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Wilderness Ecology:

a method of sampling and summarizing data for plant community classification

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CONTENTS

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Lewis F. Ohmann and Robert R. Ream

In 1966 a program of ecological research was initiated by researchers at the North Central Forest Experiment Station, USDA Forest Service, within the Boundary Waters Canoe Area (BWCA) of the Superior National Forest in northeastern Minnesota. The mission of this program is to provide basic ecological information on plant and animal communities occurring in the relatively undisturbed environment of this Wilderness Area. This information is needed to provide a basis for management decisions to achieve specific goals, such as maintenance and restoration of biotic communities. Knowledge of the makeup of plant communities and the ecological factors that influence them, especially quantitative descriptions of the vegetational and environmental components, is a basic part of this information.[1] To collect such quantitative data in the BWCA, we developed a sampling scheme that offers much flexibility and should have widespread application. Thus it is presented here so that researchers and land managers may use it in surveying and classifying plant communities of other forest lands.

The applicability of these methods for any specific forest area is related to the general management goal of that forest. Even within the BWCA this is important. According to the Wilderness Act of 1964, the general goal for the management of the BWCA and other Wilderness Areas is "the preservation of their wilderness character." The BWCA is unique among the units of the National Preservation System, however, in that it is divided into two zones: the Portal Zone, where the vegetation is managed for timber harvest along with primitive recreation values, and the Interior Zone, where timber harvest is not permitted. The management of vegetation for commercial timber harvest in the Portal Zone necessitates emphasis of silvicultural goals and techniques. The survey methods described here were designed for the Interior Zone, where wilderness goals and techniques are applicable. The Interior Zone occupies about 500,000 acres, or roughly one-half of the BWCA.

The sampling scheme can be used by those with a botanical background and knowledge of any regional flora. Specific knowledge of the structure and composition of the local vegetation, while helpful, is not necessary.

This paper describes field sampling procedures and sample summary methods used in the survey of one unit of vegetation, the upland natural vegetation of the Interior Zone of the BWCA. Ream and Ohmann (1970) show how data from these survey techniques can be further used in examining interrelationships of plant communities and their environments.

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[1] *Concurrent cooperative research is being conducted by other Federal, State, private, and University personnel on the other components of the biotic communities of this Wilderness Area.*

SAMPLE DESIGN

In designing the sample scheme, information already available for the Interior Zone of the BWCA was examined. This consisted principally of reviewing the scientific literature, reading popular accounts of voyageur travel through the area during the fur trade era, reviewing published histories of the area, and collecting official documents, maps, and aerial photographs of the area.[2] Study of this material suggested that about 300,000 acres, or 60 percent, of the Interior Zone was occupied by natural vegetation. The balance of the area was logged, either in the "cut-out and get-out" period of the early 1900's, or under controlled National Forest or State timber harvest programs of more recent years. This has been confirmed by Heinselman (1969). Because of the large area involved, and because of the limited field time and manpower available, this initial study was restricted to the natural upland vegetation and environment. For the purposes of this survey, "Upland" is defined on a topographic basis as sites upon which rainwater never accumulates, due to runoff and percolation. They are normally thought of as mineral soil sites.

In applying these survey methods to other forest units, stratifications based on general management goals, historical influences, topographical conditions, and other information should be considered.

The general extent of upland natural vegetation was outlined on U.S. Geological Survey quadrangle maps. Using a grid overlay, areas to be sampled were randomly located. To ensure representative sampling of the entire area of natural vegetation, the number of sample areas (stands) located on any one quadrangular map was proportional to the number of square miles of natural vegetation represented on the map. Random points that fell within lakes, streams, or marsh areas were immediately eliminated. To ensure a sufficient number of areas to allow rejection of those not meeting the criteria for sample acceptance in the field, about twice as many areas were established as anticipated for use. During the initial stages of study it was thought there might be an oversampling of the most common community types. In this survey it was not a problem, however. Users elsewhere might encounter this problem, and the possibility of stratifying samples on the basis of topography, moisture, geology, or some other scheme should be considered. Because the survey area was roadless, over 100 miles east to west, and up to 30 miles north to south, sample points were restricted to within 1,000 meters of the nearest canoe route or established foot trail.

Criteria for field acceptance of the randomly established sample areas were established in advance as follows:

1. The area must be upland and consist of natural vegetation.

2. The area must be a minimum of 5 acres of forested vegetation or a minimum of 100 square meters of nonforested vegetation, provided there is a margin of at least one tree height as a buffer between the nonforested vegetation and the nearest forest.

3. The stand must be located on a uniform topographic site; i.e., located entirely on one exposure, slope position, and geological substrate.

4. The sample area must be relatively homogeneous in vegetational composition as determined by visual inspection of airphotos and of the site itself. The idea is to ensure that the sample represents only one kind of plant community, not two or more. Stands with discontinuities in vegetation will be rejected. Criterion three above usually ensures this.

These criteria may be modified for use in other vegetation types or regions according to the purpose of the survey.

Two major considerations were used in designing field data forms: (a) to make the forms simple, requiring a minimum of writing, and thus reducing chance for omission of data and recording errors, and (b) to allow direct punching of the data from the field sheets onto computer cards (ADP) for automatic data processing.

[2]*Heinselman, M. L., Ohmann, L. F., Ream, R. R., and Brown, C. A problem analysis of research in the ecology of wilderness biotic communities in the Boundary Waters Canoe Area. (Unpublished report on file at North Central Forest Experiment Station, St. Paul, Minnesota.)*

[3]*Natural vegetation is defined as that composed of native species, resulting primarily from environmental factors present in the ecosystem prior to settlement (and potentially still effective, including such factors as windstorms, insect and disease outbreaks, and fire) or from gradual successional change.*

This resulted in greater efficiency as well as in reduced transcription errors. Forms were printed on high-quality paper with moisture-resistant ink to resist deterioration under wet field conditions. Where possible, species likely to be encountered in the regional flora were printed on the form.

SAMPLING METHODS

A field reconnaisance of each sample area was made to determine if it met the criteria for acceptance. When the area did not meet the criteria, it was rejected and the nearest sample area previously plotted was visited. If the area was satisfactory, the following data were collected.

General Information – Data Form EI-1 (Fig. 1)

(5)[4] A three-digit stand number.

(8) Airphoto number (the stand was outlined on the airphoto).

(17-24) The legal description of the stand as determined from the topographic map.

(25) A numerical code to identify the sampling crew. This may be important when more than one crew is involved to help answer questions that may arise concerning the data.

(26-29) Date of sampling.

(31) Elevation of sample stand as determined from the topographic map.

(35) Percent slope (five readings were taken within the sample area and averaged).

(37) Azimuth (aspect) of the stand.

(40) Position on the slope recorded as: ridgetop, upper slope, midslope, lower slope, or valley.

(41) Location of the stand in relation to the many lakes of the area, recorded as either interior, island, peninsula, or lakeshore.

(42) Distance to the nearest water body of over 5 acres.

[4]*The number at beginning of this and subsequent paragraphs refers to the initial column where the field data is to be punched on ADP cards. It also identifies location on the data form.*

(45) Geologic bedrock type as indicated on geologic bedrock maps of the area.

(47) Surface material recorded as: ground moraine, outwash plain, end moraine, lacustrine deposit, or exposed bedrock outcrop.

(49) Annual insolation received by the site as determined from appropriate tables in Frank and Lee (1966).

(53-75) Height and age of five dominant trees of forested stands. Height was determined by use of distance tape and clinometer; age by increment boring. Many of the communities in the BWCA are of postfire origin and represent single-aged canopies. This information provides a means of looking at the communities as a time series in order to evaluate succession following a disturbance.

The remaining portion of the data sheet EI-1 was used to record a general description of the sample area. There was normally enough room left on the sheet to record a brief description of the soils.

Soils

A soil pit was dug in a representative part of the stand (representative in the sense that localized swells or humps were avoided) and the following data were recorded:

(a) Litter depth. Litter depth was also recorded in each of the ground cover plots.

(b) Depth of the fermentation (02) and humus (01) layers.[5] Soils of the BWCA have little humus and so the two layers were treated as one unit.

(c) Depth of each of the major mineral soil horizons (A1, A2, B, and C) was measured and horizon texture and color were briefly described.

(d) Volume of cobbles and stone (greater than 3 inches in diameter) in the profile was estimated.

(e) A 1-quart sample of the combined fermentation and humus layer, and a quart sample of the B horizon were collected for laboratory analysis.

[5]*02 and 01 as defined by the Seventh Approximation.*

North Central Forest Experiment Station
BWCA Ecology Study

Col.

1 [E | I | | 1] Card Identification

5 Stand Number

8 Air Photo No.

17 Township

19 Range

21 Section

23 ¼ Sect. NE-1 SE-2

24 40 SW-3 NW-4

25 Crew Leader + Crew

26 Month (Oct.=0)

27 Day

29 Year

31 Elevation

35 Per Cent Slope

37 Aspect________

40 Position on Slope
1=ridgetop 3=midslope 5=valley
2=upper 4=lower

41 Location
1=interior 3=peninsula
2=island 4=lake shore

Col.

Distance to water body of over 5 acres (meters) 42

Geologic Type
01=Slate 03=Redrock 05
02=Gabbro 04=Granite 06
45

Surface Material
01=Ground Moraine 04=Lacustrine
02=Outwash 05=Bedrock
03=End Moraine
47

Insolation 49

Ages of larger trees in stand

Height 53
Species________ Age 55

Height 58
Species________ Age 60

Height 63
Species________ Age 65

Height 68
Species________ Age 70

Height 73
Species________ Age 75

Figure 1. — Form for recording general environment data within each sample stand.

Vegetative Data

A discussion of sampling efficiency versus accuracy is beyond the scope of this paper. A variety of views can be found in the ecological literature (Greig-Smith 1964, Cottam and Curtis 1956, Curtis 1959, Lindsey *et al.* 1958, Lindsey 1956, Shanks 1954, Rice and Penfound 1955). We chose 20 points as a compromise between effort in obtaining the data and the accuracy of the results needed for an extensive type survey. This choice was also influenced by the previous use of similar methods in comparable vegetation (Curtis 1959, Maycock and Curtis 1960). Use of these methods in more complex vegetation might require an increase in the number of sample points taken in each stand, depending on manpower and field time available, and extensiveness of the survey as balanced against the accuracy.

The first sample point was selected randomly and the remaining points were spaced equidistant from one another. This generally was 20 steps or 60 feet apart. We tried to space the points in block design of five rows of four points or four rows of five points, but this depended on the size of the area and its topography (fig. 2). In non-forested stands the distance between the sample points was much smaller to conform to the smaller area occupied by this vegetation.

Permanent plots in the strict sense were not established as part of this survey; the job of carrying suitable materials for permanent

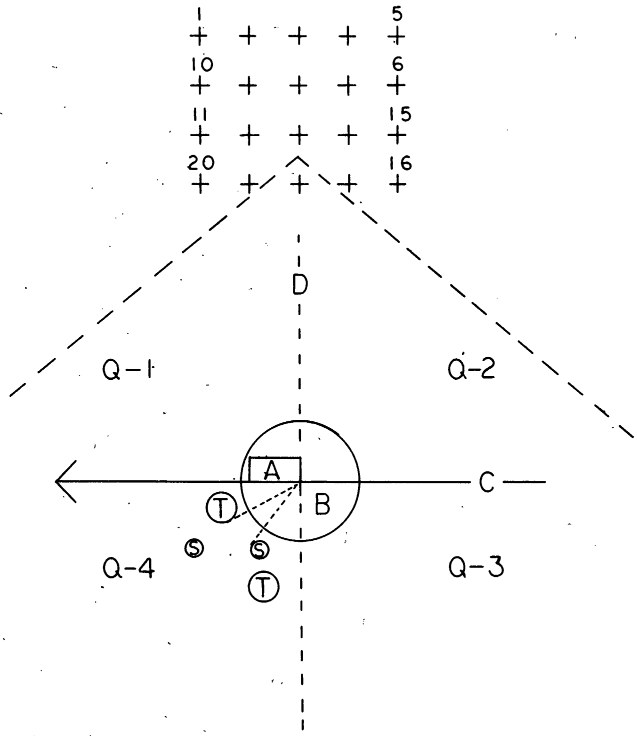

Figure 2. — The upper portion of the figure shows the distribution of sample points within a stand. The lower portion is a diagrammatic representation of the sampling system at one sample point. A is a 1 by 2-foot plot for sampling herbs and low shrubs. B is a milacre plot for sampling tall shrubs and tree seedlings. C is the line of travel and D is an imaginary line perpendicular to it, forming the four quadrants (Q) of the point-centered quarter method. S is a sapling. T is a tree.

plot marking into the Wilderness Area would have been prohibitive. The sample areas (stands) are permanently recorded on both topographic maps and on aerial photographs and can thus be resampled.

Tree and Sapling Size Classes — Data Form EI-2 (Fig. 3)

Trees [more than 4 inches diameter at breast height (d.b.h.)] and saplings (1 to 4 inches d.b.h.) were sampled by the point-centered quarter method (Cottam and Curtis 1956). The direction of travel from point to point constituted one line and an imaginary line was drawn perpendicular to it, forming four quadrants around the sample point (fig. 2). The distance to the nearest tree and sapling in each quadrant was measured and the species and d.b.h. of each was recorded. Each sheet of this data form was used to record the data from four points, so five sheets were needed per sample area. Species were recorded by a two-digit code number. We found it helpful to add the species initials to the right of the code number blanks to check against errors in recording code numbers. The notations Q1, Q2, etc. to the right of the diameter columns refer to the quadrant. Quadrants were numbered as: forward right (Q1), rear right (Q2), rear left (Q3), forward left (Q4), with regard to the direction of travel (fig. 2). This is not essential, but might be used in statistical analysis later. Distances were recorded to the nearest foot, and d.b.h. to the nearest one-tenth inch. Distances were measured with either a tape or range finder. D.b.h. was measured with a standard diameter tape. Columns 62 to 77 of the ADP card were reserved for recording dead tree species. To provide insight into the dynamics of these forest stands, we recorded any identifiable tree with a stem present at breast height or the stump of a beaver logged tree if it would have been included in the sample if still alive.

Tree Seedling Class — Data Form EI-4 (Fig. 4)

Seedlings of each tree species were counted and their projected ground cover estimated in a milacre circular plot located at each sample point used in the point-centered quarter method. Two ADP cards were punched for each species, one containing the cover data, the other the number of individuals; therefore, space is provided on the data form for a two-digit code for cover (example: *Abies balsamea* 151) and a two-digit code for number of individuals (*Abies balsamea* 152) for each species in each plot. The presence of deer, moose, and rabbit pellet groups were also noted in each milacre plot and recorded on this data form below seedlings.

Tall Shrubs — Data Form EI-5 (Fig. 5)

We arbitrarily divided the shrub species of this region into tall and low-growing shrubs for convenience of sampling. Tall shrubs were sampled in the same circular milacre plots used for tree seedlings. We recorded the number of stems for each shrub species by 1-centimeter size classes; stems were measured at 6 inches above the ground. Stem diameter was determined by use of a template. Where shrubs were

North Central Forest Experiment Station
BWCA Ecology Project - Tree and Sapling Data

Card Ident. Stand No. Point
1 E I 2 5 8
Dist. Diameter Tree Species
10 Q1
17 Q2
24 Q3
31 Q4
Dist. Diam. Sapling Species
38 Q1
44 Q2
50 Q3
56 Q4
Dist. Diameter Q Dead Tree Species
62
70

Card Ident. Stand No. Point
1 E I 2 5 8
Dist. Diameter Tree Species
10 Q1
17 Q2
24 Q3
31 Q4
Dist. Diam. Sapling Species
38 Q1
44 Q2
50 Q3
56 Q4
Dist. Diameter Q Dead Tree Species
62
70

Card Ident. Stand No. Point
1 E I 2 5 8
Dist. Diameter Tree Species
10 Q1
17 Q2
24 Q3
31 Q4
Dist. Diam. Sapling Species
38 Q1
44 Q2
50 Q3
56 Q4
Dist. Diameter Q Dead Tree Species
62
70

Card Ident. Stand No. Point
1 E I 2 5 8
Dist. Diameter Tree Species
10 Q1
17 Q2
24 Q3
31 Q4
Dist. Diam. Sapling Species
38 Q1
44 Q2
50 Q3
56 Q4
Dist. Diameter Q Dead Tree Species
62
70

Figure 3. – Form for recording tree and sapling size-class data as measured by use of the point-centered quarter method.

Card Identif. EI 4 Stand Number [ ] Tree Seedling Data

1--4 Columns 567

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
col.	8 9 10	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49
Abies bal c	151																				
Abies bal #	152																				
Acer rub c	153																				
Acer rub #	154																				
Bet pap c	155																				
Bet pap #	156																				
Pic glau c	157																				
Pic glau #	158																				
Pic mari c	159																				
Pic mari #	160																				
Pin bank c	161																				
Pin bank #	162																				
Pin res c	163																				
Pin res #	164																				
Pin str c	165																				
Pin str #	166																				
Pop tre c	167																				
Pop tre #	168																				
Thu occ c	169																				
Thu occ #	170																				
Deer Pell.	200																				

Figure 4. — Form for recording tree seedling size-class data as measured in the milacre plots.

CARD I. D. STAND NO.

E	I		5

1-2-3-4

5-6-7

SPECIES			QUADRAT NUMBER																			
	SP. CODE	B.A. CLASS CODE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IBM Column Number	8-9	10-11	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50

Figure 5. — Form for recording tall shrub data as measured in the milacre plots.

very abundant they were counted on only half of each milacre plot. Because each shrub species requires as many rows on the data form as there are diameter classes represented, no species names were preprinted. In column 8-9 a two-digit species code was later assigned. In column 10-11 a basal area (diameter class) code was recorded (01, 02, 03, 04, 05, etc.). In the rest of the columns the number of stems counted were recorded for each diameter class under the appropriate quadrate number.

In addition to diameter class and number of stems for each species, we estimated the amount of browsing on woody twigs. The following four categories were used: 0 = no browsing; 1 = 0 to ⅓ of all the tips available browsed; 2 = ⅓ to ⅔ browsed; 3 = more than ⅔ browsed. This was recorded directly under the last diameter class category for each species, using the appropriate species code and number 99 in the basal area code columns.

Ground Cover Characteristics and Vegetation — Data Form EI-3 (Fig. 6)

A 1- by 2-foot rectangular quadrat was established at each tree sample point; ground cover characteristics were recorded by percent of plot occupied. These characteristics were: bare rock, live wood, dead wood (over 1 inch diameter), bare ground, litter, lichens, and mosses. In addition, litter depth over the plot was estimated and averaged. Ground cover characteristics and most species names were preprinted on this data form, but spaces were provided for less common species.

Herbaceous and low shrub vegetation. — Low shrubs, ferns and fern allies, and herbs were recorded as the percent of projected ground cover they occupied within the 1- by 2-foot rectangular plot. This was an ocular estimate. Occasionally a species partially covered a plot but was not rooted in that plot. We recorded the plot number each time this occurred, because we wished to base frequency of occurrence values on actual rooting of a species within the sampling plot. These plot numbers were recorded in columns 51 through 62 of the data form. The summary program then subtracted those plots from the percent frequency calculation for the species. Some plants were treated as groups, because sampling was conducted throughout the growing season making some species difficult to identify during certain times of the season. For instance, because grasses and sedges are of minor importance in our vegetation, we treated all grass species as a unit and all sedge species as a unit. Identification can be as detailed or as general as the purpose of the survey indicates.

LABORATORY METHODS

Soils

Values were obtained for the combined fermentation and humus layers by ashing 1 gram of sample at 525 C. for 15 hours. The ash was brought into solution and analyzed on a Jarrell-Ash emission spectrometer model 66-000.[6] Values for phosphorus, potassium, calcium, aluminum, sodium, iron, magnesium, zinc, copper, molybdenum, manganese, and boron were determined. Samples of mineral soil (B horizon) were analyzed for exchangeable calcium, magnesium, potassium, and sodium by shaking 5 grams of soil in 20 ml. neutral normal ammonium acetate for one-half hour. This mixture was filtered and leached with an additional 80 ml. of ammonium acetate. Calcium and magnesium were analyzed on a Perkin Elmer atomic absorption spectrophotometer Model 303. Sodium and potassium were analyzed on a Perkin Elmer flame photometer. Exchangeable hydrogen was measured by the $BaCl_2$ - Triethanolamine, pH8.1 method. Extractable phosphorus was analyzed by shaking 5 grams of soil for 5 minutes in 50 ml. of Bray's No. 1 solution (0.025N HCl — 0.03N NH_3F). Molybdophosphoric blue color was developed and read on a Klett Summerson Colorimeter. Acidity (pH) was determined on a 1:1 soil-water mixture by a Beckman Zeromatic pH meter.

Mineral soil samples were analyzed by the hydrometer method (Bouyoucos 1951) for percent sand, silt, and clay. Moisture retention capacity was determined by pressure membrane extraction at 15 and pressure plate extraction at ⅓ atmospheres (Richards 1954).

Vegetation

Information from the field data forms was punched directly onto computer cards. Four computer programs were written in Fortran IV

[6] *Mention of trade names does not constitute endorsement by the USDA Forest Service.*

Card Identif. EI 3 Stand Number ☐ North Central Forest Experiment Station
1--4 Columns 567 BWCA Ecology Study

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Cover— Not Rooted In Quadrats No.						
Col.	8-10	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	
Bare Rock	001																											
Live Wood	002																											
Dead Wood	003																											
Bare Ground	004																											
Litter	005																											
Call. schr.	006																											
Clad. alpes	007																											
Clad. rangif	008																											
Clad. mitis	009																											
Clad. sylv.	010																											
Dicranum sp	011																											
Hylo splend	012																											
Hypnum cris	013																											
Polytri sp.	014																											
Lyco annot	020																											
Lyco clavat	021																											
Lyco compla	022																											
Lyco lucidu	023																											
Lyco obscu	024																											
Poly Virgin	025																											
Pterid aqui	026																											
Arcto uva	031																											
Chima umb	032																											
Gaulth hisp	033																											
Gaulth pro	034																											
Rosa acic	035																											
Rubus idae	036																											
Rubus pub	037																											
Vaccin Ang	038																											
Vaccin myr	039																											
Aralia nud	050																											
Aster mac	051																											
Clint bor	052																											
Coptis groe	053																											
Cornus can	054																											
Epilob ang	055																											
Frag vesca	056																											
Galium tri	057																											
Goodye rep	058																											
Goodye tes	059																											
Lathy ochro	060																											
Linn bore	061																											
Maianth can	062																											
Melamp lin	063																											

Figure 6. — Form for recording ground cover characteristics, low shrubs, and herbaceous species data as measured in the 1- by 2-foot plots.

language for use on a CDC-6600 computer. These programs summarize the vegetation data for each sample area. Each program is described and an example of the printout summaries included in the following section.

TREESUM

Previously prepared computer cards (EI-2, fig. 3) containing measurements for the trees and saplings are the input for this program. Program output (fig. 7) for each sample area consists of three units:

(1) *Living tree size class.* – The first three columns of figures summarize the actual number of points of occurrence, number of stems, and basal area for each species sampled within the stand. The computer uses these data plus the distance measures to calculate percent frequency of occurrence at the points, density in stems per acre, and basal area (at breast height) in square feet per acre for each species; these are totaled for the sample area. The computer also calculates relative frequency, density, dominance (basal area), and their summa-

TREE DATA FOR STAND 105 20 POINTS SAMPLED

NO. OF POINTS	NO. OF STEMS	BASAL AREA	PCENT FREQ.	DENS/ ACRE	B.A./ ACRE	SPECIES	REL. FREQ.	REL. DENS.	REL. DOM.	IMPORT. VALUE
20	64	2876	100	182	56.8	PIN BANKS	58.8	80.0	54.8	64.5
8	10	2244	40	28	44.3	PIN RESIN	23.5	12.5	42.7	26.3
2	2	49	10	6	1.0	POP TREMU	5.9	2.5	.9	3.1
1	1	25	5	3	.5	POP GRAND	2.9	1.2	.5	1.6
1	1	24	5	3	.5	QUERC RUB	2.9	1.2	.5	1.5
1	1	20	5	3	.4	BET PAPYR	2.9	1.2	.4	1.5
1	1	14	5	3	.3	PICEA MAR	2.9	1.2	.3	1.5
34	80	5250	170	227	103.7	**TOTALS*	100.0	100.0	100.0	100.0

AVE. DISTANCE = 13.8 AVE. CLOSEST INDIVIDUAL = 7.8 INDEX OF AGGREGATION = 1.32445

LIVING AND DEAD TREE STEMS TOGETHER - STAND 105

NO. OF POINTS	NO. OF STEMS	BASAL AREA	PCENT FREQ.	DENS/ ACRE	B.A./ ACRE	SPECIES	REL. FREQ.	REL. DENS.	REL. DOM.	IMPORT. VALUE
20	65	2692	100	200	57.7	PIN BANKS	60.6	81.2	53.4	65.1
8	10	2244	40	31	48.1	PIN RESIN	24.2	12.5	44.5	27.1
2	2	49	10	6	1.0	POP TREMU	6.1	2.5	1.0	3.2
1	1	24	5	3	.5	QUERC RUB	3.0	1.2	.5	1.6
1	1	20	5	3	.4	BET PAPYR	3.0	1.2	.4	1.6
1	1	14	5	3	.3	PICEA MAR	3.0	1.2	.3	1.5
33	80	5042	165	247	108.0	**TOTALS*	100.0	100.0	100.0	100.0

SUMMARY OF DEAD TREES ONLY

	NO. TREES	DEN/A	BA/A
PIN BANKS	10	31	4.4
TOTALS	10	31	4.4

SAPLING DATA FOR STAND 105

NO. OF POINTS	NO. OF STEMS	BASAL AREA	PCENT FREQ.	DENS/ ACRE	B.A./ ACRE	SPECIES	REL. FREQ.	REL. DENS.	REL. DOM.	IMPORT. VALUE
17	30	118	85	20	.6	BET PAPYR	29.8	37.5	31.0	32.8
8	12	121	40	8	.6	PIN BANKS	14.0	15.0	31.7	20.2
6	9	37	30	6	.2	ACER RUB	10.5	11.2	9.8	10.5
8	8	16	40	5	.1	PIN RESIN	14.0	10.0	4.1	9.4
6	8	24	30	5	.1	QUERC RUB	10.5	10.0	6.4	9.0
4	4	26	20	3	.1	POP GRAND	7.0	5.0	6.7	6.3
3	3	15	15	2	.1	POP TREMU	5.3	3.7	3.9	4.3
1	2	15	5	1	.1	PIN STROB	1.8	2.5	4.1	2.8
2	2	6	10	1	.0	PICEA MAR	3.5	2.5	1.5	2.5
1	1	2	5	1	.0	ABIES BAL	1.8	1.2	.5	1.2
1	1	2	5	1	.0	PICEA GLA	1.8	1.2	.5	1.2
57	80	382	285	54	1.8	**TOTALS*	100.0	100.0	100.0	100.0

Figure 7. – Example of the printout of Computer Program TREESUM.

tion – the importance value (Cottam and Curtis 1956) – for each species in the sample area. The average distance from the 20 sample points to the 80 trees measured, the average distance to the nearest individual measured at each sample point, and an index of aggregation value (Eberhardt 1967) is also printed.

(2) *Living and dead stems.* – This portion of the program is the same as described above, except that dead trees which would have been included in the sample if they were still alive are substituted as input for the next nearest live tree that was measured. A summary of the dead trees by species including number measured, density in stems per acre, and basal area in square feet per acre is also printed.

(3) *Sapling size class.* – The sapling size-class field measurements are summarized as in (1) above.

SEEDSUM

This program uses field measurements of tree seedlings (computer cards EI-4, fig. 4) and pellet group counts for moose, deer, and rabbits on the milacre plots as input. Program output (fig. 8) includes stand number, number of plots measured, number of plots on which each species occurred, number of seedlings counted, and average percent cover of the milacre plot occupied by each species. Using these data the computer calculates density in stems per acre, relative values of frequency, density, cover, and their summation, the importance value. The computer summarizes pellet groups for each species by number of plots on which they occurred, percent frequency of occurrence, and total number counted.

SHRUBSUM

Tall shrub measurements from the milacre plots at each point within the stand (computer cards EI-5, fig. 5) are used as input for this program.

Output from this program for each species (fig. 9) consists of average browse index, percent frequency of occurrence, total number of shrubs counted in all size classes, total basal area measured in all size classes, density in stems per acre, and basal area (at 6 inches above the ground) in square feet per acre; also included are relative frequency, density, dominance (basal area), and their summation, the importance value.

HERBSUM

This program uses as input all data collected in the 1- by 2-foot rectangular quadrats (computer cards EI-3, fig. 6). Program output (fig. 10) is divided into three parts: ground cover, low shrubs, and herbs.

(1) *Ground cover.* – Information on ground cover characteristics, lichens, and mosses is summarized. For each characteristic or species the following are computed: the number of points of occurrence, percent frequency of occurrence, total percent cover estimated in the 20 quadrats, and average percent cover per plot. Relative frequency, percent cover, and the importance value are also computed.

(2) *Low shrubs.* – Data are summarized for low shrubs as in (1) above.

(3) *Herbs, ferns, and fern allies.* – Data for this group are summarized as in (1) above. In

BWCA ECOLOGY STUDY- SEEDLING DATA

FOR STAND 105 20 MILACRE PLOTS

POINTS OF OCC	PCENT FREQ.	NO.OF SEED.	AVE. COVER	SEEDLINGS PER ACRE	SPECIES	REL. FREQ.	REL. DENS.	REL. COV.	REL. IMPORT. VALUE
12	60.0	43	.7	2150	ACER RUBRU	70.6	86.0	73.7	76.8
2	10.0	4	.1	200	POP TREMUL	11.8	8.0	10.5	10.1
2	10.0	2	.1	100	BETUL PAPY	11.8	4.0	10.5	8.8
1	5.0	1	.0	50	PICEA MARI	5.9	2.0	5.3	4.4
17	85.0	50	.9	2500	**TOTALS**	100.0	100.0	100.0	100.0

PELLET GROUP COUNTS- STAND 105

DEER PELLE	7	35.0	11

Figure 8. – Example of the printout of Computer Program SEEDSUM.

BWCA ECOLOGY STUDY- SHRUB DATA FOR STAND 105					20 POINTS SAMPLED					
BROWSE INDEX	FREQ. OF OCC	NO. OF SHRUBS	BASAL AREA	DENS/ ACRE	B.A./ ACRE	SPECIES	REL. FREQ.	REL. DENS.	REL. DOM.	IMPORT. VALUE
.2	70	195	38	9750	2.06	COMPT PERE	45.2	54.0	41.9	141.1
2.8	45	99	21	4950	1.13	AMELAN SPP	29.0	27.4	23.0	79.5
.5	10	39	17	1950	.92	CORYL CORN	6.5	10.8	18.7	36.0
2.5	10	18	13	900	.70	SALIX SPP	6.5	5.0	14.2	25.6
.5	20	10	2	500	.11	DIER LONIC	12.9	2.8	2.2	17.8
1.3	155	361	91	18050	4.91	**TOTALS**	100.0	100.0	100.0	300.0

Figure 9. — Example of the printout of Computer Program SHRUBSUM.

GROUND COVER DATA FOR STAND 105							
NO. OF POINTS	PCENT FREQ.	AMT. OF COVER	AVERAGE COVER	SPECIES	REL. FREQ.	REL. COVER	IMPORT. VALUE
20	100	1732	86.60	LITTER	29.4	86.6	58.0
12	60	83	4.15	DICRANUM	17.6	4.2	10.9
11	55	48	2.40	MOSSES OTH	16.2	2.4	9.3
9	45	21	1.05	CALL SCHRE	13.2	1.1	7.1
4	20	49	2.45	CLAD RANGI	5.9	2.5	4.2
4	20	12	.60	POLYTRICUM	5.9	.6	3.2
3	15	16	.80	DEAD WOOD	4.4	.8	2.6
2	10	22	1.10	CLAD MITIS	2.9	1.1	2.0
2	10	12	.60	LIVE WOOD	2.9	.6	1.8
1	5	5	.25	BARE ROCK	1.5	.3	.9
68	340	2000	100.00	**TOTALS**	100.0	100.0	100.0
HALF-SHRUB DATA FOR STAND 105							
20	100	272	13.60	VACCIN ANG	47.6	55.7	51.7
18	90	153	7.65	GALUTH PRO	42.9	31.4	37.1
3	15	57	2.85	VACCIN MYR	7.1	11.7	9.4
1	5	6	.30	ROSA ACICU	2.4	1.2	1.8
42	210	488	24.40	**TOTALS**	100.0	100.0	100.0
HERB DATA FOR STAND 105							
10	50	470	23.50	PTERID AQU	14.7	48.9	31.8
17	85	327	16.35	ASTER MACR	25.0	34.0	29.5
15	75	48	2.40	GRASSES SP	22.1	5.0	13.5
13	65	63	3.15	MIANTH CAN	19.1	6.5	12.8
6	30	32	1.60	ARALIA NUD	8.8	3.3	6.1
2	10	7	.35	TRIENT BOR	2.9	.7	1.8
2	10	6	.30	CORNUS CAN	2.9	.6	1.8
2	10	4	.20	MELAMD LIN	2.9	.4	1.7
1	5	5	.25	CLINT BORE	1.5	.5	1.0
68	340	962	48.10	**TOTALS**	100.0	100.0	100.0
AVERAGE LITTER DEPTH		.5					

Figure 10. — Example of the printout of Computer Program HERBSUM.

addition, the average litter depth for all rectangular plots within the stand is computed.

In addition to printouts the programs can provide instructions for punching summary data on ADP cards. These cards may serve as input for the further analysis of sample-area relationships, classification by community types, and community-environment relationships.

DISCUSSION

The methods described provide minimum data for plant community description. Summaries on individual stands permit the investigator to classify stands by community type using any method he chooses. We used quantitative methods (principle component and optimal agglomeration) for determining the similarity of the stands to one another (Ream and Ohmann 1970), and grouped the stands into community types on those bases. Preliminary testing of species composition of these groups showed that they differ statistically.

In keeping with the spirit of the Wilderness Act, sampling crews traveled within the BWCA by the same means available to the public. In nonmotor zones we paddled; in motor-use zones we used motors. It was apparent that our major cost would be in time spent traveling to sample areas. In an effort to reduce these costs our crews worked on 10-day schedules, spending eight or nine days in the field and camping out for six or seven nights. Travel time to sample areas was still significant but much reduced. In the kind of vegetation we were sampling, one stand was sampled per day under average conditions. In dense shrub conditions sampling often required more than one day and in sparse shrub conditions a sample was obtained in less than one day. This includes time spent traveling from camp site, locating the stand, and obtaining the sample. Each crew generally sampled six or seven stands on each trip.

These methods can be modified to better sample a particular type of vegetation. In uniform vegetation the number of sample points and plots and size of plots might be reduced, or in more complex vegetation they might be increased. Sample areas might be selected by a stratified sample based on topography, or by some other scheme. The types of data collected could be modified to fit the interests of the particular survey. In areas where soils are well described, the soil collection could be eliminated. Many modifications in the sampling method, however, will require changes in the computer summarization programs.

Office time required for such things as checking data sheets and entering species code numbers is less than 15 minutes per stand. Punching field data onto ADP cards constitutes the primary computing cost. Each stand requires 45 to 50 cards for the vegetation data, each of which costs about $0.08 to punch. If soil data and other environmental data are punched on cards, costs are slightly higher. However, the total number of cards per stand is well under 75. Other indirect computing costs are involved in writing computer programs for data summarization. While these programs may have to be modified for other areas or surveys, this would not be a major cost.

Cost of computer time itself is minor and represents a large saving over hand calculation, especially when one considers the increase in accuracy obtained.

Other costs incurred in the inventory are the chemical and mechanical analyses of soil samples. Actual costs depend on the availability of local personnel or organizations to conduct such analyses.

Materials required to conduct a vegetative survey using the methods described here are not extensive nor particularly expensive. A set of U.S. Geological Survey quadrangle maps of the survey area, diameter tapes, distance tapes, data sheets, a range finder, a shovel, an increment borer, a compass, and clipboards nearly complete the list of required items. Additional valuable items include plant keys, plant presses, and collection bags for both soils and plants.

These methods have been used for 3 years. Much of the field sampling has been handled by crews made up of senior botany or forestry undergraduates, or first-year graduate students assisted by first- or second-year botany or forestry undergraduate students. Training of the crews has been accomplished in the field by sampling up to four areas with experienced personnel.

The upland natural vegetation sampled included rock outcrops dominated by lichens, aspen-birch, maple-aspen-birch, jack pine, red pine, white pine, balsam fir, black spruce, and white-cedar communities (Ohmann and Ream 1969). The methods were about as readily applied in all these communites. The major factor in application seems to be the abundance of shrubs in each stand. Since designing these methods we have used them in three surveys. We are using the methods without modification in the areas logged in the 1890-1930 era. In an intensive survey of two 1936 wildfire areas we have had to modify the size-class categories for tree species, because trees 4 inches and larger are not frequent enough to efficiently sample as a separate class. We are using a single tree-size class of 1 inch d.b.h. and larger.

Few, if any, of the methods described above are original — most have been part of the ecological literature for some time. We have simply brought together a set of flexible, efficient methods to collect and summarize large quantities of data in a form suitable for automatic data processing and further quantitative analysis.

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