

# Resource Inventory Notes

BLM 12

July 1978



ON THE PRECISION OF DOT GRID ESTIMATES

by

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**ABSTRACT:** The often used binomial formula gives greatly overestimated standard errors for counts with systematically spaced dot grids. In this paper a method for estimation of unbiased standard errors is presented, which is based on sampling simulation and regression analysis.

## INTRODUCTION

The standard error of an area estimated with dot grid can be roughly determined with the regression Loetsch, Zöhner and Haller (1973).

$$\log S\% = 1.782 - 0.76 \log n$$

where S% = standard error percent of the estimate,

n - number of dots within the area (strictly speaking the number of expected dots which will fall into the area).

For a more precise error determination the shape of the investigated area besides its size (number of dots) has to be considered. The boundary zone - dependent on the shape - is responsible for the "mixture" of "sampling processing" and "measuring process".

To quantify the effect of n and p - where p = perimeter ratio, i.e., the perimeter of the area divided by the perimeter of a circle of the same size - a regression was developed (Zöhner 1976).

$$\log S\% = 1.739 - 0.755 \log n + 0.457 \log p.$$

This formula is based on EDP - programs for dot grid simulations on differently formed areas.

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**Published by:**

**USDI, Bureau of Land Management, D 340  
Denver Service Center, Denver Federal Center, Bldg. 50  
Denver, Colorado, 80225**

SD551  
R47  
1978:12  
(20)

The program used mainly irregularly shaped areas as simulation base. For regular figures the standard error of dot grid estimates depends on possible coincidences with the borderlines. For the square ( $p=1.13$ ), the regular triangle ( $p = 1.42$ ) and the rectangle ( $p = 1.20$  for a side proportion 1 : 2) sometimes higher standard errors have to be expected.

For practical use of this formula it will be sufficient to read the next paragraph.

### APPLICATION








If the land area to be estimated with a dot grid is a single one:

1. make the count
2. estimate (roughly) the  $p$  - value (see table 1)
3. use above formula or table 1 for an approximate estimate of standard error percent.

### Example

Your count is 82 dots and the area looks approximately like the second one from the left in table 1 ( $p = 1.5$ ). In table 1 you find for  $n = 80$   $p = 1.5$  a standard error percent of 2.41%. Therefore the standard error is  $82 (0.0241) = 1.98$  dots and if 1 dot represents 10 ha the standard error for the area estimate 820 ha is  $\pm 19.8$  ha ( $t = 1$ ).

Table 1. Standard error percent of dot grid counts

							
$p =$	1.0	1.5	2.0	2,5	3,0	3.5	4.0
5	16,27	19.58	22.33	24.72	26.87	28.83	30.65
10	9,64	11.60	13.23	14.65	15.92	17.09	18.16
20	5,71	6.87	7.84	8.68	9.44	10.12	10.76
30	4,21	5.06	5.77	6.39	6.95	7.45	7.92
40	3,38	4.07	4.65	5.14	5.59	6.00	6.38
50	2,86	3.44	3,93	4.35	4.72	5.07	5,39
60	2,49	3,00	3,42	3.79	4.12	4.42	4,70
70	2,22	2,67	3,04	3,37	3.66	3.93	4,18
80	2,01	2,41	2,75	3,05	3.31	3.55	3,78
90	1,83	2,21	2,52	2,79	3,03	3.25	3,46
100	1,69	2,04	2,33	2,58	2,80	3,00	3,19
150	1,25	1,50	1,71	1,90	2,06	2,21	2,35
200	1,00	1,21	1,38	1,53	1,66	1,78	1,89
300	0,74	0,89	1,01	1,12	1,22	1,31	1,39
400	0,59	0,72	0,82	0,90	0,98	1,05	1,12
500	0,50	0,60	0,69	0,76	0,83	0,89	0,95
750	0,37	0,45	0,51	0,56	0,61	0,66	0,70
1000	0,30	0,36	0,41	0,45	0,49	0,53	0,56

If you have a pocket computer on hand calculate

$$\log s\% = 1.739 - 0.755 \log 82 + 0.457 \log 1.5 = 0.3745$$

and

$$S\% = 2.37.$$

If the land area to be estimated consists of separated areas (Zöhrer 1977):

1. make the counts for the individual areas
2. estimate (roughly) their p - value
3. use formula or table 1 for approximate estimates of S%
4. apply law of error propagation for the sum of separated land areas.

### Example

Some dot grid is applied for seven areas which yields the counts as shown in col. 2 of table 2.

Table 2: Standard error calculation for a sum of separated land areas.

<u>Area</u> <u>No.</u>	<u>Count</u>	<u>p (estim.)</u>	<u>S% (estim.)</u>	<u>S (dots)</u>
1	66	1.0	2.3	1.52
2	145	1.5	1.5	2.18
3	118	1.5	1.9	2.24
4	19	1.0	7.3	1.39
5	60	2.5	3.8	2.28
6	51	4.0	5.3	2.70
7	17	2.0	9.5	1.62

The count of the total area is  $66 + 145 + 118 + 19 + 60 + 51 + 17 = 476$ .

The standard error of this dot count is according to t-e law of error propagation.

$$\begin{aligned} & (1.52^2 + 2.18^2 + 2.24^2 + 1.39^2 + 2.28^2 + 2.70^2 + 1.62^2)^{0.5} = \\ & = (29.13)^{0.5} = 5.40 \end{aligned}$$

If 1 dot represents 16 ha the result is

$$476 (16) \pm 5.40 (16) = 7616 \pm 86,4 \text{ ha } (\pm 1.13\%).$$

This result is an approximation but, however, more accurate than the error determination with the binomial formula.

## METHOD

Several figures, described by borderline - polygons were generated. Input for EDP - programs were x - y - coordinates and expected values of dots from 5 to 10,000. For each point density 100 sampling simulations were carried out. The resulting standard errors were fitted by regression analysis with the above mentioned logarithmic equation. The multiple coefficient of correlation squared between  $\log S\%$  and  $\log n$ ,  $\log p$  is 0.9951 and 0.9627 between  $\log S\%$  and  $\log n$ . The standard error of the first regression coefficient - 0.755 is  $\pm 0.006$  and of the second regression coefficient  $0.457 \pm 0.21$ .

In figure 1 the results are presented in graphical form.

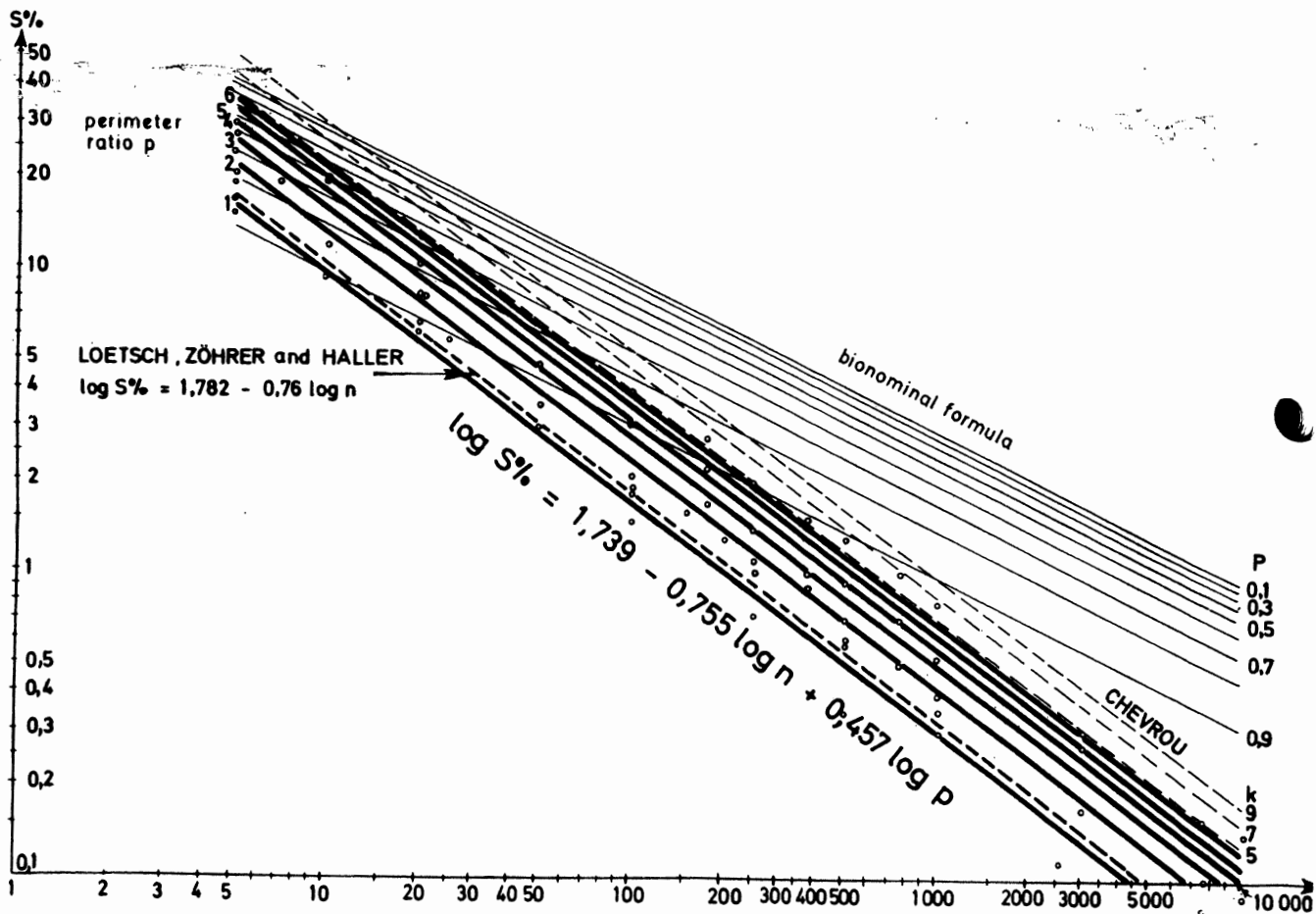


Fig. 1 Standard error percent in dependence of the number of dots and the perimeter ratio p. The broad lines represent the results of sampling simulation and regression analysis.

For the binomial formula holds

$$S^2 = P(1 - P)/N$$

where

S - standard error of proportion P,

P = proportion of the area sampled of the total area,

N = total number of points.

Using only the number of points within the area to be estimated.

$$n = N \cdot P$$

the relation is

$$S^2 = P(1-P)/n/P$$

$$= P^2(1-P)/n$$

and

$$S = P((1-P)/n)^{0.5}$$

$$S\% = 100 S/P$$

$$= 100 P((1-P)/n)^{0.5}/P$$

$$= 100 ((1-P)/n)^{0.5}$$

$$\log S\% = 0.5 \log (10,000(1-P)) - 0.5 \log n$$

It can be seen in figure 1 that the application of the binomial formula gives greatly overestimated standard errors. The results are compared with an approximation formula of Chevrou (1971, see FAO 1973).

$$S\% = 56.5 k^{0.5} n^{-0.5}$$

where k = coefficient dependent on the shape of the area.

In logarithmic form the equation reads

$$\log S\% = \log 56.5 + 0.5 \log k - 0.75 \log n$$

For k - values (for rather regular areas) 5 and 7 the equation of Chevrou yields rather overestimated standard errors.

Therefore neither the binomial formula nor the formula of Chevrou can be recommended for dot grid counts. One should prefer an empirical regression solution as presented in this paper.

Literature Cited

FAO, 1973. Manual of forest inventory with special reference to mixed tropical forests, Rome.

Loetsch, F., Zöhner, F. and K.E. Haller 1973. Forest inventory, Vol. II, München-Ben-Wien, BLV-Verlag.

Zöhner, F. 1976. Die Genauigkeit der Ermittlung von Waldflächen durch systematische Punktstichproben I (Einzelflächen). Forstwiss. Cbl., 95, 5/6 : 294-301.

\_\_\_\_\_.1977. Die Genauigkeit der Ermittlung von Waldflächen durch systematische Punktstichproben II (zusammengesetzte Flächen). Forstwiss. Cbl., 96, 5 : 313-320.

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Current Literature

Please order publications directly from addresses given below.

General

"Restoration of Lost or Obliterated Corners and Subdivisions of Sections - A Guide for Surveyors" for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, price 75¢, Stock Number 024-011-00012-7.

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"Program of Ecological Stations" (in English), "Qualidade do Ambiente e seus Reflexos Economicos e Sociais", "Legislacao Basica", "Padroes de Qualidade do Ar" "A Poluicao No Brasil", and "Sementes Plantadas Para o Desenvolvimento" are all available from Ministry of the Interior, Special Environmental Agency, Brasilia, Brasil.

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"What To Look For In An Appraisal" and "Appraising Fundamentals". Check for availability from American Institute of Real Estate Appraisers, 430 N. Michigan Ave., Chicago, IL 60611.

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Gen. Tech. Rept. RM-41 "Biotic Communities of the Southwest". order from the Rocky Mountain Forest & Range Exp. Sta., 240 W. Prospect, Ft. Collins, CO 80521.

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The February 1978 issue of the Journal of Forestry is chock-full of excellent articles on information on systems. Check your library for copies.

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SRS No. 21 "A Training Course in Sampling Concepts for Agricultural Surveys" - is available from U.S.D.A. Statistical Reporting Service, Washington, D.C. 20250.

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Tech. Paper 34 "Indexes to Survey Methodology Literature" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for \$3.60. The Stock No. is 0324-00203.

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Survey Methodology Information System (SMIS) bibliographic series is available from U.S. Bureau of the Census, Washington, D.C. 20233.

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Res. Bull. 159. "Models of Agricultural Production: Methods and Considerations". Contact College of Tropical Agriculture Order Desk, Room 108 Krauss Hall, 2500 Dole Street, Honolulu, HI 96822 for price and availability.

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Paper No. 610. "A Multi-Type Production System for Perishable Inventories" from: Purdue University, Kannert Graduate School of Management, Kannert Building, W. Lafayette, IN 47907.

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Report 75-2. "A Numerical Method for Solutions of Systems of Non-Linear Algebraic Equations" from North Carolina State Univ., Center for Marine and Coastal Studies, 1204 Burlington Labs, Raleigh, NC 27650.

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Burkhart, Harold E., R. Dean Stuck, William A. Leuschner and Marion R. Reynolds  
1978. "Allocating Inventory Resources for Multiple-use Planning." Canadian  
Journal of Forest Research 8:100-110. (March, 1978), at your local conserva-  
tion library.

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FORESTRY

Gen. Tech. Rept. SO-14 "A Practical Field Method of Site Evaluation for Eight  
Important Southern Hardwoods" from Southern Forest Experiment Station,  
T-10210 Postal Service Bldg., 701 Loyola Ave., New Orleans, LA 70113.

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Gen Tech. Rept. PNW-62 "The Forester's Almanac".

Reprint - "Estimating Area in Sampling Forest Populations on Two Successive  
Occasions" by John Hazard. For. Sci. 23 (2):253-267.

Gen. Tech. Rept. PNW-59 "Coping With Uncertainty - A Conceptual Approach for  
Timber Management Planning" all from Pacific Northwest Forest and Range  
Exp. Sta., P.O. Box 3141, Portland, OR 97208.

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Res. Bull. No. 641 "Survey: A Computerized Tree Inventory System for Land  
Use Decisions" by Joe Mawson is excellent. Both Wild and Urban Systems  
are presented. Order from University of Mass., Agricultural Exp. Sta.,  
Room 217 Stockbridge Hall, Amherst, MA 01002.

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Bibliography Series No. 3 "Urban Forestry: A Selected Bibliography of  
Publications in the University of Minnesota Forestry Library" from Univ.  
of Minnesota, St. Paul Campus Library, 1984 Buford Ave., St. Paul,  
MN 55108.

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DNR Rept. No. 36 "Investment Guidelines for Douglas Fir" from State of  
Washington, Dept. of Natural Resources, Olympia, WA 98504.

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Res. Note INT. 237 "Estimating Effect of Timber Harvesting Levels on Employment  
in Western United States" and Res. Note Int. 242 "Estimating Pinyon-  
Juniper Cordwood With the Line-Intersect Method." both from Intermountain  
Forest and Range Experiment Station, 507 25th St., Ogden, UT 84401.

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Res. Note RM 351 "Past Diameters and Gross Volumes of Plains Cottonwood in Eastern Colorado". Order from Rocky Mountain For. & Range Exp. Sta., 240 W. Prospect, Ft. Collins, CO 80521.

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"Memoria de la Cuarta Reunion Nacional Sobre Inventario Forestal Continuo"

Pub. No. 34 "Inventario Forestal Del Estaco De Chiapas"

Pub. No. 35 "Analisis de un Caso Practico A La Elaboracion de Tablas de Volumenes de Aplicacion Directa A Rodales".

Pub. No. 36 "Inventario Forestal Del Estad De Guanajuato".

Pub. No. 37 "Procedimientos Basicos para Inventarios Forestales Con Fines de Aprovechamientos Maderables".

Pub. No. 38 "Catalogo de Productos Forestales".

Pub. No. 39 "Inventario Forestal del Estado de Hidalgo".

Pub. No. 40 "Inventario Forestal del Estado de Queretaro".

Pub. No. 41 "Inventario Forestal del Estado de Quintana Roo".

Write the Direccion General del Inventario Nacional Forestal, Av. Progreso No. 5, Coyoacan, Mexico 21, D.F. for prices and availability.

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A new newsletter "Extension Forestry News Natural Resources and Environmental Improvement" is available from Extension Service, U.S. Dept. of Agriculture, Washington, D.D. 20250.

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Res. Paper PNW 138 "A Method of Estimating Log Weight" from Pacific Northwest Forest & Range Exp. Sta., Post Office Box 3141, Portland, OR 97208.

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"Forestry Research: What's New in the West" is a periodic report on the work of the USDA Forest Services' four Forest and Range Experiment Stations. To receive this publication write Forestry Research, What's New in the West, USDA Forest Service, 240 We. Prospect St. Fort Collins, CO 80521.

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"Treetop Marking System" read about it in the December issue of Equip. Tips available from USDA Forest Service, Equipment Development Center, Missoula MT 59801.

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## LAND-USE PLANNING

Comarc Commentary is an industrial newsletter on the application of Geo-Based Information Systems. The April, 1978 issue has two interesting articles on "Oilwells and Archaeology" and "Timber Inventory - the Neglected Asset". You may get on the mailing list by writing Comarc Design Systems, 315 Bay St., San Francisco, CA 94133.

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Special Pub. 47 "A Technical Guide for Determining Land Use Suitability" from Agricultural Exp. Sta., University of Illinois, Urbana, IL 61801.

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DNR Note No. 22 "LEV II". This is an interactive program written in BASIC which calculates Land Expectation Values (LEV's) for particular forest stand management alternatives. Available from Washington State Department of Natural Resources, Technical Services Division, Olympia, WA 98504.

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## PROTECTION

Res. Note INF. 210 "Estimating Fuel Weights of Grasses, Forbs and Small Woody Plants".

Gen. Tech. Rept. INT. 42 "A Method for Determining Fire History in Coniferous Forests of the Mountain West".

Res. Paper INT. 196 "Estimating Merchantable Volume and Stem Residue in Four Timber Species".

Gen. Tech. Rept. INT. 40 "Manually Calculating Fire-Danger Ratings - 1978 National Fire Danger Rating System".

Reprint - "Slope-Compensating Stick-type Angle Gage" by Meeuwig.

All available from Intermountain Forest and Range Exp. Sta., 507 25th St., Ogden, Utah 84401.

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Gen. Tech. Rept. RM-48 "The 6-Class Dwarf Mistletoe Rating System" from Rocky Mountain Forest & Range Experiment Station, 240 W. Prospect, Ft. Collins, CO 80521.

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"Automatic Transmission of Fire Weather Data by Minicomputer" in Fire Management Notes, Vol. 38, No. 4. p. 10-12. Contact you local conservation library.

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MP-1316 Procedural Guide for Estimating Within - Spot Populations of Dendroctonus Frontalis" from Texas Agric. Extension Service, USDA, Texas A&M University, College Station, TX 77843.

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RANGE and WILDLIFE

FS 659 "Live Trap for Nuisance Animal Control" from Cooperative Extension Service, South Dakota State Univ., Brookings, SD 57006.

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Gen. Tech. Rept. RM-51 "Run Wild - A Storage and Retrieval System for Wildlife Habitat Information" from Rocky Mountain Forest & Range Exp. Sta., 240 West Prospect, Ft. Collins, CO 80521.

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Agricultural Economics Miscell. Rept. 27 "A Selected Annotated Bibliography of Economic Values of Fish and Wildlife and Their Habitats" from Dept. of Agric. Economics, North Dakota State Univ., State University Station, Fargo, ND 58102.

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Neb. Tech. Series No. 1. "FIRE 1 - A Computer Program for Computation of Fishery Statistics on Samples with Aged and Non-Aged Sub Samples" from Nebraska Game and Parks Commission, P.O. Box 30370, 2200 North 33 St., Lincoln, NE 68503.

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Reprint - "Estimating Overwinter Bitterbrush Utilization from Twig Diameter - Length-Weight Relations" by Ferguson and Marsden.

Reprint - "Prediction of Understory Tree Height Growth in Northern Hardwoods" by Monserud and EK from Intermountain Forest & Exp., Sta., 507 25th St., Ogden, UT 84401.

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RECREATION

Ag. Handbook 484 "National Forest Landscape Management, Vol. 2, Ch. 3: Range " from Superintendent of Document, U.S. Government Printing Office, Washington, D.C. 20402, \$1.70.

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Gen. Tech. Rept. PSW 24-FR-14 "Tree Failures and Accidents in Recreation Areas: A Guide to Data Management for Hazard Control" from Publications Section, Pacific Southwest Station, P.O. Box 245, Berkeley, CA 94701.

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G77-348 "Landscape Tree Evaluation" presents an appraisal method which quantifies subjective values. The tree value is based upon size of tree, species, condition class and location. There is a minimum mail order charge of \$1.00 for the publication - order from Univervisty of Nebraska - Lincoln, Dept. of Ag. Communications, Agricultural Communications Bldg., Room 108 - East Campus, Lincoln, NE 68583.

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REMOTE SENSING

"Forestry Applications of NASA Remote Sensing Programs" by J.E. deSteiguer and "Declining Quality of B&W Infrared Aerial Photography - and What to Do About It" by Meyer and Marshall are contained in the April 1978 issue of the Journal of Forestry. Check for copies at your local conservation library.

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Forestry Dept.Ser. No. 9 "Forest Cover Photo-interpretation Key for the Ridge and Valley Forest Habitat Region in Alabama" from Agricultural Exp. Sta., Auburn, University, Auburn, AL 36830.

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Proceedings of the First Conference on the Economics of Remote Sensing Information Systems" Jan. 1977. Check for availability from: Dept. of Economics, San Jose State University, San Jose, CA 95192.

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SOIL, AIR and WATER

Reprint - "Estimating Regional Air Pollution Impact" by Fox and Fosberg.

Res. Note RM-350 "Extending Service Intervals for Drum-type Meteorological Instruments".

Res. Paper RM-194 "A System That Measures Blowing Snow"

SAF National Convention. October 22-26, St. Louis, MO. Contact SAF, 5400 Grosvenor Lane, Washington, D.C. 20014. The SAF Inventory, Biometrics and Remote Sensing Working Groups will be holding a joint technical meeting on "Measurements: Gateway to Knowledge" at the convention. Plan now to attend.

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National Urban Forestry Conference. November 13-16, Washington, D.C. Registration fee \$30. Contact School of Continuing Education, S.U.N.Y., College of Environmental Science & Forestry, Syracuse, NY 13210.

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Get these in your Annual Work Plan for 1979.

July 16-20. "Sampling Designs for Successive Inventories". A workshop sponsored by the Colorado State University Dept. of Forest and Wood Sciences and the SAF Inventory Working Group. Registration for this workshop will be \$300.

The following week, July 23-27 will be the 1979 Forest Inventory Workshop - sponsored by the SAF and IUFRO, also in Ft. Collins. This will be on the magnitude of the 1978 Tucson and the 1974 Ft. Collins meetings. Make plans now to attend both sessions.

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The Forest Research Institute (IPEF), a cooperative program with the University of Sao Paulo, Brazil, will hold the first Forest Inventory Symposium at Piracicaba campus. The meeting will present the inventory systems employed by the industries that cooperate with IPEF as well as official institutions. For additional information contact Hilton Thadeu Z. Do Couto, Silvicultura, ESALQ, 13.400 - Piracicaba, Sao Paulo, Brazil. No dates given.

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Miscellaneous

Call for Papers. The 1979 Forest Inventory Workshop will be held in Ft. Collins Colorado in July 1979. This workshop will be sponsored jointly by the SAF and IUFRO. Dave Bower, General Chairman, is asking for contributed papers at this time on the following areas: Multi-resource inventories, inventory projection, computer resources, sampling techniques, biomass measurement and inventory, sampling aspect of aerial photos, product estimation and metric conversion strategies. If you are interested in giving a paper, send the title and abstract to Dave, c/o Weyerhaeuser Co., P.O. Box 1060, Hot Springs, AR 71901 by 1 October 1978.

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Wanted. Lead articles, current literature and meeting announcements for publishing in the "Notes". If announcing a meeting, please allow at least a four month lag time.

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Late Announcement

Forest Growth and Yield Workshop. Sponsored by the SAF Inventory Working Group and University of New Hampshire will be held Nov. 29 thru Dec. 1, 1978 at Durham, NH. The regional workshop designed as an introductory course for forest managers and analysts who need to implement growth and yield methodology in a decision-making role. Enrollment will be limited to 25 on a first-come basis. Registration and fees will be between \$50-100. For details contact Dr. James Barrett, INER, James Hall, University of New Hampshire, Durham, NH 03824.

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