side, seedlings of different ages were coming up, often very thickly, but upon entering the forest, after the first 2 or 3 rods, no more of these were to be seen, their growth having evidently been prevented by the dense shade of the standing trees. In hardwoods, on the other hand, where the surroundings were a little more favorable, some young pines were growing here and there.

All observations reenforced the truth that there is no mysterious succession of forest growth, involving necessary alternations, and that the White Pine does actually grow and flourish for an indefinite number of generations on the same land, if only the necessary seeding has been insured.

In such regions as have just been described reforesting with the White Pine is a comparatively simple matter. Where nothing more is done than to take advantage of natural conditions by felling the trees in seed years, or by leaving seed trees here and there, an abundant crop of young pines may often be secured. As a matter of fact, large tracts in Maine and Massachusetts are coming up in this way to second-growth pine, and as the profit arising from the protection of these young forests is better understood, there is no reason to doubt that the whole matter will in a great measure regulate itself.

In the Adirondack region and in the pine belt of Michigan, Wisconsin, and Minnesota the case is far different. Under the present system forest fires are an almost necessary result of all lumbering operations. To start with, all trees that are large enough are cut, and if by chance here and there one has escaped that might produce a crop of seeds, it perishes in the fires that soon sweep over the ground, leaving hardly a living thing behind them, and burning the seeds that under other conditions might have sprung up to form a second growth of pine. On all such burned tracts pine seedlings are rarely found in any number, and yet here and there they are seen growing where the fire had left a seed tree by the side of a stream or a piece of unburned ground, thus giving the seed a chance to grow.

After making a careful study of the pine lands of Michigan for several years the conclusion seems plain that here, exactly as in New England, everything practically depends upon reseeding. Here in the Northwest the seed trees have been destroyed, the seeds in the ground have been burned, and, as an inevitable consequence, the land remains a wilderness and must remain so until some means are found of restoring the forests by artificial sowing or planting. There is nothing in the soil itself that prevents reforesting the pine lands of Michigan at once. It is because seeds are, to a great extent, wanting, and the seedlings that do start are not protected, that these pine lands are left in their desolate and unproductive condition.[1]

The experience with White Pine in Europe fully confirms the correctness of the observations above recited. White Pine abroad reproduces well, seeds abundantly, and is so particularly well suited to natural reproduction that the most experienced and competent recent writers claim that this tree fairly "demands" this form of regeneration.

ARTIFICIAL REPRODUCTION.

Concerning the artificial reproduction by seeding or planting, the experience, both in this country and Europe, is quite extensive. Not only has this species been planted frequently and for a long time in New England and in other parts of its natural range, even for forest purposes, but thrifty groves have been established also in the Western prairies beyond the limits of natural distribution. In Germany larger or smaller plantations were made in many localities near the beginning of the century.

The planting in this country has, however, not usually proceeded with a knowledge of proper forestry practice. As a rule, plants have been set out too old, and hence the planting has proved expensive; usually, also, it has been too wide spaced to secure the most desirable result in form development. Another point also usually neglected is the admixture of other species to stimulate the growth of the pines and possibly to reduce the expense of covering the ground.

In Europe the majority of pine plantations made with Scotch Pine (*Pinus silvestris*) is made with one-year-old seedlings, which is done very cheaply and expeditiously, often on unprepared ground, when one man may set 1,000 to 1,500 plants in a day.

For White Pine, especially under our conditions, where the young plants have much to contend with in the way of climatic ills, weed growth, etc., this method is probably not applicable.

Two-year and even three-year old plants, grown in seed beds and once transplanted in nursery rows, to produce a stocky root system and growth, will probably be more successful, being better prepared to overcome adversities.

The seedlings, grown from seed sown either broadcast or in drills in the seed beds, must be shaded during the first two years, as is usual with conifers in this country. After the second year they will endure the hottest sun. The shade must be graduated according to the weather, as the seedlings are liable to damp off the first season if too much shaded and to burn off if not shaded enough.

As there are about 1,800 seeds to the ounce, it will take about 5 to 6 ounces to the 100 feet of drill, unless the seed be specially poor, when greater allowance will have to be made in proportion

[1] We are likely to repeat in the Northwest, on an extensive scale, the history of several of the Eastern States. Under inducements held out to encourage immigration, many settlers have been led to take up land all through the worst part of Michigan and Wisconsin, including the "barrens." They clear the land, seed it, if they can, with clover, and put in other crops, work in the adjacent pine woods for a living, and "develop the country," thus doing for the State exactly what needs to be done and what the State has neglected to do for itself; but it is a disastrous experiment for the settlers. The many farms kept up in this way for a while may finally be abandoned, but the whole region will then be in a great measure secured against extensive fires, and the lands that have been plowed and worked over will be in a better condition for reforesting.

to the percentage of germination. In ordinary collecting the percentage of germinating seeds may not exceed 75 per cent, and, as is indicated in the discussion on seed supply (page 23), it may fall far below this figure in some years. Even if 20,000 to 25,000 seeds should germinate per pound, it would not be safe to count on more than 5,000 to 8,000 seedlings that will grow to use, and in the transplanting to nursery rows an allowance of at least 5 to 10 per cent should be made for losses, so that to secure 10,000 transplants at least 1½ pounds of seed is needed, to secure which it may take from 3 to 4 bushels of cones.

Close planting is indicated on account of the difficulty with which this pine cleans itself of its branches. It should be planted not more than 4 feet apart or, preferably, set out in mixture with a shady, slower growing companion, the Black Spruce (*Picea nigra*) being an ideal choice within its habitat, and of broad-leafed trees the Sugar Maple (*Acer saccharinum*), which, for the sake of economy, may be sown between the wider spaced (8 feet or more) plants of White Pine. The mixture should not stop here, but other kinds chosen with circumspection from the many that are found associated with the White Pine in its natural habitat should be added, as Chestnut, Yellow, and Red Birch, Basswood, Hickories, and Oaks, and of conifers, the Red Pine, Hemlock, and occasionally in some localities Arborvitæ.

Dr. Fernow has for some time (since 1887) advocated a method of forest planting in which the main or "final harvest crop" is distinguished from the mere "nurse crop" or "filler," when only 500 or 600 trees per acre, or even less, of the better kinds are set out with care as the main crop, receiving due attention in their further development, and the nurse crop is introduced of the cheapest kinds and in the cheapest manner to act as soil cover to check weed growth and stimulate height growth, straight form, and cleaning of the main crop. The White Pine would, of course, be a most excellent main crop.

By the fiftieth year or so the pines, if set out at the rate of 500, will have overtopped the nurse crop, except where trees of the latter have taken the place of a failing pine, and their crowns will have closed up, their boles straight and clean, furnishing clear lumber, if the nurse crop was properly chosen and has done its duty. The further management then would concern itself mostly with gradual thinning out of the main crop to secure the diameter accretion due to increased crown development and light. By the one hundredth year it will be reasonable to expect at least half the trees set out to have reached their highest value in maturity and size, with 15,000 to 20,000 cubic feet to the acre, for the White Pine is not only a rapid grower, but a large producer, its shade endurance permitting as large a number of trees to develop satisfactorily per acre as the Spruce, which it outgrows in height and diameter.

While planting nursery-grown seedlings as a rule furnishes better results, sowing the seeds into permanent sites may, under certain conditions, especially on soils not too prone to weed growth and in the more humid climate of the Northeastern States, prove satisfactory and cheaper.

Various methods can be employed according to circumstances. On light soils sowing broadcast on snow may furnish satisfactory results; on heavier soils preparation of the ground to receive the seed will prove indispensable. This may be done by plowing furrows or by hoeing plats of 2 or 3 feet square (the larger size where overgrowing by brushwood is to be feared) and sowing into these in drills or broadcast. Dr. Fernow devised such a method for reclothing cut-over lands on slopes in Pennsylvania grown up with brush, where it would be too expensive to prepare the entire ground. Here the plats were made larger, 4 or even 6 feet square, and into these not only pines were either planted or sown but also a nurse crop surrounding the pines, expectation being that this nurse crop will protect the pines against the encroachment of the surrounding brush growth until the pines are tall enough to fight their own battle and finally kill out the brush. A fuller description of these plantings is to be found in Bulletin 17, "Check list of the forest trees of the United States," etc., of the Division of Forestry.

PLANTING NOTES.

The following notes on planted groves, their condition, growth, and results are given a place here as recording individual experiences in various parts of the country, without intending to recommend the practices of the planters, which, from the forester's point of view, are faulty in some directions, especially in the open stand, which is advocated:

In Eastern Massachusetts, particularly in Plymouth and Bristol counties, there are numerous small bodies of White Pine that were set out from forty to fifty years ago, and whose rapid growth and healthy conditions show that there the work of planting at least has been successful. The trees composing them averaged at thirty to thirty-five years from the time of planting, not far from 45 feet in height, and measured approximately 2 feet 6 inches in circumference, breast high. These measurements vary for different bodies of pine, but are believed to represent very closely the average size at the age indicated, and in many cases the trees, are considerably larger (see measurements of growth on page 88). This growth of pine is of such value that according to competent judges of property in that region, much of the land that without the pine would be worth only $3 to $10 per acre, is worth with the standing pine $50 to $75 or more per acre according to location.

Upon visiting these different groves and conversing with men who had planted some of them, it was found that opinions and practice were quite variable, both as to time and manner of planting. Mr. S. E. Hall, of Raynham, who has had long experience, states that he has set the White Pine successfully every month in the year. The young trees, 4 to 6 inches, or even a foot high, are taken up with a piece of sod on their roots and set out in a wet time. These two conditions were particularly emphasized by Mr. Hall, who says that if they are observed the trees "will grow anywhere." He plants 10 feet apart each way and recommends this as the best distance, which is, however, not good forestry practice. In a grove set by him forty years ago the trees were set in rows at the above distance and had made a vigorous and healthy growth. In another grove, planted about the same time, the trees stood 8 feet apart each way and were apparently doing quite as well as in the first one. On the other hand, Mr. Spencer Leonard, of Bridgewater, after many years of practical trial and observation, states that having formerly set out pine trees 10 feet apart, he is now setting them at a distance of 15 feet, with a view to reduce the expense of planting and because they soon became crowded if planted closer. He, too, sets out the trees with a sod, simply plowing a furrow and setting the seedlings at the right distance. Mr. Hall digs a hole for each tree, but says that the work can be done very rapidly, and that he has himself set an acre a day.

One of the many plantations in southeastern Massachusetts known as "Leb. Pratt's grove," is within less than a mile of the village of North Middleboro. It was set out forty-two years ago. The trees were set in rows 10 feet apart each way. The grove twelve years ago even was practically impenetrable by reason of the dead interlocking branches that had never been removed.

Four trees of average size were measured in 1886 and showed diameters of 7 to 9 inches. Some were of larger and others of smaller size, though the growth was fairly even. The average height was estimated at 40 feet; the branches were dead three-quarters of the way to the top, the remaining one-fourth, say 10 feet, constituting the crown, was green and healthy. The soil was poor, that passed over from the road in reaching the grove being light sand with some gravel.

Another grove, some 3 miles northward of North Middleboro, was visited in 1886, and a greater number of measurements made. According to Mr. S. Hayward, near whose farm it stands, this grove was set out rather more than thirty, not more than thirty-five, years ago, but had not made quite as good a growth as some others have. The trees are in rows, 7½ to 8 feet apart each way, and are quite uniform in size. Beginning with the third from the north side, a fair average row, the following measurements were made of the trees taken in order as they stood. The circumference, breast high, was:

	Ft.	Ins.		Ft.	Ins.
No. 1	2	10	No. 7	2	6
No. 2	2	6½	No. 8	2	11
No. 3	2	9	No. 9	2	10
No. 4	2	4½	No. 10 *a*	{1 {0	5 10
No. 5	2	6			
No. 6	2	1	No. 11	2	0

a Two main stems and had lost a third.

The largest tree measured in the grove was 3 feet 1 inch in circumference or 1 foot in diameter, breast high. A very few have been choked out and have died after living fifteen or twenty years. An average tree on the south side measured 45 feet in height. All the trees of the grove that were still living seemed healthy and vigorous. The lower branches had died at an earlier age than in the preceding grove and the trunks were free from them for some 8 feet or more. Above this line the dead branches still remained on the trees, only those of the crowns being green and living.

Near Bridgewater, Mass., a piece of land had been sown with pine seeds some thirty-five years before, the seeds being sown broadcast and dragged in. The trees were slender and too much crowded, the smallest ones dying out. They seemed much in need of proper thinning. Some of the best specimens measured 2 feet 7 inches in circumference, breast high, but they were very uneven in size, and did not impress one nearly as favorably as those in the groves that had been regularly planted at a distance of 8 or 10 feet apart.

This second growth pine finds a ready market at the box factories of Bridgewater, Halifax, Taunton, and various other towns in this part of the State. Six dollars per cord is the price paid at present (1886; now $8 to $9) for logs delivered at the factory. Logs are accepted down to 8 inches in diameter, and in establishments where staves are made a smaller size is taken. There is no trouble in obtaining all that is wanted, there being an abundant supply of pine for box boards, staves, and the like in the immediate vicinity of the towns where they are manufactured.

A few notes on plantations made on the Western border and outside of the natural range of the White Pine will show the adaptability of the species in those regions:

There is an instructive plat of White Pines in the forest plantation of the State University of Illinois. This institution is located at Champaign, about 200 miles south of Chicago and much beyond the natural range of the pine. The history of the plat, as given in Bulletin No. 26 of the University Agricultural Experiment Station, is as follows:

White Pine seedlings were collected in the spring of 1869, put in close nursery rows and shaded with lath frames. About 8 per cent died the first year. Of a few hundred trees, purposely left without shading, 32 per cent died. After having grown in the nursery three years, they were deemed in good condition for transplanting. They were at this time 12 to 15 inches high, well-formed, healthy trees.

The land, 1 acre, where the White Pines are planted, is quite flat, what slope there is being to the south; and at least one-half of it is too wet in spring, and often in the early part of summer, for the best results in tillage. The soil is black, part of it mucky, 1 to 2 feet in depth, and underlaid, for the most part, with a rather stiff, blue clay. The trees were planted May 4, 1872, 4 feet apart each way. The White Pine is a comparatively hard tree to transplant successfully (?). The roots are soft, long and naked, with very few small or fibrous roots near the tree. Knowing the necessity of careful handling, no effort was spared, from digging in the nursery to setting in permanent place, to secure successful results.

Throughout the season the ground was kept in a good state of tillage by frequent cultivation, but it was exceedingly dry; and of nearly three thousand trees planted, two-thirds died during the summer. Of Norway Spruce, planted the same day, in the same manner, and on very similar soil, not more than 2 per cent died. It is difficult to explain this greater per cent of loss in the pines, except as we take into account the comparative method of development of the roots of the two species [and its high transpiration factor.—B. E. F.].

In the spring of 1873 the vacant spaces were filled from the nursery, and again in 1874 trees were set where needed. The result of the three plantings was an almost perfect stand of trees. The cultivation with horse and hoe was kept up thoroughly for three years. During the fourth, fifth, and sixth years the weeds were mowed. But little cultivating was done, because the ground was too wet in the early part of the season.

For a number of years after the White Pines were fairly started they made admirable growth, and promised to furnish very valuable timber for the prairie soil here, as well as for their native regions. In a report made in 1886 the following statement is made: "From the first the living trees have done exceedingly well. Very few trees have died from any cause since they began their growth in their present position. They are now remarkably healthy and vigorous, and the plantation vies with that of the European Larch in beauty and prospective value." At present they are not maintaining the early promise.

No thinning or pruning of any kind was done, except what nature does, until the winter of 1889–90. During that winter and the next the dead branches, to an average height of about 10 feet, were trimmed off, and the dead trees (some more than three hundred and fifty) were cut out. During the winter of 1891–92 sixty-eight more dead trees were cut out, and there are at present fifty-two still standing that have died since the last were cut. The trees cut out the first time had not all died recently. Some of them gave evidence of having been dead for a number of years, while others had died so lately that they still carried dead leaves. Most of the trees that have died were the smaller ones, such as were overgrown or badly crowded. A few only of the larger trees have died. Of the trees still alive, very few have any live branches lower than 20 feet. Many of them have an unthrifty look, either in the top or on the trunk, and the prospect is that there will be a very considerable number of trees to cut out year by year for some time.

The principal reason for so many trees dying is probably overcrowding [more likely owing to the stiff subsoil.—B. E. F.]. As the trees now stand they occupy a space of less than 7 feet square each. The trees have been damaged in other ways than crowding, but not, so far as can be judged, until after they had already begun to die. There is continually a thick mat of leaves on the ground, and these have been partially burned off twice, both times injuring the trees more or less from the ground up 2 or 3 feet, but apparently not any higher. Boys seem to delight to cut their names or designs in the smooth bark of the trees. Occasionally a tree is entirely girdled. The girdling soon kills the trees, but most of the smaller damage to bark soon grows over. A woolly plant louse (*Churnus pinicorticis* Fitch) has been very abundant on many of the trees, attacking the trunks and larger branches for several years. They are sometimes so abundant that the whole trunk has from a little distance a white or grayish-white appearance.

The White Pines do not cast so dense a shade now as they did ten years ago. At that time there was no undergrowth among them. At present there are small wooded plants, such as Grape, Raspberry, Cherry, Box Elder, etc., besides weeds, coming in, and there would likely be more of these were it not for the heavy mulch of leaves that covers the ground.

In 1886 the average size of the better trees was: Height, 24 feet 9 inches, and a little less than 6 inches in diameter. At present, 1895, the better trees are 38 to 40 feet high, and 8 to 9 inches in diameter. During the winter of 1882–83 the leaders of a considerable proportion of the trees were broken down by the weight of sleet. This was the cause of many trees being crooked at that point, and of others having more than one leader. Except for the trees deformed in this way nearly all have almost perfectly straight trunks. The trees are much more nearly uniform in height than in diameter. The sizes of the trees in the plat are as follows: Fifty-eight are 3 inches in diameter; one hundred and ninety-four, 4 inches; two hundred and fifty-six, 5 inches; two hundred and thirty-six, 6 inches; one hundred and forty-four, 7 inches; seventy, 8 inches; eleven, 9 inches; five, 10 inches.

In the autumn of 1895 the thirty-nine trees constituting the central row of the plantation were measured, and the average diameter, breast high, was 5.9 inches, the range being from 4.1 inches to 8.6 inches.

At the old Elgin nurseries, planted in open prairie about 1½ miles west of the Fox River, black loam soil, from 4 to 5 feet to gravel, White Pines, forty to forty-five years old, with Norway Spruce and Scotch Pine as neighbors, measure 22 inches in diameter, breast high, and are 52 feet high. In a neighboring grove, twenty-five years from seed, planted exclusively to White Pine, the trees average 11 inches in diameter and 45 feet high. When planted alternately with European Larch 5 to 6 feet apart, the White Pines, thirty-five to thirty-six years old, are perfectly straight and average 13 inches in diameter and 75 feet in height. The European Larch proves to be the best tree to plant with White Pine as a nurse. When planted with Box Elder and Ash the growth of the pines is not so satisfactory. Where Scotch Pine has been planted alternately with White Pine the latter has outgrown the Scotch, nearly all of which are killed out. In the groves where Larch is planted with White Pine the ground is completely mulched from the foliage of the Larch; drought has never affected the trees, and no grass or weeds can grow among them.

Mr. Thomas Hunt, of Ridott, Ill., set out White Pine in a plantation of 10 acres twenty-two years ago. The trees were 10 to 18 inches high when set, making their age at time of measurement about twenty-seven years.

The grove is planted on a ridge with thin clay loam underlaid with broken laminated limestone. Mr. Hunt found the land unprofitable under tillage after several years' trial. The trees of each variety are planted in solid rows, hardwoods and conifers alternating. In a plat of White and Scotch Pine, Norway Spruce, Arborvitæ, European Larch, White Elm, Box Elder, Green Ash, and Willow, the conifers have almost shaded out the hardwoods. The

Larch are the tallest and the Arborvitæ the lowest, the remaining conifers being of about equal height, averaging 35 feet. Seventy White Pines were measured, taking all the trees as they came in the rows, and including the center of the plantation. The average diameter, breast high, was 6.2 inches. The branches were dead, but still persistent to a height of 18 to 20 feet.

At the Bryant nurseries, Princeton, Ill., somewhat south of the natural limit of the White Pine, trees that were grown as ornamental nursery stock have been permitted to stand, giving some notion of the growth of the species in the rich prairie loam of that region. The oldest specimens were set in 1858 and were imported seedlings. They are now about forty-two years of age, and average about 65 feet in height. Measured trees range from 9 inches to 26 inches in diameter. Norway Spruce of the same planting equal the pines in height, but the average diameter is less. These trees stand about 30 feet apart. On the margin of a natural hardwood grove an acre of the richest prairie land was planted to White and Scotch Pine seedlings about twenty-two years ago. The trees were set 3 by 4 feet, and have never been thinned. Each species was planted pure, and one of the tallest White Pines measured 33 feet high, the average height being estimated at 26 feet. Fifty White Pines, taken as they came in the rows, were measured, breast high, the average diameter being 4½ inches. Scotch Pine showed about equal growth.

At the Iowa Agricultural College, Ames, Iowa, in the center county of the State, a piece of waste land of about 3 acres was planted to White Pine, European Larch, Box Elder, Green Ash, and Cottonwood in 1875. The plat occupies a gravelly knoll sloping to the north. The soil is a yellow clay, with much gravel, and of unknown depth. The top of the knoll forming the south side of the plantation is set with pure Larch. The Pine, Box Elder, and Ash are mixed, evidently without order. The original planting was 3½ by 3½ feet apart, and the trees now average about 10 feet apart each way. The White Pines are estimated to average 30 feet high, and twenty-six measured trees, taken as they came, ranged from 5 to 14 inches in diameter, the average being 8.7 inches. The pines are now the dominant trees of the mixture and are fully 10 feet higher than the Box Elder, which exceed the Ash 5 feet. The following diameter measurements will serve as an additional basis of comparison:

	Inches.
White Pine, as above (26 trees)	8.7
Box Elder, as above (23 trees)	4.7
Green Ash, as above (21 trees)	3.6
European Larch (planted pure on crest, 26 trees)	6
Cottonwood (same plat, base of knoll, 14 trees)	10.5

It should be added that the Cottonwoods stand wider apart than the mixture of Pine, Box Elder, and Ash, while the Larch stand closer together. All were set originally 3½ by 3½ feet, and the alternate rows have been removed throughout the plantation.

At Windom, Minn., in the southwest part of the State, Mr. E. Sevatson has included two rows of White Pine in a plantation covering 10 acres. These trees were set about thirteen years ago, when 8 to 12 inches high, and are presumably not over eighteen years old. The two rows of pine are between rows of Arborvitæ and Balsam Fir. They are about 25 feet in height, and the average diameter, breast high, of seventeen trees, taken as they came in the rows, was 5 inches. The soil is a stiff clay loam, and the plantation is about 100 feet above the surface of a lake which joins the farm. The entire country is treeless, except for groups of trees on the lake shore and groves along the Des Moines River, 3 miles distant. The White Pine in this location is less vigorous than Scotch Pine, European Larch, or Norway Spruce.

Fine trees of White Pine, set in single specimens about thirty years ago, are growing at Arbor Lodge, Nebraska City, Nebr., the home of Hon. J. Sterling Morton, ex-Secretary of Agriculture. These stand in bluff soil (a fine loam) about 2 miles west of the Missouri River. A few fine specimens may also be seen in the lawn at the homestead of Hon. A. H. Whiting, at Whiting, Monona County, Iowa, in the deep black loam of the Missouri bottoms. At Brookings, S. Dak., within 17 miles of the Minnesota line, repeated plantings of the White Pine have resulted in failure. At Franklin, Nebr., about halfway across the State, near the Kansas line, this species has failed after extended trial. Very few trees can be seen in Lincoln, Nebr., though it has been repeatedly tested there as an ornamental tree. The diminished amount of atmospheric moisture will necessarily prevent general satisfactory cultivation beyond the western boundary of Missouri, Iowa, and Minnesota.

A number of fine specimens of White Pine stand in the lawn of the Rollins homestead at Columbia, Mo., about 10 miles north of the Missouri River and halfway between the east and west boundaries of the State. The soil is a clay loam, underlaid with limestone, which outcrops at many places in the vicinity. These trees were planted in 1855, when two or three years old, by Col. J. H. Rollins. The largest is now (1897) 29 inches in diameter, breast high, and 64 feet 9 inches in height. One of the smallest is about 56 feet high and 16 inches in diameter.

Additional notes of plantations in the West might be given, but the above is sufficient to show the White Pine can be successfully grown somewhat beyond its natural range, but does not well endure the dry conditions of soil and atmosphere which it must meet in the region west of the Missouri River.

THE WHITE PINE AS A FOREST TREE IN GERMANY.

As has been stated, the White Pine was introduced quite early into England, and from there it found its way into various parts of the Continent. In England it remained largely a park tree. In Germany it has been a forest tree proper for over a century, being used quite frequently, on account of its hardiness and shade endurance, as "gap cover" to fill fail places. It has also been planted in many places on small areas as pure growth or mixture with the common European or Scotch Pine (*Pinus silvestris*) and Spruce. For a long time this "newcomer" was regarded with a feeling of doubt and even suspicion, and long before anything definite could possibly be said about the matter the merits and faults of the White Pine were extensively discussed. The "practical" man, and with him some scientific men, were satisfied that such a light-colored softwood could not possibly be durable or otherwise desirable, and the small quantities offered from time to time did not always find ready market. Of late years this condition has changed. In a series of excellent articles, Dr. L. Wappes, a Bavarian forester, records the experience had in one of the oldest bodies of White Pine in Germany, in which he shows that the tree in pure growth, and also as mixture with pine, spruce, or hardwoods, has proven a most excellent factor of the German forest; that it seeds early and heavily, and as plant material is easily and cheaply secured; that it is readily and even preferably reproduced by natural seeding, a rapid grower, capable to withstand crowding and shading, and that it is a tree especially capable of producing a large amount of timber even on poor soils, all of which coincides with the observations on its native habitat laid down in this monograph. He shows that besides the Fir (Balsam), the White Pine is the only tree which, in the Palatinate and on poor soils will, at the age of one hundred and ten years, make timber of Class I (according to German notation, diameter at half length, 22 inches and better); that while the common pine at that age furnishes only 13 per cent of Class III and better (diameter 12 inches and over), the White Pine furnishes 27 per cent, or more than double this amount of these and more valuable diameter classes. Dr. Wappes emphatically states that White Pine, wherever known, is eagerly bought, and that the opinion of the consumers has radically changed. He proves by the figures of large sales from the State forests, that since 1882 the value of White Pine has nearly doubled, while that of Spruce and common Scotch Pine has increased by only 20 per cent, and that of Fir and Larch has actually declined during this period. The following figures give an idea of the growth of White Pine abroad. The groves of the Palatinate are stocked on very inferior soil, nearly all other groves cited being on loamy sand. The figures for total volume are somewhat misleading, since they do not include the timber which has been removed from the older groves in thinnings, which would add probably from 10 to 15 per cent to make up whole production.

It will be of interest to give more in detail the conditions of the last-mentioned plantation, reported this year in Dr. Lorey's Allgemeine Forst und Jagdzeitung:

The plantation of about 9 acres, on fresh loamy sand, situated at an elevation of 2,200 feet above sea level in Wurtemberg, consists of White Pine mixed with Scotch Pine, Spruce, and Fir in single individuals or groups. The White Pine represents, numerically, two-thirds of the total number, Scotch Pine is found among the dominant growth in part, but the Spruce and the small number of Firs show only codominant and oppressed trees.

The density of the growth was reported as satisfactory until in 1875, when a snowstorm broke down much material, so that at present the density does not average over 0.7.

The stand, originating from seed, was several times thinned, and the last time, occasioned by the snowstorm, 400 White Pines were removed, with over 10,000 cubic feet of wood. The number of trees averaged 183 per acre, of which 142 White Pines, with diameters varying from 7 to 24 inches, and 16 inches in the average, yielded altogether 9,510 cubic feet, while the other species added only 1,290 cubic feet. Comparison with the other acre yields recorded shows that under these conditions the product was less than in more favored situations, either the site or light conditions reducing the growth.

The diameters represented on a sample area were distributed as follows:

Diameters ....inches..	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	18 to 20	20 to 22	22 to 24
Number of trees..........................	7	20	24	30	33	23	4	1

Of the Scotch Pines only four had reached diameters over 16 inches, and of the Spruces none over 14 inches. The superiority of the White Pine also appears from the comparison of height growth, which was established for every five years by the measurement of average sample trees, as follows:

Height growth of White Pine, Scotch Pine, and Spruce, by years.

Sample trees.	Age (years) and height growth (in feet).																	
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
White Pine height growth	2.1	9	18	29	38	45	52	59	65	71	76	81	85	89	92	95	97	100
Scotch Pine height growth	4	12	20	29	35	42	49	54	60	65	69	73	77	80	82	84	87	88
Spruce height growth	2	8	16	24	35	42	48	54	59	63	68	72	75	78	80	82	84	86

The preceding table shows how the slow growth of the first five years which the White Pine has in common with the Norway Spruce is overcome before the fifteenth year, and by the twentieth year the White Pine has distanced the Scotch Pine, gaining on it constantly until, by the ninetieth year, it has outgrown it 12 per cent.

Dimensions and yields of White Pine in German forests.

Locality.	Character of forest.	Age.	Number of trees per acre.	Average diameter (without bark).	Height.	Volume of wood, exclusive of limbs and stumps.
		Years.		*Inches.*	*Feet.*	*Cubic feet.*
Palatinate I	Pure growth	104	250	15.6	92	13,300
Palatinate II	do	68	660	9.1	66	10,000
Palatinate III	White Pine with Spruce	68	550	10.4	79	12,000
Palatinate IV	White Pine and Scotch Pine	58	330	10.3	64	6,000
Palatinate V	do	46	600	7.4	49	4,000
Palatinate VI	do	25	2,200	4	34	3,200
Prussia (Grafinrode)	White Pine mixed with Scotch Pine and Spruce.	(75 to 80)	452	(6 to 28)	(72 to 87)	13,224
Do	Pure growth	(75 to 80)	410	(8 to 18)	(80 to 87)	13,000
Prussia (Rogelwitz)	do	95	333	15	88	14,298
Frankfort on the Main	do	82	723	9.7	72	12,024
Thuringia	do	78	415	11.7	(79 to 89)	13,027
Wurtemberg	White Pine mixed with Scotch Pine, Spruce, and Fir.	93	183	16	98	10,800

From these figures the capacity of the White Pine to produce large amounts of valuable stemwood is apparent. Thus, on soil on which the 100-year-old trees developed only a height of 92 feet, over 13,000 cubic feet of stemwood, corresponding to about 60,000 to 70,000 feet B. M., American scale, were cut per acre over and above about 1,200 cubic feet of material removed in previous thinnings. In every case the White Pine excels the common pine, and even the Spruce in this respect. It should be added that most of these plantations, made in the early part of this century, were not executed according to present superior methods, the species being an exotic and expensive was set out more in orchard fashion, as most planters in our country have been apt to do, at distances of 8, 12, and more feet apart. Owing to this fact the development was probably not as satisfactory in the earlier years as it might have been had the method of close planting, either pure or in mixture, prevailed.

The superiority of growth over the German Spruce and Pine is more fully illustrated in the following table, which shows the distribution and proportion of trees of White Pine and Spruce and of White Pine and Scotch Pine that are found in given diameter classes in two mixed planted growths of these species:

Distribution and proportion of White Pine and Spruce and White Pine and Scotch Pine.

White Pine and Norway Spruce, sixty-eight years old. [65 per cent Pine; 35 per cent Spruce.]			White Pine and Scotch Pine, fifty-eight years old. [50 per cent of each.]		
Diameter of trees.	White Pine.	Norway Spruce.	Diameter of trees.	White Pine.	Scotch Pine.
Inches.	*Per cent.*	*Per cent.*	*Inches.*	*Per cent.*	*Per cent.*
4 to 6	0	9.5	4 to 6	1	2.4
6 to 8	15	30	6 to 8	19.5	32
8 to 10	30	27	8 to 10	18.7	35
10 to 12	22	26	10 to 12	26	24
12 to 14	20.5	6.8	12 to 14	23.5	4.9
14 to 16	10.5	....	14 to 16	8	1.6
16 to 18	1.5	....	16 to 18	2.4	....
			18 to 20	1	....

It appears that nearly 32 per cent of the White Pine is over 12 inches in diameter, as against less than 7 per cent of the Spruce, while 35 per cent of White Pine, as against 6.5 per cent of Scotch Pine, developed over 12 inches in the mixture of these two, and over 11 per cent of the former belongs to sizes above 14 inches, which is hardly reached at that age by its competitor. These figures prove clearly that the White Pine excels the Scotch Pine even during the age of most rapid growth, so that the difference, in view of the steady growth of White Pine and the marked decrease in rate of growth in the Scotch Pine, would be markedly greater if older timber had been compared.

Just as in its native range, the White Pine is decidedly a heart pine, the sapwood changing early into the durable and more valuable heartwood. In timber one hundred years old grown in the Palatinate the sap in many cases is less than 1 inch thick, so that 75 per cent and more of the entire stem is composed of heartwood.

In view of these facts it is quite safe to say that the White Pine in the future will be one of the prominent forest trees of Germany, and perhaps of Europe, as it will always be the king of woods in our Northern and Eastern States.

THE WOOD OF THE WHITE PINE.

THE WOOD OF THE WHITE PINE.

By Filibert Roth, *Division of Forestry.*

White Pine is a favorite material with the wood consumer in the Northeastern States on account of the combination of qualities it possesses. It is a light, soft, uniform, straight-grained timber, to be had in all markets in any quantity and in all dimensions, from the ship's mast to the clapboard. It seasons well, shrinks and warps but little, is quite durable, insect-proof, and takes oil and paint and has a good color, is light to handle, easy to saw and plane, takes nails without splitting, and is, in short, the ideal material for the carpenter and joiner, who handles the bulk of the 30 to 40 billion feet of sawed timber and lumber annually used in this country, of which White Pine furnishes over 30 per cent.

CHARACTER AND PHYSICAL PROPERTIES OF THE WOOD.

The structure of White Pine, like that of other pines, is simple. Ninety per cent and more of the weight of the dry wood is formed by the common wood fibers, or tracheids, 0.12 to 0.20 inches long, well suited for pulp material. The spring wood of each annual ring passes gradually into the summer wood and thus the sharply defined bands of hard, dark and soft, light-colored material so conspicuous in the rings of all hard pine, especially Longleaf and Cuban Pine, are absent in White Pine, making the cutting of the wood by either plane or saw much easier than is the case with hard pines. Sapwood and heartwood are quite distinct—the former white, the latter with a slightly brownish cast. The change from sapwood to heartwood takes place earlier in the young tree and the younger portions of old trees than in older timber. Thus, in a thrifty sapling thirty years old the sapwood shows about eighteen rings on the stump, but only ten rings 35 feet from the ground. In trees over one hundred years old the number of rings in the sapwood is generally over thirty at the stump, decreasing often to fifteen or twenty near the top. The number of rings in the sap, as in other pines, is smaller in thrifty and greater in slow-growing trees, while the width of the sapwood is generally least in slow-growing timber. Compared to other pines, White Pine has a narrow sap at all periods of its growth. While in the hard pines, like the Longleaf Pine, and still more in Loblolly and Shortleaf Pines, the sap forms generally from 50 to 75 per cent of the log, it is generally less than 35 per cent of mill-sized timber in White Pine. This highly valuable property of the White Pine is found in all localities, even in Europe, where the tree has been widely planted.

SPECIFIC WEIGHT.

To determine specific the weight of the wood and other physical properties a collection of seventy-three trees was made, including material from the New England States, Michigan, and Wisconsin, and also from the mountains of North Carolina.

The specific weight of the greenwood varies chiefly with the amount of sapwood and consequent abundance of moisture, since the heartwood contains but little water outside of its cell walls (except in some cases where the heartwood near the stump also contains liquid water). Generally the weight of the greenwood varies from about 40 to 50 pounds per cubic foot, and is greater in young poles than in old timber, which latter on this account floats readily, rarely sinking, even after years of immersion.

The specific weight of the kiln-dry wood varies, generally from 0.33 to 0.40 (20 to 25 pounds per cubic foot), is greater in the old tree than in the young sapling, is greater at the stump than farther up in the same stem, is independent of orientation (as great on the north side as on the south side), is no greater on clay land than on the sandy soils, and seems in these particulars quite independent of locality. The wood from the swamp trees is no heavier nor lighter than the wood from the upland trees, the trees from New England differing apparently in no way from those of either the Lake region or North Carolina.

Leaving out of consideration the specific weight of the limbs and knots (these being always heavy, as in all pines), the average specific weight of the dry wood of the stem was found to be for—

	Specific gravity.
Five trees 200 to 250 years old	0.386
Five trees 125 to 160 years old	.388
Five trees 100 to 125 years old	.383
Ten trees 75 to 99 years old	.378
Ten trees 50 to 74 years old	.366
Nineteen trees 40 to 49 years old	.353
Nineteen trees 30 to 39 years old	.351

From the above, and still more from the table following, in which the trees are grouped according to age, it will be seen that White Pine displays a uniformity of specific weight, and other properties dependent on weight, such as is entirely unknown in any other pine of the Eastern United States.

Average weight (kiln dry and green), moisture content, and shrinkage per cent of White Pine.

I.—TREES 200 TO 250 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
		Years.	*Inches.*	*mm.*			*Per cent.*	*Per cent.*
Lincoln County, Wis	5	225	23.0	1.1	38.1	69	93	7.6
Marathon County, Wis	16	250	22.0	.8	38.5	62	73	8.6
Grayling, Mich	3	205	19.0	1.3	36.0	64	95	8.5
Chippewa County, Wis	1	209	27.0	1.6	39.0	66	85	8.1
Do	2	202	19.4	1.0	38.5	66	100	8.0
Do	3	202	20.5	1.2	39.2	67	81	7.9
Average					38.6	65	88	8.1

II.—TREES 125 TO 160 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
Lincoln County, Wis	1	146	19.0	1.5	42.0	74	92	9.0
Do	2	140	22.0	1.9	36.4	72	113	8.7
Do	3	141	12.0	1.0	38.4	65	92	9.1
Do	4	140	15.0	1.2	40.5	72	87	9.8
Linville, N. C	458	158	33.0	2.1	37.1	72	110	7.7
Average					38.8	71	95	8.9

III.—TREES 100 TO 122 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
Grayling, Mich	1	110	17.5	2.2	36.0	64	96	9.2
Do	2	122	17.7	1.8	35.0	64	99	9.0
Do	4	114	9.5	1.1	39.8	79	120	9.8
Do	5	105	7.5	.9	38.3	76	121	8.5
Do	7	115	7.8	1.1	46.8	100	138	10.5
Do	8	108	7.8	1.2	38.9	78	122	8.8
Do	9	112	7.8	1.3	38.0	85	147	8.8
Do	10	111	5.0	.8	36.7	71	109	8.5
Average					38.3	74	119	8.9

IV.—TREES 75 TO 100 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
Lincoln County, Wis	6	75	4.0	0.8	36.3	68	111	8.4
Marathon County, Wis	12	84	14.0	2.0	39.4	76	110	9.0
Do	13	90	12.0	2.1	37.0	85	148	9.8
Do	14	81	15.0	2.7	36.0	73	121	9.0
Do	15	95	10.0	1.4	40.4	72	88	9.4
Grayling, Mich	6	93	7.0	1.6	40.1	90	149	8.7
Chippewa County, Wis	5	83	7.0	1.5	36.3	76	132	9.8
Do	6	94	6.3	1.0	37.0	74	115	8.0
Do	7	84	10.4	2.4	37.1	76	128	9.8
Do	9	78	10.2	1.8	38.5	76	119	8.7
Average					37.8	76	112	9.0

Average weight (kiln dry and green), moisture content, and shrinkage per cent of White Pine—Continued.

V.—TREES 50 TO 74 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
		Years.	*Inches.*	*mm.*			*Per cent.*	*Per cent.*
Lincoln County, Wis	7	60	4.5	1.3	34.3	80	148	8.5
Do	8	50	2.0	.7	39.3	70	....	8.5
Do	11	52	5.5	1.7	33.8	86	....	8.6
Chippewa County, Wis	8	65	8.0	2.9	38.7	78	122	9.0
Do	4	73	7.0	1.5	39.0	64	84	10.1
Do	10	67	4.2	1.2	35.7	72	121	8.0
Plymouth County, Mass	1	50	13.0	4.0	35.3	68	112	8.6
Do	4	52	11.0	2.8	38.5	73	106	8.6
Worcester County, Mass	16	54	14.0	3.6	39.0	69	93	8.4
Do	17	65	10.0	2.4	36.5	67	105	7.3
Do	18	60	10.0	2.3	35.5	....	....	7.5
Average	....	....	....	....	36.8	74	115	8.0

VI.—TREES 40 TO 49 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
Lincoln County, Wis	9	48	2.3	0.6	43.3	81	102	8.5
Do	10	47	6.0	2.0	31.3	86	162	8.9
Marathon County, Wis	17	40	6.0	2.2	33.5	85	173	9.0
Do	18	40	6.0	2.3	34.5	81	149	8.6
Do	19	40	2.0	1.1	33.7	71	124	8.3
Do	20	42	2.8	1.0	35.0	67	105	8.4
Do	21	44	4.0	1.4	33.8	82	158	7.9
Plymouth County, Mass	2	46	8.5	2.6	36.2	58	76	8.4
Do	3	45	9.2	3.0	36.2	65	95	8.5
Do	5	49	13.7	3.9	35.0	61	93	8.4
Do	6	47	9.5	2.8	38.0	64	81	8.1
Do	10	48	12.5	3.6	34.5	65	108	9.3
Do	11	49	10.3	3.1	39.0	67	89	9.3
Do	12	46	10.2	2.9	37.2	70	104	7.0
Worcester County, Mass	25	46	10.0	2.7	35.0	66	103	8.1
Do	26	45	12.8	3.8	35.5	67	106	8.6
Do	27	45	9.1	2.6	37.7	75	118	9.4
Merrimack County, N. H	32	41	10.3	3.4	33.0	61	98	7.9
Do	33	40	8.6	3.1	31.7	64	122	8.4
Average	....	....	....	....	35.3	70	113	8.4

VII.—TREES 30 TO 39 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
Marathon County, Wis	22	38	4.0	1.5	31.3	77	162	8.2
Plymouth County, Mass	7	36	8.3	3.5	36.5	64	93	8.3
Do	8	34	9.1	3.4	35.2	66	105	9.2
Do	9	35	12.0	4.7	35.7	66	100	7.7
Middlesex County, Mass	13	38	11.0	3.4	35.2	74	131	9.1
Do	14	38	10.8	3.6	33.7	74	147	8.2
Do	15	37	10.8	3.7	36.0	83	146	7.5
Worcester County, Mass	19	35	9.2	3.6	36.1	61	85	8.1
Do	20	33	11.2	4.8	33.6	65	108	7.0
Do	21	31	6.5	2.9	35.2	63	99	9.5
Do	22	33	10.5	4.4	33.0	72	143	9.3
Do	23	36	9.2	3.6	35.2	68	111	8.7
Do	24	35	7.0	2.9	34.5	66	109	8.2
Merrimack County, N. H	28	38	6.8	2.4	28.5	66	89	9.8
Do	29	37	7.1	2.8	36.7	67	108	10.2
Do	30	37	8.2	3.0	36.7	71	111	8.5
Do	31	39	9.5	3.2	37.7	65	99	9.0
Do	34	34	7.5	3.3	32.7	71	129	7.5
Do	35	35	9.3	3.7	34.5	74	123	9.2
Do	36	35	10.3	3.9	30.0	64	147	8.0
Average	....	....	....	....	35.1	68	104	8.5

VIII.—TREES 20 TO 30 YEARS OLD.

Locality.	Original number of trees.	Approximate age of trees.	Diameter breast high without bark.	Width of rings.	Specific gravity × 100. Kiln dry.	Specific gravity × 100. Green.	Moisture as per cent of the weight of dry wood.	Shrinkage in volume.
Linville, N. C	459	22	4.0	2.7	34.7	83	164	9.4
Do	460	26	7.0	2.8	36.9	85	156	10.2
Average	....	....	....	....	35.5	84	165	9.8

From the table it appears that the specific weight of the timber is quite independent of the rate of growth, and that the individual variation generally moves within very narrow limits. The diagrams (figs. 16 and 17) show the relation of weight for the different sections from the stump

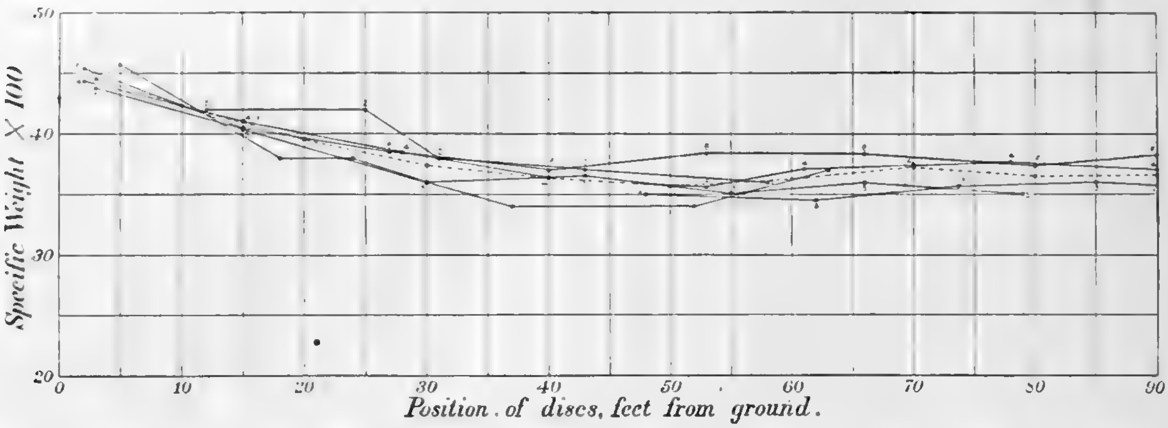


Fig. 16.—Diagram showing specific weight of wood at different cross sections of the stem; also a decrease of weight from the stump upward, and the similarity of the wood of different trees. (Five trees, over 200 years old. Dotted line indicates the average.)

upward; the slightly greater weight of the older timber, as compared to sapling material, the uniform decrease in weight from stump upward, and also the uniformity of the several individuals of any group of trees is clearly apparent from the lines. The same decrease in weight from below

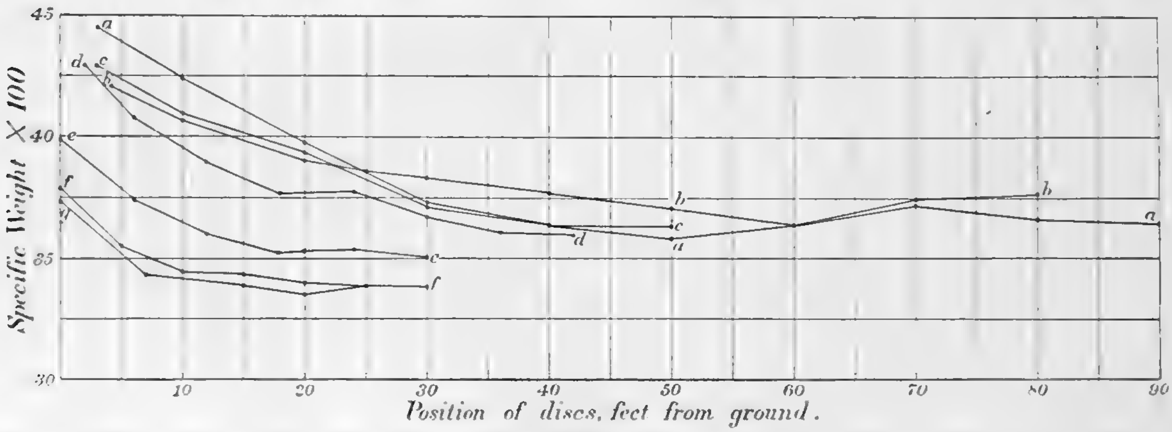


Fig. 17.—Diagram showing specific weight of kiln-dry wood at different points in the stem from ground upward: *a*, six trees, 200 to 250 years old; *b*, five trees, 125 to 160 years old; *c*, seven trees, 100 to 125 years old; *d*, ten trees, 75 to 100 years old; *e*, ten trees, 50 to 74 years old; *f*, eighteen trees, 40 to 49 years old; *g*, nineteen trees, 30 to 39 years old.

upward is observed in the wood of any given period of growth; thus, the wood of the last forty rings (next to the bark) was found to be as follows:

Decrease in weight of the wood of the last (outer) forty rings in the several disks from stump upward.

Disk number.	Specific gravity.			
	Tree No. 458	Tree No. 1.	Tree No. 2.	Tree No. 3.
I	0.37	0.42	0.44	0.45
II	.31	.39	.40	.405
III	.30	.36	.36	.39
IV	.295	.35	.36	.36
V	.31	.33	....	.37

As in other pines, there is usually an increase of weight in the crown, apparently due to an influence of the limbs, but as this influence is local, so the apparent result is local, and the weight is very irregular for the crown part of the stem; the pronounced increase is apparent only in the immediate vicinity of the limbs. The absence of a pronounced or sharply defined summer wood makes it difficult and impracticable to apply the microscopic methods to determine the variation of weight from pith to bark on any cross section. From the actual determinations of weight, it appears that for the lower portions of any normally grown tree there is usually at first an increase of weight from the pith outward, reaching a maximum somewhere between the fiftieth and eightieth ring, maintained for a long period and usually followed by a very slow decrease in weight from there on outward. This variation is generally small, and never reaches the proportions met in sections of hard pine, such as Longleaf Pine, where it commonly amounts to 75 to 100 per cent of the weight of the lightest portion.

Usually about half the weight of a green log is water. The amount of moisture generally varies in the sapwood from about 120 to 160 per cent and from 40 to 60 per cent in the heartwood, the amount for the entire log, therefore, varying with the proportion of sap and heart is greatest in saplings and least in large mature trees, in the latter from about 90 to 120 per cent of the weight of the timber after it is kiln-dried. The wood parts with its moisture as easily as any wood in the market, dries rapidly, with little injury, and may safely be kiln-dried fresh from the saw, though in actual practice this method is almost unknown in the White Pine regions, the usual way of drying by carefully piling in immense piles, being the universal way of seasoning. Well air-dried White Pine, as in an ordinary room, still retains 8 to 9 per cent moisture, and if unprotected by oil, paint, etc., is quite susceptible to changes of humidity, absorbing and giving off moisture at every change of temperature and humidity of the air.

SHRINKAGE.

In keeping with its smaller specific weight, the shrinkage of White Pine is less than that of other pines. It is greater for sap than heart, and therefore greater for sapling timber than for older trees. From the table on page 74 it appears that the shrinkage in volume varies for the several groups of trees from 8 to 9 per cent, and, like the weight, is quite uniform for the different individuals of each group.

The ease and rapidity with which White Pine seasons, and the manner of distribution of White Pine lumber, encouraging proper seasoning before use, have done much to earn for White Pine the fame of being one of the woods which do "not shrink" nor "work," a virtue which is not only in part due to the small weight and consequent small shrinkage, but is largely the result of proper handling.

STRENGTH.

Being the lightest, White Pine is also the weakest among the pines of the Eastern United States, as appears from the following general average:

Strength of White Pine at 12 per cent moisture.

	Pounds per square inch.
Compression endwise and in bending to true elastic limit	5,200
Bending to rupture	7,900
Modulus of elasticity	1,410,000
Compression across the grain (3 per cent deformation)	720
Shearing parallel to fiber	380

Out of about seven hundred tests made by the Division of Forestry, about 55 per cent fall within 10 per cent of this general average, and 90 per cent within 25 per cent of the same. Though the test series for White Pine was by no means as full as is desirable, the above average results will probably be found fairly accurate and sufficient for general purposes. The table on the next page presents the average results for the several trees.

Average strength of the wood of White Pine of different trees at 12 per cent moisture.

Locality.	Original number of trees.	Modulus of elasticity (1,000 pounds).	Bending to— Rupture.	Bending to— Relative elastic limit.	Compression endwise.	Compression across grain to 3 per cent deformation.	Shearing parallel to fiber.	Average specific weight.
			Pounds per sq. in.	*Pounds per sq. in.*	*Pounds per sq. in.*	*Pounds per sq. in.*	*Pounds per sq. in.*	
Wisconsin	101	1,360	8,100	6,200	4,600	690	460	0.42
Do	102	1,520	7,400	5,300	4,200	560	320	.36
Do	104	1,350	7,800	6,000	4,800	620	430	.40
Do	112	1,330	8,300	6,300	5,000	650	440	.39
Do	114	1,190	*a* 6,800	5,600	4,250	630	400	.36
Do	116	1,350	8,300	5,900	5,000	560	470	.385
Michigan	601	1,370	7,400	6,300	5,500	810	350	.38
Do	602	1,470	7,800	6,700	5,700	860	420	.37
Do	603	1,470	7,850	6,650	5,400	790	320	.38
Wisconsin	607	1,380	8,000	6,800	5,700	910	340	.39
Do	608	1,560	8,900	7,450	5,700	670	330	.385
Do	609	1,510	8,200	6,700	6,200	880	340	.392
Average		1,410	7,900	6,300	5,200	720	380	.384
Average for trees 601 to 609		1,460	8,000	6,760	5,700	8,200	350	38.3

a Insufficient data for a fair average.

In the above table the data for trees 101 to 116 are insufficient. Both material and tests for trees 601 to 609 were satisfactory in every respect, and the results, therefore, of far greater value than those for trees 101 to 116.

In keeping with its greater weight, the wood of the butt logs is slightly stronger than that of the top logs, and there is generally a regular difference between different parts of the same cross section, the center, as appears usual in pine, being the weakest, the heavier intermediate portion the strongest, and the peripheral part lying between the two.

For a more careful study of this relation, tests were made of a set of 2 by 2 inch sticks cut out of one log from each of three trees, in such a manner that the centers of the logs formed one set, the part midway from center to bark another set, and the outer portion of the logs a third or outer set, the latter two being all quarter-sawed pieces. The tests furnished the following average results:

Strength of 2 by 2 pieces at 12 per cent moisture.

Kind of test.	Tree No. 601.	Tree No. 602.	Tree No. 603.
	Pounds per sq. in.	*Pounds per sq. in.*	*Pounds per sq. in.*
Compression endwise	6,710	6,890	6,340
Bending to relative elastic limit	7,960	7,970	7,890
Bending to rupture	9,360	9,630	9,340
Modulus of elasticity (1,000 pounds)	1,306	1,291	1,285

It is apparent from the above that the perfect quarter-sawed material confirmed the other test results in showing the great similarity of the wood of these three trees. It also shows, however, that the effect of defects in an unselected lot reduces the strength values markedly in this species.

Arranging the results according to the position of the test pieces in the log, it is found that in compression endwise the strength was: Center pieces, 5,520 pounds, or 78 per cent; intermediate, 7,000 pounds, or 100 per cent; outside pieces, 6,680 pounds, or 95 per cent; showing that the heart pieces, as has been found in other conifers, are always the weakest, thus verifying the results of the general series. The slight decrease from the intermediate to the outside pieces is in keeping with the smaller weight of the latter and need not be ascribed to the fact that these pieces contained small proportions of sapwood. As might be expected, the uniformity of results in this properly selected and prepared material was greater than in the ordinary series. Of 58 tests, all fell within 25 per cent of the average strength and 76 per cent within 10 per cent of the average.

In connection with a general study into the maximum uniformity of wood, three scantlings of White Pine, with an average specific gravity of about 0.34 and an average compressive strength at 8 per cent moisture of 4,900 pounds, were examined, two being tested air-dry (8 per cent) and the other after being soaked for three months in cold water. The results of these tests on White Pine are embodied in the following table:

Strength of contiguous blocks of the same scantling of White Pine, select material, in compression endwise.

[Dimensions generally, 2.76 by 2.76 by 2.76 inches.]

Number of block.	Dry scantling.		Soaked scantling.	Number of block.	Dry scantling.		Soaked scantling.
	1	2	3		1	2	3
	Pounds per sq. in.	*Pounds per sq. in.*	*Pounds per sq. in.*		*Pounds per sq. in.*	*Pounds per sq. in.*	*Pounds per sq. in.*
1	4,850	5,070	2,270	26	5,070	4,860	....
2	4,860	5,150	2,390	27	4,940	4,940	....
3	4,690	5,020	2,300	28	5,020	5,010	....
4	4,840	4,770	2,260	29	5,110	4,950	....
5	4,760	4,770	*a* 5,700	30	5,020	....	....
6	4,720	4,920	2,390	31	4,950	....	....
7	4,730	4,950	2,300	32	4,820	....	....
8	4,760	4,840	2,310	33	4,950	4,690	....
9	4,750	4,860	2,290	34	4,900	4,750	....
10	4,770	*a* 6,460	2,310	35	5,040	4,670	....
11	4,730	4,860	2,340	36	5,160	4,630	....
12	4,760	5,010	2,210	37	5,120	4,800	....
13	4,770	....	2,370	38	5,100	4,730	....
14	4,670	....	2,340	39	5,230	4,660	....
15	4,600	4,960	2,340	40	5,280	*a* 6,000	....
16	4,660	....	2,340	41	5,260	4,840	....
17	4,590	....	2,330	42	5,280	4,780	....
18	4,600	....	*a* 5,710	43	5,300	4,840	....
19	4,610	4,910	2,310	44	5,310	4,870	....
20	4,880	*a* 6,600	2,260	45	5,300	5,040	....
21	4,920	4,600	2,180	46	5,350	5,150	....
22	4,870	4,650	2,130	47	5,400	5,340	....
23	4,970	4,720	....	48	5,360	5,300	....
24	4,940	4,860	....	49	5,360	5,200	....
25	....	....	....	50	5,510	....	....

a Dried at 180° F. (to about 2 per cent moisture) before testing.

It appears that in the tests on dry material the greatest difference between any two contiguous blocks of select quarter-sawed White Pine was 190 pounds per square inch, or 3.8 per cent of the total strength; that generally it was less than 2 per cent, and several times only about 0.2 per cent, but that in tests of this kind less then 200 pounds in the results can not be regarded as any difference at all, this amount being due to indeterminable differences found even in the best material, and partly due also to imperfections in the means and methods of testing. It is also clear that in the same scantling, though select and of small dimension (only 6 feet long) a difference of nearly 900 pounds per square inch, or 18 per cent of the strength, in compression endwise may be found, so that any inferences from scantling to scantling must be taken with great caution, and any accurate relations, such as the influence of seasoning, etc., can be made only in a manner similar to that employed in these uniformity tests.

From the general series of tests, also from the tests on the select 2 by 2 inch pieces, and in way of indication also from some of the tests in maximum uniformity, it appears that seasoning affects the wood of White Pine to about the same degree as that of other pines. The strength of greenwood, or wood soaked to a point where additional immersion no longer changes the volume, is independent of differences in moisture. This is quite clear from the test in uniformity of the scantling immersed for three months. Though the blocks differed (especially near the ends) within wide limits as to the amount of moisture they contained, yet the strength was found to be as uniform as in evenly dried timber. By drying green or fully saturated wood to about 2 per cent moisture (kiln-drying at 80° C.), the strength is more than doubled; and even if pieces well air-dried are kiln-dried the strength is still increased by over 40 per cent. For timber to be used under cover and kept properly ventilated, it is safe to presume that the strength, once seasoned, will be 50 per cent greater than when green, and if used in heated rooms, an increase of 100 per cent on the strength of the green timber may reasonably be expected. The diagram (fig. 18) well illustrates this feature.

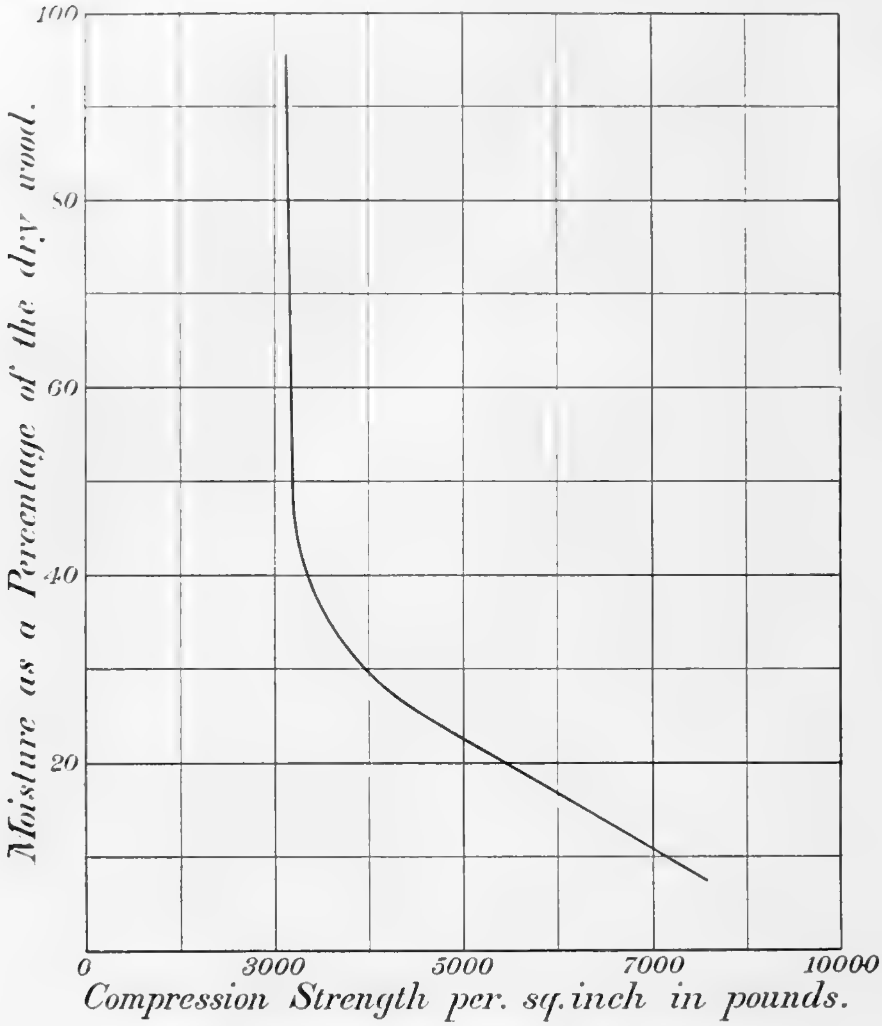


FIG. 18.—Diagram showing effect of moisture on crushing strength.

DURABILITY.

With regard to its durability, White Pine is generally underrated. The soft, light-colored wood suggests general frailty and a lack of resistance, in which resistance to decay is included. In the region where it grows the unusual great durability of the heartwood of White Pine is well known; "the stumps of White Pine last a lifetime;" old logs, covered with moss and often with young Poplars and Birch growing from their surface are uncovered and utilized as shingle bolts. White Pine shingles wear out, but rarely decay, and a good sidewalk of White Pine is considered the best to be had. As in other pines, the sapwood decays readily, but this being narrow in good logs, more than half of all White Pine sawed is good durable heart, a wood which is neither subject to decay nor to the boring insects any more than the heavy resinous heart of the Red Pine or of the Southern pines.

COMPARISON WITH OTHER WOODS.

Generally White Pine is logged and milled on a large scale, cut mostly into boards and plank, and there is to-day no common wood which is more economically handled and more carefully selected.

Compared to other pines, the White Pine is offered more extensively and has a greater influence on lumber markets than any other wood used. It is more uniform, lighter, softer, and shrinks less than any other pine; it is durable, insect proof, and suited to a much greater number of uses than the wood of other pines.

The following table exhibits the position of White Pine as to weight and strength:

Weight and strength of White Pine compared with other pines.

Name of pines.	Specific gravity.		Bending.				Compression endwise.	
			Rupture.		To relative elastic limit.			
	Actual.	Relative.	Pounds per square inch.	Relative.	Pounds per square inch.	Relative.	Pounds per square inch.	Relative.
Longleaf	61	100	12,800	100	10,300	100	8,300	100
Loblolly	53	87	11,800	92	9,500	92	7,800	94
Shortleaf	51	84	10,400	81	7,800	76	6,500	78
Red or Norway	48	78	[illegible],100	71	7,700	75	6,700	81
White	38	62	7,900	62	6,400	62	5,200	62

Of the several columns, that on specific weight being at once the simplest and most truly representative of the entire stem of mature timber, illustrates probably the relative position of these five pines most perfectly. The Southern pines, if only the saw timber is considered, will prove even heavier and stronger by several per cent than appears from this table.

USES OF WHITE PINE.

There is no wood in the United States, perhaps in the world, of which there is a greater quantity used, nor one which is put to a greater variety of uses than that of the White Pine. At present the great mass of White Pine, probably not less than 95 per cent of the entire output, is cut into even lengths, usually 12 to 18 feet long, preferably 16 feet (full 75 per cent being 16 feet), and is converted principally into boards, plank, and "dimension stuff," 1 to 4 inches thick and 4 inches and upward in width, the widths varying always by an even number of inches.

In all the better mills the slabs are cut into laths, pickets, etc., while the thickest slabs and the sound portions of very defective logs are cut into shingles. These "shingle cants" are of variable sizes, usually containing knots and decayed portions; these defects in the shingle are cut out subsequently by the knot sawyers. Shingles of regular widths are rarely made. In the sawing of the great mass of lumber the main saw merely cuts slices of various thicknesses from the logs, and their conversion into certain widths, as well as the removal of uneven edges, is left to the edger, on whose knowledge and skill much of the success of the mill depends. Usually the clear stuff, whenever possible, is left in broad and thick planks; the rest is cut into different widths so as to insure the greatest value, in most cases boards of extra width and select boards, for siding, etc., receiving preference and determining the conversion. The clear stuff, or "uppers," rarely forming over 15 per cent of the cut in our times, are used by manufacturers of sash, doors, and blinds, and by furniture men, and the most select portions by model makers and other special manufacturers where the price of the material is of secondary consideration. For material of this kind the consumer generally pays over \$50 per 1,000 feet B. M., and in some cases it is retailed at over \$100. Of the remainder, the great mass is used in the construction of frame houses, where commonly everything of wood, from cellar to roof, is made of this material. Of the inferior grades, enormous quantities are used for boxes, and much also is used as fencing and barn lumber.

For box shooks, straight-stave cooperage, pails, tubs, etc., a great deal of small sapling pine is employed. Smaller quantities of better-grade White Pine are used in mill constructions (for chutes, elevators, etc.); also in the manufacture of farm implements, for large surfaces, panelwork, etc., and in boat and ship building for decking, in fitting up cabins, for all kinds of spars, where its lightness, stiffness, and durability, together with its fine form and dimensions, render it a special favorite.

Considerable quantities of hewn and round timbers are still brought to market for export, but on the whole this trade is insignificant when compared to the entire output.

White Pine is universally seasoned in the yard; most of the lumber does not reach the consumer until a year after manufacture. The ease of working induces the consumers to do a great deal of resawing. The flooring, and even siding for the smaller markets, and for cheap construction are commonly the selected parts of sheathing and other inferior grades, as classed at the mill, and it is rare to find, in recent years, the best grades of White Pine in the smaller retailers' yards.

In the classification of White Pine a great degree of finesse has been introduced, and the closest attention is paid here, as well as in edging and trimming, to the probable future use of a given piece of material.

From the enormous consumption of White Pine alone, and also from the great variety of uses to which it is put, it is clear that any material diminution of supplies must affect extensively and intimately the wood market and wood industries of this country. The common claim of substitution of some other pine or conifer, and still more the belief in the use of hardwoods in the place of White Pine, have but little in their favor. A shipping case of White Pine requires about half the effort to make and only 50 to 65 per cent of the effort to haul or handle as one made of Southern Pine, its most natural substitute. Similarly, a White Pine lath nails with half the effort, shrinks less, and thus is far more satisfactory than one made of hard pine. For a good door or for satisfactory sash and blinds only the Cypress and White Cedar can enter as a substitute, and both are too restricted in their occurrence, and the Cypress has too little chance of future regeneration to deserve consideration as a general substitute. The transportation of Pacific coast timbers, a small portion of which have the properties of White Pine, to the densely populated Eastern United States is not likely to occur on a large scale, for the cost of hauling alone equals the value of good grades of Eastern lumber.

APPENDIX.

TABLES OF MEASUREMENTS.

APPENDIX.

TABLES OF MEASUREMENTS.

The following tables record the detail investigations, measurements, and tabulations which have served as a basis for the discussion of the growth of the White Pine. The measurements in the field were made by Mr. Austin Cary, of Bangor, Me., and by Mr. A. K. Mlodziansky, of the Division of Forestry. Mr. Mlodziansky has also executed the laborious calculations, and is responsible for their accuracy.

The methods employed in this investigation have been described in general in Bulletin No. 20, "Measuring the forest crop," of the Division of Forestry. They are in the main similar to those practiced by European foresters, with some minor and one important modification, which latter Mr. Mlodziansky has developed during the course of his work in collating the data. This modification, which refers to the analyzing of trees for ascertaining the rate of growth, consists in grouping by age classes, and instead of analyzing each single-measured tree, as is usually done in European practice, averages the data of measurement from a number of trees grouped and then analyzes the growth of the average tree thus constructed of each age class or group. In this way the work of collating is very considerably reduced and the measurements of a very much larger number of trees can be expeditiously utilized for average statement. It is needful, however, in order to be quite satisfactory, that the classification or grouping of trees be made in the woods while measuring, a task which requires considerable judgment. When the classification is so done in the woods, the mechanical work is further simplified by entering the measurements for each group in sets, the measurements of cross sections taken at the same height being entered on the same sheet for all trees of the group, when the averaging of the measurements can at once be performed on the same sheets.

The forms used in the investigation are also appended, and will serve to further elucidate the methods pursued.

Since it was not expedient to fell trees specially for these measurements, it was not always possible to secure all measurements in the most desirable form; for instance, the desirable measurement and correlation to age of diameters at breast height, and at short intervals of the height, could not be obtained, because the work was performed on trees cut in regular lumbering operations; hence, the data had to be manipulated and interpolations used so as to secure satisfactory approximations for the periodic growth. The number of trees analyzed (some 700) is so large that any deficiency of method may be considered as neutralized.

TABLES OF CUBIC AND BOARD CONTENTS OF WHITE PINE.

The tables of cubic and board contents of White Pine are based upon the measurements of pine taken for analysis from the various sites described in the tabulations of acre yields.

The stem of each individual tree was calipered at intervals of 4 or 8 feet, and the volumes of the portions between two successive diameter measurements were calculated separately, considering them as frustrums of cones. From the volumes of stems of similar height and diameter, breast high, the average volume was noted. The volumes of stems of missing dimensions was calculated by employing the corresponding factors of shape. The factor of shape is determined by dividing the volume of a tree by that of a cylinder of the same height and diameter, breast high; it shows the taper of the stem and is usually expressed in decimals, thus representing arithmetically the form of the stem. For determining the volume of a tree by means of the factor of shape, it is necessary only to measure the diameter and height of the tree, find the volume of a cylinder of the corresponding height and diameter, and multiply that volume by the factor of shape.

The lumber of stems in board feet was determined by employing Scribner's rule.

TABLE I.—*Volumes of boles of White Pine.*

[Age of trees, 30 to 250 years.]

Diameter (breast high).	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	Diameter (breast high).	Factor of shape of the boles.
	Height of trees, in feet. — Contents of the boles with bark, in cubic feet.																														
Ins.																														*Ins.*	
5	2.4	2.8	3.1																											5	0.513
6		3.9	4.5	5.0	5.5																									6	.507
7		5.4	6.0	6.7	7.4	8.0																								7	.502
8		6.9	7.8	8.7	9.5	10.4																								8	.497
9		8.7	9.8	10.9	12.0	13.0	14.1																							9	.492
10		10.7	12.0	13.3	14.6	15.9	17.3	18.6																						10	.488
11		12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0	25.6	27.2	28.8	30.4	32.0																11	.484
12			17.0	18.9	20.8	22.7	24.6	26.5	28.4	30.3	32.2	34.1	36.0	37.9																12	.480
13			19.8	22.0	24.2	26.4	28.6	30.8	33.0	35.2	37.4	39.6	41.8	44.0	46.2	48.4	50.6	52.8												13	.477
14			22.8	25.3	27.8	30.3	32.8	35.3	37.8	40.3	42.8	45.3	47.8	50.3	52.8	55.3	57.8	60.3												14	.474
15					31.7	34.6	37.5	40.4	43.3	46.2	49.1	52.0	54.9	57.8	60.7	63.6	66.5	69.4	72.3											15	.470
16						38.9	42.1	45.3	48.5	51.7	54.9	58.1	61.3	64.5	67.7	70.9	74.1	77.3	80.5											16	.465
17						43.4	47.0	50.6	54.2	57.8	61.4	65.0	68.6	72.2	75.8	79.4	83.0	86.6	90.2											17	.460
18							51.9	55.9	59.9	63.9	67.9	71.9	75.9	79.9	83.9	87.9	91.9	95.9	99.9											18	.452
19							56.9	61.3	65.7	70.1	74.5	78.9	83.3	87.7	92.1	96.5	100.9	105.3	109.7	114.1										19	.445
20									72.0	76.8	81.6	86.4	91.2	96.0	100.8	105.6	110.4	115.2	120.0	124.8										20	.440
21									77.6	82.8	88.0	93.2	98.4	103.6	108.8	114.0	119.2	124.4	129.6	134.8	140.0									21	.430
22											95.6	101.2	106.8	112.4	118.0	123.6	129.2	134.8	140.4	146.0	151.6									22	.426
23											104.0	110.1	116.2	122.3	128.4	134.5	140.6	146.7	152.8	158.9	165.0	171.1	177.2							23	.424
24											113.0	119.6	126.2	132.8	139.4	146.0	146.6	153.2	159.8	166.4	173.0	179.6	186.2							24	.423
25											121.7	128.8	135.9	143.0	150.1	157.2	164.3	171.4	178.5	185.6	192.7	199.8	206.9							25	.420
26												138.8	146.5	154.2	161.9	169.6	177.3	185.0	192.7	200.4	208.1	215.8	223.5							26	.419
27												149.6	157.9	166.2	174.5	182.8	191.1	199.4	207.7	216.0	224.3	232.6	240.9	249.2						27	.418
28													169.4	178.3	187.2	196.1	205.0	213.9	222.8	231.7	240.6	249.5	258.4	267.3	276.2					28	.417
29													180.8	190.3	199.8	209.3	218.8	228.3	237.8	247.3	256.8	266.3	275.8	285.3	294.8					29	.415
30													192.6	202.7	212.8	222.9	233.0	240.1	250.2	260.3	270.4	280.5	290.6	300.7	310.8					30	.413
31													205.1	215.9	226.7	237.5	248.3	259.1	269.9	280.7	291.5	302.3	313.1	323.9	334.7					31	.412
32														229.0	240.4	251.8	263.2	274.6	286.0	297.4	308.8	320.2	331.6	343.0	354.4					32	.410
33														242.9	255.0	267.1	279.2	291.3	303.4	315.5	327.6	339.7	351.8	363.9	376.0	388.1				33	.409
34														257.2	270.1	283.0	295.9	308.8	321.7	334.6	347.5	360.4	373.3	386.2	399.1	412.0				34	.408
35															285.5	299.1	312.7	326.3	339.9	353.5	367.1	380.7	394.3	407.9	421.5	435.1	448.7	462.3	475.9	35	.407
36															301.3	315.6	329.9	344.2	358.5	372.8	387.1	401.4	415.7	430.0	444.3	458.6	472.9	487.2	501.5	36	.406
37																332.6	347.7	362.8	377.9	393.0	408.1	423.2	438.3	453.4	468.5	483.6	498.7	513.8	528.9	37	.405
38																	365.9	381.8	397.7	413.6	429.5	445.4	461.3	477.2	493.1	509.0	524.9	540.8	556.7	38	.404
39																			418.1	434.8	451.5	468.2	484.9	501.6	518.3	535.0	551.7	568.4	585.1	39	.403
40																			437.4	454.9	472.4	489.9	507.4	524.9	542.4	559.9	577.4	594.9	612.4	40	.401
41																						513.4	531.7	550.0	568.3	586.6	604.9	623.2	641.5	41	.400
42																						537.4	556.6	575.8	595.0	614.2	633.4	652.6	671.8	42	.399
43																						561.9	582.0	602.1	622.2	642.3	662.4	682.5	702.6	43	.398
44																						586.9	607.8	628.7	649.6	670.5	691.4	712.3	733.2	44	.397
45																						612.3	634.2	656.1	678.0	699.9	721.8	743.7	765.6	45	.396
46																						638.2	661.0	683.8	706.6	729.4	752.2	775.0	797.8	46	.395
H't.	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	Height.	

TABLE II.—*Actual tapering and board contents of stems of White Pine from 5 to 51½ inches in diameter, breast high.*

Height of tree in feet.	Diameter (in inches) with bark at a height from ground of—								Number of 16-foot logs of 5 inches and more at small end.	Lumber.	Height of tree in feet.	Diameter (in inches) with bark at a height from ground of—								Number of 16-foot logs of 5 inches and more at small end.	Lumber.
	Breast high.	16 feet.	32 feet.	48 feet.	64 feet.	80 feet.	96 feet.	112 feet.				Breast high.	16 feet.	32 feet.	48 feet.	64 feet.	80 feet.	96 feet.	112 feet.		
35	5.2	4.0	1.2	......	......	......	......	......	......	......	135	25.2	22.2	20.6	19.2	16.8	14.3	11.5	7.3	7	1,018
45	5.1	4.3	2.6	......	......	......	......	......	......	......	145	25.1	22.2	20.6	18.8	17.4	15.2	12.6	9.9	7	1.093
40	6.0	5.0	2.3	......	......	......	......	......	1	......	90	26.5	21.3	19.3	16.4	12.3	6.8	......	......	5	630
55	6.2	5.4	3.9	1.7	......	......	......	......	1	......	105	26.0	21.9	20.2	18.5	14.8	9.1	......	......	5	832
45	7.1	5.7	3.2	......	......	......	......	......	1	8	115	25.9	22.7	21.3	19.0	16.7	12.9	8.9	......	6	971
60	7.2	6.2	5.0	2.4	......	......	......	......	2	12	125	26.1	22.5	20.5	19.0	16.6	13.5	10.1	......	6	971
50	8.1	6.7	4.2	......	......	......	......	......	1	8	135	26.2	22.7	21.0	19.7	18.7	16.3	13.8	10.2	7	1,227
55	8.0	6.8	5.3	2.2	......	......	......	......	2	12	145	26.0	22.2	21.0	19.5	17.9	16.1	13.6	10.6	7	1,177
55	9.1	7.7	5.6	2.8	......	......	......	......	2	19	105	27.1	22.9	21.2	18.8	15.0	11.7	......	......	5	925
45	9.5	8.0	4.2	......	......	......	......	......	1	15	115	27.0	22.6	20.4	18.7	16.5	9.3	5.6	......	6	887
70	9.2	7.7	6.5	......	......	......	......	......	2	23	125	27.0	22.7	21.1	19.4	16.4	14.1	10.4	5.3	7	983
55	10.1	8.7	6.3	3.6	......	......	......	......	2	30	140	26.8	23.6	22.2	20.8	19.0	15.1	12.6	......	6	1,229
70	10.2	9.1	8.1	5.5	......	......	......	......	3	48	150	27.0	23.1	21.0	19.0	17.5	15.2	12.0	......	6	1,109
45	11.3	8.8	4.1	......	......	......	......	......	1	22	70	28.0	24.2	21.0	18.0	......	......	......	......	3	784
55	11.2	9.2	6.8	3.4	......	......	......	......	2	37	90	28.5	23.6	21.9	19.5	15.5	7.3	......	......	5	974
65	11.1	9.6	8.2	5.5	2.7	......	......	......	3	55	105	28.0	22.9	20.6	17.9	14.2	9.3	4.0	......	5	828
55	12.3	10.0	7.0	3.0	......	......	......	......	2	44	115	28.3	23.0	21.0	19.3	16.5	12.9	7.8	......	6	999
80	12.1	10.6	9.3	7.5	4.2	......	......	......	3	80	125	28.4	24.8	22.7	20.9	18.4	15.1	8.4	4.7	7	1,230
60	12.0	10.0	7.5	3.8	......	......	......	......	2	44	140	28.3	24.8	23.1	21.6	20.0	17.4	14.5	11.7	7	1,515
45	13.5	10.9	4.2	......	......	......	......	......	1	36	155	28.1	25.3	24.2	22.5	20.7	19.0	16.7	12.0	7	1,743
60	13.2	10.9	8.1	3.4	......	......	......	......	2	58	100	29.0	23.7	21.2	18.8	15.4	10.4	8.6	......	6	934
75	13.0	11.1	10.0	7.5	5.0	......	......	......	4	87	85	29.0	23.0	20.0	14.5	8.5	......	......	......	4	671
80	13.1	11.8	10.2	8.5	6.0	4.7	......	......	5	115	115	29.1	25.0	22.8	20.6	17.2	12.5	7.9	......	6	1.203
95	13.2	12.0	10.6	8.2	5.7	......	......	......	4	122	130	29.0	24.2	22.6	21.1	18.9	15.2	12.0	7.4	7	1.279
120	13.0	12.2	11.5	10.3	9.5	8.0	6.5	......	6	193	145	29.1	24.8	23.1	21.4	19.8	18.2	15.4	12.1	7	1,518
55	14.2	11.9	8.2	3.7	......	......	......	......	2	71	100	30.0	26.5	23.8	22.5	16.5	......	......	......	4	1,268
65	14.2	12.0	9.7	4.5	......	......	......	......	2	93	110	30.1	24.6	22.1	20.4	17.6	12.5	6.5	......	6	1.114
75	14.2	12.1	10.8	8.5	4.9	......	......	......	4	126	120	30.1	25.1	23.2	21.0	18.4	14.3	9.3	......	6	1.278
85	14.2	12.9	11.3	8.7	5.5	4.0	......	......	4	139	130	30.1	25.8	23.6	21.6	19.1	15.1	10.7	8.0	7	1,388
95	14.0	12.3	11.4	9.5	7.0	3.3	......	......	4	157	145	30.0	26.2	24.8	22.9	21.0	18.9	16.3	12.3	7	1.825
70	14.7	13.0	10.7	7.2	......	......	......	......	3	115	95	31.0	26.7	23.8	19.7	14.2	11.7	10.0	......	6	1,120
85	15.0	13.3	11.8	9.7	6.2	......	......	......	4	167	115	31.1	27.1	24.3	21.2	18.1	13.2	9.3	......	6	1.318
95	15.0	13.4	12.0	10.2	7.8	5.1	......	......	5	200	125	31.0	25.1	22.7	20.8	17.9	15.1	10.0	......	6	1.202
115	15.1	13.9	12.9	11.7	10.3	8.5	6.8	......	6	284	135	31.2	26.7	24.2	22.7	20.7	18.5	14.3	10.2	7	1.650
60	16.0	14.0	9.5	6.2	......	......	......	......	3	118	145	31.1	26.7	24.6	22.7	20.8	18.3	15.9	11.5	7	1.684
85	16.1	14.0	12.3	10.0	6.6	......	......	......	4	189	105	32.0	28.3	25.5	22.7	17.6	12.3	10.0	......	6	1,395
95	16.4	14.1	13.0	11.1	8.3	5.5	......	......	5	237	115	32.0	27.2	24.9	23.2	19.1	13.9	7.1	......	6	1,409
105	16.4	14.3	12.9	11.6	9.6	6.8	......	......	5	274	125	31.9	27.1	24.9	24.0	20.9	16.2	13.4	5.4	7	1,621
120	16.5	15.5	14.0	13.0	12.0	10.0	7.5	......	6	317	135	32.0	25.9	23.9	21.5	19.1	16.5	12.6	10.0	7	1.390
60	17.0	14.3	8.0	......	......	......	......	......	2	96	145	32.2	28.2	26.4	24.2	22.1	19.9	16.3	13.3	7	2.023
125	17.0	14.9	13.0	11.6	10.0	6.8	......	......	5	257	155	32.2	27.4	26.1	24.1	22.9	21.3	18.5	15.4	7	2,181
75	17.0	14.7	12.8	9.4	4.2	......	......	......	3	193	110	33.2	29.4	26.2	22.6	18.2	11.0	......	......	5	1.511
85	17.1	14.6	13.3	11.0	6.7	2.6	......	......	4	208	125	33.1	28.7	26.0	23.8	21.3	16.7	11.6	......	6	1.779
95	17.0	15.2	13.5	11.9	9.1	5.6	2.0	......	5	263	135	33.1	28.0	25.8	24.0	21.7	18.0	12.6	9.0	7	1,787
110	16.9	15.0	13.9	12.2	10.7	8.0	......	......	5	303	145	33.2	27.9	25.8	24.5	22.6	20.0	16.8	12.7	7	1.965
75	18.5	16.0	13.8	10.2	3.5	......	......	......	3	238	105	34.0	30.0	24.5	21.5	16.5	10.0	......	......	5	1,341
85	18.2	15.4	13.7	11.0	5.2	3.0	......	......	4	221	115	34.0	27.9	25.7	22.7	18.5	13.9	9.0	......	6	1.445
90	18.0	15.2	13.3	11.7	8.6	4.8	......	......	5	235	125	34.2	28.7	26.1	23.9	21.0	14.9	8.0	5.1	7	1.705
105	18.2	16.0	14.5	13.0	10.2	7.2	......	......	5	336	135	34.0	28.3	25.6	24.3	22.2	19.1	15.1	11.7	7	1.877
120	17.8	17.0	15.5	14.0	12.0	10.0	7.0	......	6	397	145	34.0	29.4	27.1	25.3	23.4	20.4	17.5	13.7	7	2,259
80	17.8	15.4	12.9	9.8	5.0	......	......	......	3	197	155	34.3	29.2	27.7	25.5	23.7	22.0	19.5	15.3	7	2,408
65	19.1	15.9	12.4	8.5	......	......	......	......	4	192	115	35.0	27.8	25.3	23.7	20.3	14.4	10.9	......	6	1.550
85	19.0	16.5	14.9	11.9	7.9	......	......	......	4	333	125	35.1	27.8	25.8	23.6	20.8	17.2	12.6	7.0	7	1 672
95	19.2	16.3	14.9	12.8	9.4	6.0	......	......	5	322	135	35.2	30.5	28.1	25.7	23.0	20.8	17.5	12.7	7	2,368
105	19.1	16.6	15.2	13.1	11.0	8.2	7.1	......	6	394	145	35.2	30.5	28.0	26.0	23.7	20.0	14.6	12.2	7	2.309
125	19.1	17.1	16.0	14.8	13.8	12.0	9.5	9.0	7	568	155	35.2	30.3	28.5	26.3	21.5	22.3	19.3	15.7	7	2.512
80	20.0	17.4	15.0	10.9	6.8	3.0	......	......	4	288	175	35.0	31.0	29.0	28.0	27.0	24.0	23.0	18.0	7	3.067
95	20.2	17.5	16.2	13.5	10.5	5.8	......	......	5	411	105	36.2	29.5	25.0	22.5	19.5	10.0	......	......	5	1.490
105	20.2	17.4	15.9	14.1	11.1	7.3	3.0	......	5	410	115	36.1	28.3	26.1	23.0	18.1	14.3	9.2	......	6	1.521
120	20.3	18.0	16.9	15.1	13.6	11.9	9.2	5.0	7	576	125	36.0	28.0	23.9	22.1	19.2	15.0	14.0	......	6	1.474
85	21.1	18.5	16.7	13.7	9.4	......	......	......	4	423	135	36.0	29.0	28.0	19.0	14.0	10.0	......	......	5	1,285
95	20.9	18.6	16.9	14.5	11.4	5.7	......	......	5	466	155	36.0	31.3	30.0	28.0	25.0	22.8	18.9	15.0	7	2,800
105	21.0	18.5	16.9	14.5	11.9	7.8	3.5	......	5	477	105	37.0	30.0	25.0	21.5	19.0	14.0	......	......	5	1,509
115	21.3	18.4	17.4	15.5	13.6	10.9	7.0	......	6	566	125	36.9	30.5	27.9	25.1	22.7	18.3	13.1	6.0	7	2 035
135	21.0	17.3	15.8	15.0	14.3	11.3	9.5	......	6	443	145	37.0	31.8	30.5	28.7	26.5	24.2	20.8	14.2	7	2.987
85	22.0	18.2	16.0	12.8	7.6	3.2	......	......	4	369	155	37.0	29.8	26.5	25.5	23.7	24.0	18.7	14.5	7	2,396
95	22.3	19.7	18.1	15.2	11.6	6.2	3.5	......	5	522	115	38.0	30.0	25.0	23.6	19.9	13.0	8.0	......	6	1.604
105	22.1	19.5	17.9	16.0	13.3	9.8	6.7	......	6	587	125	38.0	31.5	28.5	26.3	22.9	18.5	12.5	......	6	2,204
115	22.1	19.1	17.4	15.8	13.5	10.1	6.5	......	6	586	145	38.0	31.5	23.5	22.2	20.5	17.5	13.2	10.0	7	1.751
95	22.9	19.4	17.5	14.8	11.0	5.3	......	......	5	480	130	39.0	28.8	27.7	24.0	20.0	14.8	6.8	......	6	1.706
105	23.2	19.6	17.8	15.8	12.9	8.7	......	......	5	572	155	39.0	33.0	30.0	28.5	26.0	23.0	21.5	18.0	7	3.107
115	23.1	20.1	18.8	17.1	14.9	11.7	7.7	......	6	729	135	40.0	33.0	31.2	29.5	25.3	22.0	17.3	10.2	7	2.850
140	23.2	20.1	19.2	17.7	16.4	14.7	11.9	9.0	7	912	145	41.0	37.2	33.5	31.2	28.4	25.5	20.7	15.7	7	3,561
85	24.3	20.6	18.6	15.0	9.1	4.4	......	......	4	516	140	42.0	34.5	31.8	29.0	26.2	23.0	14.3	9.1	7	2.817
100	24.1	21.0	19.0	16.6	12.4	9.0	7.5	......	6	697	150	43.0	36.8	34.1	32.3	29.7	26.2	21.8	16.3	7	3,810
115	24.0	20.4	18.9	17.3	14.6	10.9	6.8	......	6	709	135	44.0	35.6	33.9	30.7	28.7	24.4	19.5	20.0	7	3,589
120	24.2	21.3	19.3	18.2	16.3	12.6	9.9	5.7	7	839	145	45.0	37.5	34.4	30.6	28.0	23.8	18.3	13.2	7	3,411
140	24.2	21.0	19.3	18.2	16.4	14.5	9.8	8.0	7	916	140	46.0	30.0	23.0	22.5	20.0	19.0	18.0	10.0	7	1,665
85	25.0	21.3	19.0	16.5	9.7	3.5	......	......	4	625	165	46.0	38.7	35.8	34.4	32.4	29.1	25.1	21.3	7	4.702
95	25.2	21.4	19.7	16.8	10.7	4.4	......	......	4	661	160	47.0	40.4	37.4	35.3	32.4	29.6	25.9	20.9	7	4,960
105	25.1	21.2	19.5	17.5	13.9	10.1	......	......	5	738	140	50.0	41.0	38.0	35.0	31.0	27.0	21.5	13.0	7	4,483
115	25.0	21.0	19.2	17.3	14.7	11.7	7.6	......	6	760	150	51.5	41.5	38.0	34.0	31.5	23.0	18.5	15.5	7	4,350
125	25.0	22.0	20.3	19.3	17.3	14.5	11.0	8.5	7	1,012											

TABLE III.—*Measurements of White Pine grown under similar conditions, grouped in age classes for averaging.*

[The groups of trees measured are sample trees recorded in Table VI.]

Group, location, and description of site.	Tree number.	Age.	Diameter with bark (breast high).	Total height.	Factor of shape.	Ratio of the length of crown to the total height of the tree.	Volume of boles.	Accretion.	
								Current annual.	Average annual.
GROUP A.									
Massachusetts and New Hampshire.		*Yrs.*	*Inches.*	*Feet.*			*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
White Pine mixed with hardwoods on a hill. Soil, brown or yellowish sandy loam, medium-sized grain, light, loose, fresh, and well drained, with a leafy surface cover. Trees, 400-500 to the acre.	21	33	6.5	51.3	0.57	0.37	6.7	....	....
	33	42	8.6	65.3	.51	.34	13.1	....	....
	2	48	8.5	60.0	.58	.21	13.8	....	....
	19	39	9.2	55.2	.58	.42	14.3	....	....
	3	48	9.2	62.5	.57	.35	15.6	....	....
	31	41	9.5	63.0	.57	.36	16.0	....	....
	27	47	9.1	64.0	.56	.40	15.9	....	....
	25	47	10.0	62.7	.50	.35	17.0	....	....
	20	36	11.2	53.0	.52	.54	18.4	....	....
	32	44	10.3	70.0	.50	.34	21.3	....	....
	1	55	13.0	71.5	.50	.48	32.7	....	....
	26	47	12.8	69.5	.52	.37	33.1	....	....
Average..	......	44	9.8	62.3	.53	.38	18.1	0.60	0.41
GROUP B.									
Massachusetts and New Hampshire.									
White Pine on a level plain site. Soil, a brown or yellow-brown loamy sand, underlaid by sand or sand with gravel in medium or sometimes coarse grain, shallow, porous, light, moderately loose, fresh, and well drained, with an abundant leafy surface cover. Trees, 350-400 to the acre.	28	41	6.8	43.8	0.47	0.42	5.6	....	....
	29	41	7.1	51.8	.51	.51	8.0	....	....
	7	39	8.3	52.0	.43	.40	8.8	....	....
	30	40	8.2	55.0	.51	.51	9.9	....	....
	8	40	9.1	58.2	.51	.26	13.0	....	....
	6	49	9.5	63.7	.51	.43	16.3	....	....
	12	49	10.2	68.0	.45	.47	16.6	....	....
	11	50	10.3	63.0	.50	.46	19.0	....	....
	4	54	11.2	59.0	.51	.37	19.7	....	....
	9	39	12.0	59.1	.48	.51	22.4	....	....
	10	51	12.5	69.9	.52	.41	31.3	....	....
	5	52	13.7	71.5	.51	.42	36.3	....	....
Average	......	45	9.9	60.0	.50	.44	17.0	0.50	0.38
Pennsylvania.									
White Pine intermixed with hardwoods and occasional Hemlock. Soil, clayey loam, with yellow-brown shales in it, deep, fresh, and well drained.	3	46	12.0	60.0	0.43	0.62	20.2	....	....
	12	44	11.5	58.5	.47	.55	20.0	....	....
	2	44	12.5	55.0	.41	.67	19.4	....	....
	8	47	11.0	59.0	.48	.49	18.7	....	....
	16	47	11.5	56.0	.45	.50	18.3	....	....
	9	45	11.0	58.5	.49	.52	17.9	....	....
	5	47	10.5	60.0	.48	.43	17.3	....	....
	6	47	10.0	59.0	.51	.46	16.4	....	....
	21	48	10.5	58.0	.46	.48	16.3	....	....
	19	47	11.0	55.0	.42	.49	15.4	....	....
Average	......	46	11.0	58.0	.45	.52	18.0	0.70	0.39
GROUP C.									
Maine.									
White Pine with scattering Hemlock, occasional Spruce and Fir, on a level plain site; scanty undergrowth of Hazel and young Hemlock. Soil, gray sand, sometimes brown or loamy, with 3 inches vegetable mold, deep, fresh, leafy surface cover; clayey subsoil probably 4 or 5 feet below surface. Density of crown cover, 0.7. Trees, 370 to the acre.	9	50	14.5	64	0.45	0.55	33.1	....	....
	4	59	13.3	60	.44	.58	26.4	....	....
	8	55	12.8	61	.45	.38	25.6	....	....
	3	50	11.8	58	.52	.41	20.1	....	....
	10	59	10.2	65	.59	.35	22.0	....	....
	12	50	11.0	62	.50	.35	21.1	....	....
Average	......	54	12.3	62	.49	.44	24.7	0.94	0.46
Pennsylvania.									
From a young White Pine grove mixed with mature Spruce, Hemlock, and scattering hardwoods. Soil, fresh sand, well drained.	1	64	14.5	54	0.46	0.66	28.7	....	....
	2	57	14.5	58	.47	.66	31.4	....	....
	3	50	8.5	50	.48	.60	9.5	....	....
	4	47	8.0	46	.45	.61	7.3	....	....
	5	52	11.0	50	.43	.60	14.2	....	....
	6	49	11.5	46	.47	.61	15.7	....	....
	7	52	9.5	53	.46	.66	12.1	....	....
	8	54	8.0	54	.53	.66	10.1	....	....
	9	54	10.0	56	.48	.68	14.7	....	....
Average	......	53	10.5	52	47	.64	16.0	0.68	0.30
GROUP D.									
Wisconsin.									
An open grove of hardwoods, in which White Pine is scattered in varying proportions, on broken land, with frequent swamps in the hollows; undergrowth, of young hardwoods, Fir, few Hemlock, and Hornbeam. Soil, light-brown sandy loam, medium fine grain, loose, deep, fresh, and well drained, with an abundant leafy surface cover.	22	82	14.0	82	0.49	0.39	43.0	....	....
	23	81	14.7	84	.50	.42	48.0	....	....
	31	83	15.0	82	.48	.41	48.1	....	....
	27	79	15.0	83	.48	.31	50.8	....	....
	30	81	19.0	85	.46	.37	78.2	....	....
	33	89	18.7	96	.47	.51	85.7	....	....
Average..	......	82½	16.0	85	.48	.40	58.9	2.16	0.71

Table III.—*Measurements of White Pine grown under similar conditions, grouped in age classes for averaging*—**Continued.**

Group, location, and description of site.	Tree number.	Age.	Diameter with bark (breast high).	Total height.	Factor of shape.	Ratio of the length of crown to the total height of the tree.	Volume of boles.	Accretion. Current annual.	Accretion. Average annual.
GROUP E.									
Maine.									
		Yrs.	*Inches.*	*Feet.*			*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
White Pine with scattering Red and White Oak, and occasional Norway Pine, on a level; undergrowth, moderately dense, of small Hemlock and Beech, with numerous small Maple and Oak. Soil, gray or brown, fine, loamy sand, fresh, with 2 or 3 inches mold on top, and leafy surface cover; clay probably some feet below surface. Density of crown, 0.7. Trees, 126 to the acre.	7	98	28.0	100	0.41	0.60	175.3	....	....
	12	92	28.0	103	.36	.61	161.0	....	....
	13	98	25.0	92	.46	.48	140.3	....	....
	17	92	25.5	91	.42	.56	136.3	....	....
	18	92	25.0	88	.44	.46	131.7	....	....
	23	97	22.0	98	.46	.49	119.4	....	....
	21	97	20.6	102	.35	.45	118.1	....	....
	16	90	22.5	91	.46	.52	115.1	....	....
	9	102	20.0	100	.47	.43	104.0	....	....
	20	100	20.3	103	.41	.40	98.8	....	....
Average..........		96	23.7	97	.42	.50	130.0	2.10	1.35
GROUP F.									
Maine.									
White Pine with scattering Red and White Oak, and occasional Norway Pine, on a level; undergrowth, moderately dense, of small Hemlock and Beech, with numerous small Maple and Oak. Soil, gray or brown, fine, loamy sand, fresh, with 2 or 3 inches mold on top, and leafy surface cover; clay probably some feet below surface. Density of crown cover, 0.7. Trees, 126 to the acre.	4	101	20.5	95	0.43	0.40	93.3	....	....
	8	98	19.5	99	.43	.33	88.4	....	....
	22	98	19.0	96	.45	.35	84.9	....	....
	10	89	16.8	99	.46	.40	71.3	....	....
	14	93	18.5	92	.41	.52	69.9	....	....
	28	93	18.5	80	.48	.41	68.4	....	....
	19	89	18.7	79	.45	.48	67.2	....	....
	15	99	17.2	87	.49	.46	67.0	....	....
	11	89	17.2	89	.43	.38	60.7	....	....
Average..........		95	18.5	91	.45	.41	74.5	1.55	0.78
GROUP G.									
Michigan.									
Open grove on a level plain, along the banks of a river, of mixed White and Norway Pine, with scattering White Birch, and occasionally Oak, Hackmatack, and Banksian Pine; undergrowth scanty, of young Fir, Cedar (*Thuja occidentalis*), and few small Oaks. Soil, gray or light brown, sand,, medium fine-grained, porous, light, loose, dry (in places fresh), with a leafy surface cover.	1	100	13.5	94	0.44	0.57	41.0	....	....
	24	96	14.4	90	.47	(?)	48.7	....	....
	18	82	16.5	94	.47	.53	67.7	....	....
	9	99	20.0	100	.41	.46	9[illegible]9	....	....
Average..........		94	16.0	94½	.45	.51	61.5	2.13	0.65
GROUP H.									
Michigan.									
Open grove on a level plain, along the banks of a river, of mixed White and Norway Pine, with scattering White Birch, and occasionally Oak, Hackmatack, and Banksian Pine; undergrowth scanty, of young Fir, Cedar (*Thuja occidentalis*), and a few small Oaks. Soil, gray or light brown, sandy, medium, fine-grained, porous, light, loose, dry (in places fresh), with a leafy surface cover.	5	109	13.0	94½	.52	0.51	45.7	....	....
	23	112	14.0	96	.47	.47	50.2	....	....
	22	109	14.8	93	.45	.47	51.4	....	....
	15	106	15.3	85	.47	.37	53.3	....	....
	7	110	16.5	104	.41	.50	64.3	....	....
	6	109	17.0	101	.42	.59	67.6	....	....
	20	112	17.0	100	.45	(?)	72.4	....	....
	4	112	18.3	103	.44	.56	85.3	....	....
	19	108	20.5	105	.41	.49	99.1	....	....
	21	109	20.8	105	.39	.42	99.8	....	....
Average..........		109½	16.7	98½	.44	.46	68.9	1.64	0.63
GROUP I.									
Michigan.									
Norway Pine (67 per cent), mixed with White Pine (32 per cent), and occasional Rock Maple, on a level plain. Soil, yellow or gray sand, fresh, moderately loose, with a surface cover of brakes; subsoil, sandy. Density of crown cover, 0.7. Trees, 182 to the acre.	1	123	20.0	102	0.40	0.54	89.7	....	....
	22	101	20.8	90	.42	.51	92.7	....	....
	48	105	20.5	99	.42	.44	96.7	....	....
	47	104	22.7	94	.39	.59	103.0	....	....
Average..........		108	21.0	96	.41	.51	95.5	1.81	0.89
GROUP K.									
Wisconsin.									
An open grove of hardwoods, in which White Pine is scattered in varying proportions, on broken land, with frequent swamps in the hollows; undergrowth, of young hardwoods, Fir, few Hemlock, and Hornbeam. Soil, light-brown sandy loam, medium fine grain, loose, deep, fresh, and well drained, with an abundant leafy surface cover.	14	121	20.2	91	0.45	0.50	90.9	....	....
	28	125	24.5	89	.45	.58	131.8	....	....
	15	125	26.5	96	.39	.46	141.5	....	....
	16	125	26.3	105	.47	.53	176.8	....	....
	17	119	29.0	97	.42	.57	159.5	....	....
Average..........		123	25.3	95	.44	.53	145.5	2.92	1.19

TABLE III.—*Measurements of White Pine grown under similar conditions, grouped in age classes for averaging*—Continued.

Group, location, and description of site.	Tree number.	Age.	Diameter with bark (breast high).	Total height.	Factor of shape.	Ratio of the length of crown to the total height of the tree.	Volume of boles.	Accretion. Current annual.	Accretion. Average annual.
GROUP L.									
Michigan.		*Yrs.*	*Inches.*	*Feet.*			*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
White Pine (70 per cent) intermixed with Norway Pine (14 per cent) and Hemlock (15 per cent), with scattering Cedar (*Thuja occidentalis*) and Rock Maple, and occasional Beech and White Birch, on a level plain; undergrowth, dense, of young Fir. Soil, gray sand, fresh and deep, light and loose, with a surface cover of scanty leaves; subsoil, sandy loam, underlaid by clay. Density of crown, 0.8. Trees, 156 to the acre.	34	140	19.5	124	0.42	0.34	109.8	....	....
	9	136	19.7	114	.49	.31	115.1	....	....
	33	135	20.0	115	.48	.32	121.5	....	....
	37	134	22.0	113	.31	.27	123.5	....	....
	36	136	22.5	123	.39	.30	130.1	....	....
	35	135	21.7	122	.44	.32	136.4	....	....
	2	138	22.8	119	.40	.30	138.5	....	....
	22	133	23.2	116	.42	.38	141.1	....	....
	4	130	24.0	106	.43	.40	143.5	....	....
	3	135	24.0	108	.42	.35	144.7	....	....
	1	138	23.5	113	.43	.26	146.5	....	....
	16	139	25.0	122	.44	.50	187.3	....	....
Average	......	136	22.3	116	.42	.34	136.0	1.60	1.00
GROUP M.									
Michigan.									
A two-roof grove, upper roof formed of White Pine, under roof of Beech, Maple, Fir, and occasionally White Birch and Hemlock; undergrowth, moderately dense, of young hardwoods and Fir. Soil, brown loamy sand, fresh, moderately loose, with a surface cover of brakes and grass; subsoil, sand with stones.	32	133	15.2	92	0.43	0.43	48.6	....	....
	37	141	15.5	92	.46	.42	55.3	....	....
	12	132	16.3	88	.47	.66	61.7	....	....
	40	145	18.6	100	.38	.44	71.1	....	....
	25	128	20.5	98	.42	.47	94.6	....	....
	27	153	19.0	104	.41	.38	85.0	....	....
	9	131	22.5	112	.41	.46	129.4	....	....
	26	148	23.0	116	.41	.46	137.9	....	....
	31	153	23.0	100	.47	.30	137.6	....	....
	11	136	24.6	115	.41	.40	154.1	....	....
Average	......	140	19.8	102	.43	.44	95.3	1.49	0.70
GROUP N.									
Michigan.									
Norway Pine (67 per cent) mixed with White Pine (32 per cent), and occasional Rock Maple, on a level plain. Soil, yellow or gray sand, fresh, moderately loose, with a surface cover of brakes; subsoil, sandy. Density of crown cover, 0.7. Trees, 182 to the acre.	5	149	20.2	105	0.39	0.50	88.9	....	....
	6	135	21.1	114	.39	.57	107.9	....	....
	35	135	22.0	121	.40	.43	139.6	....	....
Average	......	140	21.0	113	.39	.50	112.1	2.08	0.80
GROUP O.									
Michigan.									
White Pine (70 per cent) intermixed with Norway Pine (14 per cent) and Hemlock (15 per cent), with scattering Cedar (*Thuja occidentalis*) and Rock Maple, and occasional Beech and White Birch, on a level plain; undergrowth dense, of young Fir. Soil, gray sand, fresh and deep, light and loose, with a surface cover of scanty leaves; subsoil, sandy loam, underlaid by clay. Density of crown cover, 0.8. Trees, 156 to the acre.	27	142	23.0	117	0.41	0.30	138.9	....	....
	26	142	24.0	110	.41	.39	140.6	....	....
	11	142	23.5	114	.43	.36	148.0	....	....
	20	142	22.0	119	.49	.26	157.3	....	....
	30	143	24.2	116	.45	.38	164.3	....	....
	24	149	25.0	113	.46	.34	168.8	....	....
	5	148	26.3	115	.46	.39	205.4	....	....
Average	......	142½	24.0	115	.44	.34	160.5	2.20	1.10
GROUP P.									
Wisconsin.									
White Pine mixed more or less with Yellow Birch, Rock Maple, Norway Pine, and occasional Bass, Poplar, and Elm, on uneven land, full of drift ridges and hollows, frequently full of water. Soil, a mixture of loam, sand, and stones, with 2 to 3 inches black mold on top, and fairly covered with leaves.	3	160	23.5	104	0.40	0.40	127	....	....
	4	170	24.0	119	.46	.41	172	....	....
	5	178	24.2	114	.48	.38	176	....	....
	6	170	25.7	111	.45	.41	181	....	....
	7	175	27.3	122	.43	.46	217	....	....
	8	168	30.5	114	.44	.42	256	....	....
	15	185	23.2	110	.42	.34	138	....	....
	9	173	26.0	112	.46	.28	190	....	....
Average	......	172	25.5	113	.44	.39	182	1.44	1.00
GROUP Q.									
Michigan.									
Norway Pine intermixed with White Pine in varying proportions, on rolling land, with open places of Red Oak, Maple, and Beech; no undergrowth. Soil, light-brown sand (slightly loamy), very deep, medium fine, light, loose, dry, and well drained, with a moderately leafy surface cover.	34	182	25.2	118	0.43	0.53	173.0	....	....
	18	188	26.7	118	.45	.59	202.1	....	....
	5	186	31.0	119	.45	.40	286.6	....	....
Average	......	185	27.6	118	.44	.51	220.5	2.22	1.19

Table III.—*Measurements of White Pine grown under similar conditions, grouped in age classes for averaging*—Continued.

Group, location, and description of site.	Tree number.	Age.	Diameter with bark (breast high).	Total height.	Factor of shape.	Ratio of the length of crown to the total height of the tree.	Volume of boles.	Accretion. Current annual.	Accretion. Average annual.
GROUP R. *Wisconsin.*		*Yrs.*	*Inches.*	*Feet.*			*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
White Pine intermixed with Yellow Birch, Rock Maple, Bass, and Norway Pine, on ridge land, with hollows sometimes full of water, more often open grassy swamps, with Alder and Hackmatack, fringed by pine. Soil, red clayey loam, mixed with sand and stones of all sizes, moist; subsoil, sometimes of clay, sometimes of sand.	1	204	27.3	123	0.44	0.59	219	....	....
	2	210	25.2	137	.48	.40	227	....	....
	3	207	31.0	127	.37	.35	246	....	....
	4	200	29.5	116	.43	.51	239	....	....
	5	206	29.2	130	.46	.29	282	....	....
	6	205	30.0	133	.43	.52	284	....	....
	7	210	34.0	118	.39	.37	292	....	....
	8	214	36.0	113	.39	.38	312	....	....
	9	210	39.0	130	.38	.49	415	....	....
Average	......	207	31.2	125	.42	43	279	1.67	1.34
GROUP S. *Wisconsin.*									
White Pine intermixed with Yellow Birch, Rock Maple, Bass, and Norway Pine, on ridge land, with hollows sometimes full of water, more often open grassy swamps, with Alder and Hackmatack, fringed by pine. Soil, red clayey loam, mixed with sand and stones of all sizes, moist; subsoil, sometimes of clay, sometimes of sand.	10	211	20.2	116	0.51	0.64	132	....	....
	11	228	23.6	113	.43	.42	148	....	....
	12	220	22.8	121	.45	.45	153	....	....
	13	207	27.2	107	.46	.28	200	....	....
	14	204	27.0	121	.42	.43	204	....	....
	15	205	27.0	122	.43	.25	210	....	....
	16	212	27.8	104	.41	.51	180	....	....
	17	204	27.3	112	.41	.41	186	....	....
Average	......	211	25.4	114	.44	.42	176.5	0.88	0.83
GROUP T. *Wisconsin.*									
White Pine mixed with hardwoods, on drift and somewhat uneven land; undergrowth, of young hardwoods and Fir. Soil, clayey, underlaid by a hardpan of clay and stones, fresh with 4-inch mold on top.	1	204	24.7	102	0.49	0.45	166	....	....
	2	221	27.0	113	.41	.38	183	....	....
	3	213	27.0	121	.39	.37	191	....	....
	4	214	26.0	126	.43	.41	201	....	....
	5	216	26.8	126	.42	.40	210	....	....
	6	202	24.0	134	.44	.42	187	....	....
	7	204	29.0	132	.39	.37	238	....	....
	8	212	29.0	133	.41	.39	250	....	....
	9	213	30.0	133	.44	.42	291	....	....
Average	......	211	27.0	124	.42	.44	213	1.49	1.00
GROUP U. *Wisconsin.*									
White Pine mixed more or less with Yellow Birch, Rock Maple, Norway Pine, and occasional Bass, Poplar, and Elm, on uneven land, full of drift ridges and hollows, frequently full of water. Soil, a mixture of loam, sand, and stones, with 2 to 3 inches black mold on top, and fairly covered with leaves.	10	216	31.8	121	0.43	0.40	287	....	....
	11	222	35.0	123	.42	.46	344	....	....
	12	228	24.8	116	.41	.40	160	....	....
	13	220	24.0	100	.49	.27	156	....	....
	16	220	24.5	107	.45	.35	157	....	....
	17	218	29.0	118	.44	.49	249	....	....
Average	......	221	28.2	114	.44	.39	224	1.57	1.01
GROUP V. *Michigan.*									
A two-roof grove, upper roof formed of White Pine, under roof of Beech, Maple, Fir, and occasionally White Birch and Hemlock; undergrowth, moderately dense, of young hardwoods and Fir. Soil, brown loamy sand, fresh, moderately loose, with a surface cover of brakes and grass; subsoil, sand with stones.	41	245	20.0	120	0.43	0.46	112.56	....	....
	8	242	24.5	137	.42	.41	191.07	....	....
	30	226	27.5	138	.38	(?)	215.28	....	....
	1	226	27.5	129	.41	.38	222.29	....	....
	28	220	28.3	143	.42	.60	264.49	....	....
	34	250	30.2	141	.42	.31	291.03	....	....
	10	219	33.0	121	.44	.43	317.85	....	....
	33	226	33.0	140	.38	.49	321.86	....	....
	39	237	33.0	144	.45	.77	389.57	....	....
	29	233	37.0	147	.41	.55	455.05	....	....
	3	245	40.0	125	.43	.40	479.51	....	....
Average	......	233	30.3	135	.41	.48	296.6	1.05	1.27
GROUP W. *Michigan.*									
A two-roof grove, upper roof formed by White Pine (80 per cent) and Norway Pine (20 per cent), under roof of fine, tall Hemlock; undergrowth, of young Hemlock, Beech, and Dwarf Maple. Soil, brown loamy sand, deep, fine (for sand), porous, loose, and well drained (water stands in low ground), with a moderately leafy surface cover; subsoil, same as soil.	3	234	23.2	137	0.43	0.39	169.0	....	....
	2	236	23.8	142	.44	.43	197.3	....	....
	11	235	24.5	142	.43	.43	199.1	....	....
	1	237	23.5	140	.46	.36	202.6	....	....
	6	237	24.5	145	.43	.40	205.4	....	....
	20	251	27.0	120	.43	.36	206.8	....	....
	17	232	24.5	145	.43	.47	207.0	....	....
	10	233	25.5	143	.42	.42	212.6	....	....
	16	237	25.5	145	.44	.44	227.3	....	....
	15	235	26.0	143	.43	.23	231.1	....	....
	18	245	30.0	122	.39	.35	233.9	....	....
	9	236	26.2	145	.44	.42	240.2	....	....
	4	236	27.0	150	.45	.41	271.5	....	....
	8	238	29.0	140	.43	.40	281.1	....	....
	19	244	34.0	130	.42	.62	348.1	....	....
	12	233	32.0	144	.43	.39	349.6	....	....
Average	......	237½	26.5	140	.43	.41	236.4	1.64	0.99

TABLE III.—*Measurements of White Pine grown under similar conditions, grouped in age classes for averaging*—Continued.

Group, location, and description of site.	Tree number.	Age.	Diameter with bark (breast high).	Total height.	Factor of shape.	Ratio of the length of crown to the total height of the tree.	Volume of boles.	Accretion. Current annual.	Accretion. Average annual.
GROUP X.									
Michigan.		*Yrs.*	*Inches.*	*Feet.*			*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
A two-roof grove, upper roof formed of White Pine, under roof of Beech, Maple, Fir, and occasionally White Birch and Hemlock; undergrowth, moderately dense, of young hardwoods and Fir. Soil, brown loamy sand, fresh, moderately loose, with a surface cover of brakes and grass; subsoil, sand with stones.	14	258	26.0	119	0.37	0.40	162.54	....	....
	7	252	29.2	139	.41	.46	193.21	....	....
	38	252	25.5	157	.35	.58	205.21	....	....
	23	265	27.0	126	.41	.44	207.67	....	....
	13	253	30.0	135	.39	.45	259.13	....	....
	36	256	32.0	142	.34	.59	267.87	....	....
	4	260	31.5	132	.38	.48	275.89	....	....
	42	260	29.5	155	.42	.48	311.99	....	....
	16	251	33.0	144	.33	.41	313.07	....	....
	2	256	31.0	145	.41	.59	314.06	....	....
	35	265	31.5	144	.40	.33	314.38	....	....
	6	266	33.0	139	.38	.51	316.81	....	....
	15	256	32.0	154	.41	.33	360.75	....	....
	5	258	34.0	138	.42	.59	370.50	....	....
	17	260	36.0	149	.37	.45	404.18	....	....
Average		258	30.5	141	.39	.46	285.00	1.50	1.10
GROUP Y.									
Michigan.									
Moderately dense grove of White Pine intermixed with hardwoods and Hemlock, with occasional Norway Pine, on a level plain; undergrowth, of young Hemlock and hardwoods. Soil, brown loamy sand, medium fine grain, light, loose, very deep, fresh, well drained, with a moderately leafy surface cover.	5	417	37.0	155	0.37	0.45	433.2	....	....
	1	445	35.5	141	.52	.39	510.5	....	....
	4	455	41.0	152	.41	.53	583.7	....	....
	9	426	43.0	160	.42	.56	677.3	....	....
	8	460	46.0	150	.40	.48	694.1	....	....
	7	457	47.0	160	.37	.45	721.9	....	....
	3	461	48.0	170	.38	.56	737.9	....	....
	6	435	46.0	168	.42	.51	819.6	....	....
	10	458	47.0	162	.43	.57	855.3	....	....
Average		446	43.0	157	.41	.50	670.4	2.00	1.50
GROUP Z.									
Pennsylvania.									
Hemlock mixed with White Pine, with scattering hardwoods; undergrowth, moderately dense, of young hardwoods and Hemlock. Soil, yellow clay loam of a medium grain, deep, fresh, well drained, with 2 to 3 inches mold on top, and a surface cover of scanty leaves, Fern and Teaberries.	1	260	35.5	158	0.40	0.43	435.4	....	....
	2	260	36.0	157	.43	.42	481.3	....	....
	3	259	32.0	152	.46	.44	396.0	....	....
	4	241	32.0	150	.41	.59	347.7	....	....
	10	244	33.0	146	.42	.34	365.9	....	....
	12	262	28.0	156	.43	.43	285.8	....	....
	18	265	39.0	153	.40	.42	511.1	....	....
	19	250	34.0	150	.42	.48	402.4	....	....
	20	266	44.0	144	.42	.30	638.4	....	....
	21	245	34.0	146	.40	.37	366.7	....	....
	23	248	34.0	142	.42	.37	373.4	....	....
	33	259	33.0	133	.40	.31	304.5	....	....
	34	262	33.0	146	.42	.38	369.2	....	....
	35	263	31.0	144	.36	.43	275.2	....	....
	36	241	31.5	134	.42	.34	307.7	....	....
	37	261	37.0	146	.44	.27	482.9	....	....
Average		255	34.0	147	.41	.39	390.0	2.10	1.53

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, based upon analyses of trees in Tables III and VI.*

(A) OLD-GROWTH PINE.

(1) DOMINANT TREES.

Average throughout the range.]

(224 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume.			Periodic accretion.			Average annual accretion.	Current annual accretion.
				Heart-wood.	Sapwood.	Bark.	Decade.	Height.	Volume.		
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	0.9	7.7	(?)	....	....	....	1	7.7	(?)	(?)	(?)
20	2.5	21.0	0.5	....	....	....	2	13.3	(?)	0.02	(?)
30	4.8	33.7	2.2	....	....	....	3	12.7	1.7	.07	0.17
40	6.9	46.0	5.6	....	....	....	4	12.3	3.4	.13	.34
50	8.7	56.7	10.8	40	47	13	5	10.7	5.2	.22	.52
60	10.5	66.3	18.6	....	....	....	6	9.7	7.7	.31	.77
70	12.1	74.7	28.0	....	....	....	7	8.3	9.5	.40	.95
80	13.8	82.0	38.8	....	....	....	8	7.3	10.8	.49	1.08
90	15.5	89.0	50.9	....	....	....	9	7.0	12.1	.56	1.21
100	17.2	91.3	66.0				10	5.7	15.1	.66	1.51
110	18.9	99.0	82.7	55	33	12	11	4.3	16.7	.75	1.67
120	20.6	103.7	100.3				12	4.7	17.6	.84	1.76
130	22.2	107.7	118.5	....	....	....	13	4.0	18.2	.91	1.82
140	23.7	111.3	137.3	....	....	....	14	3.7	18.8	.98	1.88
150	25.0	114.4	155.7	....	....	....	15	3.0	18.4	1.04	1.84
160	26.3	117.3	175.3	....	....	....	16	3.0	19.6	1.09	1.96
170	27.5	120.7	194.6	....	....	....	17	3.3	19.3	1.14	1.93
180	28.7	123.7	214.8	....	....	....	18	3.0	20.2	1.19	2.02
190	29.8	126.3	234.7	....	....	....	19	2.7	19.9	1.23	1.99
200	31.0	129.0	254.7	65	23	12	20	2.7	20.0	1.27	2.00
210	30.7	134.5	....	....	....	....	21	3.0	20.6	1.25	2.06
220	31.6	137.5	....	....	....	....	22	3.0	21.5	1.30	2.15
230	32.0	140.5	....	69	21	11	23	3.0	21.6	1.34	2.16

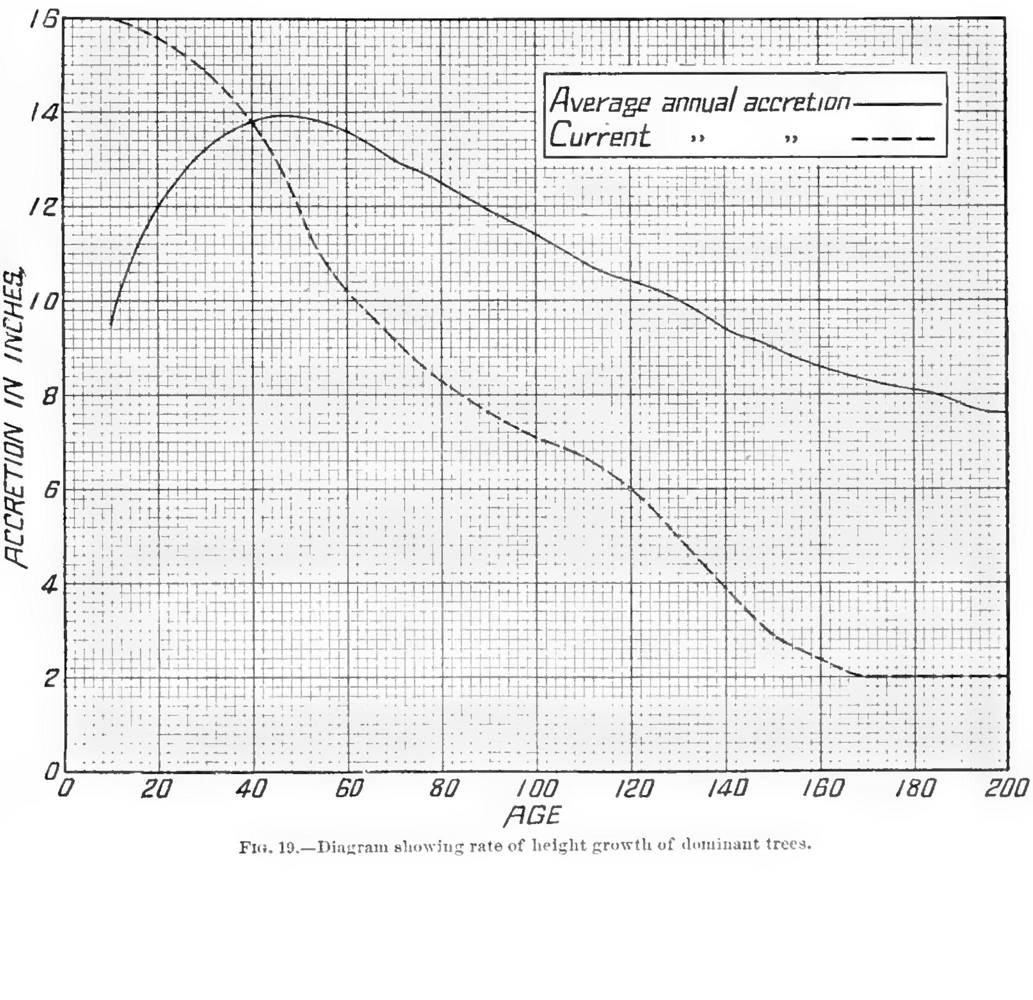


FIG. 19.—Diagram showing rate of height growth of dominant trees.

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, etc.*—Continued.

(A) OLD-GROWTH PINE—Continued.

(2) CODOMINANT TREES.

[Average throughout the range.]

(106 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume.			Periodic accretion.			Average annual accretion.	Current annual accretion.
				Heart-wood.	Sapwood.	Bark.	Decade.	Height.	Volume.		
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	0.8	6.0	(1)	....	....	....	1	6.0	(1)	(1)	(1)
20	2.3	16.0	0.4	....	....	....	2	10.0	(1)	0.02	(1)
30	4.0	28.5	1.6	....	....	....	3	12.0	1.2	.05	0.12
40	5.8	38.0	4.4	....	....	....	4	9.5	2.9	.11	.29
50	7.5	47.5	7.7	....	....	....	5	9.5	3.3	.15	.33
60	9.0	56.5	11.3	....	....	....	6	9.0	3.6	.19	.36
70	10.5	64.0	17.4	....	....	....	7	7.5	6.1	.25	.61
80	11.9	71.5	24.9	....	....	....	8	7.5	7.5	.31	.75
90	13.3	79.0	34.4	....	....	....	9	7.5	9.5	.38	.95
100	14.7	84.5	44.5	....	....	....	10	5.5	10.2	.45	1.02
110	16.0	89.5	55.5	....	....	....	11	5.0	11.0	.50	1.10
120	17.3	94.5	67.5	....	....	....	12	5.0	12.0	.56	1.20
130	18.6	99.0	78.6	....	....	....	13	4.5	11.2	.61	1.12
140	19.8	103.0	91.5	....	....	....	14	4.0	12.9	.66	1.29
150	20.8	107.0	104.0	....	....	....	15	4.0	12.5	.69	1.25
160	22.0	111.0	115.9	....	....	....	16	4.0	12.0	.72	1.20
170	23.0	114.0	127.7	....	....	....	17	3.0	11.8	.75	1.18
180	23.8	117.5	129.2	....	....	....	18	3.5	13.9	.72	1.39
190	24.7	120.0	142.9	....	....	....	19	2.5	13.7	.75	1.37
200	25.6	122.5	152.7	....	....	....	20	2.5	9.8	.76	.98
210	26.3	125.0	165.5	....	....	....	21	2.5	12.8	.79	1.28
220	27.0	127.5	179.3	....	....	....	22	2.5	13.8	.81	1.38
230	27.7	130.0	195.0	....	....	....	23	2.5	15.7	.84	1.57

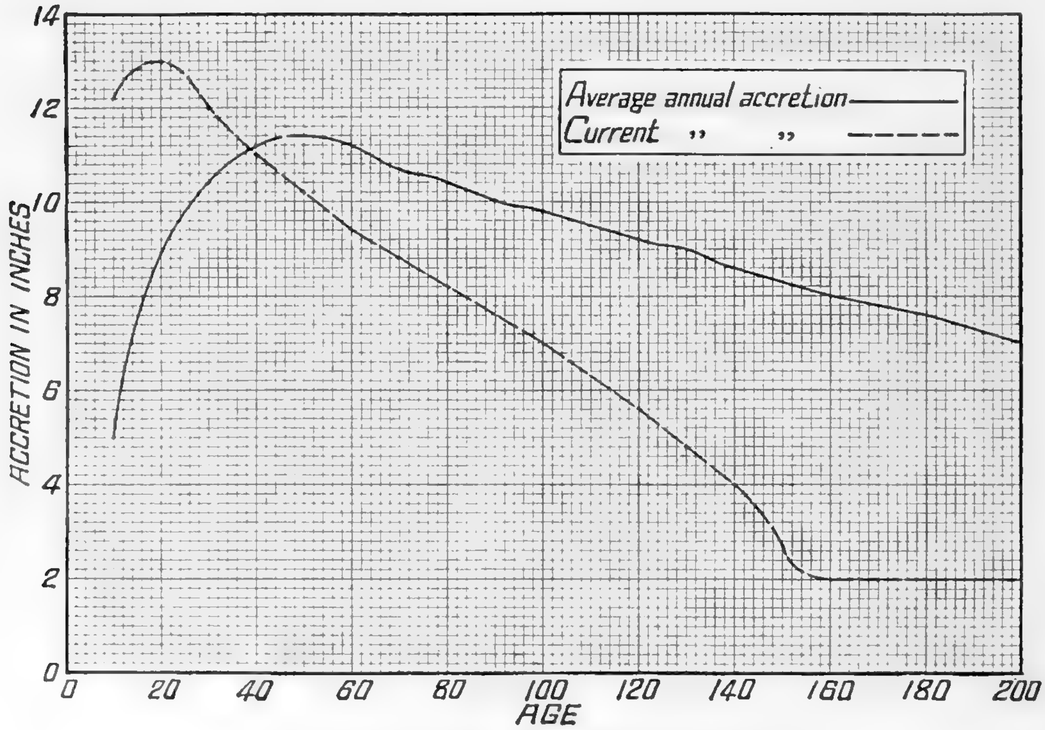


FIG. 20.—Diagram showing rate of height growth of codominant trees.

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, etc.*—Continued.

(A) OLD-GROWTH PINE—Continued.

(3) OPPRESSED TREES.

[Average throughout the range.]

(104 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume. Heart-wood.	Sapwood.	Bark.	Periodic accretion. Decade.	Height.	Volume.	Average annual accretion.	Current annual accretion.
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	0.9	4.0	(?)	....	....	....	1	4.0	(?)	(?)	(?)
20	2.0	11.0	0.4	....	....	....	2	7.0	(?)	0.02	(?)
30	3.7	18.0	0.7	....	....	....	3	7.0	0.4	.02	0.04
40	5.2	26.0	1.7	....	....	....	4	8.0	1.0	.04	.10
50	6.7	34.5	3.6	....	....	....	5	8.5	1.9	.07	.19
60	8.0	43.5	6.5	....	....	....	6	9.0	2.9	.11	.29
70	9.2	51.5	10.3	....	....	....	7	8.0	3.8	.15	.38
80	10.6	59.5	15.1	....	....	....	8	8.0	4.8	.19	.48
90	11.9	66.5	26.5	....	....	....	9	7.0	6.5	.24	.65
100	13.3	73.0	29.0				10	6.5	7.5	.29	.75
110	14.7	79.0	37.5	51	36	13	11	6.0	8.5	.35	.85
120	15.9	84.5	46.8				12	5.5	9.3	.39	.93
130	17.1	89.0	57.0	....	....	....	13	4.5	10.3	.44	1.03
140	18.2	93.5	68.5	....	....	....	14	4.5	11.5	.49	1.15
150	19.3	97.0	79.5	....	....	....	15	3.5	11.0	.54	1.10
160	20.3	100.5	90.8	....	....	....	16	3.5	11.3	.57	1.13
170	21.2	103.5	102.3	....	....	....	17	3.0	11.5	.60	1.15
180	22.2	106.5	114.0	....	....	....	18	3.0	11.8	.64	1.18
190	23.2	109.0	125.0	....	....	....	19	2.5	11.0	.66	1.10
200	23.9	111.5	136.0	60	28	12	20	2.5	11.0	.68	1.10

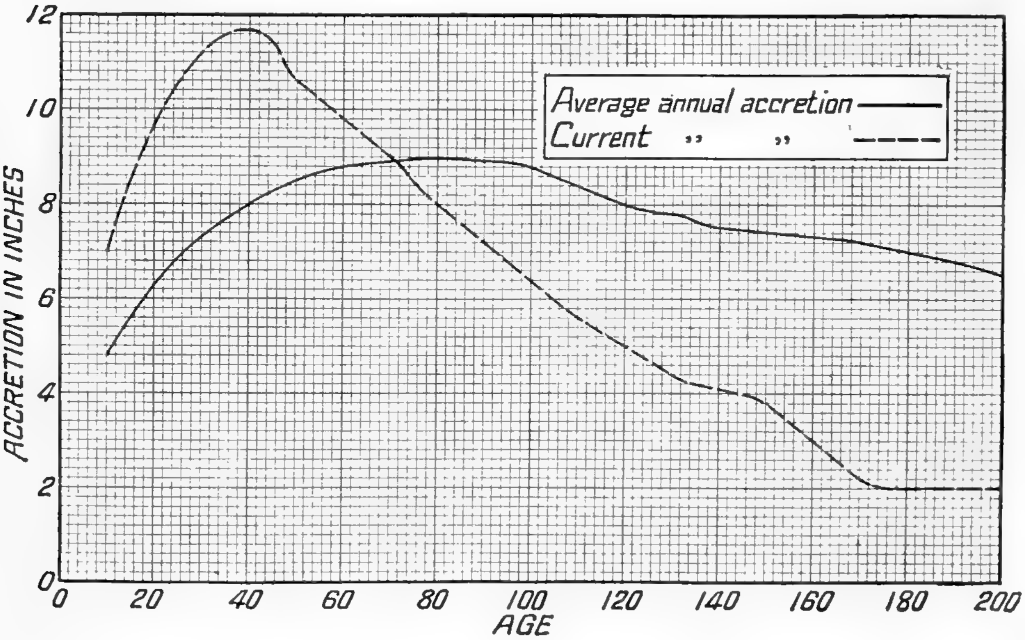


FIG. 21.—Diagram showing rate of height growth of oppressed trees.

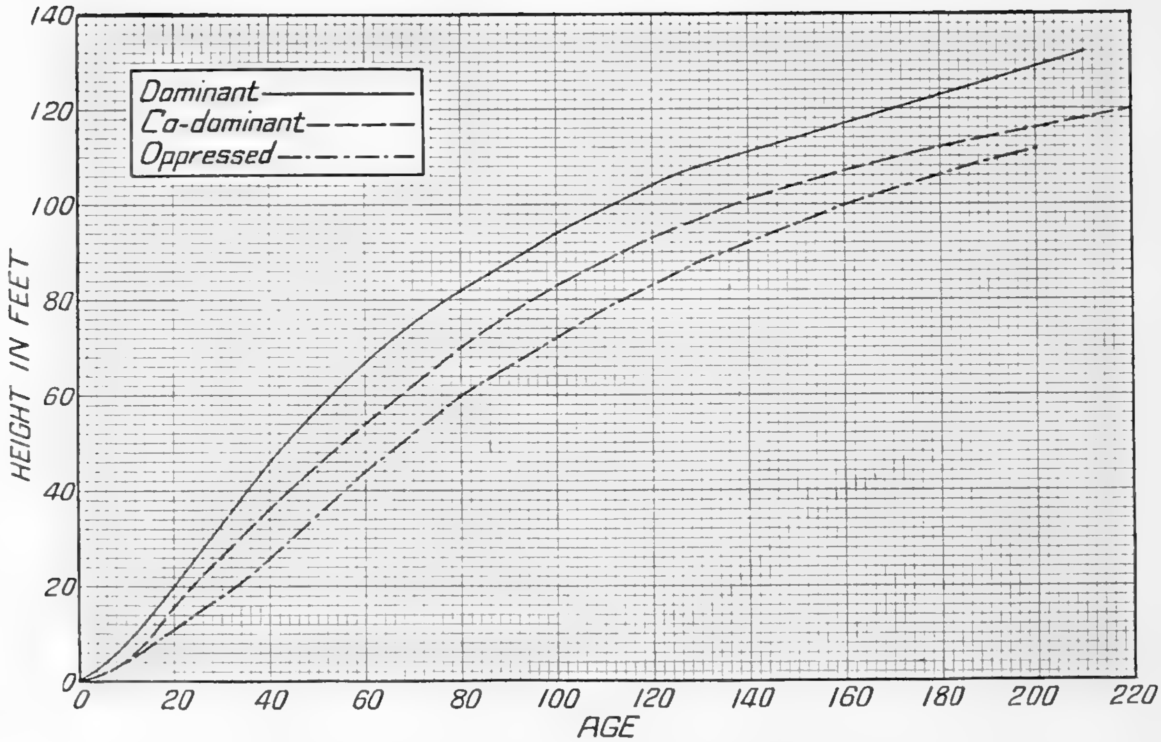


FIG. 22.—Diagram showing height growth of dominant, codominant, and oppressed trees throughout range.

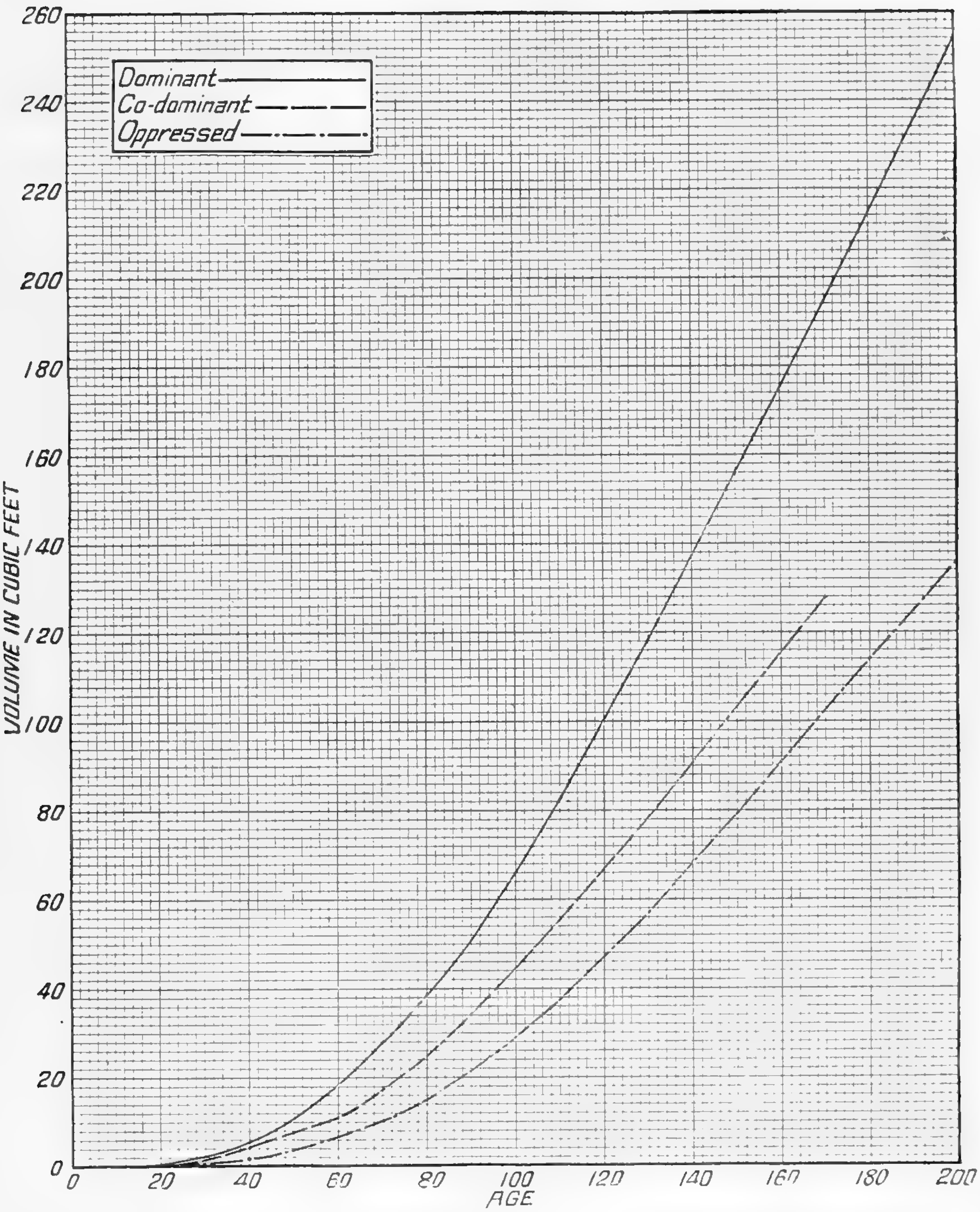


FIG. 23.—Diagram showing volume growth of dominant, codominant, and oppressed trees throughout range.

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, etc.*—Continued.

(A) OLD-GROWTH PINE—Continued.

(4) DOMINANT TREES.

[Average in Wisconsin.]

(68 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume.			Periodic accretion.			Average annual accretion.	Current annual accretion.
				Heart-wood.	Sapwood.	Bark.	Decade.	Height.	Volume.		
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	1.0	9	(?)	....	....	....	1	9	(?)	(?)	(?)
20	2.2	22	0.5	....	....	....	2	13	(?)	0.02	(?)
30	3.8	34	1.9	....	....	....	3	12	1.4	.06	0.14
40	5.3	46	3.5	....	....	....	4	12	1.6	.02	.16
50	6.6	57	7.6	....	....	....	5	11	4.1	.15	.41
60	8.0	66	13.2	....	....	....	6	9	5.6	.22	.56
70	9.3	74	21.0	....	....	....	7	8	7.8	.30	.78
80	11.0	80	30.0	....	....	....	8	6	9.0	.38	.90
90	13.0	86	41.5	....	....	....	9	6	11.5	.46	1.15
100	15.2	91	58.0	....	....	....	10	5	16.5	.58	1.65
110	17.4	95	78.0	....	....	....	11	4	20.0	.71	2.00
120	19.6	100	100.5	....	....	....	12	5	22.5	.84	2.25
130	21.8	104	124.0	....	....	....	13	4	23.5	.95	2.35
140	24.0	108	147.5	....	....	....	14	4	23.5	1.05	2.35
150	25.7	111	169.0	....	....	....	15	3	21.5	1.13	2.15
160	27.4	114	190.5	....	....	....	16	3	21.5	1.19	2.15
170	29.0	117	212.5	....	....	....	17	3	22.0	1.25	2.20
180	30.5	120	234.5	....	....	....	18	3	22.0	1.30	2.20
190	32.0	122	256.0	....	....	....	19	2	21.5	1.35	2.15
200	33.3	124	277.0	65	23	12	20	2	21.0	1.38	2.10

(5) OPPRESSED TREES.

[Average in Wisconsin.]

(55 trees.)

10	1.0	4	(?)	....	....	....	1	4	(?)	(?)	(?)
20	2.2	10	0.4	....	....	....	2	6	(?)	0.02	(?)
30	4.0	16	.7	....	....	....	3	6	0.3	.02	0.03
40	5.4	24	1.6	....	....	....	4	8	.9	.04	.09
50	6.8	32	3.2	....	....	....	5	8	1.6	.06	.16
60	8.0	40	6.0	....	....	....	6	8	2.8	.10	.28
70	9.2	47	9.5	....	....	....	7	7	3.5	.13	.35
80	10.6	55	13.5	....	....	....	8	8	4.0	.17	.40
90	12.0	62	20.0	....	....	....	9	7	6.5	.22	.65
100	13.4	69	28.0	....	....	....	10	7	8.0	.28	.80
110	14.7	75	38.0	....	....	....	11	6	10.0	.35	1.00
120	16.0	81	48.5	....	....	....	12	6	10.5	.40	1.05
130	17.2	86	60.0	....	....	....	13	5	11.5	.46	1.15
140	18.3	90	73.0	....	....	....	14	4	13.0	.52	1.30
150	19.5	94	85.0	....	....	....	15	4	12.0	.57	1.20
160	20.6	98	97.5	....	....	....	16	4	12.5	.61	1.25
170	21.6	101	109.5	....	....	....	17	3	12.0	.64	1.20
180	22.7	104	122.0	....	....	....	18	3	12.5	.68	1.25
190	23.7	107	134.0	....	....	....	19	3	12.0	.70	1.20
200	24.6	110	146.0	60	28	12	20	3	12.0	.73	1.20

(6) DOMINANT TREES.

[Average in Michigan.]

(75 trees.)

10	0.8	7	(?)	....	....	....	1	7	(?)	(?)	(?)
20	2.6	20	0.5	....	....	....	2	13	(?)	0.02	(?)
30	5.2	32	2.0	....	....	....	3	12	1.5	.07	0.15
40	7.4	43	5.5	....	....	....	4	11	3.5	.16	.35
50	9.4	53	10.5	....	....	....	5	10	5.0	.21	.50
60	11.3	63	17.6	....	....	....	6	10	7.1	.29	.71
70	13.1	72	27.0	....	....	....	7	9	9.4	.39	.94
80	14.8	80	38.2	....	....	....	8	8	11.2	.48	1.12
90	16.4	88	51.6	....	....	....	9	8	13.4	.57	1.34
100	17.9	94	65.5				10	6	13.9	.65	1.39
110	19.3	98	79.4	57	31	12	11	4	13.9	.72	1.39
120	20.6	103	93.6				12	5	14.2	.78	1.42
130	21.8	107	108.0				13	4	14.4	.83	1.44
140	23.0	110	123.5	....	....	....	14	3	15.5	.88	1.55
150	24.0	113	140.0	....	....	....	15	3	16.5	.93	1.65
160	25.1	116	158.5	....	....	....	16	3	18.5	.99	1.85
170	26.1	120	175.0	....	....	....	17	4	16.5	1.03	1.65
180	27.0	123	192.5	....	....	....	18	3	17.5	1.07	1.75
190	27.9	126	210.0	....	....	....	19	3	17.5	1.10	1.75
200	28.8	129	226.5	....	....	....	20	3	16.5	1.13	1.65
210	29.5	132	244.0	....	....	....	21	3	17.5	1.16	1.75
220	30.3	135	261.5	....	....	....	22	3	17.5	1.19	1.75
230	31.0	138	270.0	69	20	11	23	3	17.5	1.21	1.75

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, etc.*—Continued.

(A) OLD-GROWTH PINE—Continued.

(7) CODOMINANT TREES.

[Average in Michigan.]

(28 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume.			Periodic accretion.			Average annual accretion.	Current annual accretion.
				Heart-wood.	Sapwood.	Bark.	Decade.	Height.	Volume.		
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	0.7	7	(?)	....	....	....	1	7	(?)	(?)	(?)
20	2.2	16	0.4	....	....	....	2	9	(?)	0.02	(?)
30	4.0	29	1.3	....	....	....	3	13	0.9	.04	0.09
40	5.7	37	4.0	....	....	....	4	8	2.7	.10	.27
50	7.3	47	7.6	....	....	....	5	10	3.6	.15	.36
60	8.8	57	11.5	....	....	....	6	10	3.9	.19	.39
70	10.1	65	18.0	....	....	....	7	8	6.5	.26	.65
80	11.7	74	26.4	....	....	....	8	9	8.4	.33	.84
90	13.2	83	38.0	....	....	....	9	9	11.6	.42	1.16
100	14.6	89	50.0	....	....	....	10	6	12.0	.50	1.20
110	15.9	94	63.0	....	....	....	11	5	13.0	.57	1.30
120	17.2	99	77.0	....	....	....	12	5	14.0	.64	1.40
130	18.5	104	92.0	....	....	....	13	5	15.0	.71	1.50
140	19.8	108	106.0	....	....	....	14	4	14.0	.76	1.40
150	20.9	112	119.0	....	....	....	15	4	13.0	.79	1.30
160	22.1	116	130.0	....	....	....	16	4	11.0	.81	1.10
170	23.2	119	140.0	....	....	....	17	3	10.0	.82	1.00
180	24.1	123	(?)	....	....	....	18	4	....	....	....
190	25.1	126	(?)	....	....	....	19	3	....	....	....
200	26.0	129	(?)	....	....	....	20	3	....	....	....
210	26.7	132	(?)				21	3	....	....	....
220	27.4	135	(?)	63	24	13	22	3	....	....	....
230	28.0	138	(?)				23	3	....	....	....

(8) OPPRESSED TREES.

[Average in Michigan.]

(36 trees.)

10	0.7	4	(?)	....	....	....	1	4	(?)	(?)	(?)
20	1.8	12	0.3	....	....	....	2	8	(?)	0.015	(?)
30	3.3	20	.7	....	....	....	3	8	0.4	.02	0.04
40	5.0	28	1.8	....	....	....	4	8	1.1	.04	.11
50	6.6	37	4.0	....	....	....	5	9	2.2	.08	.22
60	8.0	47	7.0	....	....	....	6	10	3.0	.12	.30
70	9.2	56	11.0	....	....	....	7	9	4.0	.16	.40
80	10.5	64	16.6	....	....	....	8	8	5.6	.21	.56
90	11.8	71	23.0	....	....	....	9	7	6.4	.25	.64
100	13.2	77	30.0				10	6	7.0	.30	.70
110	14.6	83	37.0	51	36	13	11	6	7.0	.34	.70
120	15.8	88	45.0				12	5	8.0	.37	.80
130	17.0	92	54.0				13	4	9.0	.41	.90
140	18.0	97	64.0	....	....	....	14	5	10.0	.46	1.00
150	19.0	100	74.0	....	....	....	15	3	10.0	.50	1.00
160	20.0	103	84.0	....	....	....	16	3	10.0	.52	1.00
170	20.8	106	95.0	....	....	....	17	3	11.0	.56	1.10
180	21.6	109	106.0	....	....	....	18	3	11.0	.60	1.10
190	22.4	111	116.0	....	....	....	19	2	10.0	.61	1.00
200	23.2	113	126.0	....	....	....	20	2	10.0	.63	1.00
210	23.8	115	137.0	....	....	....	21	2	11.0	.65	1.10
220	24.4	117	147.0	....	....	....	22	2	10.0	.67	1.00
230	24.9	119	157.0	68	19	13	23	2	10.0	.68	1.00

(9) DOMINANT TREES.

[Average in Pennsylvania.]

(81 trees.)

10	1.0	7	(?)	....	....	....	1	7	(?)	(?)	(?)
20	2.8	21	0.5	....	....	....	2	14	(?)	0.02	(?)
30	5.5	35	2.6	....	....	....	3	14	2.1	.09	0.21
40	8.0	49	7.8	....	....	....	4	14	5.2	.20	.52
50	10.2	60	14.4	40	47	13	5	11	6.6	.29	.66
60	12.2	70	24.9	....	....	....	6	10	10.5	.41	1.05
70	14.0	78	36.1	....	....	....	7	8	11.2	.52	1.12
80	15.6	86	48.3	....	....	....	8	8	12.2	.60	1.22
90	17.1	93	59.6	....	....	....	9	7	11.3	.66	1.13
100	18.6	99	74.6				10	6	15.0	.75	1.50
110	20.0	104	90.7	53	35	12	11	5	16.1	.82	1.61
120	21.5	108	106.9				12	4	16.2	.89	1.62
130	22.9	112	123.6	....	....	....	13	4	16.7	.95	1.67
140	24.1	116	140.9	....	....	....	14	4	17.3	1.00	1.73
150	25.2	119	158.2	....	....	....	15	3	17.3	1.06	1.73
160	26.4	122	176.9	....	....	....	16	3	18.7	1.10	1.87
170	27.5	125	196.2	....	....	....	17	3	19.3	1.15	1.93
180	28.6	128	217.4	....	....	....	18	3	21.2	1.21	2.12
190	29.6	131	238.0	....	....	....	19	3	20.6	1.25	2.06
200	30.8	134	260.5	....	....	....	20	3	22.5	1.30	2.25
210	31.9	137	284.2	....	....	....	21	3	23.7	1.35	2.37
220	33.0	140	309.7	....	....	....	22	3	25.5	1.41	2.55
230	34.0	143	335.4	69	21	10	23	3	25.7	1.46	2.57

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, etc.*—Continued.

(A) OLD-GROWTH PINE—Continued.

(10) CODOMINANT TREES.

[Average in Pennsylvania.]

(78 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume.			Periodic accretion.			Average annual accretion.	Current annual accretion.
				Heart-wood.	Sapwood.	Bark.	Decade.	Height.	Volume.		
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	0.9	5	(?)	....	....	....	1	5	(?)	(?)	(?)
20	2.3	16	0.4	....	....	....	2	11	(?)	0.02	(?)
30	4.0	28	1.8	....	....	....	3	12	1.4	.06	0.14
40	5.9	39	4.8	....	....	....	4	11	3.0	.12	.30
50	7.6	48	7.8	....	....	....	5	9	3.0	.15	.30
60	9.3	56	11.1	....	....	....	6	8	3.3	.18	.33
70	10.8	63	16.7	....	....	....	7	7	5.6	.24	.56
80	12.0	69	23.3	....	....	....	8	6	6.6	.29	.66
90	13.4	75	30.7	....	....	....	9	6	7.4	.34	.74
100	14.7	80	39.0	....	....	....	10	5	8.3	.39	.83
110	16.0	85	47.9	....	....	....	11	5	8.9	.43	.89
120	17.3	90	57.9	....	....	....	12	5	10.0	.48	1.00
130	18.6	94	65.2	....	....	....	13	4	7.3	.50	.73
140	19.7	98	76.9	....	....	....	14	4	11.7	.55	1.17
150	20.7	102	88.9	....	....	....	15	4	12.0	.59	1.20
160	21.8	106	101.8	....	....	....	16	4	12.9	.63	1.29
170	22.7	109	115.3	....	....	....	17	3	13.5	.68	1.35
180	23.5	112	129.2	....	....	....	18	3	13.9	.72	1.39
190	24.3	114	142.9	....	....	....	19	2	13.7	.75	1.37
200	25.1	116	152.7	....	....	....	20	2	9.8	.76	.98
210	25.8	118	165.5	....	....	....	21	2	12.8	.79	1.28
220	26.5	120	179.3	....	....	....	22	2	13.8	.81	1.38
230	27.3	122	195.0	65	25	10	23	2	15.7	.84	1.57

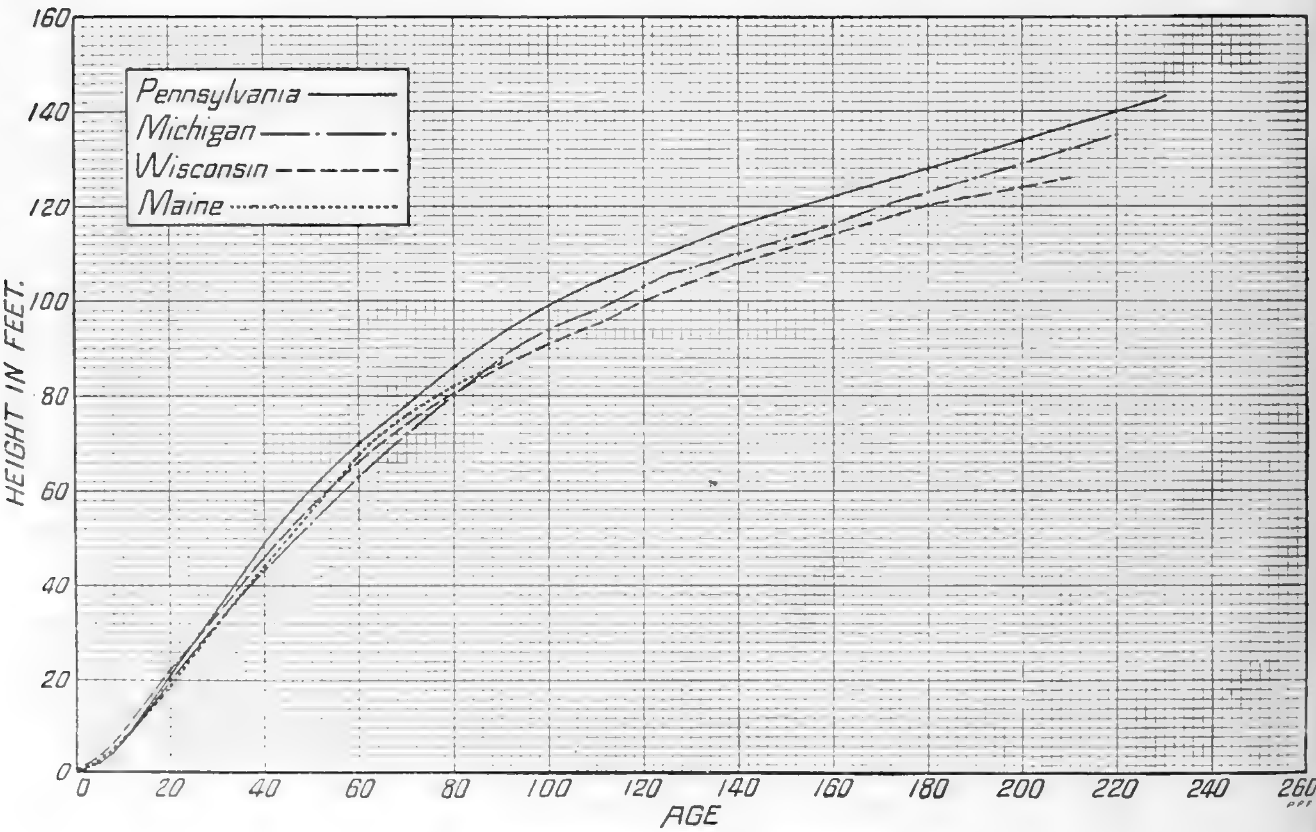


FIG. 24.—Diagram showing height growth of dominant trees, by States.

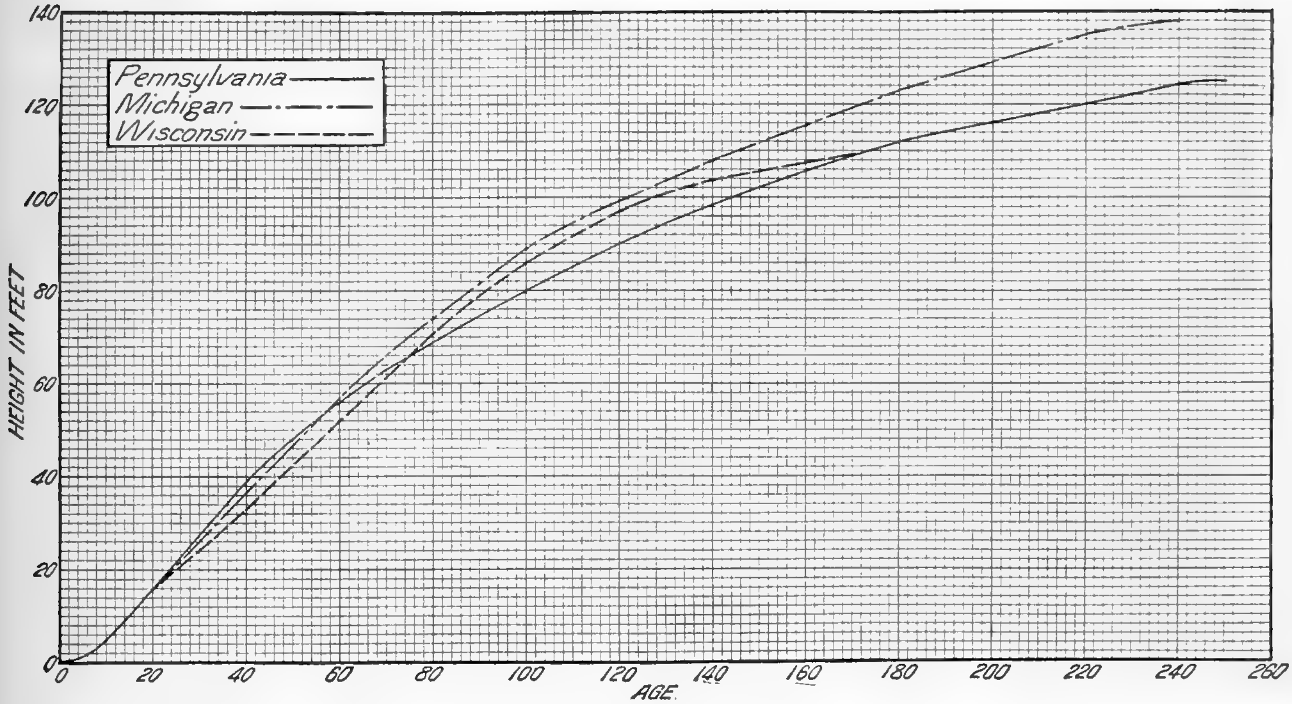


FIG. 25.—Diagram showing height growth of codominant trees, by States.

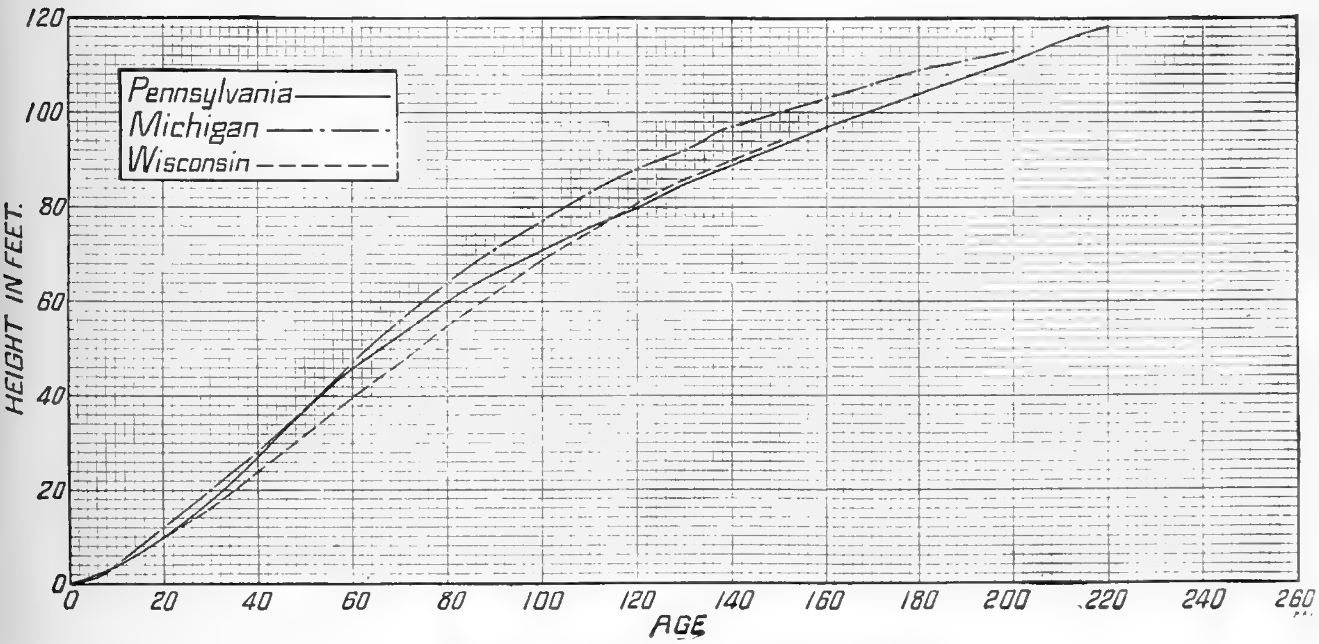


FIG. 26.—Diagram showing height growth of oppressed trees, by States.

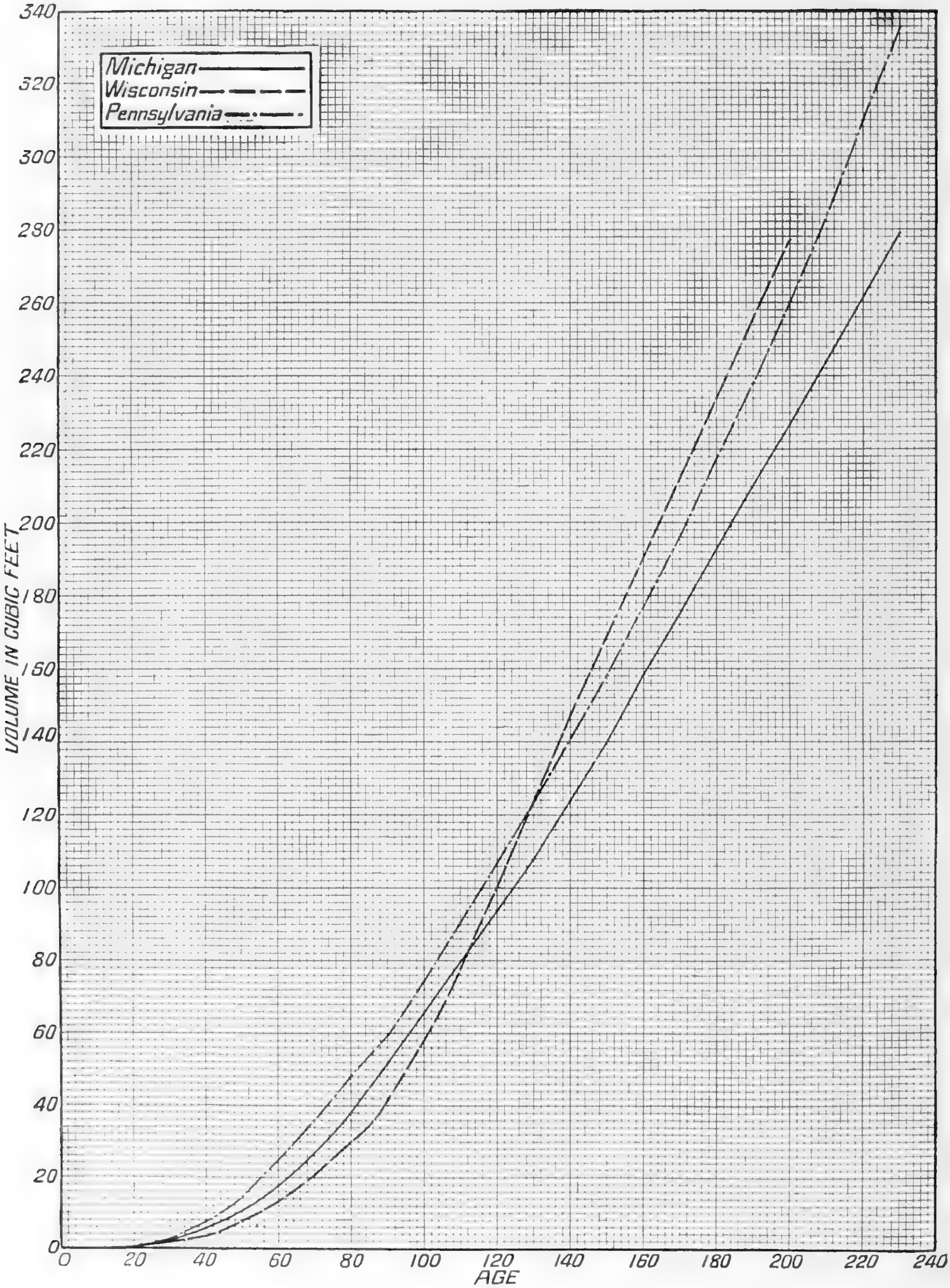


FIG. 27.—Diagram showing volume growth of dominant trees, by States.

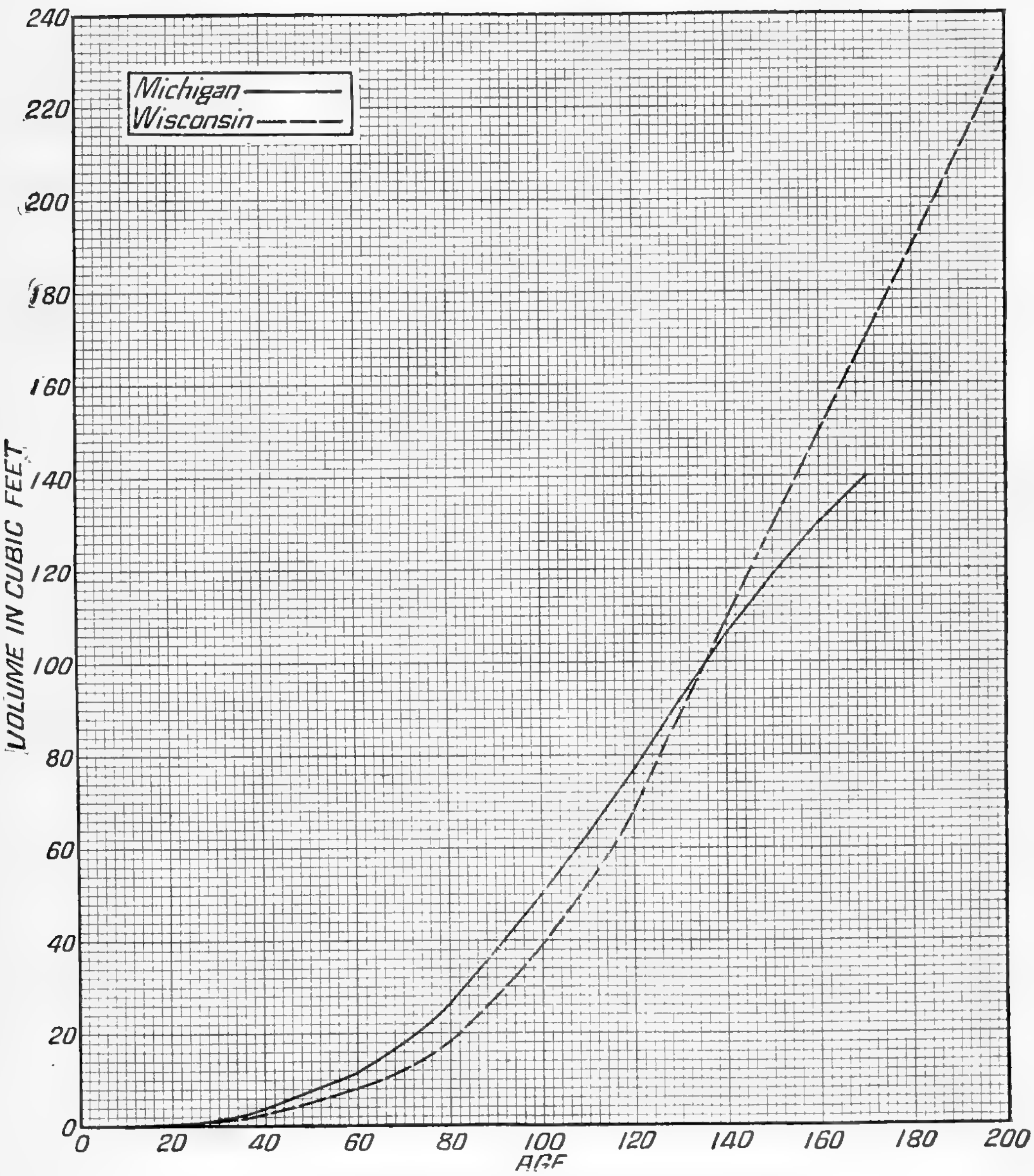


FIG. 23.—Diagram showing volume growth of codominant trees, by States.

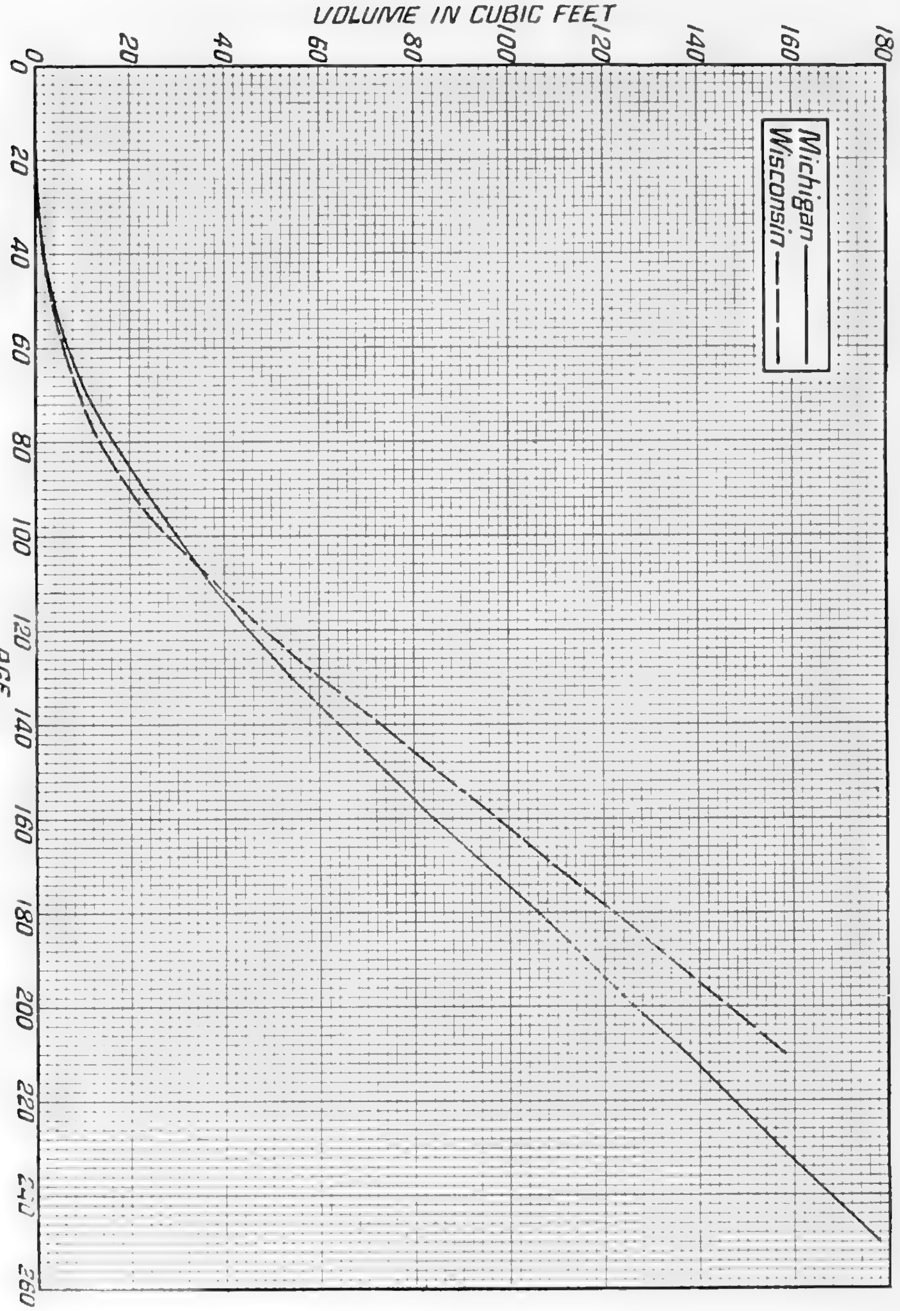


FIG. 29.—Diagram showing volume growth of oppressed trees, by States.

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, etc.*—Continued.

(*B*) SECOND-GROWTH PINE.

(11) SITE *a*: YORK COUNTY, ME.

DOMINANT TREES.

(11 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume. Heart-wood.	Sapwood.	Bark.	Periodic accretion. Decade.	Height.	Volume.	Average annual accretion.	Current annual accretion.
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	2.1	7½	0.5				1	7½	0.9	0.05	0.05
20	5.7	21	2.1				2	13½	1.6	.10	.16
30	10.2	37	6.5				3	16	4.4	.21	.44
40	14.2	49½	17.0				4	12½	10.5	.42	1.05
50	18.6	60½	34.0				5	11	17.0	.68	1.70
60	22.1	69	60.3				6	8½	26.3	1.00	2.63
70	24.6	77	82.2	58	29	10	7	8	21.9	1.17	2.19
80	26.2	85	100.0	to	to	to	8	8	17.8	1.25	1.78
90		90	(?)	60	32	11	9	5			

CODOMINANT TREES.

(33 trees.)

10	1.8	7	0.2				1	7	0.2	0.02	0.02
20	4.1	17½	.7				2	10½	.5	.03	.05
30	6.2	30	2.4				3	12½	1.7	.08	.17
40	8.6	43	6.4				4	13	4.0	.16	.40
50	11.7	56	14.6				5	13	8.2	.29	.82
60	14.8	66½	26.2				6	10½	11.6	.44	1.16
70	17.3	75	39.6	47	34	11	7	8½	13.4	.56	1.34
80	19.1	81½	54.0	to	to	to	8	6½	14.4	.67	1.44
90	21.0	87	70.0	55	41	12	9	5½	16.0	.78	1.60

OPPRESSED TREES.

(12 trees.)

10	1.5	6	(?)				1	6	(?)	(?)	(?)
20	4.5	18	0.7				2	12	(?)	0.03	(?)
30	7.2	30	2.8				3	12	2.1	.09	0.21
40	9.5	41½	6.6				4	11½	3.8	.16	.38
50	11.2	53	12.3				5	11½	5.7	.25	.57
60	12.8	66½	19.0				6	13½	6.7	.31	.67
70	14.0	75½	26.0				7	9	7.0	.36	.70
80	15.0	79½	32.4				8	4	6.4	.40	.64
90	15.4	83½	39.0	68	28	12	9	4	6.6	.43	.66

(12) SITE *c*: YORK COUNTY, ME.

DOMINANT TREES.

(10 trees.)

10	1.9	7.5	0.5				1	7.5	0.5	0.05	0.05
20	6.1	19.0	1.2				2	11.5	.7	.06	.07
30	9.4	32.0	5.0				3	13.0	3.8	.17	.38
40	12.1	45.0	12.0				4	13.0	7.0	.30	.70
50	13.9	58.0	21.4	43	45	12	5	13.0	9.4	.43	.94

DOMINANT TREES.

(8 trees.)

10	2.2	9.7	0.2				1	9.7	0.2	0.02	0.02
20	5.6	21.3	1.0				2	11.6	.8	.05	.08
30	7.7	33.4	3.8				3	12.1	2.8	.13	.28
40	9.0	43.0	8.4				4	9.6	4.6	.21	.46
50	10.3	56.0	13.0	43	45	12	5	13.0	4.6	.26	.46

(13) MASSACHUSETTS AND NEW HAMPSHIRE.

DOMINANT TREES.

(12 trees.)

10	2.2	9	0.1				1	9	0.1	0.01	0.01
20	4.7	25	1.4				2	16	1.3	.07	.13
30	7.5	39	4.3				3	14	2.9	.14	.29
40	9.6	53	9.3	40	51	9	4	14	5.0	.23	.50

(Average in Massachusetts and New Hampshire of 12 trees.)

10	2.5	10	0.5				1	10	0.5	0.05	0.05
20	5.4	33	2.0				2	23	1.5	.10	.15
30	7.8	48	6.5				3	15	4.5	.22	.45
40	9.4	58	12.5	48	46	6	4	10	6.0	.31	.60

TABLE IV.—*Dimensions, volume, and rate of growth, by decades, etc.*—Continued.

(B) SECOND-GROWTH PINE—Continued.

(14) SITE *g*: CLEARFIELD COUNTY, PA.

DOMINANT TREES.

(4 trees.)

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume. Heart-wood.	Relative per cent of total volume. Sapwood.	Relative per cent of total volume. Bark.	Periodic accretion. Decade.	Periodic accretion. Height.	Periodic accretion. Volume.	Average annual accretion.	Current annual accretion.
Years.	*Inches.*	*Feet.*	*Cubic ft.*	*Per cent.*	*Per cent.*	*Per cent.*		*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
10	2.6	9	0.1	....	....	....	1	9	0.1	0.01	0.01
20	7.3	27	3.0	....	....	....	2	18	2.9	.15	.29
30	13.2	41½	13.5	37	55	8	3	14½	10.5	.45	1.05

CODOMINANT TREES.

(5 trees.)

10	1.8	9	0.1	....	....	....	1	9	0.1	0.01	0.01
20	6.4	27	1.9	....	....	....	2	18	1.8	.09	.18
30	10.8	41	8.0	34	52	14	3	14	6.1	.20	.61

OPPRESSED TREES.

(3 trees.)

10	1.6	7	0.04	....	....	....	1	7	0.04	0.004	0.004
20	4.1	25	.60	....	....	....	2	18	.56	.03	.056
30	6.3	35	2.90	27	60	13	3	10	2.30	.10	.230

SUPPRESSED TREES.

(3 trees.)

10	1.1	6	....	....	....	....	....	....	....	....	....
20	2.4	21	....	....	....	....	....	....	....	....	....

(15) SITE *i*: FOREST COUNTY, PA.

DOMINANT TREES.

(2 trees.)

10	1.8	9	(?)	....	....	....	1	9	(?)	(?)	(?)
20	6.9	29½	2.5	....	....	....	2	20½	(?)	0.12	(?)
30	10.4	41½	9.7	....	....	....	3	12	7.2	.32	0.72
40	12.9	52½	19.0	36	54	10	4	11	9.3	.47	.93

DOMINANT TREES.

(10 trees.)

10	2.1	9	(?)	....	....	....	1	9	(?)	(?)	(?)
20	5.9	27	1.8	....	....	....	2	18	(?)	0.09	(?)
30	8.7	41½	6.0	....	....	....	3	14½	4.2	.20	0.42
40	11.0	53	13.0	35	52	13	4	11½	7.0	.32	.70

CODOMINANT TREES.

(10 trees.)

10	1.9	9	(?)	....	....	....	1	9	(?)	(?)	(?)
20	4.8	27	1.3	....	....	....	2	18	(?)	0.06	(?)
30	6.8	40	4.7	....	....	....	3	13	3.4	.16	0.34
40	8.5	52	9.8	36	53	11	4	12	5.1	.24	.51

OPPRESSED TREES.

(5 trees.)

10	2.1	7	(?)	....	....	....	1	7	(?)	(?)	....
20	4.2	23	1.0	....	....	....	2	16	(?)	0.05	....
30	5.7	36	2.7	....	....	....	3	13	1.7	.09	0.17
40	6.6	44	4.8	34	55	11	4	8	2.1	.12	.21

(16) SITE *c*: LUZERNE COUNTY, PA.

DOMINANT TREES.

(9 trees.)

10	1.0	6	(?)	....	....	....	1	6	(?)	(?)	(?)
20	3.2	19	0.4	....	....	....	2	13	(?)	0.02	(?)
30	5.9	33	2.5	....	....	....	3	14	2.1	.08	0.21
40	8.7	44½	7.2	....	....	....	4	11½	4.7	.18	.47
50	11.5	51	14.0	40	47	13	5	6½	6.8	.28	.68

TABLE V.—*Growth of diameter and cross-section area at various heights from the ground.*

(1) AVERAGE THROUGHOUT THE RANGE.

Character of growth.	Height of section from ground.	DIAMETER OF SECTION, IN INCHES, AT AGE (YEARS) OF— 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230
	Feet.																							
Dominant (224 trees).	2½	1.9	4.1	6.2	8.2	9.9	11.6	13.2	14.8	16.6	18.4	20.1	21.7	23.2	24.7	26.0	27.2	28.4	29.6	30.7	31.7	32.6	33.6	34.5
	18	2.8	5.4	7.3	9.0	10.5	11.9	13.3	14.6	15.8	17.0	18.2	19.3	20.3	21.2	22.1	22.9	23.7	24.5	25.2	25.9	26.4	26.9	
	34	2.7	5.3	7.5	9.3	10.9	12.4	13.8	15.1	16.3	17.4	18.5	19.4	20.3	21.1	21.9	22.6	23.3	24.0	24.8	25.4	26.0		
	50	2.6	5.4	7.7	9.6	11.2	12.7	14.0	15.1	16.2	17.1	18.0	18.9	19.7	20.5	21.3	22.0	22.7	23.4	24.0	24.7			
	66	2.5	5.1	7.2	9.3	10.9	12.2	13.4	14.5	15.5	16.5	17.4	18.2	18.9	19.6	20.3	20.9	21.5	22.0					
	82	2.3	4.4	6.1	7.6	9.0	10.2	11.3	12.3	13.3	14.1	14.9	15.7	16.5	17.2	17.9	18.6							
	100	1.9	3.8	5.4	6.9	8.2	9.4	10.4	11.4	12.3	13.2	14.1	14.9	15.8	16.6									
	115	1.4	2.9	4.4	5.6	6.9	8.1	9.3	10.4	11.3	12.1													
Codominant (106 trees).	2½	1.6	3.5	5.3	7.0	8.6	10.0	11.4	12.9	14.3	15.6	16.9	18.3	19.5	20.6	21.7	22.8	23.8	24.7	25.6	26.4	27.1	27.8	28.5
	18	2.4	4.9	6.7	8.3	9.6	10.8	12.0	13.1	14.1	15.1	16.0	17.0	17.8	18.5	19.2	19.9	20.6	21.2	21.8	22.4	23.0	23.6	
	34	2.6	5.1	7.0	8.6	10.0	11.2	12.3	13.3	14.2	15.1	15.9	16.7	17.4	18.1	18.7	19.4	20.0	20.6	21.1	21.8	22.4		
	50	2.6	4.9	6.9	8.6	10.1	11.4	12.4	13.4	14.3	15.2	16.0	16.8	17.5	18.2	18.9	19.5	20.2	20.8	21.4				
	66	2.2	4.3	6.1	7.6	8.9	10.0	11.0	11.9	12.7	13.5	14.3	15.0	15.7	16.3	17.0	17.6	18.2						
	82	1.9	3.8	5.3	6.7	7.9	9.0	10.0	10.9	11.7	12.4	13.1	13.7	14.3	15.0									
	98	1.6	2.9	4.2	5.4	6.5	7.6	8.5	9.6	10.2	10.8	11.5												
	114	1.0	2.0	3.1	4.2	5.2																		
Oppressed (104 trees).	2½	1.4	3.1	4.8	6.4	7.7	8.9	10.3	11.5	13.0	14.3	15.7	16.9	18.1	19.2	20.3	21.3	22.3	23.2	24.0	24.8	25.4	25.9	26.4
	18	2.1	4.2	5.8	7.1	8.1	9.2	10.1	11.2	12.4	13.4	14.4	15.3	16.1	16.9	17.7	18.4	19.0	19.5	19.9	20.3			
	34	2.2	4.4	6.2	7.9	9.3	10.5	11.6	12.7	13.6	14.4	15.2	16.0	16.7	17.4	18.0	18.4	18.8	19.1					
	50	2.1	4.3	6.2	7.7	9.1	10.4	11.6	12.6	13.6	14.5	15.4	16.2	16.8	17.4	17.8	18.2	18.7						
	66	2.4	4.7	6.4	7.9	9.1	10.3	11.3	12.2	12.9	13.5	14.0	14.5	15.0	15.5	15.9								
	82	2.3	4.1	5.7	6.9	7.8	8.4	9.1	9.8	10.2	10.6	11.0	11.4	11.9										
	100	1.9	3.8	5.0	5.9	6.7	7.4	8.1	8.6	9.0														

Character of growth.	Height of section from ground.	DIAMETER ACCRETION, IN INCHES, FOR DECADES— 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (224 trees).	2½	1.9	2.2	2.1	2.0	1.7	1.7	1.6	1.6	1.8	1.8	1.7	1.6	1.6	1.5	1.3	1.2	1.2	1.2	1.1	1.0	0.9	1.0	0.9
	18	2.8	2.6	1.9	1.7	1.5	1.4	1.4	1.3	1.2	1.2	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.5	0.5	
	34	2.7	2.6	2.2	1.8	1.6	1.5	1.4	1.3	1.2	1.1	1.1	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.8	0.6	0.6		
	50	2.6	2.8	2.3	1.9	1.6	1.5	1.3	1.1	1.1	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.7			
	66	2.5	2.6	2.1	2.1	1.6	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.7	0.7	0.7	0.6	0.6	0.5					
	82	2.3	2.1	1.7	1.5	1.4	1.2	1.1	1.0	1.0	0.8	0.8	0.8	0.8	0.7	0.7	0.7							
	100	1.9	1.9	1.6	1.5	1.3	1.2	1.0	1.0	0.9	0.9	0.9	0.8	0.9	0.8									
	115	1.4	1.5	1.5	1.2	1.3	1.2	1.2	1.1	0.9	0.8													
Codominant (106 trees).	2½	1.6	1.9	1.8	1.7	1.6	1.4	1.4	1.5	1.4	1.3	1.3	1.4	1.2	1.1	1.1	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.7
	18	2.4	2.5	1.8	1.6	1.3	1.2	1.2	1.1	1.0	1.0	0.9	1.0	0.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	
	34	2.6	2.5	1.9	1.6	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.7	0.6	0.6	0.5	0.7	0.6		
	50	2.6	2.3	2.0	1.7	1.5	1.3	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.7	0.6	0.6				
	66	2.2	2.1	1.8	1.5	1.3	1.1	1.0	0.9	0.8	0.8	0.8	0.7	0.7	0.6	0.7	0.6	0.6						
	82	1.9	1.9	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.6	0.7									
	98	1.6	1.3	1.3	1.2	1.1	1.1	0.9	1.1	0.6	0.6	0.7												
	114	1.0	1.0	1.1	1.1	1.0																		
Oppressed (104 trees).	2½	1.4	1.7	1.7	1.6	1.3	1.2	1.4	1.2	1.5	1.3	1.4	1.2	1.2	1.1	1.1	1.0	1.0	0.9	0.8	0.8	0.6	0.5	0.5
	18	2.1	2.1	1.6	1.3	1.0	1.1	0.9	1.1	1.2	1.0	1.0	0.9	0.8	0.8	0.8	0.7	0.6	0.5	0.4	0.4			
	34	2.2	2.2	1.8	1.7	1.4	1.2	1.1	1.1	0.9	0.8	0.8	0.8	9.7	0.7	0.6	0.4	0.4	0.3					
	50	2.1	2.2	1.9	1.5	1.4	1.3	1.2	1.0	1.0	0.9	0.9	0.8	0.6	0.6	0.4	0.4	0.5						
	66	2.4	2.3	1.7	1.5	1.2	1.2	1.0	0.9	0.7	0.6	0.5	0.5	0.5	0.5	0.4								
	82	2.3	1.8	1.6	1.2	0.9	0.6	0.7	0.7	0.4	0.4	0.4	0.4	0.5										
	100	1.9	1.9	1.2	0.9	0.8	0.7	0.7	0.5	0.4														

Character of growth.	Height of section from ground.	CORRESPONDING AREA ACCRETION, IN SQUARE FEET, FOR DECADES— 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (224 trees).	2½	0.02	0.07	0.13	0.16	0.18	0.20	0.21	0.24	0.30	0.33	0.35	0.35	0.36	0.39	0.35	0.36	0.38	0.38	0.37	0.34	0.32	0.35	0.32
	18	.04	.12	.13	.16	.17	.17	.19	.20	.20	.22	.23	.22	.22	.20	.21	.21	.20	.22	.20	.20	.14	.15	
	34	.04	.12	.15	.17	.18	.18	.20	.20	.20	.20	.21	.18	.19	.19	.19	.18	.18	.18	.20	.16	.16		
	50	.04	.13	.16	.18	.18	.19	.19	.18	.19	.18	.17	.17	.18	.17	.17	.18	.15	.16	.15	.16			
	66	.03	.11	.14	.15	.17	.16	.17	.12	.17	.16	.17	.15	.14	.14	.15	.15	.14	.12					
	82	.03	.07	.10	.11	.12	.13	.12	.12	.14	.13	.12	.12	.14	.13	.13	.14							
	100	.02	.06	.08	.11	.10	.12	.11	.12	.12	.13	.12	.12	.16	.14									
	115	.01	.03	.07	.07	.09	.10	.11	.10	.11														
Codominant (106 trees).	2½	.01	.06	.09	.11	.13	.15	.16	.19	.21	.21	.23	.27	.24	.23	.24	.27	.24	.23	.23	.22	.20	.21	.21
	18	.03	.10	.12	.13	.12	.14	.14	.15	.15	.15	.15	.17	.15	.14	.14	.15	.14	.14	.13	.14	.14	.15	
	34	.04	.10	.13	.13	.14	.14	.14	.14	.14	.14	.14	.13	.13	.13	.12	.14	.13	.13	.12	.15	.13		
	50	.04	.09	.14	.14	.15	.15	.13	.14	.14	.14	.13	.14	.13	.13	.13	.12	.14	.12	.13				
	66	.03	.07	.10	.11	.12	.11	.12	.11	.10	.11	.12	.11	.12	.10	.11	.10	.12						
	82	.02	.06	.08	.09	.09	.10	.10	.10	.10	.09	.10	.09	.08	.10									
	98	.02	.03	.06	.06	.07	.08	.08	.10	.07	.07	.09												
	114	.01	.01	.03	.05	.05																		
Oppressed (104 trees).	2½	.01	.04	.07	.10	.10	.11	.15	.14	.19	.20	.22	.20	.22	.22	.23	.23	.21	.22	.20	.20	.15	.14	.13
	18	.02	.08	.08	.09	.08	.10	.09	.13	.15	.14	.15	.14	.14	.13	.14	.12	.11	.10	.08	.08			
	34	.03	.08	.11	.13	.13	.13	.13	.14	.13	.12	.12	.13	.13	.12	12	.08	.08	.08					
	50	.02	.08	.11	.11	.12	.14	.14	.14	.13	.13	.13	.13	.10	.11	.07	.07	.10						
	66	.03	.09	.11	.12	.11	.12	.12	.11	.10	.09	.07	.08	.07	.08	.07								
	82	.03	.06	.09	.08	.07	.05	.07	.07	.05	.04	.05	.05	.06										
	100	.02	.06	.06	.05	.05	.06	.06	.04	.04														

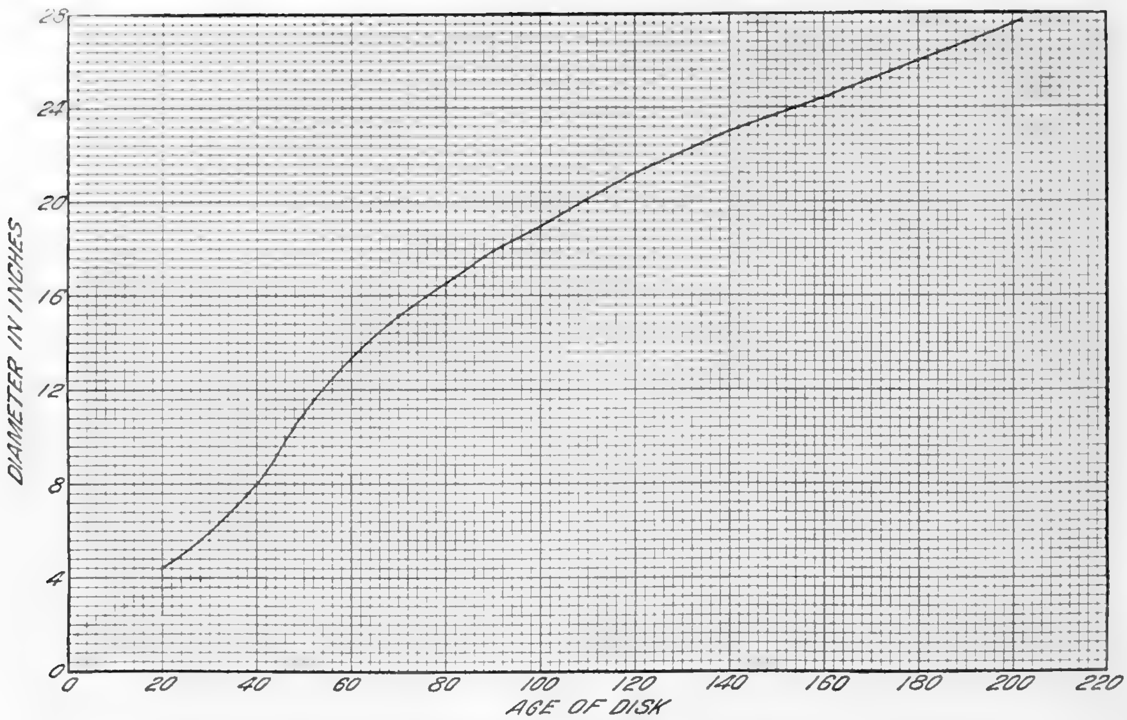


FIG. 30.—Diagram showing average progress of diameter growth (breast high) of dominant trees.

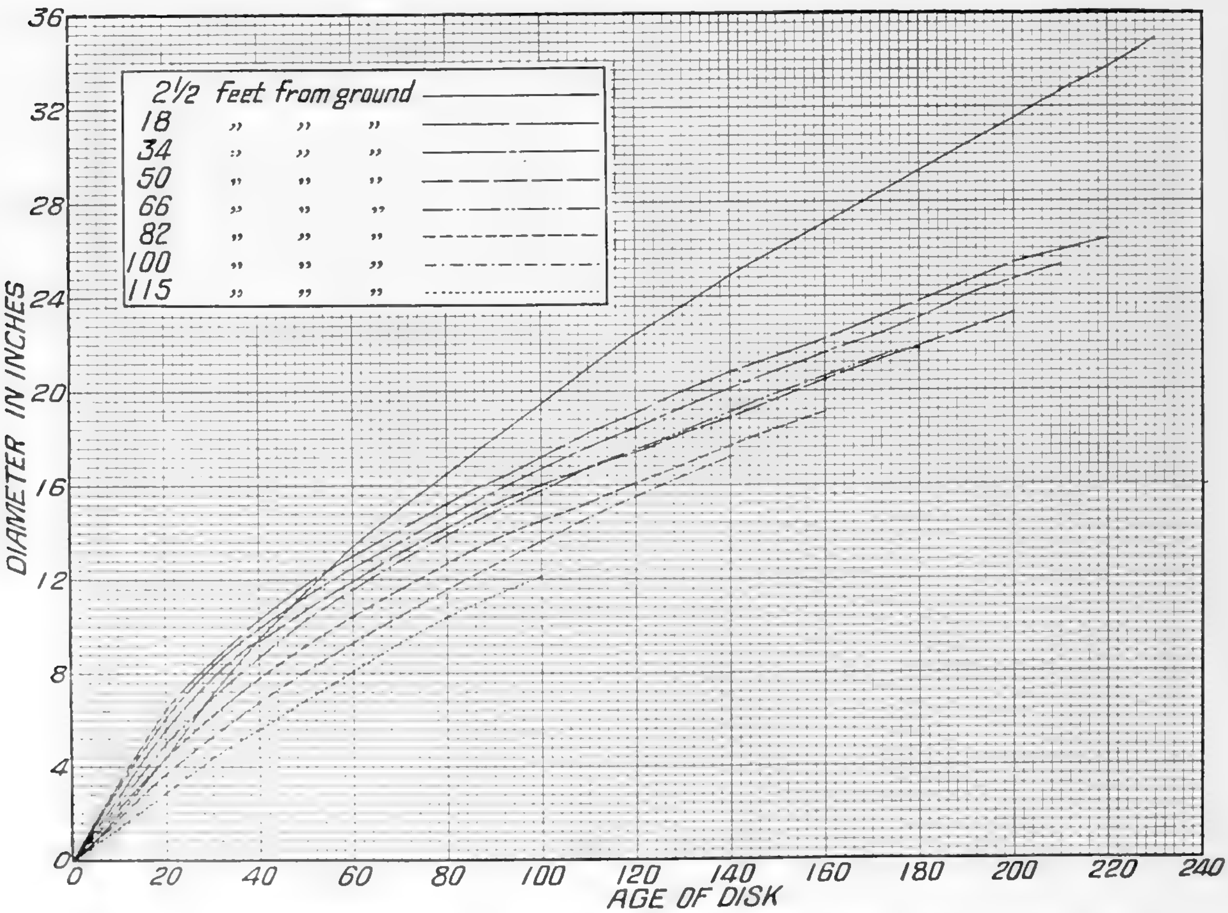


FIG. 31.—Diagram showing diameter growth of dominant trees at various heights from ground (average throughout range).

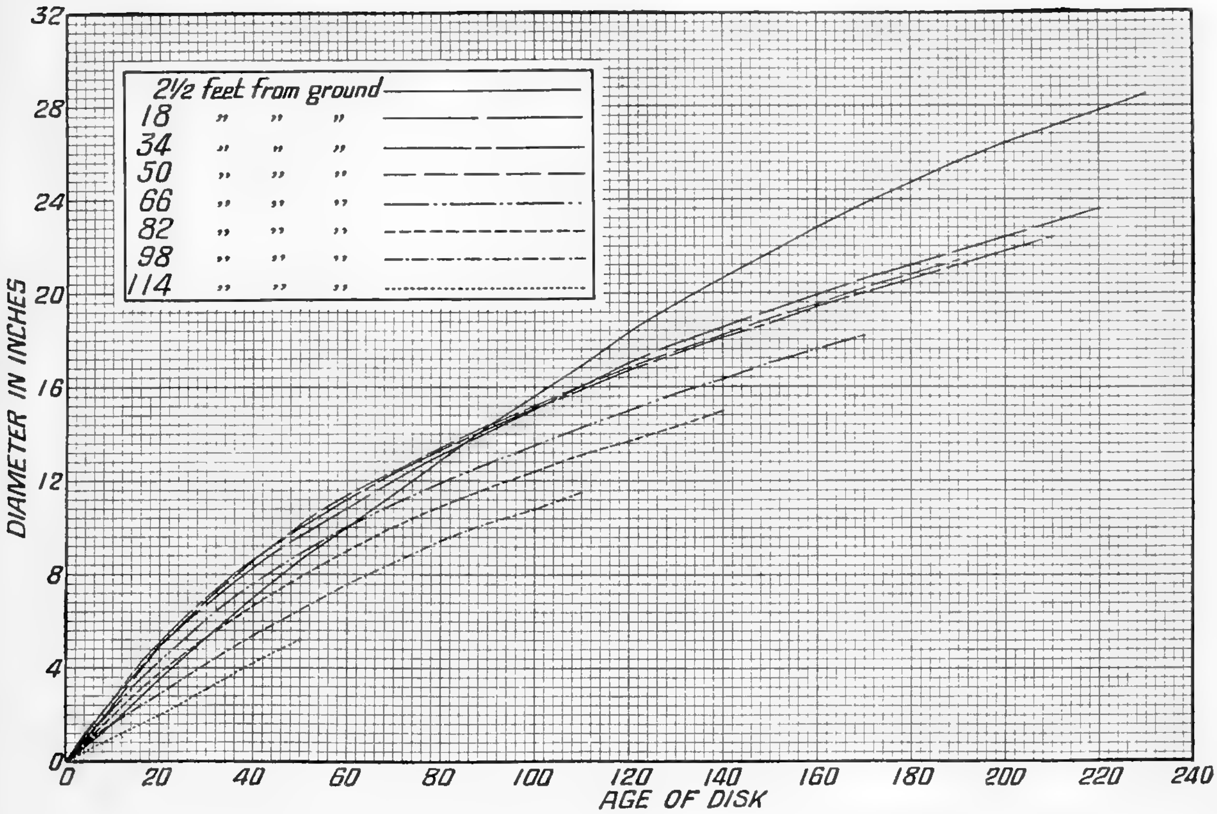


FIG. 32.—Diagram showing diameter growth of codominant trees at various heights from ground (average throughout range).

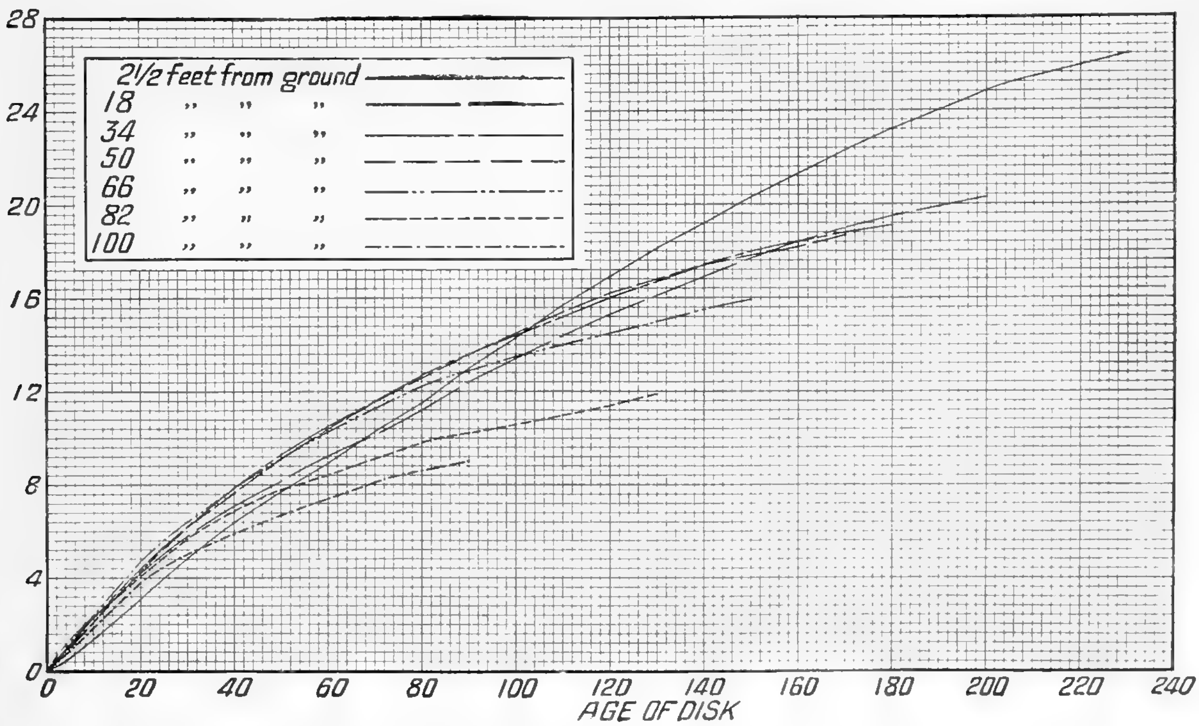


FIG. 33.—Diagram showing diameter growth of oppressed trees at various heights from ground (average throughout range).

TABLE V.—*Growth of diameter and cross-section area at various heights from the ground*—Continued.

(2) AVERAGE FOR WISCONSIN.

Character of growth.	Height of section from ground.	DIAMETER OF SECTION, IN INCHES, AT AGE (YEARS) OF—																						
		10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230
	Feet.																							
Dominant (68 trees).	2½	1.6	3.3	4.8	6.2	7.5	8.8	10.3	12.0	14.2	16.6	18.9	21.0	23.1	25.1	26.8	28.4	30.0	31.5	32.8	34.0			
	18	2.1	4.2	5.8	7.2	8.6	10.1	11.7	13.3	14.8	16.4	17.9	19.3	20.4	21.5	22.6	23.6	24.5	25.4	26.2				
	34	2.2	4.4	6.4	8.3	10.1	11.9	13.5	15.1	16.6	17.9	19.0	20.0	21.0	21.9	22.8	23.6	24.4						
	50	2.4	5.0	7.4	9.5	11.3	13.0	14.5	15.8	17.1	18.2	19.2	20.2	21.0	21.8	22.6	23.4							
	66	2.4	5.0	7.2	9.2	11.0	12.5	13.9	15.1	16.2	17.2	18.1	18.8	19.4	20.0									
	82	2.3	4.4	6.1	7.6	9.0	10.3	11.4	12.3	13.2	14.0	14.7	15.5											
Oppressed (55 trees).	2½	1.5	3.4	4.9	6.4	7.6	8.7	10.2	11.4	12.8	14.2	15.6	16.7	17.8	19.0	20.2	31.2	22.3	23.4	24.2	25.0			
	18	2.1	4.2	5.7	6.9	7.8	8.8	9.7	10.9	12.1	13.1	14.2	15.2	16.0	16.8	17.7	18.4	19.0						
	34	1.8	3.6	5.0	6.5	7.9	9.2	10.4	11.6	12.7	13.7	14.6	15.5	16.3	17.1	17.8								
	50	1.6	3.4	5.2	6.7	8.3	9.8	11.2	12.4	13.5	14.5	15.4	16.3	16.8										
	66	2.2	4.6	6.4	8.1	9.4	10.7	11.8	12.7	13.4	14.0	14.4												

Character of growth.	Height of section from ground.	DIAMETER ACCRETION, IN INCHES, FOR DECADES—																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (68 trees).	2½	1.6	1.7	1.5	1.4	1.3	1.3	1.5	1.7	2.2	2.4	2.3	2.1	2.1	2.0	1.7	1.6	1.6	1.5	1.3	1.2			
	18	2.1	2.1	1.6	1.4	1.4	1.5	1.6	1.6	1.5	1.6	1.5	1.4	1.1	1.1	1.1	1.0	0.9	0.9	0.8				
	34	2.2	2.2	2.0	1.9	1.8	1.8	1.6	1.6	1.5	1.3	1.1	1.0	1.0	0.9	0.9	0.8	0.8						
	50	2.4	2.6	2.4	2.1	1.8	1.7	1.5	1.3	1.3	1.1	1.0	1.0	0.8	0.8	0.8	0.8							
	66	2.4	2.6	2.2	2.0	1.8	1.5	1.4	1.2	1.1	1.0	0.9	0.7	0.6	0.6									
	82	2.3	2.1	1.7	1.5	1.4	1.3	1.1	0.9	0.9	0.8	0.7	0.8											
Oppressed (55 trees).	2½	1.5	1.9	1.5	1.5	1.2	1.1	1.5	1.2	1.4	1.4	1.4	1.1	1.1	1.2	1.2	1.0	1.1	1.1	0.8	0.8			
	18	2.1	2.1	1.5	1.2	0.9	1.0	0.9	1.2	1.2	1.0	1.1	1.0	0.8	0.8	0.9	0.7	0.6						
	34	1.8	1.8	1.4	1.5	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.7								
	50	1.6	1.8	1.8	1.5	1.6	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.5										
	66	2.2	2.4	1.8	1.7	1.3	1.3	1.1	0.9	0.7	0.6	0.4												

Character of growth.	Height of section from ground.	CORRESPONDING AREA ACCRETION, IN SQUARE FEET, FOR DECADES—																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (68 trees).	2½	0.01	0.05	0.07	0.08	0.10	0.11	0.16	0.20	0.32	0.40	0.45	0.45	0.51	0.53	0.48	0.48	0.51	0.50	0.40	0.43			
	18	.02	.08	.08	.10	.12	.16	.19	.21	.23	.28	.28	.28	.24	.25	.26	.26	.23	.25	.22				
	34	.03	.08	.11	.16	.18	.21	.22	.25	.26	.25	.22	.21	.22	.21	.22	.21	.21						
	50	.03	.11	.16	.19	.21	.22	.23	.21	.23	.22	.20	.21	.18	.19	.19	.21							
	66	.03	.11	.14	.18	.20	.19	.20	.19	.19	.18	.18	.14	.12	.13									
	82	.03	.08	.09	.11	.13	.14	.13	.11	.13	.12	.11	.13											
Oppressed (55 trees).	2½	.01	.05	.07	.09	.09	.10	.16	.14	.18	.21	.23	.19	.21	.24	.25	.23	.26	.28	.20	.22			
	18	.02	.08	.08	.08	.07	.09	.09	.14	.15	.13	.17	.16	.14	.14	.17	.14	.12						
	34	.02	.05	.07	.09	.11	.12	.13	.14	.15	.14	.14	.15	.14	.14	.14	.14							
	50	.01	.05	.09	.09	.13	.15	.16	.16	.15	.16	.14	.16	.09										
	66	.03	.08	.11	.14	.12	.14	.14	.12	.10	.09	.06												

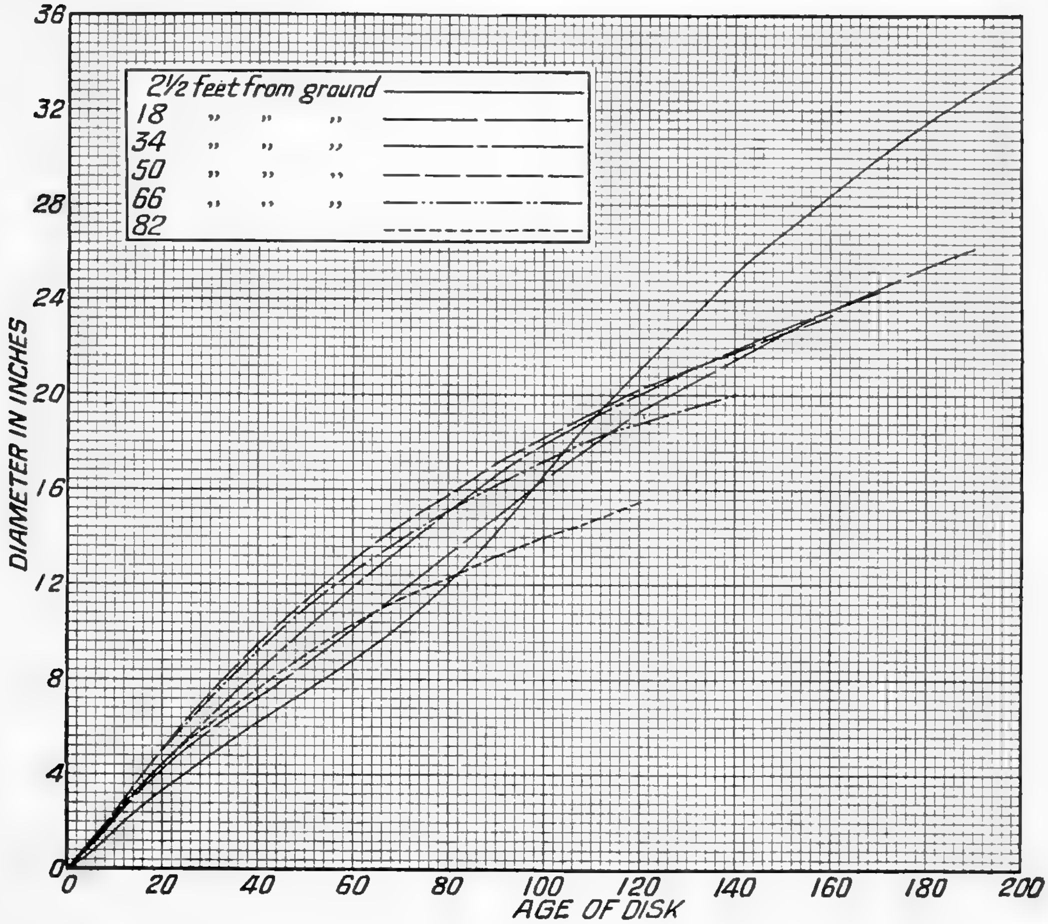


FIG. 34.—Diagram showing diameter growth of dominant trees at various heights from ground in Wisconsin.

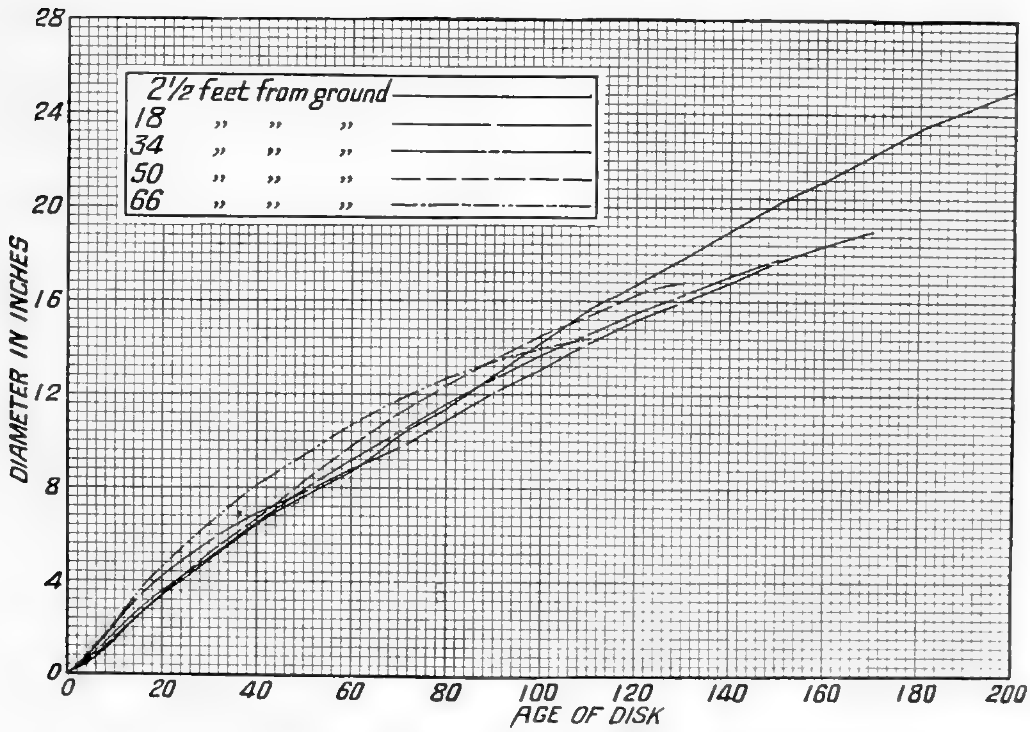


FIG. 35.—Diagram showing diameter growth of oppressed trees at various heights from ground in Wisconsin.

TABLE V.—*Growth of diameter and cross-section area at various heights from the ground*—Continued.

(3) AVERAGE FOR PENNSYLVANIA.

Character of growth.	Height of section from ground.	DIAMETER OF SECTION, IN INCHES, AT AGE (YEARS) OF—																						
		10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230
	Feet.																							
Dominant (51 trees).	2½	2.0	4.4	7.1	9.5	11.5	13.4	15.0	16.5	18.0	19.5	21.0	22.4	23.6	24.9	26.0	27.1	28.2	29.3	30.4	31.5	32.7	33.9	34.9
	18	3.4	6.4	8.5	10.3	11.8	13.0	14.1	15.2	16.2	17.2	18.2	19.1	20.0	20.8	21.5	22.2	23.0	23.8	24.6	25.4	25.9	26.4	
	34	3.2	6.1	8.3	9.9	11.3	12.5	13.6	14.7	15.7	16.7	17.6	18.4	19.3	20.1	20.9	21.6	22.3	23.1	24.0	24.7	25.3		
	50	2.7	5.6	7.8	9.4	10.7	11.9	13.1	14.2	15.2	16.0	16.7	17.4	18.2	18.9	19.7	20.5	21.2	21.9	22.6	23.3			
	66	2.5	5.0	7.0	8.7	10.3	11.6	12.8	13.9	14.9	15.8	16.7	17.5	18.3	19.1	19.9	20.6	21.3	21.8					
	82	2.2	4.4	6.2	7.8	9.2	10.5	11.6	12.7	13.7	14.5	15.3	16.1	16.9	17.7	18.4	19.1							
	100	1.8	3.7	5.3	6.8	8.1	9.3	10.4	11.6	12.6	13.6	14.6	15.5	16.4	17.2									
	115	1.4	2.9	4.4	5.6	6.9	8.1	9.3	10.4	11.3	12.1													
Codominant (78 trees).	2½	1.6	3.5	5.4	7.2	8.7	10.2	11.6	12.9	14.2	15.5	16.8	18.2	19.3	20.3	21.3	22.3	23.2	24.0	24.8	25.5	26.2	27.0	27.8
	18	2.4	4.8	6.5	8.0	9.1	10.1	11.2	12.3	13.2	14.1	14.9	15.8	16.5	17.2	17.8	18.4	19.1	19.7	20.3	21.0	21.6	22.2	
	34	2.3	4.6	6.4	7.8	9.0	10.1	11.1	12.0	12.8	13.6	14.4	15.1	15.8	16.5	17.1	17.8	18.4	19.1	19.7	20.4	21.0		
	50	2.3	4.4	6.2	7.9	9.3	10.5	11.5	12.5	13.4	14.2	14.9	15.6	16.3	16.9	17.6	18.2	18.9	19.5	20.1				
	66	2.1	4.1	5.8	7.2	8.5	9.6	10.6	11.5	12.3	13.1	13.9	14.6	15.3	15.9	16.6	17.2	17.8						
	82	1.6	3.1	4.5	5.7	6.8	7.8	8.7	9.6	10.4	11.1	11.8	12.4	13.0	13.7									
	98	1.4	2.5	3.8	5.0	6.1	7.1	8.0																
	114	1.0	2.0	3.1	4.2	5.2																		

Character of growth.	Height of section from ground.	DIAMETER ACCRETION, IN INCHES, FOR DECADES—																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (51 trees).	2½	2.0	2.4	2.7	2.4	2.0	1.9	1.6	1.5	1.5	1.5	1.5	1.4	1.2	1.3	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.0
	18	3.4	3.0	2.1	1.8	1.5	1.2	1.1	1.1	1.0	1.0	1.0	.9	.9	.8	.7	.7	.8	.8	.8	.5	.5	.5	
	34	3.2	2.9	2.2	1.6	1.4	1.2	1.1	1.1	1.0	1.0	.9	.8	.9	.8	.8	.7	.7	.8	.9	.7	.6		
	50	2.7	2.9	2.2	1.6	1.3	1.2	1.2	1.1	1.0	.8	.7	.7	.8	.7	.8	.8	.7	.7	.7	.7			
	66	2.5	2.5	2.0	1.7	1.6	1.3	1.2	1.1	1.0	.9	.9	.8	.8	.8	.8	.7	.7	.5					
	82	2.2	2.2	1.8	1.6	1.4	1.3	1.1	1.1	1.0	.8	.8	.8	.8	.8	.7	.7							
	100	1.8	1.9	1.6	1.5	1.3	1.2	1.1	1.2	1.0	1.0	1.0	.9	.9	.8									
	115	1.4	1.5	1.5	1.2	1.3	1.2	1.2	1.1	.9	.8													
Codominant (78 trees).	2½	1.6	1.9	1.9	1.8	1.5	1.5	1.4	1.3	1.3	1.3	1.3	1.4	1.1	1.0	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.8	0.8
	18	2.4	2.4	1.7	1.5	1.1	1.0	1.1	1.1	.9	.9	.8	.9	.7	.7	.6	.6	.7	.6	.6	.7	.6	.6	
	34	2.3	2.3	1.8	1.4	1.2	1.1	1.0	.9	.8	.8	.8	.7	.7	.7	.6	.7	.6	.7	.6	.7	.6		
	50	2.3	2.1	1.8	1.7	1.4	1.2	1.0	1.0	.9	.8	.7	.7	.7	.6	.7	.6	.7	.6	.6				
	66	2.1	2.0	1.7	1.4	1.3	1.1	1.0	.9	.8	.8	.8	.7	.7	.6	.7	.6	.6						
	82	1.6	1.5	1.4	1.2	1.1	1.0	.9	.9	.8	.7	.7	.6	.6	.7									
	98	1.4	1.1	1.3	1.2	1.1	1.0	.9																
	114	1.0	1.0	1.1	1.1	1.0																		

Character of growth.	Height of section from ground.	CORRESPONDING AREA ACCRETION, IN SQUARE FEET, FOR DECADES—																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (51 trees).	2½	0.02	0.08	0.17	0.22	0.23	0.25	0.25	0.26	0.29	0.30	0.33	0.34	0.30	0.34	0.31	0.31	0.34	0.34	0.36	0.37	0.42	0.44	0.37
	18	.06	.16	.17	.19	.18	.16	.16	.18	.17	.18	.20	.18	.19	.18	.16	.17	.19	.21	.21	.22	.14	.14	
	34	.05	.15	.17	.16	.17	.15	.16	.17	.16	.18	.17	.16	.18	.17	.18	.16	.17	.20	.23	.19	.16		
	50	.04	.13	.16	.15	.14	.15	.16	.17	.16	.14	.12	.13	.16	.14	.17	.17	.16	.16	.17	.16			
	66	.03	.11	.13	.14	.17	.15	.16	.16	.16	.15	.16	.15	.16	.16	.17	.18	.13	.12					
	82	.03	.07	.11	.12	.13	.14	.13	.15	.14	.13	.13	.13	.15	.15	.14	.14							
	100	.02	.05	.08	.10	.11	.11	.12	.14	.13	.15	.15	.15	.16	.14									
	115	.01	.03	.07	.07	.09	.10	.11	.12	.11	.10													
Codominant (78 trees).	2½	.01	.06	.09	.12	.13	.16	.16	.18	.19	.21	.23	.27	.22	.22	.22	.24	.22	.21	.21	.20	.19	.24	.23
	18	.03	.09	.11	.12	.10	.11	.12	.14	.13	.13	.13	.15	.12	.13	.12	.12	.14	.13	.13	.15	.14	.15	
	34	.03	.08	.11	.11	.11	.12	.11	.11	.11	.12	.12	.11	.12	.12	.11	.14	.12	.14	.13	.15	.13		
	50	.03	.07	.11	.13	.13	.13	.12	.13	.13	.12	.11	.12	.12	.11	.13	.12	.14	.12	.13				
	66	.02	.07	.09	.10	.11	.11	.11	.11	.10	.11	.12	.11	.12	.10	.12	.11	.12						
	82	.01	.04	.06	.07	.07	.08	.08	.09	.09	.08	.09	.08	.08	.10									
	98	.01	.02	.06	.06	.06	.07	.08																
	114	.01	.01	.03	.05	.05																		

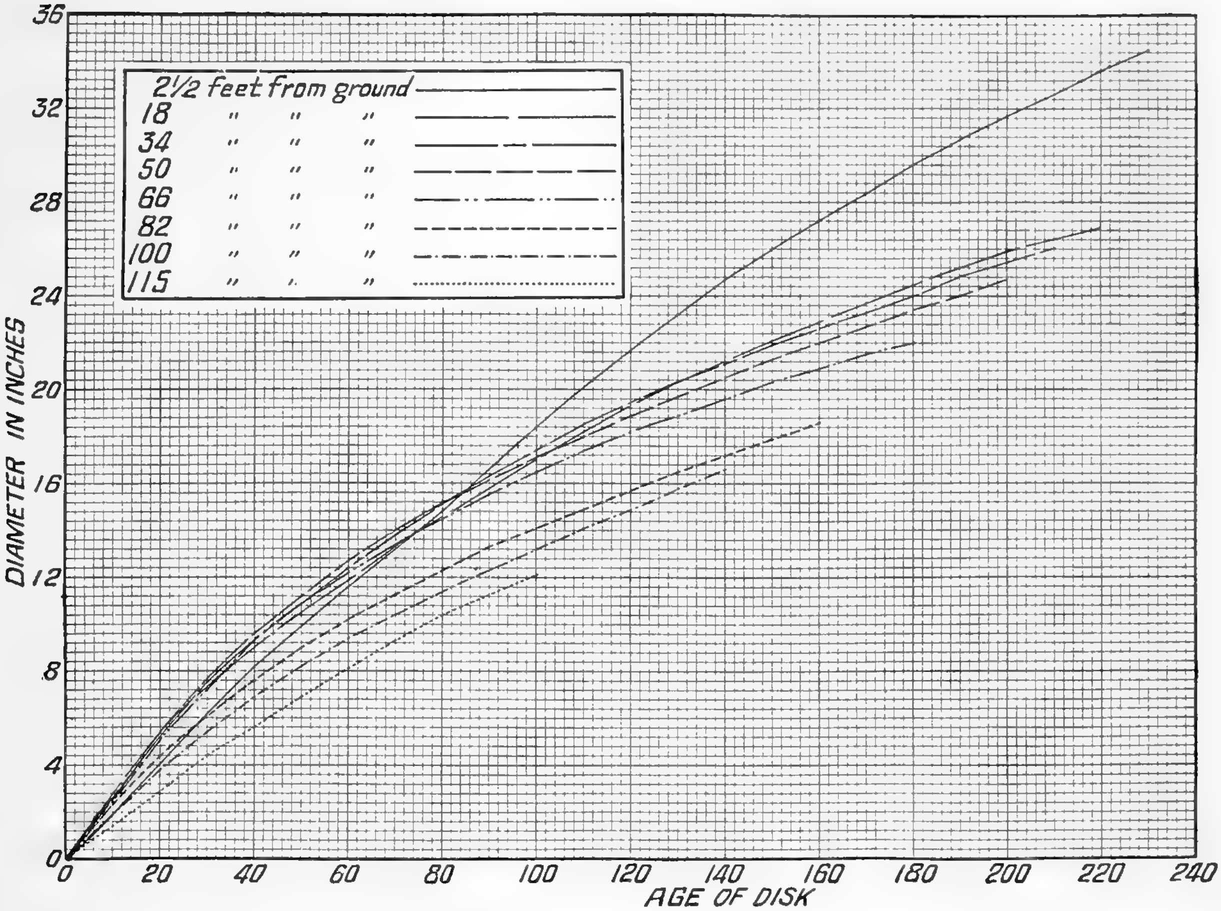


FIG. 36.—Diagram showing diameter growth of dominant trees at various heights from ground in Pennsylvania.

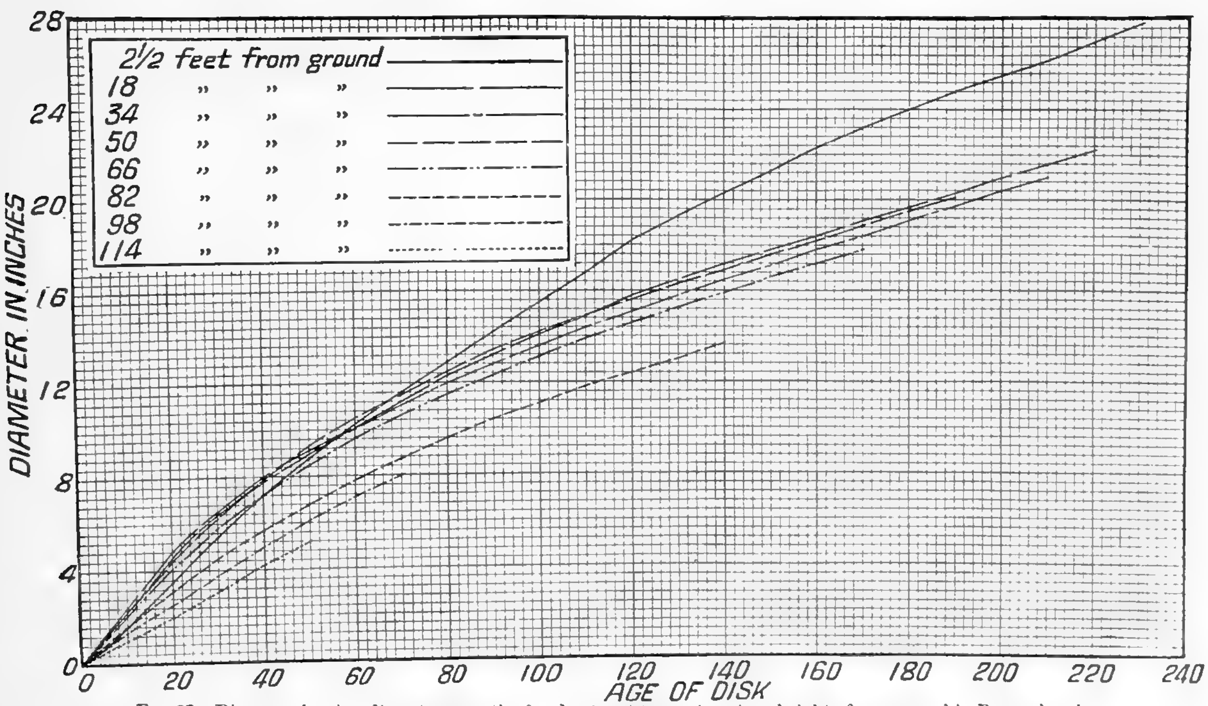


FIG. 37.—Diagram showing diameter growth of codominant trees at various heights from ground in Pennsylvania.

TABLE V.—*Growth of diameter and cross-section area at various heights from the ground*—Continued.

(4) AVERAGE FOR MICHIGAN.

Character of growth.	Height of section from ground.	DIAMETER OF SECTION, IN INCHES, AT AGE (YEARS) OF—																						
		10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230
	Feet.																							
Dominant (75 trees).	2½	2.0	4.4	6.6	8.7	10.6	12.4	14.0	15.6	17.2	18.7	20.0	21.2	22.3	23.5	24.5	25.5	26.5	27.5	28.4	29.1	29.8	30.6	31.4
	18	2.8	5.6	7.7	9.6	11.3	12.8	14.2	15.5	16.7	17.7	18.7	19.7	20.6	21.5	22.4	23.2	23.9	24.6	25.2	25.8	26.3	26.8	
	34	2.8	5.6	7.9	9.8	11.4	12.8	14.2	15.3	16.3	17.3	18.5	19.4	20.2	21.0	21.7	22.4	23.1	23.7	24.3	24.8			
	50	2.8	5.7	8.0	10.1	11.8	13.3	14.5	15.5	16.5	17.4	18.3	19.2	20.1	20.9	21.6	22.2	22.8	23.4	23.9				
	66	2.5	5.2	7.3	8.8	10.1	11.3	12.4	13.5	14.5	15.5	16.5	17.4	18.1	18.8	19.4	10.9	20.4						
	82	2.3	4.2	5.9	7.4	8.7	9.7	10.7	11.6	12.7	13.6	14.4	15.1	15.8	16.4	17.1								
	100	2.1	4.0	5.5	7.0	8.2	9.4	10.3	11.1	11.9	12.6	13.3												
Codominant (28 trees).	2½	1.5	3.4	5.1	6.7	8.3	9.6	11.0	12.6	14.1	15.4	16.7	18.1	19.4	20.5	21.6	22.8	23.8	24.7	25.6	26.4	27.1	27.7	28.3
	18	2.3	4.9	6.8	8.4	9.8	11.2	12.4	13.5	14.6	15.6	16.6	17.6	18.5	19.2	19.9	20.6	21.3	21.9	22.4	22.9	23.4	23.9	
	34	2.8	5.5	7.4	9.1	10.6	11.9	13.1	14.2	15.2	16.1	16.9	17.7	18.4	19.1	19.7	20.3	20.9	21.4	21.8				
	50	2.9	5.3	7.5	9.2	10.7	12.0	13.0	14.0	14.9	15.8	16.6	17.4	18.1	18.8	19.4	19.9	20.5	21.0					
	66	2.2	4.3	6.2	7.7	9.0	10.0	11.0	11.8	12.5	13.3	14.1	14.8	15.4	15.9	16.4	16.9							
	82	2.2	4.4	6.0	7.5	8.8	9.9	10.9	11.8	12.6	13.3	14.0	14.6	15.1	15.7									
	100	1.7	3.2	4.5	5.6	6.7	7.8	8.7	9.5	10.3	11.0	11.7												
Oppressed (36 trees).	2½	1.2	2.6	4.4	6.1	7.5	8.8	10.1	11.3	12.8	14.0	15.3	16.5	17.7	18.7	19.7	20.6	21.4	22.1	22.9	23.6	24.2	24.7	25.2
	18	2.0	4.0	5.6	7.0	8.1	9.2	10.0	11.0	12.1	13.1	14.0	14.7	15.5	16.2	16.8	17.3	17.8	18.3	18.7	19.1			
	34	2.5	5.1	7.2	9.0	10.3	11.4	12.4	13.3	14.0	14.6	15.2	15.8	16.4	16.9	17.4	17.8	18.2	18.5					
	50	2.5	5.0	6.9	8.3	9.5	10.6	11.6	12.4	13.2	13.9	14.6	15.2	15.8	16.4	16.8	17.2	17.7						
	66	2.5	4.7	6.3	7.6	8.7	9.7	10.6	11.4	12.1	12.7	13.3	13.8	14.3	14.8	15.2								
	82	2.3	4.1	5.7	6.9	7.8	8.4	9.1	9.8	10.2	10.6	11.0	11.4	11.9										
	100	1.9	3.8	5.0	5.9	6.7	7.4	8.1	8.6	9.0														

Character of growth.	Height of section from ground.	DIAMETER ACCRETION, IN INCHES, FOR DECADES—																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (75 trees).	2½	2.0	2.4	2.2	2.1	1.9	1.8	1.6	1.6	1.6	1.5	1.3	1.2	1.1	1.2	1.0	1.0	1.0	1.0	0.9	0.7	0.7	0.8	0.8
	18	2.8	2.8	2.1	1.9	1.7	1.5	1.4	1.3	1.2	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	
	34	2.8	2.8	2.3	1.9	1.6	1.4	1.4	1.1	1.0	1.0	1.2	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.5			
	50	2.8	2.9	2.3	2.1	1.7	1.5	1.2	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.6	0.5				
	66	2.5	2.7	2.1	1.5	1.3	1.2	1.1	1.1	1.0	1.0	1.0	0.9	0.7	0.7	0.6	0.5	0.5						
	82	2.3	1.9	1.7	1.5	1.3	1.0	1.0	0.9	1.1	0.9	0.8	0.7	0.7	0.6	0.7								
	100	2.1	1.9	1.5	1.5	1.2	1.2	0.9	0.8	0.8	0.7	0.7												
Codominant (28 trees).	2½	1.5	1.9	1.7	1.6	1.6	1.3	1.4	1.6	1.5	1.3	1.3	1.4	1.3	1.1	1.1	1.2	1.0	0.9	0.9	0.8	0.7	0.6	0.6
	18	2.3	2.6	1.9	1.6	1.4	1.4	1.2	1.1	1.1	2.0	1.0	1.0	0.9	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.5	
	34	2.8	2.7	1.9	1.7	1.5	1.3	1.2	1.1	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.4				
	50	2.9	2.4	2.2	1.7	1.5	1.3	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.6	0.5					
	66	2.2	2.1	1.9	1.5	1.3	1.0	1.0	0.8	0.7	0.8	0.8	0.7	0.6	0.5	0.5	0.5	0.4						
	82	2.2	2.2	1.6	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.6									
	100	1.7	1.5	1.3	1.1	1.1	1.1	0.9	0.8	0.8	0.7	0.7												
Oppressed (36 trees).	2½	1.2	1.4	1.8	1.7	1.4	1.3	1.3	1.2	1.5	1.2	1.3	1.2	1.2	1.0	1.0	0.9	0.8	0.7	0.8	0.7	0.6	0.5	0.5
	18	2.0	2.0	1.6	1.4	1.1	1.1	0.8	1.0	1.1	1.0	0.9	0.7	0.8	0.7	0.6	0.5	0.5	0.5	0.4	0.4			
	34	2.5	2.6	2.1	1.8	1.3	1.1	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.3					
	50	2.5	2.5	1.9	1.4	1.2	1.1	1.0	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.4	0.4	0.5						
	66	2.5	2.2	1.6	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4								
	82	2.3	1.8	1.6	1.2	0.9	0.6	0.7	0.7	0.4	0.4	0.4	0.4	0.5										
	100	1.9	1.9	1.2	0.9	0.8	0.7	0.7	0.5	0.4														

Character of growth.	Height of section from ground	CORRESPONDING AREA ACCRETION, IN SQUARE FEET, FOR DECADES—																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Feet.																							
Dominant (75 trees).	2½	0.02	0.08	0.14	0.17	0.20	0.23	0.23	0.26	0.28	0.30	0.27	0.27	0.26	0.30	0.26	0.28	0.28	0.29	0.28	0.22	0.22	0.27	0.27
	18	.04	.13	.15	.18	.20	.19	.21	.21	.21	.19	.20	.21	.22	.18	.22	.19	.18	.19	.16	.17	.14	.15	
	34	.04	.13	.17	.18	.19	.18	.21	.18	.17	.18	.24	.18	.17	.18	.17	.17	.17	.15	.16	.13			
	50	.04	.14	.17	.21	.20	.20	.19	.16	.17	.17	.18	.18	.19	.18	.16	.15	.14	.16	.12				
	66	.03	.12	.14	.13	.14	.14	.14	.15	.16	.16	.17	.17	.14	.14	.12	.11	.11						
	82	.03	.07	.09	.11	.11	.10	.11	.11	.15	.13	.12	.11	.12	.11	.12								
	100	.02	.07	.07	.11	.09	.12	.10	.09	.10	.10	.09	.08											
Codominant (28 trees).	2½	.01	.05	.08	.10	.13	.13	.16	.20	.22	.21	.23	.27	.26	.24	.25	.29	.26	.24	.24	.23	.20	.18	.19
	18	.03	.10	.12	.13	.14	.16	.16	.15	.17	.17	.17	.19	.18	.14	.15	.18	.13	.14	.13	.12	.13		
	34	.04	.12	.14	.15	.16	.16	.17	.16	.16	.15	.15	.15	.14	.14	.13	.13	.13	.11	.10				
	50	.05	.10	.16	.15	.16	.16	.14	.15	.14	.15	.14	.15	.14	.14	.12	.11	.13	.11					
	66	.03	.07	.11	.11	.12	.10	.12	.10	.09	.11	.12	.11	.10	.09	.09	.09							
	82	.03	.07	.10	.11	.11	.11	.12	.11	.11	.09	.11	.09	.08	.10									
	100	.02	.04	.05	.06	.07	.09	.08	.08	.09	.08	.09												
Oppressed (36 trees).	2½	.01	.03	.06	.10	.11	.11	.14	.14	.19	.18	.21	.20	.23	.20	.21	.22	.16	.16	.20	.18	.15	.14	.13
	18	.02	.07	.08	.10	.09	.10	.08	.12	.14	.14	.13	.11	.13	.12	.11	.09	.10	.10	.08	.08			
	34	.03	.11	.14	.16	.14	.13	.12	.13	.11	.09	.10	.10	.11	.09	.09	.08	.08	.06					
	50	.03	.11	.12	.12	.11	.12	.12	.11	.11	.10	.11	.10	.10	.11	.07	.07	.10						
	66	.03	.09	.10	.09	.10	.10	.10	.10	.09	.08	.08	.08	.07	.08	.07								
	82	.03	.06	.09	.08	.07	.05	.07	.07	.05	.04	.05	.05	.06										
	100	.02	.06	.06	.05	.05	.06	.06	.04	.04														

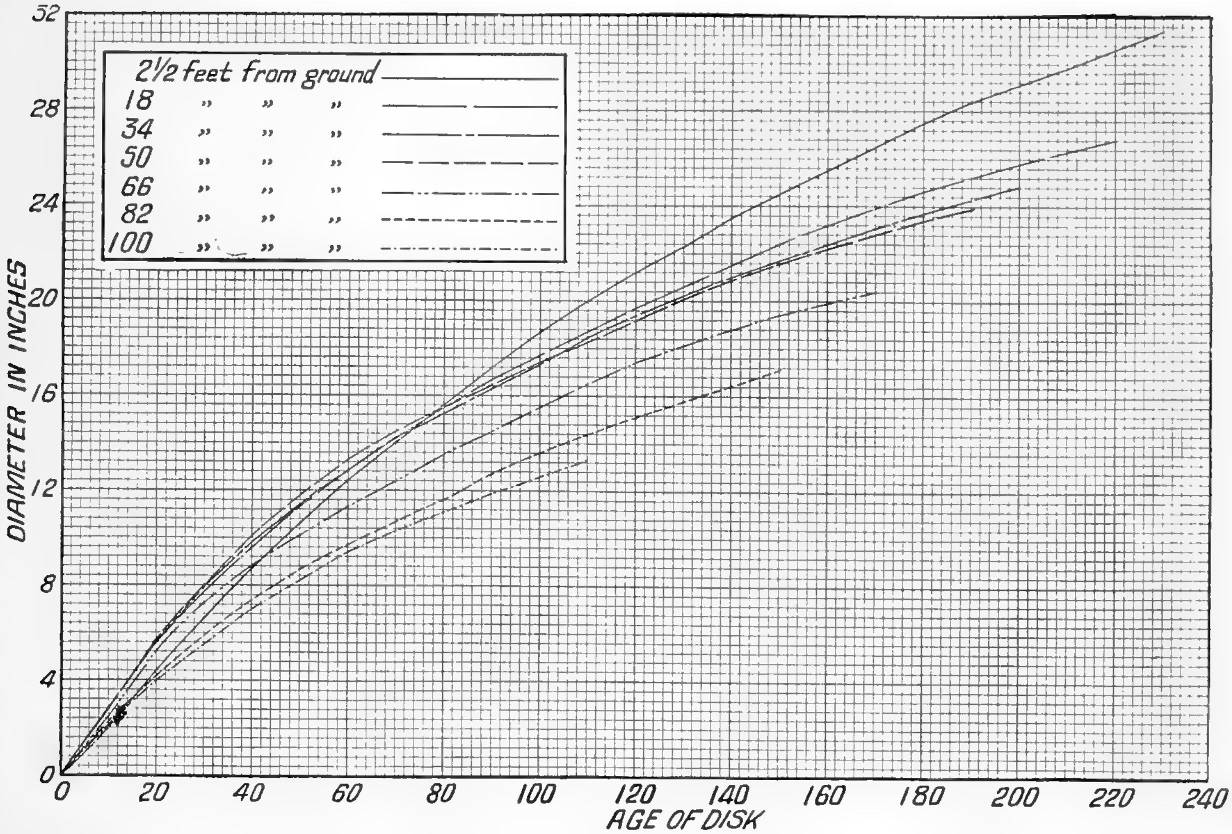


FIG. 38.—Diagram showing diameter growth of dominant trees at various heights from ground in Michigan.

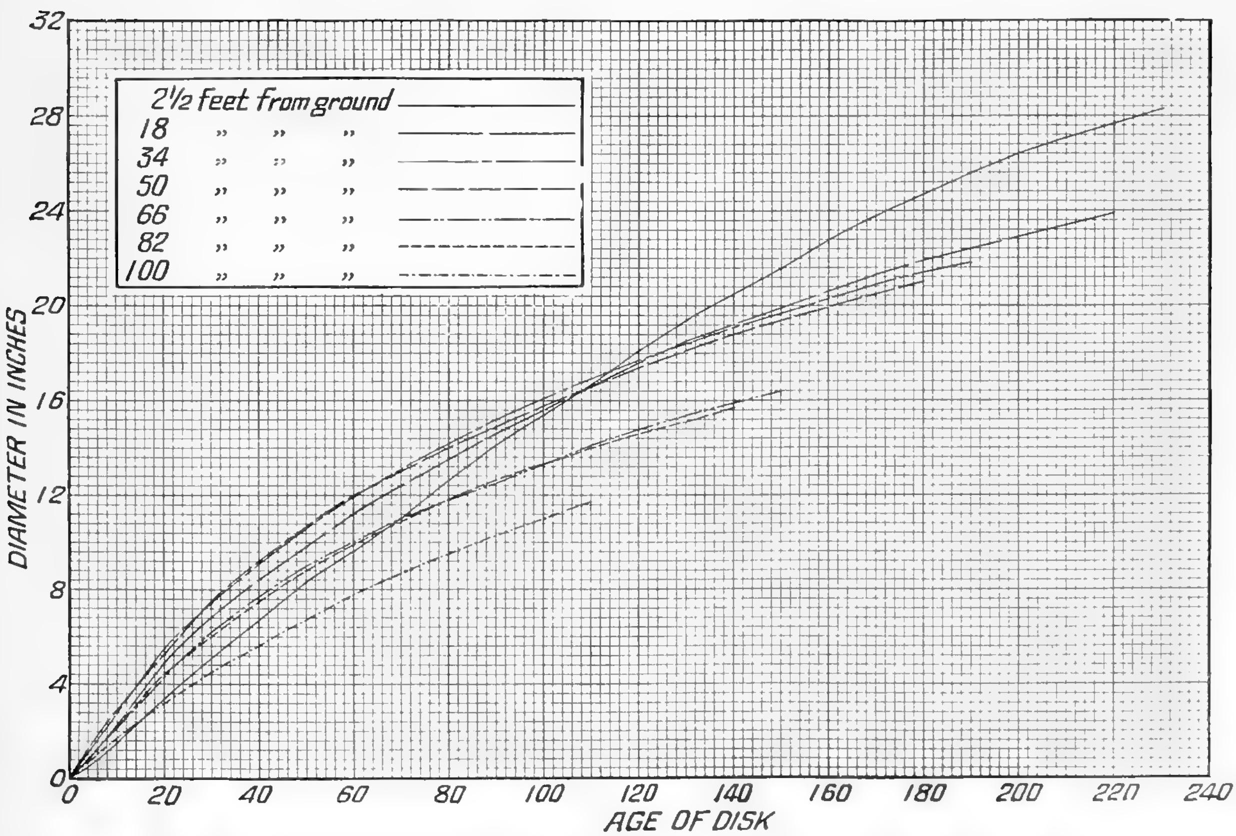


FIG. 39.—Diagram showing diameter growth of codominant trees at various heights from ground in Michigan.

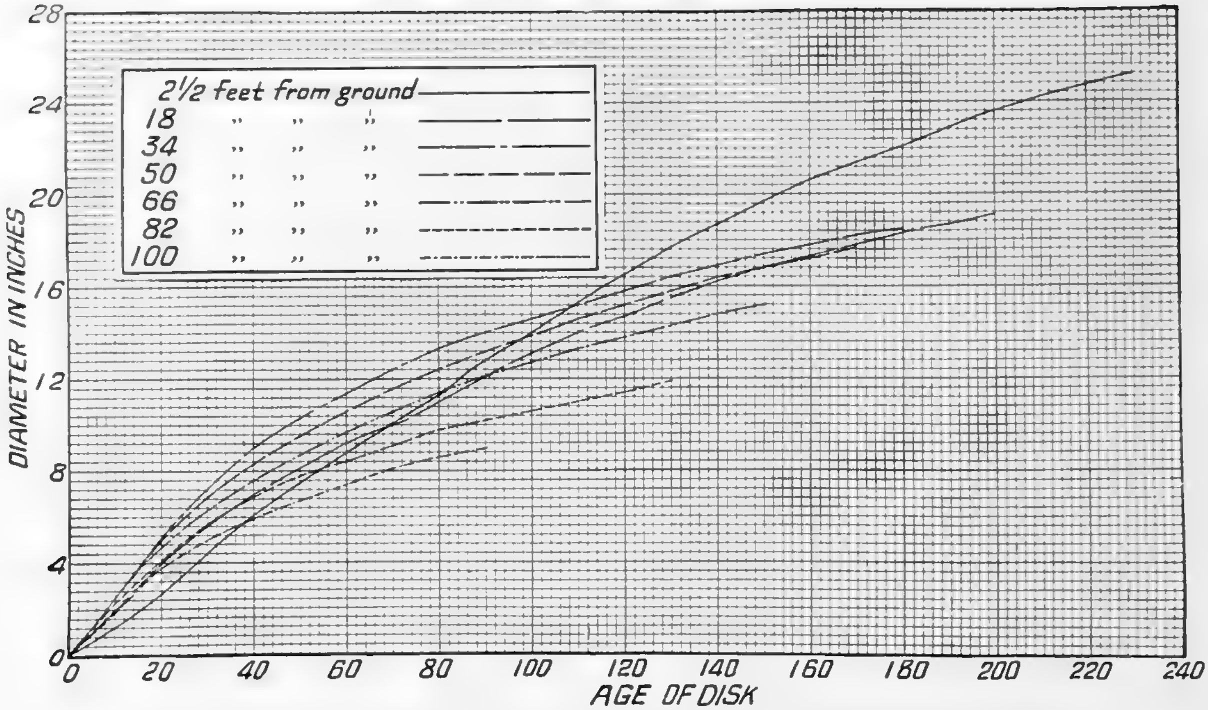


FIG. 40.—Diagram showing diameter growth of oppressed trees at various heights from ground in Michigan.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees.*

A.—MICHIGAN:

(1) SITE *a*: Presque Isle County. Sample area: 1 acre.

[700 to 800 feet above sea level.]

Soil: Yellow or gray sand, moderately loose, deep; subsoil with small stones, surface cover of brakes, huckleberry, etc.,

Forest conditions: Red Pine (61 per cent), mixed with White Pine (36 per cent), and occasional Maple, Poplar, Cedar (3 per cent), on level.

Age of pine: 100 to 150 years.
Density of crown cover: 0.6.

Number of trees: 181.

Classification:		White Pine.	Red Pine.
Dominant	per cent..	40	46
Oppressed	do....	27	26
Suppressed	do....	43	28

ACRE YIELD.

White Pine.					Red Pine.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*
4	3 to 6		....		9	....	
17	6 to 10		170		25	6 to 10	
1	10		18		4	10	
4	11		100		7	11	
2	12		69		7	12	
5	13		175		5	13	80 to 100
6	14		240		7	14	
7	15	80 to 100	322		9	15	
4	16		232		13	16	
5	17		325		12	17	
3	18		216		9	18	
2	19		158		3	19	
2	21		186		3	20	
3	22		303				
1	24		119				
2	27		366				

68 trees:
Total cubic feet.......................... 2,900
Total feet B. M 14,350

113 trees:
Total cubic feet. 3,813
Total feet B. M. 18,300

Total yield: Pine, 32,650 feet B. M., of which White Pine 44 per cent.
Average annual accretion: White Pine. 57 cubic feet.
272 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

MEASUREMENTS OF SAMPLE TREES.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
Age class: 80 to 100 years.										
DOMINANT GROWTH.										
13	100	19.0	94	5.2	75.4	0.40	0.52	2.0	1.50	0.75
42	100	20.2	95	4.9	99.6	.48	.42	.8	.80	1.00
29	95	21.5	100	4.1	115.4	.45	.48	1.0	1.15	1.21
Average	98	20.2	96	4.7	96.8	.44	.47	1.3	1.15	.99
OPPRESSED GROWTH.										
66	98	14.5	78	5.9	46.9	0.52	0.42	2.2	1.03	0.47
SUPPRESSED GROWTH.										
19	92	10.5	72.0	8.2	20.6	0.47	0.26	1.2	0.25	0.22
11	84	10.0	73.0	7.6	20.9	.53	.48	3.7	.77	.25
Average	88	10.2	72.5	7.9	20.7	.50	.37	2.4	.51	.23
Age class: 100 to 150 years.										
DOMINANT GROWTH.										
1	123	20.0	10.2	5.5	89.7	0.40	0.54	2.9	2.60	0.73
22	101	20.8	90.0	4.7	92.7	.42	.51	2.0	1.85	.91
48	105	20.5	99.0	5.1	96.7	.42	.44	1.3	1.26	.92
47	104	22.7	94.0	4.7	103.0	.39	.59	1.5	1.55	.99
Average	108	21.0	96.0	5.0	95.5	.41	.52	1.9	1.81	.89
5	149	20.2	105.0	7.6	88.9	.39	.50	2.0	1.78	.60
6	135	21.0	114.0	6.2	107.9	.39	.57	2.2	2.37	.80
35	135	22.0	121.0	5.5	139.6	.40	.43	1.5	2.10	1.03
Average	139.7	21.1	113.0	6.4	112.1	.39	.50	1.9	2.08	.81
OPPRESSED GROWTH.										
9	102	16.0	85.0	6.6	48.8	0.41	0.46	2.5	1.22	0.47
31	102	15.1	86.0	6.7	49.4	.46	.40	1.4	.69	.48
45	102	17.0	84.0	6.0	58.5	.44	.61	1.7	.99	.57
43	105	16.8	87.0	6.1	67.3	.49	.42	.7	.47	.64
Average	103	16.2	85.5	6.3	56.0	.45	.47	1.6	.84	.54
4	127	17.0	88.0	6.7	56.9	.41	.54	5.2	2.96	.44
40	134	15.0	94.0	8.6	57.6	.50	.30	2.2	1.26	.43
3	147	18.0	91.0	7.9	66.0	.41	.44	4.9	3.23	.44
Average	136	16.7	91.0	7.7	60.2	.44	.43	4.1	2.48	.44
SUPPRESSED GROWTH.										
39	127	11.0	69	1.2	24.6	0.54	0.22	3.2	0.79	0.19
Age class: 250 to 300 years.										
DOMINANT GROWTH.										
7	284	33.0	135	8.7	319.2	0.39	....	0.6	1.91	1.12

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

(2) SITE *b*: Presque Isle County. Sample area: 1 acre.

[700 to 800 feet above sea level.]

Soil: Deep, loose, gray sand, covered with leaves; said to be underlaid by clay.

Forest conditions: White Pine (68 per cent), intermixed with Red Pine (14 per cent), Hemlock (18 per cent), with scattering Cedar.

Age of pine: 130 to 140 years.
Density of crown cover: 0.7 to 0.8.
Number of trees: 181.

Classification:

		White Pine
Dominant	per cent	52
Oppressed	do	18
Suppressed	do	30

ACRE YIELD.

White Pine. Number of trees.	White Pine. Diameter (breast high).	White Pine. Height.	White Pine. Volume. Bole.	White Pine. Volume. Merchantable timber.	Red Pine. Number of trees.	Red Pine. Diameter (breast high).	Red Pine. Height.	Hemlock. Number of trees.	Hemlock. Diameter (breast high).	Hemlock. Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
28	6 to 10	100 to 120	280		1	6 to 10	100 to 120	20	6 to 10	40 to 60
5	10		95		1	14		11	10 to 14	
6	11		192		1	15		3	14 to 18	
7	12		266		5	16				
6	13		264		6	17				
11	14		550		1	18				
9	15		522		3	19				
6	16		384		2	20				
10	17		720		5	21				
8	18		640		1	22				
7	19		616							
6	20		690							
6	21		744							
7	22		945							
1	23		147							
1	24		153							
3	26		555							
1	27		199							
1	30		240							

White Pine: 129 trees: Total cubic feet 8,202; Total feet B. M 39,300.
Red Pine: 26 trees: Total cubic feet 2,440.
Hemlock: 34 trees: Total cubic feet 520.

Total yield: All species, 11,162 cubic feet, of which White Pine 73 per cent.
Average annual accretion: White Pine, 63 cubic feet.
302 feet B. M.

MEASUREMENTS OF SAMPLE TREES.

Age class: 130 to 150 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
34	140	19.5	124	6.5	109.8	0.42	0.34	1.0	1.10	0.78
9	136	19.7	114	6.7	115.9	.49	.31	1.2	1.39	.85
33	135	20.0	115	6.2	121.5	.48	.32	1.6	1.94	.90
37	134	22.0	113	6.0	123.5	.31	.27	.7	.86	.92
36	136	22.5	123	6.5	130.1	.39	.30	1.4	1.82	.96
35	135	21.7	122	5.9	136.4	.44	.32	.7	.95	1.01
2	138	22.8	119	6.1	138.5	.40	.30	1.0	1.38	1.00
22	133	23.2	116	5.5	141.1	.42	.38	1.2	1.69	1.06
4	130	24.0	106	5.3	143.5	.43	.40	1.8	2.58	1.10
3	135	24.0	108	5.6	144.7	.42	.35	.9	1.30	1.07
1	138	23.5	113	5.7	146.5	.43	.26	1.0	1.46	1.06
16	139	25.0	122	5.2	187.3	.44	.50	1.5	2.81	1.27
Average	135.7	22.3	116	5.9	136.6	.42	.34	1.2	1.61	1.00
27	142	23.0	117	5.8	138.9	.41	.30	1.2	1.67	.98
26	142	24.0	110	5.8	140.6	.41	.39	1.6	2.11	.99
11	142	24.5	114	5.7	148.0	.43	.36	1.8	2.66	1.04
29	142	22.0	119	6.0	157.3	.49	.26	1.5	2.36	1.11
30	143	24.2	116	5.8	164.3	.45	.38	1.7	2.79	1.14
24	149	25.0	113	5.7	168.8	.46	.34	.8	1.35	1.06
5	148	26.3	115	5.5	205.4	.46	.39	1.2	2.46	1.39
Average	144	24.0	115	5.8	160.5	.44	.34	1.4	2.20	1.10

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

MEASUREMENTS OF SAMPLE TREES—Continued.

OPPRESSED GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
7	132	17.8	114	6.7	83.6	0.41	0.42	1.2	1.00	0.63
12	139	18.5	112	7.8	88.4	.42	.38	1.1	.97	.63
18	135	18.0	116	7.2	91.2	.44	.27	.9	.82	.67
28	135	17.5	110	7.3	92.0	.49	.36	1.6	1.47	.67
14	135	19.5	107	6.8	95.6	.43	.42	.5	.48	.70
29	140	18.5	102	7.5	98.2	.51	.27	1.9	1.87	.70
Average	136	18.3	110	7.2	91.5	.45	.35	1.2	1.10	.67

SUPPRESSED GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
8	131	15.0	115	8.5	66.2	0.47	0.35	1.0	0.66	0.50
32	135	17.5	(?)	7.2	73.9	(?)	(?)	2.4	1.77	.55
31	238	17.4	104	7.3	78.6	.45	.29	1.7	1.34	.57
13	131	16.4	114	7.7	79.7	.47	.28	1.3	1.04	.61
17	138	19.0	103	7.0	80.6	.39	.28	1.6	1.29	.58
Average	134.6	17.0	109	7.5	75.8	.44	.30	1.6	1.22	.56
6	142	21.0	109	7.2	121.7	.46	.44	1.5	1.82	.85
25	154	19.0	97	7.7	78.6	.41	.41	1.4	1.10	.50
Average	148	20.0	103	7.5	100.0	.43	.42	1.4	1.46	.67

(3) SITE *d:* Montmorency County.

Sample area: 1 acre.

Age of pine: 250 to 270 years.

Density of crown cover: 0.5.

Number of trees: 113.

Soil: Fresh, loose gray sand, turning brown and red below, with surface cover of brakes and checkerberry; subsoil, brown sand, sometimes loamy, and in spots clay.

Forest conditions: White Pine (54 per cent) mixed with Red Pine (35 per cent) and Hemlock (11 per cent).

Damaged by fire twelve years before; sample area shows 15 per cent dead trees and 20 per cent damaged by fire.

ACRE YIELD.

White Pine.					Red Pine.			Hemlock.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
2	10		36		2	13		2	3 to 6	40
1	12		38		1	14		1	9	
3	13		159		3	15		1	11	50 to 80
1	14		60		1	16		2	12	
3	15		207		3	17		6	15	
3	16		231		3	18	120 to 140	1	20	
1	17		86		6	19				
1	18		96		5	20				
3	19		315		4	21				
2	21	120 to 140	280		8	22				
6	22		906		1	23				
5	23		855		1	24				
9	24		1,611		1	30				
4	25		800							
1	26		216							
3	27		696							
2	28		498							
7	29		1,862							
2	30		560							
1	31		302							
1	33		340							

White Pine	Red Pine	Hemlock
61 trees: Total cubic feet 10,154; Total feet B. M. 60,900	39 trees: Total cubic feet 5,256; Total feet B. M. 25,200	13 trees.

Total yield: Pine, 86,100 feet B. M., of which White Pine 66 per cent.
Average annual accretion: Pine, 59 cubic feet.
331 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

(4) SITE *e:* Montmorency County.

Sample area: one-half acre.

Soil: Brown or red sandy loam, light, loose, dry, with stones, and surface cover of brakes and other weeds.

Forest conditions: Red Pine (59 per cent) mixed with White Pine (41 per cent); no undergrowth; level.

Age of pine: 100 to 120 years.

Density of crown cover: 0.5.

Number of trees: 110.

Classification:		White Pine.	Red Pine.
Dominant	per cent	65	60
Oppressed	do	18	34
Suppressed	do	17	6

HALF-ACRE YIELD.

White Pine. Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Red Pine. Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*
2	3 to 6		....		4	3 to 6	
2	6 to 10		20		6	6 to 10	
4	10		72		4	10	
2	11		56		2	11	
2	12		68		6	12	
6	13	80 to 100	234		4	13	
8	14		360		6	14	
2	15		104		2	15	80 to 100
6	16		348		2	16	
2	17		130		4	17	
4	18		288		10	18	
6	19		474		6	19	
					4	20	
					2	21	
					2	22	
46 trees: Total cubic feet			2,154		64 trees: Total cubic feet		3,532
Total feet B. M.			9,030		Total feet B. M.		14,800

Total yield: Pine, 23,830 feet B. M., of which White Pine 38 per cent.

Average annual accretion: Pine, 51 cubic feet.
217 feet B. M.

MEASUREMENTS OF SAMPLE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. feet.*			*Per cent.*	*Cu. feet.*	*Cu. feet.*
3	120	18	96	6.5	71.6	0.42	0.41	1.1	0.79	0.60

OPPRESSED GROWTH.

4	118	14	95	7.4	55.0	0.53	0.31	1.1	0.60	0.46

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

(5) SITE *f*: Montmorency County. Sample area: 1 acre.

Soil: Brown, dry sand, with stones, and surface cover of brakes and grass.
Forest conditions: Red Pine (94 per cent) with scattering White Pine (6 per cent) on a level plain; no undergrowth save very small shrubs of scattered Oak (characteristic of this locality). About 15 per cent of trees injured by fire in 1891.

Age of pine: 160 to 180 years.
Density of crown cover: 0.6.

Number of trees: 115.

Classification: Red Pine.
Dominant .... per cent.. 72
Oppressed .... do.... 13
Suppressed .... do.... 15

ACRE YIELD.

White Pine.					Red Pine.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*		*Inches.*	*Feet.*
1	15		52		1	10	
2	16	90	116		1	11	
1 (dead)	18	to	....		5 (2 dead)	12	
1 (dead)	21	100	....		5	13	
1	22		112		8 (3 dead)	14	
1	23		122		13 (1 dead)	15	90
					18 (4 dead)	16	to
					20 (3 dead)	17	100
					24 (4 dead)	18	
					5	19	
					5	20	
					2	21	
					1	22	
7 trees: Total cubic feet .... 402; Total feet B. M 1,690					108 trees: Total cubic feet ... 6,863; Total feet B. M 28,800		

Total yield: Pine, 30,490 feet B. M., of which White Pine 5 per cent.
Average annual accretion: Pine, 42 cubic feet.
179 feet B. M.

(6) SITE *g*: Crawford County. Sample area: 1 acre.

[About 1,200 feet above sea level.]

Soil: Brown, loamy sand, deep, fresh, moderately loose, with surface cover of fern and grass; sand with stones underlies the soil.
Forest conditions: Two-story stand, upper story of White Pine (1 Red Pine of 26 inches in diameter), with 0.3 density of crown cover, lower story of Fir (22 from 4 to 10 inches in diameter), Beech (4 from 4 to 10 inches in diameter), and Hemlock (19 from 4 to 10 inches in diameter); undergrowth moderately dense, of Maple, Fir, Hemlock, and Beech. Percentages: White Pine, 50; Hemlock, 20; Fir, 25; hardwoods, 5.

Age of pine: 250 to 260 years.
Density of crown cover: 0.7.

Number of trees: (?).

Classification: White Pine.
Dominant .... per cent.. 77
Oppressed .... do.... 13
Suppressed .... do.... 10

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
3	16		213	
1	18	100	79	
2	21	to	228	
1	23	120	134	
1	24		146	
3	25		471	
2	26		432	
4	27		464	
7	28		1,743	
2	29		532	
5	30	130	1,400	
2	31	to	604	
5	32	150	1,600	
3	33		1,020	
1	35		381	
1	36		401	
1	42		537	
44 trees: Total cubic feet .... 10,385; Total feet B. M 62,300				

Average annual accretion: White Pine, 40 cubic feet.
240 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

MEASUREMENTS OF SAMPLE TREES.

Age class: 130 to 150 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
32	133	15.2	92	8.3	48.59	0.43	0.43	2.2	1.07	0.36
37	141	15.5	92	8.2	55.32	.46	.42	2.3	1.27	.39
12	132	16.3	88	7.5	61.70	.47	.66	.8	.49	.46
40	145	18.6	100	7.0	71.11	.58	.44	2.0	1.42	.49
25	128	20.5	98	7.0	94.56	.42	.47	1.5	1.42	.73
27	152	19.0	104	7.3	84.97	.41	.38	1.4	1.19	.55
9	131	22.5	112	5.4	129.42	.41	.46	.7	.91	.98
26	148	23.0	116	6.8	137.91	.41	.46	1.9	2.62	.93
31	153	23.0	100	5.9	137.63	.47	.30	1.7	2.40	.90
11	136	24.6	115	5.2	154.12	.41	.40	1.4	2.16	1.13
Average	140	19.8	102	6.9	97.5	.43	.43	1.6	1.49	.69

OPPRESSED GROWTH.

18	109	14	82	7.5	40.53	0.46	0.56	4.5	1.82	0.37

Age class: 220 to 240 years.

DOMINANT GROWTH.

41	245	20.0	120	11.0	112.56	0.43	0.46	0.9	1.01	0.46
8	242	24.5	137	9.9	191.07	.42	.41	.5	.95	.79
30	226	27.5	138	7.6	215.28	.38	....	.4	.86	.95
1	226	27.5	129	7.6	222.29	.41	.38	.4	.89	.98
28	220	28.3	143	7.1	264.49	.42	.60	.8	2.11	1.20
34	250	30.2	141	8.7	291.03	.42	.31	.4	1.16	1.16
10	219	33.0	121	6.3	317.85	.44	.43	.7	2.22	1.45
33	226	33.0	140	7.1	321.86	.38	.49	.8	2.57	1.42
39	237	33.0	144	7.2	389.57	.45	.77	.6	2.34	1.64
29	233	37.0	147	6.1	455.05	.41	.55	.6	2.73	1.95
3	245	40.0	125	5.4	479.51	.43	.40	.5	2.40	1.96
Average	233	30.4	135	7.6	296.41	0.41	.48	.6	1.75	1.27
14	258	26.0	119	10.0	162.54	0.37	0.40	0.4	0.65	0.63
7	252	25.2	139	9.5	193.21	.41	.46	.4	.77	.76
38	252	25.5	115	9.5	205.21	.35	.58	.9	1.85	.81
23	265	27.0	126	10.4	207.67	.41	.44	.5	1.05	.78
13	253	30.0	135	8.8	259.13	.39	.45	.4	1.03	1.02
36	256	32.0	142	8.1	267.87	.34	.59	.4	1.07	1.04
4	260	31.5	132	8.3	275.89	.38	.48	.7	1.93	1.06
42	260	29.5	155	8.9	311.99	.42	.48	.3	.93	1.20
16	251	33.0	144	7.1	313.07	.33	.41	.9	2.82	1.24
2	256	31.0	145	7.6	314.06	.41	.39	.5	1.57	1.22
35	265	31.5	144	8.2	314.38	.40	.33	.4	1.25	1.18
6	266	33.0	139	8.0	316.81	.38	.51	.4	1.27	1.19
15	256	32.0	154	7.4	360.75	.41	.33	.7	2.52	1.41
5	258	34.0	138	7.6	370.50	.42	.59	.8	2.96	1.43
17	260	36.0	149	7.5	404.18	.37	.45	.2	.81	1.55
Average	258	30.5	138	8.5	285.15	.39	.45	.5	1.50	1.10

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

(7) SITE *h*: Crawford County.

Soil: Brown, loamy sand, medium fine, light, loose, very deep, fresh, well drained, with surface cover of abundant leaves.
Forest conditions: Moderately dense stand of White Pine intermixed with Hemlock and Beech, with scattering Yellow and White Birch and occasional Red Pine, on a level plain; undergrowth of young Hemlock and hardwoods.

MEASUREMENTS OF SAMPLE TREES.

Age class: 420 to 450 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
5	417	37.0	155	14.0	433.2	0.37	0.45	0.4	1.73	1.03
1	445	35.5	141	10.0	510.5	.52	.39	.6	3.06	1.15
4	455	41.0	152	11.0	583.7	.41	.53	.2	1.17	1.28
9	426	43.0	160	10.5	677.3	.42	.56	.4	2.71	1.59
8	460	46.0	150	(?)	694.1	.40	.48	.3	2.08	1.51
7	457	47.0	160	(?)	721.9	.37	.45	.4	2.89	1.59
3	461	46.0	170	10.0	737.9	.38	.56	.3	2.21	1.60
6	435	46.0	168	(?)	819.6	.42	.51	.4	3.28	1.88
10	458	47.0	162	10.5	855.3	.42	.57	.5	4.28	1.86
Average	446	43.0	157	11.0	670.4	.41	.50	.4	2.60	1.50

Age class: 270 to 290 years.

2	274	45.0	150	7.1	604.3	0.36	0.52	0.4	2.4	2.20

(8) SITE *i*: Crawford County.

Sample area: 1 acre.
Age of pine: 95 to 105 years.
Density of crown cover: 0.6.
Number of trees: 364.

Soil: Brown, loamy sand of medium grain, light, loose, deep, fresh, well drained, with 2 to 3 inches mold on top and surface cover of leaves.
Forest conditions: White Pine (47 per cent) mixed with hardwoods (30 per cent) and Hemlock (23 per cent), on a gentle slope; undergrowth scanty, of young Hemlock and Maple.
Classification:

		White Pine.
Dominant	per cent	47
Oppressed	do	18
Suppressed	do	35

ACRE YIELD.

White Pine.					Hemlock.			Maple.			Beech.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cu. ft.*	*Feet B. M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
4	3 to 6	90 to 110	....		18	3 to 6	60 to 80	26	3 to 6	40	20	3 to 6	40 to 50
52	6 to 10		520		44	6 to 10		28	6 to 10		14	6 to 10	
9	10		162		3	10		2	10		1	10	
8	11		256		3	11							
12	12		456		4	12							
15	13		660		2	13		White Birch.			Yellow Birch.		
16	14		600		2	14							
11	15		638		3	16							
11	16		704		1	18		6	6 to 10	40 to 60	2	6 to 10	
13	17		936		1	20		4	10				
8	18		640		2	23		2	14				
5	19		435					1	1				
4	20		384					2	17				
3	21		309										
1	23		122										
1	25		143										
173 trees: Total cubic feet 7,165; Total feet B. M 28,650					83 trees: Total cubic ft. 1,330; Total feet B. M. 4,780			71 trees.			37 trees.		

Total yield: White Pine and Hemlock, 33,430 feet B. M., of which White Pine 87 per cent.
Average annual accretion: White Pine, 71 cubic feet.
286 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

MEASUREMENTS OF SAMPLE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
3	100	16.5	98	(?)	64.5	0.44	0.45	1.7	1.10	0.64
7	98	16.5	106	(?)	68.4	.43	.40	2.2	1.50	.70
6	103	17.0	104	5.3	71.7	.43	.45	1.5	1.07	.70
4	100	19.5	100	4.9	94.6	.45	(?)	1.7	1.61	.95
8	103	18.5	109	4.8	95.9	.47	.37	2.1	2.01	.93
Average	101	17.6	103	5.0	79.0	.44	.42	1.8	1.46	.78

CODOMINANT GROWTH.

5	95	14.0	94	6.6	49.6	0.49	0.38	2.0	0.99	0.52
1	101	15.3	91	5.8	52.1	.43	(?)	4.2	2.46	.51
2	101	15.5	96	6.0	62.8	.49	.57	2.6	1.63	.62
Average	99	15.0	94	6.1	54.8	.47	.44	2.9	1.69	.55

(9) SITE *j*: Crawford County.

Soil: Gray or light sand, medium fine grain, porous, light, loose, dry (in places fresh), with a moderately leafy surface cover.

Forest conditions: Open stand of mixed White Pine and Norway Pine with scattering White Birch and occasional Oak, Hackmatack, and Banksian Pine on a level plain along the banks of a river; undergrowth scanty, of young Fir, Cedar (*Thuja occidentalis*), and a few small Oaks.

MEASUREMENTS OF SAMPLE TREES.

Age class: 90 to 110 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
5	109	13.0	94.0	7.6	45.7	0.52	0.51	3.2	1.46	0.42
23	112	14.0	96.0	7.3	50.2	.47	.47	3.5	1.75	.44
22	109	14.8	93.0	6.7	51.4	.45	.47	2.2	1.14	.47
15	106	15.3	85.0	6.5	53.3	.47	.37	2.5	1.33	.50
7	110	16.5	104.0	6.5	64.3	.41	.30	2.2	1.41	.58
6	109	17.0	101.0	6.3	67.6	.42	.59	1.8	1.22	.62
20	112	17.0	100.0	6.1	72.4	.45	(?)	3.4	2.46	.65
4	112	18.3	103.0	5.8	85.3	.44	.56	2.5	2.13	.76
19	108	20.5	105.0	4.8	99.1	.41	.49	1.9	1.88	.91
21	109	20.8	105.0	5.0	99.8	.39	.42	1.6	1.60	.91
Average	109.6	16.7	98.6	6.3	68.9	.44	.46	2.5	1.64	.63

CODOMINANT GROWTH.

1	100	13.5	94.0	7.0	41.0	0.44	0.57	2.0	0.82	0.41
24	96	14.4	90.0	6.6	48.7	.47	(?)	4.3	2.08	.50
18	82	16.5	94.0	4.8	65.7	.47	.53	4.0	2.63	.80
9	99	20.0	100.0	4.4	90.9	.41	.46	3.3	3.00	.91
Average	94	16.1	94.5	5.7	61.6	.45	.52	3.4	2.13	.65

Age class: 150 to 160 years.

DOMINANT GROWTH.

2	158	22.5	114.0	6.6	124.9	0.40	0.36	2.4	3.00	0.80
13	157	21.8	115.0	7.0	121.1	.40	.58	1.2	1.45	.80
Average	157.5	22.1	114.5	6.8	123.0	.40	.47	1.8	2.22	.80

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

(10) SITE *k:* Roscommon County. Sample area: 1 acre.

[About 1,000 feet above sea level.]

Half acre No. 1.

Soil: Brown, loamy sand, deep, fine (for sand), porous, loose, fresh, and well drained (water stands in low ground), with a moderately leafy surface cover; subsoil, same as soil.
Forest conditions: Two-story stand on a gentle slope, upper story of White Pine (80 per cent) and Red Pine (20 per cent), lower story of fine tall Hemlock; undergrowth scanty, of young Hemlock, Beech, and dwarf Maple.

Age of pine: 230 to 240 years.
Density of crown cover: 0.8 to 0.9.
Number of trees: 186.

Classification:

	White Pine.
Dominant .... per cent..	63
Oppressed .... do....	21
Suppressed .... do...	16

HALF-ACRE YIELD.

White Pine.					Red Pine.			Hemlock.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cu. feet.*	*Feet B.M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
6	11	80 to 125	192		2	14	•	32	6 to 10	60
2	15		116		2	16	80 to 150	4	10	70 to 80
2	16		123		4	18		6	11	
4	17		288		14	19		2	12	
2	18		160		6	21		6	14	
6	19		528		2	23		8	15	100 to 120
2	20	130 to 150	250		2	24		2	17	
4	21		5.0		2	25		2	18	
8	22		1,216					4	19	
12	24		2,076					2	20	
8	25		1,544					2	21	
6	27		1,344					2	22	
8	28		1,920					2	23	
2	30		540					2	24	
4	33		1,312							
76 trees: Total cubic feet .... 12,174; Total feet B.M 58,400					34 trees: Total cubic feet. 4,270; Total feet B.M. 20,500			76 trees: Total cubic feet. 3,616; Total feet B.M. 13,000		

Total yield: All species 20,060 cubic feet, of which White Pine was 61 per cent.
Average annual accretion: White Pine, 52 cubic feet.
248 feet B. M.

MEASUREMENTS OF SAMPLE TREES.

Age class: 230 to 250 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. feet.*			*Per cent.*	*Cu. feet.*	*Cu. feet.*
3	234	23.2	137	10.0	169.0	0.43	0.39	0.8	1.35	0.72
2	236	23.8	142	9.6	197.3	.44	.43	.7	1.38	.83
11	235	24.5	142	9.2	199.1	.43	.43	.7	1.39	.84
1	237	23.5	140	9.6	202.6	.46	.36	.8	1.62	.86
6	237	24.5	145	9.0	205.4	.43	.40	.5	1.03	.86
17	232	24.7	145	(1)	207.0	.43	.47	1.0	2.07	.89
10	233	25.5	143	8.4	212.6	.42	.42	.5	1.06	.91
16	237	25.5	145	9.1	227.3	.44	.44	.9	2.04	.96
15	235	26.0	143	9.0	231.1	.43	.23	.7	1.62	.98
18	245	30.0	122	(1)	233.9	.39	.35	.8	1.87	.95
9	236	26.2	145	9.0	240.2	.44	.42	.3	0.72	1.01
4	236	27.0	150	8.5	271.5	.45	.41	.8	2.17	1.15
8	238	29.0	140	7.8	281.1	.43	.40	.6	1.69	1.18
19	244	34.0	130	7.0	348.1	.42	.62	.5	1.74	1.42
12	233	32.0	144	7.0	349.6	.43	.39	1.0	3.50	1.50
20	251	27.0	120	9.1	206.8	.43	.36	.5	1.03	.82
Average ..	237	26.6	140	8.7	236.4	.43	.41	.7	1.64	.99

OPPRESSED GROWTH

14	237	21	136	11.0	133.8	0.41	0.51	0.7	0.94	0.56

SUPPRESSED GROWTH.

7	235	13.0	120	17.7	61.1	0.55	0.31	0.6	0.37	0.26
5	229	15.3	126	15.2	86.7	.52	.41	.6	.52	.37
Average ...	232	14.1	123	16.4	73.9	.53	.36	.6	.45	.31

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

Half acre No. 2.

Soil: Moist, low ground, near swamp.
Forest conditions: White Pine (51 per cent) and Hemlock (49 per cent).
Classification:

	White Pine.
Dominant .... per cent..	80
Oppressed .... do....	10
Suppressed .... do....	10

Age of pine: 230 to 240 years.
Density of crown cover: 0.5.
Number of trees: 118.

HALF-ACRE YIELD.

White Pine.					Hemlock.		
			Volume.				
Number of trees.	Diameter (breast high).	Height.	Bole.	Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cu. feet.*	*Feet B. M.*		*Inches.*	*Feet.*
2	15		116		6	6 to 10	60
4	18	80 to 125	320		6	11	
2	19		176		4	12	70 to 80
2	22		304		4	13	
2	24		360		4	14	
2	25		400		6	15	
4	26		864		6	16	
2	28		498		6	17	100 to 120
4	29		1,064		2	19	
6	30		1,680		10	20	
2	31	130 to 150	604		2	24	
4	32		1,280		2	25	
12	33		4,080				
2	34		720				
2	35		762				
4	36		1,604				
2	37		846				
2	38		890				
60 trees: Total cubic feet .... 16,586; Total feet B. M 99,400					58 trees: Total cubic feet. 4,490; Total feet B. M.. 16,160		

Total yield: White Pine and Hemlock 21,076 cubic feet, of which White Pine 71 per cent.
Average annual accretion: White Pine, 70 cubic feet.
423 feet B. M.

(11) SITE *l*: Roscommon County. Sample area: 1 acre.

Soil: Light-brown, dry sand, loose, light, very deep, well drained (?), with 1 inch mold on top and surface cover of leaves.
Forest conditions: Red Pine (84 per cent) intermixed with White Pine (16 per cent), with occasional Beech on a gentle slope (angle 5°); no undergrowth.
Classification:

	White Pine.	Red Pine.
Dominant .... per cent..	57	62
Oppressed .... do....	24	31
Suppressed .... do....	19	7

Age of pine: (?)
Density of crown cover: (?)
Number of trees: 136.

ACRE YIELD.

White Pine.					Red Pine.			Beech.		
			Volume.							
Number of trees.	Diameter (breast high).	Height.	Bole.	Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
2	10		36		1	6 to 10		1	3 to 6	40
1	11		32		2	10		1	6 to 10	
1	12		38		3	11				
2	13		96		7	12				
1	14		55		13	13				
2	15		126		26	14	90 to 100			
2	16	100 to 120	142		16	15				
3	18		261		18	16				
1	19		96		16	17				
2	21		228		5	18				
2	22		246		5	19				
1	23		134		1	20				
1	27		199							
21 trees: Total cubic feet .... 1,689; Total feet B. M 7,090					113 trees: Total cubic feet. 6,207; Total feet B. M. 26,060			2 trees.		

Total yield: Pine 7,896 cubic feet, of which White Pine 21 per cent.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

(12) SITE *m*: Roscommon County. Sample area: 4 acres.

[900 to 1,000 feet above sea level.]

Acre No. 1.

Soil: Dry, light-brown sand, medium fine, deep, well drained, with moderately leafy surface cover.
Forest conditions: Red Pine (53 per cent) with White Pine (39 per cent) and hardwoods (8 per cent) on uneven ground; stand open, and open places with Red Oak and Maple.

Age of pine: 160 to 200 years.
Density of crown cover: (?).
Number of trees: 91.

Classification:

		White Pine.	Red Pine.
Dominant	per cent..	73	87
Oppressed	do....	19	11
Suppressed	do....	8	2

ACRE YIELD.

White Pine.					Red Pine.			Oak.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
1	14		55		1	13		1	Under 3	40
1	17		79		2	14		3	3 to 6	
1	18		88		1	15				
3	19		288		2	16				
2	20		210		6	17		Maple.		
2	21		228		5	18	100 to 120			
5	22		615		7	19				
2	23	100 to 120	268		8	20				
3	24		438		3	21		2	3 to 6	40
2	25		314		7	22		2	6 to 10	
5	26		845		2	23				
4	27		732		2	24				
2	28		392		1	25				
1	33		267							
1	34		283							
1	39		451							
36 trees: Total cubic feet .... 5,553; Total feet B. M 26,600					47 trees: Total cubic feet. 5,360; Total feet B. M. 26,000			8 trees.		

Total yield: Pine, 10,913 cubic feet.
52,600 feet B. M., of which White Pine 50 per cent.
Average annual accretion: Pine, 61 cubic feet.
298 feet B. M.

Acre No. 2.

Soil: Dry, light-brown sand, medium fine, deep, well drained, with moderately leafy surface cover.
Forest conditions: Red Pine (75 per cent) with White Pine (25 per cent) intermixed; level.

Age of pine: 160 to 200 years.
Density of crown cover: (?).
Number of trees: 153.

Classification:

		White Pine.	Red Pine.
Dominant	per cent..	62	74
Oppressed	do....	25	23
Suppressed	do....	13	3

ACRE YIELD.

White Pine.					Red Pine.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*
2	6 to 10				....	6 to 10	
1	11				3	10	
1	12				9	12	
4	14				12	13	
1	15				8	14	100 to 120
7	16				32	15	
4	17	100 to 120			17	16	
3	18				18	17	
3	19				8	18	
1	20				4	19	
6	21				2	20	
2	22						
3	23						
1	25						
39 trees: Total cubic feet .... 3,332; Total feet B. M 15,980					113 trees: Total cubic feet. 7,914; Total feet B. M. 33,240		

Total yield: Pine, 11,246 cubic feet.
49,220 feet B. M., of which White Pine 32 per cent.
Average annual accretion: Pine, 95 cubic feet.
273 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

Acre No. 3.

Soil: Light brown, dry sand, medium fine, deep, well drained, with a moderately leafy surface cover.
Forest conditions: Red Pine (90 per cent) intermixed with White Pine (10 per cent); level.

Age of pine: 160 to 200 years.
Density of crown cover: (?)
Number of trees: 117.

Classification:

		White Pine.	Red Pine.
Dominant	per cent..	75	80
Oppressed	do....	17	12
Suppressed	do....	8	8

ACRE YIELD.

White Pine.					Red Pine.		
			Volume.				
Number of trees.	Diameter (breast high).	Height.	Bole.	Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*
1	6 to 10	100 to 120	10		5	6 to 10	100 to 120
1	13		48		1	10	
2	14		110		1	11	
1	19		96		6	12	
1	20		105		3	13	
3	22		369		12	14	
2	25		314		10	15	
1	26		169		15	16	
					25	17	
					12	18	
					4	19	
					6	20	
					2	21	
					2	22	
					1	23	
12 trees: Total cubic feet 1,221; Total feet B. M 5,120					105 trees: Total cubic feet.. 8,170; Total feet B. M.. 34,300		

Total yield: Pine, 9.391 cubic feet.
39,420 feet B. M., of which White Pine 15 per cent.
Average annual accretion: Pine, 52 cubic feet.
219 feet B. M.

Acre No. 4.

Soil: Light-brown, fresh, loose sand, medium fine, deep, well drained, with a moderately leafy surface cover.
Forest conditions: Red Pine (61 per cent) intermixed with White Pine (33 per cent) and hardwoods (6 per cent); scattered young Oak and Beech on uneven ground.

Age of pine: 160 to 200 years.
Density of crown cover: (?)
Number of trees: (?).

Classification:

		White Pine.	Red Pine.
Dominant	per cent..	47	72
Oppressed	do....	14	15
Suppressed	do....	39	3

ACRE YIELD.

White Pine.					Red Pine.			Oak.		
			Volume.							
Number of trees.	Diameter (breast high).	Height.	Bole.	Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Ft. B. M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
6	6 to 10	100 to 120	63		1	11	100 to 120	1	3 to 6	40
3	10		54		2	12				
3	11		96		2	13				
1	12		38		6	14				
2	13		96		14	15				
2	14		110		11	16				
4	15		252		8	17				
3	16		213		13	18				
4	18		352		12	19		Beech.		
2	19		192		12	20				
2	20		210		2	21				
4	22		492		2	22		3	3 to 6	40 to 60
2	23		268					3	6 to 10	
1	25		157					1	13	
3	26		507					1	14	
1	27		183							
1	34		283							
44 trees: Total cubic feet 3,563; Total feet B. M 14,960					85 trees: Total cubic ft. 7,572; Total ft. B. M. 31,800			9 trees.		

Total yield: Pine, 11,135 cubic feet.
46,760 feet B. M., of which White Pine 32 per cent.
Average annual accretion: Pine, 62 cubic feet.
259 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

MEASUREMENTS OF SAMPLE TREES.

Age class: 160 to 180 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
9	178	24.2	118	7.5	170.1	0.46	0.54	1.2	2.04	0.95
29	173	27.2	121	6.2	218.8	.45	.28	.7	1.53	1.26
24	163	26.5	120	6.2	211.0	.46	.31	.7	1.47	1.29
Average	171	26.0	120	6.6	200.0	.46	.38	.9	1.68	1.17
34	182	25.2	118	7.4	173.0	.43	.53	1.3	2.25	.95
18	188	26.7	118	6.9	202.1	.45	.59	1.2	2.42	1.07
5	186	31.0	119	5.5	286.6	.45	.40	.7	2.0	1.54
Average	185	27.6	118	6.6	220.5	.44	.51	1.1	2.22	1.19

CODOMINANT GROWTH.

15	179	19.0	125.0	9.9	118.4	0.48	0.26	0.8	0.95	0.66
7	185	17.0	125.0	11.5	79.2	.41	.51	1.5	1.19	.42
10	185	20.3	105.0	9.1	111.8	.46	.32	.8	.89	.60
6	184	24.5	109.0	7.4	128.6	.36	.38	1.0	1.29	.70
33	182	22.0	111.0	7.7	134.3	.45	.44	1.5	2.01	.73
Average	184	20.9	112.5	8.9	113.5	.42	.41	1.2	1.34	.61

OPPRESSED GROWTH.

36	165	18	103	8.7	87.9	0.47	0.46	1.2	1.05	0.53

Age class: Over 200 years.

DOMINANT GROWTH.

19	211	28.5	119	7.3	218.9	0.41	0.63	1.3	2.84	1.03

OPPRESSED GROWTH.

13	206	22	119	9.7	144.4	0.46	0.38	0.6	0.87	0.70

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

A.—MICHIGAN—Continued.

(13) SITE II: Roscommon County. Sample area: 1 acre.

[900 to 1,000 feet above sea level.]

Soil: Light-brown, loamy sand, fresh, light, loose, fine, well drained, with 2 to 3 inches mold on top, and a surface cover of abundant leaves.

Forest conditions: Hardwoods (69 per cent) mixed with White Pine (31 per cent) situated on a slope (angle 10°); undergrowth scanty, of young Oak and Beech. [The single Red Pine standing rather exceptional. About 20 to 25 per cent of Red Pine would have been more typical.]

Age of pine: 160 to 200 years.
Density of crown cover: (?)
Number of trees: 130.

Classification:

	White Pine.
Dominant .... per cent..	80
Oppressed .... do....	10
Suppressed .... do....	10

ACRE YIELD.

White Pine.					Beech.			Rock Maple.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic ft.*	*Feet B.M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
1	11		32		26	3 to 6		6	6 to 10	
3	13		159		34	6 to 10		1	10	
1	14		60		4	11		1	12	
1	15		72		6	12		1	13	
1	17		90		1	13		1	14	
2	20		240		1	14		1	17	
3	21		387		1	15				
3	23		477		1	16				
1	24		166		1	18		Red Oak.		
3	25	100 to 130	555							
3	26		600							
4	27		864					1	6 to 10	
4	28		924					1	12	
1	29		247					1	13	
2	31		560					1	26	
2	32		594							
2	33		630							
2	34		668							
1	36		373							
40 trees: Total cubic feet .... 7,698; Total feet B. M 36,950					75 trees.			15 trees.		

Average annual accretion: White Pine, 42 cubic feet.
205 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN:

(1) SITE *a:* Washburn County. Sample area: 2 acres.

[1,200 feet above sea level.]

Acre No. 1.

Soil: Fresh clay, underlaid by hardpan of clay and stones; 4 inches of mold, surface cover leafy. Age of pine: 200 to 220 years.
Forest conditions: Two-story stand, White Pine occupying upper story, hardwoods (Maple, Yellow Birch, Elm or Basswoods, or Hornbeam) the lower story; undergrowth dense, of young hardwoods, 1 to 3 inches in diameter, 20 to 30 feet high. White Pine, 56 per cent; hardwoods, 44 per cent. Density of crown cover: (!). Number of trees: 76.
Classification:

	White Pine.
Dominant .... per cent..	73
Oppressed .... do....	9
Suppressed .... do....	18

ACRE YIELD.

White Pine.					Maple.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*		*Inches.*	*Feet.*
2	11		64		1	3 to 6	40
3	14		165		18	6 to 10	60
1	16		71		3	10 to 14	80
1	17		79				
1	18	80 to 120	88				
1	19		96			Elm.	
1	20		105				
1	21		114				
3	22		420				
3	24		480		2	6 to 10	60
2	26		384				
3	27		621				
4	28		924			Yellow Birch.	
1	29	120 to 135	247				
4	30		1,040				
1	31		280				
3	32		891		1	6 to 10	60
4	33		1,260		4	10 to 14	80
2	34		694		4	14 to 18	
1	35		367				
1	38		429				
43 trees: Total cubic feet .... 8,119; Total feet B. M 52,920					33 trees:		

Average annual accretion: White Pine, 38 cubic feet.
252 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

Acre No. 2.

Soil: Fresh clay, underlaid by hardpan of clay and stones; 4 inches of mold, surface cover leafy.
Forest conditions: Two-story stand, White Pine occupying the upper story and hardwoods (Maple, Yellow Birch, Elm or Basswood, or Hornbeam) the lower story; undergrowth scanty, of young hardwoods and Fir. White Pine, 52 per cent; hardwoods, 48 per cent.

Age of pine: 200 to 220 years.
Density of crown cover: (?)

Number of trees: 132.

Classification:

		White Pine.
Dominant	per cent..	75
Oppressed	do....	22
Suppressed	do....	3

ACRE YIELD.

White Pine. Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
1	14	80 to 120	55	
1	16		71	
3	19		288	
2	20		210	
1	21		114	
2	22		280	
6	23	120 to 140	918	
9	24		1,440	
3	25		534	
6	26		1,152	
5	27		1,035	
5	28		1,155	
6	29		1,482	
3	30		780	
2	31		560	
1	33		315	
1	34		347	
3	35		1,101	
3	36		1,161	
1	37		408	
1	38		429	
1	39		485	
3	40		1,521	

69 trees:
Total cubic feet 15,849
Total feet B. M 95,040

Species	Number of trees.	Diameter (breast high).	Height.
		Inches.	*Feet.*
Fir.	5	3 to 6	40
Elm.	1	3 to 6	40
Hornbeam.	5	3 to 6	40
	1	6 to 10	60
Yellow Birch.	12	3 to 10	40
	16	6 to 10	60
	2	10 to 14	80
	3	14 to 18	80
	1	19	86
Butternut.	1	3 to 6	40
	1	6 to 10	60
Basswood.	9	3 to 6	40
	6	6 to 10	60

63 trees.

Average annual accretion: White Pine, 75 cubic feet.
452 feet B. M.

MEASUREMENTS OF SAMPLE TREES.

Tree number.	Age.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Average annual accretion.
	Years.	*Inches.*	*Feet.*	*Cu. ft.*			*Cu. ft.*
1	204	24.7	102.0	166	0.49	0.45	0.81
2	221	27.0	113.0	183	.41	.37	.82
3	213	27.0	121.5	191	.40	.53	.90
4	214	26.0	126.0	201	.43	.52	.94
5	216	26.8	126.0	210	.42	.46	.97
6	202	24.0	134.0	187	.44	.40	.93
7	204	29.0	132.0	238	.39	.39	1.17
8	212	29.0	133.0	250	.41	.42	1.18
9	213	30.0	133.5	291	.44	.47	1.37
Average	211	27.0	124.0	213	.42	.44	1.01

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

(2) SITE *c*: Washburn County. Sample area: 3 acres.

[1,400 feet above sea level.]

Acre No. 1.

Soil: Light-colored clay, underlaid by sand at a depth of about 2 feet; fresh, moist in hollow, with 3 inches mold on top and surface cover of leaves.

Forest conditions: Two-story stand of typical open pine growth, upper story of White Pine (22 per cent), lower story of hardwoods (74 per cent), mainly Rock Maple, scattering Yellow Birch, and occasional Elm, Hornbeam, and Fir (4 per cent); undergrowth, moderately dense, of young hardwoods.

Age of pine: 200 to 220 (few 160) years.

Density of crown cover: (?)

Number of trees: 88.

ACRE YIELD.

White Pine.					Rock Maple.			Yellow Birch.			Elm.		
Number of trees.	Diameter (breast high).	Height.	Volume: Bole.	Volume: Merchantable timber.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cu. ft.*	*Ft. B. M.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
2	18	80 to 120	160		18	3 to 6	40	1	3 to 6	40	1	15	80
1	19		87		24	6 to 10	60	3	6 to 10	60			
1	21		103		6	10 to 14	80	2	10 to 14	80			
2	23		318		1	17	80	1	15	80	Hornbeam.		
2	26		400		1	19	80	1	16	80			
1	28		231					1	17	80	3	3 to 6	40
1	32		297					1	20	80			
1	33	120 to 140	315					1	31	Over 80	Fir.		
1	34		334										
2	35		706								4	3 to 6	4
3	38		1,335										
1	40		490										
1	46		638										
19 trees: Total cubic feet ..... 5,414; Total feet B. M 32,480					50 trees.			11 trees.			8 trees.		

Average annual accretion: White Pine, 26 cubic feet.
155 feet B. M.

Acre No. 2.

Soil: Light-colored clay, underlaid by sand at a depth of about 2 feet; fresh, moist in hollow, with 3 inches mold on top and surface cover of leaves.

Forest conditions: Two-story stand of White Pine (44 per cent) mixed with hardwoods (53 per cent), upper story of pine, the lower story of hardwoods (Rock Maple intermixed with Yellow Birch and scattering Hornbeam and Elm) and occasional Fir (3 per cent); no undergrowth.

Age of pine: 200 to 220 (few 160) years.

Density of crown cover: (?)

Number of trees: 136

Classification:

		White Pine.
Dominant	per cent..	68
Oppressed	do....	26
Suppressed	do....	6

ACRE YIELD.

White Pine.				Rock Maple.		
Number of trees.	Diameter (breast high).	Volume: Bole.	Volume: Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*
4	6 to 10	40		36	3 to 6	40
4	14	20		16	6 to 10	60
4	18	320				
4	19	348		Yellow Birch.		
4	20	384				
12	24	1,992				
4	26	800		12	6 to 10	60
4	29	988		4	10 to 14	80
8	31	2,240		4	14 to 18	
8	32	2,376				
4	45	2,448		Fir.		
				4	3 to 6	40
60 trees: Total cubic feet ..... 12,136; Total feet B. M 72,810				76 trees:		

Average annual accretion: White Pine, 58 cubic feet.
347 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

Acre No. 3.

Soil: Light-colored clay, underlaid by sand at a depth of about 2 feet; fresh, moist in hollow, with 3 inches mold on top, and surface cover of leaves.

Forest conditions: Two-story stand of White Pine (40 per cent) mixed with hardwoods (47 per cent), upper story of hardwoods (Rock Maple intermixed with Yellow Birch and scattering Hornbeam and Elm) and occasional Fir (13 per cent); moderately dense undergrowth, of very young hardwoods.

Age of pine: 200 to 220 (few 160) years.

Density of crown cover: (*l*).

Number of trees: 123.

Classification:

		White Pine.
Dominant	per cent..	76
Oppressed	do....	8
Suppressed	do....	16

ACRE YIELD.

White Pine.

Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
1	13		44	
1	15		58	
2	17		144	
3	18	80 to 120	240	
1	19		87	
5	20		480	
3	23		477	
3	24		498	
1	25		185	
2	26		400	
3	27		648	
3	28		693	
2	29		494	
2	30		520	
5	31		1,400	
2	33	120 to 140	630	
1	34		334	
1	35		353	
3	36		1,203	
1	37		423	
2	42		1,074	
1	43		562	
1	44		584	
1	46		638	

50 trees:
Total cubic feet........................ 12,169
Total feet B. M........................ 73,000

Rock Maple.

Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*
18	3 to 6	40
19	6 to 10	60
6	10 to 14	80
1	14 to 18	

Yellow Birch.

Number of trees.	Diameter (breast high).	Height.
1	3 to 6	40
2	6 to 10	60
3	10 to 14	
1	14	
1	15	80
1	18	
1	19	

54 trees.

Elm.

Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*
1	6 to 10	60
1	14 to 18	80

Basswood.

Number of trees.	Diameter (breast high).	Height.
1	60 to 10	60

Fir.

Number of trees.	Diameter (breast high).	Height.
12	3 to 6	40
4	6 to 10	60

19 trees.

Average annual accretion: White Pine, 58 cubic feet.
348 feet B. M.

MEASUREMENTS OF SAMPLE TREES

Age class: 100 to 150 years.

Tree number.	Age.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Average annual accretion.
	Years.	*Inches.*	*Feet.*	*Cu. ft.*			*Cu. ft.*
46	107	18.5	86.0	63	0.39	0.44	0.59
47	104	18.0	80.0	70	.49	.63	.67
48	102	18.7	86.5	74	.45	.61	.73
49	120	19.3	90.0	81	.46	.55	.68
50	101	14.0	75.0	41	.52	.40	.41
Average	107	17.7	83.5	66	.46	.52	.61
25	102	12.8	77.5	34	.49	.30	.34
26	102	13.2	73.5	36	.51	.48	.35
27	100	14.0	75.0	46	.57	.37	.46
28	102	15.7	79.5	56	.52	.58	.55
29	103	22.2	83.0	97	.43	.49	.94
30	112	18.8	86.0	81	.49	.50	.70
31	118	17.0	86.5	69	.50	.41	.59
32	105	5.6	41.5	4	.56	.56	.38
Average	105.5	15.0	75.0	53	.51	.46	.54
1	104	15.3	91.0	52	.45	....	.50
2	104	15.5	96.0	63	.50	.51	.61
3	101	16.5	98.0	65	.44	.41	.64
4	105	19.5	100.0	95	.45	....	.90
5	100	14.0	94.0	50	.50	.38	.50
6	105	17.0	104.0	72	.44	.45	.69
7	102	16.5	106.0	68	.43	.41	.67
8	105	18.5	109.0	96	.47	.38	.91
Average	103	16.6	100.0	70	.46	.42	.68
1	137	24.0	105.0	118	.36	.31	.86
2	142	27.8	108.0	201	.44	.43	1.42
Average	139.5	26.0	106.5	159	.40	.37	1.14

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued

B.—WISCONSIN—Continued.

MEASUREMENTS OF SAMPLE TREES—Continued.

Age class: 150 to 200 years.

Tree number.	Age.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Average annual accretion.
	Years.	*Inches.*	*Feet.*	*Cu. ft.*			*Cu. ft.*
13	207	19.0	94.5	94	0.50	0.45	0.45
14	200	20.3	101.0	100	.44	.55	.50
15	208	22.6	96.0	121	.45	.40	.58
16	195	24.2	97.0	133	.43	.32	.68
17	197	24.2	112.5	146	.41	.54	.74
18	196	23.0	116.0	154	.46	.46	.79
19	205	23.5	113.5	161	.47	.42	.78
20	198	25.8	106.5	166	.43	.42	.84
21	217	29.5	114.5	192	.35	.58	.88
22	197	29.0	115.0	236	.45	.63	1.20
23	210	31.0	115.0	253	.42	.59	1.20
24	202	30.5	127.5	282	.44	.47	1.40
25	205	33.3	120.0	304	.42	.43	1.48
26	205	25.6	100.5	161	.44	.39	.78
27	204	25.3	116.5	175	.43	.51	.86
28	225	28.2	110.0	175	.37	.50	.78
29	206	28.5	103.0	183	.40	.43	.89
30	207	28.5	119.0	213	.40	.34	1.03
31	204	32.0	111.5	274	.44	.54	1.34
32	205	32.0	115.0	281	.44	.69	1.37
33	200	34.0	117.0	285	.39	.43	1.43
34	201	28.3	119.0	208	.40	.61	1.03
Average	204	27.0	111.0	195	.47	.49	1.75
40	195	16.0	108.0	75	.47	.44	.38
35	201	22.2	95.0	115	0.45	0.63	0.57
36	191	29.0	116.0	216	.41	.55	1.13
37	216	28.5	120.0	262	.49	.52	1.21
38	220	34.5	128.0	308	.37	.56	1.40
39	207	35.0	126.0	342	.41	.39	1.65
Average	207	29.8	117.0	249	.43	.53	1.19
1	204	34.0	118.0	274	.37	.51	1.34
2	209	35.5	121.0	305	.37	.55	1.46
3	200	35.0	116.0	306	.40	.41	1.53
4	212	34.0	120.0	313	.42	.42	1.48
5	210	33.5	141.0	323	.37	.50	1.54
6	212	37.0	128.0	355	.37	.64	1.68
7	214	38.0	114.0	357	.40	.47	1.67
8	206	38.0	127.0	371	.37	.46	1.80
9	220	37.0	127.0	399	.42	.61	1.81
10	210	42.0	140.0	506	.38	.60	2.41
11	210	43.0	144.0	577	.40	.56	2.75
12	210	50.0	138.0	726	.39	.51	3.46
Average	210	38.0	128.0	401	.39	.52	1.91
41	166	25.0	105.0	158	.44	.38	.95
42	151	29.5	103.0	175	.36	.52	1.16
43	167	28.7	96.0	176	.41	.55	1.05
44	155	29.0	101.5	201	.43	.52	1.30
45	155	28.0	113.5	217	.45	.41	1.40
Average	159	28.0	104.0	185	.42	.47	1.17

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

(3) SITE *e*: Barron County. Sample area: 3 acres.

Acre No. 1.

Soil: Clayey loam mixed with sand and stones, leaf cover underlaid by 2 to 3 inches mold; subsoil, clay in places and in others sand.

Forest conditions: Ridges covered with White Pine (65 per cent) intermixed with hardwoods (32 per cent), mainly Rock Maple, few Yellow Birch, Hornbeam, Basswood, and occasional Elm, with scattering Fir (2 per cent) and Red Pine (1 per cent); hollows sometimes full of water, but more often open, grassy swamps, with Alder and Hackmatack, fringed by pine.

Age of pine: 160 to 200 (few 90 to 100) years.

Density of crown cover: (*1*).

Number of trees: 166.

Classification:

	White Pine.
Dominant .... per cent..	57
Oppressed .... do....	30
Suppressed .... do....	13

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
4	6 to 10		40	
4	11		112	
6	12		204	
2	13		78	
6	14	80	270	
10	15	to	520	
8	16	100	464	
2	17		130	
6	18		432	
4	19		316	
8	20		688	
2	21		248	
4	22		536	
4	23		584	
6	24		918	
8	25	110	1,368	
6	26	to	1,110	
4	27	130	796	
2	28		426	
8	30		1,920	
4	32		548	
2	33		582	

108 trees:
Total cubic feet 12,290
Total feet B. M. 58,990

Number of trees.	Diameter (breast high).	Height.
Red Pine.		
	Inches.	*Feet.*
2	18	100
Maple.		
20	3 to 6	40
18	6 to 10	60
Yellow Birch.		
4	3 to 6	40
Hornbeam.		
6	3 to 6	40
Basswood.		
4	3 to 6	40
Fir.		
4	3 to 6	40

58 trees.

Average annual accretion: White Pine, 65 cubic feet.
310 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

Acre No. 2.

Soil: Clayey loam mixed with sand and stones, leaf cover underlaid by 2 to 3 inches mold; subsoil, clay in places and in others sand.

Forest conditions: Ridges covered with White Pine (49 per cent) intermixed with hardwoods (51 per cent), mainly Rock Maple, few Yellow Birch, Hornbeam, Basswood, and occasional Elm, with scattering Fir and Red Pine; hollows sometimes full of water, but more often open, grassy swamps, with Alder and Hackmatack, fringed by pine.

Age of pine: 160 to 200 (few 90 to 100) years.

Density of crown cover: (?).

Number of trees: 110.

Classification:

	White Pine.
Dominant ....per cent..	78
Oppressed ....do...	22
Suppressed ....do....	0

ACRE YIELD.

White Pine.					Maple.		
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*		*Inches.*	*Feet.*
2	6 to 10	80 to 100	20		26	3 to 6	40
2	19		158		16	6 to 10	60
2	20		172		2	10 to 14	80
4	21	110 to 130	496				
4	22		536			**Yellow Birch.**	
2	23		292		2	23	80
10	24		1,530				
2	26		370			**Hornbeam.**	
10	27		1,990		10	3 to 6	40
2	28		426				
2	29		456				
6	30		480				
2	32		548				
2	35		652				
2	42		1,074				
54 trees: Total cubic feet .... 9,200; Total feet B. M 41,160					56 trees.		

Average annual accretion: White Pine, 48 cubic feet.
216 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

Acre No. 3.

Soil: Clayey loam mixed with sand and stones, leaf cover underlaid by 2 to 3 inches mold; subsoil, clay in places and in others sand.

Forest conditions: Ridges covered with White Pine (59 per cent) intermixed with hardwoods (38 per cent), mainly Rock Maple, few Yellow Birch, Hornbeam, Basswood, and occasional Elm, with scattering Fir (3 per cent) and Red Pine; hollows sometimes full of water, but more often open, grassy swamps, with Alder and Hackmatack, fringed by pine.

Classification:

		White Pine.
Dominant	per cent..	61
Oppressed	do....	15
Suppressed	do...	24

Age of pine: 160 to 220 (few 90 to 100) years.

Density of crown cover: (?).

Number of trees: 144.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
3	6 to 10		30	
1	11		28	
1	13		39	
5	14		225	
1	15	80 to 100	52	
11	17		715	
5	18		360	
7	19		553	
6	20		516	
4	21		496	
4	22		536	
6	23		876	
4	24		612	
5	25		855	
3	26		555	
1	27	110 to 130	199	
4	28		852	
1	29		228	
5	30		1,200	
2	31		518	
1	32		274	
1	34		360	
1	35		380	
1	36	140	401	
1	38		445	
1	40		490	

85 trees:
Total cubic feet 11,795
Total feet B. M 56,610

Species	Number of trees.	Diameter (breast high).	Height.
		Inches.	*Feet.*
Maple.	22	3 to 6	40
	11	6 to 10	60
Hornbeam.	3	3 to 6	40
Basswood.	4	3 to 6	40
	2	6 to 10	60
Fir.	5	3 to 6	40

49 trees.

Average annual accretion: White Pine, 62 cubic feet.
298 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

MEASUREMENTS OF SAMPLE TREES.

Age class: 200 to 220 years.

Tree number.	Age.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Average annual accretion.
	Years.	*Inches.*	*Feet.*	*Cu. ft.*			*Cu. ft.*
1	204	27.3	123.0	219	0.44	0.59	1.07
2	210	25.2	137.0	227	.48	.40	1.08
3	207	31.0	127.5	246	.37	.35	1.19
4	200	29.5	116.0	239	.43	.51	1.20
5	206	29.2	130.5	282	.46	.29	1.37
6	205	30.0	133.0	284	.43	.52	1.38
7	210	34.0	118.5	292	.39	.37	1.40
8	214	36.0	113.5	312	.39	.38	1.46
9	210	39.0	130.0	415	.38	.49	1.98
Average	207	31.0	125.0	280	.42	.43	1.35
10	211	20.2	116.0	132	.51	.64	.63
11	228	23.6	113.0	148	.43	.42	.65
12	220	22.8	121.0	153	.45	.45	.70
13	207	27.2	107.5	200	.46	.28	.97
14	204	27.0	121.0	204	.42	.43	1.00
15	205	27.0	122.0	210	.43	.25	1.02
16	212	27.8	104.5	180	.41	.51	.85
17	204	27.3	112.0	186	.41	.41	.91
Average	211	25.0	114.0	177	.44	.42	.84

Age class: 160 to 180 years.

18	168	30.0	121.5	206	0.35	0.49	1.22
19	165	28.4	120.0	224	.41	.50	1.36
20	173	28.4	127.0	257	.46	.35	1.49
21	163	17.8	91.5	72	.46	.34	.44
22	162	23.0	101.0	130	.46	.54	.80
23	174	28.0	108.5	167	.36	.54	.96
24	166	25.4	104.0	166	.45	.52	1.00
Average	167	26.0	110.0	174	.42	.47	1.04

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

(4) SITE *f*: Washburn County.

Soil: Light brown sandy loam, medium fine grain, loose, deep, fresh, well drained, with abundant leafy surface cover.

Forest conditions: An open stand of hardwoods (Rock Maple, Yellow Birch, and scattering Basswood, with Hemlock, and occasional Red Oak, White Birch, and Poplar), in which White Pine is scattered in varying proportions, on broken land, with frequent swamps in the hollows; undergrowth of young hardwoods, Fir and Hornbeam, and few Hemlock.

MEASUREMENTS OF SAMPLE TREES.

Age class: 80 to 100 years.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cubic feet.*			*Per cent.*	*Cubic feet.*	*Cubic feet.*
51	54	5.5	37	....	3.2	0.52	0.57	....	....	.06
52	62	6.0	40	....	4.2	.53	.50	....	....	.07
53	68	6.8	46	....	5.5	.48	.72	....	....	.08
54	90	6.8	38	....	4.8	.50	.45	....	....	.05
Average	68.5	6.3	40	....	4.4	.51	.56	....	....	.06

DOMINANT GROWTH.

22	82	14.0	82	5.5	43.0	0.49	0.39	4.0	1.72	0.52
23	81	14.7	84	5.0	48.0	.50	.42	2.7	1.30	.60
31	83	15.0	82	4.6	48.1	.48	.41	5.2	2.50	.58
27	79	15.0	83	4.8	50.8	.48	.31	3.2	1.62	.64
30	81	19.0	85	3.9	78.2	.46	.37	2.4	1.88	.96
33	89	18.7	96	3.9	85.7	.47	.51	4.6	3.94	.96
Average	82.5	16.0	85	4.6	59.0	.48	.40	3.7	2.16	.71

OPPRESSED GROWTH.

26	82	11.3	101	6.6	30.0	0.42	0.40	3.1	0.93	0.36
32	81	11.8	77	6.2	30.5	.50	.37	4.0	1.22	.37
29	80	11.9	81	5.7	32.8	.51	.33	4.6	1.51	.41
24	92	14.5	79	5.6	39.7	.43	.54	3.6	1.43	.43
Average	84	12.4	84.5	6.0	33.3	.46	.41	3.8	1.27	.39

SUPPRESSED GROWTH.

18	127	14	73	6.5	39.7	0.50	0.31	4.3	1.71	0.31

Age class: 120 to 130 years.

DOMINANT GROWTH.

14	121	20.2	91	5.4	90.9	0.45	0.50	3.4	3.09	0.75
28	125	24.5	89	4.0	131.8	.45	.58	2.9	3.82	1.05
15	125	26.5	96	4.0	141.5	.39	.46	1.5	2.12	1.13
16	125	26.3	105	4.1	176.8	.47	.53	1.6	2.83	1.41
17	119	29.0	97	3.8	184.5	.42	.57	1.5	2.77	1.55
Average	123	25.3	95	4.3	145.1	.44	.53	2.2	2.92	1.18

Age class: 220 to 230 years.

DOMINANT GROWTH.

35	223	30.5	116	7.0	237.4	0.40	0.38	0.8	1.90	1.06
10	223	31.0	112	7.0	246.6	.42	.56	.6	1.48	1.10
12	228	35.3	124	6.0	322.2	.40	.48	.5	1.61	1.41
5	219	35.0	118	6.0	359.9	.45	.44	.7	2.52	1.64
Average	223	33.0	117	6.5	291.5	.42	.46	.6	1.88	1.30

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

(5) SITE *g*: Washburn County. Sample area, 1 acre.

Soil: Loam, generally fresh, sand and stone mixed, 2 to 3 inches mold on top, and a surface cover of leaves.

Age of pine: 160 to 230 years.
Density of crown cover: (?)

Forest conditions: Two-story stand, upper story of White Pine (54 per cent) and Red Pine (9 per cent), second story of Fir (13 per cent) and hardwoods (24 per cent)—Maple, with scattering White and Yellow Birch, occasional Oak and Elm, Hemlock occurring singly; undergrowth scanty, of young hardwoods, uneven land full of drift ridges and hollows, often with steep inclines, the hollows frequently full of water.

Number of trees: 143.

Classification:

		White Pine.
Dominant	per cent..	70
Oppressed	do....	15
Suppressed	do....	15

ACRE YIELD.

White Pine.

Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
3	6 to 10	80 to 100	30	
3	11		84	
1	12		34	
3	13		117	
4	14		180	
5	15		260	
2	16		116	
5	17		325	
2	18	100 to 120	176	
5	19		480	
5	20		525	
8	21		912	
4	22		492	
3	23		402	
3	24		438	
5	25		785	
6	26		1,014	
2	27		364	
3	29		627	
1	31		237	
1	32		251	
1	33		267	
2	34		566	

77 trees:
Total cubic feet........................ 8,682
Total feet B. M 41,600

Red Pine.

Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*
1	15	80 to 120
2	16	
1	17	
2	18	
1	19	
3	20	
1	24	
1	25	
1	26	

13 trees:
Total cubic feet.. 1,469
Total feet B. M .. 6,160

Number of trees.	Diameter (breast high).	Height.
Maple.		
	Inches.	*Feet.*
9	3 to 6	40
16	6 to 10	60
3	10 to 14	80
Birch.		
2	3 to 6	40
3	6 to 10	60
1	14	80
1	16	
Fir.		
16	3 to 6	40
2	6 to 10	60

53 trees.

Average annual accretion: Pine, 51 cubic feet.
239 feet B. M.

MEASUREMENTS OF SAMPLE TREES.

Age class: 220 to 230 years.

Tree number.	Age.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Average annual accretion.
	Years.	*Inches.*	*Feet.*	*Cubic feet.*			*Cubic feet.*
10	216	31.8	121.5	287	0.43	0.40	1.33
11	222	35.0	123.5	344	.42	.46	1.55
12	228	24.8	116.5	160	.41	.40	.70
13	220	24.0	100.0	156	.49	.27	.78
14	208	15.0	96.0	58	.50	.47	.28
16	220	24.5	107.5	157	.45	.35	.71
17	218	29.0	118.0	240	.44	.49	1.10
Average	219	26.3	112.0	200	.45	.40	.92

Age class: 160 to 180 years.

3	160	23.5	104.5	127	0.40	0.40	0.79
4	170	24.0	119.0	172	.46	.41	1.01
5	178	24.2	114.0	176	.48	.38	.99
6	170	25.7	111.5	181	.45	.41	1.07
7	175	27.3	122.0	217	.43	.46	1.24
8	168	30.5	114.0	256	.44	.42	1.52
15	185	23.2	110.5	138	.42	.34	.74
9	173	26.0	112.0	190	.46	.28	1.10
Average	172	25.5	113.0	182	.44	.39	1.06

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

B.—WISCONSIN—Continued.

(6) SITE 10: Lincoln County.

Soil: Red, compact clay (black on top), well drained, with leafy surface cover.
Forest conditions: A mixed stand of White Pine (50 per cent), Hemlock (30 per cent), and Birch (20 per cent), rolling country.

MEASUREMENTS OF SAMPLE TREES.

Age class: 100 to 150 years.

Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.
	Inches.	*Feet.*	*Cu. ft.*			*Inches.*	*Feet.*	*Cu. ft.*	
60	21.0	97	108.1	0.48	25	36.5	114	308.5	.38
5	20.5	97	105.8	.48					
86	36.5	104	276.2	.37	Average	28.6	103	199.6	.43

Age class: 150 to 200 years.

Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.
37	24.0	117	122.2	0.33	40	31.0	132	273.2	.40
79	24.0	98	137.7	.44	88	35.0	118	287.7	.36
95	27.0	101	140.5	.35	38	34.0	133	313.8	.37
45	24.0	104	136.7	.42	44	35.0	138	311.4	.34
48	25.0	87	140.1	.47	39	32.0	140	318.6	.41
76	24.0	121	178.6	.47	84	36.0	127	283.2	.35
19	24.0	121	180.7	.47	27	36.0	157	365.8	.33
78	33.0	107	236.8	.37					
94	34.0	105	249.0	.38	Average	30.0	120	231.2	.38
47	33.0	136	257.1	.32					

Age class: 200 to 250 years.

Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.
90	25.0	105	102.2	0.29	75	36.0	103	263.5	.36
22	25.0	111	105.2	.28	23	33.5	114	267.8	.38
13	22.0	118	129.9	.42	89	33.5	115	267.8	.38
67	25.0	97	136.6	.41	35	29.0	123	277.3	.48
92	25.0	101	139.4	.40	99	37.0	110	274.4	.33
6	24.0	115	151.7	.42	34	32.0	129	286.2	.40
57	24.0	115	153.5	.42	82	38.0	123	290.5	.30
81	27.0	106	173.5	.41	55	35.0	133	314.0	.35
33	30.0	119	180.4	.31	17	38.0	149	315.7	.27
96	31.0	97	181.5	.36	4	35.0	149	335.6	.34
100	29.0	97	182.7	.41	61	35.0	148	339.8	.34
71	27.0	98	185.6	.48	20	34.0	138	361.5	.41
31	27.0	126	194.2	.39	10	51.5	148	634.8	.30
65	30.0	115	194.6	.34					
58	28.5	127	202.0	.36	Average	31.7	119	235.5	.36
73	35.0	108	208.6	.29					
28	29.0	135	209.7	.34	8	26.0	126	159.1	.34
50	26.0	117	215.4	.50	69	27.0	119	164.6	.35
14	26.0	117	216.6	.50	51	26.0	126	167.0	.36
63	28.5	127	216.8	.38	52	27.0	152	188.3	.31
54	30.0	129	217.2	.34	12	27.0	152	194.3	.32
68	31.0	94	218.8	.44	83	30.0	126	207.9	.34
66	31.0	101	220.7	.42	56	31.0	113	227.1	.38
32	32.0	136	221.1	.29	80	34.0	129	240.6	.30
7	31.0	114	223.5	.37	72	33.0	116	256.9	.37
59	31.0	121	228.4	.36	62	32.0	137	257.0	.34
91	32.0	119	230.8	.35	3	32.0	137	263.0	.34
2	31.0	122	233.1	0.36	85	32.0	108	272.3	.45
87	36.0	110	237.6	.31	21	34.0	137	276.2	.32
24	36.0	119	239.6	.28	18	36.0	126	279.6	.31
30	38.0	137	243.2	.22	26	32.0	138	293.4	.38
1	35.0	128	247.5	.29	9	36.0	135	303.6	.32
16	35.0	128	248.2	.29	29	34.0	134	310.0	.37
97	33.0	105	255.4	.41	70	34.0	134	321.9	.38
93	37.0	101	256.8	.34	41	35.0	129	341.6	.40
74	38.0	119	258.8	.28					
49	33.5	139	260.1	.32	Average	31.5	130	248.6	.35
77	34.0	104	261.4	.40					

Age class: 300 to 350 years.

Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Tree number.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.
98	31.0	115	215.9	0.36	15	33.0	136	332.0	0.41
42	30.0	132	219.8	.34	64	36.0	124	237.0	.27
53	30.0	120	231.9	.39	36	34.0	146	380.4	.41
46	36.0	124	240.3	.27					
43	33.0	129	296.2	.39	Average	34.3	129	273.6	.33
11	46.0	140	309.4	.19					

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

C.—PENNSYLVANIA:

(1) SITE *d:* Clinton County. Sample area: 2 acres.

[2,000 feet above sea level.]

Soil: Rocky, underlaid by sand, stone, or slates in places, sand or clay or a mixture of both in varying proportions; no soil to depth of 4 to 5 feet, rocks covered with 3 inches mold, and Rock Fern, Laurel, Green Brier, and in openings some Blackberries are seen.
Forest conditions: Hemlock (60 per cent) intermixed with White Pine (24 per cent), scattering Black Birch and Yellow Birch and occasional Oak, Chestnut, and Maple, on steep slopes bordering Hyner Run; undergrowth, moderately dense, of young Hemlock near the run and Birch and hardwoods above named near top of slope.

Age of pine: 240 to 260 years.
Density of crown cover: 0.4 to 0.5; openings near top of slope.

Number of trees per acre: 96.

YIELD FOR THE TWO ACRES.

White Pine.

Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cu. ft.*	*Feet B. M.*
1	10	80		
2	11	80	108	432
1	13	80		
3	19	130	959	4,494
4	22	130		
1	23	130	190	1,000
5	25	130	1,085	6,150
2	26	135	514	2,780
2	27	135		
3	28	135	1,995	9,800
2	29	135		
3	30	135	915	5,850
1	31	145	310	2,000
3	32	145	1,170	6,900
5	33	145	2,400	14,400
1	34	145		
2	35	145	960	5,600
2	39	145		
2	40	145	3,066	19,800
1	41	145		
1	42	145		

47 trees:
Total cubic feet 6,836
Total feet B. M. 39,603

Hemlock.

Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*
10	3 to 6	
24	6 to 10	
3	11	
4	12	
4	13	
5	14	
9	15	
3	16	
7	17	
3	18	
8	19	80 to 100
5	20	
2	21	
3	22	
8	23	
5	25	
1	26	
3	27	
4	28	
2	30	
1	36	

Oak.

Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*
2	6 to 10	35 to 60
3	10 to 14	

Birch.

Number of trees.	Diameter (breast high).	Height.
5	3 to 6	
10	6 to 10	40 to 60
1	10 to 14	
1	14 to 18	

Chestnut.

Number of trees.	Diameter (breast high).	Height.
3	6 to 10	
1	10 to 14	40 to 60
1	14 to 18	

Maple.

Number of trees.	Diameter (breast high).	Height.
1	3 to 6	
3	6 to 10	
1	10 to 14	

146 trees:
Total cubic feet 11,148
Total feet B. M. 66,005

Average annual accretion: All species, 49 cubic feet.
264 feet B. M.

MEASUREMENTS OF SAMPLE TREES.

Age class: 180 to 200 years.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cu. ft.*	*Feet B. M.*			
10	194	26.0	116	56	6.6	170.8	908	0.40	0.51	44
11	199	30.0	114	56	5.6	214.4	1,273	.38	.51	49
12	197	26.5	105	56	7.0	183.3	997	.45	.46	45
13	196	23.0	95	40	7.4	111.1	490	.40	.58	37
14	199	29.0	103	52	6.3	220.6	1,290	.46	.49	48
15	189	23.0	104	60	8.0	106.4	534	.35	.42	41
16	186	22.0	104	54	7.8	128.0	643	.46	.48	42
17	189	25.5	105	45	6.9	176.1	892	47	.57	42
18	197	26.0	101	50	7.3	155.7	791	.42	.50	42
19	183	26.5	88	40	7.2	151.2	760	.45	.54	41
Average	193	26.0	103	51	7.0	162.0	858	.42	.51	43

Age class: 230 to 250 years.

DOMINANT GROWTH.

21	256	34.0	158	94	7.5	416.3	2,660	0.42	0.40	53
22	242	35.0	150	82	6.2	376.1	2,261	.37	.45	50
Average	249	34.5	154	88	6.8	396.0	2,460	.40	.42	51
4	201	40.0	129	64	5.0	401.7	2,300	.36	.50	47

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

C.—PENNSYLVANIA—Continued.

MEASUREMENTS OF SAMPLE TREES—Continued.

Age class: 230 to 250 years.

CODOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cu. ft.*	*Feet B. M.*			
1	245	28.5	132	94	7.0	256.6	1,583	0.44	0.29	51
2	232	23.0	132	78	9.3	160.6	766	.42	.41	39
20	256	23.5	141	96	10.1	192.7	1,066	.45	.32	46
Average	244	25.0	135	89	8.8	203.0	1,138	.44	.34	45
5	229	25.0	120	60	7.1	197.6	1,100	.48	.50	46
6	234	23.0	116	60	9.3	160.4	888	.48	.48	46
7	(?)	28.0	124	72	(?)	224.2	1,348	.42	.42	50
8	231	27.0	110	60	7.8	190.2	1,070	.43	.45	47
9	229	30.0	120	52	7.7	268.0	1,535	.45	.56	48
Average	231	26.5	118	61	8.0	208.0	1,188	.45	.48	47

(2) SITE *f*: Clearfield County. Sample area: 1 acre.

[1,200 to 1,500 feet above sea level.]

Soil: Yellow clayey loam of medium grain (fine shales in it), deep, fresh, well drained, with 2 to 3 inches mold on top, and surface cover of scanty leaves, Fern, Teaberries, and scattering Dogwood (Laurel northeast corner and north side); subsoil, laminated shale of indefinite depth.

Forest conditions: Hemlock (62 per cent) mixed with White Pine (28 per cent), with occasional hardwoods (10 per cent), Maple, Beech, and Birch, on hill sloping toward southwest, bordered by left-hand branch of Narrow Creek; undergrowth, moderately dense, of very young Beech, Hemlock, and occasional Birch and Cucumber.

Age of pine: 240 to 260 years.
Density of crown cover: 0.7; in places, 0.8.
Number of trees: 132.

ACRE YIELD.

White Pine. Number of trees.	White Pine. Diameter (breast high).	White Pine. Height.	White Pine. Volume. Bole.	White Pine. Volume. Merchantable timber.	Hemlock. Number of trees.	Hemlock. Diameter (breast high).	Hemlock. Height.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*		*Inches.*	*Feet.*
2	15	120	360	1,360	17	6 to 10	80 to 100
2	17	120			4	10 to 14	
2	18	130			3	14	
1	19	130			4	15	
1	20	130	1,370	6,420	1	16	
4	21	130			8	17	
2	22	130			6	18	
2	23	130	570	3,000	6	19	
1	24	130			8	20	
3	25	135	651	3,690	5	21	
1	26	135	257	1,390	8	22	
2	27	135			3	23	
1	28	135	1,140	6,600	3	25	
1	29	135			1	26	
2	30	145	610	3,900	4	27	
4	31	145	1,220	7,800	1	28	
1	32	145	390	2,300	1	29	
2	34	145	800	4,800	1	30	
1	40	145	511	3,300			
1	41	145	511	3,300			
1	45	145	638	4,400			

Maple. Number of trees.	Maple. Diameter (breast high).	Maple. Height.
	Inches.	*Feet.*
2	6 to 10	40 to 60
3	14 to 18	

Beech. Number of trees.	Beech. Diameter (breast high).	Beech. Height.
2	10 to 14	50
1	14 to 18	

Birch. Number of trees.	Birch. Diameter (breast high).	Birch. Height.
1	6 to 10	40
2	10 to 14	

37 trees:
Total cubic feet 9,028
Total feet B. M 52,260

95 trees:
Total cubic feet 15,686
Total feet B. M 90,103

Average annual accretion: All species, 63 cubic feet.
360 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

C.—PENNSYLVANIA—Continued.

MEASUREMENTS OF SAMPLE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cu. ft.*	*Ft. B. M.*			
1	260	35.5	158	90	7.6	435.4	3,030	0.40	0.43	58
2	260	36.0	157	90	7.0	481.3	3,401	.43	.42	59
3	259	32.0	152	84	7.8	396.0	2,637	.46	.44	55
4	241	32.0	150	62	6.6	347.7	2,079	.41	.59	50
10	244	33.0	146	96	6.8	365.9	2,384	.42	.34	54
12	262	28.0	156	88	9.0	285.8	1,648	.43	.43	47
18	265	39.0	153	88	6.0	511.1	3,318	.40	.42	54
19	250	34.0	150	78	6.3	402.4	2,397	.42	.48	49
20	266	44.0	144	100	5.7	638.4	4,388	.42	.30	57
21	245	34.0	146	92	7.1	366.7	2,248	.40	.37	51
23	248	34.0	142	90	7.2	373.4	2,318	.42	.37	51
33	259	33.0	133	91	8.0	304.5	1,770	.40	.31	48
34	262	33.0	146	90	7.4	369.2	2,220	.42	.38	50
35	263	31.0	144	82	8.5	275.2	1,458	.36	.43	44
36	241	31.5	134	88	7.1	307.7	1,853	.42	.34	50
37	261	37.0	146	106	6.7	482.9	2,970	.44	.27	50
Average	255	34	147	88	7.0	390.0	2,507	.41	.39	52

CODOMINANT GROWTH.

28	262	28.5	138	75	9.8	264.3	1,551	0.43	0.45	49
25	244	28.5	138	107	7.7	298.1	1,954	.49	.22	54
24	245	25.0	130	84	9.3	192.1	1,102	.43	.35	48
22	246	31.0	130	82	7.3	310.3	1,731	.45	.37	46
5	264	29.0	140	100	8.4	300.4	1,905	.47	.28	52
6	264	29.0	140	110	8.5	291.4	1,631	.45	.21	47
7	262	29.0	152	112	9.5	302.8	1,854	.46	.26	51
8	235	29.0	142	86	....	248.6	1,318	.38	.39	44
9	236	32.0	142	84	....	287.7	1,648	.36	.41	48
11	244	30.0	141	81	7.5	305.3	1,947	.44	.42	53
13	258	23.0	147	93	9.6	206.0	1,048	.48	.37	42
14	242	25.0	139	98	....	217.1	1,233	.46	.30	47
15	262	26.0	136	98	....	257.2	1,389	.51	.28	45
16	235	24.5	124	93	....	163.8	815	.40	.25	41
17	262	25.0	128	108	....	214.4	1,183	.49	.16	46
26	245	26.0	136	98	9.3	199.2	1,021	.40	.28	47
30	259	26.5	134	90	9.2	228.6	1,336	.44	.32	48
29	264	28.0	141	84	9.2	276.5	1,577	.46	.40	47
31	262	25.5	132	88	10.0	191.8	863	.41	.33	37
32	261	26.0	142	99	9.1	239.9	1,322	.46	.30	46
Average	253	27	138	93	9.0	250.0	1,421	.44	.32	47

OPPRESSED GROWTH.

27	259	19.0	132	94	11.6	138.8	683	0.53	0.29	41
38	260	23.0	137	96	11.1	189.6	987	.48	.30	43
39	258	20.5	123	109	13.0	130.9	558	.46	.11	35
40	261	16.5	120	82	13.7	89.6	339	.50	.31	31
Average	259	20.0	128	95	12.3	137.0	642	.49	.25	37

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

C.—PENNSYLVANIA—Continued.

(3) SITE *h:* Clearfield County. Sample area: 1 acre.

[1,200 to 1,500 feet above sea level.]

Soil: Yellow clayey loam, of medium grain, with fine shales, deep, fresh, well drained, with 2 to 3 inches mold on top, and surface cover of scanty leaves, Fern, Dogwood, and Blackberries; subsoil, laminated shale of indefinite depth.

Forest conditions: Hemlock (47 per cent) and White Pine (30 per cent) with scattering Beech and occasional Black Birch (hardwoods 23 per cent); undergrowth scanty, of young Beech with a few Black Birch and Basswood.

Age of pine: 240 to 260 years.
Density of crown cover: 0.5 to 0.7; in places openings.

Number of trees: 78.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
1	18	130	137	642
1	20	130	137	642
1	21	130	137	642
1	22	130	137	642
1	23	130	} 380	2,000
1	24	130		
2	26	135	514	2,780
2	28	135	570	3,300
3	31	145	915	5,850
4	32	145	1,560	9,200
2	34	145	800	4,800
1	35	145	} 960	6,400
1	36	145		
1	40	145	} 1,022	6,600
1	41	145		

23 trees:
Total cubic feet 7,269
Total feet B. M 43,490

Hemlock.		
Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*
1	3 to 6	80 to 100
2	7	
2	8	
1	9	
2	11	
1	16	
4	17	
1	18	
2	19	
3	20	
3	21	
2	23	
3	24	
1	25	
4	26	
1	27	
3	28	
1	33	

Beech.		
Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*
16	6 to 10	30 to 40
Black Birch.		
1	6 to 10	40
1	10 to 14	

55 trees:
Total cubic feet 11,224
Total feet B. M 66,900

Average annual accretion: All species, 45 cubic feet.
268 feet B. M.

(4) SITE *i:* Jefferson County. Sample area: 1 acre.

[1,500 to 1,800 feet above sea level.]

Soil: Reddish-brown clayey loam, deep, fresh, well drained, with 2 to 3 inches mold on top and a surface cover of abundant leaves and ground Hemlock; subsoil, laminated shale of indefinite depth.

Forest conditions: Hardwoods (71 per cent)—mainly Beech, White Oak, and Maple—mixed with Hemlock (22 per cent) and scattering White Pine (7 per cent) on ridge; undergrowth, moderately dense, of very young Beech and some Maple.

Age of pine: 230 to 240 years.

Density of crown cover: 0.7; in places 0.8.

Number of trees: 155.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cu. feet.*	*Feet B. M*
1	12	90	30.0	120
1	17	99	70.2	236
1	19	102	90.3	386
1	23	122	152.3	656
1	24½	126	174.9	820
1	30½	136	300.0	1,682
1	31½	140	278.2	1,425
1	35½	140	401.2	2,605
2	37	147	949.4	5,755
1	40	138	487.1	3,056

11 trees:
Total cubic feet 2,933
Total feet B. M 16,741

Beech.			Maple.			Hemlock.		
Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.	Number of trees.	Diameter (breast high).	Height.
	Inches.	*Feet.*		*Inches.*	*Feet.*		*Inches.*	*Feet.*
37	3 to 6	40 to 60	5	6 to 10	50 to 60	5	3 to 6	60 to 80
14	6 to 10		9	10 to 14		15	6 to 10	
17	10 to 14		2	14 to 18		4	10 to 14	
1	18 to 24		3	18 to 24		3	14 to 18	
White Oak.			**Chestnut.**			7	18 to 24	
4	14 to 18	80	2	3 to 6	20 to 30	3	over 30	100
7	18 to 24							
6	24 to 30							

144 trees:
Total cubic feet 5,526

Average annual accretion: White Pine, 12 cubic feet.
71 feet B. M.

TABLE VI.—*Acre yields of White Pine and measurements of sample trees*—Continued.

C.—PENNSYLVANIA—Continued.

MEASUREMENTS OF SAMPLE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic feet.*	*Feet B. M.*			
1	228	30.5	136	80	5.6	300.0	1,682	0.43	0.41	47
2	239	40.0	138	80	5.6	487.1	3,056	.40	.42	52
3	234	37.0	146	72	5.4	482.8	2,626	.44	.51	45
4	240	31.5	140	86	9.6	278.2	1,425	.37	.39	42
5	239	37.0	148	96	6.1	466.6	3,129	.42	.35	56
6	239	35.5	140	80	6.1	401.2	2,605	.42	.43	54
Average	236	35.0	141	82	6.4	403.0	2,420	.41	.42	49

OPPRESSED GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
7	235	23.0	122	86	9.3	152.3	656	0.43	0.29	35
8	238	24.5	126	92	8.7	174.9	820	.42	.27	36
Average	236	23.5	124	89	9.0	163.0	738	.42	.28	35

SUPPRESSED GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
9	230 to 240	19	102	50	(?)	90.3	386	0.44	0.51	35
10		17	99	80	(?)	70.2	236	.44	.19	28
Average	....	18	100	65	....	80.0	311	.44	.35	31

(5) SITE *k*: Jefferson County.

[1,500 to 1,600 feet above sea level.]

Soil: Reddish-brown clayey loam, deep, fresh, and drained by Windfall Run.
Forest conditions: White Pine, with Hemlock and occasional hardwoods; Hemlock comparatively small, acting as an underwood, giving ample shade to the stems of the White Pine.

MEASUREMENTS OF SAMPLE TREES.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic feet*	*Feet B. M.*			
11	247	32.5	146	96	6.3	398.0	2,221	0.47	0.34	46
12	241	35.0	176	90	7.3	499.2	3,003	.42	.49	50
13	238	32.5	142	96	6.2	359.7	2,053	.41	.32	48
14	236	32.5	158	96	8.2	386.3	2,244	.42	.40	48
15	238	34.0	148	96	6.2	382.4	2,236	.41	.35	49
16	241	30.0	143	96	8.0	322.2	1,832	.46	.33	47
17	233	31.0	145	90	6.5	323.4	2,464	.42	.38	63
18	227	29.5	142	88	6.6	255.8	1,391	.38	.38	45
19	342	32.0	153	100	7.2	335.5	1,985	.39	.34	46
20	236	35.0	158	112	6.2	485.3	2,795	.46	.29	48
21	240	34.5	152	90	6.2	396.8	2,312	.45	.41	49
22	236	32.5	158	92	5.8	387.9	2,243	.42	.41	48
Average	238	32.5	152	95	6.7	378.0	2,231	.43	.37	49

YIELD OF SECOND-GROWTH WHITE PINE, WITH MEASUREMENTS OF YOUNG PINE TAKEN FOR ANALYSIS.

The yield of second-growth White Pine on selected sample areas in the States named is shown in the following notes and tabulations, which also give, for illustration, the number of trees, volume, and average annual accretion of pine, the soil, forest conditions, acre yields, and measurements of sample young pines taken for analysis:

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis.*

A.—PENNSYLVANIA:

(1) SITE *c:* Luzerne County. Sample area: 1 acre.

[1,400 to 1,500 feet above sea level.]

Half acre No. 1.

Soil: Dark-brown loamy sand, medium grain, with pebbles and gravel, light, loose, deep, fresh, drained by Bear Creek and a number of other small streams, 2 inches mold on top, and a surface cover of abundant leaves and scanty fern.

Forest conditions: White Pine, mixed with Maple, Beech, Hemlock, and scattering Yellow and White Birch, White and Red Oak, and occasional Black Cherry, in a valley sloping toward southwest and bordered on all sides by hills over 300 feet above station; undergrowth moderately dense, of young Hemlock, Beech, Maple, Birch.[1]

Age of pine: 60 to 80 years.

Density of crown cover: 0.5.

Number of trees: 216.

HALF-ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
2	6	50	11	
2	7	50	12	
2	8	50	19	
10	9	50	115	
4	10	50	60	
6	11	60	126	
6	12	60	150	
8	13	60	208	
8	14	60	240	
4	15	80	176	
4	16	80	184	
8	17	80	456	
2	18	80	135	
4	19	80	276	
6	20	80	750	
2	22	80		
2	23	80		
80 trees:				
Total cubic feet				2,918
Total feet B. M.				14,006

Average annual accretion: White Pine, 41 cubic feet.

[1] *Intermixed species:* Maple, 68; Beech, 22; Hemlock, 18; Yellow and White Birch, 14; White and Red Oak, 12; Cherry 2.
Undergrowth: Young Hemlock, 280; Beech, 146; Maple, 84; Birch, 12.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

A.—PENNSYLVANIA—Continued.

Half acre No. 2.

Soil: Reddish-brown sandy loam, fine grain, medium loose, deep, fresh, drained by Bear Creek, 2 to 3 inches mold on top, and surface cover of abundant leaves; Laurel and few Fern.

Forest conditions: White Pine (154) mixed with Maple, scattering Beech, Hemlock, and occasional Spruce, on uneven ground of a valley sloping toward northeast and bordered on all sides by hills over 300 feet above station; undergrowth, moderately dense, of young Hemlock, Beech, Maple, and a few young Spruce.[1]

Age of pine: 60 to 80 years.
Density of crown cover: 0.5 to 0.8.

Number of trees: 232.

HALF-ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
14	3 to 6	40	....	
2	6	50	11	
4	7	50	24	
12	8	50	114	
10	9	50	115	
14	10	50	210	
10	11	60	210	
8	12	60	200	
12	13	60	312	
16	14	60	480	
4	15	80	176	
4	16	80	184	
14	17	80	798	
8	19	80	552	
6	20	80	1,650	
6	21	80		
4	22	80		
4	24	80		
2	25	80		

154 trees:
Total cubic feet 5,036
Total feet B.M. 24,173

Average annual accretion: White Pine, 72 cubic feet.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

Forest conditions: Ridge land densely covered with young hardwoods—mainly White Oak and Red Oak, among which White Pine is scattered.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic feet.*	*Feet B.M.*			
1	123	29.0	84	34	3.5	140.6	627	0.36	0.60	37
2	132	20.0	81	20	5.7	78.1	369	.44	.75	*a* 39
3	134	22.0	81	16	5.7	81.6	369	.38	.80	*a* 38
4	128	31.0	90	20	3.8	193.8	935	.41	.77	40
Average...	129	25.5	84	22	4.7	124.0	575	.40	.73	38

a Oppressed for the last forty years.

[1] *Intermixed species:* Maple, 36; Hemlock, 16; Beech, 18; Spruce, 8.
Undergrowth: Young Hemlock, 200; Beech, 66; Maple, 24.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

A.—PENNSYLVANIA—Continued.

Soil: Reddish-brown sandy loam, medium loose, fresh, deep, and well drained, with surface cover of abundant leaves.
Forest conditions: Hardwoods—mainly Beech, Oak, Maple, Chestnut, and Birch—mixed with White Pine, Pitch Pine, Hemlock, and occasional Spruce.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume.		Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
						Tree.	Merchantable timber.			
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic feet.*	*Feet B. M.*			
1	163	29	116	50	5.0	191.4	947	0.36	0.57	40
1	98	25.0	84	32	3.5	121.2	530	.42	.62	36
2	96	20.0	73	32	4.3	76.1	360	.48	.56	40
3	92	31.0	97	32	2.5	210.0	976	.41	.67	40
4	97	19.5	76	26	4.3	67.0	363	.42	.66	45
Average	96	24.0	82	30	3.5	118.0	557	.43	.63	40

Soil: Fresh sand, well drained.
Forest conditions: A young White Pine grove mixed with mature Spruce, Hemlock, and scattering hardwoods.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume.		Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
						Tree.	Merchantable timber.			
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic feet.*	*Feet B. M.*			
1	64	14.5	54	18	4.0	28.7	110	0.46	0.66	31
2	57	14.5	58	20	2.7	31.4	144	.47	.66	38
3	50	8.5	50	20	4.8	9.5	43	.48	.60	36
4	47	8.0	46	18	5.0	7.3	32	.45	.61	37
5	52	11.0	50	20	3.7	14.2	54	.43	.60	31
6	49	11.5	46	18	3.6	15.7	59	.47	.61	31
7	52	9.5	53	18	4.0	12.1	48	.46	.66	33
8	54	8.0	54	18	5.7	10.1	34	.53	.66	27
9	54	10.0	56	18	4.3	14.7	59	.48	.68	33
Average	53	10.5	52	19	4.2	16.0	65	.47	.64	33

(2) SITE *e*: Clinton County. Sample area: 1 acre.

[1,500 to 1,600 feet above sea level.]

Soil: Loamy sand with rocks on face of slope, the brown-yellowish coarse grain full of shales, surface cover of 2 to 3 inches mold and abundant leaves.
Forest conditions: Brush of very young White, Red, and Chestnut Oak, with scattering White Pine (14), and occasional Chestnut Oak (6), Jack Pine (3), and Norway Pine (2), on a steep hill 300 feet above station, facing south; undergrowth, dense, of young hardwoods of same species as above.

Age of pine: 120 to 130 years.
Density of crown cover: 0.2 (scattered).

Number of trees: 25.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
1	10	70	19	....
1	15	76	46	161
1	19	84	66	370
3	21	85	270	1,245
1	22	87	99	432
3	24	85	345	1,449
3	25	85	372	2,004
1	29	85	151	760

14 trees:
Total cubic feet........................ 1,368
Total feet B. M........................ 6 421

Average annual accretion: White Pine, 11 cubic feet.
57 feet B. M.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

A.—PENNSYLVANIA—Continued.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice (per cent used of total volume of stem).
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic feet.*	*Feet B. M.*			
1	125	21.0	78	40	4.8	88.6	404	0.47	0.48	39
2	124	24.0	86	28	5.4	115.8	483	.42	.67	34
3	124	22.0	87	34	5.5	99.0	432	.43	.61	36
4	116	18.5	79	36	6.2	63.9	280	.43	.54	36
5	122	19.5	85	40	5.9	79.7	364	.45	.53	38
6	(?)	24.5	83	36	(?)	124.5	668	.46	.56	44
7	120	21.0	89	38	5.4	94.5	429	.44	.57	37
8	128	19.0	84	40	6.4	66.2	370	.40	.52	46
9	127	19.5	88	40	5.7	92.0	446	.50	.54	40
10	122	15.0	76	36	7.1	46.2	161	.49	.52	30
11	125	17.0	84	36	6.9	61.4	267	.46	.57	36
12	(?)	20.5	76	38	(?)	78.0	293	.45	.50	31
Average	123	20	83	37	6.0	84.0	383	.45	.55	37

(3) SITE *g*: Clearfield County. Sample area: 1 acre.

[1,200 to 1,500 feet above sea level.]

Soil: Yellow clayey loam, medium grain, deep, fresh, well drained (three small streams cross the hollow in different directions), with 2 to 3 inches mold on top, surface cover of leaves, Fern, Ground Pine, Wintergreen, Elderberry, Blackberry, and Dogwood; subsoil laminated shale of indefinite depth.

Forest conditions: Young White Pine intermixed with young hardwoods in hollow extending north and south, and bounded on the west by hill over 2 feet above station; undergrowth dense, of very small and various hardwoods, mainly Black Birch, Maple, and Beech, and few White Birch and Hemlock.[1]

Age of pine: 25 to 35 years.

Density of crown cover: 0.5 to 0.6.

Number of trees: (?)

ACRE YIELD.

White Pine. Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
154	Under 3	....	4.5	
41	3 to 5	16 to 37	61.5	
54	6 to 10	40 to 47	432.0	
34	10 to 14	42 to 50	612.0	
2	14 to 18	....	42.0	

285 trees:
Total cubic feet 1,152

Average annual accretion: White Pine, 38 cubic feet.

[1] *Intermixed species:* White Pine, 131+154 small; Aspen, 12+54 small; Beech, 1+137 small; Maple, 6+254 small; Oak, 5+12 small; White Ash, 3+21 small; Cucumber, 6+90 small; Black Cherry, 2+77 small; Black Birch, 17+415 small; Hamamelis, 4 small; Basswood, 6 small; Tulip, 13 small; Ironwood, 2 small; Chestnut, 2 small; Willow, 10 small; Hemlock, 50 small.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

A.—PENNSYLVANIA—Continued.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic ft.*		
DOMINANT GROWTH.								
10	33	13.5	43.8	11.0	1.6	21.0	0.48	0.75
17	36	14.0	47.0	14.0	1.9	20.9	.41	.70
9	35	12.5	49.0	18.5	2.1	18.8	.45	.62
11	34	13.5	43.0	12.0	1.9	18.1	.42	.72
Average	34	13.4	46.0	14.0	1.9	19.7	.44	.70
CODOMINANT GROWTH.								
14	32	11.2	42.5	19.5	1.7	12.6	0.45	0.54
15	31	9.5	47.0	28.0	2.5	10.9	.47	.40
16	34	8.0	45.0	28.0	3.1	7.7	.48	.38
7	34	8.0	41.8	22.5	3.5	6.7	.45	.46
13	34	7.2	41.5	14.8	3.9	5.2	.47	.64
Average	33	8.8	43.0	22.0	2.9	8.6	.46	.48
OPPRESSED GROWTH.								
6	31	6.0	39.8	25.0	3.8	4.0	0.51	0.37
8	33	5.2	37.0	21.5	4.7	2.8	.55	.42
12	29	5.0	32.5	14.0	4.3	2.1	.48	.57
Average	31	5.4	36.0	20.0	4.3	3.0	.51	.45
SUPPRESSED GROWTH.								
5	27	3.0	27.0	13.0	7.0	0.7	0.53	0.51
2	30	3.3	23.5	9.0	7.9	.7	.44	.61
3	27	3.1	27.8	14.0	7.4	.6	.47	.49
Average	27	3.1	26.0	12.0	7.4	.7	.48	.54
1	22	3.0	16.0	16.0	4.8	.4	.59	1.00
4	24	2.5	24.0	7.0	5.9	.3	.41	.71
Average	23	2.7	20.0	11.0	5.3	.3	.50	.85

(4) SITE *j:* Forest County. Sample area: 1 acre.

[1,100 to 1,200 feet above sea level.]

Soil: Yellowish-brown clayey loam, with shales, deep, fresh, drained on south by Beaver Creek and on the west by Hickory Creek, 3 to 4 inches mold on top, and surface cover of leaves and Fern; subsoil, laminated shale of indefinite depth.

Forest conditions: Young White Pine intermixed with hardwoods and occasional Hemlock on slope facing southwest; undergrowth dense, of very young Hemlock, Birch, Beech, some Maple and Ironwood, and a few other hardwoods.[1]

Age of pine: 40 to 50 years.
Density of crown cover: 0.8 (in places thick and crowded, and in other places openings).
Number of trees: (?).

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
144	3 and under	20 to 40	53	
41	4			
49	5	46	572	
34	6	46		
23	7	46		
24	8	54	839	
28	9	54		
21	10	54		
12	11	58	306	
4	12	58		
1	13	58		
1	14	61	56	
1	15	61		

383 trees:
Total cubic feet........................ 1,826

Average annual accretion: White Pine, 40 cubic feet.

[1] *Intermixed species:* White Pine, 239+144 small; Hemlock, 78+248 small; Beech, 50+160 small; Maple, 46+108 small; Oak (White and Red), 20+12 small; Ash, 16+9 small; Black Birch, 73+76 small; Yellow Birch, 59+189 small; Ironwood, 13+100 small; Black Cherry, 15+2 small; Hickory, 2; Cucumber, 2; Juneberry, 50; few small Aspen, Butternut, and Waterbeech.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

A.—PENNSYLVANIA—Continued.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.
	Years.	*Inches.*	*Feet.*	*Feet.*	*No.*	*Cubic ft.*		
3	46	12.0	60.0	23	3.5	20.2	0.43	0.62
12	44	11.5	58.5	26	3.4	20.0	.47	.55
2	44	12.5	55.0	18	3.4	19.4	.41	.67
8	47	11.0	59.0	30	3.3	18.7	.48	.49
16	47	11.5	66.0	28	3.3	18.3	.45	.50
9	45	11.0	58.5	28	2.7	17.9	.49	.52
5	47	10.5	60.0	34	3.7	17.3	.48	.43
6	47	10.0	59.0	32	3.3	16.4	.51	.46
21	48	10.5	58.0	30	3.6	16.3	.46	.48
19	47	11.0	55.0	28	3.1	15.4	.42	.49
Average	46	11.0	58.0	28	3.3	18.0	.45	.52
7	47	14.0	64.0	34	2.9	29.6	.43	.47
15	46	14.0	58.0	22	3.0	26.9	.43	.62
Average	46	14.0	61.0	28	3.0	28.2	.43	.54

CODOMINANT GROWTH.

18	43	9.5	56.0	28	4.1	13.9	0.50	0.50
14	43	10.0	52.5	30	4.2	13.9	.48	.43
24	46	10.0	53.0	28	3.9	13.7	.47	.47
11	45	9.5	58.0	30	4.9	13.1	.46	.48
17	44	9.0	58.0	32	3.9	12.9	.47	.44
4	45	9.0	46.0	23	4.9	11.4	.46	.59
26	45	8.5	50.0	30	4.6	10.0	.51	.40
13	43	8.0	54.0	28	3.7	9.6	.51	.48
1	47	8.0	50.0	20	5.1	9.2	.53	.60
10	44	8.0	56.0	36	5.1	8.6	.44	.53
Average	44	9.0	54.0	28	4.4	11.5	.48	.49

OPPRESSED GROWTH.

27	43	7.5	48	22	5.0	7.9	0.54	0.54
20	42	7.0	46	30	5.0	6.6	.53	.34
25	43	7.5	46	30	5.2	6.1	.43	.35
22	43	5.0	45	28	6.9	3.1	.50	.38
23	44	5.5	46	38	6.8	3.6	.47	.17
Average	43	6.5	46	30	5.8	5.4	.49	.35

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

B.—MAINE:

(1) SITE *a:* York County. Sample area: One-half acre.

Soil: Gray or brown fine, loamy sand, deep, fresh, 2 to 3 inches mold on top and leafy surface cover, and clay probably some feet below surface.

Age of pine: 90 to 100 years.
Density of crown cover: 0.5.

Forest conditions: White Pine, with scattering Red Oak and White Oak and occasional Norway Pine on a level; undergrowth, moderately dense, of small Hemlock and Beech and numerous small Maple and Oak.

Number of trees: 118.

Classification:		White Pine.
Dominant	per cent..	26
Codominant	do....	40
Oppressed	do....	18
Suppressed	do....	16

HALF ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
2	10	75	42	
8	11	75	192	
8	12	75	233	
4	12	85	120	
6	13	85	222	
4	14	75	154	
8	14	85	332	
8	15	85	384	
8	16	85	408	
8	17	85	528	
10	18	85	690	
18	19	85	1,323	
2	20	85	152	
4	21	85	320	
6	22	85	534	
6	23	85	660	
2	24	95	250	
2	25	95	280	
4	26	95	560	
118 trees: Total cubic feet			7,383	

Average annual accretion: White Pine, 77 cubic feet.
Current annual accretion: White Pine, 160 cubic feet.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

Age class: 90 to 100 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cubic ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
7	98	28.0	100	2.9	175.3	0.41	0.60	....	....	....
12	92	28.0	103	2.7	161.0	.36	.61	....	....	....
3	98	25.0	92	3.2	140.3	.46	.48	....	....	....
17	92	25.5	91	3.0	136.3	.42	.56	....	....	....
18	92	25.0	88	3.2	131.7	.44	.46	....	....	....
23	97	22.0	98	3.8	119.4	.46	.49	....	....	....
21	97	20.6	102	4.1	118.1	.35	.45	....	....	....
16	90	22.5	91	3.4	115.1	.46	.52	....	....	....
9	102	20.0	100	4.1	104.0	.47	.43	....	....	....
20	100	20.3	103	4.3	98.8	.41	.40	....	....	....
Average	96	23.7	97	3.5	130.0	.42	.50	....	....	....

CODOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
4	101	20.5	95	3.8	93.3	0.43	0.40	....	....	....
8	98	19.5	99	3.8	88.4	.43	.33	....	....	....
22	98	19.0	96	4.1	84.9	.45	.35	....	....	....
10	89	16.8	99	3.8	71.3	.46	.40	....	....	....
14	93	18.5	92	4.3	69.9	.41	.52	....	....	....
28	93	18.5	80	4.6	68.4	.48	.41	....	....	....
19	89	18.7	79	4.1	67.2	.45	.48	....	....	....
15	99	17.2	87	4.6	67.0	.49	.46	....	....	....
11	89	17.2	89	4.0	60.7	.43	.38	....	....	....
Average	94	18.5	91	4.1	74.5	.45	.41	....	....	....

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

B.—MAINE—Continued.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES—Continued.

OPPRESSED GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cubic ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
25	100	15.0	93	5.4	55.5	0.48	0.27			
1	100	15.0	90	6.5	55.3	.51	.36			
26	99	14.0	90	6.0	47.3	.49	.21			
6	86	14.3	88	5.0	43.1	.42	.18			
24	97	13.5	81	5.8	37.3	.46	.20			
5	99	12.6	86	7.2	37.1	.50	.14			
13	91	13.2	80	5.2	35.9	.48	.30			
27	99	12.0	80	6.3	30.7	.49	.22			
Average	96	13.7	86	6.0	42.8	.48	.23			

Age class: 50 to 60 years.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion (Per cent.)	Current annual accretion (Cu. ft.)	Average annual accretion.
2	55	14.0	61	3.2	34.2	0.52	0.69	5.4	1.85	0.62
1	60	14.7	69	3.3	39.8	.50	.47	4.0	1.59	.66
3	60	17.0	61	3.1	42.8	.44	.64	4.6	1.97	.71
4	59	19.1	65	2.8	60.7	.47	.69	4.4	2.67	1.03
Average	58.5	16.2	64	3.1	44.4	.48	.62	4.6	2.02	.75

(2) SITE *c:* York County. Sample area: 1 acre.

One-fourth acre No. 1.

Soil: Gray sand, sometimes brown or loamy, deep, fresh, with 3 inches vegetable mold, and a leafy surface cover; subsoil clayey, probably 4 or 5 feet below surface.
Forest conditions: White Pine, with scattering Hemlock and occasional Spruce and Fir, on a level plain; undergrowth, scanty, of Hazel and young Hemlock.[1]

Age of pine: 50 to 60 years.
Density of crown cover: 0.7.
Number of trees: 328.

Classification:

	White Pine.
Dominant ....per cent..	9
Codominant ....do....	45
Oppressed ....do....	23
Suppressed ....do....	23

ONE-FOURTH ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
4	6	45	20	
32	7	55	256	
60	7	45	330	
84	8	55	840	
8	8	45	72	
36	9	55	414	
8	10	65	144	
52	10	55	780	
8	11	....	144	
12	12	65	306	
12	12	55	240	
4	13	65	116	
8	17	75	408	
328 trees: Total cubic feet			4,070	

Average annual accretion: White Pine, 74 cubic feet.
Current annual accretion: White Pine, 133 cubic feet.

[1] *Intermixed species:* Young White Pine, 160; Hemlock, 20 mature and 20 small.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

B.—MAINE—Continued.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.
	Years.	*Inches.*	*Feet.*	*No.*	*Cubic feet.*		
9	50	14.5	64	2.8	33.1	0.45	0.55
4	59	13.3	60	3.8	26.4	.44	.58
8	55	12.8	61	3.3	25.6	.45	.38
3	50	11.8	58	3.5	20.1	.52	.41
10	59	10.2	65	4.4	22.0	.59	.35
12	50	11.0	62	3.7	21.1	.50	.35
Average	54	12.3	62	3.6	24.7	.49	.44

CODOMINANT GROWTH.

11	52	10.0	59	4.3	16.1	0.50	0.40
5	50	9.0	58	4.3	13.4	.52	.41
20	51	8.8	58	4.6	13.3	.54	.38
7	50	9.4	54	4.3	12.3	.46	(?)
27	51	8.1	56	5.1	10.7	.55	.35
6	50	8.4	55	4.5	10.6	.50	.40
1	49	8.1	56	5.0	10.2	.52	.34
29	52	8.0	57	5.5	10.1	.50	.37
Average	51	8.7	57	4.7	12.1	.51	.39

OPPRESSED GROWTH.

22	49	7.7	53	5.2	9.6	0.56	0.30
2	52	7.8	54	5.0	9.5	.50	.26
21	49	8.0	51	5.0	9.5	.53	.39
30	48	7.7	54	5.1	9.0	.52	.40
25	50	7.4	58	5.6	9.0	.50	.33
19	51	8.2	47	5.1	8.9	.51	.34
17	50	7.4	54	5.6	8.0	.50	.30
Average	50	7.8	73	5.2	9.1	.52	.33

SUPPRESSED GROWTH.

14	55	6.3	57	(?)	6.3	0.51	0.31
16	48	6.9	49	5.7	5.8	.44	.28
26	46	6.3	51	5.5	5.5	.47	.25
13	46	6.2	47	5.8	5.1	.51	.27
15	48	5.6	50	7.0	4.3	.52	.20
28	50	6.0	39	8.0	3.7	.48	.56
23	48	5.3	46	7.6	3.6	.47	.26
24	52	5.0	48	8.3	3.4	.52	.43
18	52	5.0	46	10.0	3.2	.50	.27
Average	50	5.8	48	7.2	4.5	.49	.31

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

B.—MAINE—Continued.

One-fourth acre No. 2.

Soil: Brown sandy loam with little pebbles in it, deep, fresh, 3 inches black soil and mold on top, and leafy surface cover; clay probably 8 to 12 inches below surface.
Forest conditions: White Pine, with occasional Norway Pine, on a slope to north 5° to 10°; undergrowth scanty, of Hemlock, Oak, and Fir.

Age of pine: 50 to 60 years.
Density of crown cover: 0.8
Number of trees: 396.

Classification:

		White Pine.
Dominant	per cent..	18
Codominant	do....	27
Oppressed	do....	24
Suppressed	do....	31

ONE-FOURTH ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
4	6	65	28	
28	6	55	168	
20	7	65	190	
20	7	55	160	
84	8	65	1,008	
24	8	55	240	
36	9	65	522	
32	10	65	576	
8	10	75	168	
40	11	65	880	
4	11	75	100	
16	12	65	408	
24	12	75	696	
8	13	65	232	
16	13	75	552	
4	14	65	132	
12	14	75	462	
8	15	65	292	
4	16	75	184	
4	17	75	204	

396 trees:
Total cubic feet........................ 7,202

Average annual accretion: White Pine, 131 cubic feet.

One-half acre No. 3.

Soil: Brown sand, deep, fresh, and leafy surface cover; clay probably 4 to 6 feet below surface.
Forest conditions: White Pine intermixed with Norway Pine and occasional Spruce and Fir, on a slope to north; undergrowth scanty, of small and few Hemlock, Fir, and Spruce.

Age of pine: 50 to 60 years.
Density of crown cover: 0.8.
Number of trees: 314.

Classification:

		White Pine.
Dominant	per cent..	8
Codominant	do....	36
Oppressed	do....	30
Suppressed	do....	26

HALF-ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
18	7	65	162	
48	7	55	384	
60	8	65	720	
26	8	55	260	
44	9	65	638	
6	9	55	69	
4	10	75	82	
38	10	65	684	
10	11	75	250	
28	11	65	616	
4	12	75	116	
14	12	65	357	
4	13	75	138	
6	13	65	174	
2	14	75	77	
2	15	65	73	

314 trees:
Total cubic feet........................ 4,800

Average annual accretion: White Pine, 87 cubic feet.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

B.—MAINE—Continued.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

DOMINANT GROWTH.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.
	Years.	*Inches.*	*Feet.*	*No.*	*Cu. ft.*		
7	89	21.8	86	3.7	89.3	0.40	0.42
8	85	19.6	85	4.0	76.5	.43	.50
5	92	17.3	87	4.4	69.5	.48	.52
13	92	19.3	79	4.2	69.3	.42	.47
2	82	18.8	80	3.8	68.6	.43	.39
10	82	17.7	85	4.4	67.4	.46	.41
14	96	18.5	75	4.4	66.6	.42	.46
11	91	17.2	85	4.5	66.4	.49	.48
15	91	17.2	82	4.4	63.7	.49	.45
Average	89	18.6	83	4.2	70.8	.45	.46
9	89	24.0	85	3.3	123.5	.45	.54

SUPPRESSED GROWTH.

3	100	12.6	57	8.0	24.9	0.50	0.54
1	190	10.0	69	8.7	20.1	.53	.39
Average	95	11.3	63	8.3	22.5	.51	.46

PENOBSCOT COUNTY.

Tree number.	Age.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*Cu. ft.*			*Per cent.*	*Cu. ft.*	*Cu. ft.*
9	66	12.5	76	31.83	0.49	0.40	2.8	0.89	0.48
1	77	16.0	62	34.55	.39	.69	3.3	1.14	.44
7	73	12.7	80	35.51	.52	.45	3.7	1.31	.48
10	74	13.0	80	36.00	.48	.40	3.1	1.12	.48
6	70	13.0	77	35.15	.50	.52	3.0	1.05	.50
8	69	13.2	82	38.49	.51	.35	3.6	1.38	.55
3	73	13.5	83	40.43	.49	.32	2.1	.85	.55
5	75	14.7	83	43.20	.45	.35	2.5	1.08	.57
1	70	15.7	81	42.34	.40	.43	3.6	1.51	.60
4	73	14.5	82	45.10	.47	.39	3.2	1.44	.61
2	79	17.0	74	51.14	.43	.43	2.0	1.02	.65
3	77	16.5	78	51.28	.44	.65	3.8	1.95	.66
2	72	15.2	85	51.91	.48	.30	2.0	1.04	.72
Average	73	14.4	79	41.30	.46	.44	3.0	1.21	.56

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

C.—MASSACHUSETTS:

(1) SITE *a*: Holbrook, Norfolk County.

Sample area: 1 acre.
Age of pine: 35 to 38 years.
Density of crown cover: 0.6.
Number of trees: 286.

Soil: Yellowish-brown sandy loam, shallow, loose, dry, with 1 or 2 inches mold on top and a moderately leafy surface cover; subsoil, sand with stones and gravel.

Forest conditions: White Pine on a slope (angle about 10°); undergrowth scanty, of Red Cedar with scattering Hemlock and White and Red Oak.[1]

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
169	8	60	1,690	
5	10	60	80	
18	10	70	342	
24	11	70	528	
23	12	70	598	
28	13	70	868	
11	14	70	385	
7	15	70	280	
1	17	70	51	

286 trees:
Total cubic feet........................ 4,822

Average annual accretion: White Pine, 131 cubic feet.

(2) SITE *b*: Pembroke, Plymouth County.

Sample area: 1 acre.
Age of pine: 50 to 55 years.
Density of crown cover: Thick and quite even.
Number of trees: 339.

Soil: Yellowish-brown sandy loam, medium grain, light, loose, fresh, with 2 to 3 inches mold on top and surface cover of abundant leaves.

Forest conditions: White Pine with scattering Oak, Maple, Gray Birch, and occasional Sassafras and Hornbeam; undergrowth moderately dense of above species of hardwoods.[2]

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
226	8	60	2,260	
19	10	60	304	
18	10	70	342	
38	11	70	836	
22	12	70	572	
10	13	70	310	
2	14	70	70	
3	15	70	120	
1	16	70	45	

339 trees:
Total cubic feet........................ 4,859

Average annual accretion: White Pine, 92 cubic feet.

---

[1] *Intermixed species:* Red Cedar, 2 from 6 to 10 inches diameter and under 60 feet high; 8 from 3 to 6 inches diameter and under 40 feet high. Red Oak, 1 over 6 inches diameter and under 60 feet high; 1 over 3 inches diameter and under 40 feet high. Hemlock, 4 from 3 to 6 inches diameter and under 40 feet high. White Oak, 3 from 3 to 6 inches diameter and under 40 feet high. Young White Pine, 85.
Undergrowth: Red Cedar, 29; White Oak, 1; and Hemlock, 3.

[2] *Intermixed species:* Oak, 10 from 10 to 14 inches diameter and under 80 feet high; 1 over 6 inches diameter and over 60 feet high; 6 from 6 to 10 inches diameter and under 60 feet high; 2 from 3 to 6 inches diameter and over 40 feet high. Maple, 4 from 3 to 6 inches diameter and over 40 feet high; 8 from 3 to 6 inches diameter and under 40 feet high. Gray Birch, 1 over 6 inches diameter and over 60 feet high; 6 from 6 to 10 inches diameter and under 60 feet high; 43 from 3 to 6 inches diameter and over 40 feet high. Young White Pine, 69.
Undergrowth: Gray Birch, 21; Maple, 38; Hornbeam, 1, and Sassafras, 3.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

C.—MASSACHUSETTS—Continued.

(3) SITE *c*: Hanson, Plymouth County. Sample area: 1 acre.

Soil: Yellowish loamy sand, medium grain, porous, light, loose, deep, dry, and well drained, with about 2 inches mold on top and surface cover of abundant leaves; subsoil, sand and gravel.
Forest conditions: Pure White Pine on level plain, originally mixed with hardwoods, but ten years ago hardwoods and dying pine cut out, leaving young oaks 1 to 2 feet high throughout site; undergrowth of hardwoods.[1]

Age of pine: 50 to 55 years.
Density of crown cover: (?)

Number of trees: 310.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
127	8	55	1,143	
19	10	55	285	
21	10	70	399	
39	11	70	858	
31	12	70	806	
23	13	70	713	
22	14	70	770	
16	15	70	640	
8	16	70	360	
2	17	70	102	
2	18	70	112	
310 trees: Total cubic feet			6,188	

Average annual accretion: White Pine, 123 cubic feet.

(4) SITE *d*: Weymouth, Norfolk County. Sample area: 1 acre.

[180 feet above sea level.]

Soil: Brown or yellow sandy loam, medium grain, shallow, light, loose, dry, and well drained, with 1 or 2 inches mold on top and surface cover of abundant leaves; subsoil, gravel and stone.
Forest conditions: White Pine, with scattering Red Oak and occasional Maple and Hornbeam on somewhat hilly site; undergrowth dense, of White Oak, Red Oak, Gray Birch, and Black Birch.[2]

Age of pine: 50 years.
Density of crown cover: (?)

Number of trees: 295.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
174	8	60	1,740	
36	10	65	612	
26	11	70	572	
21	12	70	546	
16	13	70	496	
10	14	70	350	
4	15	70	160	
3	16	70	135	
1	17	70	51	
3	19	70	183	
1	21	70	78	
295 trees: Total cubic feet			4,923	

Average annual accretion: White Pine, 98 cubic feet.

[1] *Undergrowth:* Hemlock, 7; Maple, 1; Red Cedar, 1; Black Birch, 4; Cherry, 4; Poplar, 1; White Oak, 1, with numerous small oaks.

[2] *Intermixed species:* White Oak, 5 from 3 to 6 inches diameter and over 40 feet high; 16 from 3 to 6 inches diameter and under 40 feet high. Gray Birch, 8 from 3 to 6 inches diameter and over 40 feet high; 7 from 3 to 6 inches diameter and under 40 feet high. Red Oak, 2 from 10 to 14 inches diameter and under 80 feet high; 20 from 6 to 10 inches diameter and under 60 feet high; 12 from 3 to 6 inches diameter and over 40 feet high; 23 from 3 to 6 inches diameter and under 40 feet high. Cherry, 1 over 3 inches diameter and under 40 feet high. Black Birch, 2 from 3 to 6 inches diameter and under 40 feet high. Red Cedar, 1 over 3 inches diameter and under 40 feet high. Maple, 1 over 3 inches diameter and over 40 feet high. Young White Pine, 47.

Undergrowth: White Oak, 35, and numerous small ones; Cherry, 2; Red Cedar, 1; Red Oak, 4; Black Birch, 19, and numerous small ones; Hemlock, 1; Gray Birch, 2; Hornbeam, 1.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

C.—MASSACHUSETTS—Continued.

(5) SITE *e:* Bridgewater, Plymouth County. Sample area: 1 acre.

[100 feet above sea level.]

Soil: Dark-brown loamy sand, medium grain, light, loose, shallow, fresh, with about 2 inches mold on top, and surface cover of abundant leaves; subsoil, yellow fine sand.
Forest conditions: Cultivated White Pine, with occasional Gray Birch, on level plain; undergrowth of scattering Oak and Maple.[1]

Age of pine: 45 years.
Density of crown cover: (?)
Number of trees: 374.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
240	8	55	2,160	
1	10	55	15	
42	10	60	672	
22	11	60	418	
27	12	60	621	
15	13	60	390	
13	14	65	429	
6	15	65	222	
2	16	65	84	
4	17	70	204	
2	18	70	112	

374 trees:
Total cubic feet 5,327

Average annual accretion: White Pine, 118 cubic feet.

(6) SITE *f:* Bridgewater, Plymouth County. Sample area: 1 acre.

[100 feet above sea level.]

Soil: Light-brown sandy loam, medium grain, shallow, light, loose, dry, well drained, with about 2 inches mold on top, and surface cover of abundant leaves; subsoil, gravel of all sizes.
Forest conditions: Cultivated White Pine, intermixed with young hardwoods and Pitch Pine. (Pine seedlings from woods, 1 to 2 feet high, set in furrows at 6 or 8 feet each way.)[2]

Age of pine: 25 years.
Density of crown cover: (?).
Number of trees: 560.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
115	3	20	....	
184	3 to 6	30	....	
211	6 to 8	30	1,055	
47	8 to 10	30	423	
1	10	35	11	
2	14	35	46	

560 trees:
Total cubic feet 1,536

Average annual accretion: White Pine, 61 cubic feet.

[1] *Intermixed species:* Gray Birch, 4 from 6 to 10 inches diameter and under 60 feet high; 7 from 3 to 6 inches diameter and over 40 feet high.
Undergrowth: White Oak, 23; Maple, 3.

[2] *Intermixed species:* Gray Birch, 13 from 3 to 6 inches diameter and under 30 feet high. Pitch Pine, 1 over 8 inches diameter and under 30 feet high; 5 from 6 to 8 inches diameter and under 30 feet high; 28 from 3 to 6 inches diameter and under 30 feet high. Red Cedar, 1 over 3 inches diameter and under 30 feet high.
Undergrowth: Oak, 97; Gray Birch, 54; Pitch Pine, 16; Maple, 8; Cherry, 3; Hickory, 1.

TABLE VII.—*Acre yields of second growth White Pine, with measurements of young pine taken for analysis*—Continued.

C.—MASSACHUSETTS—Continued.

(7) SITE *g:* Grafton, Middlesex County. Sample area: 1 acre.

[500 feet above sea level.]

Soil: Brown, nearly black, sandy loam, medium grain, shallow, fresh, well drained, with 1 or 2 inches mold on top, and moderately leafy surface cover; subsoil, rock on ridge, yellowish sand on low ground.

Forest conditions: White Pine on hill; undergrowth, dense, of Maple and Oak and some Chestnut, Cherry, Gray Birch, and other hardwoods.[1]

Age of pine: 40 years.
Density of crown cover: 0.8 to 0.2.
Number of trees: 323.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
176	8	60	1,760	
2	10	60	32	
43	10	70	817	
44	11	70	968	
23	12	70	598	
21	13	70	651	
8	14	70	280	
4	15	70	160	
2	18	70	112	
323 trees: Total cubic feet........................ 5,378				

Average annual accretion: White Pine, 134 cubic feet.

(8) SITE *h:* Worcester, Worcester County. Sample area: 1 acre.

[About 600 feet above sea level.]

Soil: Brown sandy loam, medium grain, deep, fresh, well drained, with about 1 inch mold on top and a moderately leafy surface cover; subsoil, drift gravel and stones.

Forest conditions: White Pine, with scattering Gray Birch and occasional Poplar and Pitch Pine on a hill; undergrowth, scanty, of Hemlock.[2]

Age of pine: 30 to 35 years.
Density of crown cover: 0.6 to 0.8 (in places 0.2 and 0.4).
Number of trees: 301.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
193	8	60	1,930	
39	10	70	741	
34	11	70	748	
13	12	70	338	
12	13	70	372	
5	14	70	175	
3	15	70	120	
1	16	70	45	
1	17	70	51	
301 trees: Total cubic feet........................ 4,520				

Average annual accretion: White Pine, 141 cubic feet.

[1] *Intermixed species:* Pitch Pine, 1 over 3 inches diameter and over 40 feet high; 1 over 6 inches diameter and under 60 feet high; 1 over 10 inches diameter and under 80 feet high. White Birch, 2 from 3 to 6 inches diameter and over 40 feet high. Gray Birch, 6 from 3 to 6 inches diameter and under 40 feet high. Young White Pine, 35.

Undergrowth (under 3 inches diameter and under 40 feet high): Maple, 204 (mostly Striped Maple); Oak, 133; Chestnut, 19; Cherry, 11; Gray Birch, 6; Thorn, 4; Hamamelis, 3; Hickory, 1; Hemlock, 1; Elm, 2.

[2] *Intermixed species:* Pitch Pine, 3 from 6 to 10 inches diameter and under 60 feet high. *Populus grandidentata*, 1 over 6 inches diameter and under 60 feet high. Gray Birch, 6 from 6 to 10 inches diameter and under 60 feet high; 31 from 3 to 6 inches diameter and over 40 feet high. Poplar, 2 from 6 to 10 inches diameter and under 60 feet high. Hemlock, 1 over 3 inches diameter and under 40 feet high. Young White Pine, 90.

Undergrowth: Oak, 53; Gray Birch, 1, and a few small Cherry, not counted.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

C.—MASSACHUSETTS—Continued.

(9) SITE *i:* Northbridge, Worcester County. Sample area: 1 acre.

[500 feet above sea level.]

Soil: Yellow sandy loam, fine grain, deep, fresh, well drained, with about 4 inches mold on top, and a moderately leafy surface cover; subsoil, probably ledge rock.
Forest conditions: White Pine, with occasional Birch and Maple, on a hill; undergrowth, moderately dense, of Oak, Maple and Chestnut.[1]

Age of pine: 35 years.
Density of crown cover: 0.8.
Number of trees: 413.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
284	8	50	2,556	
53	10	70	1,007	
36	11	70	792	
20	12	70	520	
11	13	70	341	
7	14	70	245	
2	15	70	80	
413 trees: Total cubic feet			5,540	

Average annual accretion: White Pine, 158 cubic feet.

(10) SITE *j:* Brookfield, Worcester County. Sample area: 1 acre.

[800 to 900 feet above sea level.]

Soil: Dark brown or black loam, fine grain, light, deep, fresh, well drained, with about 2 inches mold on top and a moderately leafy surface cover; subsoil, rock not far below surface.
Forest conditions: White Pine, with occasional Pitch Pine and hardwoods on north slope of uneven land; undergrowth dense, of various hardwoods, with Oak and Chestnut predominating.[2]

Age of pine: 35 to 40 years.
Density of crown cover: 0.8.
Number of trees: 303.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
165	8	55	1,485	
43	9	55	516	
1	10	55	15	
33	10	60	528	
25	11	60	475	
14	12	60	322	
14	13	60	364	
7	14	65	231	
1	15	65	37	
303 trees: Total cubic feet			3,973	

Average annual accretion: White Pine, 104 cubic feet.

[1] *Intermixed species:* White Maple, 1 over 6 inches diameter and under 60 feet high; 2 from 3 to 6 inches diameter and over 40 feet high. Maple, 2 from 10 to 14 inches diameter and under 80 feet high; 8 from 3 to 6 inches diameter and over 40 feet high; 1 over 3 inches diameter and under 40 feet high. Apple, 1 over 3 inches diameter and over 40 feet high. Young White Pine, 77.

Undergrowth: Oak, 152 (and numerous small trees); Chestnut, 52; Gray Birch, 1; Maple, 12 (and numerous small trees); White Maple, 3.

[2] *Intermixed species:* Pitch Pine, 2 from 10 to 14 inches diameter and under 80 feet high; 5 from 6 to 10 inches diameter and under 60 feet high. Oak, 1 over 6 inches diameter and under 60 feet high; 1 over 3 inches diameter and over 40 feet high; 1 over 3 inches diameter and under 40 feet high. Gray Birch, 21 from 3 to 6 inches diameter and over 40 feet high; 4 from 3 to 6 inches diameter and under 40 feet high. White Birch, 1 over 3 inches diameter and over 40 feet high. Maple, 1 over 6 inches diameter and under 60 feet high; 1 over 3 inches diameter and under 40 feet high. Chestnut, 1 over 10 inches diameter and under 80 feet high; 1 over 3 inches diameter and under 40 feet high. Poplar, 1 over 10 inches diameter and under 80 feet high. Young White Pine, 89.

Undergrowth: Oak, 404; Chestnut, 188; Maple (Red and White), 93; Black Birch, 27; Hemlock, 7; Ash, 30; Gray Birch, 32; Cherry (and numerous small trees), 1. Numerous small Poplars not counted.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

C.—MASSACHUSETTS—Continued.

(11) SITE *k*: Charlton, Worcester County. Sample area: 1 acre.

[About 800 feet above sea level.]

Soil: Dark-brown sandy loam, medium grain, loose, deep, fresh, well drained, with about 2 inches mold on top, and a moderately leafy surface cover; subsoil, rock and sand.

Forest conditions: White Pine, nearly pure, with 18 young trees on a hill; undergrowth scanty, of Chestnut, Maple, Oak, and Cherry.

Age of pine: 48 years.
Density of crown cover: 0.6.
Number of trees: 446.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
277	8	60	2,770	
62	10	70	1,178	
50	11	70	1,100	
29	12	70	754	
13	13	70	403	
9	14	70	315	
3	15	70	120	
3	16	70	135	
446 trees: Total cubic feet			6,775	

Average annual accretion: White Pine, 141 cubic feet.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

Tree number.	Age.	Diameter (breast high).	Height.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Average annual accretion.
SITE *b*.							
	Years.	*Inches.*	*Feet.*	*Cu. ft.*			*Cu. ft.*
1	52.0	13.0	71.5	31.7	0.47	0.47	0.61
2	50.0	9.0	60.0	13.8	.52	.22	.28
3	48.0	9.2	62.5	15.6	.54	.36	.32
Average	50.0	10.4	65.0	20.4	.51	.35	.40
SITE *c*.							
4	54.0	11.3	59.0	19.7	0.48	0.37	0.36
5	52.0	13.8	71.5	36.3	.49	.42	.70
6	50.0	9.5	64.0	16.3	.52	.28	.33
Average	52.0	11.5	65.0	27.4	.50	.36	.46
SITE *e*.							
7	39.0	8.3	52.0	8.8	0.45	0.40	0.22
8	39.0	9.2	58.0	13.0	.49	.36	.33
9	39.0	12.0	59.0	22.4	.48	.50	.57
Average	39.0	9.8	56.0	14.7	.47	.42	.37
SITE *i*.							
19	40.0	9.5	55.0	14.3	0.53	0.42	0.36
20	36.0	11.2	53.0	18.4	.51	.55	.51
21	33.0	6.5	51.0	6.7	.57	.37	.20
Average	36.3	9.0	53.0	13.1	.54	.45	.36
SITE *j*.							
22	37.0	10.5	53.0	16.4	0.51	0.45	0.44
23	39.0	9.3	55.0	13.8	.54	.44	.35
24	39.0	7.0	52.0	7.9	.56	.37	.20
Average	38.3	8.9	53.0	12.7	.54	.42	.33
SITE *k*.							
25	48.0	10.0	63.0	17.0	0.50	0.26	0.35
26	48.0	12.8	69.5	33.0	.53	.38	.69
27	48.0	9.1	64.0	16.0	.54	.40	.33
Average	48.0	10.6	65.5	22.0	.52	.35	.46

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

D.—NEW HAMPSHIRE:

(1) SITE *l:* Boscawen, Merrimack County. Sample area: 1 acre.

[300 feet above sea level.]

Soil: Dark-brown loamy sand, coarse grain, porous, loose, shallow, dry, well drained, with 1 inch mold on top and moderately leafy surface cover; subsoil, yellow sand.

Forest conditions: White Pine, with scattering Red Pine on somewhat uneven land, which slopes east to the Merrimack River and falls off west to bordering run; undergrowth of few Hemlock and small White Pine.[1]

Age of pine: 40 years.
Density of crown cover: (?)
Number of trees: 1,077.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
150	Under 3	20	....	
619	3 to 6	40	....	
195	6 to 8	50	1,365	
65	8 to 10	50	715	
30	10	50	390	
7	11	50	112	
4	12	50	76	
5	13	50	110	
1	14	50	25	
1	16	50	39	
1,077 trees: Total cubic feet			2,832	

Average annual accretion: White Pine, 71 cubic feet.

(2) SITE *m:* Franklin, Merrimack County. Sample area: 1 acre.

[900 to 1,000 feet above sea level.]

Soil: Brown sandy loam, medium grain, compact, moist, well drained, with 1 to 3 inches mold on top and moderately leafy surface cover; subsoil, rock.

Forest conditions: White Pine intermixed with Maple and Birch, on a hill; undergrowth, moderately dense, of young Maple, Birch, and other scattering hardwoods.[2]

Age of pine: 40 to 45 years.
Density of crown cover: 0.9.
Number of trees: 410.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume.	
			Bole.	Merchantable timber.
	Inches.	*Feet*	*Cubic feet.*	*Feet B. M.*
298	8	60	2,980	
7	9	60	91	
47	10	70	893	
38	11	70	836	
9	12	70	234	
7	13	70	217	
2	14	70	70	
1	15	70	40	
1	16	70	45	
410 trees: Total cubic feet			5,406	

Average annual accretion: White Pine, 120 cubic feet.

---

[1] *Intermixed species:* Red Pine, 1 over 10 inches diameter and under 40 feet high; 2 from 8 to 10 inches diameter and under 40 feet high; 4 from 6 to 8 inches diameter and over 40 feet high; 4 from 6 to 8 inches diameter and under 40 feet high; 5 from 3 to 6 inches diameter and over 40 feet high; 13 from 3 to 6 inches diameter and under 40 feet high. Red Pine, 1 over 8 inches diameter and over 40 feet high; 1 over 3 inches diameter and over 40 feet high; 1 over 3 inches diameter and under 40 feet high.

Undergrowth: Hemlock, 26; Gray Birch, 1.

[2] *Intermixed species:* Red Maple, 11 from 6 to 10 inches diameter and over 60 feet high; 6 from 6 to 10 inches diameter and under 60 feet high; 30 from 3 to 6 inches diameter and over 40 feet high; 3 from 3 to 6 inches diameter and under 40 feet high. White Birch, 7 from 10 to 14 inches diameter and under 80 feet high; 26 from 6 to 10 inches diameter and over 60 feet high; 29 from 3 to 6 inches diameter and over 40 feet high. Red Oak, 2 from 3 to 6 inches diameter and over 40 feet high. *Prunus serotina*, 1 over 6 inches diameter and under 60 feet high. Poplar, 2 from 6 to 10 inches diameter and over 60 feet high. Hemlock, 2 from 3 to 6 inches diameter and under 40 feet high. Chestnut, 1 over 6 inches diameter and over 60 feet high. Young White Pine, 119.

Undergrowth: Red Maple, 23; Cherry, 3; Hamamelis, 14; White Birch, 2; Hemlock, 4; Ash, 1; Poplar, 1.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

D.—NEW HAMPSHIRE—Continued.

(3) SITE *n:* Hopkinton, Merrimack County. Sample area: 1 acre.

[800 to 900 feet above sea level.]

Soil: Brown, gray, or nearly black sandy loam, fine grain, moist, well drained, with mold on top and moderately leafy surface cover; subsoil, rock.
Forest conditions: White Pine, with occasional Red Pine, on a hill; undergrowth, moderately dense, of Hemlock and scattering hardwoods; on occasions dead and little suppressed trees cut out and trimming done.[1]

Age of pine: 60 to 65 years.
Density of crown cover: 0.8 to 0.9.

Number of trees: 291.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
54	8	60	540	
43	10	70	817	
48	11	70	1,056	
36	12	70	936	
37	13	70	1,147	
27	14	70	945	
14	15	70	560	
14	16	70	630	
8	17	80	464	
3	18	80	192	
3	19	80	210	
1	20	80	77	
2	22	80	192	
1	23	80	104	
291 trees: Total cubic feet			7,870	

Average annual accretion: White Pine, 127 cubic feet.

(4) SITE *o:* Hopkinton, Merrimack County. Sample area: 1 acre.

[800 to 900 feet above sea level.]

Soil: Brown loam, fine grain, moderately loose, fresh, well drained, with 3 to 4 inches mold on top and leafy surface cover; subsoil, rocks not very far down.
Forest conditions: White Pine with occasional Red Pine on a north slope of hill; undergrowth, moderately dense, of Elm, Maple, Hemlock, and occasional hardwoods.[2]

Age of pine: 35 to 40 years.
Density of crown cover: 0.8.

Number of trees: 435.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
63	3 to 6	40	....	
189	6 to 10	50	1,701	
56	10	60	876	
52	11	60	988	
26	12	60	598	
27	13	60	702	
8	14	60	240	
11	15	65	418	
3	16	65	126	
435 trees: Total cubic feet			5,649	

Average annual accretion: White Pine, 148 cubic feet.

[1] *Intermixed species:* Red Pine, 6 from 10 to 14 inches diameter and under 80 feet high; Maple, 1 over 10 inches diameter and under 80 feet high.
Undergrowth: Hemlock, 98; Beech, 4.

[2] *Intermixed species:* Red Pine, 3 from 10 to 14 inches diameter and under 80 feet high. Maple, 2 from 3 to 6 inches diameter and over 40 feet high. White Birch, 1 over 3 inches diameter and over 40 feet high. Apple, 2 from 10 to 14 inches diameter and under 80 feet high. Hemlock, 3 from 3 to 6 inches diameter and under 40 feet high.
Undergrowth: Elm, 64; *Cornus alternifolia*, 1; Beech, 1; Hemlock, 36; Cherry, 2; Ash, 1; Hamamelis, 1; Maple, 62; numerous small Maples; small Oaks.

Table VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

D.—NEW HAMPSHIRE—Continued.

(5) Site *p*: Litchfield, Hillsboro County. Sample area: 1 acre.

[About 250 feet above sea level.]

Soil: Dark-brown sandy loam, fine grain, porous, light, loose, shallow, dry, well drained, with about 2 inches mold on top and moderately leafy surface cover; subsoil, yellowish fine sand with clay about 4 to 6 feet below surface.

Forest conditions: White Pine with scattering Pitch Pine on level plain; undergrowth scanty, of Maple, Birch, and few other hardwoods.[1]

Age of pine: 35 to 40 years.
Density of crown cover: 0.7 to 0.8.
Number of trees: 517.

ACRE YIELD.

White Pine.

Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
5	Under 3	20	....	
182	3 to 6	40	....	
233	6 to 10	50	2,097	
30	10	60	480	
19	11	60	361	
13	12	60	199	
10	13	60	260	
12	14	65	396	
6	15	65	222	
2	16	65	84	
2	17	70	102	
1	18	70	56	
1	19	70	61	
1	22	70	78	
517 trees: Total cubic feet			4,396	

Average annual accretion: White Pine, 15 cubic feet.

(6) Site *q*: Hillsboro County. Sample area: 1 acre.

[About 700 feet above sea level.]

Soil: Brown loam, fine grain, deep, moist, well drained, with 2 to 4 inches mold on top and abundant leafy surface cover; subsoil, compact, clayey sand.

Forest conditions: White Pine with scattering Maple and Hemlock on hill; undergrowth dense, of Maple, Oak, Chestnut mainly, and few other scattering hardwoods.[2]

Age of pine: 40 to 45 years.
Density of crown cover: In clusters.
Number of trees: 371.

ACRE YIELD.

White Pine.

Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B.M.*
76	3 to 6	40	....	
153	6 to 10	50	1,377	
36	10	60	576	
40	11	60	760	
31	12	60	713	
17	13	60	442	
8	14	60	240	
6	15	65	222	
3	16	65	126	
1	17	65	47	
371 trees: Total cubic feet			4,503	

Average annual accretion: White Pine, 107 cubic feet.

[1] *Intermixed species:* Gray Birch, 1 over 3 inches diameter and over 40 feet high, 1 over 3 inches diameter and under 40 feet high. Maple, 1 over 6 inches diameter and under 60 feet high; 1 over 3 inches diameter and over 40 feet high; 2 over 3 inches diameter and under 40 feet high. Pitch Pine, 1 over 10 inches diameter and over 80 feet high, 9 from 10 to 14 inches diameter and under 80 feet high.
Undergrowth: Maple, 9; Gray Birch, 8; Cherry, 1; Oak, 4; Spruce, 1; numerous small Oaks and Poplars.

[2] *Intermixed species:* Hemlock, 12 from 6 to 10 inches diameter and under 60 feet high; 8 from 3 to 6 inches diameter and under 40 feet high. Maple, 1 over 10 inches diameter and under 80 feet high; 2 from 6 to 10 inches diameter and over 60 feet high; 21 from 6 to 10 inches diameter and under 60 feet high; 26 from 3 to 6 inches diameter and over 40 feet high; 11 from 3 to 6 inches diameter and under 40 feet high. White Oak, 5 from 3 to 6 inches diameter and over 40 feet high; 3 from 3 to 6 inches diameter and under 40 feet high. Cherry, 1 over 10 inches diameter and under 80 feet high; 1 over 6 inches diameter and under 60 feet high; 2 from 3 to 6 inches diameter and over 40 feet high.
Undergrowth: Chestnut, 202; Cherry, 8; Maple, 492; Black Birch, 3; Ash, 21; White Oak, 229; Hemlock, 20; Elm, 9; Thorn, 1.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

D.—NEW HAMPSHIRE—Continued.

(7) SITE *r*: Milford, Hillsboro County. [300 to 400 feet above sea level.] Sample area: 2 acres.

Acre No. 1.

Soil: Dark-brown sandy loam, fine grain, shallow, dry, well drained, with 1 to 2 inches mold on top and surface cover of abundant leaves; subsoil, light colored and powdery, 6 to 10 inches deep, probably sandy lower down.

Forest conditions: White Pine on slope; undergrowth, dense, of Oak mixed with Maple, Chestnut, and other scattering hardwoods.[1]

Age of pine: 35 to 40 years.
Density of crown cover: Full.
Number of trees: 794.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
339	3 to 6	40	....	
323	6 to 8	50	2,261	
108	8 to 10	50	1,188	
11	10	50	143	
9	11	50	144	
2	12	50	38	
2	13	50	44	
794 trees: Total cubic feet 3,818				

Average annual accretion: White Pine, 109 cubic feet.

Acre No. 2.

Soil: Brown sandy loam, medium grain, loose, fresh, 1 foot deep, with 2 inches mold on top and a moderately leafy surface cover.

Forest conditions: White Pine with scattering Maple on north slope of hill; undergrowth, in parts moderately dense, of Ash, Maple, and few other hardwoods, and in denser parts very little undergrowth.[2]

Age of pine: 35 to 40 years.
Density of crown cover: 0.6 to 0.7.
Number of trees: 503.

ACRE YIELD.

White Pine.				
Number of trees.	Diameter (breast high).	Height.	Volume. Bole.	Volume. Merchantable timber.
	Inches.	*Feet.*	*Cubic feet.*	*Feet B. M.*
151	3 to 6	40	....	
236	6 to 10	50	2,124	
44	10	55	660	
21	11	55	378	
17	12	55	357	
10	13	55	240	
11	14	60	330	
5	15	60	175	
3	16	60	117	
2	17	60	86	
1	19	60	57	
1	20	70	72	
1	21	70	78	
503 trees: Total cubic feet 4,674				

Average annual accretion: White Pine, 123 cubic feet.

[1] *Intermixed species:* Oak, 1 over 10 inches diameter and over 50 feet high; 1 over 8 inches diameter and under 50 feet high; 3 from 3 to 6 inches diameter and over 40 feet high.
Undergrowth: Oak, 381; Maple, 64; Chestnut, 41; Gray Birch, 4; Yellow Birch, 1; Hemlock, 1; Cherry, 14, with numerous small trees.

[2] *Intermixed species:* Maple, 1 over 10 inches diameter and under 80 feet high; 5 from 6 to 10 inches diameter and under 60 feet high; 4 from 3 to 6 inches diameter and over 40 feet high; 2 from 3 to 6 inches diameter and under 40 feet high. Cherry, 1 over 6 inches diameter and under 60 feet high; 2 from 3 to 6 inches diameter and under 40 feet high. Apple, 1 over 6 inches diameter and under 60 feet high; 1 over 3 inches diameter and under 40 feet high. Pitch Pine, 2 from 6 to 10 inches diameter and under 60 feet high. White Birch, 1 over 6 inches diameter and over 60 feet high.
Undergrowth: Ash, 45; Maple, 8; Cherry, 3; Oak, 5; Hamamelis, 10; Chestnut, 1; Elm, 2.

TABLE VII.—*Acre yields of second-growth White Pine, with measurements of young pine taken for analysis*—Continued.

D.—NEW HAMPSHIRE—Continued.

MEASUREMENTS OF SAMPLE YOUNG PINE TREES.

Age class: Under 50 years.

Tree number.	Age.	Diameter (breast high).	Height.	Rings per inch on stump.	Volume of tree.	Factor of shape.	Ratio of length of crown to total height of tree.	Current annual accretion.		Average annual accretion.
	Years.	*Inches.*	*Feet.*	*No.*	*Cubic ft.*			*Per cent.*	*Cubic ft.*	*Cubic ft.*
SITE *l.*										
28	41	6.8	44	....	5.6	0.51	0.43	....	....	0.30
29	41	7.1	52	....	8.0	.56	.51	....	....	.20
30	41	8.2	55	....	10.0	.51	.51	....	....	.24
Average	41	7.4	50	....	7.9	.53	.48	....	....	.25
SITE *m.*										
31	42	9.7	63	....	16	0.50	0.38	....	....	0.38
32	42	10.4	70	....	21.3	.51	.34	....	....	.51
33	42	8.7	65	....	13.1	.49	.34	....	....	.31
Average	42	9.6	66	....	16.8	.50	.35	....	....	.40
SITE *o.*										
35	38	9.3	57.5	....	13.8	0.51	0.39	....	....	0.36
36	39	10.3	62.5	....	18.0	.50	.40	....	....	.46
Average	38.5	9.8	60	....	15.9	.50	.39	....	....	.41
SITE *r.*										
1	81	17	73	4	48.2	0.42	0.53	4.6	2.22	0.59
2	77	17	74	4	52.4	.44	.55	3.0	1.57	.68
Average	79	17	73.5	4	50.3	.43	.54	3.8	1.89	.63

SCHEDULES AND SAMPLE RECORDS.

SCHEDULES AND SAMPLE RECORDS.

FORMS USED IN THE INVESTIGATION.

FORM NO. 1.

United States Department of Agriculture.
DIVISION OF FORESTRY.

RECORDS OF TREE MEASUREMENTS.

Name of collector: N.
Species: White Pine.
Year: 1897.

GENERAL DESCRIPTION OF STATION.

[Denoted by capital letter.]

State: Pennsylvania. County: Clearfield. Town: Dubois.
Longitude: 78° 45′. Latitude: 41° 3′. Altitude: 1,200 to 1,500 feet.
General configuration: Plains hills plateau *mountainous.*
General trend of valleys or hills: (Not noted.)
Climatic features: (Meteorological tables furnished.)

General forest conditions of the region: This region in 1876 extended over 20,000 acres. The lumber operation carried on for twenty years by Mr. Du Bois left for the present only from 1,500 to 2,000 acres standing timber in a primeval condition.

Three typical forms of forest conditions are suggested to the observer:

(1) Hemlock and White Pine forest, with an admixture of mature hardwoods and a number of young hardwoods and young Hemlock, which form the undergrowth.

(2) Hemlock mixed with White Pine, with scattering hardwoods; the undergrowth usually moderately dense, consists mainly of young Hemlock with the admixture of young hardwoods.

(3) Hardwoods intermixed with White Pine and scattering Hemlock. The undergrowth here consists mainly of young hardwoods.

Among the hardwoods, the Oak, Birch, and Maple form the staple of the hardwood forest, while the Beech, Chestnut, Hickory, Cucumber, Ash, Cherry, and Basswood are comparatively few in number. The region has a uniform soil and subsoil as it may be judged by the sample areas NN. 5, 6, and 7, and is well provided with moisture by the many streams crossing it all over in different directions.

FORM NO. 2.

DESCRIPTION OF SITE.

[Denoted by small letter.]

Sample area, No. 5: (One acre.)

Conformation of surface: Hill sloping toward southwest, where it is bordered by the left-hand branch of Irish Narrow Creek.

Soil and drainage conditions: Yellow clay loam of a medium grain (fine shale in it), deep, fresh, well drained, with 2 to 3 inches mold on top.

Subsoil: Laminated shale of an indefinite depth.

Soil cover: Scanty leaves, fern, and teaberries.

Origin of stand: Natural regeneration.

Form: Uniform; storied. White Pine forms first and Hemlock the second.

Composition: A stand of Hemlock mixed with White Pine, intermixed with scattering Maple, Beech, and Birch.

Undergrowth: Absent; dense; moderately dense; scanty; consists of very young Beech, Hemlock, and occasional Birch, Cucumber, and Dogwood (Laurel in northeast corner).

Density of stand: 0.7 (in places 0.8).

REMARKS.—Crowns of White Pine generally well developed; clear and straight stems. Age of White Pine 230 to 260 years. Age of Hemlock almost the same as that of White Pine.

ACRE-YIELD MEASUREMENTS.

Diameter at breast height (in inches).	Name of species.															Undergrowth.		
	White Pine.			Hemlock.			Maple.			Beech.			Birch.				Diameter (breast high).	
	Dominant height from 140 to 160 feet.	Codominant height from 100 to 140.	Oppressed height from 80 to 100.	Dominant height from 90 to 120.	Codominant height from 80 to 120.	Oppressed height from 60 to 80.	Dominant height from 80 to 100.	Codominant height from 60 to 80.	Oppressed height from 40 to 60.	Dominant height from 80 to 100.	Codominant height from 60 to 80.	Oppressed height from 40 to 60.	Dominant height from 80 to 100.	Codominant height from 60 to 80.	Oppressed height from 40 to 60.	Name of species.	3–6 inches.	Under 3 inches.
6																		29
7						~~////~~ ~~////~~	/											36
8													/					43
9						///										Hemlock.		37
10						//												34
11													/					11
12						////							/					47
13										//								38
14						///												31
15						///	/									Maple.		42
16			/				/											38
17					/	~~////~~												
18				/	~~////~~													
19			/	////	//					/								
20					///	/												
21				/	//													
22				///	~~////~~											Beech.		
23		/	/	///														10
24																		
25		~~////~~																
26		/																4
27				////												Birch.		
28		/																
29		/		/														
30		/		/														
31	/																	
32	/																	
33	//																	
34	//																	
35																Cucumber.		
36	/																	
37																		
38																		
39																		
40																		
41																		
42																		
43																		
44																		
45																		

DEDUCED RESULTS.

Total number of trees on the acre: 132, of which there were—
First species: White Pine, 37; dominant, 41 per cent; codominant, 48 per cent; oppressed, 11 per cent.
Second: Hemlock, 84; dominant, 32 per cent; codominant, 26 per cent; oppressed, 42 per cent.
Third: Maple, 5.
Fourth: Beech, 3.
Fifth: Birch, 3.
Total yield of the acre: Volume of stems, 15,686 cubic feet; merchantable timber, 90,103 feet B. M.
Of which there were—
First species: White Pine, 58 per cent of total yield.
Second species: Hemlock, 42 per cent of total yield.
Third, fourth, and fifth species: Hemlock not taken into consideration.
Average annual accretion: In cubic feet, 65; merchantable timber, in feet B. M., 375.

FORM NO. 3.

MEASUREMENTS OF SAMPLE TREES.

SITE: *f*. SPECIES: White Pine.

Tree No.	Diameter (in inches) at a height (in feet) from ground of—																	Height to base of crown.	Total height of tree.	Character of growth.			Merchantable timber (feet B. M.).	Condition of timber.						Position and surrounding species.	Remarks.
	Breast height.	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128			Dominant.	Codominant.	Oppressed.		Sound.	Defective.	Crooked.	Clear.	Knotty.	Windshaken.		
1	35½	34	29	28	28	27	26½	26	25	24	23	22	20	19	16½	13	11	90	158	×	...	...	3,030	×	...	...	...	...	...	White Pine, Hemlock, and small Beech.	
2	36	33	31	30	29	28	28	27	26	26	25	23	21½	19½	18	15	13	90	157	×	...	...	3,401	×	...	...	...	...	...	Hemlock, Pine, Birch, Maple, and Ash.	
3	32	30	28	28	27	25½	25	24½	24½	23½	23½	21½	19½	18	15½	12½	....	84	152	×	...	...	2,637	....	...	...	...	...	...	Hemlock and Pine.	
4	32	30	27½	26	26	25	24	23½	22½	21½	20½	18½	17½	15	12½	10½	8	62	150		...	...	2,079	....	...	...	...	...	...	do	
5	29	27½	26	25	25	24	23	22	21½	21	18½	17	15½	14	11½	8	6	100	140	...		...	1,905		...	...	...	...	...	do	Crowded.
6	29	26½	25½	24½	23½	23	22½	21½	20	20	19	17½	16	15	13	9	7	110	140	...		...	1,631		...	...	...	...	...	do	Do.
7	29	27½	25½	24½	23½	23	21½	21	21	19½	19	18	16½	15½	14	12½	9½	112	152	...		...	1,854		...	...	...	...	...	do	Do.
8	29	26	23½	22½	22	21	20	19	18½	18½	17	16½	14½	13	11	8	6	86	142	...		...	1,313	Core at butt.	...	...	...	...	...	do	Do.
9	32	28½	25½	24½	23½	23	22	21	21	18½	18	16½	15	14	11	8	7	84	142	...	×	...	1,648	do	...	...	...	...	...	do	Do.
10	33	30½	29	27½	26½	25½	25	21	23	21½	21	19	18	15½	13½	12½	8	96	146	×	...	...	2,384	×	...	...	...	...	...	do	Crown free.
11	30	28½	27	25	24½	24	23	22½	20½	19½	18½	17½	16½	13½	11½	9	6	81	141	...	×	...	1,947	....	...	...	...	...	...	do	Somewhat crowded.
12	28	27	24½	24	23	23	22	21	20½	19½	19	17	16	13½	12	9½	8	88	156	×	...	...	1,648	....	...	...	...	...	...	do	
13	23	20½	20½	20½	20½	19½	19	18½	17	16½	15	15	14	12½	11½	9½	7½	93	141	...	×	...	1,048	....	...	...	...	...	...	do	Crowded.
14	25	23½	22½	22	21	20½	19½	18½	18	17½	16	14½	13	11½	9	6½	....	98	139	...		...	1,233	Core at butt.	...	...	...	...	...	do	Do.
15	26	24½	23½	22½	21½	21	21	20½	20½	18½	17½	17	16	14	12½	10	7	98	136	...	×	...	1,389	do	...	...	...	...	...	do	Top killed; somewhat crowded.
16	24½	21½	19½	19	18½	17½	17	16½	16	14½	14	12	10½	8	4½	....	....	93	124	...	×	...	815	do	...	...	...	...	...	do	Crowded.
17	25	23½	22	21	20	20	19	19	18	17½	16½	15	14	12½	8½	....	....	108	128	...	×	...	1,183	do	...	...	...	...	...	do	Do.
18	39	36	33	32½	30	29½	28½	28	26	26	23	22½	21½	18½	18	14½	11½	88	153	×	...	...	3,318	....	...	...	...	...	...	do	At 134 feet top lost; free crown about 16 feet.
19	34	32	30	29	28	27½	26½	25	24½	23	22	19½	18	16½	13½	10½	8	78	134	×	...	...	2,397	....	...	...	...	...	...	do	
20	44	39	38	36½	35½	34	32½	31½	30½	28	27	26	23	21½	20	14½	10½	100	141	×	...	...	4,388	×	...	...	...	...	...	do	Crown free.
21	34	31½	28	27	26½	25½	24½	23½	22½	21½	21	19½	18	16½	14½	11½	8	92	146	×	...	...	2,248	×	...	...	...	...	...	do	Crown free; sound.
22	31	29	27	27	25	24	23	23	21	19½	19½	17	14½	12	9½	....	....	82	130	...		...	1,731		...	...	...	...	...	do	Crown somewhat crowded.
23	34	31½	29	28	27	25½	25	24	23½	22	20½	20½	18	16½	13½	9½	6	90	142	×	...	...	2,318	×	...	...	...	...	...	do	Crown free.
24	25	23½	22	21	20	19	18½	17½	16½	15	14	13	12	10	7	....	....	84	130	...	×	...	1,102	×	...	...	...	...	...	do	Somewhat crowded.
25	28½	26½	25½	21½	21½	21	22½	21½	21	20½	19	18	16	15½	13	11	5	107	138	...	×	...	1,954	×	...	...	...	...	...	do	Do.
26	26	24	21½	21	20½	19	18	17	16½	16	15	14	12½	11½	9	6	....	98	136	...	×	...	1,021	....	...	...	...	...	...	do	
27	19	18	17½	17½	16½	16	15½	15	14	14	13	12	11½	9½	8½	6½	....	94	132	...	...	×	683	×	...	...	...	...	...	do	Crown very crowded.
28	28½	26	24	23	22½	22	21½	21	20	19	18	17	15	13½	10½	7	....	75	138	...	×	1	1,551	×	...	...	...	...	...	do	
30	26½	24½	23	22½	21	20½	20	19½	19½	18	16½	15	13	11	9	6	....	90	134	...		...	1,336	Core at butt.	...	...	...	...	...	do	Somewhat crowded.
33	33	30	27½	25½	25½	24½	23	22	21	20	18	16	13½	12½	9	5½	....	91	133	×	...	...	1,770	×	...	...	...	...	...	do	Free exposure.
34	33	30	27½	27	26	25	25	24½	23½	22½	21	20	19	15½	15½	12	9	90	146	×	...	...	2,220	×	...	...	...	...	...	do	Do.
35	31	27	24½	23½	23	22½	21½	20½	20	19½	19	16½	14½	13	11	8	5½	82	136	×	...	...	1,458	×	...	...	...	...	...	do	Top about 8 feet not found.
36	31½	28½	26½	26	25	24	24	23½	21½	21	19	16½	15	12	10	7½	....	88	134	×	...	...	1,855	×	...	...	...	...	...	do	Do.
37	37	35	32½	32	31	30	28½	28	26½	26	23½	22½	21½	17	14	11½	8	106	146	×	...	...	2,970	×	...	...	...	...	...	do	Do.
38	23	22	21½	20	19½	19	18	17½	17	16	15	14	12½	11	9	5	....	96	137	...	•	×	987	×	...	...	...	...	...	do	Crown very crowded.
39	20½	18	18	17½	17	16	15	14½	13½	12½	12	11½	10½	9½	5	....	....	109	123	...	...	×	558	....	...	...	...	...	...	do	Do.
40	16½	16	15½	15	14	13½	13	12½	12	11	10	8½	7½	4½	....	....	....	82	120	...	...	×	339	....	...	...	...	...	...	do	Crown very small.

FORM NO. 4.

MEASUREMENTS OF DIAMETER DEVELOPMENT.

SECTION: Stump.

SITE *f*. AGE CLASS: ——. SPECIES: White Pine.

Tree No.	Height from ground.	Thickness of bark.	Sapwood.		Number of rings.	Radius at age of—																														Entire radius.	Remarks.
			Number of rings.	Width.		10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300		
		mm		mm																																	
1	2	48	36	38	254	38	80	105	125	139	157	179	198	218	244	273	292	306	320	329	336	341	348	359	367	376	385	395	406	410	....	....	Dominant.	....	....	415	
2	2	25	33	37	254	24	54	71	85	96	109	139	163	180	213	235	259	281	308	325	336	346	364	386	397	408	418	429	444	452	....	....		....	....	454	
3	2	55	33	35	253	34	72	98	119	135	156	177	192	209	228	250	267	283	300	312	319	326	335	343	351	363	375	388	389	400	....	....		....	....	405	
4	2	55	20	25	235	25	59	107	133	178	200	221	256	276	304	313	330	346	357	369	377	388	398	407	417	426	435	442	....	....	....	....		....	....	447	
10	2	40	47	30	238	38	78	116	115	180	205	244	248	257	276	295	309	322	333	350	362	370	389	398	408	415	422	430	....	....	....	....		....	....	434	
12	2	30	45	28	256	32	61	80	99	121	138	158	178	186	200	214	229	240	253	268	275	284	294	303	310	319	329	334	339	345	....	....		....	....	350	
18	2	50	28	38	259	24	46	74	102	121	142	175	201	223	246	268	295	321	349	375	391	409	426	441	457	464	481	498	513	528	....	....		....	....	541	
19	2	50	35	50	244	27	53	75	103	129	154	182	199	212	232	250	263	282	303	311	322	336	349	364	392	417	432	453	472	....	....	....		....	....	477	
20	2	50	30	18	260	37	89	133	165	200	251	292	345	372	392	409	426	444	461	477	488	500	509	516	525	537	547	544	561	567	571	....		....	....	....	
21	2	40	37	30	239	25	58	82	102	121	139	158	175	186	203	225	245	270	294	315	334	347	359	369	378	385	395	406	....	....	....	....		....	....	416	
23	2	49	24	22	242	19	53	77	99	120	144	167	190	210	244	257	274	288	302	311	324	342	353	359	366	374	383	413	420	....	....	....		....	....	421	
36	2	25	35	45	235	26	56	77	92	109	120	130	138	150	180	200	222	246	265	278	292	305	318	331	350	378	388	406	....	....	....	....		....	....	415	
34	2	40	46	35	256	23	60	97	133	160	187	222	261	275	290	302	316	328	336	348	357	367	376	382	390	398	408	415	423	429	....	....		....	....	432	
33	2	48	33	25	253	27	57	85	116	141	168	191	220	229	241	251	265	282	293	307	319	330	342	349	358	369	378	385	390	395	....	....		....	....	397	
35	2	50	41	28	257	34	74	110	138	161	182	209	222	229	237	246	255	265	276	289	293	304	318	329	338	345	352	358	365	373	....	....		....	....	378	
37	2	30	46	27	255	28	76	106	152	178	203	234	267	283	303	323	341	356	370	386	398	411	422	432	439	445	452	458	466	473	....	....		....	....	476	
28	2	39	48	28	256	36	72	104	135	160	178	195	207	211	218	225	237	251	262	270	274	279	285	289	293	298	306	312	320	325	....	....	Codominant.	....	....	328	
25	2	40	38	35	238	15	41	58	71	89	104	114	133	153	173	198	220	237	249	261	276	289	303	319	335	350	365	375	....	....	....	....		....	....	381	
24	2	37	25	25	239	15	45	73	94	110	123	131	136	140	146	155	165	173	181	189	197	208	218	237	255	277	298	314	....	....	....	....		....	....	320	
22	2	40	43	30	240	32	71	111	137	156	195	218	241	254	263	275	293	306	316	324	332	343	356	365	375	385	390	407	412	....	....	....		....	....	....	
5	2	45	35	25	258	26	53	70	86	104	120	140	156	168	178	191	204	219	238	251	263	277	294	309	324	337	347	356	363	373	....	....		....	....	382	
6	2	40	28	25	258	23	71	102	122	146	166	183	202	218	227	239	253	264	276	286	293	299	306	318	327	338	349	358	365	372	....	....		....	....	377	
7	2	30	35	24	256	25	53	92	114	128	141	155	167	177	189	204	225	236	244	255	263	269	278	287	295	302	312	319	323	334	....	....		....	....	337	
8	2	....	....	....	229							Core for 3 inches.																									
9	2	....	....	....	230							Core for 3 inches.																									
11	2	32	29	37	238	31	55	69	87	105	121	132	147	166	183	199	221	247	258	270	284	300	314	327	342	357	371	384	....	....	....	....		....	....	396	
13	2	42	32	20	252	20	61	93	114	131	144	158	172	185	199	214	226	236	246	255	264	272	282	290	295	300	309	316	321	326	....	....		....	....	327	
14	2	....	....	....	236							Core for 4½ inches.																									
15	2	....	....	....	258							Core for 5 inches.																									
16	2	....	....	....	229							Core for 3 inches.																									
17	2	....	....	....	256							Core for 6 inches.																									
26	2	27	29	40	239	25	60	81	91	112	121	125	132	145	150	164	176	184	193	200	211	222	234	247	266	281	295	310	....	....	....	....		....	....	321	
30	2	27	40	42	253	28	58	80	102	121	143	162	175	182	193	205	217	229	240	252	262	272	281	289	297	303	309	312	320	326	....	....		....	....	329	
27	2	20	45	24	253	30	66	89	106	125	141	158	173	178	183	187	193	203	209	217	224	231	236	239	242	246	252	259	264	270	....	....	Oppressed.	....	....	271½	
38	2	38	47	29	254	35	73	97	119	137	152	165	176	185	192	201	210	221	231	237	244	250	256	261	264	269	273	277	281	284	....	....		....	....	285	
39	2	32	54	24	252	37	81	102	122	127	148	156	163	167	170	176	183	191	196	200	203	205	208	214	220	226	230	235	238	241	....	....		....	....	241½	
40	2	22	35	16	255	29	64	81	101	117	131	141	151	155	158	162	170	177	183	186	191	195	200	205	208	211	215	221	225	229	....	....		....	....	232	

FORM NO. 4—Continued.

SECTION NO. 3.

SITE *f*. AGE CLASS: ——. SPECIES: White Pine.

Tree No.	Height from ground.	Thickness of bark.	Sap-wood. Number of rings.	Sap-wood. Width.	Number of rings.	Radius at age of— 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	Entire radius.	Remarks.
		mm		*mm*																																	
1	50	15	49	32	221	50	76	98	115	130	143	156	180	193	205	214	224	230	235	242	249	256	262	269	275	282	287				Dominant.					288	
2	50	17	45	35	214	35	64	81	102	118	135	153	169	195	201	219	231	242	253	265	277	288	297	307	317	324	....									327	
3	50	17	47	42	227	33	72	97	112	127	138	150	164	176	185	196	204	210	217	226	234	243	253	263	272	280	288									293	
4	50	11	50	30	208	40	74	107	129	148	162	175	188	200	210	219	228	237	245	253	258	266	272	278	282	....	....									286	
10	50	14	50	30	210	42	80	110	130	144	158	172	185	196	205	217	225	234	245	253	259	265	272	278	283	293	....									....	
12	50	12	55	32	228	26	76	95	116	130	142	155	169	178	189	198	205	209	214	219	225	230	235	241	247	252	258									264	
18	50	19	41	40	223	35	64	86	106	125	139	157	176	195	213	228	243	257	263	275	288	292	306	318	328	337	346									349	
19	50	20	39	38	209	40	67	90	106	120	132	146	165	180	194	207	217	230	241	253	265	279	290	302	311	....	....									317	
20	50	20	50	30	219	68	123	161	193	212	231	246	262	278	288	297	306	313	320	327	334	340	347	355	362	368	....									371	
21	50	16	40	34	202	33	69	91	108	120	132	147	163	176	189	201	211	221	231	241	249	258	268	276	284	....	....									286	
23	50	15	40	40	204	20	61	91	109	122	134	148	163	177	190	200	212	223	233	242	250	259	270	280	295	....	....									300	
36	50	15	45	38	202	25	37	53	67	78	96	115	134	150	167	178	190	201	211	221	228	236	245	253	261	....	....									263	
31	50	15	41	30	223	45	82	110	135	153	164	177	190	200	210	216	225	234	242	248	256	265	276	283	290	298	304									307	
33	50	15	48	30	223	48	78	103	124	142	149	158	167	174	183	187	196	204	213	218	223	231	238	243	248	254	258									260	
35	50	15	47	20	226	47	84	114	135	148	155	161	168	176	183	190	198	204	210	217	222	228	233	239	242	247	251									254	
37	50	12	44	30	217	51	103	145	173	195	214	229	232	244	253	261	269	277	289	295	302	309	314	321	328	331	....									340	
28	50	12	63	29	228	44	81	109	127	142	153	160	167	175	184	195	204	208	214	220	225	230	235	240	243	248	253				Codominant.					257	
25	50	15	50	40	188	38	69	92	117	133	156	172	184	194	204	215	226	238	245	253	261	268	278	....	....	....	....									284	
24	50	12	26	25	193	13	18	25	33	53	75	89	101	111	118	126	137	147	160	173	188	202	214	220	....	....	....									221	
22	50	15	43	27	203	34	74	107	129	148	161	174	187	197	208	216	224	230	235	241	247	254	260	266	271	....	....									273	
17	50	15	50	30	226	27	64	88	104	117	128	137	146	155	164	169	173	175	178	182	186	192	198	205	212	217	223									226	
5	50	15	43	33	220	34	66	83	97	107	116	125	136	148	159	170	182	193	213	212	225	233	241	250	258	265	272									....	
6	50	17	45	30	222	40	72	93	108	119	128	137	148	159	170	180	190	200	207	215	221	229	236	243	250	255	261									262	
7	48	13	50	30	222	40	73	93	107	120	130	140	150	160	170	180	187	197	205	214	222	229	237	244	250	255	260									263	
8	50	16	45	35	188	22	16	52	75	87	102	116	129	140	151	161	172	180	189	198	207	214	221	....	....	....	....									226	
9	50	15	42	35	192	35	58	78	96	113	131	150	162	177	189	198	208	214	230	241	250	257	264	273	....	....	....									275	
11	50	20	44	44	200	37	62	78	89	102	113	127	141	156	166	176	187	200	214	226	239	249	259	262	270	....	....									....	
13	50	12	53	33	223	31	57	74	90	99	110	119	128	135	142	149	155	162	168	174	181	188	195	201	208	215	221									223	
14	50	12	34	35	201	30	50	60	69	76	84	93	102	112	123	130	137	145	156	167	176	186	196	205	216	....	....									220	
15	50	15	39	39	219	35	62	78	88	100	107	115	123	134	142	151	158	164	172	180	189	198	209	217	228	239	....									248	
16	50	15	45	37	185	27	55	72	85	100	112	122	132	140	148	153	161	169	179	186	195	204	211	....	....	....	....									216	
26	50	10	35	35	194	21	46	65	83	89	97	107	117	123	129	137	146	155	168	179	189	199	210	220	....	....	....									223	
30	48	10	51	30	220	38	71	98	114	125	134	141	150	161	171	179	187	192	198	203	210	215	220	225	233	239	244									....	
27	50	14	40	19	223	43	71	89	103	113	117	120	122	125	129	133	138	143	148	150	152	156	160	163	167	171	174				Oppressed.					175½	
38	50	10	53	19	223	16	69	98	111	121	129	136	145	153	160	166	172	178	183	188	192	196	201	204	207	210	212									213	
39	50	12	52	19	226	30	66	86	99	108	113	116	120	127	134	139	143	146	148	151	155	160	165	169	173	176	179									181	
40	50	10	52	19	222	30	55	70	79	84	89	94	99	105	109	113	116	120	123	126	130	135	137	140	145	149	153									155	

FORM NO. 5.

SITE: *f*. AGE CLASS: 240 to 260 years. SPECIES: White Pine.

Location.	Description of site.	Tree number.	Age.	Diameter (breast high).	Height.	Height to base of crown.	Rings per inch on stump.	Volume. Tree.	Volume. Merchantable timber.	Factor of shape.	Ratio of length of crown to total height of tree.	Lumber product under present practice; per cent used of total volume of stem.	Remarks.
			Yrs	In.	Ft.		No.	Cu. ft.	Feet. B. M.				
Dubois, Clearfield County, Pa; latitude, 41° 3′; longitude, 78° 45′; altitude, 1,200 to 1,400 feet.	Hemlock, mixed with White Pine, with scattering Maple, Beech, and Birch, on a hill sloping toward southwest, where it is bordered by the left-hand branch of Narrow Creek. The moderately dense undergrowth consists of very young Beech, Hemlock, and occasional Birch and Cucumber.	1	260	35½	158	90	7.6	435.4	3,030	0.40	0.43	58	Dominant.
		2	260	36	157	90	7.0	481.3	3,401	.43	.42	59	
		3	259	32	152	84	7.8	396.0	2,637	.46	.44	55	
		4	241	32	150	62	6.6	347.7	2,079	.41	.59	50	
		10	244	33	146	96	6.8	365.9	2,384	.42	.34	54	
		12	262	28	156	88	9.0	285.8	1,648	.43	.43	47	
		18	265	39	153	88	6.0	511.1	3,318	.40	.42	54	
		19	250	34	150	78	6.3	402.4	2,397	.42	.48	49	
		20	266	44	144	100	5.7	638.4	4,388	.42	.30	57	
		21	245	34	146	92	7.1	366.7	2,248	.40	.37	51	
		23	248	34	142	90	7.2	373.4	2,318	.42	.37	51	
		33	259	33	133	91	8.0	304.5	1,770	.40	.31	48	
		34	262	33	144	90	7.4	369.2	2,220	.42	.38	50	
		35	263	31	144	82	8.5	275.2	1,458	.36	.43	44	
		36	241	31½	134	88	7.1	307.7	1,853	.42	.34	50	
		37	261	37	146	106	6.7	482.9	2,970	.44	.27	50	
	Average	...	255	34	147	88	7.0	390.0	2,507	.41	.39	52	
	Soil: Yellow clay loam of a medium grain (fine shales in it), deep, fresh, well drained, with 2 to 3 inches mold on top, and with a surface cover of scanty leaves, fern, teaberries, and scattering Dogwood (Laurel in northeast corner and on north side). Subsoil: Laminated shale of an indefinite depth.	28	262	28½	138	75	9.8	264.3	1,551	.43	.45	49	Codominant.
		25	244	28½	138	107	7.7	298.1	1,954	.49	.22	54	
		24	245	25	130	84	9.3	192.1	1,102	.43	.35	48	
		22	246	31	130	82	7.3	310.3	1,731	.45	.37	46	
		5	264	29	140	100	8.4	300.4	1,905	.47	.28	52	
		6	264	29	140	110	8.5	291.4	1,631	.45	.21	47	
		7	262	29	152	112	9.5	302.8	1,854	.46	.26	51	
		8	235	29	142	86	....	248.6	1,318	0.38	0.39	44	
		9	236	32	142	84	....	287.7	1,648	.36	.41	48	
		11	244	30	141	81	7.5	305.3	1,947	.44	.42	53	
		13	258	23	141	93	9.6	206.0	1,048	.48	.37	42	
		14	242	25	139	98	....	217.1	1,233	.46	.30	47	
		15	262	26	136	98	....	257.2	1,389	.51	.28	45	
		16	235	24½	124	93	....	163.8	815	.40	.25	41	
		17	262	25	128	108	....	214.4	1,183	.49	.16	46	
		26	245	26	136	98	9.3	199.2	1,021	.40	.28	47	
		30	259	26½	134	90	9.2	228.6	1,336	.44	.32	48	
		29	264	28	141	84	9.2	276.5	1,577	.46	.40	47	
		31	262	25½	132	88	10.0	191.8	863	.41	.33	37	
		32	261	26	142	99	9.1	239.9	1,322	.46	.30	46	
	Average......	...	253	27	138	93	9.0	250.0	1,421	.44	.32	47	
		27	259	19	132	94	11.6	138.8	683	.53	.29	41	Oppressed.
		38	260	23	137	96	11.1	189.6	987	.48	.30	43	
		39	258	20½	123	109	13.0	130.9	558	.46	.11	35	
		40	261	16½	120	82	13.7	89.6	339	.50	.31	31	
	Average......	...	259	20	128	95	12.3	137.0	642	.49	.25	37	

FORM NO. 6.

SITE: *f*. LOCATION: Clearfield County, Pa. SPECIES: White Pine. DOMINANT GROWTH: Sixteen trees.

Age.	Diameter at height of 2½ feet (without bark).	Total height of tree.	Volume of stem (without bark).	Relative per cent of total volume.			Decade.	Periodical accretion.																					Average annual accretion.	Current periodic accretion.
				Heartwood.	Sapwood.	Bark.		Height.	Diameter and corresponding area.																			Volume.		
									Cross section 1, at height of 2½ feet.		Cross section 2, at height of 18 feet.		Cross section 3, at height of 34 feet.		Cross section 4, at height of 50 feet.		Cross section 5, at height of 66 feet.		Cross section 6, at height of 82 feet.		Cross section 7, at height of 99 feet.		Cross section 8, at height of 114 feet.		Cross section 9, at height of 129 feet.				
									Diameter.	Area.	Diameter.	Area.	Diameter.	Area.	Diameter.	Area.	Diameter.	Area.	Diameter.	Area.	Diameter.	Area.	Diameter.	Area.	Diameter.	Area.			
Yrs.	*In.*	*Feet*	*Cubic feet.*	*Per ct.*	*Per ct.*	*Per ct.*		*Ft.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*In.*	*Sq. feet.*	*Cubic feet.*	*Cubic feet.*	*Cu feet.*
10	1.2	8	(1)	...	...	...	First	8	2.3	0.03	3.4	0.06	3.1	0.05	3.2	0.05	2.7	0.04	2.4	0.03	1.7	0.01	1.4	0.01	1.1	0.01	(1)	(1)	(1)
20	3.4	23	0.8	...	...	...	Second	15	2.8	.11	2.9	.16	3.4	.18	2.9	.15	2.4	.10	2.2	.08	1.7	.05	1.5	.03	1.2	.02	(1)	0.01	(1)
30	6.1	38	3.6	...	...	...	Third	15	2.3	.16	2.0	.15	2.0	.16	2.1	.17	2.3	.16	1.7	.11	1.6	.08	1.3	.06	1.1	.03	2.8	.12	0.28
40	8.2	51	9.0	...	...	...	Fourth	13	2.1	.19	1.6	.16	1.7	.18	1.6	.15	1.6	.14	1.5	.11	1.3	.08	1.2	.06	1.1	.05	5.4	.22	.54
50	10.2	64	17.0	...	...	...	Fifth	13	1.9	.22	1.6	.19	1.4	.16	1.2	.14	1.2	.13	1.3	.12	1.4	.10	1.1	.07	1.1	.06	8.0	.34	.80
60	12.2	73½	27.0	...	...	...	Sixth	9½	1.9	.25	1.2	.16	1.3	.16	1.1	.14	1.2	.14	1.2	.13	1.2	.11	1.0	.08	.9	.06	10.0	.45	1.00
70	14.2	82	40.0	...	...	...	Seventh	8½	2.1	.33	1.2	.17	1.0	.15	1.1	.15	1.2	.15	1.1	.13	1.0	.10	1.1	.09	.9	.07	13.0	.57	1.30
80	16.1	90	52.0	...	...	...	Eighth	8	1.8	.32	1.0	.16	1.1	.17	1.2	.18	1.1	.16	1.1	.14	1.1	.13	.9	.09	.9	.08	12.0	.65	1.20

INDEX.

BULLETIN No. 13.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF FORESTRY.

THE

TIMBER PINES OF THE SOUTHERN UNITED STATES.

By CHARLES MOHR, Ph. D.

TOGETHER WITH

A DISCUSSION OF THE STRUCTURE OF THEIR WOOD.

By FILIBERT ROTH.

PREPARED UNDER THE DIRECTION OF B. E. FERNOW, CHIEF OF THE DIVISION OF FORESTRY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1896.

BULLETIN No. 22.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF FORESTRY.

THE WHITE PINE.

(PINUS STROBUS Linnæus.)

BY

V. M. SPALDING,
Professor of Botany in the University of Michigan.

REVISED AND ENLARGED BY

B. E. FERNOW,
Chief of the Division of Forestry.

WITH CONTRIBUTIONS:

INSECT ENEMIES OF THE WHITE PINE . . By F. H. CHITTENDEN, Division of Entomology.
THE WOOD OF THE WHITE PINE . . . . . . By FILIBERT ROTH, Division of Forestry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.