CHANGE IN RELATIONSHIP BETWEEN DIAMETER AND HEIGHT GROWTH

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THE IMPORTANCE of the form-class factor, both as to trees and stands, and its effect on the volume of timber, has been realized for twenty years or more. In general, care is taken to select the proper form-class volume tables when computing survey stand tables. That this is important may be readily seen by simply comparing volume tables of two form-classes. A 10-inch, 60-foot red pine tree of form-class 70 has a volume of 14.0 cubic feet; one of form-class 75 has 15.1 cubic feet — a difference of nearly 8 per cent.

It is also becoming more generally recognized that site-type has an important bearing on the form and volume of trees. For example a 10-inch red pine 50 years old on a plot in a *maianthemum-corylus* site-type was 57 feet high, while a similar tree on a plot in a *trillium* site-type was 61 feet high. The respective total volumes were 13.6 cubic feet and 14.6 cubic feet, a difference of 7.3 per cent.

Although due consideration is being given to the effect of these two factors, form-class and site-type, upon the volume of stands there does not seem to be as full appreciation of the changes in relationship between diameter and height with changes in age-class, and the consequent effect on volume. Not infrequently a single diameter-height curve for a given species is accepted for all conditions on a given area.

Furthermore, owing to lack of appreciation of this fact, diameter-height curves applied to original survey data are also applied to the remeasured data taken, say, ten years later. The error thus introduced is particularly apparent and important when permanent sample plot data are concerned, where the same trees, which have changed in age, are under consideration.

It is the purpose of this article to illustrate the change that occurs in relationship between diameter and height over a period of five years, and the significance of this change in terms of cubic volume.

The diameter and the height measurements made in 1932 and 1937, on a red pine sample plot, are listed in Table 1. The diameter measurements were taken with a diameter tape, the heights with an Abney level on a tripod. The increment for the 5-year period is shown in inches and feet respectively and in percentage of the original measurements. The difference between the diameter percentage and the height percentage is also tabulated. As diameter-height curves are usually based on the average diameter and height of all the trees in each diameter-class, the average diameter and height for each diameter-class is computed. From these averages diameter-height curves are presented in Graph 1.

Obviously the two curves will not correspond if there is any difference in the increment percentage values of the diameter and the height data recorded at the two dates.

From the last column of Table 1 it may be seen that height increment was greater than diameter increment for all except three trees up to the 11-inch class. The average height increment in each of these diameter-classes is greater than the diameter increment, the excess ranging from 1.6 per cent to 3.9 per cent.

TABLE 1
Comparison of Diameter Increment with Height Increment for period 1932-37.
(Values in per cent of 1932 measurements)

Tree No.	Diameter in Inches		Increment		Height		Increment		Height Increment greater than Diam. Increment
	1932	1937	Inches	%	1932	1937	Feet	%	
<i>6-inch diameter-class</i>									
171	6.0	6.3	0.3	5.0	45	48	3	6.6	1.6
<i>7-inch diameter-class</i>									
35	7.5	8.1	0.6	8.0	52	57	5	9.6	1.6
39	7.1	7.5	0.4	5.6	54	58	4	7.5	0.9
65	7.0	7.8	0.8	11.4	51	57	6	11.7	0.3
162	6.6	7.2	0.6	9.9	41	47	6	14.6	4.7
184	7.5	8.0	0.5	6.6	48	51	3	6.2	0.4
216	7.0	7.6	0.6	8.5	51	58	7	13.7	5.2
Aver.	7.1	7.7	0.6	8.4	49	55	6	12.3	3.9
<i>8-inch diameter-class</i>									
11	7.6	8.1	0.5	6.6	55	61	6	10.9	4.3
149	7.6	8.4	0.8	10.5	51	57	6	11.7	1.2
160	7.8	8.6	0.8	10.3	47	54	7	14.9	4.6
Aver.	7.7	8.4	0.7	9.1	51	57	6	11.7	2.6
<i>9-inch diameter-class</i>									
83	8.9	9.7	0.8	9.0	53	60	7	13.2	3.2
124	8.9	9.4	0.5	5.6	56	62	6	10.7	5.1
165	9.0	9.6	0.6	6.6	55	58	3	5.5	1.1
199	8.7	9.4	0.7	8.0	55	61	6	10.9	2.9
222	9.5	10.2	0.7	7.2	54	59	5	9.3	2.1
Aver.	9.0	9.7	0.7	7.7	55	60	5	9.9	2.2
<i>10-inch diameter-class</i>									
40	10.0	10.6	0.6	6.0	57	61	4	7.0	1.0
67	10.2	11.1	0.9	8.8	56	59	3	5.4	3.4
77	10.5	11.0	0.5	4.7	58	65	7	12.1	7.4
88	10.1	10.7	0.6	5.9	62	67	5	8.1	2.2
110	9.9	10.0	0.6	6.7	54	59	5	9.3	2.6
170	10.7	11.4	0.7	6.5	60	61	1	10.7	4.2
194	10.4	11.2	0.8	7.7	55	62	7	12.7	5.0
255	10.5	11.0	0.5	4.7	54	61	7	13.0	8.3
Aver.	10.3	10.9	0.6	5.8	57	62	5	8.8	2.0
<i>11-inch diameter-class</i>									
41	10.9	11.6	0.7	6.3	60	63	3	5.0	1.3
113	11.5	12.0	0.5	4.3	61	62	1	1.6	2.7
151	10.9	11.6	0.7	6.4	57	64	7	12.3	5.9
181	11.1	11.8	0.7	6.3	59	61	2	3.4	2.9
253	11.1	11.9	0.8	7.2	56	58	2	3.6	3.6
269	11.1	12.0	0.9	8.1	62	63	1	1.6	6.5
294	11.3	12.0	0.7	6.2	54	58	4	7.4	1.2
Aver.	11.1	11.8	0.7	6.3	58	61	3	5.2	1.1
<i>12-inch diameter-class</i>									
21	11.6	12.2	0.6	5.1	65	67	2	3.1	2.0
93	12.0	12.5	0.5	4.2	58	61	3	5.2	1.0
120	12.1	12.9	0.8	6.6	62	68	6	9.5	2.9
182	11.8	12.2	0.4	3.4	61	63	2	3.3	0.1
234	11.7	12.1	0.4	3.4	57	61	4	7.0	3.6
Aver.	11.8	12.4	0.6	5.1	61	64	3	4.8	0.3
<i>13-inch diameter-class</i>									
123	13.1	13.9	0.8	6.1	61	66	5	8.2	2.1
257	13.3	13.9	0.6	4.5	58	61	3	5.2	0.7
313	13.0	13.7	0.7	5.4	59	61	2	1.7	3.7
322	13.2	13.6	0.4	3.0	59	65	6	10.2	7.2
334	12.6	13.3	0.7	5.5	59	63	4	6.8	1.3
Aver.	13.0	13.7	0.7	5.4	59	63	4	6.6	1.2
<i>All diameter-classes</i>									
Grand Aver.	10.0	—10.7	0.7	7.0	55	60	5	9.1	2.1

Taking the data as a whole, the diameter increment was 0.7 inch or 7.0 per cent, the height increment 5.0 feet or 9.1 per cent, for the 5-year period; thus the height increment rate exceeded the diameter increment rate by 2.1 per cent.

By comparing the curves based on the 40 measurements (Graph 1) with those based on all the measurements taken on the plot (Graph 2) it will be seen that the two sets of curves correspond closely, except in the 11-inch class, which indicates that about 50 carefully-measured trees may be sufficient to provide data for a reliable curve.

The difference in the curves for 1932 and 1937 (Graph 1) is approximately 4 feet in each diameter-class above the 6-inch class, or 9 per cent for the 7-inch class, declining to 7 per cent for the 12-inch class.

To translate the effect of this excess of height growth over diameter growth to terms of volume the volumes of the 40 sample trees concerned are shown in Table 2. In column 4 the volumes are given for the even inch-classes and the respective heights as shown in the 1932 diameter-height curve. In column 6 the volumes have been computed for the same even inch-classes and the 1937 height curve which shows the excess of height growth over diameter growth in the five-year period.

For this particular stand the excess increment, due entirely to the more rapid growth in height than in diameter was 33.3 cubic feet, a rate of 5.6 per cent.

It is, therefore, important to give due consideration to changes in diameter-height relationship even within a period as short as five years.

TABLE 2
Stand Tables 1932-1937
Based on excess of height increment over diameter increment

Diam. Class	No. of Trees	1932 Height	Volume	1937 Height	Volume	Increment Volume	Per Cent
Inches		Ft.	Cu. Ft.	Ft.	Cu. Ft.	Cu. Ft.	
6	1	45	4.05	48	4.29	0.24	5.9
7	6	49	35.40	53	37.86	2.46	6.9
8	3	52	24.21	56	25.86	1.65	6.8
9	5	55	53.50	59	57.00	3.50	6.5
10	8	57	109.60	61	116.00	6.40	5.8
11	7	59	119.00	62	124.60	5.60	4.7
12	5	60	102.00	64	108.50	6.50	6.3
13	5	61	121.50	65	128.50	7.00	5.8
Total	40		569.26		602.61	33.35	5.6