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Volume Tables
Plantation Grown White Pine,
PINUS STROBUS, L.

IN CONNECTICUT

HENRY W. HICOCK, ARNOLD D. RHODES AND A. RICHARD OLSON

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Connecticut
Agricultural Experiment Station
New Haven

Volume Tables For Plantation Grown White Pine

Henry W. Hicock, Arnold D. Rhodes
and A. Richard Olson*

PREFACE

During the last 40 years many thousands of acres of coniferous plantations have been established throughout the East. Northern white pine, *Pinus Strobus*, L., has been the species most commonly planted. In Connecticut alone some 10,000 acres have been set out to this species, either pure or in mixture with other conifers. Today the older plantations are producing merchantable material, the best stems measuring 12 to 14 inches in diameter at breast height and 50 to 60 feet tall. Already profitable thinnings have been made on a commercial scale in stands less than 30 years of age. In the future an ever increasing number of such stands will attain merchantable proportions.

Where efforts have been made to determine the volume of standing timber or to predict growth and yield, it has become increasingly evident that existing volume tables are unsuitable. Such tables, based on natural stands of large timber, prove inadequate when applied to plantation grown trees of dimensions only slightly greater than the lower limits of merchantability. Furthermore, the adaptation and correction of these tables to fit the desired conditions seems a less reasonable and less satisfactory solution than the construction of new tables made for and from plantation grown timber.

The hurricane of 1938 afforded the opportunity for carrying out such a project. At that time the School of Forestry, Yale University, with the aid of funds from the Charles Lathrop Pack Foundation, coöperated with the Connecticut Agricultural Experiment Station in gathering the necessary taper measurements from wind-thrown plantation trees. From these data, three volume tables for white pine have been constructed, two in cubic feet and one in board feet. Labor for the field work was provided by the Civilian Conservation Corps and the National Youth Administration.

Five hundred and thirteen trees were measured at the Rainbow Forest in East Granby and Windsor in plantations of the Connecticut Agricultural Experiment Station, and 323 in the vicinity of New Haven on the Eli Whitney Forest of the New Haven Water Company. In addition, 95 taper measurements, which had been previously taken by the Yale School of Forestry during the process of thinning plantations, were used with those more recently secured, making a total of 931 such measurements available for the construction of the volume tables. Of this number, 747 were incorporated into the board foot table and 921 into the two cubic foot tables.

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DESCRIPTION OF PLANTATIONS

The stands represent a wide variety of planting sites and planting conditions. The Rainbow plantations are situated on a site of very low productive capacity. The tract is part of an extensive glacial outwash plain about 160 to 180 feet above sea level. The soil is a coarse sand to a depth of many feet. Natural forest stands of the region are composed chiefly of pitch pine and inferior hardwoods such as gray birch, red maple, and black and scarlet oak. Prior to the establishment of the plantations, the land had been abandoned for ordinary agricultural crops for a number of years and was reverting to forest growth. Recently much land of a similar character has been reclaimed for the cultivation of shade grown tobacco. Its value for this purpose would be prohibitive for the growing of forest crops. The oldest plantations sampled were planted in 1902, the youngest, in 1907. Measured trees varied in breast high diameters from 2.4 to 12.0 inches, and in height from 23 to 49 feet. Growing space at the time of planting ranged from 20 to 50 square feet per tree. Thinnings were made in 1932 and 1936.

On the Eli Whitney Forest, plantations were established on soils of superior quality, representing the best sites for white pine in the region. Originally, these areas were farmed with fair success. The soil is, in the main, a good quality loam somewhat better than the usual run of forest soils. Organic content, texture and moisture conditions are excellent. Growth has been rapid and well sustained with some of the better stands supporting 8,000 to 10,000 board feet of low grade material per acre at 30 years. In all cases, plantings were made on recently cultivated fields, or on pasture or mowing fields, which were relatively free of shrub and tree growth. Spacing was 6 by 6 feet. The youngest stand sampled was 17 and the oldest, 30 years old. Breast high diameters ranged from 1.7 to 12.5 inches and heights from 16 to 55 feet.

SECURING THE FIELD DATA

In the field, the following measurements were taken on each tree:

a. Total height to the nearest tenth of a foot.

b. Diameter outside bark and bark thickness to the nearest tenth of an inch at—

1. Stump height, usually taken at 6 inches.[1]
2. Two and one-half feet above ground.
3. Breast height.
4. Intervals of one-, two-, three-, and four-fifths of the length of stem above breast height plus an additional measurement at mid-point for form quotient.

OFFICE COMPUTATIONS AND CONSTRUCTION OF TABLES

In view of the varied character of the stands sampled, particularly the differences in age, density of stocking and site conditions, it seemed desirable to examine the data for differences in tree form. Form quotients inside bark were co nputed for all trees. The range of individual quotients varied from 0.472 to 0.862. Ten of the most widely varying individuals

[1]In some cases, the position of the wind-thrown trees necessitated cutting at other levels.

were discarded, reducing these limits to 0.542 and 0.808, respectively. The average form quotient of the 921 trees used in the volume tables was 0.681.

The field measurements of the 921 trees finally accepted as being suitable were recorded on U. S. Forest Service Form 558a. For each tree, three volumes were determined: (a) total peeled volume, in cubic feet, of the stem including stump; (b) volume of the stem with bark, in cubic feet, between a stump height of 0.5 foot and a top diameter of 2.0 inches, outside bark; and (c) the volume of the stem, in board feet by the International Rule (0.25-inch saw kerf), between a stump height of 0.5 foot and a top diameter of 5.0 inches, inside bark. All volume determinations were made directly from the plotted taper measurements. Cubic contents were obtained by the conversion of planimetered areas, board foot volumes by graduated transparent overlays.[1] In the latter case, each tree was scaled as a composite of 8-foot logs plus a top log of shorter length, including allowance for stump height and trimming length. Trees with top diameters of less than 5.0 inches, inside bark, at 8.65 feet above ground were considered unmerchantable. The top log, when less than 8 feet in length, was scaled by a separate calculation in units of 2, 4, or 6 feet of length and the top diameter, inside bark, to the nearest tenth of an inch at that point. Thus, a top log which measured 7.5 feet in length to a 5.0-inch top diameter, inside bark, was treated as a 6-foot log with a top diameter, inside bark, somewhat larger than 5 inches. Since this top diameter rarely exceeded 5.5 inches, the possible combinations of diameter and length were so few that it was a simple matter to make up a table giving the volume of any combination at a glance.

The three sets of volumes, properly arranged and tabulated, were worked into tables by the alinement chart method as described by Bruce and Reineke.[2] Base charts were furnished by the U. S. Forest Service. The resulting volume tables and charts are presented on the following pages. Tables 1, 2, and 3 were read from Charts I, II and III, respectively. The alinement charts are somewhat easier to use for fractional diameters and odd heights because interpolation is unnecessary. If diameters are grouped by whole inch classes and heights by 5- or 10-foot classes, the tables are preferable.

Two measures of accuracy were applied to the completed alinement charts, the aggregate difference in percent and the average percentage deviation. The first measure compares the sum of all the measured volumes with the sum of the corresponding chart volumes for the same trees. By this standard, Charts I, II and III give volumes 0.08 percent low, 0.03 percent low and 0.06 percent low, respectively. These charts obviously fit the basic data, in the aggregate, well within the 1 percent tolerance usually allowed.[3]

The second measure is an average of the deviations of the measured volumes from their corresponding chart volumes, each deviation being ex-

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[1]Reineke, L. H. The Determination of Tree Volume by Planimeter. Journal of Forestry, 24: 183-189, 1926.

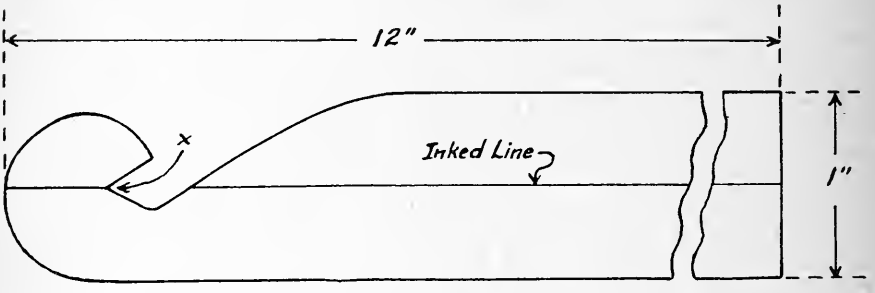
[2]Reineke, L. H. and Bruce, Donald. An Alinement-Chart Method for Preparing Forest Tree Volume Tables. Technical Bul. No. 304 U.S.D.A. Washington, 1932.

[3]Item 37a, Committee Report: Methods of Preparing Volume and Yield Tables. Journal of Forestry, 24. 653-666, 1926.

pressed as a percent of the corresponding chart value. These values for Charts I, II and III are 4.59 percent, 4.70 percent and 8.5 percent, respectively.

READING THE ALINEMENT CHART

A straightedge is necessary for reading the alinement chart. One made of a strip of transparent celluloid with a fine line scratched on the underside throws no shadow and makes reading accurate and rapid. The dimensions of the strip should be about 1 by 12 by 1/32 inches. The heavier grade of celluloid used for automobile side curtains is entirely satisfactory. To construct: (see sketch below) Scribe a very fine, straight line down the middle. Remove any burr with the thumb nail, and rub India ink into the line to make it more visible. Near one end of the straightedge, cut a V-notch as shown, being careful that the inked line bisects the angle at "X" formed by the sides of the notch. A needle mounted in a cork with the point exposed completes the equipment needed.



The volume of a tree of any given dimensions may be obtained from the chart by connecting its D.B.H. value on the left hand scale with its total height value on the right hand scale by a straight line, and reading volume at the intersection of this line with the middle scale. For example, to secure the volume of a tree 6.3 inches D.B.H. and 38.2 feet in total height using Chart I, place the point of the needle on the diameter scale at 6.3 inches, hook the straightedge around the needle and pivot it until the inked line intersects the height scale at 38.2 feet. The volume, 4.05 cubic feet, will be found at the intersection of the inked line with the volume scale.

The long axis of the needle should always be held perpendicular to the surface of the chart and the inked line should always be on the underside of the straightedge next to the chart.

APPLICATION OF THE VOLUME TABLES

As previously stated, the data for the volume tables included were secured entirely in Connecticut. If the tables are to be used in other regions, their applicability should be tested. To do this, fell 20 to 25 trees, selected to give a good range of diameters and heights, and measure after the manner employed in the construction of the table. Compute the volumes of these trees by standard methods using the same units (cubic feet or board feet) and the same limits of utilization as in the table.

Express the deviation for each tree as a percentage of the tabular volume of a tree of the same dimensions. Compute the average of these percentage deviations for comparison with the average percentage deviation as shown in the table.

Compare the total volume of the felled trees with the total of the tabular volumes of these trees to arrive at the aggregate difference. If the average percentage deviation of the local trees is not appreciably greater than that of the table, and if their aggregate difference is not more than two and one-half times the average percentage deviation of the table divided by the square root of the number of trees used in the test, correction for locality is unnecessary.

If the volumes of the local trees differ consistently from the tabular values, the table should be corrected. If the table is to be used for limits of utilization other than those used in its construction, it must be corrected to give volumes adjusted to the new limits.[1]

A volume table for local use, reading in terms of diameter only, may be made as follows:

1. Obtain sufficient heights in the field to plot a height-on-diameter curve. From this, read heights corresponding to one-inch diameter classes and tabulate, as in column 2 of the table below.

2. From the chart, read the volumes for the several paired diameter-height values and enter these in column 3 of the table.

D.B.H. in Inches (1)	Total Height in Feet (2)	Volume in Cubic Feet[2] (3)
2.0	14.4	.16
3.0	17.7	.44
4.0	20.3	.87
5.0	22.7	1.52
etc.	etc.	etc.

Columns 1 and 3 now constitute a local table reading in terms of full inches of diameter. These values may be curved to discover errors in chart reading or to provide for fractional-inch diameters.

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[1]For information on the correction of volume tables for locality and for different limits of utilization, the reader is referred to Miscellaneous Publication No. 50, U. S. Department of Agriculture, Washington, D. C. Volume, Yield and Stand Tables for Second-Growth Southern Pines, prepared by Office of Forest Experiment Stations, Forest Service, and Cooperating Agencies.

[2]Read from Chart I.

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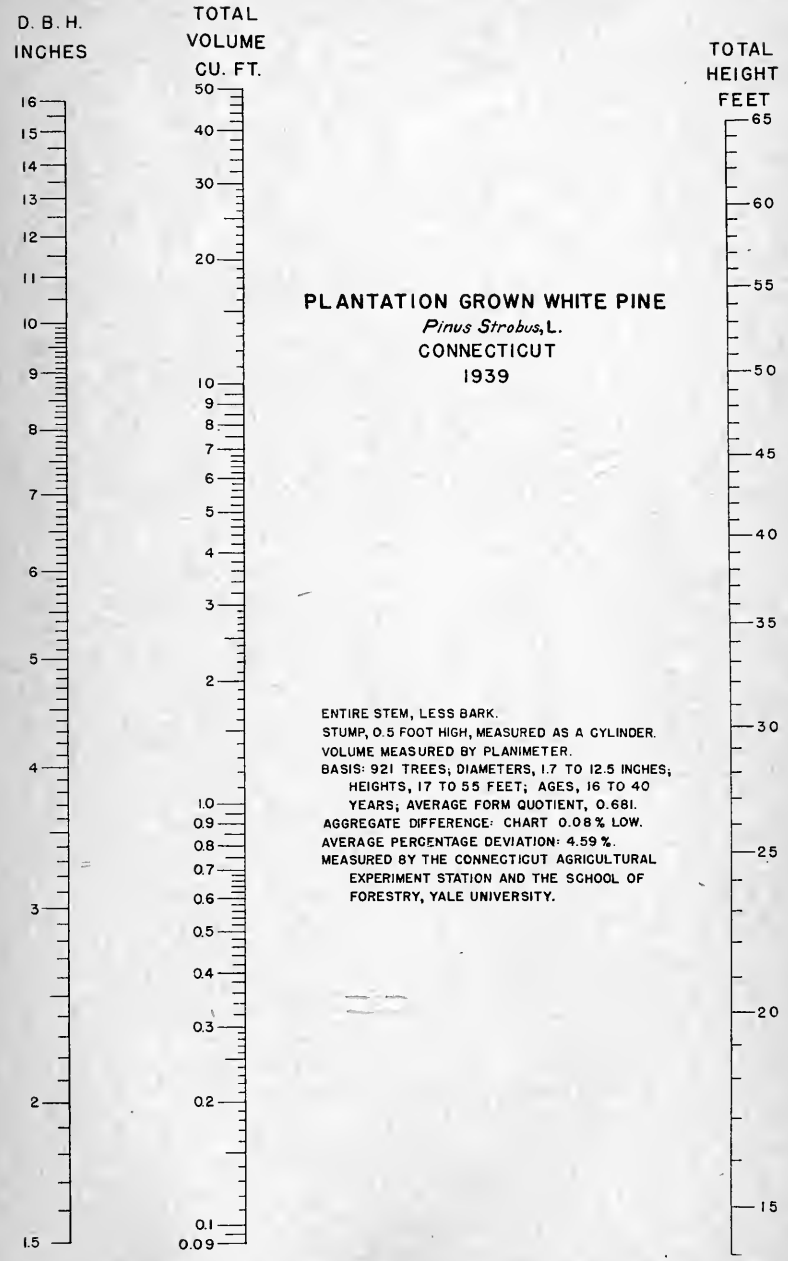

Chart I. Alinement chart for volumes of plantation grown white pine showing total contents of the stem, without bark, in cubic feet.

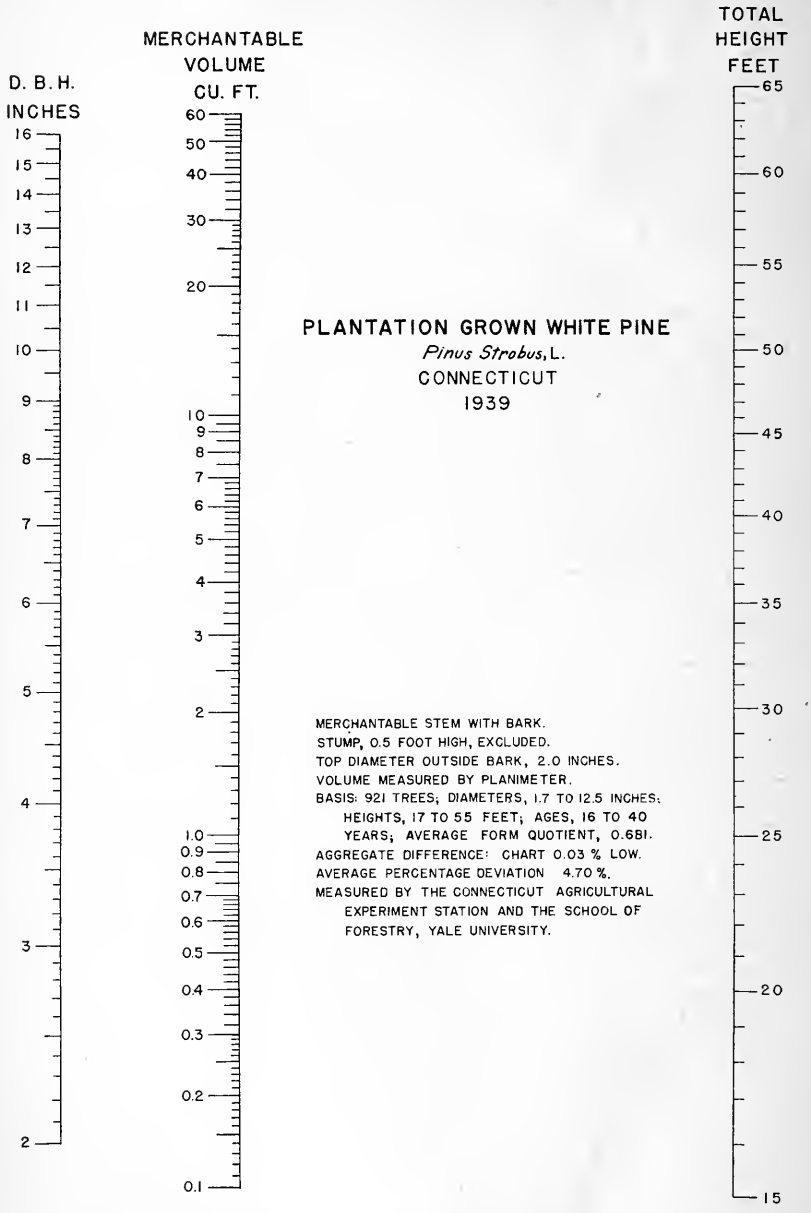

Chart II. Alinement chart for volumes of plantation grown white pine showing merchantable contents of the stem, including bark, in cubic feet.

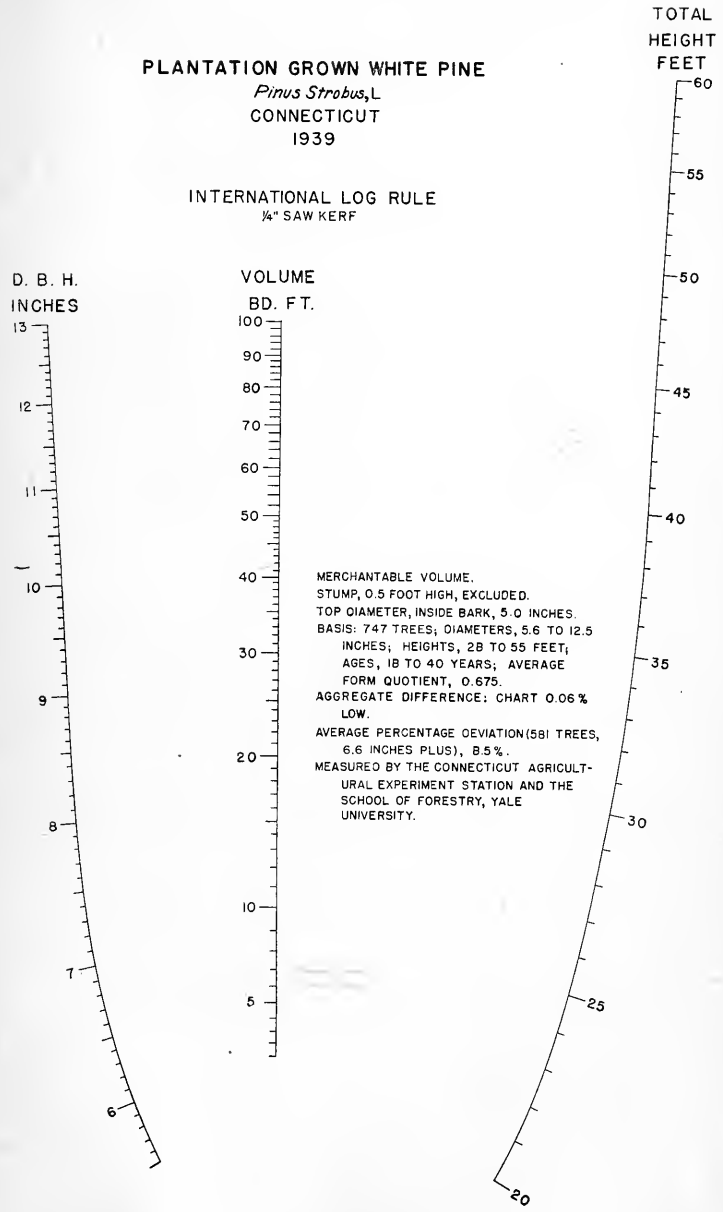

Chart III. Alinement chart for volumes of plantation grown white pine showing merchantable contents of the stem, without bark, in board feet.

TABLE 1. VOLUME TABLE FOR PLANTATION GROWN WHITE PINE SHOWING TOTAL CONTENTS OF THE STEM, WITHOUT BARK, IN CUBIC FEET. STUMP 0.5-FOOT HIGH MEASURED AS A CYLINDER. AGGREGATE DIFFERENCE: TABLE 0.08 PERCENT LOW. AVERAGE PERCENTAGE DEVIATION, 4.59 PERCENT. CONNECTICUT, 1939. READ FROM CHART I.[1]

Diameter Breast High, Inches	Total Height in Feet											Basis, Number of Trees
	15	20	25	30	35	40	45	50	55	60	65	
	Volume in Cubic Feet											
2	0.17	0.23	0.28	0.34	.....	.....	.....	.....	.....	.....	.....	2
3	0.37	0.49	0.62	0.74	0.86	0.98	.....	.....	.....	.....	.....	31
4	0.65	0.86	1.08	1.31	1.52	1.73	1.96	.....	.....	.....	.....	61
5	.....	1.33	1.68	2.03	2.34	2.66	3.00	.....	.....	.....	.....	80
6	.....	.....	2.39	2.88	3.34	3.80	4.28	4.83	.....	.....	.....	166
7	.....	.....	3.26	3.92	4.54	5.19	5.80	6.58	.....	.....	.....	174
8	.....	.....	.....	5.08	5.89	6.70	7.49	8.50	9.65	.....	.....	166
9	.....	.....	.....	6.39	7.35	8.40	9.45	10.70	12.05	13.60	15.40	140
10	.....	.....	.....	.....	9.10	10.25	11.50	13.00	14.83	16.70	18.96	67
11	.....	.....	.....	.....	10.80	12.30	13.90	15.70	17.80	20.30	23.00	26
12	.....	.....	.....	.....	.....	14.50	16.40	18.50	21.30	23.80	26.70	8
13	.....	.....	.....	.....	.....	17.00	19.20	22.00	24.60	27.50	31.00	.....
14	.....	.....	.....	.....	.....	.....	22.20	24.70	28.00	31.20	35.20	.....
15	.....	.....	.....	.....	.....	.....	.....	28.20	31.80	35.60	40.40	.....
16	.....	.....	.....	.....	.....	.....	.....	31.60	35.70	40.30	45.60	.....
Basis, Number of Trees	1	5	34	124	218	320	197	20	2	...	...	921

[1] Heavy line indicates extent of original data.

TABLE 2. VOLUME TABLE FOR PLANTATION GROWN WHITE PINE SHOWING THE MERCHANTABLE CONTENTS OF THE STEM, INCLUDING BARK, IN CUBIC FEET, BETWEEN A STUMP HEIGHT OF 0.5 FOOT AND A TOP DIAMETER OF 2.0 INCHES, OUTSIDE BARK. AGGREGATE DIFFERENCE: TABLE 0.03 PERCENT LOW. AVERAGE PERCENTAGE DEVIATION, 4.70 PERCENT. CONNECTICUT, 1939. READ FROM CHART II.[1]

Diameter Breast High, Inches	Total Height in Feet											Basis. Number of Trees
	15	20	25	30	35	40	45	50	55	60	65	
	Volume in Cubic Feet											
2	0.13	0.19	0.25	0.31	.....	.....	.....	.....	.....	.....	.....	2
3	0.34	0.48	0.61	0.75	0.88	1.02	.....	.....	.....	.....	.....	31
4	0.64	0.89	1.14	1.39	1.63	1.85	2.08	.....	.....	.....	.....	61
5	.....	1.45	1.82	2.18	2.53	2.85	3.20	.....	.....	.....	.....	80
6	.....	.....	2.58	3.07	3.59	4.06	4.53	5.10	.....	.....	.....	166
7	.....	.....	3.48	4.16	4.82	5.46	6.20	6.96	.....	.....	.....	174
8	.....	.....	.....	5.39	6.31	7.15	8.00	9.10	10.35	.....	.....	166
9	.....	.....	.....	6.79	7.85	9.00	10.25	11.40	12.85	14.65	16.65	140
10	.....	.....	.....	.....	9.80	11.05	12.30	13.90	15.70	18.00	20.70	67
11	.....	.....	.....	.....	11.60	13.10	14.70	16.60	19.00	21.90	25.30	26
12	.....	.....	.....	.....	.....	15.20	17.20	19.60	22.40	26.10	30.40	8
13	.....	.....	.....	.....	.....	17.85	20.30	23.20	26.70	31.30	36.20	...
14	.....	.....	.....	.....	.....	.....	23.60	27.00	31.30	36.55	42.60	...
15	.....	.....	.....	.....	.....	.....	.....	31.30	36.10	42.40	49.50	...
16	.....	.....	.....	.....	.....	.....	.....	35.85	41.60	48.80	57.10	...
Basis, Number of Trees	1	5	34	124	218	320	197	20	2	.....	.....	921

[1]Heavy line indicates extent of original data.

TABLE 3. VOLUME TABLE FOR PLANTATION GROWN WHITE PINE SHOWING THE MERCHANTABLE CONTENTS OF THE STEM, WITHOUT BARK, IN BOARD FEET BY THE INTERNATIONAL LOG RULE (¼-INCH SAW KERF), BETWEEN A STUMP HEIGHT OF 0.5 FOOT AND A TOP DIAMETER OF 5.0 INCHES, INSIDE BARK. AGGREGATE DIFFERENCE: TABLE 0.06 PERCENT LOW. AVERAGE PERCENTAGE DEVIATION (581 TREES, 6.6 INCHES PLUS), 8.5 PERCENT. CONNECTICUT, 1939. READ FROM CHART III.[1]

Diameter Breast High, Inches	Total Height in Feet								Basis, Number of Trees
	25	30	35	40	45	50	55	60	
	Volume in Board Feet								
6	.....	4	7	9	10	.....	.....	.....	166
7	7	10	12	15	18	21	.....	.....	174
8	.....	15	19	24	28	32	36	.....	166
9	.....	21	27	33	38	44	51	.....	140
10	.....	.....	35	43	50	59	67	75	67
11	.....	.....	43	53	63	74	84	94	26
12	.....	.....	.....	65	77	90	102	.....	8
13	.....	.....	.....	77	92	.....	.....	.....	....
Basis, Number of Trees	1	41	166	320	197	20	2	.....	747

[1]Heavy line indicates extent of original data.

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