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SELECTIVE VERSUS SYSTEMATIC SAMPLING FOR HEIGHT/DIAMETER CURVES

by

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Selective Versus Systematic Sampling for Height/Diameter Curves

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J. Krewaz[1]

INTRODUCTION

On the preparation of height/diameter curves, Chapman and Meyer (2) (p. 208) state that a "rigid mechanical selection of trees rather than large numbers, is the important feature in sampling." As data selected for the determination of site index and height/age relationships are sometimes included in the construction of height/diameter curves, a departure from mechanical sampling, the practical effects of this practice are examined in this paper. A modification in the method of constructing height/diameter curves which would permit the use of non-mechanically selected trees is also presented.

METHODS

A means of determining these effects was provided by data from the Northern Clay Belt growth and yield survey (3). In the course of this survey both a mechanical sample for the preparation of height/diameter curves and a selectively chosen sample of dominant and co-dominant trees for the determination of height/age relationships were obtained. From the data collected for black spruce, *Picea mariana* BSP., height/diameter curves from both samples were prepared for comparison (Figure 1).

In constructing the curves, average height was plotted over average diameter for each 1-inch diameter class. Freehand curves were drawn and balanced by sections.

Confidence limits at the 5 per cent level of probability were established for each diameter class of both curves. These are based on the standard error of estimate using the expression:

$$2\,\frac{\sqrt{\dfrac{\Sigma\,(Ho-Hc)^2}{n}}}{\sqrt{n}}$$

Hc = curve height of individual sample trees.

Ho = actual height of individual sample trees.

n = number of trees in the diameter class.

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TABLE 1.—CONFIDENCE LIMITS FOR CURVES "A" AND "B" BY DIAMETER CLASSES AT THE 5 PER CENT PROBABILITY LEVEL

DBH (inches)	Height in Feet		Difference	
	A	B	Significant	Not Significant
1	9 ± 0.42	8	S	
2	16 ± 0.55	14 ± 1.04	S	
3	24 ± 0.86	21 ± 0.66	S	
4	31 ± 0.82	28 ± 0.76	S	
5	38 ± 1.04	35 ± 0.89	S	
6	45 ± 1.42	42 ± 0.94	S	
7	50 ± 1.54	49 ± 1.41		N
8	55 ± 2.45	54 ± 1.31		N
9	60 ± 2.61	59 ± 2.28		N
10	63	63		

In most diameter classes, the difference in curve heights exceeds the sum of the confidence limits (Table 1) and the curves are considered significantly different at the 5 per cent level of probability.

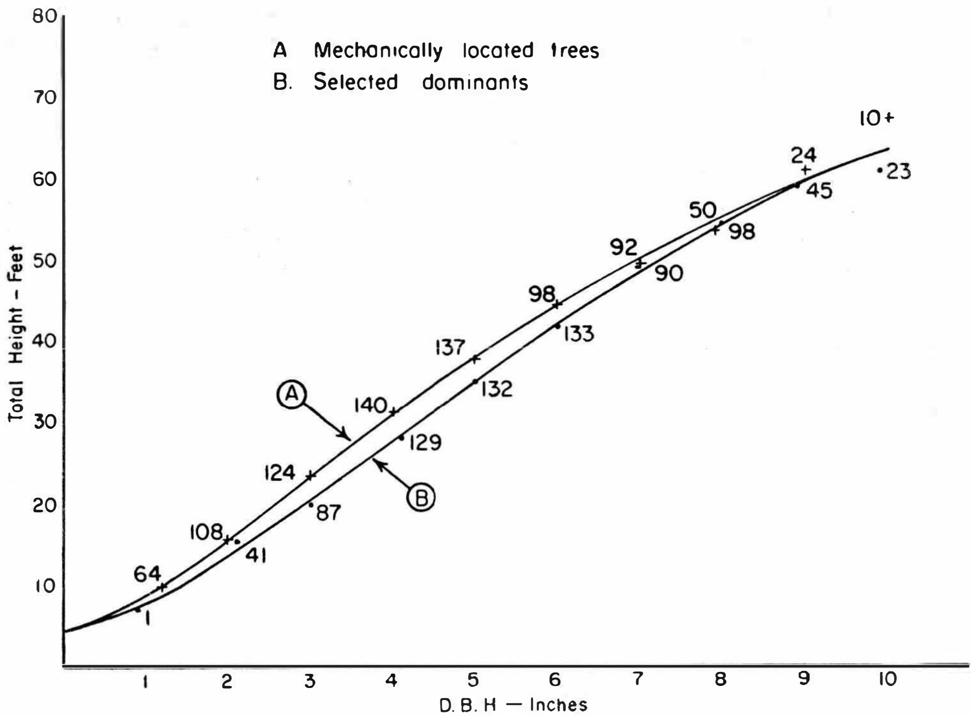

Figure 1. Height/diameter curves—mechanical sample and selected dominants.

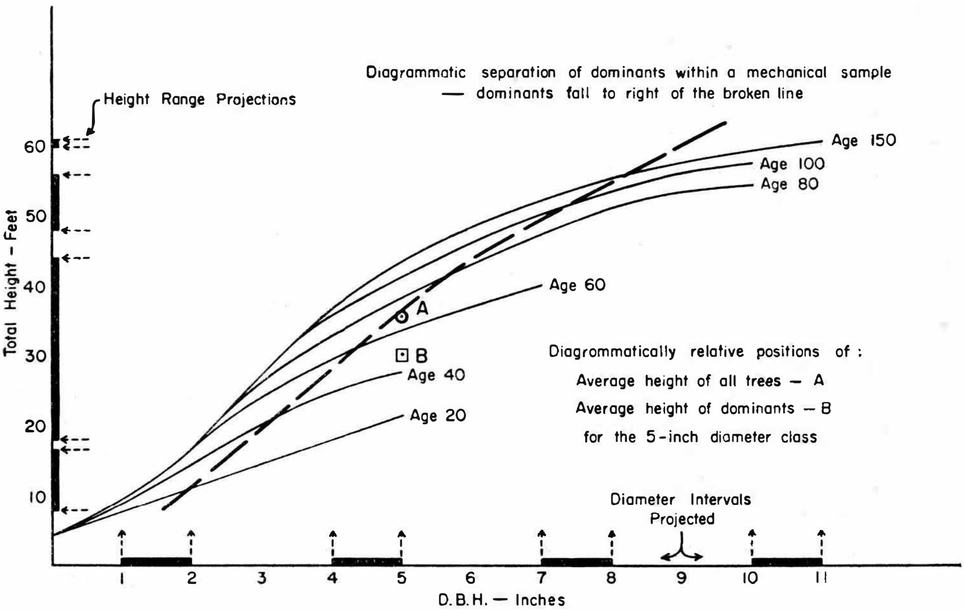

FIGURE 2. Height/diameter curves by age classes.

THE CURVES

Since the samples for both curves of Figure 1 are from the same stands, the factors of site, density, species composition and stand age should effect each curve equally. The distinct difference in the curves is the result of the difference in the sampling methods and can be directly attributed to the restricted representation of crown classes in curve B. Because dominants and co-dominants in a stand are the taller trees, the lower position of this curve may appear to be a contradictory situation. This is not the case and the situation results from factors illustrated in Figure 2.

This set of curves (Figure 2) was prepared during the analysis of the Clay Belt growth and yield data (3). It shows the height/diameter relationship by age classes for black spruce on one site as derived from the appropriate portion of the data used for curve A in Figure 1. The pattern of the curves shown is similar for all sites. A diagrammatic separation of dominants and co-dominants from the intermediate and suppressed trees in each age class is represented by the heavy broken line in Figure 2. Since the dominants and co-dominants in the stands are mainly in the larger diameter classes, they fall to the right of this line. The intermediate and suppressed trees fall to the left of it. By this separation, the trees in the lower crown classes falling within any one diameter class are on the average older and taller than the dominants and co-dominants of the same diameter. A general height/diameter curve for all age classes based only on dominants and co-dominants would consequently fall below a similar curve derived from a mechanical sample which would include all crown classes.

Figure 1 shows that the difference between curves A and B is not constant and that the curves approach each other toward their extremities. The greatest difference in height occurs in the mid-diameter classes. A similar trend may be observed in Figure 2. Several uniformly-spaced 1-inch diameter intervals were marked off on the axis of abscisses and the corresponding range in height from the lowest to the highest age classes designated on the axis of ordinates. The range of average height is greatest in the mid-diameter classes, and decreases toward both ends of the diameter scale.

The relative positions of the height/diameter curves for individual age classes produces this variation. As the maximum diameter attained in each progressively older age class increases, the minimum diameter remains relatively static. This produces a progressively greater overlapping of curves in the mid-diameter classes. The latter classes are to a varying extent represented in stands of all ages but, generally, by dominants and co-dominants in the younger stands and by the relatively taller intermediate and suppressed trees in the older stands. Consequently, for a specific diameter class in the mid-range of diameters, the average height of trees of all age classes, as illustrated by point A in Figure 2, is greater than the average height of the dominant and co-dominant trees only, as represented by point B.

In the lower diameter classes the difference between curves A and B is small because the difference in height between short and tall trees in terms of feet is not great. In the upper diameter classes, most trees are old and few age classes are represented. These trees of large diameter are mostly dominants and co-dominants. Thus the portions of curves A and B applying to the larger diameters are about the same because measurements from trees of the same kind result from both types of sampling. In the mid-diameter classes, trees from most age classes and all crown classes are more equally represented in the mechanical sample producing the greatest difference in the two types of sampling. Since the proportion of suppressed trees in a diameter class is to a large extent determined by the tolerance of a species, the difference in height/diameter curves produced by the two methods of sampling would likely be smaller for species more intolerant than black spruce.

PRACTICAL EFFECTS

To determine the practical effects of the difference between curves A and B (Figure 1), the volume per acre for an average spruce swamp site was determined and the per cent difference calculated. To determine the volume per acre, local volume tables based on each curve were constructed from a standard volume table (1) for the site. The comparative results for a well-stocked mature stand are shown in Table 2.

Table 2 shows that when curve B is used, the total cubic foot volume per acre is 7.8 per cent lower, and the merchantable cubic foot volume is 5.1 per cent lower than the corresponding volumes obtained using curve A. These percentages of underestimate constitute a considerable proportion of the error generally considered acceptable for inventory work (5 to 10 per cent). The per cent of underestimate would vary with the proportion and the distribution within diameter classes of selected dominants and co-dominants included in the construction of a height/diameter curve. A percentage correction might be applied when this type of data are used, but this could only be an estimated correction.

TABLE 2.—COMPARATIVE VOLUMES[1] DERIVED FROM CURVES "A" AND "B" (FIGURE 1)

DBH (inches)	Number of Trees per Acre	Local Volume Tables (cu. ft.)				Volume Per Acre (cu. ft.)			
		Total		Merch.[2]		Total		Merch.	
		A	B	A	B	A	B	A	B
1	250	0.03	0.02			7.5	5.0		
2	260	0.2	0.1			52.0	26.0		
3	250	0.6	0.5			150.0	125.0		
4	240	1.2	1.1	0.9	0.9	288.0	264.0	216.0	216.0
5	200	2.4	2.2	1.9	1.7	480.0	440.0	380.0	340.0
6	120	3.9	3.7	3.3	3.1	468.0	444.0	396.0	372.0
7	69	5.7	5.6	5.0	4.9	393.3	386.4	345.0	338.1
8	9	8.0	7.9	7.2	7.1	72.0	71.1	64.8	63.9
9	1	10.8	10.6	9.8	9.6	10.8	10.6	9.8	9.6
10	1	13.9	13.9	12.6	12.6	13.9	13.9	12.6	12.6
Totals.......	1,400					1,935.5	1,786.0	1,424.2	1,352.2
Per cent underestimate using curve B........							−7.8		−5.1

[1] Black spruce on site G.
[2] 4 inches d.b.h. and over—1-foot stump and 3-inch top.

A more reliable procedure is to construct height/diameter curves by age classes as shown in Figure 2. Because of the high correlation between height and age, the shorter and younger dominants and co-dominants within any diameter class are separated from the older and taller trees of the lower crown classes. Rather than reducing the average height of latter classes, the non-mechanically selected trees improve the estimate of average height within their own age and crown classes. This procedure prevents the underestimates of volume of the taller trees in each diameter class and results in a more accurate estimate of total volume.

Where stand age is not recorded, the stratification of height/diameter data by 10-foot or 20-foot stand height classes appears to be a satisfactory alternative[2]. The stand height determined by photogrammetric or ground measurement is used instead of age to select the appropriate height/diameter relationship from a sheaf of curves which are similar in form to those in Figure 2.

CONCLUSION

Height/diameter data other than that derived by non-selective methods may introduce errors of considerable magnitude into the resulting height/diameter curve. The application of a height/diameter curve based exclusively on dominants and co-dominants would result in an underestimate of volume. This situation does not arise in a properly taken mechanical sample because the various crown classes are represented in the sample in the same proportion that they occur in the forest. Where sufficient mechanically sampled data are not available it may be necessary to include selected dominants and co-dominants. In these instances reliable height/diameter curves can be obtained provided that a separate curve is prepared for each age or stand-height class.

[2] Unpublished data, A. Bickerstaff, Forestry Branch, Ottawa.

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