NOTES

NOTES ON THE USE OF BARR AND STROUD DENDROMETERS

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INTRODUCTION

In recent years the use of optical instruments, such as the Barr and Stroud dendrometer, has attracted the attention of mensurationists. The theory and manual operation of this instrument has been well reported (Jeffers, 1956; Grosenbaugh, 1963; Sandrasegaran, 1969), but experience at N.Z. Forest Products Ltd, where three dendrometers are used operationally in inventory, show that a proper field procedure has to be adopted to obtain consistency.

MEASUREMENT OF *PINUS RADIATA*

The dendrometer can measure overbark diameters from 3.8 to 500 cm, together with the distance between any two measurements. Hence, by summating the derived log volume, a total stem overbark volume is obtained. (The dendrometer does not read diameters and heights directly; they are obtained by two readings on a vernier scale and one reading on an inclinometer and converted to diameter and distance by tables which are supplied with the instrument. The expression "a diameter is measured" thus implies "two vernier readings and an inclinometer measurement are read".)

The following method has been adopted when measuring single-stemmed radiata pine trees.

(1) The dendrometer is so placed that the top of the tree can be seen. (The instrument's optics demand that it be placed at least 11 m from the tree.)

(2) The bearing from instrument to tree is recorded. (The same position is used when subsequently remeasuring the tree.)

(3) The height of the tree is measured.

(4) The diameter at stump height (defined as 15 cm above ground) is measured by calipers normal to the line of sight of the dendrometer. This diameter is not measured dendrometrically as undergrowth frequently obscures vision of this part of the tree.

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(5) Selecting internodal positions, diameters are taken at the following heights:

   (a) Midway between stump height and breast height — about 0.8 m. The distance between this diameter and the ground is measured by tape.

   (b) At breast height (1.4 m). A caliper diameter is also taken, normal to the line of sight.

   (c) At about 2 m intervals, from dbh to the base of the green crown. If the tree is malformed, more diameters are taken (the instrument may be tilted laterally so as to measure normal to a lean).

   (d) Two measurements between the green crown base to the tree top. (Since the stem must be "seen" from the ground, heavy crown density sometimes allows only one measurement.)

(6) The height of the tree is remeasured; a check is thus ensured on (3) above.

This procedure usually results in taking 8 to 11 diameter measurements. Most measurement has been done in regenerated stands aged 12 to 15 years, with heights of 20 to 30 m. For this height class, analysis has shown that more diameters are superfluous. In practice, the most difficult measurements are of diameters within 2 to 3 m of the ground. Poor light conditions give blurred definition of the tree with possible subsequent error. To offset this, a large white sighting board is put behind the tree (the black reverse face of this board is equally helpful in some conditions). As with other optical instruments, climatic conditions have a significant effect on the dendrometer's performance. It cannot be used at all in rain, and strong winds make upper stem measurements difficult.

Multi-stemmed trees present little trouble. The dendrometer is positioned normal to the fork, and the leaders are measured individually, according to the procedure described above. Trees with a persistent and excessive lean are measured normal to the defect.

Dendrometric measurement is safer and less taxing than climbing a tree. The number of trees measured per day by the dendrometer varies considerably. A seven-man field party using two dendrometers has measured over 100 trees in a day. In difficult terrain, with an unusual number of malforms, this number can be halved.

ACCURACY OF THE DENDROMETER

The accuracy of the Barr and Stroud dendrometer has been established (Grosenbaugh, 1963). It has been shown that the instrument does measure up to the maker's claims. Diameters are subject to an error of 3 mm; heights are accurate to 1.5%. N.Z. Forest Products Ltd's trials show that the method of measurement outlined in this description is consistent to within 4% by volume.

COMPARISON OF DENDROMETRIC AND CONVENTIONAL FORMS OF MEASUREMENT

All methods of measuring individual trees for volume are estimates — a point sometimes overlooked. The error associated with any volume estimation can be conveniently split into (a) avoidable error, and (b) unavoidable error. Examples of (a) are: misreading of tapes, calipers or verniers; taking an inadequate number of measurements; or applying inappropriate formulae. These are avoidable in the sense that rigid checking or more intensive measurement would eliminate much of the error. In many instances this can be achieved only by a prohibitive increase in costs. Examples of (b) are:

TABLE 1: ALL SECTIONAL VOLUMES — CALCULATED BY SMALIAN'S FORMULAE

	Volume Diameter-Tape *1*	*Volume Calipers* *2*	*Volume Dendrometer* *3*	*Height (Tape Measurement)* *4*	*Height Dendrometer Measurement* *5*
	(Measured in m^3 over bark)			*(Measured in metres)*	
1	0.84	0.82	0.81	27.43	27.49
2	0.53	0.52	0.56	23.38	23.35
3	0.69	0.68	0.69	23.93	23.68
4	0.76	0.73	0.72	26.67	25.88
5	0.53	0.53	0.54	24.69	24.75
6	1.11	1.09	1.10	26.82	26.79
7	0.77	0.74	0.78	25.45	25.45
8	0.82	0.79	0.72	24.10	24.08
9	0.81	0.80	0.80	24.57	22.83
10	0.89	0.87	0.86	25.36	25.66
11	0.44	0.42	0.45	23.22	23.16
12	0.32	0.31	0.33	22.86	22.98
13	0.38	0.37	0.37	24.96	24.81
14	0.38	0.37	0.35	23.28	23.35
15	0.32	0.32	0.32	19.23	19.03
16	0.30	0.30	0.28	20.81	20.44
17	0.34	0.34	0.35	19.54	19.51
18	0.32	0.31	0.30	20.95	21.04
19	0.36	0.36	0.34	20.95	20.56
20	0.33	0.32	0.32	20.39	20.27
21	0.17	0.17	0.17	19.26	19.08
22	0.30	0.29	0.30	20.67	20.78
23	0.16	0.16	0.17	16.82	16.84
24	0.18	0.18	0.17	18.86	18.77
25	0.29	0.27	0.27	19.71	20.00
26	0.09	0.09	0.09	14.67	14.67
27	0.21	0.21	0.21	17.75	17.75
28	0.30	0.30	0.29	16.76	16.82
29	0.11	0.11	0.10	15.91	15.80
30	0.09	0.09	0.08	15.26	15.32
Means	0.438	0.429	0.428		

the inherent limitation of any instrument; and the fact that individual trees do not accurately fit a postulated mathematical solid of revolution.

These considerations are mentioned to emphasize that comparing one method of measurement with another can be misleading, if not incorrect. Claim to a "better" form of measurement can only be valid if the standard error of the "better" estimate can be shown to be smaller than that of another method. Even if this is established, it does not automatically preclude the less efficient method.

Climbing or felling a tree and measuring with a diameter tape and chain will usually result in a slightly biased estimate. This is due to overestimation of the diameter if the tree has a non-circular cross-section. The method is consistent, however, and in many forms of inventory is an excellent form of measurement. At extra cost, the bias can be partially eliminated by two caliper measurements taken at right-angles. The geometric mean of these measurements will give a more precise estimate — that is, it is unbiased if the tree's cross-section is truly elliptical. As this is rarely the case, the method is still subject to error. Dendrometric measurement on individual trees is also liable to bias. There is an over- or underestimate of diameters, depending on whether a cross-section is measured along its major or minor axis. When a group of trees is measured, as in a field trial, this becomes irrelevant.

These points are illustrated in a field trial carried out by N.Z. Forest Products Ltd. Thirty trees (10 dominant, 10 co-dominant and 10 suppressed) were measured in three ways, first by dendrometer using the method outlined above. The trees were then felled. Diameters were measured by tape at butt, breast height, 3.0 m, 4.5 m, 6.0 m, and so on up to the terminal bud. They were then measured by caliper at the same position (two readings at right-angles). In each case, sectional lengths were measured by conventional tape.

The results are shown in Table 1. The diameter tape volumes are consistently slightly higher than the caliper volumes, while the dendrometer estimates are collectively equivalent to the caliper measurements. Columns 4 and 5 of Table 1 confirm the accuracy of the dendrometer with respect to height.

CONCLUSION

The dendrometer gives an excellent estimate of overbark volume. No claim is made to its superiority over other forms of measurement, but it has been established as a practical instrument for regular use in forest inventory.

REFERENCES

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