A Comparison of Local and Regional Leaf Characteristics in Indiana

GARY E. DOLPH
Department of Botany
Indiana University, Bloomington 47401

Abstract

Comparison of leaf size distribution and margin characteristics with importance value along a linear series of quadrats at Cedar Bluffs, Indiana, indicated that the species present in any one quadrat influenced the size distribution and ratio between species with entire and non-entire leaves. The percentage of species with entire leaves was shown to increase as consistently larger areas of Indiana were examined. The effect of these results on the utility of regionally determined climatic trends is considered.

Introduction

Two physiognomic characteristics that have been used to relate plants with their environments are leaf size and margin type. Bailey and Sinnott (1, 2) proposed, after critical analysis of regional herbarium collections and published floras, that from area to area as the mean annual temperature decreased, the percentage of species with entire leaves in a flora decreased (with the exception of physiologically dry areas—deserts, tundras, etc.—where species with small, entire leaves are abundant). Raunkiaer (8) noted a similar trend; that is, from area to area as the availability of soil moisture decreased, the percentage of individuals with large leaves in a flora decreased. Geographically, these two environmental factors produce similar distribution patterns. Nevertheless, because environmental factors are very rarely constant over a large area, local variations in their effect might be expected to cause localized plant associations to differ appreciably from broadly regional floras in terms of leaf size distribution and margin character. In this study, I have attempted to analyze local variations in these features and to relate them to the Indiana flora as a whole.

Materials and Methods

Leaf margin and size characteristics were studied in a secondary forest at Cedar Bluffs, Indiana (Sec. 18, T 7 N, R 3 W, Clear Creek Indiana Quadrangle). A line transect, consisting of 10 quadrats each 10 m^2, was oriented to run from the crest of a ridge down onto a dry stream bed below (Fig. 1). The species of dicotyledonous trees, shrubs, and vines present in each quadrat and the number of individuals in each species, their position, and their diameter at breast height were recorded. An importance value representing the sum of the relative frequency, relative density, and relative dominance (4) was calculated for each species in every quadrat. The methods of calculating relative density and relative dominance are directly applicable to single quadrats, but to calculate the relative frequency, each quadrat had to be further subdivided into four squares of equal area. The quadrat method of calculating relative frequency presented by Curtis and McIntosh (3) could then be applied within a single quadrat.

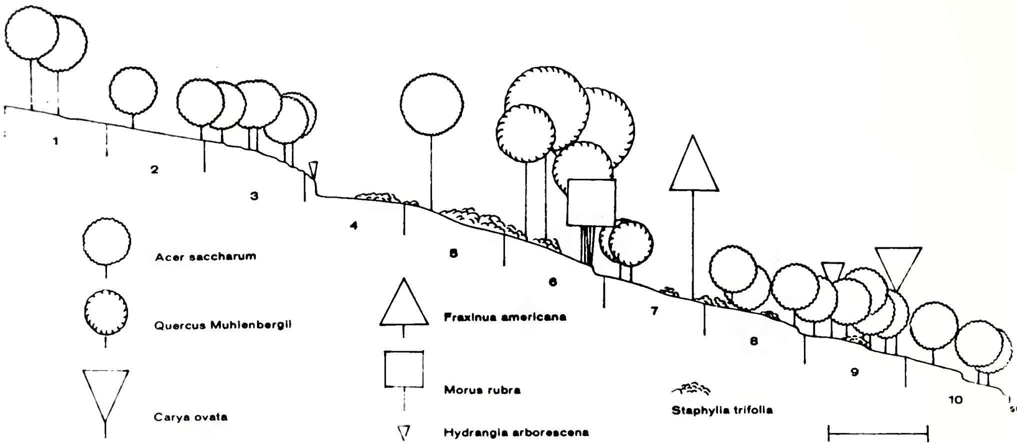

FIGURE 1. *Profile diagram indicating the spatial relationships among the trees and shrubs found along the central 2 m of the transect (actual diameter 10 m). Seedlings and saplings under 1 m in height have been omitted. The bar in the lower right indicates a distance of 10 m.*

The leaves were grouped according to surface area on the basis of a geometrical grade scale proposed by Raunkiaer (8) and modified by Webb (9). Every plant taller than 3 m was divided into 3 vertical sections—lower, middle, and upper. Three leaves were sampled from each of these sections. Three leaves were measured at random from plants shorter than 3 m but taller than 1 m. Individuals smaller than 1 m were not sampled. Leaf size was calculated by means of a grid system proposed by Heinicke (7). The leaves were divided into two classes on the basis of margin—entire and non-entire. The non-entire class consisted of leaves that were lobed, toothed, or of various combinations of the two. All leaves with continuous, unbroken margins were placed within the entire class with the exception of those leaves that had a smooth margin but were conspicuously lobed. Due to similarities in size and physiologic function, the leaflets of compound leaves were considered to be analogous to simple leaves. Because this study dealt primarily with the comparison of local and regional foliar physiognomic characters and not the effect of environment on plant distribution, no attempt has been made to establish why the vegetation changed in relation to slope.

Results

A comparison of the changes in leaf size and margin character with those in importance value indicates that size distribution and margin types are directly dependent upon the individuals growing in each quadrat. Near the ridge crest (Quadrats 1-4, Table 1), the percentage of mesophylls in each quadrat is high. This value decreases, as does the percentage of notophylls, past midslope but increases once more in Quadrat 10 approaching the values found on the ridge crest. Concomitant with the decrease in the percentage of mesophylls, that of the microphylls increased. The retention of some microphyllous individuals in Quadrat 10 prevented exact duplication of the characteristics of the ridge crest.

TABLE 1. *The percentage of leaves in each size class and the percentage of species with entire leaves are represented by quadrat. Species number indicates the number of species present in any one quadrat.*

Leaf Type	Quadrats									
	1	2	3	4	5	6	7	8	9	10
Leptophyll			None Present							
Nanophyll			3							
Microphyll	1	1	6	1	18	49	34	37	47	13
Notophyll	30	35	18	28	30	16	29	17	18	18
Mesophyll	70	65	73	71	50	35	37	46	35	66
Macrophyll					1					
Magaphyll			None Present							
Entire Leaves	0	11	11	0	9	17	18	17	8	15
Species Number	10	9	9	12	11	12	11	12	13	13

Along the ridge crest, *Acer saccharum* is the most important canopy and understory tree (Table 2), and the high percentage of mesophylls found is a function of its dominance. *Acer saccharum's* importance gradually decreases downslope, and the rise in the percentage of microphylls is associated with the increased importance of *Fraxinus americana* and the appearance of *Staphylea trifolia.* In Quadrat 10, *A. saccharum* is as important as on the ridge crest, but the presence of *Ostrya virginiana* and *Carpinus caroliniana*, both microphyllous species, prevents the duplication of the conditions seen on the ridge crest. The profile diagram presented in Figure 1 shows the variation from quadrat to quadrat and the progressive downslope trends mentioned above.

The main fluctuations encountered in the scheme (Quadrats 3, 5, and 7, Table 1) resulted from the scattered distribution of rare individuals, the patchy distribution of common ones, or the errors inherent in the sampling technique. The percentage of microphylls in Quadrat 3 was high due to a rare occurrence of *Gleditsia triacanthos.* The percentage of notophylls in Quadrat 7 increased rapidly because of the sudden decrease in the importance of *Staphylea trifolia* (Table 2). *Staphylea trifolia* displays a patchy distribution, and although the species is common in the area, it was locally rare within the quadrat. The majority of the individuals of *S. trifolia* in Quadrat

5 were smaller than 1 m and were not sampled. This accounts for the intermediate value obtained in Quadrat 5.

TABLE 2. *The importance values of each species encountered at Cedar Bluffs listed by quadrat. Note that the species are arranged according to the order of their appearance and disappearance. Nomenclature according to Deam* (5, 6).

Species	Quadrats									
	1	2	3	4	5	6	7	8	9	10
Acer saccharum	86	77	75	73	31	15	18	33	35	65
Quercus mühlenbergii	79	98	43	49	36	94	59	27	4	24
Carya cordiformis	16		6	17	19	15		67		18
Carpinus caroliniana	11	21			17	9			5	24
Morus rubra	10	25				27	10	13	14	
Fraxinus americana	49	8	10	10	66		64			44
Fraxinus quadrangulata	14	50	20	28	5	18				
Aesculus glabra		6		6						
Viburnum acerifolium		6								
Sassafras albidum	6									
Quercus alba	9									
Quercus rubra	20			9			11	8	99	11
Cercis canadensis		9	6			9	11	20	10	26
Ulmus rubra			43	12	5	10	28	20	36	17
Rhus toxicodendron			21		11	26	43	20	16	
Gleditsia triacanthos			54	6				8	12	
Hydrangea arborescens				23						
Staphylea trifolia				64	96	64	22	57	47	25
Carya ovata				6		6	28	17	16	9
Prunus serotina					5					4
Asimina triloba					12	11	7	9		
Ostrya virginiana									4	19
Celtis occidentalis									4	
Lindera benzoin										10

The percentage of species with entire leaves increased downslope due to the species distribution over the slope (Table 1, entire species). Five species with non-entire leaves that were found on the ridge crest failed to appear past midslope (Table 2). In contrast to this, eight new species were added below the center of the ridge. The net gain downslope was three species of which two had entire leaves.

Conclusions

Adequate data to allow the comparison of the leaf size distribution at Cedar Bluffs with that from other areas in Indiana is lacking, but certain comparisons may be made using the information available on margin characteristics (5, 6). The percentage of species with entire leaves found within the 10 quadrats was 12%. This was considerably lower than the value of 22% obtained when only the ridge crest was sampled by randomly selected quadrats. A survey of Deam's *Trees of Indiana* (6) and *Shrubs of Indiana* (5) indicated that 27% of the dicotyledonous trees, shrubs, and vines in Monroe County have entire leaves and that species with entire leaves account for

33% of the flora of Indiana. By increasing the regionality of the study, the floral variation is also increased, and at least in Indiana, the calculated distribution of leaf margin characteristics increases. Thus, just as the variability of the site of study is the sum of all the quadrats and does not indicate the variability of its parts, the regional flora is the sum of many different plant associations, and its utility is limited by its internal variability.

Acknowledgments

The author wishes to thank Charles Ward for his assistance in collecting and compiling the data and Dr. D. Dilcher for his critical reading of the manuscript.

This study was supported by NSF grant GB 12803 to Dr. Dilcher and an Indiana Academy of Science Grant to Mr. Dolph.

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