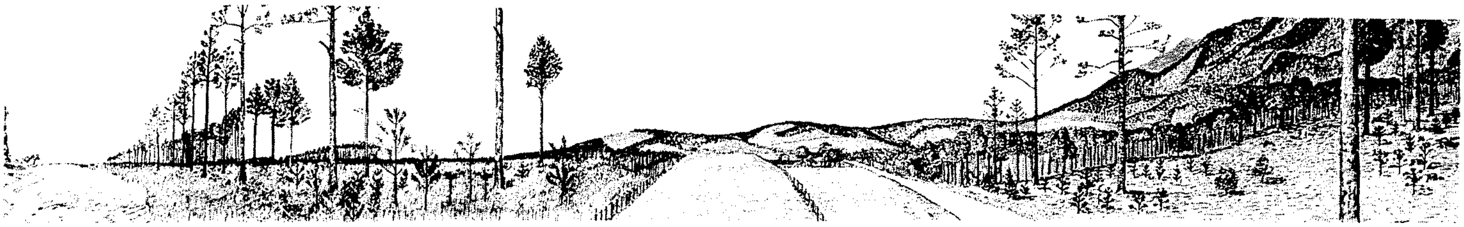

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ACCURACY OF STANDING-TREE VOLUME ESTIMATES BASED ON McCLURE MIRROR CALIPER MEASUREMENTS

Abstract. --The accuracy of standing-tree volume estimates, calculated from diameter measurements taken by a mirror caliper and with sectional aluminum poles for height control, was compared with volume estimates calculated from felled-tree measurements. Twenty-five trees which varied in species, size, and form were used in the test. The results showed that two estimates of total cubic volume in the 25 trees, obtained by separate measurers who used the mirror caliper and worked independently of one another, were within 2.1 percent of the total cubic volume calculated from the felled-tree measurements.

In 1963, Forest Survey crews in the Southeast began using the McClure Mirror Caliper[1] and sectional aluminum poles to measure upper-stem diameters and bole lengths on a subsample of the standing trees tallied on survey plots. The objective was to collect sufficient data for the development of accurate volume-prediction equations for each tree species in the Southeast. Since 1963, numerous tests conducted by Forest Survey personnel have proved that the McClure Mirror Caliper is a reliable dendrometer for obtaining upper-stem measurements under the various conditions encountered in broad-scale inventory work. Robbins and Young (7) also concluded that the mirror caliper is a suitable instrument for obtaining upper-stem measurement in their comparison of it with the Wheeler penta-prism caliper. The purpose of the study described in this paper, therefore, was not to test the accuracy of individual mirror caliper measurements, but to determine if standing-tree volume estimates based on a series of upper-stem measurements are comparable to volume estimates based on felled-tree measurements.

METHODS

Twenty-five trees, ranging in d. b.h. from 5.7 to 18.8 inches and in total height from 27 to 82 feet, were selected from an oak-pine stand on State-owned land located about 15 miles west of Tallahassee, Florida. In order to introduce as many measurement problems as possible, we

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[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval of any product or service by the United States Department of Agriculture to the exclusion of others which may be suitable.

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selected several species (loblolly pine, longleaf pine, shortleaf pine, laurel oak, and southern red oak) that also included several forked and poorly formed trees. To eliminate the felling of a large number of sample trees, we selected two faces perpendicular to one another on each tree, then painted and numbered them so that they could be identified after the trees were felled. With a standing-tree and felled-tree volume estimate based on each of the two faces measured, we obtained 100 estimates of volume from the 25 sample trees--50 standing and 50 felled.

First, d. b. h. was measured with a steel caliper and recorded for all of the sample trees. Next, two measurers who were experienced in the use of the mirror caliper, familiar with its operating principles, and working independently measured separate faces on all 25 trees following the procedure outlined by McClure (6). Marked sectional aluminum poles were extended up the trees (5) and the various measurement points identified (9). Finally, the trees-were felled and measured with a steel caliper and metallic tape. The same procedures were used to identify the measurement points on each face.

After all measurements were taken, recorded, and punched into cards, the volumes of individual tree sections were determined from their diameters and lengths. Four different calculations of the cubic volume, from the 1-foot stump to 4.0 inches d.o. b., were made for each tree by the same volume equation (4):

$$\text{Volume (cu. ft.)} = .005454154\ L \left[Dd + \frac{(D-d)^2}{K} \right]$$

where: d = average diameter of log inside bark at small end (inches)

D = average diameter of log inside bark at large end (inches)

L = length of log (feet)

K = constant (2 for paraboloid, 3 for conoid, 4 for subneloid)

RESULTS

Wilcoxon's signed rank test, illustrated by Steel and Torrie (8), indicated no significant (5-percent level) positive or negative bias in individual volume differences for measurer 1, but showed a significant bias in estimate of volumes for measurer 2. Average bias for measurer 2 was 0.29 cubic foot. The positive and negative differences among estimates of volume for each measurer can be attributed to bark roughness which made it difficult for both measurers to observe a perfect split image.

The most significant findings were that total cubic volume, outside bark, determined from the standing-tree measurements differed from the felled-tree volume determination by only 0.25 percent when both observers' estimates were pooled, and that each measurer's estimate of total volume was within 2.1 percent of the felled-tree estimate (table 1). The range of the differences among the estimates of volume for the individual trees was +2.09 to -2.92 cubic feet, with an average volume per tree of about 18.3 cubic feet (table 2).

Table 1. --Comparison of individual standing-tree volume estimates obtained by two measurers with those obtained from felled-tree measurements

MEASURER 1

Tree number	D. b. h.	Volume (outside bark) Standing tree	Volume (outside bark) Felled tree	Standing tree / Felled tree	Volume deviation
	Inches	Cubic feet	Cubic feet	Ratio	Cubic feet
1	16.8	31.04	33.08	0.9383	-2.04
2	17.5	60.99	62.53	.9753	-1.54
3	11.0	24.03	24.09	.9975	- .06
4	11.4	19.49	19.16	1.0172	+ .33
5	8.4	9.82	10.08	.9742	- .26
6	7.7	7.23	7.45	.9704	- .22
7	9.7	13.51	13.04	1.0360	+ .47
8	10.8	13.03	13.01	1.0015	+ .02
9	12.6	23.50	24.25	.9690	- .75
10	14.7	31.82	32.03	.9934	- .21
11	11.8	18.20	18.62	.9774	- .42
12	16.9	57.10	58.28	.9797	-1.18
13	8.6	10.61	10.40	1.0201	+ .21
14	5.8	2.89	3.04	.9506	- .15
15	10.7	9.63	9.33	1.0321	+ .30
16	9.8	9.87	9.73	1.0143	+ .14
17	17.9	39.22	42.14	.9307	-2.92
18	12.8	18.88	19.58	.9642	- .70
19	7.3	3.88	3.90	.9948	- .02
20	5.7	2.24	2.20	1.0181	+ .04
21	11.0	13.29	14.52	.9152	-1.23
22	10.0	14.37	13.84	1.0382	+ .53
23	7.7	6.61	6.19	1.0678	+ .42
24	7.3	5.12	5.12	1.0000	0
25	7.6	5.15	5.43	.9484	- .28
Total		451.52	461.04	.9794	-9.52

MEASURER 2

Tree number	D. b. h.	Volume (outside bark) Standing tree	Volume (outside bark) Felled tree	Standing tree / Felled tree	Volume deviation
1	16.1	31.15	30.91	1.0077	+ .24
2	17.6	59.64	58.52	1.0191	+1.12
3	11.5	26.82	24.73	1.0845	+2.09
4	11.6	21.43	20.30	1.0556	+1.13
5	7.9	9.07	9.14	.9923	- .07
6	7.9	7.96	7.63	1.0432	+ .33
7	9.2	12.38	12.84	.9641	- .46
8	10.8	14.16	14.21	.9964	- .05
9	12.6	24.69	24.32	1.0152	+ .37
10	16.2	29.53	36.58	.9656	-1.05
11	11.8	17.45	17.94	.9726	- .49
12	16.5	58.12	60.15	.9662	-2.03
13	8.7	10.50	9.80	1.0714	+ .70
14	6.5	3.86	3.52	1.0965	+ .34
15	10.4	9.74	8.52	1.1431	+1.22
16	10.1	10.35	10.14	1.0207	+ .21
17	18.8	42.03	41.83	1.0047	+ .20
18	12.2	18.93	18.16	1.0424	+ .77
19	6.7	3.85	3.59	1.0724	+ .26
20	5.7	2.17	2.10	1.0333	+ .07
21	10.9	15.03	13.82	1.0875	+1.21
22	10.7	14.52	13.57	1.0700	+ .95
23	7.7	6.07	5.68	1.0686	+ .39
24	7.5	5.38	5.06	1.0632	+ .32
25	8.5	5.34	5.86	.9112	- .52
Total		460.17	452.92	1.0160	+7.25
All total		911.69	913.96	.9975	-2.27

The accuracy of individual tree volumes, with the felled-tree volume estimates as standards, was checked by the chi-square test described by Freese (3). According to these tests, there is less than a l-in-20 chance that errors in individual tree volume estimates from mirror caliper measurements will differ from felled-tree volume estimates by more than 1.5 cubic feet. These results are comparable with the findings of Barrett and Nevers in a similar test that utilized the penta-prism to obtain the standing- tree measurements (2). If these same chi-square tests are applied to the results of still another study conducted by Arvanitis, where standing-tree volumes were obtained with both the Barr and Stroud dendrometer and a Speigel Relascope, additional comparisons can be made (1). Although procedures varied among these similar studies, the conclusion is that several instruments now available will provide standing-tree measurements comparable with felled-tree measurements for estimating volume.

In summary, the results suggest that for conditions similar to those tested, the mirror caliper, used in conjunction with the sectional aluminum poles, appears to be a useful dendrometer for determining individual tree volumes based on upper-stem measurements. It can provide estimates which are well within the accepted tolerance for most forest inventory applications.

Table 2. --Comparison of averages for standing-tree volume estimates obtained by two measurers with those obtained from felled-tree measurements

Measurer	Standing tree	Felled tree	Deviations
	- - - - - - - - - - -	Cubic feet	- - - - - - - - - - -
Number 1	18.06	18.44	-.38
Number 2	18.41	18.12	+.29

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