

Second-Growth White Pine In Wisconsin

Its Growth, Yield, and Commercial Possibilities

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IF WHITE PINE forests are to be made an important source of timber in the state either through planting or the proper handling of stands already established, it is essential to have the facts regarding the commercial possibilities of this tree. The facts which must be ascertained first of all are, how long does it take white pine to become merchantable, and what are the possible yields and money returns that may be expected when it has been grown? With this information as a background, one naturally wants to know how much it costs to plant, the kind of land best suited for the growth of the species, and what expenditures may be involved in the way of protection, thinning, and other care of the stand.

To answer these questions the Lake States Forest Experiment Station, in cooperation with the University of Wisconsin during the summer of 1929, undertook, on the basis of existing stands in the state, an investigation of the growth and yield of pure, even-aged, fully-stocked white pine stands on different soils. This analysis included both natural and planted stands, and may serve as a guide for planting operations both by private interests and the state.

Extent, Origin, and Distribution

Second-Growth—Practically no old growth white pine remains in the state of Wisconsin. What white pine there is, is largely second-growth, and even that is of limited extent—probably not over 500,000 acres in all. This area comprises pure stands of white pine as well as stands mixed with other species. Approximately 100,000 acres bears white pine in a sufficient quantity to be characterized as “the white pine type,” and only about 10,000 acres are fairly well-stocked, essentially pure stands of real economic promise. (Figure 1)

Since nearly all second-growth white pine dates from the time of logging the old stands, most of it is now 50 to 60 years old and has an average diameter of about 7 inches and is, therefore, approaching merchantability. According to a recent survey, there remained in 1923 hardly a billion feet of merchantable Norway and white pine.¹

¹ Report of the Interim Committee of Forestry and Public Lands. Wisconsin Legislature, Madison, March 1929.

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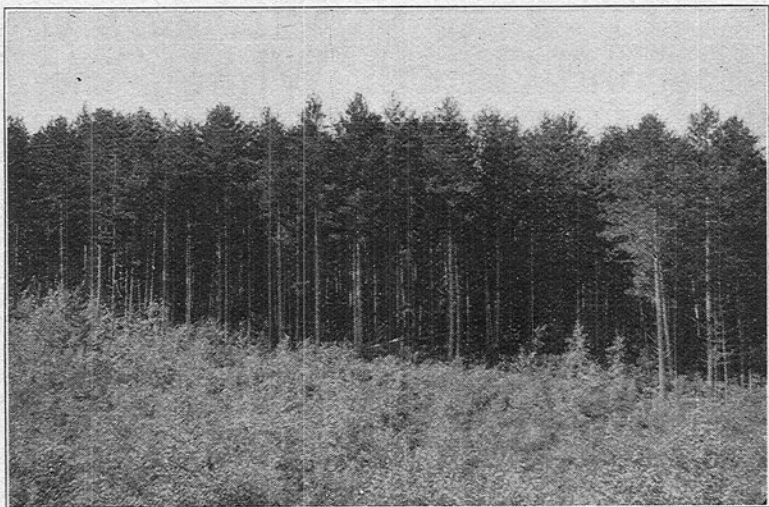


FIG. 1.—A TYPICAL, WELL-STOCKED, WHITE PINE STAND MIXED WITH SOME NORWAY

This is near Neopit, Wisconsin and is 40 years old.

As these young stands become merchantable they are being rapidly logged off. Unless, therefore white pine is to be planted on a large scale, it will soon cease to be, in the not distant future, a source of lumber in the state. The best stands of white pine already are found only as farm woodlots from 1 to 20, and rarely 40, acres in size.

If the logged-over pine land had been kept free from fire, it would now support a large amount of merchantable timber. Roth,* in 1897, estimated that there were 200,000 acres of second-growth white pine at that time in the state growing in fairly pure stands which were to yield "more than a billion feet of marketable material within 50 years time." A very small part of this area supports white pine at present.

Most of the promising second-growth white pine is located in the north central part of the state particularly in Shawano, Barron, Waupaca, and Chippewa counties, although some good stands are to be found as far north as the Michigan-Wisconsin boundary. (Figure 2) The survival of these stands can be attributed to a favorable combination of circumstances such as good seed years shortly before or after logging 30 to 65 years ago, light cuttings which left part of the virgin stand, or fire protection of areas in the proximity of settlements.

Young growth white pine occasionally occurs in mixture with other species as aspen, red oak, red and sugar maple, Norway pine, and

*Roth Filibert 1898. Forestry conditions and interest in Wisconsin. U. S. Department of Agriculture, Division of Forestry Bulletin No. 16.

hemlock. In some such mixed stands the pine ultimately crowds out the competing species. Examples of this natural conversion were noted under aspen stands on the Menominee Indian Reservation. One stand, a little over 20 years of age, contained 636 young pine trees and 1,574 aspens per acre, from 1 to 4 inches in diameter. The white pines were from 8 to 27, and the aspen 20 to 38 feet in height. No influence of the aspens upon growth of the pine was noticeable at



Fig. 2.—DISTRIBUTION OF WELL-STOCKED, WHITE PINE STANDS

that time. Another stand, 105 years old, located on Highway 4, represented the final stage of the conversion process. At first glance, it appeared as an ordinary pure, well-stocked white pine stand, having in its best part 316 white pines per acre from 6 to 18 inches in diameter and from 70 to 93 feet in height. A closer examination revealed a few old aspen trees still standing among the white pines.

Increment borings taken from trees of different sizes all showed that the pine had suffered a long period of suppression. After the aspen deteriorated, the white pine, then 70 years old, began to recover from the suppression which had hampered its development for nearly 30 years. The average height of the largest dominant trees measured was 90 feet. Two trees, however, having heights of 109 and 112 feet respectively, and showing no signs of suppression indicated that loss of height growth due to suppression amounted to about 20 feet. Apparently white pine can grow under aspen when the aspen cover is not too dense. This knowledge is encouraging since aspen now occupies almost two-thirds of the total forest area of Wisconsin.

Old Growth.—The almost insignificant area of essentially pure and even-aged second-growth white pine is in vivid contrast with the 18 million acres over which this species formerly occurred. The southern boundary of the pine belt before large-scale logging began, extended from St. Croix County southeastward through Dunn, Eau Claire, and Jackson counties down to the southern boundary of Juneau County, northeastward to Green Bay and southward along Lake Michigan to the southern boundary of Sheboygan County.

It is estimated that some 130 billion feet of pine lumber of which over 80 per cent was white pine, was removed during the last 80 years from the northern half of the state. Eighty-six billion feet was cut between 1840 and 1897 in addition to 26 billion feet wasted and destroyed by fire during the same period. The remainder, something more than 17 billion board feet, furnished the cut of later years. (Figure 3)

Bayfield County, for example, 30 years ago, had an estimated volume of 3 billion feet of pine. Today some 38,000 acres, from 35 to 50 per cent stocked with young white pine mixed with Norway, is all that remains in the county.²

White pine grew in a region characterized by relatively high humidity, low temperature, and frequent rains and snows³, and occurred on nearly all soils from the driest sands to muck showing a preference, however, for the fresh and relatively fertile soil along streams. Sometimes white pine occurred in pure stands or mixed with Norway, as on the sandy areas in Douglas, Bayfield, Jackson, Vilas, Oneida, and Marinette counties. On the heavier soils of the north central part of the state, white pine either occurred in mixture with

²Land Economic Inventory of Northern Wisconsin. (Bayfield County). Wisconsin Department of Agriculture and Markets. Bulletin 10. December 1929.

³Henry, Alfred J. 1902. The climate of the white pine belt. Forestry and Irrigation 8:419-423.



Fig. 3.—A PLANTED AND NATURAL FOREST OF WHITE PINE

- (a) White pine plantation 52 years old. Planted with wild seedlings pulled from the woods.
 (b) A virgin stand of white pine near Drummond, Wisconsin. (Courtesy of V. P. Hollis)

hardwoods or not at all. The mixed stands often produced much valuable pine lumber. Roth cites an instance of where 60 townships in the Wolf River Basin classed by himself as "much hardwoods" cut out 7,500,000,000 feet of pine lumber or nearly 5,000 feet per acre of gross land area.

The Future of White Pine

Since the amount of white pine now growing in the state is very limited, and its increase through natural means is insignificant, any attempt to restore this tree to its former prominent place must come as a result of planting. The question naturally arises as to how successful such plantings would be. The only way such an inquiry can be answered is to take stock of the factors, natural and economic, which either prevent or assure its success.

On one side of the ledger, for example, is white pine's susceptibility to natural injury from blister rust and weevil. The former, a tree disease, kills the trees outright regardless of their age and size; the latter, an insect, attacks and kills the leaders of white pine seedlings and saplings, thus deforming the trees and reducing their value. Fortunately, neither of these forms of natural injury to white pine are at present serious considerations in Wisconsin, although their potential ability to do a lot of damage should not be disregarded in planning and executing planting programs, particularly in the northern part of the state where weevil damage is apparently the worst. Furthermore, it is possible to combat both the rust and the weevil, the former by eradicating all black and wild currant, and gooseberry bushes, growing either in the pine stands themselves, or within a thousand feet of them, and the latter, by removing and destroying the leaders or terminal branches killed by weevil. Eradication of currant and gooseberry bushes will not save pine trees which have already contracted blister rust, but it will prevent the spread of the disease. Just as wheat rust spends part of its life on barberry, so does white pine blister rust spend a part of its life on currants and gooseberries. Their destruction, therefore, prevents the disease from spreading.

In spite of the fact that white pine has some qualities which render the species undesirable from the standpoint of planting, it has many others which place it in a class of desirability second to none. Among these more desirable attributes are: rapid growth, heavy yields, ability of the species to outstrip in the long run other conifers growing in the region, and inherent qualities of the wood which increase its marketability.

No other coniferous species of Wisconsin produces as high yields of wood per acre as does white pine and at the same time retain its rapidity of diameter and height growth until old age. In this respect it is much superior to Norway pine which falls off considerably in height and diameter growth after about 80 years and to white

spruce, which because of slow growth, requires a long time to reach sawlog dimensions. Jack pine, another conifer common to the state, although growing rapidly in early age, is short-lived and begins to decline almost at the time that white pine starts laying on the largest amount of wood per acre per year.

White pine is, moreover, primarily a lumber producing tree, and in this respect it has no equal. Its desirable physical properties are so well known as to make their reiteration almost unnecessary. However, in passing, it can be said that the ease with which the wood can be worked, its nailing qualities, and its durability place it in a class by itself for planing-mill products, sashes and doors, boxes and crates, car construction, matches, shade and map rollers, caskets and coffins, tanks and silos, patterns, woodenware, drawing boards, etc.

The question of future market prices for any commodity is always a difficult one. The longer the sale of the commodity is deferred, the more difficult it becomes to forecast its value. This is probably particularly true for forest crops. However, in case of white pine in Wisconsin, the mere fact that second-growth material is being cut as fast as it reaches salable dimensions, speaks for its present merchantability. If the species can maintain its present marketability, high transportation rates for shipped-in lumber and decreasing local supply of timber may combine to force the value of white pine wood products to a somewhat higher level than now exists.

In New England, second-growth white pine, mostly of poor quality, brings as much as \$14.00 a thousand feet on the stump and forms a basis of many profitable match and box manufacturing concerns. Moreover, white pine is considered so valuable there that some companies do not hesitate to invest from \$2.00 to \$7.00 an acre just to release it from suppression by inferior hardwoods.⁴

A final justification for planting white pine in Wisconsin lies in the utilization of at least 2,018 square miles,⁵ and probably much more, of rough stony land in the northern part of the state which is unfit for agriculture. To date, the amount of white pine planted in Wisconsin is almost negligible, about 2,200 acres having been planted by the end of 1929. However, it is hoped that the annual rate of planting—about 400 acres—may show an increase with the expansion of the state's reforestation program.

How the Study Was Made

As the main object of the investigation was to determine the commercial possibilities of white pine either of planted or of well-stocked natural stands, the study of growth and yield was confined to only pure, even-aged, fully-stocked stands. In other words, the purpose was to determine the capacity of different soils to produce the

⁴ Hawkins, C. C. 1924. How one wood-using industry has made use of a forester. *Journal of Forestry* 22:140-8.

⁵ Whitson, A. R. 1927. Soils of Wisconsin. Wisconsin Geological and Natural History Survey. Bulletin No. 68. Soil Series No. 49.

greatest possible yields under the most favorable conditions of stocking.

For the purposes of this study white pine stands made up of at least 90 percent of this species were considered pure.

The stands were considered even-aged if the difference between the oldest and youngest tree did not exceed 10 years for stands older than 60, and 5 years for those younger than 60 years.

A fully-stocked stand is one in which the trees fully utilize the available growing space and produce the largest amount of wood within a given time.⁶ Fully-stocked stands represent the true productive capacity of the soil. The stands which were used in the study of the yield of second-growth white pine, were the best stands actually measured in the field.

The study of yield of second-growth white pine was based on the measurements of 92 plots selected throughout the northern part of the state. At the beginning of field investigation one-quarter acre plots were decided upon as being the most desirable size for making yield studies. However, unforeseen difficulties developed which resulted in many samples being taken which were less than one-quarter acre. Heavy grazing, artificial thinnings, and natural irregularities of stocking were some of the factors necessitating this change. Actually, of the 92 useable plots selected from the total of 130 examined in northern Wisconsin, 56 percent were less than one-tenth of an acre, 34 per cent were from one to two-tenths, 9 per cent from two to three-tenths, and only 1 per cent over three-tenths of an acre in size. In making yield studies, it is probably more desirable, and certainly more accurate, to take plots small in size but uniform in stocking than large ones having many stand irregularities such as openings in the crowns, "blanks" (places where there are no trees), etc.

Field data were collected for the preparation of volume tables at the same time the yield study was being carried on. Volume tables show the wood contents of trees of different diameters and heights as a preliminary step in ascertaining the volume of the stand as a whole. Measurements taken on 105 white pine trees served as a basis for the volume tables in this bulletin.

The plots, besides being classified according to their age, were also classified according to the productive capacity of the soil or "site quality."

Forest land, like agricultural land, varies in its productive capacity. Poor tree growth in one place and excellent growth in another are caused by differences in climate, soil and moisture, etc.

The most concrete expression of site quality is the height growth of trees. The average height obtained by the tallest trees

⁶ A detailed discussion of the method used for determining full-stocking, accompanied by a graph and helpful examples of its application, appears in the second part of this report—Technical Analysis of Data.

of the stand within a given period is referred to as the "site index" of the stand.)* For white pine this period is 50 years. If a stand is said to have a site index of 60 it is understood to mean that the height of its dominant trees will be 60 feet when the stand is 50 years old; if the index is 70, the average height of the largest trees will be 70 feet in the same period of time.

The distribution of the 92 sample plots by age classes and site indexes follows:

Table 1.—Distribution of Sample Plots by Age and Site

Age in years	Site Quality					Totals
	Very poor	Poor	Medium Site index	Good in feet	Excellent	
	45	50	60	70	75	
30	..	1	3	1	..	5
40	..	2	6	2	1	11
50	2	7	20	4	..	33
60	1	6	14	2	..	23
70	..	3	1	1	..	5
80	..	..	1	1	..	2
90	..	..	2	..	..	2
100	..	..	1	1	..	2
110	..	1	2	..	..	3
120	..	2	4	..	..	6
	3	22	54	12	1	92

Only five site index classes were considered, namely, 45, 50, 60, 70 and 75. Site 60 corresponds to average conditions of growth for white pine in Wisconsin and characterizes medium sites. Site indexes 45 and 50 represent very poor and poor sites respectively, and site indexes 70 and 75 represent good and excellent sites for white pine.

Since site index expresses the rate of growth of the stand, it is only natural to expect that it should also bear a certain definite relationship to soil and ground water. Unfortunately, this can not always be clearly demonstrated because it is impossible to say in every case just how much soil contributes to growth as compared to ground water. For example, Miami fine sandy loam, an excellent soil for white pine, relatively rich in lime, may show in places, where it is deficient in water supply, the same site index as fine sand near swamps where soil moisture is more abundant. In the same way, a thin layer of Kennan loam underlain by ledge rock will usually show a low site index in spite of the fact that the soil itself is very good for white pine. Two white pine stands, one on top of a sandy hill and another at the bottom of the same hill may show different growth capacities. Colby silt loams and Boone fine sandy loams may not show high site indexes in places where they have extremely compact subsoil. A great number of similar examples could be given, all indicating that sites intermingle within short distances and that they cannot be correctly determined upon the basis of a single growth factor as soil.

* A more detailed discussion is presented in Appendix.

In spite of the fact that the surest way of determining the site index correctly is to measure the trees themselves, the application of other criteria will be found helpful. It was found in the Wisconsin investigation, for example, that soil moisture is one of the factors which affects the growth of white pine the most. High water-holding capacity of the soil and nearness of the water-table to the surface of the ground both tend to make white pine grow better. Fertile soils as a rule, have high water-holding capacities and, therefore, nearly always tend to show high site indexes. However, it should be remembered that white pine does not necessarily require a fertile soil. The species may grow well on sandy areas as long as there is sufficient soil moisture. Generally, rough and very stony land, steep hills where bed rock or ledge rocks support a thin layer of soil, dry sand, very rocky and gravelly loamy sands, and cemented soils (or those with a very pronounced hardpan formation) all show poor site for white pine, with site indexes ranging from 45 to 55, rarely exceeding site index 50 and never exceeding 55. Loamy sands, gravelly sandy loams, and soils formed under conditions of excessive moisture, as mucks, show medium site indexes ranging from 50 to 65. Some muck soils may show site indexes as low as 50 and some sandy loams may show site indexes as high as 65. Sands and loamy sands with high water table, sandy loams, loamy sands grading into loam, loams underlain by clayey substratum, and clay loams, all show good sites for white pine, with site indexes ranging from 60 to 75.

A general knowledge of soil classification in relation to growth may become very useful in judging white pine sites, especially in localities where no white pine is now growing.

Another means of judging very approximately, site conditions, is by studying the woody and herbaceous plants growing under stands of white pine. Poor sites (site index lower than 55) are characterized by an abundance of such herbaceous plants as twin flower¹, bracken fern, club moss, and especially such woody plants as sweet fern, trailing arbutus, blueberry, pipsissewa, wintergreen, and bush honeysuckle. Medium sites (site indexes between 55 and 65) are characterized by abundance of ferns, such as shield and lady ferns, solomon's seal, false solomon's seal, birthroot, hepaticas, sweet cicely, yellow wood sorrel, and milkwort, and by woody plants such as green brier and arrow wood. Mandrake, Jack-in-the pulpit, baneberry, maiden hair fern and downy yellow violet and woody plants such as alternate-leaved dogwood, gray dogwood, and prickly ash, usually indicate good sites.

The rule-of-thumb which allows for site classification upon the basis of woody and herbaceous vegetation is particularly useful for uneven-aged stands. Whenever possible site should be determined by measuring the trees themselves rather than observing the character of the plants growing under the stand.

¹ Scientific names of shrubs and herbaceous vegetation are given in the appendix.

Contents of Standing Trees

Before the yield of a stand can be determined, it is necessary to construct volume tables for individual trees. Tree volumes may be expressed in many kinds of wood units, but in this study only cubic and board feet contents of standing trees are considered. Volumes in cubic and board feet for trees of different diameters and heights are given in Tables II, III, IV, and V.

Table II.—WHITE PINE—WISCONSIN—1929

Total Volume in Cubic Feet

Diameter breast high	Total height of tree—feet												Basis
	20	30	40	50	60	70	80	90	100	110	120		
Inches	Total peeled volume—cubic feet												trees
2	.206	.310	.415										
3	.460	.720	.950	1.18	1.41								
4	.810	1.24	1.65	2.05	2.46	2.88	3.30	3.73				1	
5	2.00	2.56	3.14	3.73	4.31	4.89	5.48	6.05				1	
6	2.74	3.38	4.52	5.41	6.30	7.10						2	
7	3.63	4.82	6.10	7.22	8.26	9.40	10.5					8 5	
8		6.30	7.72	9.19	10.8	12.2	13.6	15.2				6 4	
9		7.82	9.63	11.6	13.6	15.4	17.2	19.3				5 4	
10		9.58	12.1	14.5	16.8	19.3	21.5	24.0				5	
11		11.7	14.5	17.5	20.4	23.0	26.0	29.0				4	
12			17.2	20.6	24.0	27.4	30.7	34.4	37.7			1	
13			20.3	24.3	28.4	32.3	36.2	40.3	44.2			2	
14			23.5	28.0	32.8	37.5	41.9	46.8	51.0			7	
15				32.3	37.6	42.7	48.0	53.0	58.1			5	
16				36.9	42.6	48.3	54.0	59.8	65.5			11	
17				41.5	47.8	54.5	60.5	66.6	73.0			10	
18				46.5	53.4	60.4	67.3	74.0	80.3	86.6		9	
19				51.5	59.2	67.3	74.6	81.7	88.6	95.2		9	
20					65.2	73.8	81.5	89.0	96.3	103		7	
21					71.2	80.0	88.5	96.0	103	110		7	
22					77.2	86.5	95.4	104	111	118		3	
23					83.5	93.5	103	111	118	125		1	
24					90.0	100	110	118	126	133		1	

105.

105

Volume includes stump, stem, and top without bark.

Compiled by Alinement Chart Method from data collected by S. R. Gevorkiantz and F. G. Wilson.

Cubed by Smalian's formula using short lengths.

Difference between total volume of trees used as a basis and volume as taken from the table—0.36.

Average deviation of individual tree volumes from interpolated tabular volumes, ± 4.61 .

Block indicates the extent of the original data.

Table III.—Percentage of Total Cubic Volume Which is Merchantable

Tree diameter breast high	Merchantable volume	
	Per cent of total cubic foot volume	
Inches		
4		82
5		86
6		89
7		91
8		92
9		93
10-11		94
12-13		95
14-16		96
17-24		97

Table IV.—WHITE PINE—WISCONSIN—1929

Volume in Board Feet
International (1/8-inch) Rule

Diameter breast high	Number of 16-foot logs												Basis
	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	
Ht. Class	40	50	60	70	75	80	90	100	110	115	120		
Inches					Volume Board Feet								trees
6	22	32	44										
7	25	37	50	63	77	91	106						8
8	29	44	58	73	90	106	125						7
9	34	50	66	84	104	122	145						5
10	38	56	75	97	118	141	167	192					2
11	44	63	84	112	135	162	190	217					4
12		71	95	130	157	185	215	243					1
13		78	106	146	176	209	242	272					2
14			120	163	195	235	270	305					7
15			133	181	223	263	305	343	386				5
16			145	197	243	287	335	378	425	470			10
17				220	270	319	370	420	470	525	578		11
18				240	295	349	405	462	520	575	629		9
19				262	323	379	445	509	570	630	681		10
20					350	412	487	555	618	680	739	800	6
21						450	535	600	666	740	800	869	7
22							580	645	720	795	865	937	3
23								695	772	855	930	1007	1
24								745	833	915	995	1080	
													98

Stump height 1 foot; top diameter inside of bark, 5 inches.

Trees scaled in 8.15 length. Compiled by Alinement Chart Method from data collected by S. R. Gevorkiantz and F. G. Wilson. H. C. Moser assisted in computations.

Difference between total volume of trees used as a basis and the interpolated volumes taken from table, —.13 per cent. Average deviation of individual tree volumes from interpolated tabular volumes, ±6.92 per cent.

Block indicates extent of original data.

Table V.—WHITE PINE—WISCONSIN—1929

Volume in Board Feet
Scribner Decimal C. Rule

Diameter breast high	Number of 16-foot logs												Basis
	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	trees
Inches	Volume—board feet												
8	2.8	3.4	4.7										7
9	3.1	3.8	5.2	7.0									5
10	3.4	4.2	6.0	7.9	9.8								2
11		4.6	6.8	8.9	11.0	13.3							4
12		5.1	7.7	9.9	12.5	15.2	18.0						1
13		5.7	8.5	11.1	14.0	17.3	20.0	23.0					2
14		6.4	9.4	12.5	15.8	19.3	22.5	26.1					7
15			10.4	14.0	17.8	21.4	25.2	29.8	34.1				5
16			11.6	15.7	19.8	24.0	28.8	34.0	38.8	44.0			10
17				17.7	21.9	27.0	32.5	38.3	43.4	58.9	54.0		11
18				19.3	24.1	30.4	36.4	42.7	48.4	54.0	59.0		9
19				20.9	27.0	34.1	40.6	47.6	53.2	59.0	64.2		10
20					30.4	38.0	45.0	52.3	58.3	64.1	69.4	74.0	6
21					42.2	49.7	57.0	63.4	69.0	75.0	80.0		7
22						54.4	62.0	68.2	74.5	80.9	86.2		3
23							66.8	73.3	80.0	87.2	92.8		1
24							71.5	78.6	86.0	94.0	100.0		

90

Stump height, 1 foot; top diameter inside bark, 6 inches.

Trees scaled in 8.15 foot lengths. Compiled by Alinement Chart method from data collected by S. R. Gevorkiantz and F. G. Wilson. H. C. Moser assisted in the computations.

Difference between total volume of trees used as a basis and the interpolated volumes read from the table, +0.08 per cent. Average deviation of individual trees volumes from interpolated tabular volumes, ±7.42 per cent.

Block indicates extent of original data.

The volumes in cubic feet as given in Table II include stump, stem, and top without bark; in other words, the total peeled volume of the tree. Actually, however, no tree is utilized so completely. The stump and the top always remain. To obtain the volume of the merchantable part of the tree, the volume of the stump and top must be deducted from the total volume of the tree. For a stump height of 1 foot and top diameter utilization inside bark of 3 inches, the merchantable volume will vary for trees of different diameters breast height from 82 to 97 per cent of the total volume of the tree. This is shown in Table III. In other words, the volume of the stump and the top for trees 4 inches in diameter represents 18 per cent of the total volume, and in 20-inch trees, 3 per cent.

There are a number of factors which affect the volume of any tree. As shown in the volume tables (Tables IV and V), the board foot content varies with the size (diameter), number of logs, and log rule used in calculating the contents of each individual tree. As a matter of fact, volume is affected by several other factors, but of these only one, bark thickness, need be mentioned here. The effect of bark thickness upon volume, however, is taken into consideration, for although the diameters given in the tables are for measurements *taken outside bark* at breast height, the volume in board feet is the volume as *scaled inside bark*.

Table IV shows the amount of lumber in board feet (without over-run) which may be cut by careful sawing with good equipment from different sized trees. The trees are scaled by the so-called International log rule in 8-foot log lengths (with an allowance of 0.15 feet for trimming at the mill) to a top diameter of 5 inches inside bark. This table requires that in the field the heights of trees should be estimated to a 5-inch top, and that at the mill only $\frac{1}{8}$ inch be allowed for saw kerf.

Table V gives volumes of trees in board feet as scaled by the Scribner Decimal C log rule—the rule now being used by the United States Forest Service in its timber sale administration, and the legal rule in Wisconsin. This rule is not quite so accurate for second-growth white pine as the International, since it underestimates the contents of small timber and is more wasteful of the material in the tops of the trees using as a standard top limit, 6 inches, instead of the 5 inches prescribed by the International rule.

Applicability of these tables to white pine in any locality can be easily tested by comparing the volumes of about 25 felled trees with those given in the volume tables. If the total actual volume in cubic feet of these felled trees does not vary from the volume as obtained from the table, more than 2.3 per cent, the table can be used; if it does, the table is not applicable.*

Yield of Even-aged, Fully-stocked Stands

The amount of timber in either cubic or board feet that is produced per acre within a given period of time, is known as the yield of the stand. When these yields for different periods of time such as 10, 20, 30, and 40 years are arranged tabularly, they are called yield tables. They show the rate of growth of the stand by ten year periods.

The yields of white pine for all age classes and sites are summarized in Tables VI, VII, and VIII. Detailed yield tables, separately for each site class, are given in the Appendix.

* This method is fully explained in Appendix.

Summarized Table VI.—YIELD IN CUBIC FEET PER ACRE

(Total volume—peeled)
(Stand 1 inch Diameter Breast High & Over)

Age years	Site index in feet				
	Very poor 45	Poor 50	Medium 60	Good 70	Excellent 75
Yield in cubic feet					
30	1450	1750	2250	2900	3200
40	2600	3100	4200	5150	5600
50	3550	4250	5800	7200	7900
60	4490	5350	7200	9000	9900
70		6300	8470	10570	
80		7080	9500	11900	
90		7700	10400	12950	
100		8200	11100	13750	
110		8600	11700	14400	
120		8900	12200	14900	

Summarized Table VII.—YIELD IN BOARD FEET PER ACRE

International ($\frac{1}{8}$ inch Rule)
(Stand 7 inches Diameter Breast High & Over)

Age years	Site index in feet				
	Very poor 45	Poor 50	Medium 60	Good 70	Excellent 75
Yield in board feet					
40	2400	4000	10500	15500	19000
50	7600	11500	23000	34500	39500
60	13900	19800	36500	51500	58500
70		28000	49000	66000	
80		36500	59000	77000	
90		43500	66500	85000	
100		49000	72000	91500	
110		53000	77000	96500	
120		56000	80500	100000	

Summarized Table VIII.—YIELD IN BOARD FEET PER ACRE

(Scribner Dec. C. Rule)
(Stand 8 inches Diameter Breast High & Over)

Age years	Site index in feet				
	Very poor 45	Poor 50	Medium 60	Good 70	Excellent 75
Yield in board feet					
40	550	1250	4000	6500	8100
60	2650	4500	10700	18000	22000
50	5840	9100	20500	31500	37500
70		14500	31300	46000	
80		20500	40900	57500	
90		26500	48500	66500	
100		32000	55000	74000	
110		36500	60500	79500	
120		40000	65000	84500	

The yield in cubic feet (Table VI) includes the volume of stump and of the top beyond a point 3 inches in diameter inside bark. No allowance is made for defect. The yield in board feet is given in values of the International Log Rule (Table VII) and also in the values of the Scribner Decimal C. Log Rule (Table VIII).

The yield by the Scribner Rule differs considerably from those obtained by the International Rule. At the age of 50 years, when all trees have not reached merchantability, yields by the Scribner Decimal C. Rule are about 50 per cent lower than those by the International Rule, and at the age of 100 they are about 20 per cent lower. The International Rule, besides allowing for closer utilization than the Scribner Decimal C. Rule, also considers 7-inch trees merchantable while the Scribner Rule disregards them as potential lumber-producing material. Neither rule considers defect.

The yield tables serve also as a guide as to the time at which the growth reaches its peak, and, therefore, the time when the stand should be cut. Thus they furnish a very convenient means of determining what the so-called rotation age of a forest should be. This is the age, from a technical point of view, at which the average yearly growth of the trees becomes the greatest. The average yearly growth per acre is obtained by dividing the cubic or board foot volume of the stand by its average age (Table IX). Apparently the culmina-

Table IX.—MEAN ANNUAL GROWTH

Mean annual growth—Cubic feet

Age years	Site index in feet				
	45	50	60	70	75
30	49	58	75	97	107
50	65	78	105	129	140
40	71	85	116	144	158
60	75	89	120	150	165
70		90	121	151	
80		88	119	149	
90		86	116	145	
100		82	111	137	
110		78	106	131	
120		74	101	124	

Mean Annual growth—Board feet

Age years	Site index in feet					
	50 Scribner	60 Dec. C Rule	70	50 International	60 C $\frac{1}{8}$ " Kerf	70 Rule
40	31	100	162	100	262	388
50	90	214	360	230	460	690
60	152	342	526	330	608	858
70	207	447	657	400	700	943
80	256	511	819	456	738	962
90	294	539	740	483	739	944
100	320	550	740	490	720	915
110	332	550	723	482	700	878
120	333	541	704	467	670	833

tion of the average yearly growth in cubic feet occurs at about 70 years. This is the desirable age, therefore, at which to cut the stands since the maximum cubic foot production per year has been reached. The rotation for lumber production, in contrast with cubic feet, varies with the site (Table IX). When using the International Log Rule it is 99 years for site index 50, 86 years for site index 60, and 78 years for site index 70. These rotation ages, it should be remembered, consider only the physical maturity of the stand, or the age at which most wood is laid on annually, and do not deal in any way with either the commercial utilization of white pine or with its profitableness as a crop upon purely financial grounds. It is a well-known fact that the *quality* of a stand usually increases with age. Physical rotation considers only the quantity of wood being produced and does not concern itself with the quality of the material.

As an essential part of yield tables may be considered also the total number of trees per acre, the total basal area per acre, the average height of all trees and the average diameter of all trees at different ages in the development of the stand (Tables X, XI, XII, and XIII). As a matter of fact, these data are essentially preliminary steps in the construction of the yield tables themselves.

Table X.—NUMBER OF TREES PER ACRE

(Stand 1 inch Diameter Breast High & Over)

Age Years	Site index in feet				
	Very Poor 45	Poor 50	Medium 60	Good 70	Excellent 75
Trees per acre					
30	3060	2800	2150	1800	1680
40	1510	1360	1040	890	840
50	1020	930	725	613	578
60	810	730	546	475	450
70		605	447	386	
80		510	384	327	
90		440	337	284	
100		385	303	255	
110		356	278	235	
120		330	263	220	

Table XI.—BASAL AREA PER ACRE AT BREAST HEIGHT

(Stand 1 inch Diameter Breast High and Over)

Age Years	Site index in feet				
	Very Poor 45	Poor 50	Medium 60	Good 70	Excellent 75
Basal area in square feet					
30	150	156	179	188	190
40	171	184	210	221	224
50	187	201	230	242	246
60	197	212	342	255	259
70		219	250	263	
80		224	257	271	
90		229	262	275	
100		232	265	280	
110		235	267	283	
120		237	270	285	

Table XII.—AVERAGE DIAMETER AT BREAST HEIGHT

(Stand 1 inch Diameter Breast High & Over)

Age Years	Site index in feet				
	Very Poor 45	Poor 50	Medium 60 ✓	Good 70	Excellent 75
Diameter in inches					
30	3.0	3.2	3.9	4.3	4.5
40	4.6	5.0	6.1	6.7	7.0
50	5.8	6.3	7.6	8.5	8.8
60	6.7	7.3	9.0	9.9	10.3
70		8.2	10.1	11.2	
80		9.0	11.1	12.3	
90		9.8	11.9	13.3	
100		10.5	12.6	14.2	
110		11.0	13.2	14.9	
120		11.5	13.7	15.4	

Table XIII.—AVERAGE TOTAL HEIGHT

(Stand 1 inch Diameter Breast High & Over)

Age Years	Site index in feet				
	Very Poor 45	Poor 50	Medium 60 ✓	Good 70	Excellent 75
Height in feet					
30	21	23	28	34	37
40	31	35	44	52	56
50	42	47	57	68	73
60	50	56	68	80	87
70	58	64	77	91	99
80		71	85	101	
90		77	92	109	
100		81	97	114	
110		84	101	119	
120		86	104	122	

From the table giving the number of trees per acre (Table X), it may be readily seen that the total number of trees per acre decreases with the age of the stand. Thus a fully-stocked stand 30 years old on the average site, has a total of 2,150 trees per acre. When the same stand is a hundred years old it has only 303 trees. This loss, due to natural mortality during the period that is required for a stand to grow from 30 to 100 years old, amounts, at times, to as much as 86 per cent of all trees.

Poor sites usually contain more trees per acre for stands of the same age than good sites.

The total basal area is the cross-sectional area of all trees in the stand. The total basal area divided by the total number of trees in the stand gives the basal area of the average tree and its corresponding average diameter. The average height of the stand is the same as the height of the tree having the average basal area.

If the average diameter and average height of the stand are known, the volume of this average tree can be read from volume tables, and the yield of the stand readily obtained by multiplying the volume of the average tree by the number of trees in the stand.

An example will illustrate this point. Suppose a stand has an average diameter of 7.3 inches, an average height of 56 feet, and contains 730 trees per acre. From the volume table in cubic feet (Table II) it can be seen that a tree 7.3 inches in diameter and 56 feet tall will have something more than 6.10 cubic feet of wood (volume for a tree 7.0 inches in diameter and 50 feet tall) and something less than 9.19 cubic feet (volume for a tree having a diameter of 8.0 inches and a total height of 60 feet). As a matter of fact the volume of a tree 7.3 inches in diameter and 56 feet in height amounts to 7.33 cubic feet. This, multiplied by the number of trees, 730, amounts to 5350 cubic feet per acre which is precisely as given in the basic table of yield for age 60 and site index 50 (Table VI).

Comparison of Yields of Second-Growth White Pine in Wisconsin With Those of Other Regions

In New England the growing of white pine is generally considered a profitable enterprise. It may be, therefore, of interest to learn how the yields of second-growth white pine in Wisconsin compare with those in other regions. In order to answer this question, a knowledge of the site conditions under which the stands used for comparison have grown and developed is necessary. It is obvious that a true comparison between the yields obtainable at a given age from stands grown in two different regions must be made on the basis of sites, since they express the ability of the stand to lay on wood. It would not be fair, for instance, to compare the yields of white pine in New England, where most of the second-growth stands have started on abandoned fields, with the yields of that species on dry sandy areas in other regions. Moreover, it must not be forgotten that white pine actually grows better in some sections of the country than in others, and that a region like New England may show more frequent occurrence of better sites than, for example, the Lake States.

That yields of white pine in Wisconsin do compare favorably with those in other sections of the country can be clearly demonstrated (Tables XIV and XV). They compare almost exactly with values given for Rhode Island, Massachusetts, and New Hampshire.⁹ (Table XIV) for white pine plantations grown upon loamy soil.

They also check very favorably with values¹⁰ for fully-stocked white pine stands in New Hampshire (Table XV). The New Hampshire yield tables, in their original form, include bark, so at first glance they appear to give higher yields than those obtained in Wisconsin.

⁹ Fenska, R. R. 1922. Yield table for white pine. Jour. For. 20:593-597.

¹⁰ Frothingham, E. H. 1914, White pine under forest management. U. S. Department of Agriculture, Bulletin 13.

However, when 10 per cent is deducted from the gross values the similarity of the yields in New Hampshire and Wisconsin is striking (Table XV).

Table XIV.—Acre Yields

Age	Yield per acre		
	Rhode Island, Massachusetts New Hampshire		Wisconsin
	Plantations	Fully-stocked natural stands	
	Poor site	(Index 54)	Poor site
Years	C u b i c f e e t .		
30	1980		1980
40	3475		3500
50	4800		4800
60	5900		6000

Table XV.—Acre Yields

Age years	Site index	Yield per acre	
		New Hampshire	Wisconsin
		Reduced 10% for bark	Cubic feet
50	54	4700	4900
50	64	6300	6400
50	75	7900	7900
100	53	9400	9100
100	60	11300	11100
100	68	13200	13200

Apparently then, under similar site conditions, white pine will produce as high yields in Wisconsin as in the northeastern states. The difference between the yields of the two regions probably lies chiefly in the fact that the decline of agriculture in New England opened up more favorable sites for white pine than ordinarily occur in Wisconsin. As a result, site indexes as high as 75 are more common in New England than they are in Wisconsin where white pine is now found growing chiefly upon sandy soil. Perhaps, too, the milder climate of New England has an ameliorating influence.

A comparison of fifteen fully-stocked plots of white pine in Minnesota* with similar plots in Wisconsin indicated that the yields as presented here are applicable also to Minnesota conditions.

* Obtained by Professor R. M. Brown, University of Minnesota.

Profitableness of White Pine as a Forest Crop

From a purely economic point of view any business venture must pay dividends in dollars and cents upon the money invested.

The knowledge of volume, growth, and yield for even-aged fully-stocked white pine second-growth is essential in determining the financial possibilities of white pine.

A knowledge of yields alone, however, is insufficient to render a business of any kind financially profitable. From a strictly financial point of view, the business man is concerned not only with *how much* he can produce but also with *how much profit* can he realize on each unit produced. The same economic logic applies to growing forest crops. What, then, is the situation in regard to white pine in Wisconsin? Obviously, aside from a public-welfare point of view, which would justify the planting of white pine on large, unproductive, non-agricultural areas whose tax burden is now carried by farm lands and urban industries,¹¹ the answer to this question depends upon two elements—cost of growing the crop, and its value when grown. (Figures 4, 5, and 6).

The costs involved in the growth of a forest crop are of two kinds: (1) initial costs, such as the cost of land and the cost of planting, paid at the beginning and representing the original business investment and (2) carrying charges or administrative costs such as

¹¹ Forestry research program inaugurated, 1927-1928, Agricultural Experiment Station, University of Wisconsin, Madison. Annual Report of the Director.



Fig. 4.—WHITE PINE PLANTED 16 YEARS AGO WITH WILD SEEDLINGS PULLED FROM THE WOODS

There are about 1,000 trees to the acre in this plantation, having an average diameter of 3 to 4 inches and an average height of about 22 feet. (Trees pruned in the foreground for photographer.) Sauk County.

taxes, protection against fire, losses through blister rust, insect damage, etc., also the yield tax at the time of cutting.

In Wisconsin plantations of white pine would naturally come under the forest crop law. The land will, therefore, be charged with an annual tax per acre and a yield tax of 10 per cent of the gross stumpage value at the time of cutting. All other annual charges such as protection against fire, thinnings, etc., may be placed at five cents per acre per year. The value of the land and the cost of planting will vary from one locality to another. The range in the initial investment for land and planting should be somewhere between \$5.00 and \$12.00 per acre. The amount of yield tax, which is 10 percent of the gross stumpage value, will naturally vary with the yield and the stumpage value. White pine stumpage is at the present under the most favorable market conditions, \$15.00 per thousand board feet.

Table XVI.—Financial Yield Tables

For Fully-Stocked Second-Growth White Pine
at 80 Years

If the stumpage values are equal to the cost of production, they will return land rental, planting costs, five cents per acre per year protection costs, and taxes as fixed under the Forest Crop Law;—ten cents per acre per year and a 10 per cent severance tax.

Cost of planting plus land value* per acre	Site quality	Cost of producing a thousand board feet of lumber with a compound interest rate of			
		3%	4%	5%	6%
\$5.00	Good	\$3.25	\$4.92	\$8.33	\$15.24
6.00	Yield—57,500	3.43	5.33	9.19	17.08
7.00	board feet	3.61	5.73	10.05	18.92
8.00	per acre—	3.80	6.13	10.91	20.76
10.00	(Scribner	4.17	6.93	12.64	24.44
12.00	Dec. C.)	4.54	7.73	14.36	28.12
5.00	Medium	3.95	6.31	11.10	20.82
6.00	Yield—40,900	4.22	6.88	12.31	23.40
7.00	board feet	4.48	7.44	13.52	25.99
8.00	per acre—	4.74	8.01	14.73	28.58
10.00	(Scribner	5.26	9.13	17.15	33.75
12.00	Dec. C.)	5.78	10.26	19.58	38.92
5.00	Poor	6.40	11.11	20.65	40.04
6.00	Yield—20,500	6.92	12.23	23.06	45.20
7.00	board feet	7.44	13.36	25.48	50.36
8.00	per acre—	7.96	14.48	27.90	55.52
10.00	(Scribner	8.99	16.73	32.73	65.84
12.00	Dec. C.)	10.33	18.98	37.57	76.16

*Land values range from \$.50 to \$2.50 per acre; planting costs from \$4.00 to \$10.00 per acre. In this computation land was taken to equal one dollar.

On the basis of these initial investment costs for land and planting and annual carrying charges, and with the knowledge of yields on different soils and the stumpage values, it is possible by use of a well-known formula¹² for compound interest to construct financial yield tables for white pine stands of different ages. One such table (Table XVI.) is presented here. It is for a fully-stocked stand at 80 years on good, medium, and poor soils.

As it may be inferred from the table, if the stumpage price in 80 years will not exceed present prices, the venture will prove unprofitable if the initial investments and carrying charges are compounded at 6 per cent interest. The growing of white pine, however, will pay 5 per cent on the investment and still leave a net profit on the better soils particularly if the cost of land and planting does not exceed \$12 or \$13. At 3 per cent, growing white pine is a profitable

¹² The cost values given in the table are computed by the formula

$$\frac{(C \text{ plus } S \text{ plus } E) (1.0p^n) \text{ minus } (S \text{ plus } E)}{b} \text{ plus } f$$

where C is the initial cost per acre; S, the land value; E, the amount of capital necessary to pay enough interest to defray annual expenses; .op, the interest rate; n, the number of years each dollar invested will be carried at the .op rate of interest; b, the yield in M board feet per acre, and f, the severance or yield tax. By deducting cost values obtained by this formula from the gross stumpage value the profit or loss of the planting is readily ascertained.



Fig. 5.—EXTERIOR VIEW OF A WHITE PINE PLANTATION 33 YEARS OLD

This is growing on moist Plainfield sand in Waushara County. Planted, using a 6'x6' spacing, with wild seedlings 12 to 30 inches in height. The average diameter of this stand is estimated to be about 8 inches.

business even on the poorest soils, and with initial investments for land and planting as high as \$12 per acre. These returns are probably the highest for a stand 80 years old as this age the stand reaches its highest board foot production. They would be lower for stands 40, 60, and 100 years old. This would also be true for stands which are not fully stocked. On the other hand, they would be higher if instead of the Scribner Decimal C, the International log rule which gives a greater merchantable content, was used.

No allowance was made in these computations for loss from decay, insect damage, breakage, and similar losses. To be on the conservative side it may well be assumed that only 50 to 75 per cent of the yield given in the table will be realized. Table XVI does not pretend to give absolute figures directly applicable to white pine stands. It serves, however, as a guide for preparing such tables on the basis of known facts.

There is only one way to check the reliability of the various values, and that is to grow the timber, keep an account of the cost of doing it, sell the lumber, and calculate the profit upon this basis. This is exactly what has been done in New England states. As nearly as can be determined from yield values and present stumpage values, a venture of growing an 80-year old white pine should net in the neighborhood of 4 or 5 per cent compound interest, but forestry, like most business enterprises, is subject to the "ups and downs" of market values and market competition. A manufacturer finds it difficult



Fig. 6.—INTERIOR VIEW OF THE SAME 33-YEAR OLD PLANTATION
The large tree in the inside row, left foreground, is 12 inches in diameter
and 40 feet in height.

to predict prices for a year ahead of time. A timber grower finds it infinitely more difficult to predict the values of his forest crop 60, 80, or 100 years in the future. However, this fact need not serve as a damper to planting white pine, since forestry does not face the problem of future market uncertainty any more than agriculture or the industrial world.

CONCLUSIONS

1. White pine in Wisconsin is no longer an important source of lumber. Unrestricted cuttings and repeated forest fires have greatly reduced the natural extension of this species in the state.

2. The total area which supports white pine now, both in pure and mixed stands, and under all conditions of density is not over 500,000 acres. Only 2 percent of this area contains white pine growing in fairly good stands, at least 50 per cent stocked and essentially pure.

3. These stands are found chiefly in farm woodlots or in relatively well settled districts, such as Shawano, Waupaca, Barron, and Chippewa counties, where they escape fires. In a few years they will approach merchantability and will be logged-off.

4. At present Wisconsin imports white pine lumber from other states and pays high transportation charges.

5. Any attempt to restore white pine to its former prominent place must come as a result of planting.

6. There are at least 2,000 square miles of rough stony land in the northern part of the state which is unfit for agriculture, but is suitable for planting white pine.

7. The total acreage of white pine planted in Wisconsin by the end of 1929 was only about 2,200 acres. This amounts to planting at the rate of about 400 acres per year.

8. No other coniferous species in Wisconsin produces as high yields of wood per acre and at the same time retains its rapidity of growth until old age.

9. White pine is primarily a lumber producing tree, and in this respect it has no equal.

10. White pine is susceptible to injury from blister rust and weevil. Both blister rust and weevil are controllable and do not present a serious obstacle to planting on a large scale.

11. White pine on average sites will produce 10,500 board feet per acre at the age of 40; at 60, 36,500 board feet, and at 80 years 59,000 board feet. (Scaled by International Log Rule).

12. On poor site its yield in 40 years is only 2,400 board feet, but on the best sites at the same age 19,000 board feet (scaled by the International Log Rule).

13. The yields of white pine in Wisconsin are about equal to those in New England.

14. The growing of white pine under the provisions of the forest crop law will earn 5 per cent on the original investment and annual carrying charges and still leave an additional profit on the better soils, particularly if the cost of the land and planting does not exceed \$12 to \$13 per acre.

APPENDIX ANALYSIS OF DATA AND METHODS

Detailed Yield Tables

Generalized yield tables for all ages and site classes (Tables VI, VII, and VIII) are given in the main body of the report. To make it easier, however, to select information about any one factor, the facts are presented also in a series of more detailed tables (Tables XVII, XVIII, XIX, XX, and XXI) separately for each site class. A brief explanation accompanies each table to make clear just what information it gives.

Selection of Plots in the Field

The study of yield presupposes finding plots in the field of different ages but of the same composition, growing on similar soil, and having the same degree of stocking. The accuracy of the results depends entirely upon the ability to select in the field for purposes of comparison uniform stands at different stages of their development. It is for this reason that the study of yield was confined to pure, even-aged, fully-stocked white pine stands. The composition of the stand, its age, and site are more or less easily determined. The degree of stocking on the other hand, presents many difficulties. How can one tell that two stands, of say 20 and 40 years, having the same composition and growing on the same soil, have the same degree of stocking and are, therefore, comparable? The determination of the degree of stocking or the normality is, therefore, important.

Rejection of Plots

Both the field and office technique used in collecting and preparing volume and yield tables for white pine are essentially the same as outlined by the Committee on the standardization of volume and yield tables.¹³ In the preparation of yield tables the method described by D. Bruce was also very helpful.¹⁴

Usually the sifting out of understocked or abnormal plots is done in the office. Stands which deviate in basal area by more than a certain arbitrary value are discarded. In this respect the standard practice was adhered to. In addition, however, a new scheme for determining the normality or abnormality of the stand was used

¹³ Methods of preparing volume and yield tables 1926. Jour. Forestry 24:653-666.

¹⁴ Bruce D. 1926. A method of preparing timber yield tables. Jour. Agr. Research 32:543-557.

which permitted certain stands to be thrown out from further consideration. The average diameter of the trees in the stand and total basal area per acre are used as a criterion of its degree of stocking.

Only recently the significance of the average diameter in characterizing normal or fully-stocked stands has been appreciated.¹⁵

The substance of this relationship is briefly this: in fully-stocked stands having a certain average diameter there must be a corresponding average number of trees in the stand.

The average diameter of the stand is that diameter which corresponds to the average basal area. This basal area is obtained by dividing the sum of the cross-sectional areas of all tree stems at breast height by the number of trees. Thus the basal area of the average tree, if multiplied by the total number of trees per acre will give the total basal area of the stand which is usually taken as a measure of the degree of stocking. If, on the basis of the number of trees in the stand the white pine plots used in this study are plotted on cross section paper on which the horizontal line is the average diameter of the stand and the vertical line is the number of trees per acre, the curve assumes the form shown in Figure 7.

By means of the curve it is possible to judge the normality of any stand measured in the field. Suppose it is desired to know whether a certain white pine plot is fully-stocked or normal. Suppose that the plot in question has 400 trees per acre with an average diameter of 6.7 inches. By reference to the graph it can be seen that a fully-stocked stand having an average diameter of 6.7 inches should contain 850 trees per acre. The measured plot is therefore, less than 50 per cent fully-stocked. The graph also shows how the total number of trees per acre in fully-stocked white pine stands decreases with the increase of average diameter of the stand, and also how closely, at least for practical purposes, the number of trees in the stands of the same or nearly the same average diameter correspond to each other. Stands, for example, having an average diameter of about 10 inches, vary in the total number of trees from 400 to 500 per acre.

For comparison a few points (crosses) representing rejected plots, or stands not considered fully-stocked, are also shown on the graph.

Frequently an exact measure of the degree of stocking requiring the determination of basal area may not be needed in the field, as in the cases of cruising timber or selecting plots, but instead an approximate method of interpreting stocking in terms of number of trees may be desired. Here again the graph will prove helpful.

An experienced cruiser after a quick tally of the trees on the plot, will be able to estimate the average diameter of the stand within half an inch, and by dividing the actual number of trees per acre by

¹⁵ Tarashkevitch, A. 1926. The composition of pure stands. Collection of Works on Forestry, Leningrad Agricultural Institute, pp. 106-135, Russian.

Tjurin, A. 1927. The construction of even-aged stands. Memoirs of the Varonege Institute of Agriculture, Vol. 8, pp. 5-49. Russian.

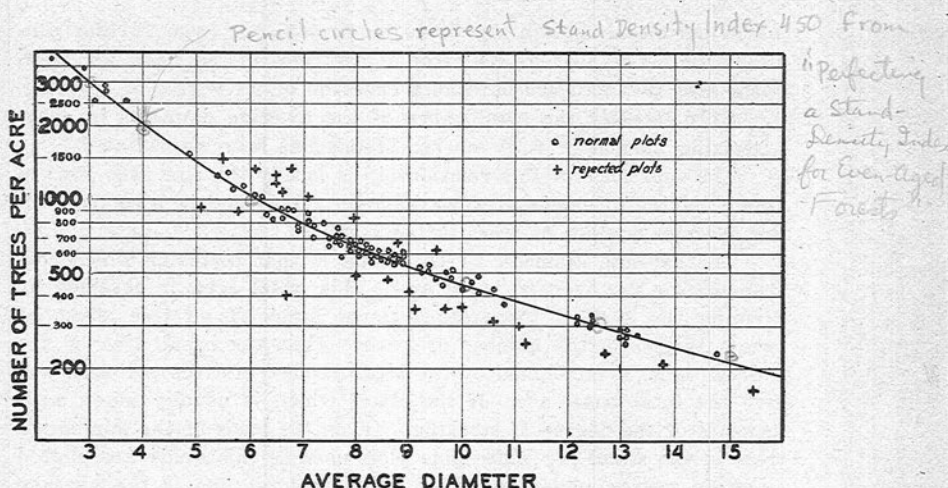


Fig. 7.—THE RELATIONSHIP BETWEEN NUMBER OF TREES PER ACRE AND THE AVERAGE DIAMETER OF THE STAND

the number of trees shown on the graph for a stand having that average diameter and expressing this ratio in terms of a hundred, the true value of the degree of stocking can be ascertained within 10 per cent. In this connection it should be noted that the ratio between the number of trees in two stands having the same average diameter is the same as the ratio between their basal areas, since the average basal area of these two stands is the same.

The application of this method resulted in marked uniformity of the selected plots as regards the basal areas, volume per acre, number of trees, etc. By the use of this method the average deviations of individual plots from the yield tables were smaller than those usually obtained in similar studies which speaks well for its accuracy. For example, the average deviation for total basal area per acre as obtained by its use, was only 7.0 per cent, the average deviation for total cubic foot volume only 8.0 per cent, and for the total number of trees per acre, 16.0 per cent. The deviation, when using the International board foot volume table, was 15.6 per cent, and 22.1 per cent when using the Scribner table.

Determination of Site Index

The determination of site indexes for the purpose of classifying the growth capacities of white pine on various soils is not so difficult as might be supposed. However, it involves a certain definite procedure and for that reason a detailed description of the method, accompanied by tables, figures, and examples, is included here.

The first point that must be considered in classifying site is the selection of the plot itself. It should, of course, be located in an even-aged, fully-stocked stand. Any convenient sized area may be

staked out for purposes of determining the site index, the only restrictions being that the sample confines itself to a single type of soil, topography, etc., and that there are at least 100 to 300 trees²⁶ growing within its boundaries. Ordinarily the plot will not have to be larger than one-half acre.

After the plot has been located, the next step is to make a hundred per cent tally of all trees one inch and over in diameter. Dominant and co-dominant (largest and tallest) trees are tallied separately from the others. The diameter tally is followed by the measurement of heights for trees of all diameter classes found growing upon the plot. Measured heights are then plotted over their corresponding diameters on cross-section paper. Enough heights should be taken to facilitate the construction of a well defined height-over-diameter curve. Basal area of dominant and co-dominant trees is then computed (using basal area tables) and the average diameter of dominant trees is found by dividing the total basal area for these two classes of trees by their total number, and finding in the basal area table the diameter which corresponds to this average. The height of the dominant tree having the average diameter as computed by means of basal area tables is then read from the height-over-diameter curve. Dominant and co-dominant trees that have not been affected by previous suppression, fire damage, disease or cuttings should be used in making site determinations.

The height of an average dominant tree in a fully-stocked stand corresponds very closely to the average height of the dominant trees, which is only to say that the height for any dominant tree is about the same as the average for them all. Therefore, a less accurate but quicker method of determining the height of an average dominant tree can be suggested. This method requires the height measurement of about a dozen representative dominant and co-dominant trees. Later these heights are averaged. For example, if five heights, 66, 63, 67, 69, and 65 feet are averaged, the result will be 66 feet, or the height of the average dominant tree which is considered to be the same as the average height of all dominant trees on the plot.

Once the height and diameter of the average dominant tree has been determined there remains a single step to be taken before the site index can be ascertained. The age of the dominant trees must be known. This information is obtained by either felling or boring at least five dominant trees. Usually it is more desirable to cut the trees and count the rings on the stump than to bore them with an increment borer, but oftentimes it is not possible to do this. If the increment borer is used, the core should be taken one foot above the ground and six years (time necessary for a white pine seedling to grow one foot tall) added to the total number of rings counted. The total age of the tree may also be determined by adding 10 years to the ring count of the increment core taken at breast height (4½ feet

²⁶ Methods of preparing volume and yield tables. 1926. Jour. Forestry 24:653-666.

Table XVII.—Detailed Yield Table for Fully-Stocked Stands of White Pine

Site index 45 (very poor site)						All values on a per acre basis			
Age	Height of average dominant tree	Average height of all trees	Average diameter at breast height	Number of trees 1" and over	Total basal area	Yield			
						Total cubic feet	Board feet		Number of plots
							International log rule	Scribner Decimal C	
Years	Feet	Feet	Inches		Sq. feet				
30	24	21	3.0	3060	150	1450			
40	35	31	4.6	1510	171	2600	2400	550	
50	45	42	5.8	1020	187	3550	7600	2650	2
60	53	50	6.7	810	197	4490	13900	5840	1

Trees 1-inch and over in diameter at breast height make up the total cubic-foot yield. Trees 7 inches and over in diameter cut to a 5-inch top diameter make up the International board foot yield, and trees 8 inches and over in diameter cut to a 6-inch top diameter make up the Scribner board foot yield. Volume does not include bark.

Table XVIII.—Detailed Yield Table for Fully-Stocked Stands of White Pine

Site index 50 (poor site)						All values on a per acre basis			
Age	Height of average dominant tree	Average height of all trees	Average diameter at breast height	Number of trees 1" and over	Total basal area	Yield			Number of plots
						Total cubic feet	Board feet		
							International Log rule	Scribner Decimal C	
Years	Feet	Feet	Inches		Sq. feet				
30	27	23	3.2	2800	156	1750			1
40	39	35	5.0	1360	184	3100			2
50	50	47	6.3	930	201	4250	4000	1250	7
60	59	56	7.3	730	212	5350	11500	4500	6
70	67	64	8.2	605	219	6300	19800	9100	3
80	74	71	9.0	510	224	7080	28000	14500	
90	79	77	9.8	440	229	7700	36500	20500	
100	83	81	10.5	385	232	8200	43500	26500	
110	86	84	11.0	356	235	8600	49000	32000	1
120	88	86	11.5	330	237	8900	53000	36500	2
							56000	40000	

Table XIX.—Detailed Yield Table for Fully-Stocked Stands of White Pine

Site index 60 (medium site) ✓						All values on a per acre basis			
Age	Height of average dominant tree	Average height of all trees	Average diameter at breast height	Number of trees 1" and over	Total basal area	Yield			
						Total cubic feet	Board feet		Number of plots
							International log rule	Scribner Decimal C	
Years	Feet	Feet	Inches		Sq. feet				
30	32	28	3.9	2150	179	2250			3
40	47	44	6.1	1040	210	4200	10500	4000	6
50	60	57	7.6	725	230	5800	23000	10700	20
60	71	68	9.0	546	242	7200	36500	20500	14
70	80	77	10.1	447	250	8470	49000	31300	1
80	88	85	11.1	384	257	9500	59000	40900	1
90	94	92	11.9	337	262	10400	66500	48500	2
100	99	97	12.6	303	265	11100	72000	55000	1
110	103	101	13.2	278	267	11700	77000	60500	2
120	106	104	13.7	263	270	12200	80500	65000	4

Table XX.—Detailed Yield Table for Fully Stocked Stands of White Pine

Site index 70 (Good site)						All values on a per acre basis			
Age	Height of average dominant tree	Average height of all trees	Average diameter at breast height	Number of trees 1" and over	Total basal area	Yield			
						Total cubic feet	Board feet		Number of plots
							International log rule	Scribner Decimal C	
Years	Feet	Feet	Inches		Sq. feet				
30	38	34	4.3	1800	188	2900			1
40	55	52	6.7	890	221	5150	15500	6500	2
50	70	68	8.5	613	242	7200	34500	18000	4
60	82	80	9.9	475	255	9000	51500	31500	2
70	93	91	11.2	386	263	10570	66000	46000	1
80	103	101	12.3	327	271	11900	77000	57500	1
90	110	109	13.3	284	275	12950	85000	66500	
100	115	114	14.2	255	280	13750	91500	74000	1
110	120	119	14.9	235	283	14400	96500	79500	
120	123	122	15.4	220	285	14900	100000	84500	

above the ground). Care should be used to bore all the way to the center of the tree.

After the height of an average dominant tree and the age of the stand have been determined for a number of samples, the data are summarized in the form of a graph (Figure 8) which can be used to

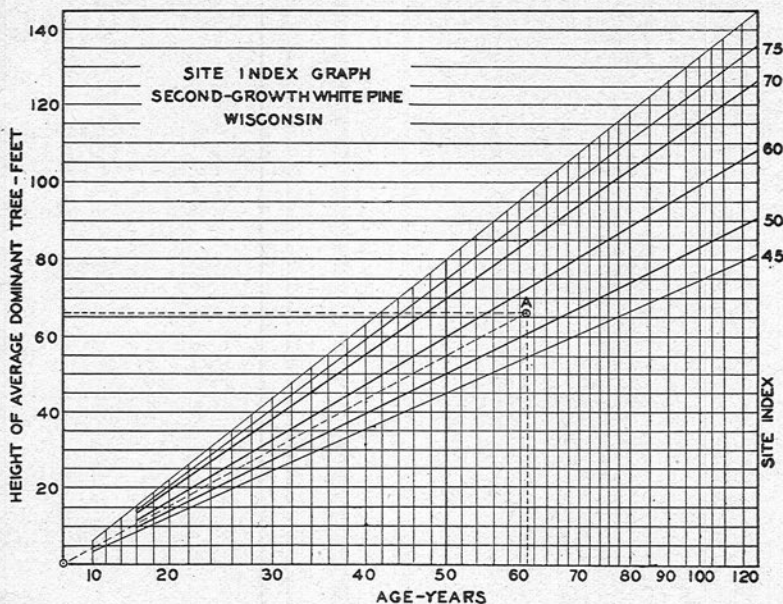


Fig. 8.—SITE INDEX GRAPH FOR WHITE PINE

measure the ability of any fully-stocked white pine stand to produce wood. How can this be done? Just in this way. Suppose that the average age of a fully-stocked stand of white pine is 61 years and that the height of its average dominant tree is 66 feet. With this information at hand, the graph becomes useful. There are three scales on the site index graph—one at the bottom which tells how old the stand is, one at the left which tells how tall the average dominant tree is, and one at the right which tells how tall the average dominant tree will grow in 50 years. The stand in question is 61 years old and the height of its average dominant tree is 66 feet. The answer desired is, how tall was this same average dominant tree at 50 years? The answer is obtained in the following way: turning to the site index graph, 61, is read on the scale of age (bottom) and 66 on the scale of height (right). Perpendicular lines are then extended from these two points until the lines cross (point A on Figure 8). This point where the lines cross will read 66 feet on the scale of height and 61 years on the scale of age. If another line is now drawn from point A to the extreme left hand corner of the graph (zero age and zero height)

the height of the average dominant tree now 61 years old and 66 feet tall can be determined 11 years ago, i.e. at 50 years of age. The extended (dotted) line crosses the heavy vertical line drawn upward from age 50 (bottom scale) midway between 50 and 60 feet on the height (left) scale. The site index is, therefore, 55, and represents the height of an average dominant tree or the average height of dominant trees, as the case may be, which will be attained or has been attained at the age of 50 years.

For the sake of convenience several lines representing site indexes of 45, 50, 60, 70, and 75 are present on the graph. The site index graph also shows the height growth of dominant trees for any given site index.

It is interesting to note in connection with a discussion on height growth, that the farmers in Wisconsin have worked out a rule-of-thumb for determining whether a stand of white pine 40 to 80 years old is growing poorly or well. By this rule, any normal, well-stocked stand between the ages of 40 and 80 years which does not add a foot a year to height is considered to be growing slower than average (poor site), and stands which put on a foot or more of height growth yearly are considered to be growing as well or better than average (good site). As a matter of fact, this rule is not a bad one since actual figures show that after a white pine has reached an age of 10 years (the period required for it to reach a height of 4½ feet or breast-height) the species normally adds about one foot of height growth each year.

Height is used as an indicator of site because of its effect upon the volume of the stand. The importance of this statement is at once apparent if volume in cubic feet of a stand is plotted over the average height of dominant (largest) trees (See Figure 9). Age does not enter in this relationship. Fully-stocked plots having the same average diameter contain about the same number of trees per acre regardless of soil, moisture, and other factors affecting growth. Any difference in total volume either in board or cubic feet for these stands must come as a result of more logs being cut from a single tree. In other words, if the average height of the trees growing on one plot is greater than that for those growing upon another, the stand having the tallest trees will produce the most wood per acre.

Variations in height growth of dominant trees upon the basis of site for stands of the same age are presented in tabular form (Table XXII.) The table shows that these variations constitute real differences. Take, for example, stands having an age of 50 years. The height of the average dominant tree is 45, 50, 60, 70, and 75 feet respectively, and the difference between the height of trees growing on the poorest soil, 45 feet, and the height of those growing upon the best soil, 75 feet, is 30 feet or at least one good log. It is obvious, therefore, that in order to estimate future yields of forest stands it is necessary to determine the quality of site as accurately as possible.

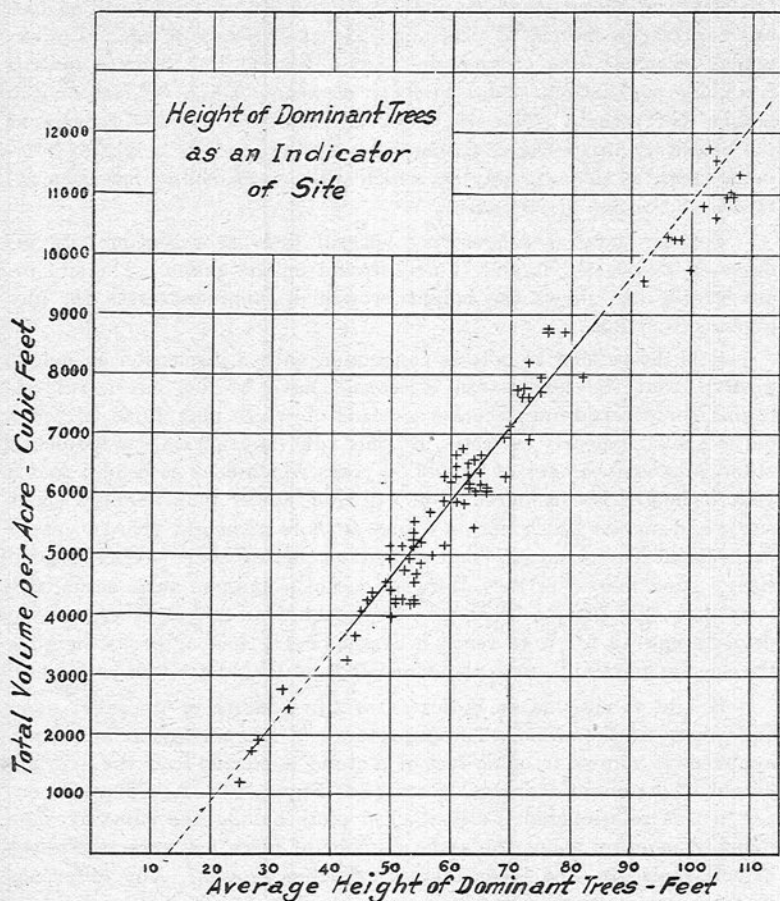


Fig. 9.—THE RELATIONSHIP BETWEEN THE HEIGHT OF DOMINANT TREES AND THE VOLUME PER ACRE

Application of Normal Yield Tables to Understocked Stands

One of the uses of yield tables is to predict growth of stands. If an owner has a young, even-aged, fully-stocked stand 10 years old and he wants to know at what rate it is growing or how much timber it will have, say at 60 years, the yield tables give him a direct answer. This, however, is true only in the case the stand is fully-stocked.

As a matter of fact, the majority of stands of second-growth white pine in Wisconsin are in a decidedly understocked condition. Therefore, before an estimate of their future yields can be made, the degree to which they are understocked must be determined. This is

Table XXI.—Detailed Yield Table for Fully-Stocked Stands of White Pine

Site index 75 (excellent site)						All values on a per acre basis			
Age	Height of average dominant tree	Average height of all trees	Average diameter at breast height	Number of trees 1" and over	Total basal area	Yield			
						Total cubic feet	Board Feet		Number of plots
							International log rule	Scribner Decimal C	
Years	Feet	Feet	Inches		Sq. feet				
30	41	37	4.5	1680	190	3200			1
40	59	56	7.0	840	224	5600	19000	8100	
50	75	73	8.8	578	246	7900	39500	22000	
60	89	87	10.3	450	259	9900	58500	37500	

Table XXII.—TOTAL HEIGHT OF AVERAGE DOMINANT TREE

(Stand 1 inch Diameter Breast High & Over)

Site index in feet

Age Years	Very poor 45	Poor 50	Medium 60	Good 70	Very Excellent 70
	Height in feet				
20	12	14	16	19	20
30	24	27	32	38	41
40	35	39	47	55	59
50	45	50	60	70	75
60	53	59	71	82	89
70	60	67	80	93	101
80	66	74	88	103	111
90		79	94	110	
100		83	99	115	
110		86	103	120	
120		88	106	123	

*Values read from Figure 9.

done by comparing the basal area per acre as given in Table XI for fully-stocked stands with the basal area of stand whose normality is being measured. For example, a fully-stocked white pine stand 70 years old with a site index of 60, should have a total basal area of 250 square feet per acre. If instead it has a basal area of only 180 square feet per acre, it is obviously only 72 per cent normal or 28 per cent understocked. On the other hand, if the basal area had been more than 250 square feet per acre, the stand would have been overstocked. The basal area of understocked stands is ordinarily assumed to approach normality as they grow older. However, this rate of approach, providing the stands are not too young, is sometimes quite slow. Up to the present time its exact rate, expressed numerically, is not known. It seems a fairly conservative estimate though, that during a period as short as 20 to 30 years, an under-stocked stand makes little progress toward attaining normality. This means that if a stand is 72 per cent normal at the age of 70 years that it will also be about 28 per cent understocked at the age of 90 years. Such an assumption is conservative since it is better to predict less yield and get more than vice versa. Actually, the trees on the understocked stand are producing *more basal area per tree* than those growing in normal stands.¹⁷ The way the whole scheme works out is something like this: A stand 70 years old, growing upon a site having an index of 60, may be found to be 72 per cent normal in respect to total basal area per acre. Following the line of reasoning just presented, the assumption is made that 20 years later, or at the age of 90, the stand will still be 72 per cent normal. The yield for a normal fully-stocked stand of white pine 90 years old is 10,400 cubic feet. (Table VI). Seventy-two per cent of 10,400 cubic feet is 7,500 cubic feet, which is the amount of wood that may be expected from this stand, 70 years old, 72 per cent normal, and growing upon a site showing an index of 60, 20 years later.

Stand Tables

A stand table is a tabular presentation of the total number of trees per acre and their distribution by diameter classes in the stand. Practically all yield tables, however, including the white pine tables given in the main body of this bulletin, show only the total number of trees in the stand at different ages without an indication of how these trees are distributed among the different diameter classes. In actual practice it is not enough to know what the total number of trees in the stand may be, but it is also important to know how many trees there are in the stand of different sizes for this determines their utilization for lumber or other purposes.

An attempt is made here, again by the use of average diameter, to indicate not only the total number of trees of all sizes but also the

¹⁷ Gevorkiantz, S. R. and Hosley, N. W. 1929. Form and development of white pine stands in relation to growing space. Harvard Forest Bulletin No. 13.

number in each size or group of sizes by gradations of one to several inches.

The total number of trees in and above a certain diameter class for stands of different ages, separated by poor, medium, and good sites are shown in Table XXIII. The construction of this stand table

Table XXIII.—Stand Table for Pure, Even-Aged, Fully-Stocked Second-Growth White Pine

Age Years	Number of trees per acre in and above given diameter breast high class				
	1 inch	4 inches	7 inches	8 inches	10 inches
	0.6+	2.6+	Poor Site Site index 50	7.6+	9.6+
50	930	888	354	158	12
60	730	718	438	285	62
70	605	600	454	357	139
80	510	508	423	357	184
90	440	439	386	339	211
100	385	385	357	324	227
110	356	355	335	310	235
120	330	330	315	297	234
		Medium Site ✓ Site index 60			
50	725	715	471	326	94
60	546	544	453	382	197
70	447	447	405	362	239
80	384	384	363	338	255
90	337	337	325	308	248
100	303	303	295	285	241
		Good Site Site index 70			
50	613	610	472	368	162
60	475	475	423	373	245
70	386	386	365	340	259
80	327	327	317	302	252

is based on a now well-recognized relationship between the average diameter and the number of trees in the stand. As the result of analyzing a large number of yield tables in several European countries and for different species, a definite relationship has been established between the average diameter of an even-aged, fully-stocked stand and the number of trees in each diameter class. In other words, if the average diameter of a fully-stocked stand is, say 10 inches, then the number of trees in the 1 inch, 2 inch, 11 inch and other diameter classes bears a definite relationship to the total number of trees per acre. The number of trees approaching the average size predominates, and the number of trees larger or smaller than those having the average diameter is progressively diminishing. This relationship, established for several European species, has also been tested on 80 typical fully-stocked white pine stands in Wisconsin and was proven to hold good.

It was found that regardless of age or site, stands having the same average diameter had the same range of size classes and the

Table XXIV.—Distribution of Diameters in a Fully-Stocked White Pine Stand

Diameter expressed in per cent of the average diameter	Number of trees in each diameter class	Number of trees in and below each diameter class
Per cent	Per cent	Per cent
30	.10	.10
40	.78	.88
50	2.62	3.50
60	6.00	9.50
70	9.50	19.50
80	13.00	32.00
90	15.00	47.00
100	16.00	63.00
110	13.50	76.50
120	10.00	86.50
130	6.70	93.20
140	3.80	97.00
150	2.00	99.00
160	.67	99.67
170	.26	99.93
180	.07	100.00
	100.00	

same percentage of trees in any specific diameter class. Table XXIV and Figure 10 express concretely this relationship.

If the diameter of the average tree is designated as 100 per cent then the number of trees having approximately the same diameter as the average tree will constitute 16 per cent of the total number of trees in the stand. Trees whose diameters are 90 per cent of the diameter of the average tree will form 15 per cent of the total number of trees. Trees whose diameters are only half that of the average tree will form 2.62 per cent of all trees. Similarly, trees whose diameters are one and one-half times as much as that of the average tree will constitute 2 per cent of the total number of trees, etc.

This can be made still clearer by substituting actual figures for percentages. Thus, if the total number of trees in a 50-year-old stand having a site index of 60 and an average diameter of 7.6 inches, is 730 per acre, then the number of trees in the 7.6 to 8.5 inch diameter class should be 16 per cent of the total per acre, or 117 trees. The number of trees whose diameter is approximately 3.8 inches—half the size of the average diameter should be 19. The number of trees whose diameter is about 11.4 inches—one and one-half times the average—should be 15, etc.

The distribution of all trees in a fully-stocked, even-aged stand may also be expressed cumulatively by considering the total number of trees in and below a given diameter class. It can be seen, for instance, (Table XXIV.) that 32 per cent of all trees per acre have diameters which are equal to or less than 85 per cent of the diameter of the average tree, 63 per cent of all trees have diameters equal to or less than those of the average tree class (100 per cent), 99 per cent of all trees have diameters equal to or less than 150 per cent of the diameter of the average tree, etc. These cumulative values were

plotted on special cross-section paper and a curve drawn through the points (Figure 10.)

On the basis of the relationship between the average diameter and the number of trees of different diameters in the stand shown in Table XXIV and Figure 10, the stand tables for white pine were constructed* (Table XXIII).

It must be understood, however, that these stand tables are applicable only to normal or fully-stocked stands. Well-stocked stands, not quite normal, may show about the same distribution of diameters as normal stands but since it is not known at what degree of stocking the relationship ceases to hold, it is best not to apply such stand tables to any but fully-stocked, even-aged white pine second-growth.

Checking Volume Tables

If it is at all possible, the applicability of any volume table should be checked by comparing the values given in the table with volume as scaled and computed in the field for trees representing several diameter and height classes. This may be done by felling about 25 trees and computing their volume by the standard method. The computed volumes are then compared to the values given in the table to see whether they are more or less, and the difference is called the plus or minus deviation. These deviations are then expressed as percentages of the volumes given in the table. The actual volumes of the measured trees are then totalled. This is then compared with the total volume as read from the volume table for trees of the same size, and the difference between the two is expressed in percentage of the sum of the volumes as taken from the volume table. This value is

*A more elaborate discussion of this method of constructing stand tables is now in preparation.

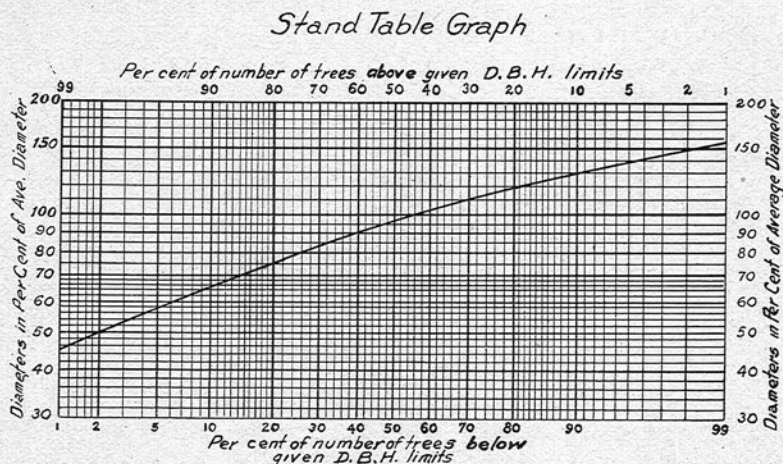


Fig. 10.—STAND TABLE GRAPH

called the aggregate difference. If the average deviation of the felled trees does not differ considerably from that of the table, and if the aggregate difference of the sample is not more than $2\frac{1}{2}$ times the average deviation of the table divided by the square root of the number of felled trees, then the volume table in question may be considered applicable to the locality. If 25 trees, well distributed by diameter and height classes, are used for the test in each case, this rule may be further simplified. This second scheme requires that the aggregate difference of felled trees should not be more than one-half of the average deviation of the table. For example, if the average deviation of individual tree volumes from the table value in cubic feet is ± 4.61 per cent (Table II.) the allowable deviation for the aggregate difference is ± 2.3 per cent.

Bark Factor

The ratio between the diameter of a tree at breast high outside bark and the diameter at the same point inside bark is the "bark factor." If the bark factor is known, the double thickness of the bark can be obtained by multiplying the diameter as measured outside the bark by the bark factor. While this ratio remains constant within narrow limits the actual double bark thickness varies with the size of the tree. For white pine, the ratio between the diameter outside bark and inside bark was found to range from 0.85 to 0.96 with an average of 0.91. If it is, therefore, desired to determine what the bark thickness of a 10-inch tree is as measured outside bark, its diameter is multiplied by the factor 0.91 which gives the diameter inside bark as 9.1 inches. The difference between the diameter breast high outside bark, 10 inches, and the diameter inside bark, 9.1 inches, is 0.9 inch which is the double thickness of the bark of a 10-inch tree. In case of a 5-inch tree, the inside diameter is 5 inches X .91 or 4.6 inches and the double bark thickness is .4 inch.

Common and Scientific Names of Shrubs and Herbaceous Vegetation in the Text

(Gray's Manual of Botany. Seventh Edition)

Common Names	Scientific Names
Baneberry	<i>Actaea alba</i> (L.) Mill.
Birthroot	<i>Trillium grandiflorum</i> (Michx.) Salisb.
Blueberry	<i>Vaccinium pennsylvanicum</i> Lan.
Braken fern	<i>Pteris aquilina</i> L.
Bush honeysuckle	<i>Diervilla lonicera</i> L.
Club moss	<i>Lycopodium obscurum</i> L.
Down yellow violet	<i>Viola pubescens</i> Ait.
False Solomon's seal	<i>Smilacina racemosa</i> (L.) Desf.
Gray dogwood	<i>Cornus paniculata</i> L'Her.
Greenbrier	<i>Smilax rotundifolia</i> L.
Hepatica	<i>Hepatica triloba</i> Chaix H. acuti- loba DC.
Jack-in-the-pulpit	<i>Arisaema triphyllum</i> L.
Lady fern	<i>Asplenium filix-femina</i> (L.) Bernh.
Maidenhair fern	<i>Adiantum pedatum</i> L.
Mandrake	<i>Podophyllum peltatum</i> L.
Milkwort	<i>Polygala paucifolia</i> Willd.
Pipsissewa	<i>Chimaphila umbellata</i> (L.) Nutt.
Prickly ash	<i>Zanthoxylum americanum</i> Mill.
Shield fern	<i>Aspidium spinulosum</i> (O. F. Mull- er) Sw.
Sweet fern	<i>Myrica asplenifolia</i> L.
Sweet Cicely	<i>Osmorhiza claytoni</i> (Michx.) Clarke
Solomon's seal	<i>Polygonatum biflorum</i> (Walt) Ell
Trailing arbutus	<i>Epigaea repens</i> L.
Twin flower	<i>Linnaea borealis</i> L.
Wintergreen	<i>Gaultheria procumbens</i> L.
Yellow-wood sorrel	<i>Oxalis stricta</i> L.
Alternate-leaved dogwood	<i>Cornus alternifolia</i> L. f.
Arrow-wood	<i>Viburnum dentatum</i> L.

