

Resource Inventory Notes

BLM 6

July, 1977



AN ILLUSTRATION OF LIST SAMPLING

by

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INTRODUCTION

Most foresters have used simple random sampling and many are familiar with 3P sampling. In its simplest form, random sampling is conducted so that each member of the population has an equal chance of appearing in the sample (Snedecor and Cochran 1967). This, then, is equal probability sampling.

With 3P sampling, as developed by L. R. Grosenbaugh (1974), the probability of a member of the population, usually a tree, being selected as a sample is proportional to a guessed value, usually related to volume. This form of sampling has unequal probabilities. The random numbers generated between 1 and KZ, where KZ equals the total predicted values expected divided by the number of 3P samples desired, provides a form of list sampling. Unfortunately, the exact number of 3P samples obtained is known only after the sampling is completed, which may mean too few or too many were obtained for the precision originally specified (Schreuder et al. 1968).

If a list of the members of a population is available before sampling is initiated, list sampling can be used instead of 3P sampling and one is assured of obtaining the number of samples specified. Such lists are usually not available in forest inventory studies, but sometimes may be, as when updating data on permanent plots.

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PROCEDURE FOR LIST SAMPLING

The procedure outlined for list sampling here, using an unrealistically small population for illustration, is similar to one given by Wiant (1976).

Let column B of Table 1 represent the cubic foot volumes of a population of 30 trees as measured 10 years ago. Column C gives the volumes today.

Rather than re-measure each tree, we could have selected a list sample with the probability of a tree appearing in the sample proportional to its volume 10 years ago. This may distribute the sample better over size classes than a simple random sample. In theory, sampling is with replacement, which means an item designated in column A may appear in the sample more than once. In practice, with large populations and relatively small sample sizes, the difference between sampling with or without replacement can be ignored (Loetsch et al. 1973).

Cumulative totals of column B are needed, as shown in column D. Column E gives numbers from which random samples will be drawn. It can be seen that the second assigned number, or only number if a value in column B equals 1, equals the cumulative total in that row. The first assigned number in a row equals the second assigned number in the previous row plus 1. This chore is easily computerized.

Let the sample number, n , equal 5. The 5 random numbers drawn between 1 and 303 result in the following:

<u>Random number</u>	<u>Item number</u>	<u>Initial volume(X)</u>	<u>Present volume(Y)</u>	<u>$r = Y/X$</u>
232	15	3	8	2.6667
200	13	33	85	2.5758
52	4	96	119	1.2396
239	19	8	17	2.1250
225	13	33	85	2.5758
			Total	11.1829
			Average	2.2366

Table 1. Data for sampling examples.

A	B	C	D	E
Item no.	Initial volume(X)	Present volume(Y)	Cumulative totals of B	Assigned range
1	3	8	3	1-3
2	3	12	6	4-6
3	12	21	18	7-18
4	96	119	114	19-114
5	56	85	170	115-170
6	8	16	178	171-178
7	1	5	179	179
8	1	3	180	180
9	3	5	183	181-183
10	1	5	184	184
11	8	21	192	185-192
12	3	5	195	193-195
13	33	85	228	196-228
14	1	5	229	229
15	3	8	232	230-232
16	1	5	233	233
17	1	8	234	234
18	3	8	237	235-237
19	8	17	245	238-245
20	8	21	253	246-253
21	3	8	256	254-256
22	3	12	259	257-259
23	12	21	271	260-271
24	3	12	274	272-274
25	3	5	277	275-277
26	5	12	282	278-282
27	12	22	294	283-294
28	1	5	295	295
29	5	12	300	296-300
30	3	8	303	301-303

Totals 303 579

$$\bar{x} = 10.1 \quad \bar{y} = 19.3$$

The average Y/X -ratio (\bar{r}) times the total initial volume (ΣX) provides an estimate of the present volume ($\Sigma \hat{Y}$):

$$\begin{aligned}\Sigma \hat{Y} &= (\bar{r})(\Sigma X) \\ &= (2.2366)(303) \\ &= 678 \text{ cubic feet}\end{aligned}$$

The variance of \bar{r} , $S\bar{r}^2$, is estimated as shown by Husch et al. (1972) as:

$$\begin{aligned}S\bar{r}^2 &= \frac{\Sigma r^2 - \frac{(\Sigma r)^2}{n}}{n(n-1)} \\ &= 0.07108\end{aligned}$$

The standard error is:

$$\begin{aligned}S\bar{r} &= \sqrt{0.07108} \\ &= 0.26661\end{aligned}$$

Expressed as a percent of the mean, sampling error is:

$$\begin{aligned}\frac{0.26661}{2.2366} (100) \\ = 11.9\%\end{aligned}$$

We can now state that there is approximately a 2 in 3 chance that the population value lies between $678 \pm 11.9\%$ and a 19 in 20 chance it is between $678 \pm (2)(11.9\%)$ or $\pm 23.8\%$. Although we would usually not know the population value for ΣY in the real world, in this example it is within $678 \pm 23.8\%$.

Instead of list sampling, we could have randomly selected 5 trees from column C, determined the average volume of those trees, and multiplied that value by 30 to obtain an estimate of total present volume. Sampling error would be calculated in the usual fashion. As Loetsch et al. (1973) point out, list sampling will be more efficient than this form of random sampling if the correlation coefficient between X - and Y -values exceeds about 0.5. In this example, it is 0.96, so we expect list sampling to be more efficient than the simple random design.

To complicate things a bit, let us assume the values in column B represent cord per acre figures for 30 randomly located permanent plots established 10 years ago. Percent sampling error for the 30 plots, is calculated as:

$$\left(\frac{\sqrt{\frac{\Sigma X^2 - (\Sigma X)^2/n}{n(n-1)}}}{\bar{X}} \right) (100) = 35.6\%$$

In addition to that sampling error, we have sampling error due to list sampling. Also, a covariance term should be included, but will be ignored here as is often done in practice. It should be pointed out that ignoring the covariance term may be unwise, and some problems are encountered in its calculation (Wiant 1975, 1976).

The combined sampling error is the square root of the sum of the squares of these two sampling errors. In our example:

$$\begin{aligned} \text{Combined sampling error} &= \sqrt{(35.6)^2 + (11.9)^2} \\ &= 37.5\% \end{aligned}$$

List sampling will undoubtedly increase in popularity as foresters continue their search for more efficient sampling designs.

Literature Cited

- Grosenbaugh, L. R. 1974. STX 3-3-73. USDA Forest Service. Res. Paper SE-117.
- Husch, B., C. I. Miller, and T. W. Beers. 1972. Forest mensuration. 2nd ed., The Ronald Press Co., N.Y.
- Loetsch, F., F. Zohrer, and K. E. Haller. 1973. Forest inventory. Vol. 2, BLV Verlagsgesellschaft, Munchen, West Germany.
- Schreuder, H. T., J. Sedransk, and K. D. Ware. 1968. 3-P sampling and some alternatives, I. For. Sci. 14: 429-453.
- Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods. 6th ed., The Iowa State Univ. Press, Ames.
- Wiant, Jr., H.V. 1975. Influence of rounding on calculations of relative errors of combined 3P and point sample cruises. W.Va. Forest. Notes 4: 7-8.
- _____ 1976. Elementary 3P sampling. W.Va. Univ. Agri. and Forest. Exp. Sta. Bul. 650T.

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CURRENT LITERATURE

GENERAL

"Regression Problems from Repeated Measurements" by Sullivan and Reynolds. See Forest Science, Dec. 76, 22: 382-385 at your local library.

"Ecosystems and Resources of the Massachusetts Coast" from Institute for Man and His Environment, University of Massachusetts, Amherst, MA 01402.

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ECOSYM Progress Report 1 - "A Classification and Information System for Management and Wildland Ecosystems: the Conceptual Framework" Dept. of Forestry & Outdoor Recreation, Utah State University, Logan, UT 84322.

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FWS 1-76 "Aids for Unit Planning on the Appalachian National Forests" from Div. of Forestry and Wildlife Resources, VPI, Blacksburg, VA 24061.

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Regional Guide 4 "Classification, Designation, Identification = Confusion" by Fred Hall from USDA Forest Service R-6, P.O. Box 3623, Portland, OR 97208.

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Reprint: "Reducing Bias in Dry Leaf Weight Estimates of Big Sagebrush" by Harniss and Murray.

Reprint: "Computerization of Data Handling for Long-Term Forest Research Plots" by Marshall and Deitschman.

Reprint: "Predicting Crown Weights for 11 Rocky Mountain Conifers" by Brown.

Reprint: "The Two-Axis Method: A New Method to Calculate Average Precipitation over a Basin by Bethlahmy.

Res. Note Int - 212 "Relationship of Stump Diameter to Diameter at Breast Height for Seven Tree Species in Arizona and New Mexico.

May all be ordered from Intermountain Forest and Range Exp. Station, 507 25th Street, Ogden, UT 84401.

FORESTRY

Want the latest on Forest Management? Get on the mailing list of the US Forest Service's Forest Grams. Forest Grams-West is published by USDA Forest Service, State & Private Forestry, P.O. Box 3623, Portland OR 97208. Forest Gram-South is available from USDA Forest Service, State & Private Forestry, 1720 Peachtree Rd. NW., Atlanta GA 30309.

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Pub. #27 "Procedimientos Basicos Para Inventorios Forestales Con Fines De Aprovechamientos Maderables" from Dir. General, Inventario National Forestal, Avenida Progreso No. 5, Coyoacan 21 DF Mexico.

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FOR-9 "Measuring Farm Timber" from Cooperative Extension Service, University of Kentucky, Lexington KY 40506.

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"Conversion Factors for the Pacific Northwest Forest Industries" \$5.30 from Institute of Forest Products, College of Forest Resources, 115 Anderson Hall, AR-10, University of Washington, Seattle, WA 98195. 112p

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"Western Washington Forest Inventory" in Pixel Facts, Vol. 7, March 1977. Available from NASA, Ames Research Center, Moffett Field, CA 94035.

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"Probability Tables for Containerized Seedlings" and "Minimum Cost Calculation for Container Planting" by Space and Balmer may be obtained from USDA Forest Service, SA, Suite 901, 1720 Peachtree St. N.W., Atlanta GA 30309.

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Bull. No. 14. "Tree Biomass and Productivity For Three Habitat Types of Northern Idaho" and Bull. No. 11, "Evaluating Riparian Habitats from Color Aerial Photography" from Northern Idaho and University of Idaho, College of Forestry, Wildlife and Range Sciences, Moscow, ID 83843.

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Special Report 30 "An Identification of the Prime Forest Lands of Arkansas" from Agricultural Experiment Station, Div. of Agriculture, University of Arkansas, Fayetteville, AR 72701.

PROTECTION

Coop. Ext. Pub. 1118 "How to Make Boll Weevil and Boll Worm Counts" from Cooperative Extension Srv., Louisiana State University, University Station, Baton Rouge, LA 70803.

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Gen. Tech. Rept. PNW 51 "Photo Series for Quantifying Forest Residues in the: Coastal Douglas-Fir, Hemlock Type Coastal Douglas-Fir, Hardwood Type", and Gen. Tech. Rept. PNW 52 "Photo Series for Quantifying Forest Residues in the: Ponderosa Type, Ponderosa Pine and Associated Species Type, Lodgepole Pine Type. Available from the Pacific Northwest Forest and Range Exp. Sta., P.O. Box 3141, Portland, OR 97208.

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MP 1241 "Incidence and Control of Cotton Root Rot Observed with Color Infrared Photography" from: Texas Agricultural Experiment Station, Texas A&M University System, College Station, TX 77843.

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RANGE

G-73-67 "Estimating Quantities of Hay and Silage" from Extension Service, University of Nebraska, Lincoln, NE 68503.

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"National Range Handbook" from USDA Soil Conservation Service, Washington, D.C. 20250.

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Drop us a line for a copy of: S-5396AAA "A LAND-SAT Study of Ephemeral and Perennial Rangeland Vegetation and Soils" by Bentley et al. Address to the Attention of D-350.

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RECREATION

"Manual for Museums" by Ralph Lewis. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is \$4.75 and the stock number is 024-005-00643-5.

Res. Paper NE 354 "PREVIEW: Computer Assistance for Visual Management of Forested Landscapes" and Res. Paper NE 355 "PROGRAM HTVOL The Determination of Tree Crown Volume by Layers" from - Northeastern Forest Exp. Station, 6816 Market St., Upper Darby, PA 19082.

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Tech. Bull. 133 "The Demand for Non-Unique Outdoor Recreational Services: Methodological Issues" from - Agricultural Exp. Sta., Oregon State University, Corvallis, OR 97331.

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REMOTE SENSING

IAFHE RSL Research Report 77-1 "Specifications for Improvement of Toned Contrast in Lake States Forest Aerial Photography", Report 77-2 "A field Evaluation of Small-Scale Forest Resource Aerial Photography" and a listing of other current publications may be obtained from IAFHE Remote Sensing Laboratory, University of Minnesota, College of Forestry, 1530 North Cleveland Ave., St. Paul MN 55108.

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"Remote Sensing of Environment" by Lintz and Simonett 1976. Write the Addison - Wesley Publishing Company, Inc., Advanced Book Program, Reading, MA 01867 for the price of this 694 paged text.

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SOILS & WATERSHED

MP-97 "Benchmark & Key Soils of Oklahoma, a Modern Classification System" from Agricultural Exp. Sta., Oklahoma State University, Stillwater, OK 74074.

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Res. Note PNW 281 "An improved Technique for Freeze Sampling Streambed Sediments" Pacific N.W. Forest & Range Exp. Sta., P.O. 3141, Portland, OR 97208.

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"Manual of Sampling Analysis and Reporting Procedures for Wastewaters" Ohio EPA, P.O. Box 1049, Columbus OH 43216.

Pub. No. 62 "Designing a River Basin Sampling System" from Water Resources Res. Ctr, A-211 Graduate Research CTR, University of Massachusetts, Amherst, MA 01002.

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WILDLIFE

"Guidelines for Line Transect Sampling of Biological Populations" and "Mathematical Models for Non-parametric Inferences from Line Transect Data" from Utah Cooperative Wildlife Research Unit, UMC 52, Utah State University, Logan, Utah 84322.

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Special Report 39, "Methods for Locating, Trapping, and Banding Band-Tailed Pigeons in Colorado" Colorado Division of Wildlife, 6060 N. Broadway, Denver, CO 80216.

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IAFHE RSL Research Report 77-3 "Application of Large Scale 35mm Color and Color Infrared Aerial Photography to Analysis of Fish and Wildlife Resources on Disturbed Lands" from: IAFHE Remote Sensing Lab, University of Minnesota College of Forestry, 1530 North Cleveland Ave., St. Paul, MN 55108.

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MEETINGS

"Sampling Techniques and Timber Inventory Systems Workshops" will be held at Athens, Georgia, August 29 through September 2, 1977. This workshop is sponsored by the Georgia Center for Continuing Education, the USDA Forest Service Southeastern Area State and Private Forestry, and the Society of American Foresters' Inventory Working Group. Space will be limited. For further information contact Chuck Chehock, c/o USFS Cooperative Forestry, 1720 Peachtree Road, N.W., Atlanta, GA 30309.

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Color Photography in the Plant Sciences Workshop, Co-sponsored by the American Society of Photogrammetry and the Remote Sensing and Photogrammetry Working Group, SAF. Fort Collins, Colorado, August, 1977. For information contact Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, Colorado 80521.

Western Forest Genetics Assoc. Annual Meeting will be held August 2-4, 1977 at Colorado State University. For details contact Dr. Gilbert H. Fechner, Dept. of Forest and Wood Sciences, 104 Forestry Bldg., Colorado State Univ., Ft. Collins, CO 80523

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Renewable Resources for Industrial Materials Workshop. September 12-14, 1977 conventional methods of forest resources supply analysis will be discussed as well as other major issues identified by the Committee on Renewable Resources for Industrial Materials (CORRIM). Contact the Division of Continuing Education, College of Forest Resources, University of Washington, Seattle, WA 98195 for details.

RTN July 7

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Integrated Inventories of Renewable Natural Resources, A national workshop, sponsored by the University of Arizona's School of Renewable Natural Resources, and the Society of American Forester's Inventory working group in cooperation with the USDA Forest Service, USDI Bureau of Land Management, and the Renewable Natural Resources Foundation will be held Jan. 8-12, 1978 at the Marriott Hotel in Tucson. A smattering of the nearly 70 papers that will be presented include:

"Principles for integrating Inventories of Renewable Resources" by Ken Ware.

"Error Processing Systems for Integrated Resource Data" by Bill Rasmussen.

"Multiresource Inventories in Mexico" by Miquel Cabellero Deloya.

"Current Fisheries Inventory Techniques" by Jim Mullan.

"Soil Surveys - The Basis for Management" by Doug Pease.

Make plans to attend now. Registration information will be mailed shortly.

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National Forest Inventory: Why it is Needed and How to Best Conduct It. Sponsored by IUFRO Subject Groups S4.02 and S4.04 to be held in Bucharest, Romania, June 18-24, 1978. For further information contact Tiberius (Mike) Cunia, SUNY College of Environmental Science and Forestry, Syracuse, New York 13210, USA.

A joint meeting of the International Union of Forestry Research Organizations (IUFRO) and the International Society for Photogrammetry (ISP) Commission VII (Interpretation of Data) is scheduled for June 29 to July 7, 1978, probably in Freiburg, West Germany. For more information contact R.C. Heller, College of Forestry, University of Idaho, Moscow, Idaho 83843.

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MISCELLANEOUS

ERRATA

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Page 5 equation should read:

$$P = \frac{2.09 \times 25.7}{\sqrt{20 \times 46.8}} \quad \text{instead of} \quad P = \frac{2.09 \times 25.7}{20 \times 46.8}$$

Page 9. The price of the Proceedings of the Symposium and Specialty Conference on Instream Flow Needs is \$20 instead \$12 per two volume set. Order prepaid from American Fisheries Society, 5410 Grosvenor Lane, Bethesda, MD 20014.

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