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The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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AN ECOLOGICAL STUDY OF THE RELATIONSHIP BETWEEN DIRECTION OF SLOPE, ELEVATION AND FOREST COVER IN BROWN COUNTY, INDIANA

By CARL R. MCQUEENEY

The complexities of our deciduous forests, though constantly under the scrutiny of investigators from various fields of botany, present many problems which are poorly understood. Each area, regardless of size, presents new problems which may or may not be peculiar to the area in question. For this reason, it is imperative that as problems arise, they be treated in a quantitative, comparative manner. The primary object of this study is to illustrate the limits placed upon various species of tall trees by environmental factors introduced as a result of the direction and angle of the exposure, as well as the elevation, with special reference to sugar maple.

The area considered herein lies near the northernmost tip of unglaciated Indiana in the eastern part of Brown County. The phytosociological balance is in a sensitive state, due at least in part to the relationship of climate to physiography. Extensive ecological studies of this general region have been made by Friesner and Potzger, resulting in a more thorough understanding of the vegetative complex (11, 15, 18).

METHODS

The land on which this survey was made is owned by Mr. Joseph DeWess and lies on the north side of state road 46, eight miles east of Nashville. The terrain is cut by deep twisting valleys in such a way that slopes facing all directions are available. Care was taken to select slopes which faced directly east, north, south and west, respectively. Each slope was divided into two areas consisting of lower and upper elevations, the line of demarcation between upper and lower areas is the approximate upper limit in this area for Acer saccharum,* using the east-facing slope as a standard. The vertical elevation of

* The species *Acer nigrum* was included in all tabulations with *Acer saccharum* due to the similarity of the two species.

this line is 48 feet above the valley floor. The line of demarcation for the west slope is 70 feet above the valley floor. The angle of each slope was recorded.

Sampling was by means of 100 sq. meter quadrats which were spaced 10 meters apart except where crowded conditions made this impossible. Tabulations were made on the basis of 25 quadrats for each area, except areas D and G where the slopes changed direction, curtailing the available space to 20 quadrats each. All woody species one meter or more in height were tabulated to illustrate reproduction and those one inch or more D.B.H. were measured and tabulated. All tabulations were made during the winter of 1948-49 while crown cover was absent.

OBSERVATIONS

A total of 47 woody species was found in the combined areas studied, 22 tall trees, 9 small trees and tall shrubs, and 16 small shrubs including one liana. The species were not evenly distributed on the four slopes, several of the total species being absent from each (table IV). The upper elevation of the south-facing slope, Area F, supported a total of 16 species, while on the north, east and west exposures, the total species present ranged from 26 to 28 for upper elevations and from 28 to 30 for lower elevations.

The most representative member of the dominant tall tree species was *Quercus alba* which was present in significant numbers in all areas, reaching its maximum development in the upper elevation of the south-facing slope where, with *Q. velutina,* it controlled the crown cover (table III). *Carya glabra* and *Acer rubrum* were also quite well represented in all areas in comparison to other tall tree species. The secondary layer was dominated overall by three major species, *Cornus florida, Ostrya virginiana* and *Sassafras albidum* with exceptions as later described. *Hamamelis virginiana, Smilax rotundifolia* and *Viburnum acerifolium* were the most widely distributed and abundant shrubs.

On the east-facing slope, lower elevation, the following trees were dominant: *Acer saccharum, Fagus grandifolia, Quercus alba,* and *Q. velutina.* Quercus played a more important part in controlling the crown cover, though the trend of succession appears to favor the Acer-Fagus type of dominance. The secondary layer was controlled by *Ostrya virginiana* and *Sassafras albidum,* and the shrub layer by

Ostrya virginiana in the lower elevation, and by *O. virginiana, C. florida* and *Sassafras albidum* on the upper elevation. *Viburnum acerifolium* and *Smilax rotundifolia* dominated the shrub layer in both elevations. *Rubus allegheniensis* was also present in significant numbers in several quadrats of the upper elevation (table I).

On all exposures, a correlation between elevation and the presence of *Acer saccharum* and *Fagus grandifolia* was evident. This was especially true of the south-facing slope where the habitat was more xerophytic on the upper elevation. On this slope *Acer saccharum* and *Fagus grandifolia* were both prominent on the lower elevation, while *F. grandifolia* was completely absent, and *A. saccharum* was represented by only two stems on the upper elevation. A similar condition was observed on the east-facing slope. On the north and west-facing slopes, though this condition was present, the correlation was considerably reduced (fig. 2).

The combined species of Quercus showed a correlation on north, south and east-facing slopes, which was the reverse of the correlation between elevation and Acer-Fagus. This was especially pronounced on the south-facing slope where Quercus maintained exclusive control of the upper elevation (table III). The combined species of Carya did not show this correlation but appeared to reach its maximum development in the transitional area between the most mesophytic and more xerophytic types of habitat, hence being more prominent on the lower elevations of east and south-facing slopes and the upper elevations of north and west-facing slopes (table III). This apparent tendency toward the preference of a habitat more mesophytic than that best suited to the more xerophytic species of Quercus may be due partially to selective cutting. *Vaccinium stamineum* var. *neglectum*, a comparatively rare species found only in the unglaciated area (8), was found on the west-facing slope. Deam (8) lists this species as being near its western limits. Another species of more or less infrequent occurrence, *Carya tomentosa*, was found on the upper elevation of the west-facing slope. Deam (8) has listed no record of this species from Brown County.

DISCUSSION

The student of modern plant ecology must base many of his concepts upon the literature of those who have preceded him, and upon the greatly disturbed remains of a vegetation which is no longer con-

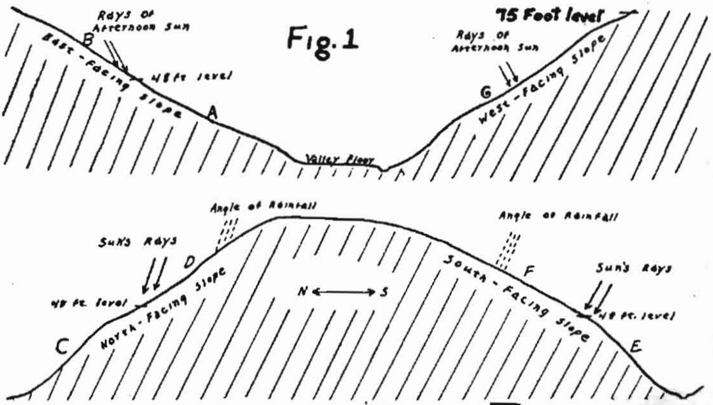
Fig. 1
Rays of Afternoon Sun
75 Foot level
East-Facing Slope
48 ft. level
West-Facing Slope
Valley Floor
B
A
G
Angle of Rainfall
Sun's Rays
48 ft. level
North-Facing Slope
South-Facing Slope
N ← → S
C
D
F
E

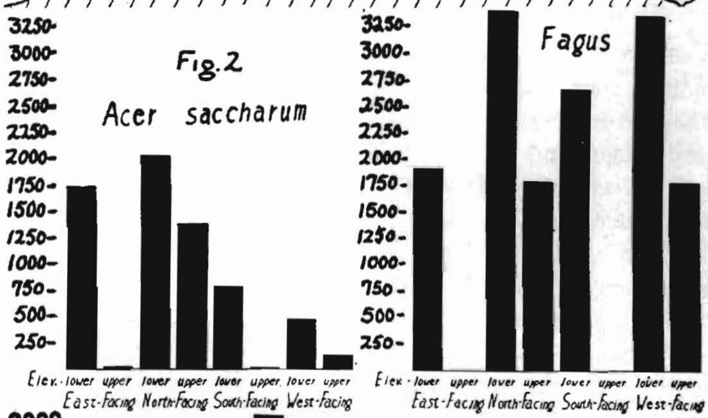
Fig. 2
Acer saccharum
Fagus
3250-
3000-
2750-
2500-
2250-
2000-
1750-
1500-
1250-
1000-
750-
500-
250-
Elev. - lower upper lower upper lower upper lower upper
East-Facing North-Facing South-Facing West-Facing

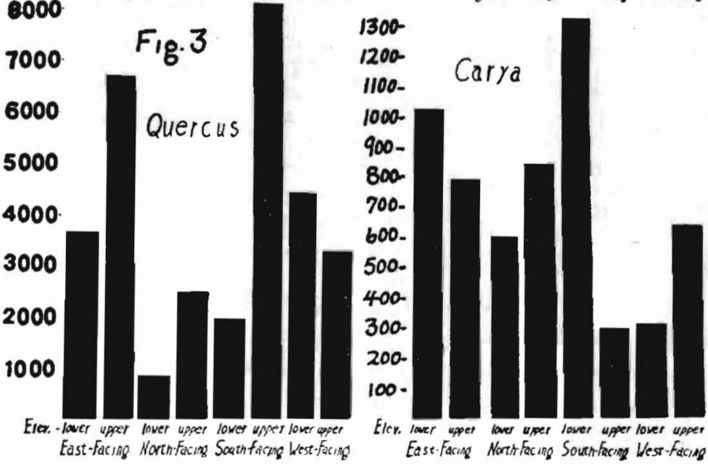
Fig. 3
Quercus
Carya
8000
7000
6000
5000
4000
3000
2000
1000
1300-
1200-
1100-
1000-
900-
800-
700-
600-
500-
400-
300-
200-
100-
Elev. - lower upper lower upper lower upper lower upper
East-Facing North-Facing South-Facing West-Facing

trolled by natural phenomenona alone. The complexities wrought by nature are increased ten-fold by the destructive hand of man. A forested area such as was studied for this paper can never give positive proof as to what associations might exist if there had been no disturbance. The conditions that one finds in disturbed areas are perhaps even more important than those found in forest primeval in that they show the trend of succession.

Indiana, as described by Friesner (9), is a "critical botanical area" in which many species are near their northern or western limits. Hence, it follows that slight climatic, edaphic, or physiographic variations may be responsible for definite vegetative differences. This is especially true where slopes are concerned since the presence of hills makes variations of these factors a certainty.

Visher (22) in describing the dynamics of the slope concludes that in Indiana four major climatic differences are significant on north and south-facing slopes: (1) North-facing slopes remain snow-covered longer and are thus protected from excessive run-off and alternate freezing and thawing. (2) Alternate freezing and thawing on south-facing slopes results in heaving of top soil and killing of shallow roots, which in turn increases erosion. (3) "The rains of Indiana come largely with southerly or southeasterly winds and beat down slightly stronger and more abundantly on south-facing than on north-facing slopes." (4) Warm season temperatures are greater on south-facing slopes, increasing evaporation (fig. 1).

There is some controversy as to whether southeasterly or southwesterly surface winds accompany most rains. According to a report by the United States Weather Bureau (20) southern Indiana "comes under the influence of both northwest and southwest storms, and it lies in the path of a considerable number of the latter which pass up the Ohio Valley." Monthly climatological reports for Indianapolis (21) show that rains were accompanied by both southeasterly and southwesterly winds to a similar degree during a period of two years.

The angle of inclination may also be of great importance in determining the vegetative complex due to an increase in run-off. Braun-Blanquet (1) states that the indirect effect of the angle of inclination on vegetation is due to the influence on the water supply and the shifting of the angle of incidence of the sun's rays. The nature of the underlying strata may also greatly affect water relationships (23). According to Logan (14) Brown County is within the outcrop of Borden rocks.

The function of slopes in Indiana is thus to affect the vegetation to a degree which is a direct result of the balance set up between topography, edaphic factors and climate. This balance is affected by the direction and angle of exposure, elevation, protection afforded by terrain, soil type, intensity of rainfall, temperatures and evaporation, plus other somewhat less obvious factors.

Friesner and Potzger (11) have shown that in this part of Indiana, evaporation was higher and available soil moisture lower on south-facing than on north-facing slopes during late spring and summer seasons. In a study of microclimate in central Indiana, Potzger (16) found that "surface soil had 30% and soil at six-inch depths 28%, more moisture on the north than on the south slope."

Potzger (15), in his studies of "Topography and Forest Types in Indiana," states, "the transition from beech-maple on the north-facing slopes to oak-hickory on the south-facing slopes is not gradual but abrupt and decisive." In the present study this was found to be true not only for the north and south-facing slopes but also for the upper and lower elevation of the south-facing slope. Area E, the lower elevation of the south-facing slope, was protected to a large degree by a north-facing slope on the opposite side of a deep ravine. At the point where the influence of the north-facing slope was no longer apparent on the south-facing slope, the angle of inclination rapidly changed from about 25° to 18° and the vegetation changed from the "mixed mesophytic" community to an oak community in the space of a few yards. The term "mixed mesophytic" was taken from Braun (2). Such changes in vegetation are to be expected for as Gleason (12) states, "abrupt transitions are in every case correlated with abrupt differences in the immigrating plant population." A comparatively slight difference in vegetation was noted on the two respective elevations for the north-facing slope where better protection from climatic conditions was present.

The east- and west-facing slopes were located on opposite sides of a wide valley and hence were in no way protected. It is apparent that the afternoon sun would in this case cause the west-facing slope to be more xerophytic than the east-facing slope. Visher (22) points out that in the United States, west-facing slopes become warmer than east-facing slopes. This difference in temperature may be partially responsible for the fact that *Acer saccharum* was less prominent on the west-facing slope. Costello (7) observed that corresponding associations were found higher on east-facing than west-facing slopes along the Missouri River.

The marked zoning of species in relation to elevation as especially illustrated in the case of *A. saccharum* (fig. 2) is probably due primarily to soil moisture conditions. *Fagus grandifolia* reacts to zoning in a similar manner (fig. 2) and in many cases shows a greater sensitivity to water relationships. There is considerable evidence that other factors may be of importance, however, as may be seen on the west-facing slope of this area. On this slope, Fagus was prominent in both lower and upper elevations, while *A. saccharum* was greatly restricted. This might lead one to say that Fagus has a wider range of habitat, concerning moisture conditions, than *A. saccharum* if it were not for the fact that, as Potzger (17) states, "*A. saccharum* may invade and ecese in habitats which are too dry for Fagus." When opposing conditions such as this are evident, it is obvious that factors other than moisture conditions are active in determining the vegetative complex.

Friesner and Ek (10) in comparing microclimatic factors with species distribution in an area of poor surface drainage, found that Acer-Quercus-Fagus communities occurred on less compact, better aerated soils than Quercus-Ulmus communities. This led Secor (19) to attribute the failure of *A. saccharum* to successfully invade certain areas of the Illinoian Drift Plain to drainage, soil aeration and surface moisture factors. In areas where surface drainage is obviously rapid and the direction of exposure determines to a large degree the amount of evaporation, it is reasonable to expect that the soil on a south-facing slope would be more compact and more poorly aerated than that of a corresponding north-facing slope, due to a lack of humus in the former. Thus poorer aeration of the soil in the areas under consideration may be a factor which tends to prevent the invasion of *Acer saccharum* on the dryer portions of south-facing slopes. This factor probably is important in this area only when other factors are sufficiently near the optimum to remove them from the role of limiting factors. Another factor in favor of the soil structure theory lies in the comparatively small number of sugar maple on the lower elevation of the south-facing slope where the steepest places were covered with less litter and fewer stems of sugar maple.

Acid soils may also be an important factor in the limiting of *A. saccharum* in certain areas, though the general trend of thought does not favor this theory (10, 11, 19). No tests were made to determine soil acidity; the abundance of *Gaylussacia baccata* and *Vaccinium vacillans,* however, is an indication that the soil of the upper elevations of the west-facing and south-facing slopes is acid. It has been well established that these two species are indicators of acid soil (5, 24). The hydrogen ion concentration may be due to what Gleason (12) describes as the "environmental control of the physical factors by the plant life itself."

In a study of a nearby area (18), it has been shown that the exposure influences the number of species present. The authors found that east and west-facing slopes appeared to support less species than north and south-facing slopes. They attributed this partially to a reduced number of quadrats from the former exposures. In the DeWess area, however, the number of quadrats from each slope was more nearly the same and opposite results were obtained. The total species on each slope was as follows: east-facing, 35 species; west-facing, 35 species; south-facing, 31 species; north-facing, 30 species. This indicated that east and west-facing slopes may support a greater variety of species, possibly due to greater competition on the north-facing slope and more rigorous habitat on the south-facing slope. It may, on the other hand, be due to disturbance. Cobbe (6) found a larger number of species on northern slopes in southwestern Ohio.

Previous papers have shown that elevation has an indirect effect upon the vegetation. Cain, Friesner and Potzger (4) described the variations of vegetation as influenced by altitude on a river bluff. They found that beech and maple were more frequent on the lower levels while oak and hickory were more frequent on the upper levels. A similar but somewhat accentuated condition was described by Little (13) in Caddo County, Oklahoma, where relic colonies of *A. saccharum* associated with other mesophytic species dominated the canyon floor, and the more xerophytic canyon rims, 30 to 70 feet above, supported several species of Quercus and Juniperus virginiana. Braun (3) observed that in the Cumberland Mountains, beech extended about half the distance up the south and west-facing slopes and two-thirds or more of the distance up the north and east-facing slopes.

Each individual area of this study proved to be an isolated vegetative community surrounded by other communities of similar species but of different composition. The forces of succession constantly struggle toward a homogeneous forest association while the overpowering microclimatic conditions repel each attempted invasion. Beyond a doubt, an unlimited number of sugar maple seeds germinate above the 48-foot level of the south and east-facing slopes each year, only to perish each summer. Hence, as Potzger (16) has pointed out, the microclimate in central Indiana will remain stable as long as there is no change in the macroclimate.

SUMMARY AND CONCLUSIONS

1. This study deals with the vegetative complex of north, south, east, and west-facing slopes of an area in Brown County, Indiana.

2. Each slope was divided into upper and lower elevations to show the indirect effect of elevation and studied by means of 100 sq. meter quadrats.

3. Forty-seven woody species were encountered, 22 tall trees, 9 small trees and tall shrubs, and 16 small shrubs including 1 liana.

4. The dominant tall trees species were: *Quercus alba, Fagus grandifolia, Acer saccharum, Q. velutina, Q. borealis maxima, Carya glabra,* and *A. rubrum*. These species were represented in different proportions for most areas.

5. The north-facing slope supported the most mesophytic and the south-facing slope the most xerophytic species.

6. The upper elevations tended to support the more xerophytic species and the lower elevations the more mesophytic species.

7. *Acer saccharum* was prominent on the lower elevations of the east and south-facing slopes but dropped out abruptly at the 48-ft. level. A similar correlation was observed for *Fagus grandifolia*.

ACKNOWLEDGMENTS

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TABLE I

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Tall Trees	A	15	6	10	6				22	44	319.7
	B	32	14	17	2				33	72	268.6
	C	9	5	6	6		1		18	52	575.7
	D	14	11	16	4				31	70	412.6
Acer rubrum	E	4	4	2	4	4			14	44	681.7
	F	44	57	11					68	96	179.1
	G	28	3	7	3				13	45	223.8
	H	105	13	12	7				32	80	439.0
	A	98	173	63	7	1		1	245	100	1740.7
	B	16	5	2					7	24	22.8
	C	70	125	44	6	4	1	1	181	100	2016.9
	D	29	46	28	6			1	81	90	1091.1
A. saccharum	E	92	53	16	5	3			77	72	776.0
	F		1	1					2	04	7.9
	G	55	11	11	1		1		24	85	422.5
	H	5	1	1		1			3	16	136.7

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
	A	1		4	1				5	08	116.8
	B				1				1	04	63.6
Carya cordiformis	C	2								08	
	E	1			1				1	08	50.3
	G	1								05	
	H	2								08	
	A	13	14	20	4				38	68	440.6
	B	52	52	24	3	1			80	92	573.4
	C	5	21	9	8				38	68	489.3
C. glabra	D	13	13	14	5				32	70	480.7
	E	3	2	6	3	2			13	48	452.4
	F	26	70	13					83	92	221.5
	G	13	11	7	2				20	65	201.4
	H	87	19	24	6				49	84	511.9

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
C. ovata	A	12	9	20	4				33	72	461.0
	B	2	7	8	2				17	20	153.9
	C				3				3	12	117.0
	D	1	3	10	3				16	50	212.8
	E	17	23	28	6	2			59	76	830.0
	F	2	2	4	1				7	24	91.9
	G	21	3		1				4	50	40.8
	H		2	3	2				7	24	122.5
C. tomentosa	H	5		3					3	04	33.8
Celtis occidentalis	G	1								05	
Fagus grandifolia	A	5	3	5	4	5		1	18	32	1882.6
	B	1								04	
	C	12	57	16	7	7	2	3	92	96	3420.4
	D	11	7	3	3	1	2	1	17	60	1395.7

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Fagus grandifolia	E	10	39	20	31	4	1		95	80	2624.0
	G	11	5	9	21	9		1	45	80	2646.3
	H	24	15	20	16	4		1	56	76	1760.8
Fraxinus americana	A	3	2	9	6	1			18	40	445.3
	B	5		1					1	16	7.1
	C	10	8	6	2				16	52	181.4
	D	3	2	1					3	20	18.8
	E	35	9	6	2				17	64	201.4
	F	7								24	
	G	7		2					2	30	18.1
	H	1								04	
F. biltmoreana	B	1								04	
Juglans cinerea	B				1				1	04	63.6
	C			1	2				3	08	121.0
	D				2				2	10	127.2

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
J. nigra	H		2						2	04	1.6
Juniperus virginiana var. crebra	B	1								04	
Liriodendron tulipifera	A			1		1			2	08	120.2
	C	1		2		1			3	08	127.2
	D	1	1		1	1			3	15	152.4
	E				1	2			3	08	388.0
	G	4	1						1	15	3.1
Nyssa sylvatica	A		3	6	3				12	28	225.7
	B	3	3						3	16	9.4
	C	1	6	1					7	20	26.7
	D	2	2	1	1				4	25	61.3
	E	5	3						3	12	2.4
	F	4	6						6	24	7.1
	G	9	3	1					4	20	14.1
	H	20	2	1					3	24	11.0

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Populus grandidentata	B		3	1	5				9	08	351.9
	D			1					1	05	12.6
	H	1		2	2				4	12	93.5
Prunus serotina	A	2		3	7	1			11	32	398.2
	B	7	1	2	1	1			5	20	161.0
	C	1	1	1	3				5	16	161.0
	D	2	1	1	3				5	30	142.9
	E	7	4	1	2				7	28	97.4
	G	5	2						2	10	1.6
	H	1								04	
Quercus alba	A	4	4	11	19	1		1	36	60	1898.1
	B	11	23	75	59	2			159	96	3767.6
	C	2	6	9	3	1			19	56	346.4
	D	8	4	10	13	1			28	70	744.9
	E	18	8	7	5	1			21	54	479.9
	F	18	88	139	90	2	1		320	100	5771.9
	G	8	4	13	20	7			44	55	2083.2
	H	33	12	27	17	5			61	76	1671.1

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Q. borealis var. maxima	C					1			1	04	132.7
	D		1	1	4	3		1	10	35	1076.8
	E	1	1			2	1		4	12	523.1
	G	33		2	6	2	1	1	12	50	1288.1
	H	1								04	
Q. velutina	A		3	2	13	9			27	56	1756.2
	B	1	3	5	20	10	2		40	76	2921.5
	C	2	6	1	3		1		11	32	420.2
	D					1			1	05	153.9
	E		2	5	3	4	1		15	24	923.6
	F	2		7	10	12	1	1	31	56	2642.7
	G	7	1		1				2	25	79.3
	H	31	4	6	12	7			29	64	1584.9
Ulmus americana	A	5								12	
	C					1			1	04	113.1
	E	2	2	3	1				6	24	96.6
	G	9								15	

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
U. rubra	A	25	1	1	6				8	44	293.0
	B	12								25	
	G	14		1					1	15	19.6
Small Trees Tall Shrubs	A	1	2						2	08	1.6
	B	6	3						3	20	7.1
Amelanchier canadensis	C		3						3	08	7.1
	D	1								05	
	E		5						5	12	8.6
	G	13								10	
	H		1						1	04	0.8
Asimina triloba	E	1								04	
Carpinus caroliniana	A	13	3	2					5	28	23.6
	C	11	7	1					8	48	14.9
	D	13	7	2					9	35	26.7

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Carpinus caroliniana	E	7	1						1	24	0.7
	G	111	8						8	44	18.1
	H	33	2						2	36	1.6
Cercis canadensis	A			2					2	04	14.1
	E	3	2						2	04	6.3
Cornus florida	A	6	1	1					2	24	7.9
	B	71	19	4					23	84	63.1
	C	36	6	3					9	68	58.1
	D	31	14	7	2				23	90	173.6
	E	40	18	3	1				22	60	88.3
	F	15	12						12	36	21.2
	G	60	11						11	70	18.1
	H	43	3	5					8	68	53.7
Crataegus sp.?	E	1								04	

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Morus rubra	A	1								04	
Ostrya virginiana	A	215	25	9					34	96	129.6
	B	111	19	2					21	60	59.7
	C	114	5	4	1				10	68	115.5
	D	146	25	9					34	85	149.5
	E	92	6	4					10	72	56.5
	F		1						1	04	3.1
	G	168	20	7					27	90	104.5
	H	158	41	2					43	80	74.6
Sassafras albidum	A	5	3	11					14	36	166.5
	B	23	9	18	1				28	56	238.0
	C	10		1	1				2	24	98.2
	D	5	2	9	2				13	64	191.6
	E	6		7					7	12	98.2
	F	16	5	5					10	44	46.3
	G	43								35	
	H	55	1	4	5				10	44	322.8

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Shrubs											
Corylus americana	D	47								70	
	E	24								32	
	G	3								10	
Dirca palustris	A	6								04	
	C	5								08	
	D	1								05	
	E	1								04	
Gaylussacia baccata	H	*									
Hamamelis virginiana	A	15								44	
	B	21								28	
	C	5								20	
	D	16								40	

* Stems of these species were present as indicated but were not tabulated.

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F): west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Hamamelis virginiana	E	17								36	
	F	8								08	
	G	16								40	
	H	11								24	
Hydrangia arborescens	A	1								04	
	B	1								04	
Lindera benzoin	A	2								04	
	C	15								16	
	E	59								40	
Rubus allegheniensis	E	1								04	
	G	52								15	
R. occidentalis	B	1								04	
	G	1								05	
	H	10								04	

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Sambucus canadensis	C	6								04	
Smilax glauca	A	1								04	
	B	2								08	
	F	11								16	
S. hispida	A	2								08	
	C	5								12	
	D	5								10	
	H	1								04	
S. rotundifolia	A	18								40	
	B	1464								72	
	C	26								28	
	D	30								20	
	E	193								96	
	F	443								88	
	G	36								20	
	H	286								64	

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Vaccinum stamineum var. neglectum	H	*									
V. vacillans	F	*									
	G	*									
	H	*									
Viburnum acerifolium	A	30								44	
	B	67								60	
	C	46								44	
	D	48								65	
	E	7								12	
	F	29								28	
	G	261								80	
	H	289								68	

* Stems of these species were present as indicated but were not tabulated.

TABLE I—(Continued)

Stems present in lower and upper elevations of each of the four slopes. East-facing: lower elevation (A), upper (B); north-facing: lower elevation (C), upper (D); south-facing: lower elevation (E), upper (F); west-facing: lower elevation (G), upper (H). All areas 25 quadrats each except (D) and (G).

Species	Area	Below 1"	1-2	3-5	6-10	11-15	16-20	Above 20"	Total above 1"	F. I.	Basal Area sq. in.
Vitis sp.?	A	5								16	
	B	16								44	
	C	4								12	
	D	4								20	
	E	5								16	
	F	5								20	
	G	1								05	

TABLE II

Relation of Elevation to Presence of *Acer saccharum* and *Fagus grandifolia* on East-, North-, South-, and West-facing Slopes.

Slope Direction	Species	Area (Quads.)	Elevation above valley floor	Approx. angle of slope	Stems below 1"	Stems above 1"	F. I.	Basal Area sq. in.
East-facing	Acer	A(25)	Below 48 ft.	8.5°	98	245	100	1740.5
		B(25)	48-75 ft.	15.0°	16	7	24	22.8
	Fagus	A(25)	Below 48 ft.	8.5°	5	18	32	1882.6
		B(25)	48-75 ft.	15.0°	1	0	4	0
North-facing	Acer	C(25)	Below 48 ft.	28-34°	70	181	100	2016.9
		D(20)	Above 48 ft.	17.0°	29	81	90	1091.1
	Fagus	C(25)	Below 48 ft.	28-34°	12	92	96	3420.4
		D(20)	Above 48 ft.	17.0°	11	17	60	1395.7
South-facing	Acer	E(25)	Below 48 ft.	25-31°	92	77	72	776.0
		F(25)	Above 48 ft.	18.0°	0	2	4	7.9
	Fagus	E(25)	Below 48 ft.	25-31°	10	95	80	2224.0
		F(25)	Above 48 ft.	18.0°	0	0	0	0
West-facing	Acer	G(20)	Below 70 ft.	28.0°	55	24	85	442.6
		H(25)	75-145 ft.	28.0°	5	3	16	136.7
	Fagus	G(20)	Below 70 ft.	28.0°	11	45	80	2646.3
		H(25)	75-145 ft.	28.0°	24	56	76	1760.8

TABLE III

Relation of Elevation to Presence of Species of Carya and Quercus on East-, North-, South-, and West-facing Slopes

Slope Direction	Species of	Area (Quads.)	Elevation above valley floor	Approx. angle of slope	Total stems below 1″	Total stems above 1″	Combined basal areas—sq. in.
East-facing	Quercus	A (25)	Below 48 ft.	8.5°	4	63	3654.2
	(2 spp.)	B (25)	48-75 ft.	15.0°	12	199	6689.0
	Carya	A (25)	Below 48 ft.	8.5°	26	76	1018.4
	(3 spp.)	B (25)	48-75 ft.	15.0°	54	98	790.9
North-facing	Quercus	C (25)	Below 48 ft.	28-34°	4	31	899.3
	(3 spp.)	D (20)	Above 48 ft.	17.0°	8	39	1975.6
	Carya (3)	C (25)	Below 48 ft.	28-34°	7	41	606.3
	(2 spp.)	D (20)	Above 48 ft.	17°	14	48	693.5
South-facing	Quercus (3)	E (25)	Below 48 ft.	25-31°	19	40	1926.6
	(2 spp.)	F (25)	Above 48 ft.	18°	20	351	8414.6
	Carya (3)	E (25)	Below 48 ft.	25-31°	21	72	1332.7
	(2 spp.)	F (25)	Above 48 ft.	18°	28	90	313.4
West-facing	Quercus	G (20)	Below 70 ft.	28°	48	58	3450.6
	(3 spp.)	H (25)	75-145 ft.	28°	65	90	3256.0
	Carya	G (20)	Below 70 ft.	28°	35	24	242.2
	(4 spp.)	H (25)	75-145 ft.	28°	94	59	668.2

TABLE IV

Distribution and Density of Species on All Slopes

Tall trees, small trees & tall shrubs	Shrubs
1. Only stem below 1″ present	1. 1-10 stems present
2. 1-10 stems above 1″ present	2. 11-20 stems present
3. 11-20 stems above 1″ present	3. 21-50 stems present
4. 21-50 stems above 1″ present	4. 51-100 stems present
5. Over 50 stems above 1″ present	5. Over 100 stems present

*Stems present but not tabulated.

Exposure	East		North		South		West	
Species	A	B	C	D	E	F	G	H
Tall Trees								
Acer rubrum	4	4	3	4	3	5	3	4
A. saccharum	5	2	5	5	5	2	4	2
Carya cordiformis	2	2	1		2		1	1
C. glabra	4	5	4	4	3	5	3	4
C. ovata	4	3	2	3	5	2	2	2
C. tomentosa								2
Celtis occidentalis							1	
Fagus grandifolia	3	1	5	3	5		4	5
Fraxinus americana	3	2	3	2	3	1	2	1
F. biltmoreana		1						
Juglans cinera		2	2	2				
J. nigra								2
Juniperus virginiana, var. crebra		1						
Liriodendron tulipifera	2		2	2	2		2	
Nyssa sylvatica	3	2	2	2	2	2	2	2
Populus grandidentata		2		1				2
Prunus serotina	3	2	2	2	2		2	1
Quercus alba	4	5	3	4	4	5	4	5
Q. borealis maxima			2	2	2		3	1
Q. velutina	4	4	3	2	3	4	2	3
Ulmus americana	1		2		2		1	
U. rubra	2	1					2	
Total number species for each area	14	16	15	14	14	8	16	15
Small Trees and Tall Shrubs								
Amelanchier canadensis	2	2	2	1	2		1	2
Asimina triloba					1			
Carpinus caroliniana	2		2	2	2		2	2
Cercis canadensis	2				2			
Cornus florida	2	4	2	4	4	3	3	2

TABLE IV—(Continued)

Distribution and Density of Species on All Slopes

Exposure Species	East A	East B	North C	North D	South E	South F	West G	West H
Crataegus sp.					1			
Morus rubra	1							
Ostrya virginiana	4	4	2	4	2	2	4	4
Sassafras albidum	3	4	2	3	2	2	1	2
Total number species for each area	7	4	5	5	8	3	5	5
Small Shrubs								
Corylus americana				3	3		1	
Dirca palustris	1		1	1	1			
Gaylussacia baccata								*
Hamamelis virginiana	2	3	1	2	2	1	2	2
Hydrangia arborescens	1	1						
Lindera benzoin	1		2		4			
Rubus allegheniensis					1		4	
R. occidentalis		1					1	1
Sambucus canadensis			1					
Smilax glauca	1	1				2		
S. hispida	1		1	1				1
S. rotundifolia	2	5	3	3	5	5	3	5
Vaccinium stamineum neglectum								*
V. vacillans						*	*	*
Viburnum acerifolium	3	4	3	3	1	3	5	5
Vitis sp.?	1	2	1	1	1	1	1	
Total number species for each area	9	7	8	7	8	5	8	8
Total number all woody species	30	27	28	26	30	16	29	28