Resource Inventory Notes

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COMPARISON OF POINT - 3P SAMPLING DESIGNS

by

Harry V. Wiant, Jr.[1/]

ABSTRACT - Two point - 3P sampling designs were compared by simulation using data from a 36-year-old Appalachian hardwood stand. Results indicate the selection of points rather than individual trees for measurement as 3P sampling units may reduce field time needed if a second visit is required for dendrometry.

INTRODUCTION

Sampling forest populations with a probability proportional to prediction, 3P sampling, as originally proposed required visiting each tree in the population (Grosenbaugh 1964). Multi-stage sampling, including a combination of 3P and point sampling, was introduced a few years later (Grosenbaugh 1971).

Two designs which may be used in cruising where tree heights are determined for all point sample "in-trees" are:

1. Individual trees are selected for measurement with a probability proportional to their heights (Grosenbaugh 1971, 1974; Rennie 1976).

2. Individual point sampling units are selected with a probability proportional to the sum of heights of all in-trees on those points. All in-trees on those points are measured (Wiant 1974, 1975a, 1975b, 1976).

Data collected on 383 point sampling units (BAF=10) with 1256 in-trees on the West Virginia University Forest were used to compare these designs. This Appalachian hardwood forest is evenaged with scattered old-growth residuals and was about 36 years old when data were collected. Volumes per acre averaged 2871 ± 5% board feet (Int. - 1/4").

1/ The Author - Harry V. Wiant, Jr. is professor of forestry, Division of Forestry, West Virginia University, Morgantown, West Virginia University Agricultural and Forestry Experiment Station Scientific Paper No. 1481

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Procedure

Five samples of 20 sampling units each, excluding those with no sawtimber volume, were selected with a probability proportional to summed log heights using list sampling to approximate 3P sampling (Wiant 1976). For comparison, an equal number of samples were selected randomly.

The same number of in-trees as in each of the five samples was selected with a probability proportional to the number of logs in each tree using list sampling to approximate 3P sampling. All sampling was without replacement, as in 3P sampling.

Ratios of per-acre volumes (V) represented by each point or tree selected as a 3P sample to the number of 16-foot logs (L) contained were calculated.

Results

The average V/L-ratio times the average number of logs on all 383 point sampling units was used to predict the average volume obtained by measuring all point samples. The percent deviation for each estimate is shown in Table 1. The two 3P systems gave similar accuracy. A random selection of points performed somewhat more poorly.

Second-stage sampling errors, calculated as shown by Wiant (1976), are given in Table 2. The sampling errors for points selected randomly and by 3P were very similar, but sampling errors based on the 3P selection of individual trees were considerably lower. This is not unexpected as error calculations for 3P trees were based on 91 to 124 ratios while those for 3P points were based on 20 ratios.

Table 1. Accuracy of sample estimates of volume.

	Percent deviation of estimate from that based on 383 point samples		
Test	20 random points	20, 3P points	3P by trees
1	2.4	0.9	-1.1
2	2.3	-0.1	1.2
3	1.6	0.9	0.0
4	1.9	-0.2	-0.2
5	0.7	0.2	0.1
Absolute average	1.78	0.46	0.52

Table 2. Second-stage sampling error, ignoring the covariance term.

Test	Sampling error (%)		
	20 random points	20, 3P points	3P by trees
1	1.3	1.1	0.8
2	1.8	1.4	0.8
3	1.2	1.3	0.7
4	1.3	1.4	0.8
5	1.5	1.3	0.8
Average	1.42	1.30	0.78

The coefficient of variation (CV) for ratios are shown in Table 3. The random and 3P point designs were similar, but ratios based on individual trees has greater variation. This, again, is not unexpected as averages tend to vary less than individual observations from a given population. The number of sampling units (n) needed for a specified sampling error (E) can be estimated by the relation:

$$n = \frac{t^2 \ CV^2}{E^2}$$

For a 1 percent sampling error 2 in 3 times, letting t equal 1.0 and using average values shown in Table 3, the number of sampling units needed are:

random points	40
3P points	33
3P trees	65

In these tests, the number of points visited ranged from 78 to 85 percent of the number of individual trees desired, averaging 82 percent. To obtain 65 trees, then, would require visiting 53 points, or 61 percent more points than required if points are used as sampling units. On the other hand, as there were 5.5 in-trees on the average 3P point sampling unit, an estimated 182 in-trees would be measured on 33 points. This is almost three times as many trees as must be measured using individual trees as sampling units. In many situations, it may be cheaper to visit 61 percent fewer points and measure three times as many trees than to do the reverse, especially if a second visit to previously established sampling locations is required for dendrometry.

The number of observations needed for a 1 percent second-stage sampling error is not excessive in this example. Ignoring the covariance term as is usually done in practice, and which is often unreasonably large and negative in these designs 1/ (Wiant 1976),

$$\text{approximate sampling error} = \sqrt{(5)^2 + (1)^2}$$

$$= 5.1\%$$

Thus, the second-stage increases the first-stage sampling error by an insignificant amount.

An advantage of the random sampling design should not be ignored. One can be certain of obtaining the number of samples desired, and that is not feasible with 3P sampling.

The 3P sampling method has been used for updating inventories based for permanent sample points (Van Hooser 1972, 1973; Wiant 1975b, 1976). However, since a list of the previously measured trees and points is available, list sampling, as described by Wiant (1976), is feasible and will provide the specified number of observations. Using individual points rather than trees as sampling units may again reduce the time required for remeasurement. In addition, trees which have reached merchantable size since the last inventory (ingrowth) will be accounted for using points but not using trees as sampling units.

1/ The V/L-ratio for all point samples in this study had a highly significant inverse relation to L (r = -0.26).

Table 3. Coefficients of variation for ratios.

Test	Coefficient of variation (%)		
	20 random points	20, 3P points	3P by trees
1	6.0	4.7	7.7
2	8.1	6.1	8.4
3	5.4	6.0	7.8
4	5.9	6.3	8.0
5	6.4	5.8	8.4
Average	6.36	5.78	8.06

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