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VEGETATIVE STRUCTURE OF AN ESSENTIALLY UNDISTURBED BEECH-MAPLE ECOSYSTEM IN CENTRAL OHIO[1]

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Abstract. All woody stems ≥2.5 cm diameter at breast height (dbh) occurring within 1 ha of an essentially undisturbed beech-maple ecosystem of central Ohio were inventoried for species, vegetative level,and dbh, and values were derived for mean area, density, dominance (basal area) and frequency. Species importance values (sum of relative density, relative dominance and relative frequency) were also calculated. The total number of individuals occurring with the 1 ha sample area was 1456 of which 15%, 73%, 6% and 6% occurred in the shrub, smalltree, subcanopy and canopy vegetative levels, respectively. Total basal area of all individuals was 32.7 m² of which the shrub, smalltree, subcanopy and canopy levels contributed approximately 1%, 7%, 20% and 72%, respectively. *Fagus grandifolia* and *Acer saccharum* had the greatest species importance values for each of the vegetative levels (values for the shrub level were not calculated) and the value of the former for all individuals ≥2.5 cm dbh was greater than the latter by a factor of about 2.

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At the time of settlement, the vegetation of gentle slopes of ground moraine of central and northern Ohio was characterized by a forest continuum the canopy of which was predominantly composed of individuals of *Fagus grandifolia* and *Acer saccharum*. The former species was more prevalent at lower elevations while the latter was more prevalent on higher elevations, sometimes occurring in essentially pure stands atop the swells. The basic components of the continuum were individuals of the following vegetative levels: canopy, subcanopy, smalltree, shrub and herb. Unfortunately, there has never been a detailed quantitative phytosociological study of this continuum because undisturbed ecosystems of this kind are, for all practical purposes, nonexistent. The quantitative data presented in our study describes the vegetative structure of one of the few remaining relatively undisturbed beech-maple ecosystems occurring at mid-elevation on a gentle slope of ground moraine in central Ohio. DeSelm (1952) reported, however, that cattle from an adjoining pasture were allowed to enter the woods until about 1950, and "In 1922 most of the ash was removed from the stand."

The study area was 22 km ENE of the center of Columbus. It was centered at 39° 58′ 25″ N Lat. and 82° 44′ 45″ W Long. and occurred within the northern half of the SW¼ of Sec. 3, T. 16 N., R. 20 W. of Etna Township, Licking County, Ohio. Three ecological studies were conducted in the woodlot prior to the present study and concerned vertical temperature gradients (Christy 1952), vertical carbon dioxide gradients (DeSelm 1952) and fate of seedlings and saplings of canopy dominants (Laufersweiler 1955).

METHODS

All woody stems ≥2.5 cm diameter breast height (dbh) occurring within 100 ares (10 x 10 m nonpermanent quadrats) were inventoried during 1970 and 1971 for species, dbh and vegetative level. The range in elevation of the crowns of the shrub, smalltree, subcanopy and canopy individuals was determined (ca. 1–3, 3–13, 13–25 and 25–35 m, respectively). Then the extremes of stem diameters of individuals with crowns within these ranges were ascertained by sampling and used to classify each individual as to vegetative level. The 100 ares were located alternately along 200 m parallel lines which were 20 m apart and extended south from a line

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oriented east-west and 20 m within the north boundary of the woodlot. This line began 30 m from the west boundary of the woods and extended east about 100 m. Many individuals of the shrub level had dbh values <2.5 cm and consequently were not recorded in the data.

Parameters quantified were density, mean area, dominance (basal area) and frequency. In addition, relative density, relative dominance, relative frequency and species importance value as defined by Curtis and McIntosh (1950, 1951) were determined for each species per community and vegetative level.

Asimina triloba. (The scientific terminology used is that of Fernald 1950.)

The area/woody individual (mean area) is an important ecological parameter (reported as ares/individual, table 2). The mean area of woody stems ≥2.5 cm dbh in the sample area was 0.07 ares, *i.e.* 7 m^2. Least mean area values per species were 0.26 and 0.29 ares for *F. grandifolia* and *A. saccharum*, respectively.

TABLE 1

Relationships between stem diameter at breast height (dbh in cm) and vegetative level.

Species*	Shrub**	Smalltree	Subcanopy	Canopy
Fagus grandifolia	<2.5	2.5–22.9†	23.0–48.5†	>48.5
Acer saccharum	<2.0	2.0–12.9	13.0–33.0	>33.0
Fraxinus americana	<2.0	2.0–17.9	18.0–30.0	>30.0
Lindera benzoin	<8.1	—	—	—
Carpinus caroliniana	<2.5	2.5–13.2	—	—
Ostrya virginiana	<2.5	2.5–14.2	—	—
Prunus serotina	<2.5	2.5–17.9	18.0–30.0	>30.0
Asimina triloba	<2.3	2.3– 5.3	—	—
Quercus rubra	<2.5	2.5–17.9	18.0–30.0	>30.0
Ulmus sp.	<2.5	2.5–17.9	—	—
Quercus alba	<2.5	2.5–17.9	18.0–30.0	>30.0
Viburnum lentago	<4.1	—	—	—
Cornus florida	<4.3	—	—	—
Tilia americana	<2.5	2.5–17.9	—	—
Carya sp.	<2.5	2.5–17.9	—	—
Acer rubrum	<2.5	2.5–17.9	—	—
Gleditsia triacanthos	<2.5	2.5–17.9	—	—

*Species listed according to importance value (see table 4).

**Woody individuals greater than 1 m in height and less than the dbh value presented in the table.

†Range.

RESULTS AND DISCUSSION

Stem diameter ranges and densities per vegetative level are presented in tables 1 and 2, respectively. The total number of individuals ≥2.5 cm dbh occurring in the 1 ha sample area was 1456 of which 15%, 73%, 6% and 6% occurred in the shrub, smalltree, subcanopy and canopy vegetative levels, respectively. Individuals of *Fagus grandifolia*, *Acer saccharum* *Fraxinus americana* and *Prunus serotina*, the 4 species with the greatest canopy and subcanopy importance values, comprised 63% of the individuals; 18% of the individuals were either *Carpinus caroliniana* or *Ostrya virginiana* (the species used to delimit the smalltree level) and 15% of the individuals were *Lindera benzoin*, the shrub level dominant. The remaining 4% of the stems were mostly Mean areas of individuals of all other species were markedly greater than these values and extended to 100 ares for 4 species.

Total basal area of individuals ≥2.5 cm dbh was about 327 x 10^3 cm^2, of which the shrub, smalltree, subcanopy and canopy levels contributed approximately 1%, 7%, 20% and 72%, respectively (table 3). Individuals of *F. grandifolia* accounted for 66% of the total basal area while *A. saccharum* and *F. americana* accounted for 18% and 7%, respectively. The remaining 9% was contributed by individuals representing 14 species.

The percentages of the 100 quadrats in which individuals of a given species occurred (*i.e.* frequency) indicate that the frequency values of *F. grandifolia* and *A. saccharum* were relatively high (greater

TABLE 2

Mean area and density of woody individuals ≥2.5 cm dbh per vegetative level and community.

Species	Mean area (ares/individual)					Density (individuals/hectare)				
	Shrub	Small-tree	Sub-canopy	Canopy	Commun.	Shrub	Small-tree	Sub-canopy	Canopy	Commun.
*Fagus grandifolia**	—	0.3	2.7	1.7	0.3	0	295	37	59	391
Acer saccharum	—	0.3	3.7	4.6	0.3	0	296	27	22	345
Fraxinus americana	—	0.8	11.1	11.1	0.7	0	125	9	9	143
Lindera benzoin	0.5	—	—	—	0.5	217	0	0	0	217
Carpinus caroliniana	—	0.7	—	—	0.7	0	149	0	0	149
Ostrya virginiana	—	0.9	—	—	0.9	0	109	0	0	109
Prunus serotina	—	3.1	9.1	50.0	2.2	0	32	11	2	45
Asimina triloba	—	3.5	—	—	3.5	0	29	0	0	29
Quercus rubra	—	33.3	—	100	25.0	0	3	0	1	4
Ulmus sp.	—	11.1	—	—	11.1	0	9	0	0	9
Quercus alba	—	33.3	100	—	25.0	0	3	1	0	4
Viburnum lentago	33.3	—	—	—	33.3	3	0	0	0	3
Cornus florida	50.0	—	—	—	50.0	2	0	0	0	2
Tilia americana	—	100	—	—	100	0	1	0	0	1
Carya sp.	—	100	—	—	100	0	1	0	0	1
Acer rubrum	—	100	—	—	100	0	1	0	0	1
Gleditsia triacanthos	—	100	—	—	100	0	1	0	0	1
Unknown sp.	—	50.0	—	—	50.0	0	2	0	0	2
All species	0.5	0.1	1.2	1.1	0.07					
Totals						222	1056	85	93	1456

*Species listed according to importance value (see table 4).

TABLE 3

Dominance (basal area) and frequency of woody individuals ≥2.5 cm dbh per vegetative level and community.

Species	Basal area (cm²/hectare)					Frequency (%)				
	Shrub	Small-Tree	Sub-canopy	Canopy	Commun.	Shrub	Small-tree	Sub-canopy	Canopy	Commun.
*Fagus grandifolia**	0	6,530	48,074	162,516	217,120	0	76	30	48	91
Acer saccharum	0	5,770	6,826	46,142	58,738	0	70	18	20	82
Fraxinus americana	0	3,057	3,853	17,303	24,213	0	44	7	8	53
Lindera benzoin	2,189	0	0	0	2,189	50	0	0	0	50
Carpinus caroliniana	0	3,790	0	0	3,790	0	49	0	0	49
Ostrya virginiana	0	3,350	0	≈0	3,350	0	40	0	0	40
Prunus serotina	0	845	5,446	2,015	8,306	0	16	8	2	19
Asimina triloba	0	374	0	0	374	0	6	0	0	6
Quercus rubra	0	52	0	7,126	7,178	0	3	0	1	4
Ulmus sp.	0	553	0	0	553	0	8	0	0	8
Quercus alba	0	39	682	0	721	0	2	1	0	2
Viburnum lentago	31	0	0	0	31	3	0	0	0	3
Cornus florida	25	0	0	0	25	2	0	0	0	2
Tilia americana	0	22	0	0	22	0	1	0	0	1
Carya sp.	0	7	0	0	7	0	1	0	0	1
Acer rubrum	0	5	0	0	5	0	1	0	0	1
Gleditisa triacanthos	0	9	0	0	9	0	1	0	0	1
Unknown sp.	0	63	0	0	63	0	1	0	0	1
Totals	2.245	24,466	64,881	235,102	326,694					

*Species listed according to importance value (see table 4).

than 80%). Frequency values of 3 species were essentially 50%, namely *F. americana*, *L. benzoin* and *C. caroliniana*. All other species, with the exception of *O. virginiana* (40%), were characterized by frequency values markedly less than 50%.

Canopy-Subcanopy Level. Density values of canopy and subcanopy individuals were nearly equal and totaled 178 indiv/ha, ca. 54% and 28% of these individuals were *F. grandifolia* and *A. saccharum*, respectively. The remaining trees were mostly individuals of *F. americana* or *P. serotina* (table 2).

Mean area values of canopy and subcanopy individuals also were nearly equal and about 1 are/indiv (table 2). On the average, each are contained ca. 2 canopy-subcanopy individuals. Mean area of all canopy and subcanopy individuals of *F. grandifolia* was about 1, and the corresponding value for such individuals of *A. sacchrum* was ca. 2 ares/indiv. Mean area values for each of the remaining canopy-subcanopy species were > 5.5 ares/indiv. It appears, therefore, that the probability of direct contact between crowns and/or root systems of canopy-subcanopy members of the same species was great, relatively great and small in regards to individuals of *F. grandifolia*, *A. saccharum* and other canopy-subcanopy species, respectively.

Total basal area of canopy individuals was 3.6 times the basal area of subcanopy individuals. Collectively, the basal area of these 2 levels totaled ca. 3×10^5 cm^2, which was 92% of the total basal area of all stems ≥2.5 cm dbh (table 3).

Smalltree and Shrub Level. Density of smalltree individuals was far greater than densities of other vegetative levels and was 1056 indiv/ha (table 2). The density of shrub individuals would have been markedly greater than the value 222 if shrub stems <2.5 cm dbh had been included in the data. The mean area value for small trees was 0.1 are/indiv. Total basal area was ca. 24,500 cm^2/ha, which is roughly 7.5% of the total basal area of stems ≥2.5 cm dbh occurring within the 1 ha sample area.

It should be noted that none of the 15 species represented in the small tree level were represented in the shrub level. It is inferred that a recent, marked change occurred in the effectiveness of the rejection mechanism of the ecosystem that allowed many established but small woody individuals to quickly attain the 2.5 cm dbh size class. (Such a phenomenon was observed and quantified in a mixed oak ecosystem of south-central Ohio in 1957.) This may explain why the smalltree level is predominantly composed of individuals of an even-aged cohort. The data of tables 1 and 3 reveal the presence of a relatively well-developed shrub level dominated by individuals of *L. benzoin*.

Species Considerations. The relative importance of a given species within an ecosystem can be estimated by calculation of a species importance value. This is considered as the sum of relative

TABLE 4

Species in order of importance values (rel. density+rel. dominance+rel. freq.) per vegetative level and community of individuals ≥2.5 cm dbh.

Species*	Smalltree	Subcanopy	Canopy	Commun.
Fagus grandifiolia	79	165	193	115
Acer saccharum	74	70	69	62
Fraxinus americana	38	28	27	30
Lindera benzoin	0	0	0	28
Carpinus caroliniana	45	0	0	23
Ostrya virginiana	37	0	0	18
Prunus serotina	12	34	6	10
Asimina triloba	6	0	0	4
Quercus rubra	1	0	5	3
Ulmus sp.	6	0	0	3
Quercus alba	1	4	0	1

*Species with values of <1 are not included.

density, relative dominance (basal area) and relative frequency (table 4). These data reveal that *F. grandifolia* and *A. saccharum* had the greatest species importance values for each of the vegetative levels, and that the former had a community value approximately twice that of the latter. It appears that individuals of these 2 species do indeed dominate the internal environment of the study ecosystem, and that individuals of the former are more important than the latter. The data in table 4 suggest that individuals of the following species also play important roles in the dynamics of the beech-maple ecosystem: *F. americana*, *P. serotina*, *C. caroliniana*, *O. virginiana* and *L. benzoin*. The first two species are represented in all vegetative levels, the following two are represented only by smalltree individuals, and individuals of the latter 2 species are confined to the shrub level.

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ANNOUNCEMENTS

The 5th Midwest Biomedical Engineering Conference and Work Shop sponsored by the OSU Bio-Medical Center and The Central Ohio Engineering Community Council will be held at the OSU Center for Tomorrow May 30–31. For further information, write Herman R. Weed, Bio-Medical Engineering Center, Ohio State University, 257 Dreese Lab, 2015 Neil Avenue, Columbus, OH 43210.