Resource Inventory Notes

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SAMPLING PRECISION AND PROBABILITY

by

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The number of plots required for a sufficient sample depends upon variation among plots, confidence or probability level we wish to have in our data, and the precision with which we wish to sample. Sampling with high precision with supreme confidence in the data requires a different number of sample plots than when we are satisfied with either a lower precision or less confidence, or both.

The formula for calculating number of plots necessary to sample with a desired precision and level of probability (confidence) is as follows:

$$N = \left(\frac{ts}{p\bar{x}} \right)^2$$

Where: N = number of plots necessary to sample within certain prescribed precision and confidence;
t = value which establishes the level of probability (confidence);
s = standard deviation, a measure of variability;
p = sampling precision (this value is expressed as a percentage and varies depending upon the sampling precision desired;
$\bar{x}$ = the mean or average of a group of values

The value for "t" varies with the probability or confidence level chosen. The value for different confidence levels or probability is as follows based on a sample of 10 and 20 plots:

Probability:	50%	60%	70%	80%	90%	95%	99%	
"t" value:	0.70	0.88	1.10	1.38	1.83	2.26	3.25	9 degrees of freedom
	0.69	0.86	1.07	1.33	1.73	2.09	2.86	19 degrees of freedom

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For example, choosing a probability or confidence level of 99% means we can be certain that 99 times out of a 100 our sample size will provide the precision required; at a confidence level of 95%, the odds are 19 to 1; at 70%, the odds are about 2 to 1; etc.

The values for "s" and " $\bar{x}$ " are calculated from the sample of 10 plots which have been clipped or estimated.

The value for "p" may be 5, 10, 20, 25, etc. percent or some other percentage chosen. It is the precision with which we wish to sample.

In a formula expressed thus:

$$N = \left(\frac{2.26\ s}{.10\ \bar{x}} \right)^2$$

means that we will sample within $\pm$ 10 percent of the population mean or average with 95% confidence that the number of plots (N) sampled will provide this precision.

The calculation of "s" (standard deviation) is somewhat complex even while seated at your desk in the office with a good calculator. It is even more difficult in the field. An estimate of the value "s" can be derived by the following simple table. 2/

If "n" is near this number	Then "s" is roughly estimated by dividing range by
5	2
10	3
25	4
100	5

Examples of using the above formula for different confidence levels and precision follow. Assume 10 individual plots have been selected along the transect line and total yield of current years' growth is clipped or estimated and recorded as follows:

2/ Source: Snedecor, George W. and William C. Cochran, 1974, Statistical Methods. Iowa State University Press, Ames, Iowa. 593 p.

Plot (N)	Current Yield, grams
1	57
2	43
3	64
4	51
5	49
6	60
7	71
8	48
9	66
10	54
Total	563 grams

$$\text{Mean } \bar{x} = \frac{563}{10} = 56.3 \text{ grams}$$

The range is 71-43

$$s = \frac{71-43}{3} \text{ (from table above)}$$

$$s = \frac{71-43}{3} = \frac{28}{3} = 9.3 \text{ grams}$$

Example 1: Sample within $\pm$ 10% of the mean with 95% confidence.

$$N = \left(\frac{2.26 \times 9.3}{.10 \times 56.3}\right)^2 = \left(\frac{21.0}{5.63}\right)^2 = (3.73)^2 = 14 \text{ plots rounded up}$$

Four additional plots are needed in addition to the 10 already clipped or estimated to sample with the precision and confidence desired.

Example 2: Sample within $\pm$ 5% of the mean with 99% confidence.

$$N = \left(\frac{3.25 \times 9.3}{.05 \times 56.3}\right)^2 = \left(\frac{30.2}{2.82}\right)^2 = (10.71)^2 = 115 \text{ plots}$$

Considering money and manpower, it is probably impossible to sample with this precision and confidence in most biological communities.

Example 3: Sample within $\pm$ 10% of the mean with 90% confidence.

$$N = \left(\frac{1.83 \times 9.3}{.10 \times 56.3}\right)^2 = \left(\frac{17.0}{5.63}\right)^2 = (3.02)^2 = 10 \text{ plots}$$

The original 10-plot sample was adequate to sample with this precision and probability.

After sampling , the estimated precision obtained can be calculated by solving for "p" in the original formula as follows:

$$P = \frac{t\ s}{\sqrt{n}\ \bar{x}}$$

Using a hypothetical example, assume the following yields were recorded from 10 plots.

Plot (n)	Yield, grams
1	12
2	89
3	43
4	19
5	70
6	52
7	38
8	44
9	29
10	61
Total	457 grams

$$\text{Mean } \bar{x} = \frac{457}{10} = 45.7 \text{ grams}$$

$$S = \frac{89-12}{3} = \frac{77}{3} = 25.7 \text{ grams}$$

To sample this site within $\pm$ 10% of the mean with 95% confidence requires the following number of plots.

$$N = \left(\frac{2.26 \times 25.7}{.10 \times 45.7}\right)^2 = \left(\frac{58.1}{4.57}\right)^2 = (12.7)^2 = 162 \text{ plots}$$

It is determined that it is impractical to collect data from this many more plots. Ten additional plots are sampled. The sampling precision for the total 20 plots is calculated as follows for 95% confidence level.

1st Sample		2nd Sample	
Plot (N)	Yield, grams	Plot (N)	Yield, grams
1	12	11	59
2	89	12	32
3	43	13	27
4	19	14	66
5	70	15	41
6	52	16	54
7	38	17	77
8	44	18	20
9	29	19	55
10	61	20	47
		Total	935 grams
		Mean $\bar{x}$	46.8 grams

$$S = \frac{89-12}{3} = \frac{77}{3} = 25.7 \text{ grams}$$

$$P = \frac{2.09 \times 25.7}{20 \times 46.8} = \frac{2.09 \times 25.7}{4.47 \times 46.8} = \frac{53.71}{209.2} = 0.26 \text{ precision}$$

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CURRENT LITERATURE

- The January 1977 issue of Forest Industries has a very interesting article on "Forest Management Decisions Aided by Electronic Calculations, Graphics", on pages 40 and 41. Copies of Forest Industries may be available at your local library or forestry school.

- DNR Rept. 26 - "Measuring and Interpreting Douglas Fir Management Practices". Order from State Department of Natural Resources, Technical Services Division, Olympia, Washington 98504.

- "Check Your Timber Sales" Circular 477, Cooperative Extension Service, University of Georgia, College of Agriculture, Athens, Georgia 30602.

- "Comprehensive Log Scale Tree-Volume Tarif Tables for Douglas Fir" by Chambers and Jenkins. Available for $3.00 from Commissioner of Public Lands, State of Washington, Department of Natural Resources, Operations Research Section, Division of Technical Services, Olympia, Washington 98504.

- "A Timber Inventory, Bear River Area Utah" by David C. Schen, is available from Utah Forestry and Fire Control, 1596 West North Temple, Salt Lake City, Utah 84116.

- PNW Bull. #31 - "Measuring Trees" by Sander. Order from Extension Service, Oregon State University, Corvallis, Oregon 97331. This informative bulletin covers trees and logs, cruising the woodland, size specifications and volume tables.

- Res. Note SE-234 - "Accuracy and Cost of Several Methods for Geographically Locating Forest Survey Sample Plots". Order from S.E. Forest Experiment Station, P.O. Box 2570, Asheville, North Carolina 28802.

- Res. Bull. NE-46 - "The Forest Resources of Vermont"
  Res. Bull. NE-47 - "The Timber Industries of West Virginia"
  Res. Bull. NE-48 - "Forest Statistics for Massachusetts"
  Res. Bull. NE-49 - "Forest Statistics for Rhode Island"

  The above are available from Northeastern Forest Experiment Station, 6816 Market Street, Upper Darby, Pennsylvania 19082.

- Res. Bull. SO-61 - "East Texas Forests: Status and Trends". Order from Southern Forest Experiment Station, T-10210 Postal Service Building, 701 Loyola Avenue, New Orleans, Louisiana 70113.

- Gen. Tech. Rept. PSW-16 - "National Forest System Working Circles: A Question of Site and Ownership Composition" from Pacific Southwest Forest and Range Experiment Station, P.O. Box 245, Berkeley, California 94701.

- Note #116 - "Metric Unit Equations for Southern Pine" from Agriculture Experiment Station, Louisiana State University, Baton Rouge, Louisiana 70803.

- Inf. Rep. NOR - X-167 - "Assessment of Regeneration Stocking Standards Used in Alberta" by I.E. Bella, from Canadian Forestry Service, Northern Forest Research Centre, 5320-122 St., Edmonton, Alberta, Canada T6H 3S5.

- Rept. No. 75-22 - "Evaluation of 35mm Vertical Aerial Photography for Estimating Tree Mortality" can be obtained from USDA, Forest Service, State and Private Forestry, Missoula, Montana 59801.

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INSECTS

- Bull. B-723 - "Sampling Cotton and other Field Crops for Insects" from Department of Entomology, Oklahoma State University, Stillwater, Oklahoma 74874.

- MP - 1267 - "Procedural Guide for Quantitatively Sampling Within Tree Populations of Dendroctonus frontalis" from Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas 77843.

- Res. Note RM-311 - "Insects: A Guide to Their Collection, Identification, Preservation and Shipment" by Stein, may be ordered from Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, Colorado 80521.

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RANGE

- Bull. No. 9 - "Use of Satellite Imagery for Classifying and Monitoring Rangelands in Southern Idaho", Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho 83843.

- Bull. NS9 - "Range Resources of the South" from University of Georgia, College of Agriculture Experiment Station, Athens, Georgia 30602.

- Res. Paper PSW-113 - "Evaluation of Skylab (EREP) Data for Forest and Rangeland Surveys" from Pacific Southwest Forest and Range Experiment Station, P.O. Box 245, Berkeley, California 94701.

- RSI - 72-16 - "Application of Remote Sensing Techniques to Cropland and Rangeland Soil Water Inventory" from Remote Sensing Institute, South Dakota State University, University Station, Brookings, South Dakota 57006.

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RECREATION

- Marine Technical Report No. 13 - "Factors Related to Beach Use" by Spaulding, from University of Rhode Island, Marine Advisory Service, Narragansett, Rhode Island 02882.

- "1974 Recreation Statistics" summarizes recreation use on lands administered by the Corps of Engineers, available from Superintendent of Documents, US Government Printing Office, Washington, D.C. 20402. Price 80¢, Stock No. 008-022-00098-4.

- "The Demand for Non-Unique Outdoor Recreational Services: Methodological Issues" can be obtained from Agricultural Experiment Station, Oregon State University, Corvallis, Oregon 97331.

- Special Report No. 78 - "Land Use Controls for Outdoor Recreation Areas" Agriculture and Home Economics Experiment Station, Iowa State University, Ames, Iowa 50011.

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SOILS

- Reprint "An Instrument and Techniques for Collecting Peat Core Sampled in Peatland Surveys" from Great Lakes Forest Research Center, Canadian Forestry Service, P.O. Box 490, Sault Ste. Marie, Ontario, Canada.

- Extension Circular 628 - "How to Take a Soil Sample and Why" from Oregon State University, Extension Service, Corvallis, Oregon 97331.

- HPR Report No. 76 - "Early Detection and Correction of Sinkhole Problems in Alabama, with a Preliminary Evaluation or Remote Sensing Applications" by Newton, from Alabama Highway Department, Montgomery, Alabama 36104.

- Special Report 321 - "Methods of Soil Analysis used in the Soil Testing Laboratory at Oregon State University" from Agricultural Experiment Station, Oregon State University, Corvallis, Oregon 97331.

- X - 103P - "Sampling Soils for Fertilizer and Amendment Recommendations" from Bulletin Room, Colorado State University, Fort Collins, Colorado 80523.

- Res. Report No. 89 - "The Montana Automated Data Processing System for Soil Inventories" from Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana 59715.

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WATER

- WRIS Info. Bull. No. 23 - "Conversion Factors Useful in Water Resources Management" - WRIS, Department of Ecology, Olympia, Washington 98504.

- "Satellite Monitoring Earth Resources May Also Be Valuable Tool in Predicting Floods" by Rombach. Write Susquehanna River Basin Commission, 5012 Lenker Street, Mechanicsburg, Pennsylvania 17055.

- Tech. Manual No. 1 - "Manual for Estimating Flood Characteristics of Natural Flow Streams in Colorado" from Colorado Water Conservation Board, 823 State Centennial Building, 1313 Sherman Street, Denver, Colorado 80203.

- Pub. No. 58 - "A Review of Statistical Procedures Used for Examination of Water Data" by Gross, from Water Resources Research Center, A-211 Graduate Research Center, University of Massachusetts, Amherst, Massachusetts 01002.

- Miscellaneous Series No. 32 - "A Guide to the Use of HISARS - A Hydrologic Information Storage and Retrieval System" by Molnau and Bulletin No. 552 - "Water Measurement" by Larsen can be ordered from Cooperative Extension Service, USDA, University of Idaho, Moscow, Idaho 83843.

- "Snow Sensor Evaluation in the Sierra Nevada, California" from State Department of Water Resources, 1416 Ninth Street, P.O. Box 388, Sacramento, California 95802.

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WILDLIFE

Drop us a line (Attention D-360) and we will send you a copy of "Data Requirements for Terrestrial Wildlife Habitat Inventory" by Dick Kerr and Ken Brown.

- Wildlife Tech. Bull. 5 - "Ram Horn Growth and Population Quality: Their Significance to Dall Sheep Management in Alaska" from Alaska Department of Fish and Game, Subport Building, Juneau, Alaska 99801.

- Investigational Report No. 335 - "Analysis of the Composition of Fish Populations in Minnesota's Rivers and Streams" may be ordered from Minnesota Department of Natural Resources, Division of Fish and Wildlife, Ecological Services Section 390, Centennial Building, St. Paul, Minnesota 55155. The use of the diversity index and related ideas are discussed to analyze fish species composition.

- Copies of "Instream Flow Symposium" are now available from American Fisheries Society, 5410 Grosvenor Lane, Bethesda, Maryland 20014 at $12.00 per copy.

- "A Program for Fish and Wildlife Habitat on the National Forests in Minnesota" from State of Minnesota, Department of Natural Resources, Centennial Office Building, St. Paul, Minnesota 55155.

- Bulletin 691 - "Simulation of a Commercially Harvested Alligator Population in Louisiana" from Louisiana Agricultural Experiment Station, P.O. Drawer E, University Station, Baton Rouge, Louisiana 70803.

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OTHER

- Bull. No. 28 - "Remote Sensing 20 Years Change in Hampden County Massachusetts, 1952-1972" from University of Massachusetts, Agricultural Experiment Station, Amherst, Massachusetts 01002.

- Map "Ecoregions of the United States" by Bob Bailey, from U.S. Forest Service, 324 25th Street, Ogden, Utah 84401.

- Fire Control Notes 35 - "Gathering Fire Danger Data by Use of Satellites" by Innes. California Division of Forestry, 1416 9th Street, Sacramento, California 95814.

- "Land Use Terms and Definitions", Cooperative Extension Service, University of Nebraska, Lincoln, Nebraska 68504.

- Program Report 25.3 - "Guidelines for Conducting Surveys Concerning Transportation" from Washington State Library, Olympia, Washington 98504.

- Proceedings for the "Resource Data Management Symposium" held last August at Purdue are now available. Copies may be obtained by sending a check or money order made payable to Purdue University in an amount equal to $5.00 per copy desired. Send orders to: John W. Moser, Jr., Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana 47907.

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MEETINGS

Forestry and Wildland Resource Institute will be held for high school students this coming summer at Virginia Polytechnic Institute and State University. The fee will be $100.00. For further details contact W. A. McElfresh, Director, 304 Cheatham Hall, VPI & SU, Blacksburg, Virginia 24061.

The Fourth Purdue Symposium on Machine Processing of Remotely Sensed Data, Purdue University, West Lafayette, Indiana, June 21-23, 1977 (Co-sponsored by the Remote Sensing and Photogrammetry Working Group, SAF). For information contact D. B. Morrison, LARS, Purdue University, West Lafayette, Indiana 47904.

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.

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, University of Idaho, Moscow, Idaho.

"Forest Resource Management, A Systems Approach", July 6-15, 1977; "Timber Sampling on Successive Occasions", July 18-22, 1977; and "Sampling Human Populations", July 25-29, 1977 are on the workshop slate at Fort Collins this summer. For further information contact the Office of Conferences and Institutes, Residential Conference Center, Colorado State University, Fort Collins, Colorado 80523.

"Sampling Techniques and Timber Inventory Systems Workshop" 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 Chuch Chehock, c/o USFS Cooperative Forestry, 1720 Peachtree Road, N.W., Atlanta, Georgia 30309.

INTEGRATED INVENTORIES

"Data Requirements for Management of Range Lands" by Floyd Kinsinger

"Inventorying Small Streams and Channels on Wildland Watersheds" by R. L. Beschta

"Land Classification as a Base for Integrated Inventory of Renewable Resources" by Phil Gimbarzevsky

"National Integrated Inventories - Is What you Need - What You Do" by Tom Hamilton

"35mm Aerial Photography Applications to Resource Inventory and Management Planning" by Merle Meyer

These are just a sampling of the papers you'll be hearing at the "Integrated Inventories of Renewable Natural Resources" Workshop. Make plans to attend. Now is the time to schedule the workshop in your annual work plans. The location will be the Marriott Hotel in Tucson, Arizona. The dates are January 8-12, 1978. Registration information will be forthcoming.

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