Sample-Plot Statistics in University Woods

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Data for this study of the University Woods east-northeast of Urbana were obtained in 1935 by M. E. Barnes, Everett Green, Dawn Neil, and the authors. Tabulations from 42 scattered circular plots of one-eighth acre size studied by John Hanley in 1931 were also available. The 1935 plots comprise 64 tenth-acre squares arranged in a grid (528 feet square), south of the middle of the 60-acre forest. Of the 30 tree species observed in this mixed mesic forest, 24 are represented in the plots. Abundance data were plotted separately for trees of the different species for 36 of Hanley's circles, for the 64 contiguous squares, and for a composite sample totaling 10 acres. For the latter we find the leading species represented as follows: Hard maple, 36.5 trees per acre; American elm 15.7, white ash 15.5, red elm 11.9, linden 9.4, buckeye 7.0, hackberry 5.3, papaw 3.7, northern red oak 3.5, walnut 3.3, blue ash 2.9. Yellow oak, Q. Muhlenbergii (No. 16 in order of abundance, but with larger trees than most other species) 1.3 per acre; bur oak (No. 17, also large trees) 1.0; trees of all species, 125.6 per acre.

The relation between size of plot and number of species represented in a plot was studied by arranging neighboring squares of the grid into groups of graduated sizes, 0.1 to 1.6 acres, according to patterns giving as nearly regular shape and arrangement of groups of squares as was permitted. Thus the 64 squares were arranged successively into 32 2's, 21 3's, 16 4's, 12 5's, etc., up to 4 16's. Other rearrangements gave somewhat less dependable data for plots aggregating 24, 32, and 48 squares. From the mean numbers of species for the successive sizes of the aggregates, a species-area curve was constructed. Mean species numbers for different-sized plots:

0.1 acre	5.4 spp.	0.7 acre	13.5 spp.	1.4 acre	15.8 spp.
0.2	8.1	0.8	14.0	1.6	16.3
0.3	9.8	0.9	14.0	2.4	17.6
0.4	11.1	1.0	14.8	3.2	18.8
0.5	11.3	1.1	15.0	4.8	19.8
0.6	12.3	1.2	15.6	6.4	21.0

In this species-area curve, which is logarithmic in form, the change of direction is greatest at about 0.8 acre. An 0.8-acre plot, 8 per cent of the 10-acre sample, contains 14 of the 24 species of that sample, or 58 per cent. It is evident that further additions of species require larger increases in sizes of plots; 0.8 acre is taken to be the *minimal area* (for trees) in mature mixed mesic forest in east-central Illinois. This minimal area is the smallest practicable unit which by itself may be taken as representative of its community.

The influence of shape of plot upon constancy of numbers of individual trees and species in a plot was studied by comparing four groupings of 0.8-acre plots within the 6.4-acre grid, as shown in the following table:

No. and Shape of Units		Trees per unit	Species per unit	Variance: S.D. as %
5	Circles	67–122	13.6	5.9
8	Compact plots	70–118	14.0	7.2
8	N-S strips	72–103	14.13	8.2
8	E-W strips	63–111		10.1

The figures for variance of species-number in the table represent the standard deviation of the mean species-number for each grouping, expressed as percentage of that mean. The smaller the variance, the more nearly alike are species-number results for different plots or units of one particular shape. It is seen that the most compact units (circles) give least variable species-numbers. The least compact units (strips, 66 by 528 feet) are considerably more variable. For greatest dependability, circular plots are recommended, but where the units must be contiguous, squares or short oblongs are nearly as good.

The differences in mean species-number per unit when units vary greatly in shape or degree of compactness, are believed to be real. Any tendency toward aggregation of several or numerous trees of one species into a clump might give such a clump heavier representation within a compact unit than within a narrow strip, thus tending to make less room for other species inside the compact unit. For reconnoissance surveys, line or strip methods thus seem to offer an advantage in disclosing a larger proportion of the total number of species.

A great and unpredictable variability in number of individual trees in different units of whatever shape, shows in one of the columns. It is presumably due to uneven distribution of size-classes in an all-aged mixed stand, particularly since some species are mostly very small trees (e. g., papaw). Species-number is thus a more tractable object of statistical study than is the number of individual trees.

A search for the species of *general* distribution throughout the areas sampled was made by selecting the species of 100 per cent frequency in 0.8-acre units of the four groupings tabulated above. Only five species were found in *all* 0.8-acre plots. These are: hard maple, the two elms, linden, and blue ash. Correlation with order of abundance is not very good. White ash (No. 3 in abundance) is missing from fair-sized areas in the woods. Blue ash, though in every 0.8-acre plot, is only No. 11 in abundance.

So far as adequacy and economy of sampling are concerned, it was very evident that many scattered small plots are superior to a considerably larger number of contiguous plots (or in other words, to one large plot of greater total area). Dispersion of sample areas is indispensable for an adequate representation of the stand. The 0.2-acre size is recommended for small plots, since it gives a much better representation of species (mean no. for 0.2 acre 8.12, range 5 to 11; for 0.1 acre, mean 5.38, range 2 to 9). Also, 0.2-acre plots are much less variable.

The 10-acre total (one-sixth of the stand) is considered inadequate as a sample of the woods as a whole. Twelve acres dispersed in 60 plots may be suggested. The unexpectedly large size of an adequate sample, and the greater size of minimal area than was expected, are considered to be an expression of great variability in composition of this highly mixed forest community. It is submitted that a forest with numerous tree species is very different from the supposedly uniform association which from a distance it may appear to be. Ecologists frequently credit such forests with too high a degree of uniformity.

High content of soil organic matter, dominance in an earlier stage of bur oak, elm, and yellow oak, and complete *absence* of white oak, are attributed to a history of development from prairie upland only a few hundred years ago. Such forests in this part of Illinois are thus very different from those usually referred to the oak-hickory type.