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A Statistical Study of a Heech-maple Association at Turkey Run State Park

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A STATISTICAL STUDY OF A BEECH-MAPLE ASSOCIATION AT TURKEY RUN STATE PARK, PARKE COUNTY, INDIANA

By MABEL M. ESTEN

INTRODUCTION

In 1928 Braun-Blanquet and Pavillard (1) published the "Vocabulaire de Sociologie Végétale," in which an attempt was made to define and standardize the various current concepts relating to descriptive phytosociology. Since the continental concepts vary somewhat from those of American workers, the terminology differs slightly. The terms relating to the organization of any plant community are, according to them, arranged in a sociological "Reléve" or floristic enumeration in which each species of plant is given with the coefficient or number corresponding to the class to which it belongs in the analytical or synthetic concepts. Cain (2) has arranged these concepts into a tabular form which is convenient for use in a statistical study of any plant community. Up to the present, no field study of any American plant community has been made which uses all the concepts embodied in Cain's summary, although several studies have considered a few of them. In the present study of a beech-maple association, the analytical concepts of density, dominance, frequence, sociability, vitality, periodicity and stratification, and the synecological concepts of life-form and leaf-size classes were considered. Since a complete explanation of these concepts is given in Braun-Blanquet and Pavillard's work (1) and also in Cain's study (2), they will be explained only in brief form here.

EXPLANATION OF CONCEPTS

The concept of *density* concerns the number of individuals per unit area, that is, the abundance divided by the area.

Dominance or coverage is concerned with the space occupied by individuals of each species. In this study foliage or crown coverage is considered. The scale of dominance is expressed in five classes as follows:

Class 1—Covering 1-5 per cent. of the area.

Class 2—Covering 6-25 per cent. of the area.

Class 3—Covering 26-50 per cent. of the area.

Class 4—Covering 51-75 per cent. of the area.

Class 5—Covering 76-100 per cent. of the area.

Frequence is an expression in per cent. indicating the relation the quadrats in which a species is found bear to the total number of quadrats examined. There are five classes of frequency listed alphabetically as follows:

Class A (1)—Species found in 1-20 per cent. of quadrats.

Class B (2)—Species found in 21-40 per cent. of quadrats.

Class C (3)—Species found in 41-60 per cent. of quadrats.

Class D (4)—Species found in 61-80 per cent. of quadrats.

Class E (5)—Species found in 81-100 per cent. of quadrats.

Sociability concerns the manner in which individuals of one species occur in relation to each other and to individuals of other species. It is divided into five classes:

Class 1—Species in isolation.

Class 2—Species in groups.

Class 3—Species in numbers.

Class 4—Species in small colonies.

Class 5—Species in large colonies.

Vitality concerns the degree of vigor and prosperity of the species, that is, the degree of consummation of all normal functions of growth and reproduction. There are three vitality classes:

Class 1—Species of low vitality, stunted vegetative form and having little or no fruit.

Class 2—Species with good vegetative form but having an incomplete life cycle.

Class 3—Species performing all normal functions.

The *periodicity* of plants is determined in this study by the season during which they flower. The four classes of periodicity, corresponding to the calendar seasons, are as follows:

Class 1—Spring or vernal.

Class 2—Summer or estival.

Class 3—Autumn or autumnal.

Class 4—Winter or hibernal.

Stratification or layering classes are the divisions of the plant community into horizontal layers, superimposed on each other. In this study the strata were considered as follows:

Class 1—Tall trees, above thirty-five feet in height.

Class 2—Short trees, below thirty-five feet in height.

Class 3—Woody shrubs and vines.

Class 4—Herbs (all sizes).

Life-forms are determined according to Raunkiaer's (see Smith, 7) classification of plants on the basis of the location of the perennating bud. There are ten classes, six of which are found in the present study:

Therophytes (Th.)—Annuals living over in the form of seeds.

Geophytes (G.)—Plants with vegetative organs, bulbs, tubers, rhizomes or similar structures, below the surface of the soil. Geophytes are one of the three divisions of the Cryptophytes: Hydrophytes and Helophytes being absent here.

Hemicryptophytes (H.)—Herbaceous plants with the dormant buds just below the surface of the soil.

Chamæphytes (Ch.)—Creeping or rosette plants with the perennating buds on the ground or not more than 25 cm. above it.

Phanerophytes—Woody plants with dormant buds more than 25 cm. above the soil surface. These plants are classified according to height as Nanophanerophytes (N.), from 25 cm. to 2 meters high; Microphanerophytes (M.), 2-8 meters; Mesophanerophytes (Ms.), 8-30 meters; and Megaphanerophytes (Mg.), over 30 meters high.

Leaf-sizes are based on Raunkiaer's (see Smith, 7) classification according to size of typical leaves. The classes follow:

1. Leptophyll (Lepto.), 25 sq. mm. or less in surface.
2. Nanophyll (Nano.), 25 sq. mm.-225 sq. mm.
3. Microphyll (Micro.), 225 sq. mm.-2,025 sq. mm.
4. Mesophyll (Meso.), 2,025 sq. mm.-18,225 sq. mm.
5. Macrophyll (Macro.), 18,225 sq. mm.-164,025 sq. mm.
6. Megaphyll (Mega.), larger than macrophyll.

LOCALITY AND METHOD

Indiana contains a few tracts of virgin timber and others which are practically so, that is, little selective cutting and no grazing have taken place. Since they are few and are rapidly decreasing, it is necessary that studies be made of them soon in order that contributions to their vegetational history be preserved. A virgin beech-maple association *(Fagus grandifolia-Acer saccharum)* at Turkey Run State Park, Parke county, Indiana, was selected as the site of a statistical study according

to the ecological concepts outlined above. The tract under consideration is approximately four and one-half acres in size and is bounded on all sides by deep ravines. On the east and north the sandstone canyons are about 60-70 feet in depth. Along a very narrow strip of sloping land next to the rim of these canyons and on the upper limits of them is a practically pure stand of *Tsuga canadensis,* a relict association which has been studied by Daubenmire (3). The beech-maple climax comes to the edge of the hemlocks. On the west and south sides of the plateau the ravines are less deep and the sandstone has been covered by soil, so the association comes to the rim of the ravines. In the entire area covered by the beech-maple association, a small amount of cutting has been done, but this is so slight that it was considered of little importance in the results to be gained from the study.

Twenty-five one-meter square, twenty-five four-meter square, and twenty-five ten-meter square quadrats were regularly and widely distributed and permanently marked throughout the area covered by the beech-maple association. These were so arranged that the one-square-meter quadrats were enclosed in the sixteen-square-meter and the sixteen-square-meter within the 100-square-meter quadrats.

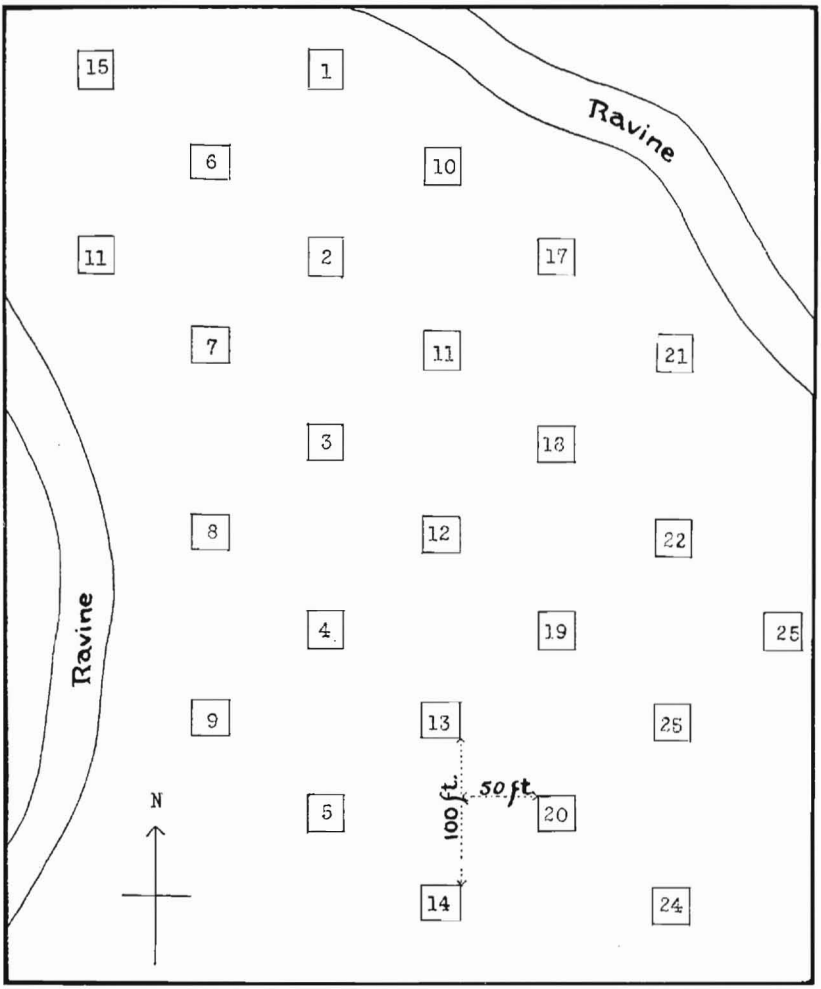
The quadrats were distributed as evenly as possible over the entire area covered by the beech-maple association as shown in Figure 1.

Woody plants above two inches in diameter four and one-half feet above the ground (diameter breast high, DBH) were studied in the ten-meter quadrats, woody plants below two inches (DBH) in the four-meter quadrats and herbaceous plants in the one-meter quadrats. In order that as complete a study as possible might be made during the growing season, the work was begun early in April and continued until late in November. At intervals of approximately two weeks during the period of study all the quadrats were observed and additions made to the total floristic list for the quadrats. Also, a complete floristic list for the entire area was made.

Since the twenty-five one-meter quadrats covered only approximately 0.1 per cent. of the total area and the total of thirty-two herbaceous plants in the quadrats was 43 per cent. of the total number of herbaceous plants in the entire area, it is seen that in this case the sampling or quadrat method, although of small area, gives a fairly accurate analysis, at least of the most characteristic species of the vegetation.

The four-meter quadrats covered approximately 1.6 per cent. of the

FIGURE 1. DISTRIBUTION OF QUADRATS IN AREA



area. The twenty-six species of woody plants below two inches (DBH) which are found in them are 70 per cent. of the total number of species of woody plants in the entire area. However, in the total list no attempt was made to differentiate size classes so there can be no indication of the efficiency of the method. The same is true of the ten-meter quadrats,

TABLE I. SOCIOLOGICAL SUMMARY OF SPECIES OCCURRING IN ONE-METER QUADRATS

CONCEPTS RELATING TO SPECIES COMPOSING A PLANT COMMUNITY

	I ORGANIZATION — Analytic							II
	Quantitative			Qualitative				SYN-ECOLOGY
FLORISTIC LIST — Species	a. DENSITY	b. DOMINANCE (Classes 1-5)	c. FREQUENCE (Classes 1-5, A-E)	a. SOCIABILITY (Classes 1-3)	b. VITALITY (Classes 1-3)	c. PERIODICITY (Classes 1-4)	d. STRATIFICATION (Classes 1-5)	a. LIFE FORM (Classes 1-10)	b. LEAF SIZE (Classes 1-6)
Actæa alba	.04	1	A	2	3	1	4	G.	Micro.
Adiantum pedatum	.24	1	A	2	3	2	4	H.	Nano.
Arisæma triphyllum	1.12	1	B	2	3	1	4	G.	Meso.
Aspidium marginale	.04	1	A	2	3	2	4	H.	Micro.
A. marginale elegans	.08	1	A	2	3	2	4	H.	Micro.
Asplenium angustifolium	.04	1	A	2	3	2	4	H.	Micro.
Brachyelytrum erectum	.84	1	A	2	3	2	4	H.	Micro.
Carex (Sp?)	.04	1	A	2	3	2	4	H.	Meso.
Circaea lutetiana	1.12	1	A	2	3	2	4	H.	Meso.
Claytonia virginica	4.16	1	C	4	3	1	4	G.	Micro.
Cystopteris fragilis	.04	1	A	2	3	2	4	H.	Nano.
Dentaria laciniata	7.24	1	C	2	3	1	4	G.	Micro.
Desmodium nudiflorum	.04	1	A	2	3	2	4	G.	Micro.
Dicentra canadensis	70.72	2	D	4	3	1	4	G.	Micro.
Epifagus virginiana	.88	1	A	4	3	2	4	G.	Leafless
Erythronium americanum	33.24	1	E	4	3	1	4	G.	Micro.
Galium aparine	.48	1	A	4	3	1,2	4	Th.	Nano.
G. circæzans	.40	1	A	2	3	1,2	4	H.	Micro.
G. concinnum	4.32	1	A	4	3	1,2	4	H.	Lepto.
Geum canadensis	.04	1	A	2	3	1,2	4	H.	Micro.
Hydrophyllum appendiculatum	.12	1	A	2	3	1	4	H.	Meso.
H. macrophyllum	.04	1	A	2	3	1	4	H.	Meso.
Impatiens pallida	.12	1	A	4	3	2	4	Th.	Meso.
Lappula virginiana	.08	1	A	3	3	2	4	Th.	Meso.
Oxalis violacea	.04	1	A	2	3	1	4	G.	Micro.
Phytolacca decandra	.48	1	A	2	3	2	4	G.	Meso.
Pilea pumila	.08	1	A	2	3	2	4	Th.	Macro.
Podophyllum peltatum	2.84	1	B	2	2	1	4	G.	Meso.
Polygonum scandens	.04	1	A	2	3	2	4	H.	Meso.
Smilacina racemosa	.44	1	A	2	3	1	4	G.	Meso.
Trillium recurvatum	.04	1	A	2	3	1	4	G.	Meso.
Viola papilionacea	.16	1	A	2	3	1	4	H.	Meso.

which covered about 10 per cent. of the area. The twelve species above two inches (DBH) in the quadrats are approximately 32 per cent. of the total number of woody species.

SUMMARY AND DISCUSSION OF RESULTS IN THE ONE-METER QUADRATS

Table I gives the complete statistical summary for herbaceous species found in the one-meter quadrats.

The concept of *density* concerns the number of individuals per unit area, and the numerical value is gained by dividing the total number of individuals by the total number of one-meter quadrats. Density may thus be defined here as the average number of individuals of a species in a quadrat. From the previous table, it will be observed that *Dicentra canadensis* has the highest density, 70.72, and *Erythronium americanum* is second highest with a density of 33.24. The total density of all species is 129.60 plants per square meter.

None of the species found in the one-meter quadrats covered more than 5 per cent. of the area of the quadrats, except *Dicentra canadensis,* which covered from 6 to 25 per cent. of the area. This low dominance is no doubt due to the fact that all the plants considered in the one-meter quadrats were herbaceous and were small, early flowering types.

Eighty-two per cent. of the species were in Class A of frequency; that is, they appeared in only from 1.0 to 20 per cent. of the quadrats. Six per cent. were in Class B and the same in Class C. Three per cent. were in Class D and 3 per cent. in Class E. *Erythronium americanum* was the only species appearing in Class E, the class of highest frequence, and it occurred in 88 per cent. of the quadrats. A comparison of these frequency percentages with those of Raunkiaer and Kenoyer will be given later with the comparisons of the percentages of the four- and ten-meter quadrats.

Sociability concerns the manner in which species occur in relation to others, and the classes given in the summary were estimated on the basis of the numbers of individuals of all species growing in the quadrats. It will be noted that 75 per cent. of all the species appeared in Class 2; that is, they appeared in small groups. No species were found in isolation nor in Class 5, although seven species were in Class 4 and one in Class 3.

All plants except *Podophyllum peltatum* exhibited a vitality of 3, performing all normal functions of vegetative growth and reproduction. Due to some undetermined cause, practically none of the plants of *Podophyllum peltatum* produced flowers and fruit, although they had a normal vegetative growth and were consequently in Class 2.

The classes of periodicity were determined on the basis of the calendar seasons during which the plants bloomed. A few species continued blooming during two seasons, but the majority of species produced flowers only in one season. Forty-one per cent. of the species were found to be spring flowering and 47 per cent. summer flowering. These percentages support the generally accepted observation of the vernal and estival aspect of the herbaceous plants found in beech-maple associations. Twelve per cent. of the species flowered during two seasons. These were *Geum canadensis* and the three species of *Galium*.

No attempt was made to indicate subdivisions in the strata of species in the quadrats, and they were grouped only in the four large classes indicated previously. Since only herbaceous plants were studied in the small quadrats, all species were in Class 4. Only Pteridophytes and Spermatophytes were considered, and consequently a possible fifth stratum, a moss-lichen or carpet layer, was omitted. It was very poorly developed in this association.

Raunkiaer's classification of plants on the basis of the location of the perennating bud was used to determine the life-forms of the species present. The complete description of the ten life-form classes and the normal spectrum is given by Smith (7) and Fuller and Bakke (5). Withrow (8) has made use of the spectrum in a study of some plant communities of the Cincinnati region, but has subdivided the phanerophytes into different height classes from those of Raunkiaer. As a result, her work is not comparable with Raunkiaer's or any similar study unless all the phanerophytes are considered together without subdivision into the height classes. They have been so considered in making the following comparison of her results in a climax mixed mesophytic forest of the Cincinnati region with Raunkiaer's normal spectrum and the spectrum of all species found in the entire area of the beech-maple association of the present study.

LIFE FORM CLASSES	WITHROW Climax Mixed Mesophytic Forest		PRESENT STUDY Total Flora		RAUNKIAER Normal Spectrum	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Phanerophyte	43	33.58	38	32		47
Chamæphyte	5	3.88	3	3		9
Hemicryptophyte	44	34.4	45	39		27
Cryptophyte-Geophyte	30	23.4	24	21		3
Therophyte	5	3.9	6	5		13
Succulent	1	.78				
Totals	128	99.94	116	100	400	99

The predominance of hemicryptophytic life forms in the climax mixed mesophytic forest studied by Withrow and in the beech-maple association of the present study is in direct agreement with the findings of Raunkiaer (see Smith, 7, and Fuller and Bakke, 5) and Ennis (4). Phanerophytes are next important in dominance. The vegetation considered in the present study showed the direct connection with the climate of moderate temperature and rainfall which was apparent in the previous studies of similar associations.

In the twenty-five one-meter quadrats the herbaceous plants considered were in three life forms: Geophyte, 41 per cent., Hemicryptophyte, 47 per cent., and Therophyte, 12 per cent.

Raunkiaer's leaf size classes were used with the following tabulation of results:

LEAF SIZE	NO. HERBACEOUS SPECIES	PER CENT.
Leptophyll	1	3
Nanophyll	3	9
Microphyll	13	41
Mesophyll	13	41
Macrophyll	1	3
Aphyllous	1	3

The above tabulation shows clearly the dominance of the microphyll and mesophyll sizes over the other sizes, that is, the majority of the leaves were between 225 sq. mm. and 18,225 sq. mm. in surface area. In the case of compound leaves, one leaflet was considered the unit for measurement. The scale drawings of Fuller and Bakke (5) were used in determining the leaf sizes.

The following herbaceous species were found in the area but did not appear in any of the quadrats where herbaceous plants were considered: *Anemonella thalictroides, Arabis lævigata, Asarum canadense, Aspidium*

TABLE II. SOCIOLOGICAL SUMMARY OF SPECIES OCCURRING IN FOUR-METER QUADRATS

CONCEPTS RELATING TO SPECIES COMPOSING A PLANT COMMUNITY

	I								II	
	ORGANIZATION									
	ANALYTIC									
	Quantitative			Qualitative					SYN-ECOLOGY	
FLORISTIC LIST OF WOODY PLANTS LESS THAN TWO INCHES IN DIAMETER	a. DENSITY	b. DOMINANCE (Classes 1-5)	c. FREQUENCE (Classes 1-5, A-E)	a SOCIABILITY (Classes 1-5)	b. VITALITY (Classes 1-3)	c. PERIODICITY (Classes 1-4)	d. STRATIFICATION (Classes 1-5)		a. LIFE FORM (Classes 1-10)	b. LEAF SIZE (Classes 1-6)
SPECIES										
Acer saccharum	15.96	2	E	3	3	1	1		Ms.	Meso.
Asimina tribola	.52	1	A	2	3	1	2		M.	Meso.
Carpinus caroliniana	1.12	1	B	2	3	1	2		Ms.	Meso.
Carya cordiformis	.32	1	B	2	3	1	1		Ms.	Meso.
Cornus florida	.92	1	A	2	3	1	2		M.	Meso.
Dirca palustris	2.24	1	C	3	3	1	3		N.	Meso.
Evonymus obovatus	17.76	1	A	3	3	2	3		Ch.	Micro.
Fagus grandifolia	1.12	1	C	2	3	1	1		Mg.	Meso.
Fraxinus lanceolata	2.52	1	C	2	3	1	1		Ms.	Meso.
Juglans nigra	.08	1	A	2	3	1	1		Mg.	Meso.
Liriodendron tulipifera	.20	1	A	2	3	1	1		Mg.	Meso.
Menispermum canadense	.08	1	A	2	3	2	3		N.	Meso.
Morus rubra	.24	1	A	2	3	1	2		Ms.	Meso.
Nyssa sylvatica	1.04	1	A	3	3	1	1		Mg.	Meso.
Ostrya virginiana	.64	1	A	2	3	1	2		Ms.	Meso.
Prunus serotina	.80	1	B	2	3	1	2		Ms.	Meso.
Psedera quinquefolia	56.92	2	E	4	3	2	3		Ch.	Meso.
Quercus alba	.20	1	A	2	3	1	1		Mg.	Meso.
Ribes cynosbati	.56	1	A	2	3	1	3		N.	Micro.
Rubus trivialis	.08	1	A	2	3	1	3		N.	Meso.
Sambucus canadensis	.04	1	A	2	3	2	3		N.	Micro.
Sassafras variifolium	.08	1	A	2	3	1	2		N.	Meso.
Smilax hispida	.04	1	A	2	3	1	3		N.	Meso.
Ulmus fulva	.96	1	A	2	3	4	1		Ms.	Meso.
Viburnum acerifolium	2.84	1	A	3	3	1	3		N.	Meso.
Vitis cordifolia	.12	1	A	2	3	2	3		N.	Meso.

noveboracense, Asplenium acrosticoides, Botrychium virginianum, Campanula americana, Carex (sp?), Caulophyllum thalictroides, Chenopodium album, Collinsonia canadensis, Epipactis pubescens, Erigenia bulbosa, Eupatorium urticæfolium, Hybanthus concolor, Isopyrum biternatum, Laportea canadensis, Medeola virginiana, Mitchella repens, Monotropa uniflora, Osmorrhiza claytoni, Panax quinquefolium, Phacelia bipinnatifida, Phegopteris hexagonoptera, Phlox divaricata, Phryma leptostachya, Pogonia trianthophora, Polygonatum biflorum, Polystichum acrosticoides, Prenanthes alba, Pyrola elliptica, Sanguinaria canadensis, Sanicula trifoliata, Solanum nigrum, Solidago cæsia, Stylophorum diphyllum, Tradescantia pilosa, Trillium declinatum, Urtica gracilis, Viola palmata, V. scabiuscula, V. sororia and *V. striata.*

SUMMARY AND DISCUSSION OF RESULTS IN FOUR-METER QUADRATS

Table II gives the complete statistical summary for the woody species below two inches diameter which were considered in the four-meter quadrats.

The twenty-six species of woody plants here considered make up 70 per cent. of the total of thirty-nine woody plants in the entire area of the association, but there was no attempt made to differentiate between plants above and below two inches diameter in the total area list.

The total density for the twenty-five quadrats is 107.40 plants per 16 square meters. The species of greatest density was *Psedera quinquefolia* (56.92), which in some places was so dense that it was almost impossible to count. Since it reproduces vegetatively by means of stolons, each young rooted shoot was considered a separate plant. *Sambucus canadensis* and *Smilax hispida* were equally low in density, only one plant of each being found in the total twenty-five quadrats.

Crown coverage was considered the basis of determining the classes of dominance. Only two species covered more than 5 per cent. of the quadrat area, *viz., Acer saccharum* and *Psedera quinquefolia.* Because of the spreading of the branches, *Acer saccharum* covered from 6-25 per cent. of the area, and *Psedera quinquefolia,* although smaller in size, reached the same class because of the large number of individual plants found—a total of 1,422 plants.

Acer saccharum was found in each of the four-meter quadrats and therefore had a frequency of 100 per cent., putting it in Class E.

Psedera quinquefolia was also in Class E but had a frequency per cent. of only 84. There were no species in Class D, but there were three in Class B and eighteen in Class A. There is no direct obligate relationship between dominance and frequence, but it is interesting to note that in these quadrats *Acer saccharum* was highest in both dominance and frequence.

Approximately 77 per cent. of the species had a sociability of 2, appearing in small groups. Nineteen per cent. of them were in Class 3 and 4 per cent. in Class 4. *Psedera quinquefolia* was in Class 4 of sociability and also of greatest density in the four-meter quadrats, which seems to be a logical correlation.

All the plants had a vitality of Class 3, indicating that they all were normal in both vegetative and reproductive functions. The vernal aspect of the beech-maple association was further brought out in the fact that approximately 77 per cent. of the woody species below two inches in diameter flowered during the spring season. Nineteen per cent. flowered during the summer and only one plant, *Ulmus fulva,* flowered during the winter season. None of the species were autumnal in flowering.

Since herbaceous plants were not considered in these sample areas, only three classes of stratification appear. Class 1 included trees above thirty-five feet in height; Class 2 were trees below thirty-five feet, and Class 3 included all shrubs and vines regardless of height. Vines may be classed according to the height they attain, but were combined with the shrubs in this study. About 35 per cent. of the species were in Class 1, 27 per cent. in Class 2 and 38 per cent. in Class 3.

The spectrum for percentages of each life-form class in the total number of four-meter quadrats is here given:

LIFE-FORM CLASSES	PER CENT. FOUR-METER QUADRATS
Phanerophyte—	
Nanophanerophyte	34
Microphanerophyte	8
Mesophanerophyte	31
Megaphanerophyte	19
Chamæphyte	8

Due to the fact that herbaceous plants were not considered in the four-meter quadrats, there was less variation in leaf sizes than in the one-meter quadrats. Approximately 88 per cent. of the species were mesophylls and the other 12 per cent. were microphylls. The mesophyllous character shows a direct correlation with the climate.

The following woody species appeared in the entire area but not in any of the quadrats: *Acer negundo, Æsculus glabra, Benzoin æstivale, Cornus alternifolia, Evonymus atropurpureus, Hydrangea arborescens, Juglans cinerea, Rhus toxicodendron, Rubus occidentalis, Tilia americana* and *Tsuga canadensis.*

TABLE III. SOCIOLOGICAL SUMMARY OF SPECIES OCCURRING IN TEN-METER QUADRATS

CONCEPTS RELATING TO SPECIES COMPOSING A PLANT COMMUNITY

	I ORGANIZATION								II SYN-ECOLOGY	
	ANALYTIC									
	Quantitative			Qualitative						
FLORISTIC LIST WOODY PLANTS MORE THAN TWO INCHES IN DIAMETER	a. DENSITY	b. DOMINANCE (Classes 1-5)	c. FREQUENCE (Classes 1-5, A-E)	a. SOCIABILITY (Classes 1-5)	b. VITALITY (Classes 1-3)	c. PERIODICITY (Classes 1-4)	d. STRATIFICATION (Classes 1-5)		a. LIFE FORM (Classes 1-10)	b. LEAF SIZE (Classes 1-6)
SPECIES										
Acer saccharum	1.60	2	D	3	3	1	1		Ms.	Meso.
Carpinus caroliniana	.20	1	A	2	3	1	2		Ms.	Meso.
Carya cordiformis	.08	1	A	2	3	1	1		Ms.	Meso.
Carya ovata	.04	1	A	2	3	1	1		Ms.	Meso.
Celtis occidentalis	.04	1	A	1	3	1	1		Ms.	Meso.
Cornus florida	.12	1	A	2	3	1	2		Ms.	Meso.
Fagus grandifolia	1.48	3	E	3	3	1	1		Mg.	Meso.
Fraxinus lanceolata	.08	1	A	2	3	1	2		Ms.	Meso.
Ostrya virginiana	.36	1	A	2	3	1	2		Ms.	Meso.
Quercus alba	.08	1	A	2	3	1	1		Mg.	Meso.
Quercus muhlenbergii	.04	1	A	2	3	1	1		Mg.	Meso.
Ulmus fulva	.12	1	A	2	3	4	1		Ms.	Meso.

SUMMARY AND DISCUSSION OF RESULTS IN TEN-METER QUADRATS

Table III shows the complete statistical summary for the woody species above two inches diameter which were considered in the twenty-five ten-meter quadrats.

In the ten-meter quadrats there was a total of forty individuals of *Acer saccharum* and thirty-seven of *Fagus grandifolia* above two inches

in diameter. This is in marked contrast to the four-meter quadrats, where there were 399 individuals of *Acer saccharum* and only twenty-eight of *Fagus grandifolia* below two inches in diameter. At the first glance at these figures, it would seem that *Acer saccharum* is fast supplanting instead of being a codominant with *Fagus grandifolia.* However, the results of only one season's work are insufficient for such a conclusion. There was a very abundant crop of beechnuts this season which may cause the figures to be entirely reversed in a few years. Also, there may be a greater mortality among beech seedlings than maple, and there may be a greater mortality among the maples at a later stage of development than there is among the beeches. Although there were a few less beeches than maples in the ten-meter quadrats, in a general survey of the entire area it was apparent that there were more large beech trees than large maples. The diameter measurements showed that the beeches were also much larger than the maples. This is shown in the chart giving the diameter breast-high measurements of the trees considered in the ten-meter quadrats. The largest trees of the area are the white oaks, *Quercus alba,* but only one medium-sized individual appeared in the quadrats. The white oak is not reproducing itself, since it was absent from the seedling and sapling flora. This does not prejudice its Class 3 vitality but its competition ability under beech-maple dominance. It would seem that *Quercus alba* had been dominant many years ago and is now practically replaced by *Fagus grandifolia,* which, in turn, may be replaced by *Acer saccharum,* since the latter is more important at present in the lower strata.

The density of *Acer saccharum,* 1.6 plants per ten-meter quadrat, is slightly higher than that of *Fagus grandifolia* which has a density of 1.48. The difference in the size of the two species is shown by the dominance figures, which are based on the extent of crown coverage. *Fagus grandifolia* has a dominance of Class 3, covering 26-50 per cent. of the area, and *Acer saccharum* is in Class 2, covering only 5-25 per cent. of the area of the twenty-five ten-meter quadrats.

It is interesting to note that *Fagus grandifolia* is higher than *Acer saccharum* in both dominance and frequence. *Fagus grandifolia* is in Class E of frequence, appearing in 84 per cent. of the twenty-five ten-meter quadrats, while *Acer saccharum* is in Class D, for it appears in only 68 per cent. of the quadrats. Raunkiaer (see Smith (7) and Fuller and Bakke (5), in Europe, and Kenoyer (6)), in America, made exten-

TABLE IV. DBH CLASSES OF TREES IN TEN-METER QUADRATS

CLASSES DBH	ACER SACCHARUM	CARPINUS CAROLINIANA	CARYA CORDIFORMIS	CARYA OVATA	CELTIS OCCIDENTALIS	CORNUS FLORIDA	FAGUS GRANDIFOLIA	FRAXINUS LANCEOLATA	OSTRYA VIRGINIANA	QUERCUS ALBA	QUERCUS MUHLENBERGII
2	23	5	1		1	3	10		3		
4	12						3	1	4		1
6			1					1	3		
8	1						1				
10							5			1	1
12	1						1				
14							3				
16							3				
18							3				
20							3				
22				1			1				
24							1				
26							2				
28											
30							1				

sive quadrat studies, and, on the basis of the results, gave numerical values to the various frequency classes. For the purpose of comparison, these are given in tabular form with the frequency percentages for the three sizes of quadrats in the present study.

AUTHOR	LOCATION AND NO. OF PERCENTAGES INVOLVED	PER CENT. IN FREQUENCY CLASSES A	B	C	D	E
Raunkiaer	European, 8,087	53	14	9	8	16
Kenoyer	American, 1,425	69	12	6	4	9
This Study	25 One-meter Quadrats	82	6	6	3	3
This Study	25 Four-Meter Quadrats	69	12	12	0	7
This Study	25 Ten-Meter Quadrats	84	0	0	8	8

As in the case of the one- and four-meter quadrats, the majority of species considered in the ten-meter quadrats were in Class 2 of sociability. All species were in Class 3 of vitality, performing all normal functions, and all were vernal in respect to flowering period.

Eight of the twelve species above two inches diameter were in the tall tree stratum, above thirty-five feet in height, and the other four were in

the short tree stratum, below thirty-five feet. Only two life forms were exhibited, 75 per cent. of the species being in the Mesophanerophyte class and 25 per cent. in the Megaphanerophyte class. All twelve species were mesophyllous in leaf size.

SUMMARY OF RESULTS

ONE-METER QUADRATS. The total number of herbaceous species in the twenty-five one-meter quadrats was thirty-two, approximately 43 per cent. of the number of species in the entire area covered by the association. *Dicentra canadensis* was the species of highest density and dominance, but *Erythronium americanum* was highest in frequence. Seventy-five per cent. of the species were in Class 2 of sociability and the rest in Classes 3 and 4. All plants exhibited a vitality of Class 3 except *Podophyllum peltatum,* which was in Class 2. All species flowered during the spring or summer and 12 per cent. flowered during both seasons. Only herbaceous plants were studied in the one-meter quadrats, so all were in Class 4 of stratification. Hemicryptophytic forms predominated, with geophytes second and therophytes next in importance. Microphyll and mesophyll leaf sizes were clearly dominant over the other sizes exhibited.

FOUR-METER QUADRATS. The twenty-six species of woody plants below two inches in diameter make up about 70 per cent. of the total number of woody plants in the entire area of the association. *Psedera quinquefolia* was very high in density (56.92) and was equal to *Acer saccharum* in dominance. *Acer saccharum* had a frequency of 100 per cent., appearing in each of the twenty-five four-meter quadrats. *Psedera quinquefolia* was in the same class, E, but had a frequency of 84 per cent. Seventy per cent. of the species were in Class 2 of sociability and all species were in Class 3 of vitality. Seventy per cent. of the species flowered during the summer. Thirty-five per cent. were in Class 1 of stratification, 27 per cent. in Class 2 and 38 per cent. in Class 3. The majority of species were nanophanerophytic and mesophanerophytic in life form. Eighty-eight per cent. were mesophyllous in leaf size and the other 12 per cent. were microphyllous.

TEN-METER QUADRATS. *Acer saccharum* and *Fagus grandifolia* were approximately the same in density in the ten-meter quadrats, where only woody plants above two inches in diameter were considered, but *Acer saccharum* was slightly higher. *Fagus grandifolia* was the highest

species in both dominance and frequency classes, with *Acer saccharum* second highest. The majority of species considered were in Class 2 of sociability and all were in Class 3 of vitality. All species were vernal in flowering period. Approximately 67 per cent. of the species were in the tall tree stratum, above thirty-five feet in height. Seventy-five per cent. were Mesophanerophytes and the other 25 per cent. were Megaphanerophytes. All twelve species considered were mesophyllous in leaf size.

GENERAL SUMMARY

Permanent quadrats have been located in a beech-maple association at Turkey Run State Park, where they are available for future study. During the period from early April until late November of 1931 the vegetation was studied in the quadrats to determine the density, dominance, frequence, sociability, vitality, periodicity, stratification, life forms and leaf sizes of all the species of Pteridophytes and Spermatophytes occurring there.

In the herbaceous stratum it was found that the species were essentially vernal and estival in character, with the early spring species highest in density, dominance and frequence. The predominance of hemicryptophytic life forms was found to be in agreement with previous studies of similar plant associations.

Since Turkey Run State Park is near the western limits for *Fagus grandifolia,* and because *Acer saccharum* and *Fagus grandifolia* have long been considered codominants in associations of this type, especial attention was paid to these two species. It was evident in the entire area and in the large quadrats where trees above two inches in diameter were considered that beech was higher in both coverage and frequence than maple, although maple was slightly higher in density. On an average basis, the beech trees were much larger than the maples and were clearly much older. In the four-meter quadrats, where seedlings and saplings under two inches in diameter were counted, a great difference was noted in the reproduction of the two species. In 1931 there were 399 individuals of *Acer saccharum* as contrasted to twenty-eight of *Fagus grandifolia.* Although the seedlings were not separated from the saplings in the total count, the great majority of these individuals were seedlings. The maples of sapling size far outnumbered the beeches of the same size. In 1932 a count was made of the beech and maple seedlings and saplings in the same area and the maples showed an even greater

gain in the reproductive layer over the beeches. At this time there were 1433 maples and seventy-three beeches, most of these being seedlings. Although no definite conclusions may be drawn from a study of only two seasons, the evidence so far gained seems to show that *Acer saccharum* may be succeeding *Fagus grandifolia* in this area, instead of being codominant with it.

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