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CRUISING PROCEDURES FOR ESTIMATING TOTAL STAND BIOMASS

BY

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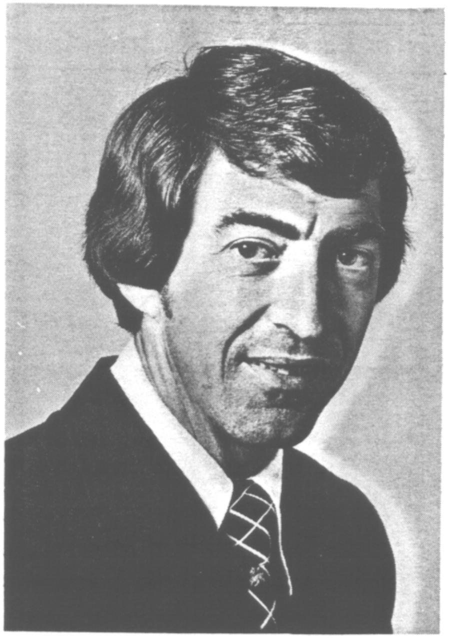

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CRUISING PROCEDURES FOR ESTIMATING TOTAL STAND BIOMASS

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INTRODUCTION

Much of the commercial forest land in the South is occupied by small and poorly formed trees that will never be marketable as sawtimber. As fuelwood markets develop, landowners will be able to sell this poor timber to make room for thrifty stands of desirable trees. In such operations, some saw logs may be produced, but most of the material, including tree tops and small trees will be chipped. A method therefore is needed for estimating the biomass in such stands so that a fair market price can be established for the wood.

This report describes and evaluates three cruising methods for estimating total stand biomass in poorly stocked southern pine and hardwood forests. In these methods, biomass is estimated for trees 1-inch d.b.h. and larger. Weights of smaller stems are ignored.

PROCEDURES

Total Stand Biomass Cruising

On a 3.2-acre tract of mixed hardwoods in north Georgia we tested two estimation methods. The first method was a variable plot cruise with a 10-factor prism. Two service foresters from the Georgia Forestry Commission each cruised the same 10 systematically located plots in the stand. They tallied trees in seven classes: pine sawtimber, pine pulpwood, pine understory, hardwood sawtimber, hardwood pulp, hardwood understory, and cull hardwood. Basal areas in these classes were then used to predict total stand biomass with factors developed by Hughes (1978) as shown in table 1.

In the second sampling scheme, ten 1/20-acre fixed radius plots (radius = 26.3 feet) were systematically located throughout the stand. On each plot, all trees 1.0 inches d.b.h. and larger were measured, and species, d.b.h. to the nearest 0.1 inch, and total height were tallied. The weight of each tallied tree was predicted with regression equations available in the literature (Taras and Clark 1974; Clark and Taras 1976; Clark and Schroeder 1977; Clark, et al. 1980; Clark and Phillips 1980; Phillips 1977; Phillips 1981; and Wiant, et al. 1979). Weights were summed and converted to tons of biomass per acre by multiplying the total for each 1/20-acre plot by 20.

All trees larger than 1 inch in diameter were then harvested. Some saw logs were extracted at the landing and weighed separately on electronically operated platform scales. The remaining material was chipped with a commercial chip harvester. Chips were blown into a van and weighed on portable highway scales. Weights of sample loads were verified on local pulpwood scales. Some high stumps (higher than 0.5 foot) were left by the tree fellers, and some tree biomass was left on the site by the separator that was attached to the chipper. These components were measured and will be described later.

On a second tract of 31.5 acres of mixed pine and hardwoods in west Georgia we tested three methods of estimating total stand biomass. The first method was a prism cruise similar to the one used in the first stand. Twenty-seven 10-factor prism plots were systematically located throughout the stand.

The second method utilized was what we call "fixed radius ocular plots." All trees 1-inch d.b.h. and larger were tallied on 1/20-acre plots by 2-inch d.b.h. classes and by three broad species categories: hard hardwoods, soft hardwoods, and pine. Tree diameters and limits of the plots were estimated by eye. Twenty-seven plots were systematically located throughout the stand.

The third plot type was a "fixed radius detailed tally plot." All trees 5.0-inches d.b.h. and larger on a 1/20-acre plot were tallied by species, d.b.h. to the nearest tenth of an inch, and total height. Trees 1.0 to 4.9 inches d.b.h. were tallied on a 1/100-acre plot taken at the same plot center. Diameters and heights were measured. Fourteen such plots were systematically located throughout the stand.

As with the first stand, prism plot tallies were used in conjunction with biomass factors developed by Hughes (table 1) to predict total stand biomass in tons per acre. The weight of individual trees tallied on the fixed radius plots (both ocular and detailed) were determined by applying prediction equations available in the literature. Individual tree weights were summed to get plot weights, which were in turn converted to tons per acre.

Total trees 1 inch d.b.h. and larger in the second stand were chipped by a commercial operator, and chips were weighed on delivery at a local papermill. Again, some of the biomass was not removed from the site. The chip harvester had a separator that left about 8 percent of stand biomass on the site. And, some trees were intentionally left standing as shade trees since the site was to be converted to pasture. There were also some high stumps. These components were measured and will be described later.

RESULTS AND DISCUSSION

Stand Comparisons

The two stands we examined were similar in many respects. The first stand (the 3.2-acre tract in north Georgia) contained 1,096 trees per acre of which 124 were overstory trees greater than 5.0 inches d.b.h. and 972 were understory trees from 1.0 to 4.9 inches d.b.h. The second stand (the 31.5 acres in west Georgia) contained 1,178 trees per acre with 205 trees in the overstory and 973 in the understory (table 2). The first stand contained over 98 percent hardwoods, but the second stand was approximately 35 percent hardwood and 65 percent pine. For trees larger than 5.0 inches d.b.h., average d.b.h. was 9.2 inches in stand 1 and 8.1 inches in stand 2. For the same trees, average height was 62 feet in stand 1 and 58 feet in stand 2.

Table 1.--Biomass factors for converting prism cruise tallies to tons of biomass per acre for whole trees and tree components[1/][2/]

Tree size class	Total biomass	Stem (to a 4-inch d.o.b. top)	Saw logs (to 8-inch d.o.b. pine, 10-inch d.o.b.) hardwood	Topwood (from saw log to a 4-inch d.o.b.)	Fuelwood (topwood plus crown)
	Tons of biomass/10 sq.ft. of basal area				
Pine sawtimber (9.0" d.b.h. & larger)	15.2	12.5	10.0	2.5	2.7
Pine pulpwood (5.0-8.9" d.b.h.)	8.4	5.7	--	--	2.7
Pine saplings (1.0-4.9" d.b.h.)	5.3	--	--	--	--
Hardwood sawtimber (11.0" d.b.h. & larger)	17.5	11.5	7.9	3.6	6.0
Hardwood pulpwood (5.0-10.9" d.b.h.)	10.5	7.3	--	--	3.2
Cull hardwood (5.0" d.b.h. & larger)	12.5	--	--	--	--
Hardwood sapling (1.0-4.9" d.b.h.)	5.6	--	--	--	--

1/ After Hughes, McDavid. 1978. Estimating the aboveground biomass and its component timber products of the southern forest. In Energy in the southern forest. 27th Annual Symp., Louisiana State Univ., Baton Rouge, LA, p. 62-83.

2/ To determine stand biomass, multiply the number of tally trees in each tree size class by the appropriate factor. For example, if the average cruise of say 20 plots is 3 pine sawtimber trees, 4 pine pulpwood trees and 1 hardwood sapling tree, the estimated total stand biomass is: 3(15.2) + 4(8.4) + 1(5.6) =84.8 tons per acre.

Table 2.--Basal area and stand biomass estimates by three cruising methods for two stands in Georgia

Stand no.	Size of stand	Stand component	Stems per acre[a]	Basal area estimates by cruise method: Prism plots	Fixed 1/20-acre: Ocular tally plots	Fixed 1/20-acre: Detailed tally plots	Stand biomass estimates by cruise method: Prism plots	Fixed 1/20-acre: Ocular tally plots	Fixed 1/20-acre: Detailed tally plots	Actual stand biomass
	Acres			- - - - - Sq. ft./acre- - - - -			- - - - - - Tons/Acre- - - - -			
1	3.2	Overstory	124	63.0[b]	- -	60.8	64.2[b]	- -	62.1	59.7
		Understory	972	35.5[b]	27.5[b]	31.1	19.8[b]	17.8[b]	19.8	19.1
		Total stand	1,096	98.5	- -	91.9	84.0	- -	81.9	78.8
2	31.5	Overstory	205	61.1	71.5	77.8	70.8	68.5	64.7	- - [c]
		Understory	973	31.9	27.7	27.2	16.2	20.3	20.3	- - [c]
		Total stand	1,178	93.0	99.2	105.0	87.0	88.8	85.0	81.6

[a] from fixed actual tally plots.
[b] average of estimates by two cruisers.
[c] actual stand biomass was not separated by overstory and understory in this stand.

Basal Area Estimates

Estimates of basal area per acre for the two stands by three cruising methods and by overstory, understory, and total stand are given in table 2. Basal area estimates for the three cruising methods were fairly consistent except for the overstory of stand number 2. In this stand the average basal area from 27 prism plots was 61.1 square feet per acre compared to 71.5 square feet per acre on 27 fixed ocular tally plots and 77.8 square feet per acre on 14 fixed radius detailed tally plots. The differences may be due in part to different sampling intensities.

Basal area estimates seem to be well correlated with tons of biomass per acre. For each square foot of basal area in the overstory there appears to be about 1 ton of biomass per acre. For each 3 square feet of basal area in the understory there are approximately 2 tons of understory biomass per acre.

Stand Biomass Estimates

Fixed radius detailed tally plots yielded the most accurate estimates of biomass in the two stands. Prism plots and fixed radius ocular plots yielded poorer estimates. Fixed radius detailed tally plots overestimated actual stand biomass by about 4 percent. Prism plot estimates were high by 7.5 and 6.6 percent, respectively, for stands 1 and 2. The ocular plots in stand 2 overestimated total stand biomass by 8.8 percent (table 2).

Although the detailed tally plots were the most accurate, they are not necessarily the best. The amount of time required to tally detailed information on these plots was about 21 minutes, compared to 11 minutes on ocular plots and 4 minutes on prism plots. Thus, approximately 2 ocular plots and 5 prism plots can be taken in the amount of time required to measure one detailed tally plot.

A prism cruise using biomass factors by Hughes (table 1) does not include tree height as a variable. Thus, poor estimates can result if the factors are applied to very short or very tall stands and no adjustments are made. For example, on a 1.04-acre demonstration area set up by the Georgia Forestry Commission, virginia and shortleaf pines averaged only 50 feet tall although the diameters of dominant trees were 10 to 12 inches. Two foresters cruised the stand using 10-factor prisms to tally the trees marked to be cut. Applying Hughes' factors to their cruise data yielded biomass estimates of 72.1 and 73.1 tons per acre, respectively. When the trees marked to be thinned were harvested and weighed, we found that only 58.4 tons of biomass per acre had been removed. The cruise estimates were high by 23 to 25 percent. The same kind of error can result with any method that does not account for differences in tree height.

Biomass Harvested

Not all of the biomass was removed from the two sites that were total-tree chipped in this study. The first tract (the 3.2-acre tract in north Georgia) produced 53.5 tons per acre of total tree chips and 14.5 tons per acre of saw logs (table 3). Another 10.8 tons per acre were left on the site as material returned to the site by the chip harvester separator (bark, twigs, and needles), as high stumps (above 0.5 feet), and as standing trees left on the site. The 68 tons of biomass per acre removed represented 86.3 percent of the available biomass on this site.

From the second area total-tree chipped (the 31.5 acres in west Georgia), 73.8 tons of chips per acre were removed and 7.8 tons of biomass were left on the site (table 3). Saw logs were not cut on this tract. The 73.8 tons of biomass per acre removed represented 90.4 percent of the available biomass on this tract.

RECOMMENDATIONS

1. When a quick estimate of stand biomass is needed, the best approach is to put in a series of 10-factor prism plots and use the biomass factors provided by Hughes in table 1. An individual prism plot takes only about 4 minutes to put in. If the sample is representative, the results are very acceptable. Our tests indicate that the Hughes factors which were developed in Louisiana tend to overestimate slightly in stands in the Southeastern United States.

As always, people who use a prism to cruise timber should be thoroughly trained in its use. For example, the cruiser should hold the prism over plot center and rotate his body around the prism rather than stand on plot center and rotate the prism around his body. The cruiser should take care to check a tree's critical angle (which determines its "in" or "out" status) at exactly 4.5 feet from ground level. And finally, he should make sure he holds the prism perpendicular to his eye. Borderline trees (those that appear to be just "in" or just "out") should be checked by pulling a measuring tape from plot center to the tree to check the tree's distance from plot center against its actual d.b.h. An acceptable alternative to this approach is to tally every other borderline tree.

Table 3.--Biomass removed as total-tree chips and saw logs and biomass remaining as residue from the chip separator, high stumps, and residual standing trees for two test areas in Georgia

Test area	Size of test area	Total-tree chips harvested	Saw logs harvested	Residue from chip separator	Residual as high stumps[1/]	Residual standing trees on test area	Total stand biomass
	Acres	Tons/acre					
1	3.2	53.5	14.5	2.3	1.4	7.1	78.8
2	31.5	73.8	----	6.2	0.3	1.3	81.6

1/ stumps cut above 0.5 feet.

2. If one feels more comfortable with a fixed plot tally but does not need detailed biomass data by species and actual d.b.h., the best approach is to put in a series of 1/20-acre plots and tally trees by pine, hard hardwood, and soft hardwood classes and by 2-inch diameter classes. This type of plot takes about 11 minutes to put in and gives good accuracy. A person who uses this cruising method should have experience in estimating tree diameters or he should test his ability to estimate tree diameters by measuring a few trees on the first plot. Regression equations and yield tables for converting plot tallies to pounds and ultimately to tons of biomass per acre are available from the Utilization of Southern Timber Work Unit, USDA Forest Service, Athens, Georgia 30602.

3. If estimates of total stand biomass by species, d.b.h., and total height are desired, and if maximum accuracy is needed even at higher costs, then a series of 1/20-acre fixed radius detailed tally plots should be used. These plots require an average of 21 minutes to measure, but the tally on these plots is fairly straight forward and requires less judgment by the cruiser. Weight equations and tables needed to convert cruise data to weight for total trees by individual species are available from the Utilization of Southern Timber Work Unit, USDA Forest Service, Athens, Georgia 30602.

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A typical low quality hardwood stand suitable for total-tree chipping.

GEORGIA FORESTRY COMMISSION

A. Ray Shirley, Director
John W. Mixon, Chief of Forest Research

Cost $1,381.
Quantity 5,000