A Quantitative Method of Habitat Description

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Reprinted from AUDUBON FIELD NOTES
December 1970, Volume 24, Number 6, pp. 727–36
Published by the National Audubon Society

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Two programs sponsored by the National Audubon Society are directed at making mixed-species estimates of bird populations in terms of 100 acres of fairly uniform habitat. These are the Breeding-Bird Census (Hall 1964), started in 1936, and the Winter Bird-Population Study (Kolb, 1965), started in 1948. Although the field techniques differ between these two types of studies, the results published in *Audubon Field Notes* look much alike. They consist of brief accounts of the location and characteristics of a study plot and a summary list of bird species present in order of their decreasing abundance. Bird counts are followed by estimates of the number that would be expected in 100 acres of similar vegetation (number of territorial male birds only in the case of the Breeding-Bird Census). Some estimates of aspects of the vegetation, such as average tree size, percent canopy cover, and percent of tree species distribution in the canopy, accompany descriptions of the area. But until now no standard technique for obtaining vegetation data has been recommended. Since the sampling procedure may influence the results, comparisons between studies as presently reported are unreliable. However, if quantitative vegetation data could be obtained in a simple and regular manner, the usefulness of both the Breeding-Bird Censuses and the Winter Bird-Population Studies would be increased many fold. Variation in sizes and other characteristics of territories of a species in different habitats could be related to variation in the structure of the vegetation. Comparisons between the avifaunas of different areas, or among successional sequences within one area over the years, could be interpreted in terms of gradients in types of habitat. We suggest below a simple method for quantitative habitat description which we have found useful. We offer sample data and summary sheets and comparisons with other methods.

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It is clear that the structure of the vegetation required by any particular bird species is quite specific (Dumas 1950, Marshall, 1957, Oelke 1966). Although it is impossible to know whether a bird actually selects a specific area because of its structure, independently of other qualities, ornithologists have often assumed this to be the case (Lack 1933, 1937; Lack and Venables 1939; Svärdson 1949; Tinbergen 1951; and others). They assume further that birds have species-specific psychological preferences for certain visual combinations of the structure of the environment. If bird distribution within a continent is based in any significant part on adaptation to various factors of a heterogeneous environment, surely the extra time required to obtain quantitative habitat descriptions to accompany bird population studies would be well spent. For examples of several interesting approaches to the analysis of this type of data see Bond (1957), Beals (1960) and Tramer (1969).

FOUR METHODS COMPARED

In the course of an investigation of the habitats of breeding birds in Arkansas, we tried four of the methods recommended by plant ecologists for making quantitative estimates of vegetation. These included *plotless* methods, such as the quarter method (Cottam and Curtis 1956, Phillips 1959) and the wandering quarter method (Catana 1963), and *areal* methods, such as 0.01-acre armlength transects (Rice and Penfound 1955, Penfound and Rice 1957) and 0.1-acre circular plots (Lindsey, Barton and Miles 1958). We tested the field efficiencies of these four methods and compared results with a complete census in an eight-acre tract of upland deciduous woods in the Ozark Plateau.

The plotless methods are based on the principle that the average area occupied by each tree is the reciprocal of the density of

the trees. Transects along compass lines are made through the woods, the species and diameters of the nearest trees within 90 degrees of a specified point (or within a 90° angle bisected by the compass line, in the case of the wandering quarter method) are recorded and distances measured. The sum of the distances divided by the number of trees gives the average distance between trees. The density of trees per acre can be estimated by dividing the numbr of square feet per acre (43,560) by the square of the average distance between trees. Basal area or dominance (an estimate of woody biomass) can be determined from the same data. The basal area of an individual tree is the cross sectional area of the trunk at 4.5 feet from the ground. Knowing the density and size classes of the trees, you can estimate total basal area for the entire tract.

The areal sampling methods are simply ways of sampling small plots of known size and extrapolating to estimate the density and basal area of the whole study plot. Estimations of frequency (a function of both density and evenness of distribution) can be made by finding the percent of the sample plots in which a given species occurs. One-hundredth-acre rectangles are sampled by recording trees intercepted by one's outstretched arms (six feet) while walking along a compass line for 72.5 feet. Tenth-acre circles are sampled by recording trees within 37 feet (radius of a 0.1-acre circle) of a point. This method will be described in more detail below.

Table 1. Average work accomplished in 30 minutes of field effort, recording the species and diameters of trees in an upland Ozark forest in Arkansas.

Sampling method	Number of Units	Number of trees identified and measured
Quarter method	12 quarters	48
Wandering quarter method	40 trees	40
Tenth-acre circles	2 circles	57
Hundredth-acre rectangles	6 rectangles	19

Table 2. Total numbers of trees in eight-acre study plot and percent of total. Names follow Moore (1960).

Common Name	Scientific Name	Total Trees	Trees / Acre	%
Winged Elm	*Ulmus alata*	752	94.0	35.5
Post Oak	*Quercus stellata*	276	34.5	13.0
Black Oak	*Quercus velutina*	194	24.3	9.2
Redbud	*Cercis canadensis*	126	15.8	5.9
Hackberry	*Celtis occidentalis*	121	15.1	5.7
American Elm	*Ulmus americana*	97	12.1	4.6
Slippery Elm	*Ulmus rubra*	95	11.9	4.5
White Ash	*Fraxinus americana*	83	10.4	3.9
Red Mulberry	*Morus rubra*	72	9.0	3.4
Chinkapin Oak	*Quercus muehlenbergii*	44	5.5	2.1
Eastern Red Cedar	*Juniperus virginiana*	39	4.9	1.8
Bitternut Hickory	*Carya cordiformis*	16	2.0	0.8
Flowering Dogwood	*Cornus florida*	15	1.9	0.7
Osage-orange	*Maclura pomifera*	13	1.6	0.6
Honeylocust	*Gleditsia triacanthos*	9	1.1	0.4
White Oak	*Quercus alba*	9	1.1	0.4
Black Hickory	*Carya texana*	9	1.1	0.4
American Plum	*Prunus americana*	8	1.0	0.4
Black Cherry	*Prunus serotina*	7	—	—
Black Walnut	*Juglans nigra*	4	—	—
Privet	*Ligustrum* sp.	2	—	—
Hawthorn	*Crataegus* spp.	2	—	—
Common Persimmon	*Diospyros virginiana*	1	—	—
Rusty Blackhaw	*Viburnum rufidulum*	1	—	—
Southern Red Oak	*Quercus falcata*	1	—	—
Dead tree		122	15.3	5.8
Total		2118	264.8	100%

Table 1 gives the average work accomplished in 30 minutes of field effort by one observer, assuming that he is familiar with the method and the species of trees present in his study area. Also, the amount accomplished will vary with the density of the vegetation and whether the observer has a second person along to record for him. Table 2 gives the results of the complete census of the trees in our study area. This involved marking of each of the eight acres with string, recording the species and diameter of each of 2118 trees greater than three inches in diameter, and dabbing each with paint to show that it had been counted. The area is part of a 45-acre tract on a west-facing slope within the city limits of Fayetteville, Arkansas, and is within one mile of the University of Arkansas. It was originally part of the mixed oak-hickory forest that typifies these sites in the Ozarks. Partial clearing and selective cutting of the largest trees in the early part of this century permitted invasion by pioneer species such as the Winged Elm (*Ulmus alata*), Eastern Red Cedar (*Juniperus virginiana*), Osage-orange (*Maclura pomifera*), American Plum (*Prunus americana*), Honeylocust (*Gleditsia triacanthos*), and Common Persimmon (*Diospyros virginiana*).

Figure 1 shows the results of the four sampling procedures in terms of their ability to predict the actual density of trees at the end of a specified period of field effort. Although the study area is small (8 acres), it is heterogeneous, being dominated at one end by small Winged Elms and at the other end by large Post Oaks. As a whole the area is probably more heterogeneous than the average larger areas on which breeding-bird surveys and winter bird-population studies are conducted. Results from the two plotless methods (quarter method and wandering quarter method) tended to overestimate the total tree density and to underestimate the tree density by species. Results from the two areal methods, hundredth-acre rectangles and tenth-acre circles, on the other hand, give fairly accurate estimates of total density and density of single species within two hours of field effort. For study plots in edge habitats hundredth-acre

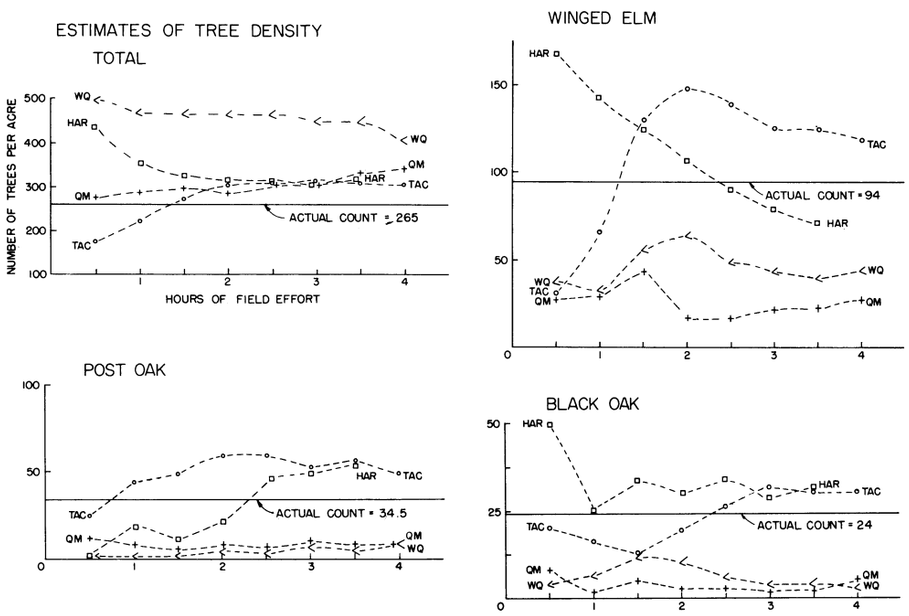


Figure 1. The results of estimates of tree density in terms of the amount of field effort using four sampling procedures. QM quarter method; WQ wandering quarter method; HAR hundredth-acre rectangles; TAC tenth-acre circles.

rectangles (armlength transects) oriented at random would probably be the most appropriate. For studies in forests having a fairly uniform tree distribution, we prefer tenth-acre circles. A description of the procedure for the latter method accompanied by a sample field sheet and summary sheet are given below in the hope that others will try this system of analysis. For our area the sampling of five randomly-chosen tenth-acre circles permitted adequate estimates of the density, dominance (basal area) and frequency (evenness of distribution) of trees in the forest. The totals need only be doubled to transpose the data to estimates per acre. In addition we suggest simple techniques for estimating shrub density, ground cover, canopy cover and canopy height.

The large differences among the relative efficiencies of the four sampling methods deserve comment. Apparently the method used, the size of the plot, and the amount of field effort expended influence the results obtained to an unsuspected degree. With the plotless methods either our sample sizes were too small or we did not take the data properly. Although we tried to pace accurately, the slope of the ground may have affected the length of steps. Also, analysis of data from these methods involves squaring mean distances, and this magnifies small errors. Even though the plotless techniques are mathematically sound, in practice they appear to be less accurate than the areal methods.

PROCEDURE

The only equipment needed for estimating density, basal area, and frequency of trees, canopy height, shrub density, percent ground cover and percent canopy cover is: 1) 2 yardsticks, 2) an ocular tube, 3) a mirror, 4) a level and 5) a clipboard (Figure 2). One yardstick should be brightly colored so that it may be seen easily through the forest. It should have hole in one end with string tied through it, so that the stick can be hung on a twig by the loop.

The most accurate way to measure tree diameters is with calipers or a forester's diameter tape. A simple and convenient substitute, called a Baltimore "reach stick" (Forbes 1955), can be made from the second yardstick. Cut it off at 28 inches and mark a new scale on it according to your reach. This is the distance from the eye to the fist with arm outstretched and head lowered. Use the calibrations in Table 3 which most nearly match

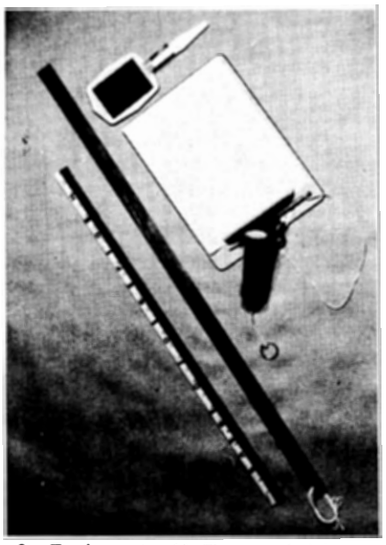


Figure 2. Equipment: 1) Two yardsticks — one with a string loop so that it may be hung on a branch, the other marked with a Biltmore scale for estimating tree diameters; 2) An ocular tube — a sighting device used to estimate ground cover and canopy cover, made from a cardboard cylinder with cross threads taped to one end and a weight suspended from the other; 3) and 4) a mirror with a level taped to it for determinations of canopy height; and 5) a clipboard, pencil and data sheets.

your particular reach. Kurfew Cruising Sticks marked with a Biltmore scale for a reach of 25 inches are available from Forestry Supplies, Inc. (Catalog Number 59740; 205 West Rankin Street, Jackson, Mississippi, 39202) for $3.00 plus tax and shipping charges. The calibrations on the stick are derived from the solution of similar triangles, based on the formula $S = \sqrt{\frac{a\ D^2}{a + D}}$ where S is the graduation on the stick, a is the reach of the observer, and D is the diameter of the tree. If carefully used, this stick is sufficiently accurate for the purposes desired here, and it is much more efficient timewise than any other method. The diameters of standing trees are commonly measured at breast height (DBH), 4½ feet above the ground. Hold the stick horizontally at arm's length and at breast height and read it (with one eye closed) from that height. Lower the eye to the level of the stick, do not raise the stick to eye level. When the left edge of the

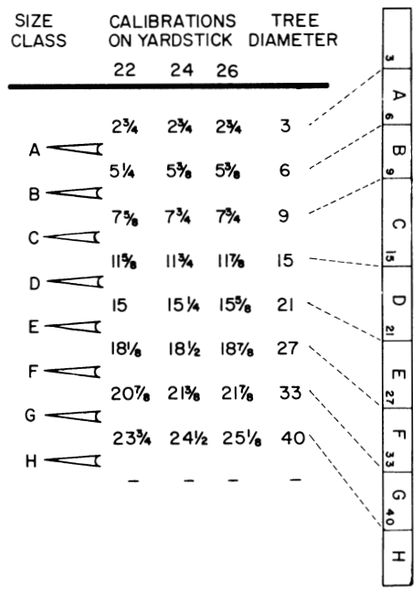


Table 3. Calibrations to be marked on the Biltmore "reach stick" for estimating the diameter size classes of trees, adjusted for the distance from the observer's eye to his fist with arm outstretched (see Figures 2, 3A and the text for explanation).

stick is lined up with the left side of the tree, the diameter size class can be read from the right edge (Figure 3A).

Sight the original 36-inch yardstick from a distance of 37 feet (radius of a tenth-acre circle) by holding the "reach stick" vertically at arm's length (Figure 3B). Mark the back side of the "reach stick" accordingly. This will be approximately 1¾ inches from the end. Now, when you hang the first yardstick in the woods at the center of your circle, you can tell whether you are within the area to be sampled by using this simple sighting method. Staying within the circle you can record the species and size classes of trees. Use abbreviated word descriptions for the unknowns and identify the dominant five species later. The information from five 0.1-acre circular plots may be sufficient to estimate tree density, dominance and frequency for the entire area. A simple way to find out whether your sample is adequate is to continue recording until the last two estimates of the total tree density per acre do not differ by more than 25 trees. To obtain estimates of total tree density per acre, multiply the following numbers by the number of trees counted:

Number of Circles	Multiply by
5	2.0
6	1.6
7	1.4
8	1.3
9	1.1
10	1.0

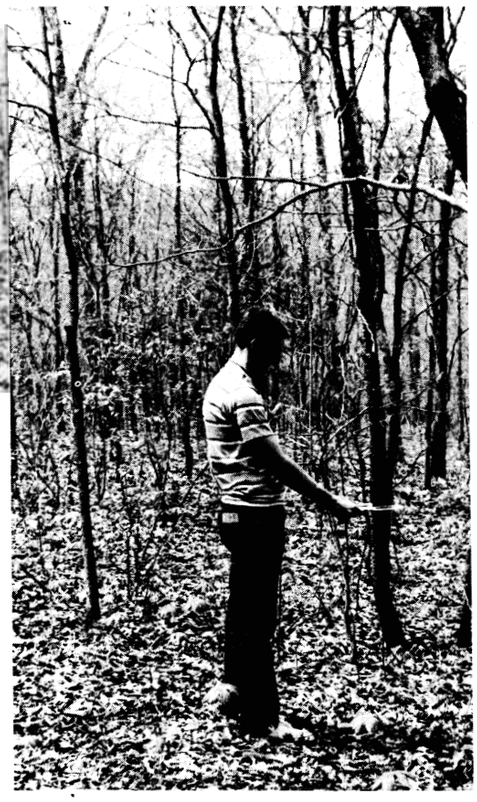
The choice of the centers of the circles must be random. Any attempt to select typical places is likely to be biased. For the Breeding-Bird Census, count the number of tags which mark the corners of acres and subtract the number which occur on the perimeter. For a 100-acre plot marked 1-11

Figure 3. Procedure: A) Holding the "reach stick" at arm's length with the left edge lined up with the left side of the tree, read the diameter size class.

B) If the image of a yardstick suspended from a branch is greater than 1¾ inches, when sighted at armslength against the "reach stick", you are within 37 feet of the yardstick (radius of a 0.1-acre circle).

C) Sight directly upwards through the ocular tube to determine the presence or absence of canopy cover.

D) Sight the ground four feet from the observer to determine the presence of absence of green vegetation on the ground.



E) Holding the mirror level, walk toward a tree until the crown appears in the mirror. Three feet plus the distance from the mirror to the tree equals the height of the tree.

on one axis and A-K on the other, it takes 121 tags to mark a grid of 100 square acres. Of these, 81 are in the interior of the plot. In this case you would make 81 small slips of paper marked B2, B3 . . ., B10; C2, C3, . . ., C10; . . .; J2, J3, . . ., J10. Mix up the slips and draw ten, keeping track of the order in which they were drawn. This will tell you the location of the centers of the sample circles and the order in which to take them. You will probably not need to use all ten. In the case of the Winter Bird-Population Study, mark a grid on your map of the study area, and proceed as above. Determine the locations of the circles by pacing from the edge of the area.

If you prefer to use the metric system, the following conversions can be used:

To convert	*Into*	*Multiply by*
acres	hectares	0.4
feet	meters	0.3
square feet	square meters	0.093
square feet	square centimeters	929.0
inches	centimeters	2.5

The sample circles will have an area of 0.04 hectares and a radius of 11.28 meters. The reach stick can be calibrated in centimeters using the formula given above if centimeters are substituted for inches throughout the procedure.

To estimate shrub density make two transects at right angles to one another across the 0.1-acre circle, counting the number of

FIELD SHEET FOR VEGETATION DATA

LOCATION: Archer Woods | Distance & direction to nearest town having a post office: Fayetteville, Ark.

SIZE: 8 acres DATE: 9/25/'67 | LATITUDE - LONGITUDE:

DESCRIPTION OF AREA: oak-hickory upland forest

TOPOGRAPHY: west-facing slope

TENTH-ACRE CIRCLES

TREES: (DIAMETER SIZE CLASSES A-H: 3-6, 6-9, 9-15, 15-21, 21-27, 27-33, 33-40, >40)

SPECIES*	Circle 1	Circle 2	Circle 3	Circle 4	Circle 5	Circle 6
1 Winged Elm	AAAAB	C	AAAA BBB	AAABAAAAAAAAA	AAAAAAAAAABBB	AD
2 Dead Tree	ABD	BB	AC	B		
3 Mulberry	AA				A	
4 White Ash	EE	A	AAAAA		A	D
5 Slippery Elm	AAA		AAAA			
6 Hackberry	A		AB			
7 Redbud	AA	B				A
8 Black Oak	C	AAA	A	A		AAAAAAAAAAA
9 Black Hickory		A	C			A
10 Post Oak		A B DDF		BBBCCCCCCDEF	ABBBB CCC	
Honey Locust		A	A			
Chestnut Oak			C			
White Oak				B	E	
Cedar				C		
Dogwood				A		

SHRUBS: (NUMBER OF WOODY STEMS LESS THAN 3 INCHES d.b.h. INTERCEPTED IN 2 ARMLENGTH TRANSECTS)

Young winged elms mostly	23	33	1	5	14	6	5	13	8	10		

GROUND COVER: (20 RANDOM + OR - SIGHTINGS THROUGH OCULAR TUBE FOR PRESENCE OR ABSENCE OF GREEN VEGETATION)

Symphorocarpus	--+-+------	----------+	+-+-+++-++	---++--+++	-+-+--------
very little grass	-------+-	-+--------	++++-++----	----+-----	-----+--++

CANOPY COVER: (20 + OR - SIGHTINGS THROUGH OCULAR TUBE FOR PRESENCE OR ABSENCE OF GREEN VEGETATION)

++---+++-+- ---++++++	++++++++++ ++++++++++	+++++++++++ ++++++++++	+++++++++++ ++++++++-+	++++++++++ ++++++++++

CANOPY HEIGHT: (MAXIMUM CANOPY HEIGHT IN FEET)

	40	70	50	45	50

* Use abbreviated descriptions of trees, shrubs, or herbs to designate species to be identified later (eg smooth bark, heart-shaped leaf) It is important to identify only the five dominant species

To check the adequacy of the sample: Total number of trees in 5 circles x 2 = 226 = estimated trees/acre

Total number of trees in 6 circles x 1.6 = 210

Difference = 16

If the difference is less than 25 trees, the sample is adequate If it is greater than 25 trees, see procedure

Figure 4. Sample field sheet.

SUMMARY SHEET FOR TENTH-ACRE CIRCLES

NUMBER OF CIRCLES = 5

TREES: DENSITY[1] — SPECIES	NUMBER OF TREES IN ALL CIRCLES BY DIAMETER SIZE CLASS								TOTAL	TREES/ACRE[2] (BY SPECIES)	RELATIVE DENSITY[3] (BY SPECIES)	BASAL AREA[5] — CROSS SECTIONAL AREA OF THE TRUNK AT 4.5 FT. FROM THE GROUND (d.b.h.)								TOTAL BASAL AREA (BY SPECIES; SQ. FT.)	RELATIVE DOMINANCE[7] (BY SPECIES)	FREQUENCY[8]	
	A 3-6	B 6-9	C 9-15	D 15-21	E 21-27	F 27-33	G 33-40	H[4] >40				A[6] (0.1)	B (0.3)	C (0.8)	D (1.8)	E (3.1)	F (4.9)	G (7.1)	H (.005 d2)			NO. OF CIRCLES IN WHICH SPECIES OCCURRED	RELATIVE FREQUENCY[9]
1 Winged Elm	30	8	1						39	78	36	3.0	2.4	0.8						6.2	11	4	80
2 Dead Tree	2	4	1	1					8	16	7	0.2	1.2	0.8	1.8					4.0	7	4	80
3 Mulberry	4								4	8	4	0.4								0.4	1	2	40
4 White Ash	7				2				9	18	9	0.7				6.2				6.9	13	4	80
5 Slippery Elm	7								7	14	6	0.7								0.7	1	2	40
6 Hackberry	2	1							3	6	3	0.2	0.3							0.5	1	2	40
7 Redbud	2	1							3	6	4	0.2	0.3							0.5	1	2	40
8 Black Oak	5		1						6	12	5	0.5		0.8						1.3	2	4	80
9 Black Hickory	1		1						2	4	3	0.1		0.8						0.9	2	2	40
10 Post Oak	2	8	9	3	1	2			25	50	22	0.2	2.4	7.2	5.4	3.1	9.8			28.1	51	3	60
Other	3	1	2		1				7	14	7	0.3	0.3	1.6		3.1				5.3	10	·	
TOTALS	65	23	15	4	4	2			113	226	100%	6.5	6.9	12.0	7.2	12.4	9.8			54.8	100%		100%
TREES/ACRE (BY SIZE CLASS)	130	46	30	8	8	4			BASAL AREA (BY SIZE CLASS)			(3.0	13.8	24.0	14.4	24.8	19.6						
RELATIVE DENSITY (BY SIZE CLASS)	57	20	11	4	4	2			RELATIVE BASAL AREA (BY SIZE CLASS)			12	13	22	13	22	18						

SHRUBS: Total shrub stems in all transects (2 per circle) × 1000, divided by the number of transects = 23600 Shrub stems per acre

GROUND COVER: Total pluses (+) recorded (20 sightings per circle) × 100, divided by the total number of sightings = 29 % Ground Cover

CANOPY COVER: Total pluses (+) recorded (20 sightings per circle) × 100, divided by the total number of sightings = 90 % Canopy Cover

CANOPY HEIGHT: Average = 51 Range = 40-70

NOTES:

1) Number per unit area

2) Total trees counted × { 2 if 5 circles; 16 " 6 "; 14 " 7 "; 13 " 8 "; 11 " 9 "; 10 " 10 " }

3) Relative density is the percent of the total number of trees which are the species in question: $\frac{\text{number of trees of the species}}{\text{total number of trees of all species}} \times 100$

4) Give estimated diameter

5) Basal area is the cross sectional area of the trunk of a tree at 4.5 feet (d.b.h.)

6) Multiply the number of trees in all circles in size class A times 0.1 (average area in square feet for this size class)

7) $\frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100$

8) Frequency indicates the evenness of distribution of a species

9) $\frac{\text{Number of circles in which the species occurred}}{\text{Total number of circles}} \times 100$

Figure 5. Sample summary and analysis sheet.

woody stems less than three inches in diameter intercepted by your outstretched arms. The total number of shrubs counted in two transects in each of five 0.1-acre circles times 10 equals an estimate of shrub stems per acre.

An ocular tube can be made by taping cross threads across one end of a cardboard cylinder from a roll of bathroom tissue. A weight suspended from the other end will help you sight directly upwards for determinations of canopy cover (Figure 3C). By sighting directly overhead on alternate steps of a transect of the circle you can record 20 plus or minus readings for the presence or absence of canopy cover sighted where the threads cross. Likewise, 20 plus or minus readings, taken at random through the tube held at arm's length and pointed downward about four feet from the observer, can provide a record of the presence or absence of green vegetation on the ground (Figure 3D).

Simple triangulation techniques for estimating canopy height can be found in the Boy Scout Handbook, the Farmers' Almanac and elsewhere. We recommend the following: Tape a small level to a mirror. The level shown in Figure 2 was made from a small vial of water having one air bubble. Holding the mirror at arm's length three feet from the ground, walk toward a tree until the *crown* of the tree appears in the mirror (Figure 3E). Three feet plus the distance from the mirror to the tree equals the height of the tree. If you have determined the length of your step previously, find the number of steps between the mirror and the tree and multiply by the length of your average step. Take one reading in each circle.

Figure 4 is a sample sheet designed for recording data in the field. Figure 5 is a summary and analysis sheet. Information abstracted from the summary sheets could accompany each breeding bird census and winter bird-population study. For example:

> Trees, 3-in. diameter and over, based on five 0.1-acre circular samples, 226 / acre; total basal area 109.6 square feet / acre. Species comprising 90% of the total number of trees [figures after each give number of trees / acre, relative density (%), relative dominance, frequency, in that sequence]: Winged Elm, *Ulmus alata* 78,36,11,80; Post Oak, *Quercus stellata* 50,22,51,40; White Ash, *Fraxinus americana* 18,9, 13,80; Dead trees 16,7,7,80; Slippery Elm, *Ulmus rubra* 14,6,1,40; Black Oak, *Quercus velutina* 12,5,2,80; Red Mulberry, *Morus rubra* 8,4,1,40; Redbud, *Cercis canadensis* 6,4,1,40; Hackberry, *Celtis occidentalis* 6,3,1,40. Trees by diameter size class (figures after each class give number of trees / acre, relative density (%), basal area in square feet / acre, relative dominance): A (3-6 in.) 130, 57, 13.0, 12; B (6-9 in.) 46, 20, 13.8, 13; C (9-15 in.) 30, 11, 24.0, 22; D (15-21 in.) 8, 4, 14.4, 13; E (21-27 in.) 8, 4, 24.8, 22; F (27-33 in.) 4, 2, 19.6, 18. Shrub stems / acre, 23,600; Ground cover 29%; Canopy cover 90%; Average canopy height 51 feet (range 40-70).

The analysis should be repeated every few years in study areas in which the structure of the vegetation is changing markedly. If the National Audubon Society would act as a data bank for the original sheets, and if the data are procured in a regular manner which would permit comparisons later, a file will accumulate that will be potentially useful for other types of habitat analyses in the future. Optimal methods for the quantitative habitat description of grassland, desert, edge and town situations will be recommended in a later paper.

CONCLUSION

We think that the usefulness of the Breeding-Bird Census and the Winter Bird-Population Study would be increased greatly if observers would provide accompanying quantitative data on the structure of the vegetation. By sampling five or more tenth-acre circular plots this information can be obtained with a maximum of accuracy and a minimum of effort. Additional word descriptions of the physiognomy of the area and other non-botanical features will still be valuable.

ACKNOWLEDGMENTS

We thank Douglas A. James and Edward E. Dale, Jr. for advice, Richard F. Johnston and Chandler S. Robbins for suggestions regarding the manuscript, Ronald Beumer for assistance in the field, and John Haldeman for devising the method for estimating canopy height. We thank James E. Dunn for assistance with analysis, Mr. and Mrs. Laird Archer for permitting us to work on their property, and the several children who thought it was fun to spend weekends painting trees.

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Reprinted from **AMERICAN BIRDS**, January 1978, Vol. 32, No. 1, pp. 18-21
Published by THE NATIONAL AUDUBON SOCIETY
Printed in U. S. A.

On understanding quantitative surveys of vegetation

by Frances C. James

What those numbers mean and how to use them to envision a census area

SEVERAL YEARS AGO A standardized quantitative method of describing the vegetation in census areas was proposed (James and Shugart, 1970), along with the suggestion that, if compilers of Breeding Bird Censuses and Winter Bird-Population Studies would adopt this method, the censuses could be compared and analyzed in various new ways. The method involves locating five to ten 0.1-acre randomly-distributed circular plots within the study area, making certain measurements on these plots, and then extrapolating to describe the vegetation per acre (or per hectare, which equals 2.471 acres). The radius of a 0.1-acre plot is 37 feet, 3 inches.

The method is only appropriate for areas with trees. All the common trees in a 0.1-acre circle that are larger than 3 inches "DBH or dbh" in *American Birds* (diameter breast height, assumed to be 4½ feet from the ground) are identified to species and their DBH is recorded. This permits a description of the trees by species and by size class in terms of their "density," "basal area" and "frequency." The density is simply the number of trees per unit area. The basal area, sometimes called "dominance," is the sum of the cross sectional areas of the trees at 4½ feet. It was originated by foresters as a way of estimating the marketable timber in a forest. Here it is useful as an estimate of the amount of woody vegetation present for each species of tree or each size class of trees. Frequency is a statistic that estimates the evenness of distribution. It is the percent of the 0.1-acre circles that has trees of the species in question. A sample summary sheet for this type of information is given in James and Shugart (*op. cit.*). But there is an error on that sheet in the instructions for estimating the number of shrubs (see below).

THE FOLLOWING EXAMPLE of a quantitative survey was one prepared by Anthony Erskine for a new site in a Black Cottonwood floodplain forest in British Columbia (Erskine, 1975a). It is in the recommended format (James and Shugart, *ibid.*; Van Velzen, 1972):

> A quantitative survey of the vegetation gave: Trees 3-inches diameter and over, 237 per acre; total basal area, 170.5 ft² per acre. Species comprising 90% of the total number of trees: Black Cottonwood, 100, 42, 72,

100; Quaking Aspen, 68, 28, 14, 45; Mountain Alder, 33, 14, 2, 82; White Spruce 12, 5, 6, 41; Beaked Willow (*S. bebbiana*), 12, 5, 1, 55. Trees by diameter size class: A (3-6 in.) 86, 36, 9.6, 6; B (6-9 in.) 61, 26, 18.9, 11; C (9-12 in.) 37, 15, 22.2, 13; D (12-15 in.) 23, 10, 23.1, 14; E (15-21 in.) 16, 7, 28.8, 17; F (21-27 in.) 7, 3, 21.4, 13; G (27-33 in.) 4, 2, 20.1, 12; H (33-46 in.), 3, 2, 26.3, 16. Shrub stems per acre, 7850 (est.); ground cover, 58%; canopy cover, 57%; mean canopy height, 73 ft. (range 35-90).

The sets of numbers after the names of the trees and the size classes are not explained in this example, but in many others there are two parenthetical explanations. The first comes just before the species of trees:

> [figures after each give number of trees/acre, relative density (%), relative dominance (%), frequency (%), in that sequence].

Before the size class information often comes the phrase:

> [figures after each size class give number of trees/acre, relative density (%), basal area (square feet/acre), relative dominance (%)].

By taking transects across the circle and checking the presence or absence of canopy cover, an estimate of percent canopy cover can be determined. Counts of the shrub stems intercepted about 4½ feet above the ground by crossing the circle with out-stretched arms will give an estimate of the shrub density of the area. This statistic has not been very useful, partly because shrub stems are hard to define, but also because there is an error in the formula for estimating shrub stems per acre (James and Shugart, *ibid.*, p. 734). The instructions on pp. 732 and 735 are correct, but the form on p. 734 should read,

> SHRUBS: Total shrub stems in all transects (2 per circle) × 100, divided by the number of transects,

making the estimate in that example 2360, not 23600. I apologize for this error. Actually we need a new way to estimate shrubs, one that expresses how patchy or heterogeneous their distribution is. The final estimates are of the percent ground covered by green vegetation, and of the canopy height.

A COMPARISON BETWEEN Erskine's Black Cottonwood floodplain forest and a subalpine conifer forest (Erskine, 1975b) in the same general area can be made by comparing the photographs that accompany the reports and by comparing the quantitative vegetation surveys (Figs. 1 and 2).

The Black Cottonwood floodplain forest had 33 species of birds, 278 territorial males per

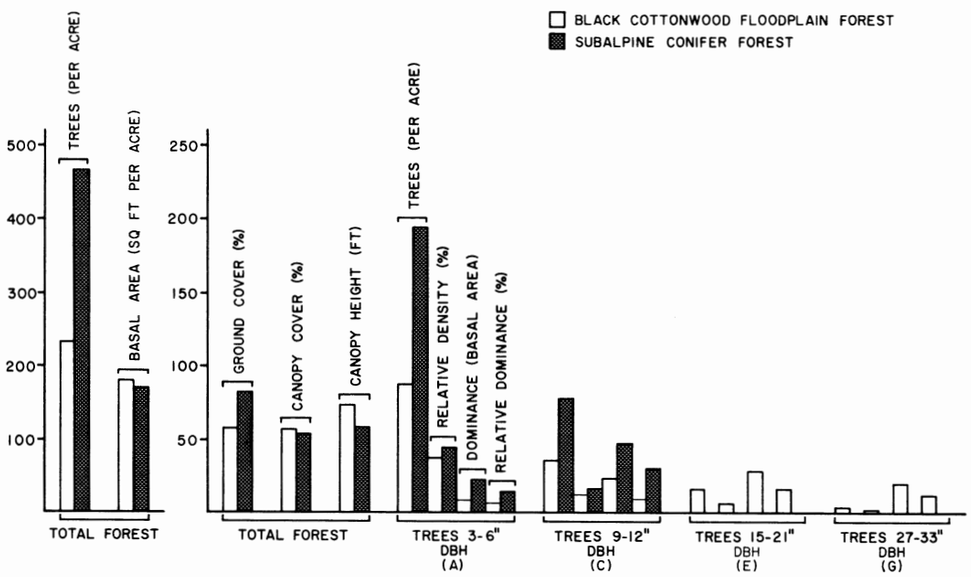

Figure 1. A comparison between the structure of the vegetation in two Breeding Bird Census areas studied in British Columbia: A Black Cottonwood floodplain forest (open bars) and a subalpine conifer forest (darkened bars). Data from Erskine (1975a, b).

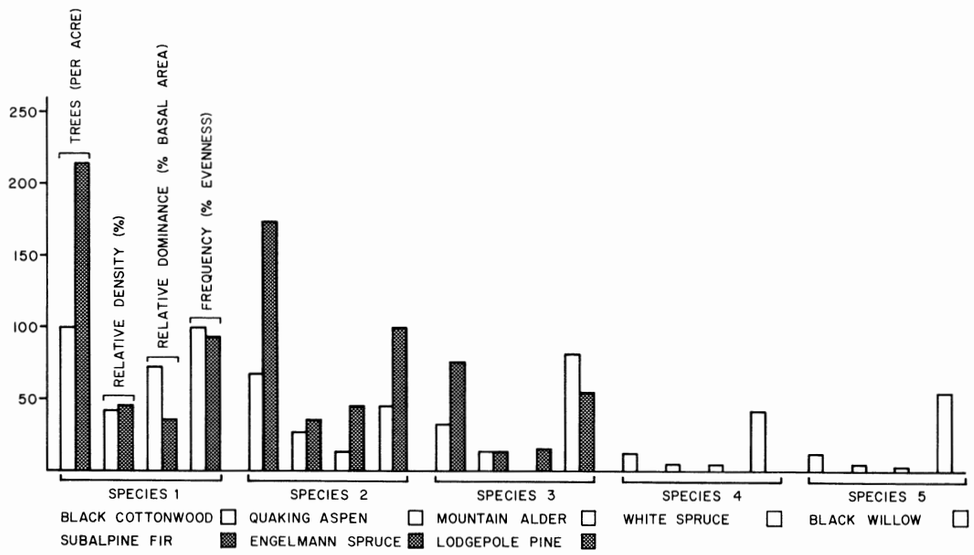

Figure 2. A comparison of the major species of trees for the same areas as in Figure 1, a Black Cottonwood floodplain forest (open bars) and a subalpine conifer forest (darkened bars).

Census 133. Scattered spruces with dense shrub layer. Photo/Anthony J. Erskine.

Census 135. Under canopy on Subalpine Conifer Forest Plot. Photo/Anthony J. Erskine.

100 acres. The most common species were American Redstarts, Warbling Vireos and Swainson's Thrushes. The site is a mature floodplain forest in which five species of trees comprise 90% of the trees larger than 3 inches DBH. The Black Cottonwoods dominate the entire site, being the most numerous trees (highest density), having the most biomass (greatest basal area), and occurring in all sections (highest frequency). The Quaking Aspen are clumped in certain areas (lower frequency), and have considerably less biomass. The Mountain Alder is less common but more evenly distributed than the aspen. The White Spruce comprises only 5% of the trees but was found in 40% of the circles.

THE SUBALPINE CONIFER FOREST had only 14 species of birds, 54 territorial males per 100 acres. The most common species were Townsend's Warblers, Ruby-crowned and Golden-crowned Kinglets. Three species of trees accounted for 90% of the vegetation. The amount of woody biomass (total basal area) and the canopy cover were about the same as in the cottonwood forest, but there were more than twice as many trees in the conifer forest, and the average canopy height was lower. Subalpine Fir and Engelmann Spruce were common and widely distributed. Lodgepole Pines occurred on about half of the plots sampled. The number of small trees per acre (3-6" DBH) was more than twice that in the deciduous floodplain forest.

From 1971-1976 compilers of approximately 110 census areas in the U.S. and Canada have submitted vegetation surveys of this type to *American Birds*. These are being stored on magnetic tape in the computing center at Florida State University. Within the next year we should be able to provide them on request to persons interested in specific types of habitat analysis. We are optimistic about the potential usefulness of this information for studies of habitat selection, avian community organization, ecological succession, and forest management. I would like to thank Noel Wamer for assistance with this effort at F.S.U.

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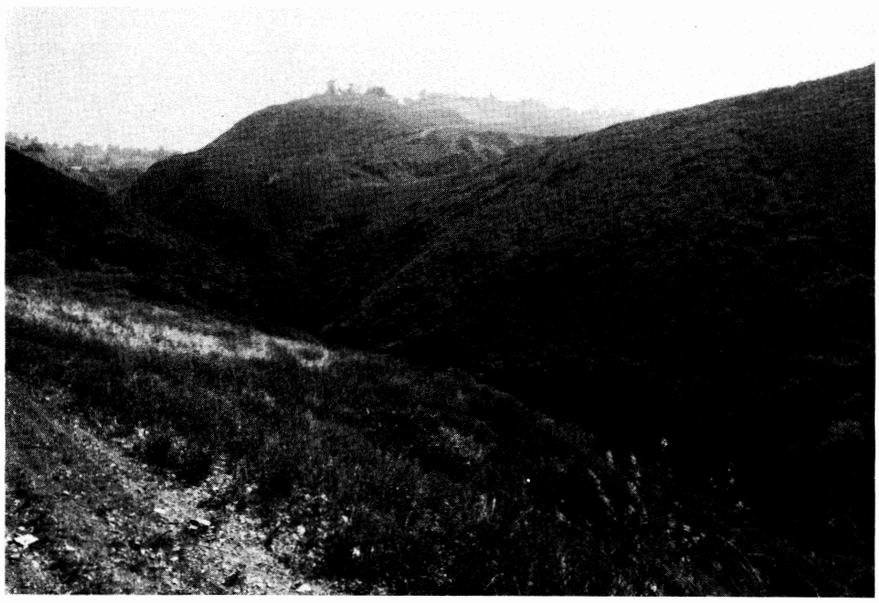

Census 149, page 106. Undisturbed Coastal Sage Scrub. Photo/R. H. Matson.