BOOTSTRAP TEST OF 3P AND POINT SAMPLING ERROR

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ABSTRACT. The sampling error calculated for a 3P and point sampling system generally ignores the covariance term. Bootstrap estimates of sampling errors for three forests provided evidence that this approach is acceptable for practical purposes.

Building on work by Grosenbaugh (1967, 1971), Wiant (1976) developed a sampling system combining 3P and point sampling, where the estimated sum of logs on "in-trees" is recorded at all first-phase sample points and all in-trees are measured for volume estimates at the second-phase, 3P-selected sample points. The parametric percent sampling error (E) has been estimated as

$$E = 100 \left[(S1/n1)^2 + (S2/n2)^2 \right]^{1/2} \qquad (1)$$

where

S1 = standard error for first-phase sample,

n1 = number of first-phase sample points,

S2 = standard error for second-phase sample ratios (measured per-acre volume/estimated sum of logs), and

n2 = number of second-phase sample points.

The covariance term between first-phase estimates and the ratios of measured volume to first-phase estimates for second-phase sample points has been ignored and is sometimes unreasonably large and negative (Van Hooser 1972, 1973, Wiant 1976). However, the usefulness of the sampling error calculated without the covariance term has not been established.

The "bootstrap" technique, described by Efron and Gong (1983), and by Schreuder et al. (1987) in a forestry context, provides nonparametric estimation of statistical error. Sampling with replacement is used on the original data set to estimate the variable of interest. This is repeated many times and sampling error is calculated using all those simulated estimates.

PROCEDURES

Data were available from three field tests. One consisted of 384 first-phase permanent point samples (BAF=10) established on the West Virginia University Forest near Morgantown in 1967. An inventory update was conducted on this Appalachian hardwood forest in 1975 using 29 second-phase, 3P-selected points (Wiant 1976). Estimated volume in 1975 was 4.4 mbf/ac.

Another data set was from a 3P and point sampling cruise conducted on an upland oak forest in southeastern Ohio. There were 99 first-phase sample points (BAF=10) and 12 second-phase, 3P-selected points (Wiant and Cristan 1987). Volume averaged 9.2 mbf/ac.

The last data set was from a cruise conducted on an Appalachian hardwood forest near Morgantown, West Virginia. There were 42 first-phase sample points (BAF=10) and 12 second-phase, 3P-selected points. Volume averaged 2.6 mbf/ac.

The first-phase variable used was estimated number of 16-foot logs on in-trees (except for the WVU Forest where per-acre volume estimates made in 1967 were used). The second phase involved tree measurements (dbh, number of logs) necessary to obtain per-acre volume estimates. Volume per acre (V) was estimated as:

$$V = (\Sigma L/n1)(\Sigma R/n2) \qquad (2)$$

where

L = estimated number of 16-foot logs, and

R = ratio of measured volume to estimated number of 16-foot logs on 3P sample point.

A total of 2000 random selections of sample sizes n1 and n2 were made for each forest, calculation V each time. Sampling error (e) was calculated as:

$$e = \left[\Sigma (V-\bar{v})^2 / (2000-1) \right]^{1/2} \qquad (3)$$

where

$\bar{v}$ = average predicted volume for the 2000 simulations.

That sampling error was expressed as a percent of the mean volume.

RESULTS

Table 1 shows no important differences in standard error estimates using the bootstrap method and the parametric approximation which ignores the covariance term. Sampling errors differed by no more than 1%, not an important difference from a practical viewpoint. (Inclusion of the covariance term gave impossible negative variance estimates for the WVU and Ohio forests.)

These findings cannot be generalized as only approximations are being compared. However, there is no evidence that ignoring the covariance term gives unreasonable estimates of the sampling error for the 3P and point sampling method.

Table 1. Comparison of means and standard errors derived by parametric and nonparametric methods for three forests (results of a second 2000-iteration in parenthesis show consistency of this technique)

Forest	Mean volume/ac		Standard error (volume)		Standard error (%)[a]	
	Parametric	Nonparametric	Parametric	Nonparametric	Parametric	Nonparametric
WVU Forest	4404	4450 (4440)	314	316 (310)	7.1	7.2 (7.0)
Ohio Forest	9186	9180 (9206)	551	533 (525)	6.0	5.8 (5.7)
Finn Tract	2611	2415 (2417)	308	275 (271)	11.5	10.5 (10.4)

[a] Based on parametric mean.

LITERATURE CITED

EFRON, B., and G. GONG. 1983. A leisurely look at the bootstrap, the jackknife, and cross-validation. Am. Stat. 37: 36-48.

GROSENBAUGH, L. R. 1967. STX-FORTRAN-4 program for estimates of tree populations from 3P sample-tree-measurements. USDA For. Serv. Res. Pap. PSW-13.

GROSENBAUGH, L. R. 1971. STX 1-11-71 for dendrometry of multistage 3P samples. USDA For. Serv. FS-277.

SCHREUDER, H. T., H. G. Li, and C. T. Scott. 1987. Jackknife and bootstrap estimation for sampling with partial replacement. For. Sci. 33: 676-689.

VAN HOOSER, D. D. 1972. Evaluation of two-stage 3P sampling for forest surveys. USDA For. Serv. Res. Pap. SO-77.

VAN HOOSER, D. D. 1973. Field evaluation of two-stage 3P sampling. USDA For. Serv. Res. Pap. SO-86.

WIANT, H. V., JR. 1974. Combine 3P and point sampling for efficient cruising. W. Va. For. Notes 2: 12-15.

WIANT, H. V., JR. 1976. Elementary 3P sampling. W. Va. Univ. Agric. and For. Exp. Stn. Bull. 650T.

WIANT, H. V., JR., and R. R. Cristan. 1987. A test of 3P and point sampling. W. Va. For. Notes 13: 34.