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Department of Northern Affairs and National Resources
FORESTRY BRANCH

TAPER CURVES AND VOLUME TABLES FOR PLANTATION RED PINE

by

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Taper Curves and Volume Tables for Plantation Red Pine

by

W. M. STIELL[1]

INTRODUCTION

The purpose of this study was to provide improved means for estimating the contents of plantation-grown red pine in Ontario. Few available volume data are directly applicable, since they are based on measurements made in stands with a different type of development—i.e. natural stands, or plantations in other regions where growth rates may differ appreciably. Further, volumes are not generally expressed in terms most convenient for the standards of utilization current in the plantations in question.

In order to meet the objectives of the project, all field work was carried out in pure red pine plantations, located in southern Ontario, and the results have been presented in what appear to be the most useful forms. This study was undertaken in 1959, at the request of the Reforestation Branch, Division of Timber, Ontario Department of Lands and Forests, who undertook marking and felling trees of the required sizes. The Forest Research Division of the Forestry Branch made all measurements, and the author assumed responsibility for securing the data and making the compilations on which this report is based.

METHODS

Stands

The plantations had all been row-planted on old-field sites, at an average spacing of about 6 by 6 feet. Ages ranged from 17 to 35 years from planting. Survival had been high. The stands were healthy and stem form was generally good, with occasional forks, or crooks resulting from snow breakage, the principal defects likely to influence the factors under investigation. Some stands, particularly the older ones, had received one or more thinnings.

Field Work

All measurements were made on full-length felled and limbed trees, on which breast height had been marked before cutting. Some of these trees were felled as part of a regular thinning program, others were cut especially for this project.

Tree Sizes

Measurements were taken throughout the available range of merchantable sizes. Where possible, 10 trees in each one-inch diameter and five-foot height class were measured. In this way the diameter range sampled was 3 to 10 inches, and the height range was 25 to 60 feet.

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[1]Forestry Officer, Forestry Branch, Dept. Northern Affairs and National Resources, Ottawa.

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Measurements

The following measurements were taken on each tree:

(1) Stump height.
(2) Height above breast height.
(3) Diameter outside bark, and bark thickness (sum of two measurements at different points on the circumference) at:
    (a) Stump height.
    (b) Breast height.
    (c) Tenths of height above breast height.

Height measurements were taken with a metallic tape, to the nearest tenth of a foot. Diameter (measured with a tape) and bark thickness (measured with a Swedish bark gauge) were recorded to the nearest hundredth of an inch.

Where measurement points fell at branch nodes, or at small local deformities, the tape was moved up or down the stem to where the normal rate of taper appeared to be resumed. Badly damaged or defective trees were rejected.

Compilation

Form-class

Inside-bark measurements were obtained for all diameters by subtracting double bark thickness from outside-bark values. The form-class, i.e. the ratio of d.i.b. at half the height above breast height to d.b.h. (i.b.), was computed for each tree. The data were then grouped by one-inch d.b.h. (o.b.) and five-foot height classes.

While some variation in form-class was found within each of these groups, there was no consistent association of form-class and age between stands of different ages making up the same height and diameter group. It was concluded, therefore, that the height and diameter groups used here were small enough adequately to define changes in tree size and form-class, and that there would be no advantage in classifying further on age.

Taper Curves

For each one-inch d.b.h. (o.b.) and five-foot height class, the d.i.b. and height values were summed and averaged. Average total height was adjusted to the even five feet of the height class, and actual heights at the various diameter measurement points up the stem were adjusted proportionately—i.e. by applying the ratio average total height/five-foot class height.

For each height class, d.i.b. was plotted over height above ground, by d.b.h. (o.b.) classes, and free-hand curves were fitted to the points. These curves were refined in the usual manner, first by plotting d.i.b. over d.b.h. (o.b.) by height above ground, and then by re-plotting in the original form. It was found that the original data were so consistent that smooth curves, from which there were remarkably few deviations, could be fitted to the initial plot. It was considered that these curves indicated the correct relationships, and subsequent harmonizing was used chiefly to adjust values to the even inch classes, and little attempt was made to produce series of curves with equidistant vertical intervals. In a few cases, where sample data were lacking, yet the size class seemed likely to exist, additional curves were extrapolated. The final taper curves are presented as Figures 1 to 8.

These curves will be useful primarily for estimating the numbers of roundwood products in trees of different size. The curves readily accommodate any combination of stump height, and product specifications of length and of top and butt diameter. At present, dimensions have been standardized for only two red

pine roundwood products within the sizes defined by these curves—transmission poles and reinforcing stubs. Table 1 shows, for each standard pole class, the longest pole available in a tree of given height and diameter, above a 6-inch stump. The table was prepared by applying the specifications set forth by the Canadian Standards Association[2] directly to the curves, and thus represents average utilization for each height and diameter class. (Table 1a, which has been adapted from the CSA Specification, indicates the standard pole dimensions.) Similarly, Table 2 shows the largest reinforcing stub contained in each height and diameter class, according to the standard dimensions given in Table 2a.

Taper curves can also be used in the construction of volume tables, as shown in the following sections.

Total Volume

Total tree volumes in cubic feet were calculated by applying Newton's formula[3] to 5-foot sections, and summing the section values. Diameters at the base, mid-point, and top of each section were read directly from the taper curves. Tree volumes were plotted over d.b.h. (o.b.) by height class, and curves were fitted and harmonized by the usual procedure for three variables.

Total volumes are presented in Table 3. Their main value will be in studies of growth and yield.

Merchantable Cubic Volume

These volumes are for 50-inch bolts, to the nearest whole bolt, and to a top d.i.b. of not less than 3 inches, above a stump height of 6 inches. The general procedure used for calculating total volumes was used again here. In applying the formula, however, the diameters used were those at the ends and middle of 50-inch sections, but the section length was taken as 48 inches, to conform with scaling practice.

Merchantable cubic volumes are shown in Table 4. They will be useful for estimating tree contents in terms of 4-foot pulpwood—a standard product of early plantation thinnings.

Merchantable Board Foot and Cubic Volumes

Board foot volumes were calculated for trees containing at least one log 8 feet 3 inches long to a minimum top d.i.b. of 6 inches, above a 6-inch stump. The number and size of logs, to the nearest whole foot of length (plus 3 inches trim allowance), for each height and d.b.h. (o.b.) class was determined from the taper curves. Board foot volumes for each class were then obtained by applying the Ontario Log Rule. Volume/diameter curves were again harmonized to produce the final values. The merchantable cubic volume for 50-inch bolts contained in the remaining portions of the same trees was also calculated.

These board foot and cubic volumes are shown in Table 5. They represent the potential sawlog and pulpwood utilization of trees 7 inches d.b.h. and over.

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[2]Canadian Standards Association. 1960. Specification for the physical properties of jack, lodgepole and red pine poles and reinforcing stubs. (Third Ed.). 015.3.

[3]Section volume = (Length/6) (area base + 4 × area middle + area top).

TAPER CURVES *for* PLANTATION RED PINE

by one-inch d.b.h. (o.b.) classes

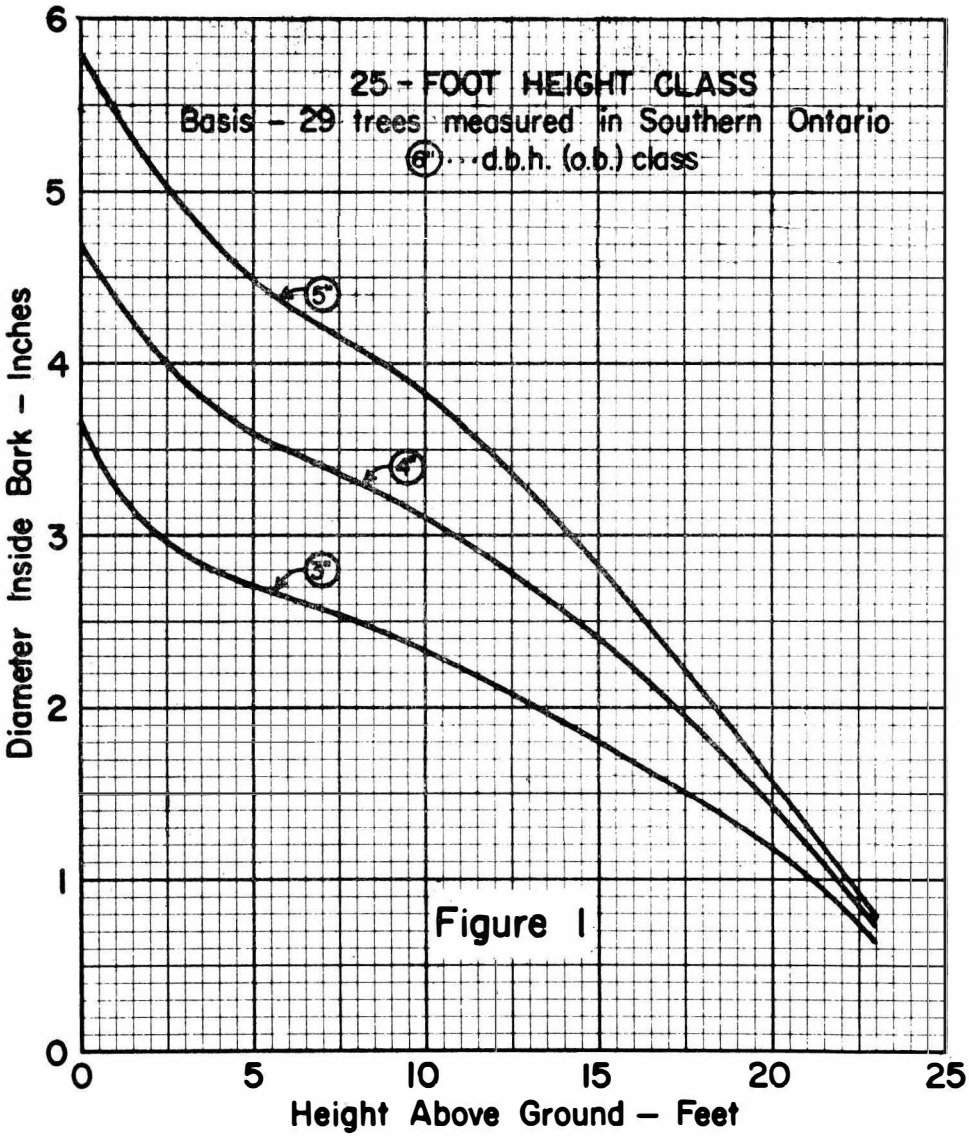

Figure 1

TAPER CURVES *for* PLANTATION RED PINE

by one-inch d.b.h. (o.b.) classes

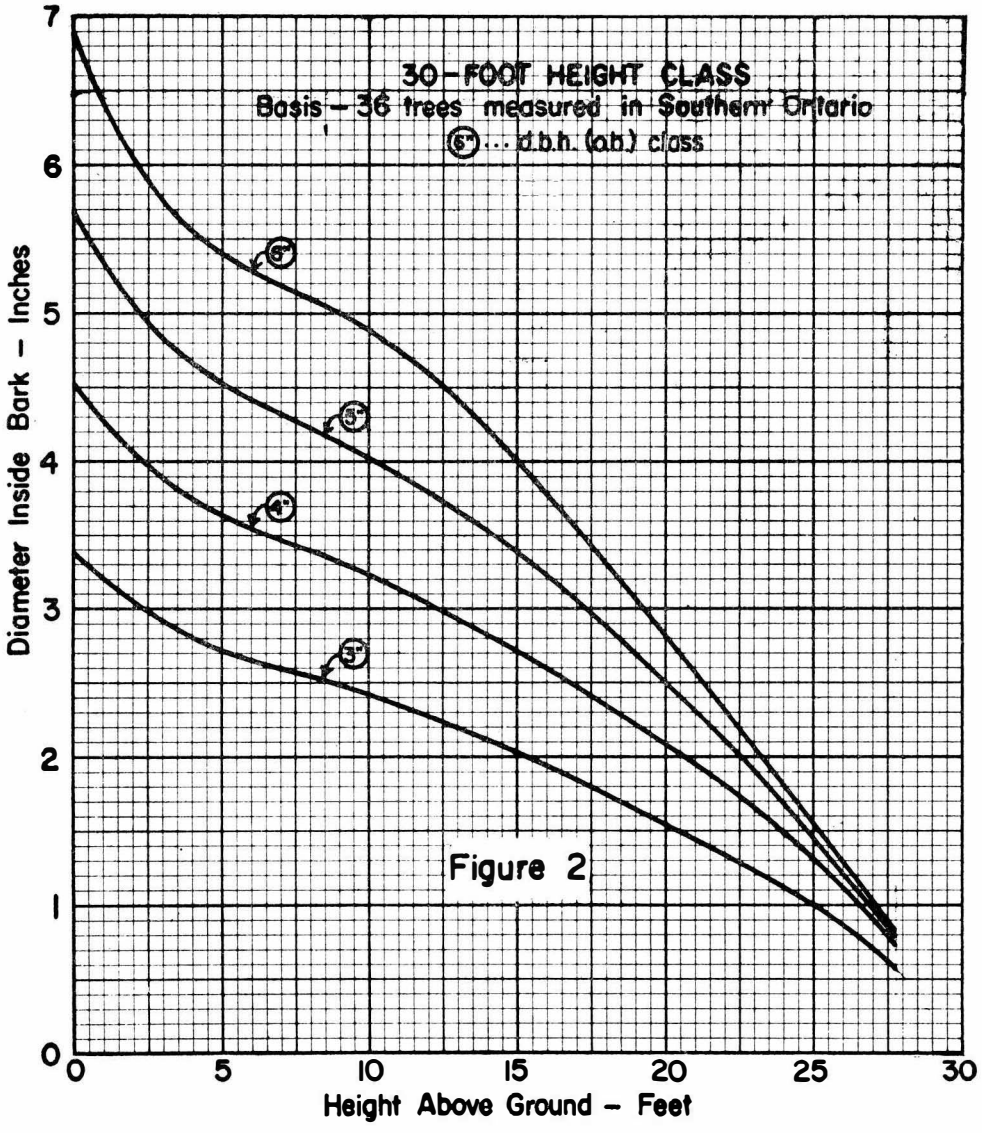

Figure 2

TAPER CURVES *for* PLANTATION RED PINE
by one-inch d.b.h. (o.b.) classes

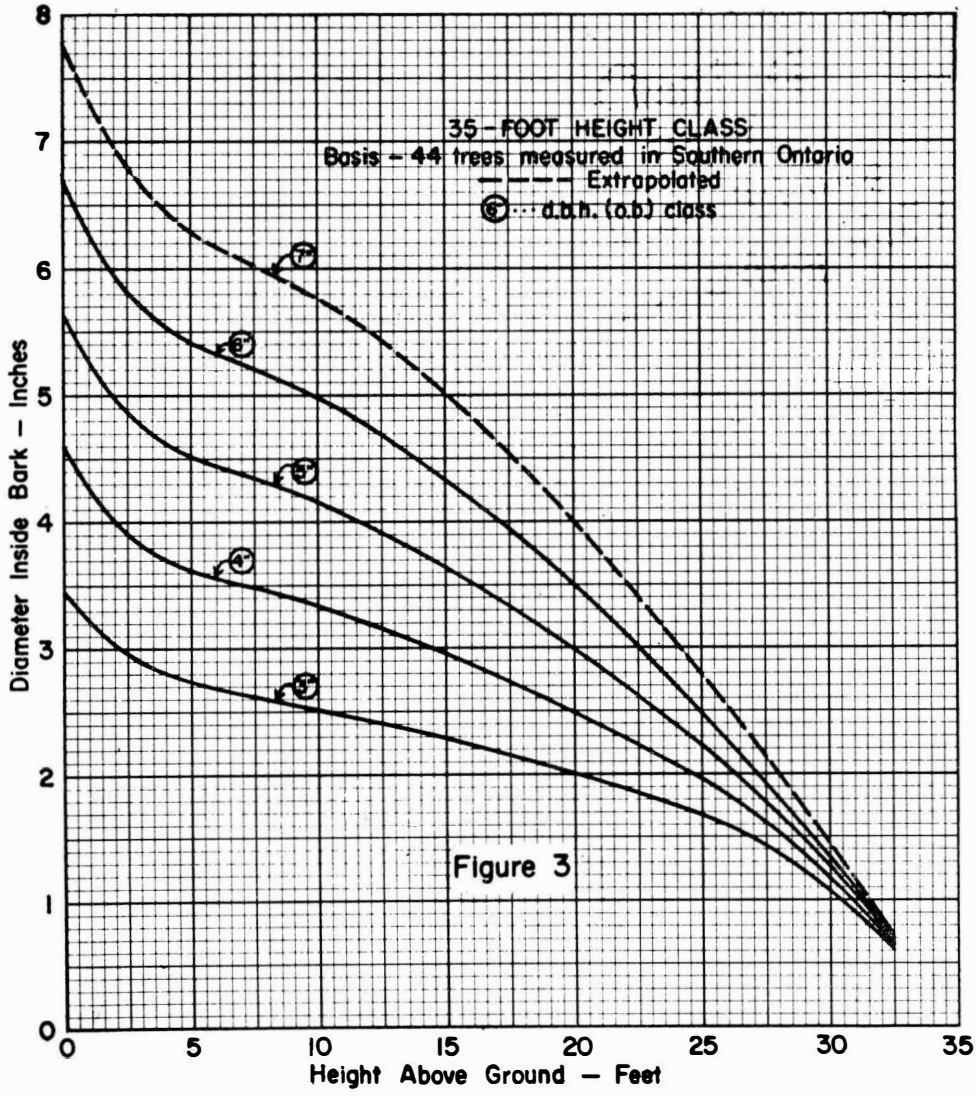

Figure 3

TAPER CURVES *for* PLANTATION RED PINE
by one-inch d.b.h. (o.b.) classes

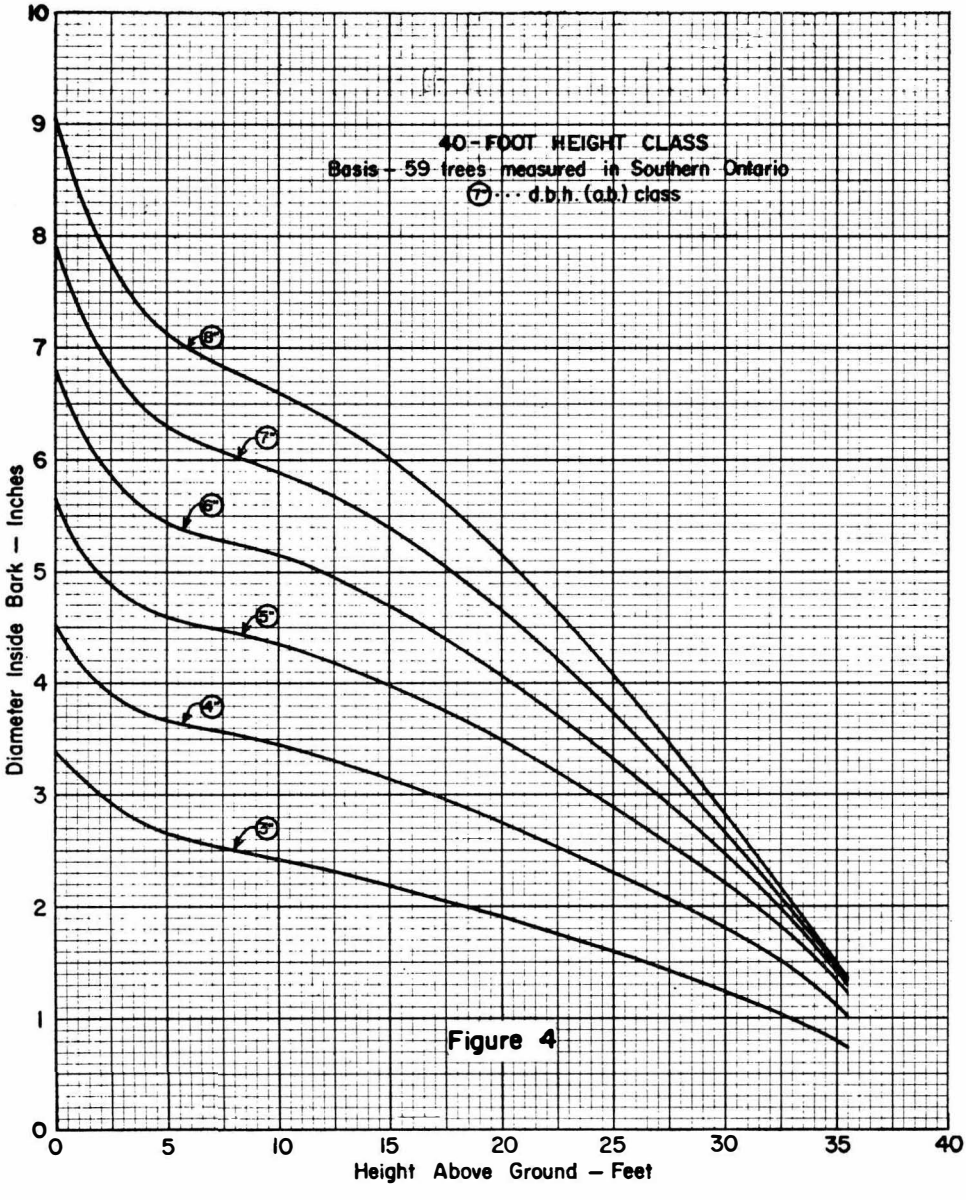

Figure 4

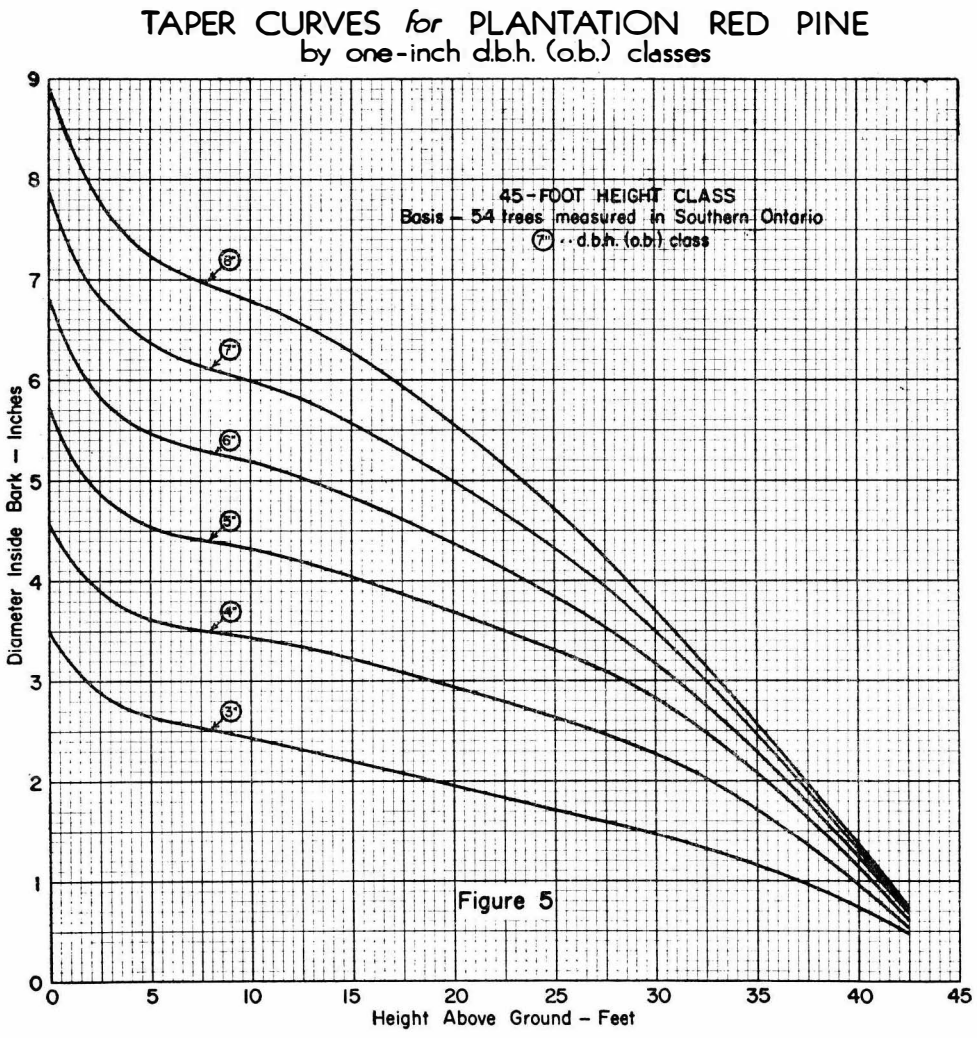
TAPER CURVES for PLANTATION RED PINE
by one-inch d.b.h. (o.b.) classes
45-FOOT HEIGHT CLASS
Basis – 54 trees measured in Southern Ontario
(7") .. d.b.h. (o.b.) class
8"
7"
6"
5"
4"
3"
Diameter Inside Bark – Inches
Height Above Ground – Feet
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45

Figure 5

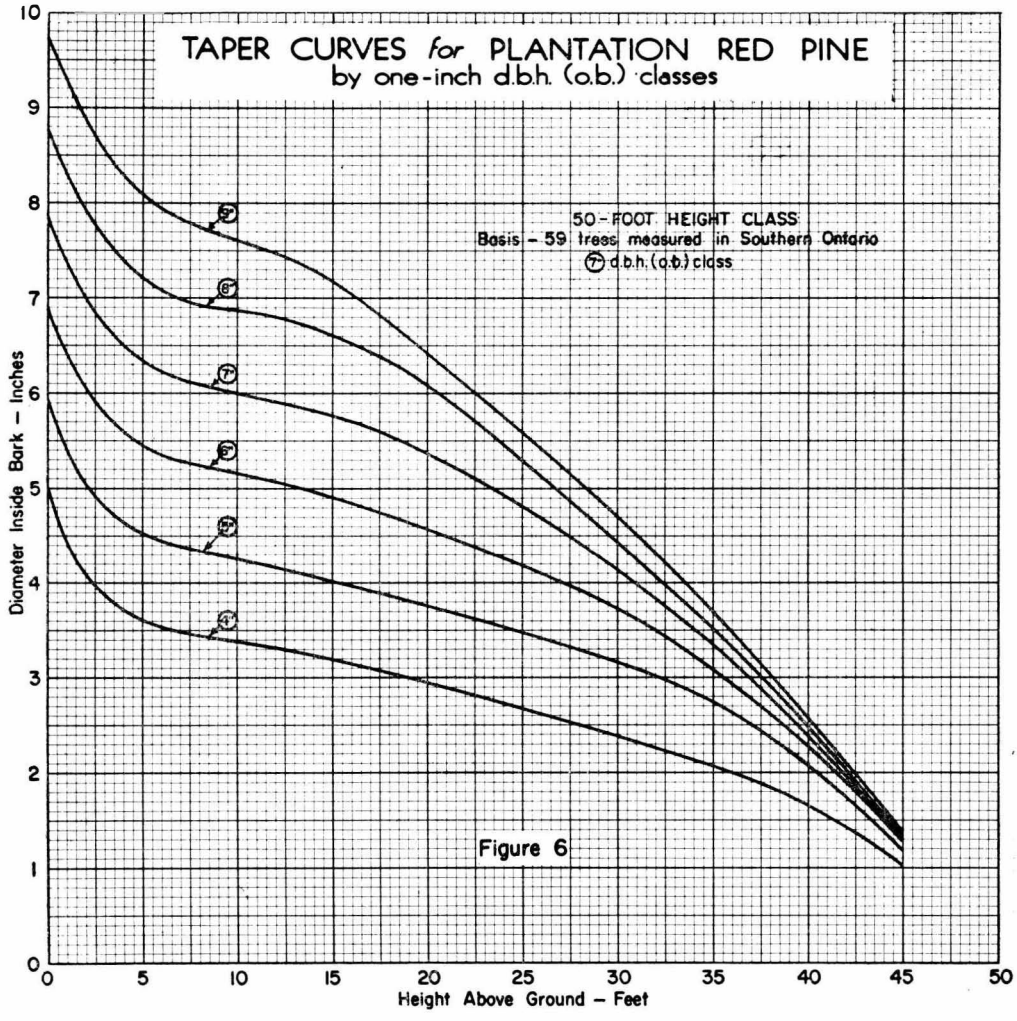
TAPER CURVES for PLANTATION RED PINE
by one-inch d.b.h. (o.b.) classes
50-FOOT HEIGHT CLASS
Basis - 59 trees measured in Southern Ontario
(7") d.b.h. (o.b.) class
Diameter Inside Bark - Inches
Height Above Ground - Feet
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35
40
45
50

Figure 6

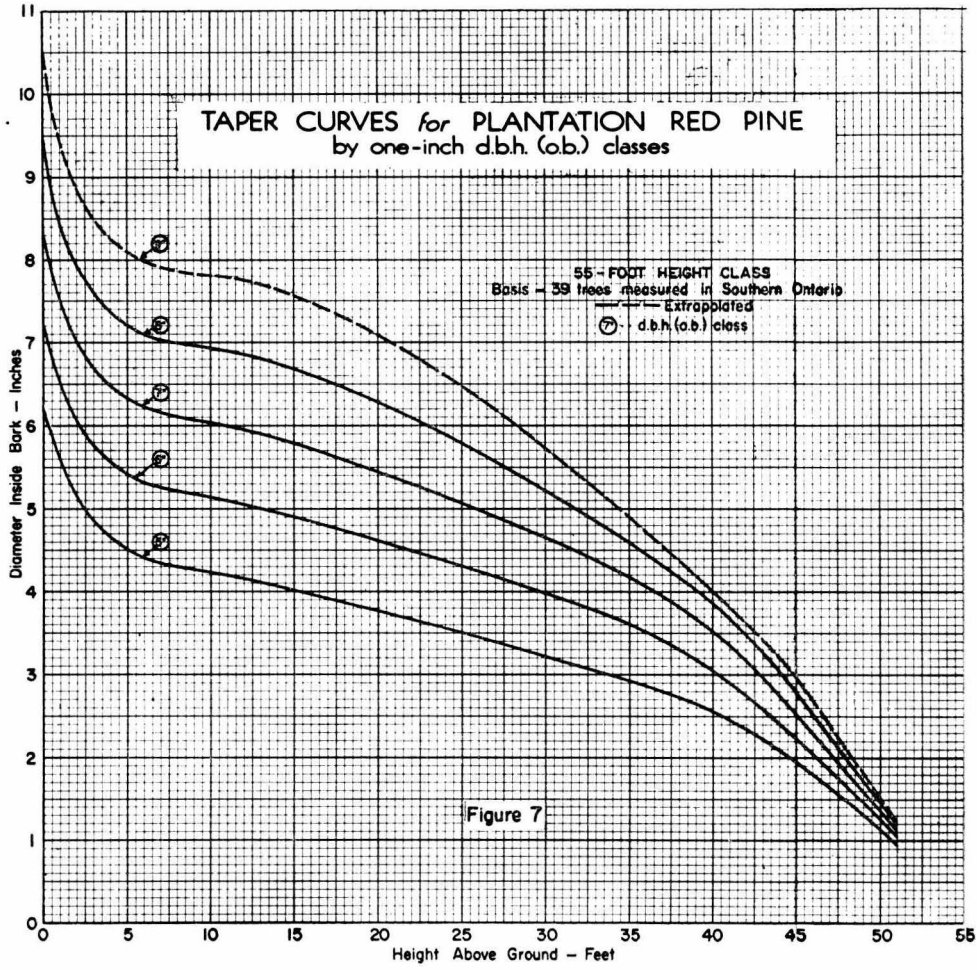
TAPER CURVES for PLANTATION RED PINE
by one-inch d.b.h. (o.b.) classes
55 - FOOT HEIGHT CLASS
Basis - 39 trees measured in Southern Ontario
Extrapolated
(7) - d.b.h. (o.b.) class
Diameter Inside Bark - Inches
Height Above Ground - Feet
0
1
2
3
4
5
6
7
8
9
10
11
0
5
10
15
20
25
30
35
40
45
50
55

Figure 7

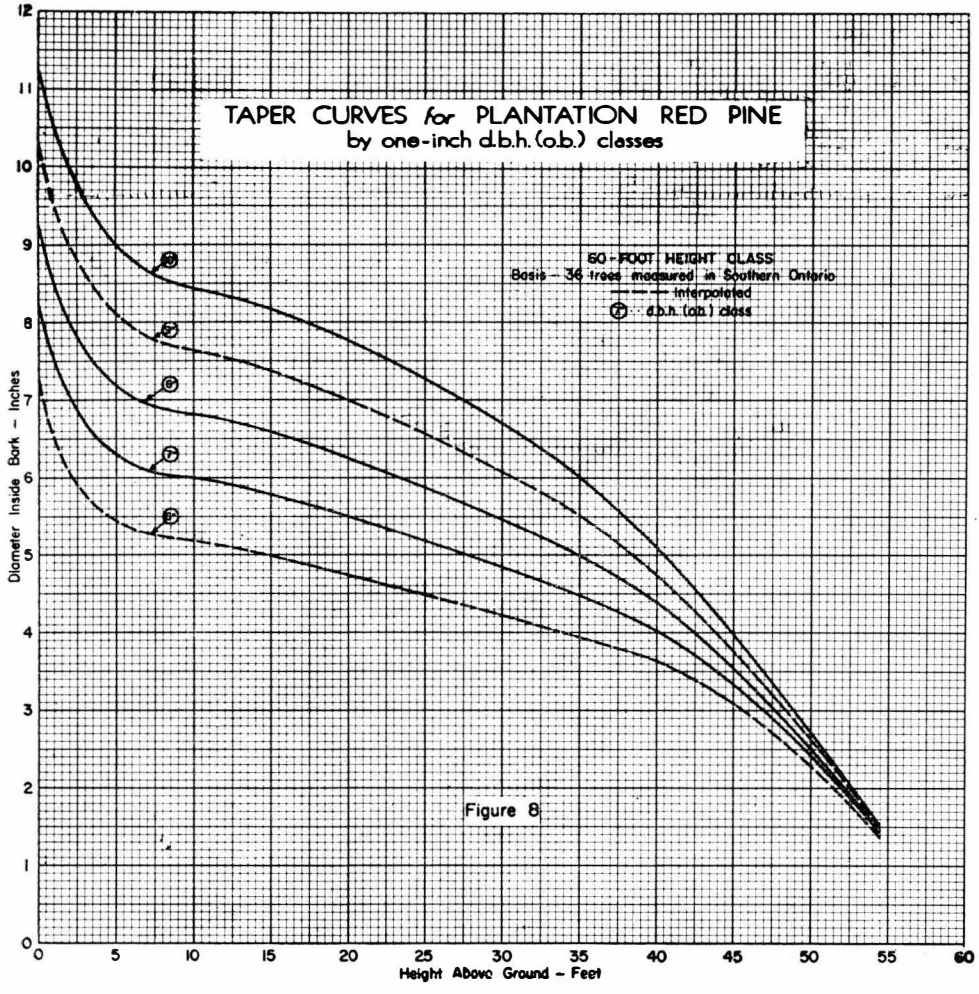
TAPER CURVES for PLANTATION RED PINE
by one-inch d.b.h. (o.b.) classes
50-FOOT HEIGHT CLASS
Basis – 36 trees measured in Southern Ontario
interpolated
d.b.h. (o.b.) class
Diameter Inside Bark – Inches
Height Above Ground – Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
0
5
10
15
20
25
30
35
40
45
50
55
60

Figure 8

Table 1. Plantation Red Pine
Alternative Pole Utilization

Tree Diameter Class	Tree Height Class					
	35′	40′	45′	50′	55′	60′
	Longest Pole Available (Pole Class-Length)					
5″	—	10–16′	10–16′	10–18′	10–18′	—
6″	10–16′	10–20′	10–22′	9–16′ 10–25′	9–16′ 10–25′	9–18′ 10–25′
7″	10–20′	8–18′ 10–22′	8–18′ 9–20′ 10–25′	8–18′ 9–22′ 10–25′	8–18′ 9–25′ 10–25′	8–18′ 9–30′ 10–25′
8″	—	6–16′ 7–20′ 8–20′ 10–25′	6–18′ 7–20′ 8–22′	6–18′ 7–20′ 8–25′	6–18′ 7–20′ 8–25′ 9–30′	6–18′ 7–20′ 8–25′ 9–30′
9″	—	—	—	5–18′ 6–22′ 7–25′ 8–25′	5–18′ 6–22′ 7–25′ 8–30′	5–18′ 6–22′ 7–25′ 8–30′
10″	—	—	—	—	—	4–20′ 5–22′ 6–25′ 7–35′ 8–35′

(Above a stump height of 6 inches)

Table 1a. Dimensions of Red Pine Poles[1]

Length in Feet	Pole Class						
	4	5	6	7	8	*9	**10
	Minimum Top Diameter in Inches						
	6.68	6.05	5.41	4.77	4.77	4.77	3.82
	Minimum Diameter (Inches) at 6 Feet from Butt						
16	—	7.16	6.68	6.20	5.73	Diameter 6′ from butt of class 9 and 10 poles to be less than that shown for corresponding diameter of class 8 pole of same length.	
18	8.27	7.64	7.00	6.52	6.05		
20	8.59	7.95	7.32	6.84	6.36		
22	9.07	8.43	7.80	7.16	6.68		
25	9.55	8.91	8.11	7.64	7.00		
30	10.34	9.55	8.91	8.27	7.64		
35	10.98	10.18	9.55	8.75	8.11		

*Maximum length—30′
**Maximum length—25′

[1]Adapted from CSA Specification 015.3. 1960.

Table 2. Plantation Red Pine

Reinforcing Stub Utilization

Tree Diameter Class		Tree Height Class 50′	55′	60′
9″	Stub Class	W	W	W
	Stub Length	10′	10′	10′
10″	Stub Class	—	—	W
	Stub Length			11′

(Above a stump height of 6 inches)

Table 2a. Dimensions of Red Pine Reinforcing Stubs[1]

Length in Feet	Stub Class Y	X	W
	Minimum Diameter (Inches) at 6 Feet from Butt		
10	10.50	8.91	7.64
11		10.18	8.75
13			9.55

[1]Adapted from CSA Specification 015.3. 1960.

Table 3. Plantation Red Pine

Total Volume

Tree Diameter Class	Tree Height Class 25′	30′	35′	40′	45′	50′	55′	60′
	Cubic Feet							
3″	0.65	0.72	0.78	0.85	0.95			
4″	1.09	1.25	1.43	1.62	1.80	2.00		
5″	1.60	1.95	2.21	2.58	2.85	3.23	3.46	
6″		2.68	3.13	3.68	4.15	4.62	5.06	5.68
7″			4.12	4.80	5.48	6.10	6.83	7.45
8″				6.02	6.87	7.62	8.70	9.50
9″						9.30	10.50	11.9
10″								14.4

(Top and stump included)

Basis—366 trees measured in southern Ontario

Table 4. Plantation Red Pine

Merchantable Cubic Volume

Tree Diameter Class	Tree Height Class							
	25′	30′	35′	40′	45′	50′	55′	60′
	Cubic Feet							
4″	0.6	0.7	0.8	0.9	1.0	1.1		
5″	1.2	1.5	1.8	2.0	2.2	2.5	2.8	
6″		2.2	2.6	3.1	3.5	4.0	4.4	4.9
7″			3.5	4.1	4.8	5.4	6.0	6.7
8″				5.1	6.0	6.9	7.8	8.7
9″						8.3	9.7	10.8
10″								13.0

(Volumes for 50-inch bolts, to the nearest whole bolt and to a top d.i.b. of not less than 3 inches, above a stump height of 6 inches.)

Basis—313 trees measured in southern Ontario

Table 5. Plantation Red Pine

Board Foot and Merchantable Cubic Volume

Tree Diameter Class		Tree Height Class				
		40′	45′	50′	55′	60′
7″	Ft.b.m.		9	9	10	11
	Cu. ft.		2.7	3.3	3.9	4.5
8″	Ft.b.m.	15	18	20	23	26
	Cu. ft.	1.6	1.7	2.0	2.5	2.8
9″	Ft.b.m.			30	36	41
	Cu. ft.			1.7	1.9	2.2
10″	Ft.b.m.				(49)	57
	Cu. ft.				(1.4)	1.6

(*Board feet*, Ontario Log Rule, for logs not less than 8 feet 3 inches long to a top d.i.b. of not less than 6 inches, above a stump height of 6 inches. *Cubic feet* for 50-inch bolts in remainder of tree, to the nearest bolt and to a top d.i.b. of not less than 3 inches.)

Basis—104 trees measured in southern Ontario