Resource Inventory Notes

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# 3P OR NOT 3P 1/

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## I. INTRODUCTION

Since 3P (probability proportional to prediction) sampling was first described by Grosenbaugh (1964) in 1963, it has been slowly gaining popularity as a fast, efficient way to cruise and inventory timber. Even though 3P has been around for over 12 years, people are still confused and hesitant about using it. The purpose of this paper is to clarify some misconceptions about 3P and offer some guidelines as to when it may be used.

## II. SAMPLING TECHNIQUES

There are several ways to select trees and plots, measure them, and process the data collected. Some of the more common sampling techniques in cruising and/or inventory include the 100% count, a random sample, a systematic sample, and more recently, 3P.

### A. 100% Sample

For the following discussion we consider all the trees: 1) to be cut within a sale or on a tract, 2) on a fixed are plot, or 3) picked up by a prism on a variable plot as our entire population or 100% count. (The 100% count may also be thought of as all the plots in an inventory unit instead of all the trees on a plot). In the 100% count each tree or plot is visited and measured. Because the entire population is measured, there is no sampling error. The 100% count is extremely time consuming. Consequently, alternatives to measuring every tree are desirable even though we will have some sampling error.

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B. The Random Sample

In the random sample, we still have to visit the same trees (or plots) as in the 100% count. However, we don't have to measure all the trees but randomly select a few trees out of the visited population. The number of trees selected to be measured depends on the anticipated variability of the entire population. The difference between the random sample and the 100% system is that we are measuring fewer trees, resulting in some sampling error. We are still visiting or looking at each tree in the population, however.

C. The Systematic Sample

As in the random sample, we will visit each tree (or plot) in the population and measure only a few. Trees are selected based on some sampling interval (e.g., every 10th tree encounter is measured). Again, the number of trees selected for measurement will depend on the variation of the population as a whole. As with the random sample, we will have sampling error. Both the systematic and random designs are equal probability sampling techniques.

D. The 3P Sample

In the 3P sample, we still have to visit each tree (or plot) in our population. Now we insert an extra step -- we guess a value (usually volume) for each tree visited. We then sample the visited population based on probability proportional to the predicted value using a table of random numbers. This sampling procedure is explained in several publications (Johnson, 1972, Dilworth and Bell, 1974). Sampling with 3P provides nothing more than an unequal probability sample somewhat similar to that provided by a prism. As with the other sampling designs previously mentioned, we visit each tree and measure only a few. Three-P differs from random sampling and systematical sampling in that the variation is based on the ratio between the measured and the guessed value. Consequently, with the 3P sample, the expected coefficient of variation is lower and fewer trees need to be measured to be within the same allowable error as with the random or systematic sample.

The advantage of 3P sampling over the random and systematic sampling is that for a given allowable error, the cruiser can get by with measuring fewer trees. Wiant (1976), for example, indicates that instead of measuring 2500 randomly selected trees in a given sale area he could get by with only 100 trees using a 3P sample and still be within the same allowable error. Similar results have been reported elsewhere (Van Hooser, 1972, Bonner, 1972). Over all, 3P sampling is a very fast and efficient way of obtaining information about a particular facet (such as volume) of a population.

By using 3P sampling and the measuring technique normally applied, the cruiser can save time spent on a tract or plot. This time saving can be put to use in 3 different ways:

1. The cruiser could move to another tract or job sooner.
2. The cruiser could measure some additional trees to reduce the sampling error.
3. The cruiser could use more sophisticated equipment and take more accurate or detailed measurements on the 3P sampled trees.

The choice or combination of choices, of course, is up to the cruiser.

## III. PROBLEMS AND MISCONCEPTIONS

If 3P is so efficient, why isn't it used more? There are several reasons why people are reluctant to use 3P sampling (or any other "new" system). These may include:

1. Too much trouble to change systems.
2. No advantage in new system.
3. No self confidence or no confidence in the system.
4. Lack authority to switch.
5. Do not have the special equipment to use the new sampling technique.

There is not much that can be done for those that believe it is too much trouble to change systems. Perhaps it really is too much trouble. One must consider the cost of retraining crews, designing and printing new forms, outling new compilation procedures, etc.

Likewise, in a given situation, there may not be any advantage in going to a more efficient system. People, when thinking of 3P often lose sight of the fact that the sampling technique does not reduce the number of trees that have to be visited. The literature has contributed to their oversight. For example, a paper by Space (1973) indicates that a million acres can be inventoried by only measuring 221, 3P-selected trees. No mention is made of the fact that some 2000 other trees still had to be visited.

A cost-benefit study should be conducted. By going to a more efficient system, you will be spending less time measuring trees. At the same time, you will be collecting less data. Will the more efficient system produce all the information you really require?

For example, 3P-sampled trees alone may not be enough to develop stand and stock tables normally required in a given inventory. The sampling intensity may not be qreat enough to generate reliable estimates for various species and diameter classes present. Consequently, data may also need to be collected or measured on the other trees that were visited. Generally speaking, 3P is not a good system to use for the construction of frequency tables.

The time saved in measuring only 3P sample trees may be negligible if you have access problems. In some parts of the western United States, for example, it may take 3-4 hours just to reach a plot. The work day would not be reduced appreciable if you were measuring only 1 tree or all the trees on the plot.

Some schemes using 3P advocate making the estimates of volume first out in the field, going back to the office to draw the 3P sample, and then returning to the field to measure the 3P sample trees. It is difficult to see how this could be efficient under any circumstances. Analyze your needs and current procedures; perhaps it really isn't efficient to switch to a new system.

Self confidence or confidence in the system can only be acquired by trying the system yourself. Training courses are available as well as publications on 3P sampling (Lund, 1975). In addition, technical advice on how to proceed is available through state forestry offices, consultants, universities, the extension service, the U.S. Forest Service, and other agencies.

Many of us lack the authority to change or adopt new systems. This can only be overcome by developing a selling program via demonstrations to show that time and money can be saved by adopting the new system. Many people incorrectly believe that 3P sampling requires the use of dendrometers and computers; dendrometers and computers have been used with 3P sampling to get more detailed measurements. The fact that there is a "3P Package" available (Mesavage, 1971) has also lead to this misconception. The truth is that 3P does not require more exotic equipment (except for a table of random numbers) than the instruments the cruiser now uses. To rephrase it, 3P is no more tied to computers and dendrometers than the system you are now using.

There are many ways to measure the sampled trees. These include using a Biltmore stick, diameter tape and abney, a relascope, or various other dendrometers. Similarly, there are many ways of compiling the data collected. This may be done by paper and pencil, slide rule, hand calculators and computers. Trees may be sampled by any of the above sampling schemes, they may be measured by any of the tree measuring devices, and the results may be processed by any of the data compilers. No sampling system is restricted to any particular measuring device and/or data processing system. Each is independent of one another.

You <u>can</u> capitalize on the time saved on a plot or a tract using 3P sampling by taking detailed measurements with more sophisticated equipment if you wish; but, this is not a requirement of 3P sampling. As indicated before, the only additional "equipment" needed for 3P sampling is a table or list of random numbers. Such tables are available in any good statistical or forest mensuration text. In addition, random number generator routines are available for man programmable calculators and most computers. Your local university may be able to furnish you with such lists.

## IV. WHEN TO USE 3P

A. You must be interested in a precise estimate of a specific item (i.e., volume on a tract of land), in order to use 3P most effectively. Like any other sampling system, 3P is most efficient for the purpose for which the sample was drawn. The most accurate data will come from the variable (i.e., volume) used to select the sample items. Because you are sampling for volume, don't expect to get equally reliable data on age, diameters, heights, etc. Even if you sample for volume, you may not get reliable volume information for all species present unless you use some type of species stratification (i.e., 3P sample each species or species group).

B. It is also desirable to orient the sample toward selection of objects with highly predicted values. This may be because these items are more variable, more valuable, contain a higher proportion of the volume of the population, or for other considerations. If, for example, an estimate of frequency is desired, an equal probability sample would be best. You must be able to predict or guess with some certainty the value of the specific item. If you are interested in volume, you have to be able to fairly well guess the volume in each tree. Three-P sampling will not work to any advantage if there is no correlation between the estimated and the true value of the item.

C. There should be little or no cost difference in making the measurements on a large tree or a small one. For example, it takes nearly as much time to measure a tree 24" in diameter as it does one 42" in diameter. Objects selected for measurements should be measured for approximately equal cost or at least the additional cost should not increase appreciably with size.

D. There should be a large amount of variation present in the population. Three-P would probably not be efficient to use in a plantation where all the trees are the same size.

If variation is low, there is little advantage over equal probability sampling from the standpoint of sampling efficiency. Thus from a practical standpoint, equal probability sampling may be less cumbersome to use.

E. Because of the way random numbers are used, 3P tends to sample larger items rather than smaller items. This is generally no problem in timber sales where we are usually more interested in the larger trees; however, you should keep in mind that like prism cruising, 3P does favor the larger objects.

Before deciding for or against 3P, ask yourself the following questions:

Are you just starting an inventory or cruising system, or are you revamping an old one? If you are just starting a system, consider 3P; it could save you money, particularly if you are interested in volume.

If you are revamping, what is wrong with your present system? In cruising, if you want to reduce your field time, consider 3P.

In inventory, if you use 3P and have to revisit plots to get the "measured trees," you may want to consider some other system. In either case, changes will mean new manuals, forms, perhaps special equipment and data processing programs.

Be sure you really have to change your system. Make sure that incorporating a new scheme will not result in the loss of data collected earlier or in the failure to collect needed data.

What is the nature of the stands in which you'll be working? Are they homogeneous in species composition or heterogeneous? If they are homogeneous but with a large amount of variation in size, 3P sampling may be used. If not, you may want to consider some other sampling technique.

Will a detailed sample of 200-300 trees give you all, or nearly all, the tree information you want with the desired accuracy or precision? If so, consider 3P; if not, use some other system or supplement the 3P sample.

Are you dissatisfied with your present volume equations or formulas? Perhaps 3P sampling and the use of more sophisticated equipment such as dendrometry and the STX Program can be used to eliminate volume tables and to determine produce and outturn estimations for growth measurements. It may be desirable, in some cases, to use 3P subsampling for those purposes even where a conventional inventory is established.

## V. CONCLUSIONS

The 3P sampling design is efficient; it requires visiting the normal number of trees but only measuring a few. Those that are measured can be done much more accurately than would be economically possible with many sampling designs. Three-P sampling may be more precise than many other sampling designs, particularly when the expected number of trees to be visited is large (exceeding 100). This is the case in most forest appraisal and inventory situations.

Three-P does not have to apply to forestry or trees. It can be used to sample anything for which a value (volume, number, weight, size) can be estimated with some reliability cheaper than it can be measured. Each object must be visited and the value estimated. The 3P sampling then selects the objects on which detailed measurements will be taken.

Don't adopt 3P just because it is currently in vogue, but don't forsake it because it is new. It is a sampling tool that can be used effectively. Any time you use a highly efficient sampling technique, make certain it will give you all the information you need. If it will not, then it is not efficient in your situation. Before adopting 3P, or any other new system, analyze your own needs and THINK!

## LITERATURE CITED

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Dilworth, J. Richard and John F. Bell, 1974: Variable probability sampling - variable plot and three-P. Ore. State Univ. Bookstores, Inc., Corvallis, Ore. 130p.

Grosenbaugh, L. R., 1964: Some suggestions for better sample - tree measurements. Soc. Am. For. Proc., Oct. 20-23, 1963. Boston, Mass., p 36-42.

Johnson, Evert W.: Basic 3P sampling. Auburn Univ., Agric. Exp. Stn. For. Dep. Serv. 5, 12p.

Lund, H. Gyde, 1975: Three-P sampling: an annotated bibliography. USDA For. Serv., Northeast Area, State and Private For., Upper Darby, Penn., 25p.

Mesavage, Clement, 1971: STX timber estimating with 3P sampling and dendrometry. USDA For. Serv., Agric. Handb. 415, 135p.

Space, James C., 1973: What is three-P sampling and how can it be used? Pap. presented at twelfth Auburn For. Forum, Auburn Univ., Auburn, Ala., June 20, 10p.

Space, James C., 1974: Three-P forest inventory: design, procedures, data processing. March, 58p. USDA For. Serv., Southeast Area, State and Private For., Altanta, Ga.

Van Hooser, Dwane D., 1972: Evaluation of two-stage 3P sampling for forest surveys. USDA Forest Serv. Res. Pap. WO-77, 9p.

Wiant, Harry V., Jr., 1974: Combine 3P and point sampling for efficient cruising. For. Notes 2:12-15. W. Va. Univ., Morgantown, W. Va.

Wiant, Harry V. Jr., 1976: Elementary 3P sampling. Unpublished manuscript. W. Va. Univ., Morgantown, W. Va., 45p.

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## CURRENT LITERATURE

"Three-P Sampling: An Efficient Sampling Technique for Forest Inventory" is a paper presented at the IUFRO Congress in Oslo, Norway in June 1976 by Space and Turman. Copies are available from James C. Space, USDA Forest Service, Cooperative Forestry, South Bldg., 12th and Independence St., Washington, DC 20250.

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Reprint #R-272 "Developing a Sampling Method to Determine Effects of Insects on Yield on Southern Pine Orchards" is available from the Southeastern Forest Experiment Station, P.O. Box 2570, Asheville, N.C. 28802. Also ask for Res. Bull. SE-34 "Forest Statistics for the Coastal Plain of Virginia," Res. Note SE-225 "Sampling Weight of Pine Foliage and Twigs by Microwave Signal Attenuation," Res. Pap. SE-136 "Deer Browse Resources of the Chattahoochee National Forest," and Res. Pap. SE-137 "Deer Browse Resources of the Oconee National Forest."

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"Land Slope in West Virginia" by Lee, Chang, and Hill explains a procedure for sampling and determining slope steepness from topographic maps. The article appears in West Virginia Agriculture and Forestry 6 (3):13-16 available from the Dean, College of Agriculture and Forestry, West Virginia University, Morgantown, West Virginia 26506.

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Publication B-36 "An Analysis of the Cost and Usefulness of Area Frame, List Frame, and Multiple Frame Sampling for Estimating Livestock Inventories in Nevada" by Hayes and Ching is available from the Cooperative Extension Service, University of Nevada, Reno, Nevada 89507.

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Forestry Departmental Series No. 6 & 7 provides forest cover photo - interpretation keys from the piedmont and mountain forest habitat regions in Alabama. These are by Evert Johnson and Larry Sellman and are available from the Agricultural Experiment Station, Auburn University, Auburn, Alabama 36830.

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Reprints "Quantification of Outdoor Recreationists' Preferences" by Driver; "Sampling Shrub Ranges with an Electronic Capacitance Instrument" by Morris, Johnson, and Nea; and Res. Note RM-307 "Trapping Anesthetizing and Marking the Abert Squirrel" are available from the Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, Colorado 80522.

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The North Central Forest Experiment Station, Folwell Avenue, St. Paul, Minnesota 55108, has several publications that are of interest. These include: Gen. Tech. Rept. NC-20 "Estimating Aspen Volume and Weight for Individual Trees, Diameter Classes, or Entire Stands"; Gen. Tech. Rept. NC-17 "Introduction to Uses and Interpretation of Principal Component Analysis in Forest Biology"; Gen Tech. Rept. NC-15 "Local Net Volume Equations for Missouri"; and Res. Note NC-199 "A Local Net Volume Equation for Iowa."

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A couple of interesting publications are available from our office. These include Tech. Note 276, "Resource Flows and Values" by W. A. Flick and reprint "Multiple Resource Inventory System" by H. G. Lund and M. Kniesel. Drop us a line and we'll send you copies.

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Extension Folder 323 describing "Careful Soil Sampling - the Key to Reliable Soil Test Information" can be obtained from the USDA Extension Service, North Carolina State University, Raleigh, North Carolina 27607.

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Jeff Wartluft has published "A Suggested Glossary of Terms and Standards for Measuring Wood and Bark Mill Residues." Write the Northeastern Forest Exp. Station, 6816 Market Street, Upper Darby, Pennsylvania 19082 and ask for Research Note NE-217.

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Canada has published several informative reports on inventory. These include FMR-X-40 "Tree Diameters and Volumes from Large-Scale Aerial Photographs"; FMR-X-66 "The Forestry Radar Altimeter Tested in the Tropics"; FMR-X-86 "Measurement of Tropical Trees on Large-Scale Aerial Photographs"; and "Selected Metric (SI) Units and Conversion Factors for Canadian Forestry." These reports are available from the Forest Management Institute, Department of the Environment, Majestic Building, 396 Cooper Street, Ottowa, Ontario, CANADA.

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MUJWRRC Report 67 describes "Application of Microwave Water Sensing Techniques to Watersheds." Copies are available from the Water Resources Research Center, Bozeman, Montana 59715.

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Research Bulletin No. 929 "Thin Prisms as Angle Gauges in Forest Inventory" by Miller and Beers, gives information on conventional prisms and Fresnel prisms not available in forestry literature. Obtain your copy from Mailing

Room, Purdue University Agricultural Experiment Station, Agricultural Administration Building, West Lafayette, Indiana 47907.

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"Biomass Sampling Methods for Puckerbrush Stands" by Harold E. Young is available from the School of Forest Resources, University of Maine, Orono, Maine 04473.

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"Computer Generation of Points on a Plane" and "Treatment of Boundary Line Overlap in a Forest Sampling Simulator" by Lee Wensel appear in Hilgardia Vol. 43, No. 5, June 1975. This is available from Agricultural Experiment Station, University of California, Berkeley, California 94720.

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Several recent articles of interest have appeared in journals which may be available through your local library. These include:

- "Municipal Watershed Management Survey" by Dissmeyer and Swank. J. Am. Water Works Assoc. 68(2):97-100. 1976.

- "Environmental Data Management Tools" by M. E. Foley. Electronic Progress 17(4):15-20. 1975.

- "Estimating Recreation Use" by Siderelis and Tyre. Georgia Recreator 4(2):20-22. 1975.

- "Suggestions and Criteria for more Effective Regression Sampling" by Demaerschalk and Kozak. Can. J. For. Res. 5(3):496-497. 1975.

- "Use Color Infrared Photography for Forest Land Inventories" by Malmgren and Garn. J. Soil and Water Conservation 30(3):125-158.

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## MEETINGS

### Sampling and Data Processing

Time is growing short for signing up for the two concurrent sessions on sampling and data processing workshops being held at the University of New Hampshire, November 8-11, 1976. Class size will be limited. For further information, contact Prof. James Barrett, INER, University of New Hampshire, Durham, New Hampshire, 03284.

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## Integrated Inventories

Coming in 1977 - "Integrated Inventories of Renewable Natural Resources." This will be a National (and perhaps international) symposium sponsored by the Society of American Foresters' Inventory Working Group and the School of Renewable Natural Resources, University of Arizona. The dates have been set for October 11-14, 1977, and the place will be Tucson, Arizona. So mark your calendars and plan to attend. We'll keep you posted as the program develops.

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## S.A.F.

Just a reminder, the Society of American Forester's Inventory Working Group will hold its annual business meeting at 5 PM, October 4th during the national convention in New Orleans. The meeting place will be posted.

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## Midwest Mensurationists

The Midwest Forest Mensurationists and the Midwestern Forest Economists will be meeting September 16-17, 1976 at the Homestead in Glen Arbor, Michigan. For further details contact Bob Stone, c/o Forest Products Laboratory, Box 5130, Madison, Wisconsin 53705.

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## MISCELLANEOUS

The Remote Sensing Project, formerly located at the U.S. Forest Service Pacific Southwest Forest and Range Experiment Station has moved to the Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, Colorado 80521. The project will be combined with the Renewable Resource Supply and Evaluation Techniques project headed by Dick Driscoll.

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Have an article you wish to have printed in the "Notes"? Got a publication that others may be interested in? Do you have a meeting or workshop planned? Whatever, send in your material and we'll try to get it into the "Notes". We need at least a 2 or 3-month lead for meetings. Please send all correspondence regarding the "Notes" to the address on the front page, Attn: Resource Inventory Notes.

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