THE USE OF THE BITTERLICH SAMPLING TECHNIQUE IN AN ATHENS COUNTY, OHIO FOREST[1]

MICHAEL E. HELD and WARREN A. WISTENDAHL, Department of Botany, Ohio University, Athens, OH 45701

Abstract. The Bitterlich variable radius method of forest sampling was used in an upland oak forest at the Waterloo Wildlife Research Station in Athens County, Ohio. Species and density data were recorded for 52 Bitterlich points included in the area sampled. Minimum sample size was determined using the running means test and an estimate of the number of points needed to obtain a standard error within 5% of the mean. These tests led to the selection of a minimum sample size of 14 Bitterlich points.

OHIO J. SCI. 78(1): 26, 1978

During the fall of 1975, an upland forest at the Waterloo Wildlife Research Station in Athens County, OH, was studied using the Bitterlich method of plotless forest sampling (Grosenbaugh 1952). This method is more efficient than the quadrat method for determining tree species composition and basal area values (Lindsey *et al* 1958). Although density values per unit area cannot be obtained, the number of trees sampled per point may be used as an indication of density (Cox 1976).

The number of Bitterlich points used has varied widely with the type of plant community being sampled and topographic considerations related to the community (Rice and Penfound 1955, Nemeth 1968, Sechrest and Cooper 1970, Stringer and Stringer 1974). The purpose of this study was to determine an adequate sample size needed to sample the tree composition of a representative forest in southeastern Ohio using the prism technique of the Bitterlich variable radius, plotless sampling method.

MATERIALS AND METHODS

The Bitterlich method of sampling differs from the plot or quadrat methods in that the probability for the inclusion of a given tree in the data is proportional to the basal area of the tree, rather than to the area of the plot sampled. The relationship of the distance to a given tree and its diameter is the basis for the Bitterlich sampling method and is easily converted to basal area in square feet per acre or equivalent units (Grosenbaugh 1952).

A calibrated glass prism (2 x 4 cm) with a basal area factor of 10 (available from Forestry Suppliers, Jackson, MS 39204) was used in sampling in this study in place of the original Bitterlich stick. The researcher stood successively at each sampling point and viewed each tree within a 360° circle around each point through the prism held at arms length. The prism optically displaced that portion of a tree trunk which was viewed. If the displaced portion appeared to be offset from the tree trunk, the species name of the tree was not recorded. Such individuals had optically small diameters because of their distance from the sampling point. Conversely, trees of larger diameters did not appear to be offset and were recorded.

The forest area sampled at the Waterloo Wildlife Research Station is located on hilly terrain encompassing west- through south- to east-facing slopes. The sample area was arbitrarily divided into 3 sections: a lower slope, a mid slope, and an upper slope and ridge. A sample area of approximately 10 ha was sampled by selecting points at random. Starting at an arbitrary point on the lower, west-facing slope the locations of successive points were determined by using a table of random numbers. The last number of each successive 5 numeral unit in the table was used to indicate the number of paces from the farthest tree recorded at the initial, and subsequently at the preceeding, sampling point. This placed sampling points far enough apart, at least 10 m from the farthest tree, to avoid duplicate sampling of individual trees. The pacing followed contours starting at the lower slope and moving upslope as the limits of the area were reached. The penultimate number in the random unit indicated the number of paces either upslope or downslope from the location determined by the last number of the unit. The use of either the upslope or the downslope direction for the establishment of the new sampling point was determined from

[1]Manuscript received January 28, 1977 and in revised form August 9, 1977 (#77-10).

the third from the last number in the random number unit. An odd number indicated the use of the upslope point and conversely, an even number indicated the downslope point. This procedure provided an unbiased sample of a total of 52 points for the area.

The data were analysed comparing total samples for each section of the area and for the entire sample area. These comparisons included species composition and stem density (number of stems per sample). Statistical treatments used in the analysis of the data included the running mean test (Kershaw 1973) and an estimate of the minimum number of points required to obtain a standard error within 5% of the mean. This value was determined using the following formula:

$$n = s^2/y$$

where n is the number of samples necessary to obtain a standard error within the stated percentage of the mean, y is the observed mean multiplied by the stated percent expressed as a decimal, and s^2 is the variance of the mean (Squiers and Wistendahl 1976).

RESULTS AND DISCUSSION

The species composition was predominantly oak, with *Quercus rubra* as the dominant species, and *Q. prinus*, *Q. alba*, and *Q. velutina* as subdominants. Other components of the forest which were found only on lower and mid-slope areas were: *Acer rubrum*, *Carya tomentosa*, *C. glabra*, *Liriodendron tulipifera*, *Tilia americana*, *Fraxinus americana*, and *Oxydendrum arboreum*. The forest species composition was similar to that reported by Trammell (1964) and Nixon *et al* (1968) for studies within the Waterloo Station.

The total basal area of this forest system was determined from the Bitterlich sampling to be 23.8 m^2/ha, with 90% of that total contributed by the 4 oak species combined and 50% contributed by *Quercus rubra* alone. The basal area value indicated that this stand, which was last disturbed prior to 1900 (Nixon 1963), is approaching climax (Held and Winstead 1975).

Eleven species and 363 individuals were recorded in 52 Bitterlich sample points (table 1). An estimate of the minimum number of sample points necessary to fall within a given variance range is a tool to test the adequacy of sampling. The number of points necessary to give a 5% standard error of the mean, for species composition, was less than 7 (table 2). For density, the number of points needed for an adequate sample was less than 15.

TABLE 1

Number of species and individuals recorded within three topographic subsamples at the Waterloo Wildlife Research Station.

Sample	Number of points sampled	Number of species recorded	Number of individuals recorded
Total	52	11	363
Upper slope	14	4	116
Mid-slope	21	8	155
Lower slope	17	10	92

The running mean test, calculated for stem density, indicated that less than 17 points were necessary to obtain values within 5% error of the mean in all cases except the total sample. For the total sample a minimum of 36 points were needed. This large value was the result of using all 363 individuals in the calculation but in the calculations for the 3 topographic subsamples, stem density values were much lower. When the running mean was calculated for species composition, a minimum of 14 points were necessary to obtain values within 5% of that obtained with 52 points.

TABLE 2

Number of Bitterlich points necessary to give 5% standard error and for an adequate sample using running mean test.

Sample	5% SEM		Running Mean Test	
	Density	Species	Density	Species
Total (N=52)	14	7	36	14
Upper Slope	7	5	8	14
Mid-slope	12	7	16	14
Lower Slope	12	7	16	14

The number of sample points necessary in a study is a function of the number of individuals between points (Mueller-Dombois and Ellenberg 1974). Although there is a minimum of Bitterlich points needed to describe adequately the composition of the forest Kershaw (1973) recommends a sample size at least 50% over the minimum. The use of a greater number of points provides a better measure of the mean of the sample and reduces the standard error. The minimum number of sampling points is an estimate and, except for basic statistical considerations, there is no objective criterion for its selection. At the risk of introducing personal bias, sample size should be augmented by preliminary observations of the plant community to note differences and variations within the system.

Acknowledgments. The authors express gratitude to Mr. Robert W. Donohoe, Director of the Waterloo Wildlife Research Station, Ohio Department of Natural Resources, for permission to do this research at the Station. We also express thanks to Jean D. Wistendahl and Dr. Irwin A. Ungar for their critical evaluation of the manuscript.

LITERATURE CITED

Cox, G. W. 1976 Laboratory Manual of General Ecology. Wm. C. Brown, Dubuque. 195 p.

Grosenbaugh, L. R. 1952 Plotless timber estimates—new, fast, easy. J. Forest. 50: 32–37.

Held, M. E. and J. E. Winstead 1975 Basal area and climax status in mesic forest systems. Ann. Bot. 39: 1147–1148.

Kershaw, K. A. 1973 Quantitative and Dynamic Plant Ecology. American Elsevier Publishing, New York. 308 pp.

Lindsey, A. A., J. D. Barton and S. R. Miles 1958 Field efficiencies of forest sampling methods. Ecology 39: 428–444.

Mueller-Dombois, D. and H. Ellenberg 1974 Aims and Methods in Vegetation Ecology. John Wiley, New York. 547 pp.

Nemeth, J. C. 1968 The hardwood vegetation and soils of Hill Demonstration Forest, Durham County, North Carolina. J. Elisha Mitchell Sci. Soc. 84: 482–491.

Nixon, C. M. 1963 Effects of timber management on squirrel and ruffed grouse population density and dynamics. Ohio Div. Wildlife Proj. W–105–R–4. Job. 24. 53 p.

———, D. M. Worley and M. W. McClain 1968 Food habits of squirrels in southeast Ohio. J. Wildl. Manag. 32: 294–305.

Rice, E. L. and W. T. Penfound 1955 An evaluation of the variable-radius and paired-tree methods in the blackjack-post oak forest. Ecology 36: 315–320.

Sechrest, C. G. and A. W. Cooper 1970 An analysis of the vegetation and soils of upland hardwood stands in the Piedmont and Coastal Plain of Moore County, North Carolina. Castanea 35: 26–57.

Squiers, E. R. and W. A. Wistendahl 1976 Sample unit selection for studies of herbaceous oldfield vegetation. Ohio J. Sci. 76: 185–188.

Stringer, P. W. and M. H. L. Stringer 1974 Studies on the bryophytes of southern Manitoba. VI. An ecological study of the bryophytes of coniferous forests in Bird's Hill Provincial Park. Bryologist 77: 1–16.

Trammell, J. R. 1964 Vegetation analysis and preliminary mast sampling at Waterloo Wildlife Experiment Station, Athens County, Ohio. Unpubl. M.S. Thesis. Ohio University, Athens. 117 pp.