The Structure and Dynamics of the Vegetation of the Winton Woods Forest, Hamilton County, Ohio

William S. Bryant
Department of Biology
Thomas More College
Crestview Hills, Kentucky 41017

Prepared for:
Hamilton County Park District
Hamilton County, Ohio

Submitted: January 10, 1985

Introduction

Early work on the vegetation of southwestern Ohio was largely due to the efforts of the late E. Lucy Braun (1916, 1917, 1921, 1935, 1936a, 1936b, 1950, 1951, 1969) and students under her direction: Giesler (1926), Segelken (1929), Irwin (1929), Withrow (1932), Diehl (1933), Thompson (1939) and Cobbe (1943). In addition to vegetation, various of these papers considered flora, plant succession, and phytogeography. More recently, Vankat, et al. (1975) and Hoye, et al. (1978) presented detailed analyses of local forested areas, Hueston Woods and Shawnee Lookout Park, respectively.

The climax type for Hamilton County was considered to be mixed mesophytic (Braun 1916, 1921, 1936a, Withrow 1932, Diehl 1933), however, other forest types here and elsewhere in southwestern Ohio include beech-maple (Braun 1916, 1936a, Diehl 1933, Vankat, et al. 1975), oak-hickory (Diehl 1933, Cobbe 1943), pin oak-red maple (Braun 1916, 1936a, Diehl 1933), beech (Braun 1916, 1936a, Diehl 1933), oak-ash-maple (Diehl 1933, Braun 1950), and willow-cottonwood-soft maple (Diehl 1933). Additionally, Irwin (1929) reported on prairie remnants.

In an attempt to characterize the presettlement virgin forests and their distribution in Ohio, Sears (1925) used General Land Office survey data. However, similar surveys for the 1788 Symmes Purchase were not available to him. Even with this deficiency, Sears (1929) recognized beech-maple and beech-oak for the southwestern corner of the state.

Braun and Jones (1926) briefly annotated the outstanding natural areas of Ohio listing 8 such areas for the Cincinnati Region. The latter included various forest types and one prairie. In a more recent compilation of Ohio's outstanding natural areas, Herrick (1974) listed 15 for Hamilton County.

Today, old-growth forests in the Greater Cincinnati area occur as scattered remnants and are largely confined to parks and/or preserves. Some knowledge of the structure and composition of these remnants is essential if they are to be understood and properly managed.

The primary aim of this study was to quantitatively analyze the vegetation of one of the old-growth forest remnants in Hamilton County, Ohio. The forest selected was a Designated Ohio Natural Area located in Winton Woods Park (Figure 1). Herrick (1974) noted beech woods and mixed mesophytic forest for Winton Woods, but no thorough studies have been attempted there.

The Study Area

The forest is in two segments because it is dissected by Winton Road. It is bounded on the north by the village of Greenhills and on the south by successional forests and old fields. Foot trails cut through both forest segments, but aside from this, the remnants of an old road, and an above ground pipeline on the northern border of the forest, recent human disturbance appears to be minimal.

The topography is gently rolling and is cut by three small streams. These streams have formed small ravines and drain to Mill Creek on the south.

The forest is in an area of Illinoian glacial till deposits. The soils of the forest, the Bonnell silt loam and the Rossmoyne silt loam, are characteristic of the Illinoian till plain (Lerch, et al. 1982). The Bonnell is a fine,mixed, mesic Typic Hapludalfs. This soil is well-drained yet permeability is slow (Lerch, et al. 1982). The Rossmoyne is a fine-silty, mixed, mesic Aquic Hapludalfs. This soil shows moderate permeability above the fragipan and slow permeability in the fragipan. Root growth is restricted to the area above the fragipan. During extended wet periods, a perched high water table occurs between depths of 46 to 91 cm (18 - 36 inches)

(Lerch, et al. 1982) which during cold weather creates a high potential for frost action.

The climate of Hamilton County is of the continental type with cold winters and hot summers. Average annual precipitation is 101.6 cm (40 inches) with over 50 percent of this falling during the growing season (Lerch, et al. 1982).

Methods and Materials

Vegetation was sampled during September and October 1984. Trees were sampled in 0.04-hectare (ha) circular plots, saplings in 0.01-ha circular plots, and seedlings in 0.004-ha circular plots. Shrubs were sampled in the latter two sized plots.

Woody plants with diameters breast height (dbh) of 10 cm (4 inches) or greater were classed as trees. Seedlings and saplings were placed in appropriate size classes with a sampling template. Seedlings in Class 1 were woody plants from 15.2 cm to 1.37 m high (6 inches - 4.5 feet); those in Class 2 were over 1.37 m hight with diameters at ground level less than 1.27 cm (0.5 inch). All sapling size classes were 1.37 m or more in height. Saplings in Class 3 were from 1.27 to 3.81 cm (0.5-1.5 inches) in diameter; Class 4 were from 3.81 to 6.35 cm (1.5-2.5 inches) in diameter; and Class 5 were from 6.35 to 9.99 cm (2.5-3.99 inches) in diameter. A total of 32 plots were sampled for trees and 15 for seedlings-saplings. Plots were spaced at 30-m intervals along straight-line transects in a N to S direction in the forest.

The relative frequency (RF), relative density (RD), relative dominance (RDo), and importance value (IV) were determined for each tree species. Woody stems per unit area [e.g. trees/hectare (t/ha) or trees/acre (t/a)] were also determined.

Soil moisture percentage and soil pH were determined with a Kelway Soil Tester. Both values were determined near the center of the plots and to a depth of $\approx$ 10 cm. Notes were kept on tree-falls and standing dead trees in the plots and their creation of canopy gaps.

The similarity coefficient (C) as used by Bray and Curtis (1957) was applied for determining vegetational similarity between this forest and others in the area. It is expressed as $C = (2w)/(a + b)$, where a = the sum of importance values of all tree species in one stand, b = a similar sum for a second stand, and w = the sum of the lesser values for only those species which are common to the two stands.

The Shannon-Wiener function was used as a measure of species diversity. The function is: $H' = -\sum p_i \log_2 p_i$ where p_i is the sampling probability.

Results

There was a total of 15 tree species and 240.05 t/ha (97.09 t/a) in the Winton Woods forest. The most important tree species was Acer saccharum (sugar maple, IV 101.25) followed by Fagus grandifolia (beech, IV 76.17) and Fraxinus americana (white ash, IV 59.43) (Table 1). Other associates of more than minor importance included Prunus serotina (black cherry, IV 16.75) and Juglans nigra (black walnut, IV 11.38). Although sugar maple ranked first in IV and RD, it was third in RDo which indicates high numbers of small trees. On the contrary, beech ranked second in IV and RD, but first in RDo indicating fewer trees but of greater basal area. White ash followed the trend in beech of large trees in terms of basal area, but not of the numbers of sugar maple. The total basal area of the forest was 28.85 m^2/ha with $\approx$ 82% contributed by beech, ash, and maple.

If $\geq$ 12 inches dbh ($\approx$30 cm dbh) is used as the criterion to denote canopy status (Abrell and Jackson 1977) then only 47.59% (114.24 t/ha) of the trees are members of the canopy as compared to 52.41% (125.82 t/ha) in the subcanopy. Although there are more trees in the subcanopy, over 89% of the basal area is in the canopy members. Over 81% of the canopy trees are beech, white ash, and sugar maple, however, the subcanopy dominant is sugar maple with over 83% of the individuals (Table 2).

In general the forest followed the inverted-J curve indicative of all aged forests (Figure 2). A regression line was plotted according to standard methods (e.g. Pielou 1974) and the correlation coefficient (r) was computed for the graph and used to further compute a coefficient of determination as $100r^2$. The $100r^2$ value was 82. Schmelz and Lindsey (1965) stated that values approaching 100 for the coefficient of determination are indicative of low disturbance thus 18% of the variation cannot be attributed to linearity. The past history of the forest is not known, but some unnatural disturbance (e.g. grazing and/or logging) is suggested by the $100r^2$ value and the presence of Ailanthus altissima (tree-of-heaven) although this alien was of minor importance.

Small scale natural disturbance was fairly frequent as reflected by standing dead and overthrown trees. These types of natural disturbances were found in 28% of the plots sampled. Thirteen individual trees were involved in producing the canopy openings or gaps with beech as the major gap-producing species.

Overall tree species diversity was 2.18. When only canopy trees were considered H' = 2.48 and subcanopy diversity was 1.06. The latter value indicates the dominance of one species, sugar maple, in the subcanopy.

Sugar maple was the only tree species found in each of the 5 seedling-sapling size classes (Table 3). Thirteen of the 15 tree species were represented in at least the seedling stage indicating reproduction by the canopy members. Beyond the seedling stage mortality was extremely high.

Asimina triloba (pawpaw) was the dominant shrub, both in terms of numbers and presence in the sapling class. Pawpaw appeared to be the most abundant species in gaps. Introduced shrubs, especially Lonicera tartarica (bush honeysuckle), were present and point to past disturbance.

During the sampling period soil moisture averaged 51.09% and soil pH 6.5. The soil moisture range was fairly wide (20-68%) and may reflect the influence and difference in the two soils present.

Discussion

The Winton Woods forest is a beech-maple stand with major contribution by white ash. This agrees with Sears (1925) who found that in the typical presettlement beech-sugar maple there was a sprinkling of white ash and red oak.

Braun (1950) considered the beech-maple region to be entirely within the area covered by the last or Wisconsin ice sheet. In Indiana, Lindsey, et al. (1965) found beech-maple to extend well south of the Wisconsin glacial limits onto Illinoian terrain. The Winton Woods forest is on Illinoian deposits and is in the vicinity of beech-maple mapped by Diehl (1933) for Hamilton County.

Vankat, et a. (1975) gave a thorough review of the literature on the southern beech-maple. They pointed out that many writers have considered the southern beech-maple to be successional in nature, but they considered Hueston Woods to be typical beech-maple. The coefficient of similarity between Hueston Woods and Winton Woods is

≈76%. Bray and Curtis (1957) suggested that replicate samples of the same forest probably would have values ≈ 80-85%.

Held and Winstead (1975) suggested that basal area of 30 m^2/ha be regarded as an indicator of old-growth forests in the Midwest. The basal area at Winton Woods is 28.85 m^2/ha which closely approaches the 30 m^2 suggested.

At Hueston Woods, Vankat, et al. (1975) distinguished between closed and open forest. The open forest was primarily those areas in gaps and Runkle (1981, 1982) extensively studied gaps at Hueston Woods and elsewhere. In his studies, Runkle found that regeneration in small gaps was sufficient to perpetuate the current canopy species composition. More detailed work on this phenomenon at Winton Woods is needed. Vankat, et al. (1975) found low replacement for beech in the closed forest, but greater replacement in the canopy gaps and for that reason considered beech to be maintaining itself. At Hueston Woods and Winton Woods, sugar maple was clearly the dominant seedling-sapling species. Curtis (1959) reported that in Wisconsin, sugar maple benefits from release and from its dominant subcanopy position at Winton Woods sugar maple is in best position to occupy the gaps. The species that appeared to be the initial invader of gaps at Winton Woods was pawpaw, however, this will undoubtedly be a temporary dominance since pawpaw is a shrub or small tree, never a canopy member.

The major gap-producing tree at Winton Woods is beech. Romme and Martin (1982) found beech to be the major gap-producer at Lilley Cornett Woods, Kentucky with beech falls being more frequent than would be estimated by its relative density. This could also be said at Winton Woods based on relative density, however, based on canopy percentages could be expected. It seems probable that the

high incidence of gaps due to overthrow can be attributed to the soils. Root growth in the Rossmoyne silt loam is restricted to the area above the fragipan and the perched high water table in winter creates the high potential for frost action (Lerch, et al. 1982). The buckling and loosening of the soil around the shallow rooted species, especially beech (Braun 1936b), combined with wind action could be the major contributors to the overthrow. Romme and Martin (1982) found a higher incidence of tree breakage than overthrow, but these appeared to be about equal at Winton Woods.

Although Braun (1950) suggested that beech-maple is a stage in the climatic succession leading to the establishment of a mixed mesophytic climax where dissection has modified the otherwise flat topography, the similarity of Winton Woods to Hueston Woods would seem to imply beech-maple. The similarity to the Pawpaw Ridge section of Caldwell Park, Hamilton County, Ohio is $\approx$ 66% (Bryant and Roschke unpub.). Caldwell Park is a mixed mesophytic forest or a beech-maple segregate of the mixed mesophytic and has high species diversity (H' = 3.35). Monk (1967) used Braun's (1950) tables for the Beech-Maple Forest Region and calculated a H' value of 2.36 ± .19. The overall species diversity of 2.18 falls near the lower portion of this range, but the canopy H' of 2.48 is near the upper limits.

It can be concluded that the Winton Woods forest is an old-growth stand that may have experienced some unnatural disturbance in the past, but is in the long-term process of recovery. Natural disturbance produced by overthrow and standing dead trees is a part of the dynamics of forest communities. In general, the seedling-sapling layer is composed of the canopy species. The forest is moving

toward a dynamic stability. Other forests in the immediate vicinity should be investigated and compared to the Winton Woods forest to determine more about the status of beech-maple south of the Wisconsin glacial limits.

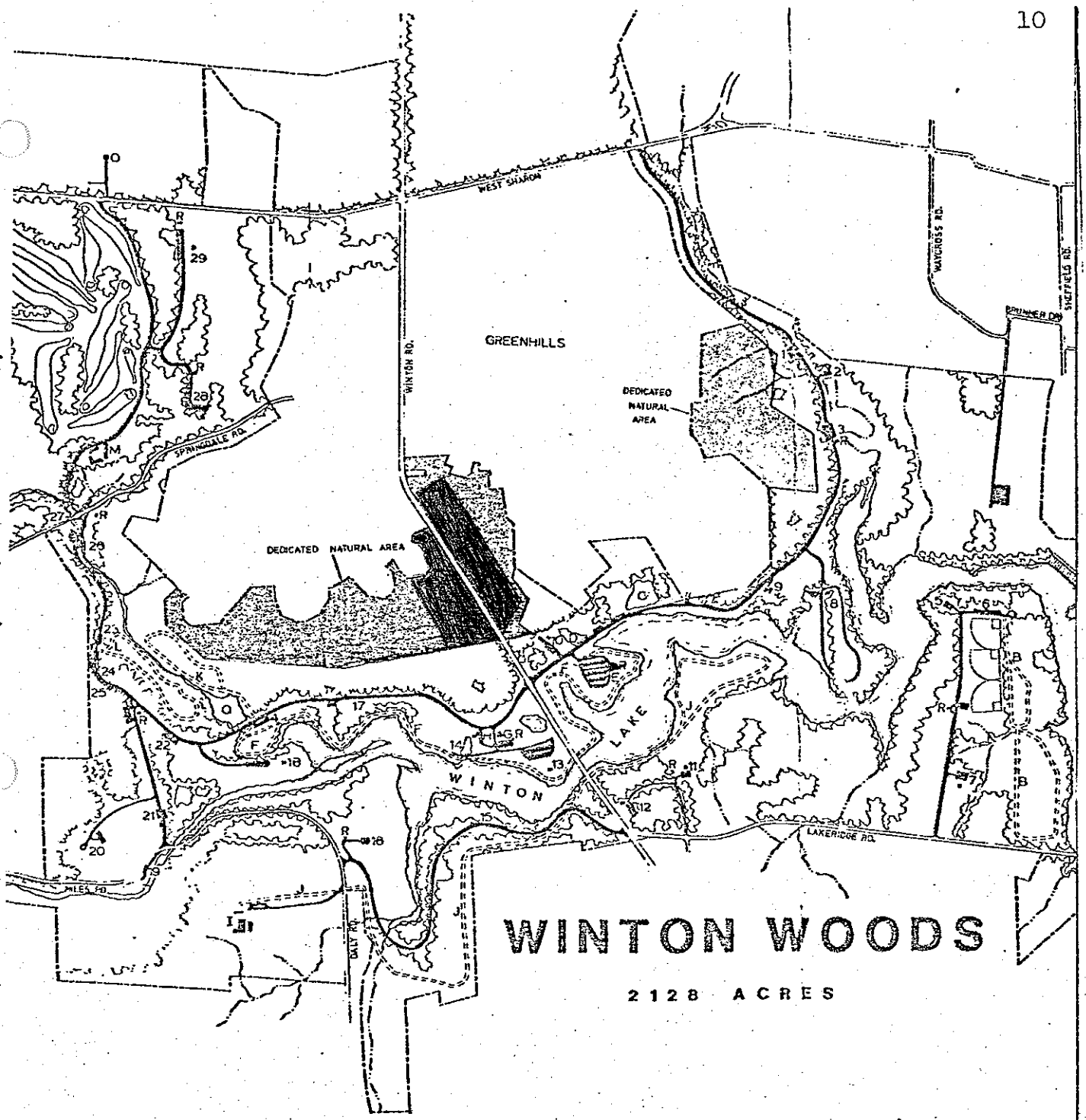

Figure 1. The location of the Winton Woods Forest, Hamilton County, Ohio. The study area is marked with red.

Table 1. The number (N), relative frequency (RF), relative density (RD), relative dominance (RDo), and importance value (IV) for all tree species at Winton Woods Forest, Hamilton County, Ohio.

	N	RF	RD	RDo	IV
Acer saccharum	162	29.25	52.09	19.91	101.25
Fagus grandifolia	61	21.70	19.61	34.86	76.17
Fraxinus americana	48	16.98	15.43	27.02	59.43
Prunus serotina	10	8.49	3.22	5.24	16.95
Juglans nigra	6	5.66	1.93	3.79	11.38
Ulmus rubra	5	4.72	1.61	1.06	7.39
Quercus alba	5	1.89	1.61	2.54	6.08
Nyssa sylvatica	3	1.89	0.96	1.67	4.52
Quercus rubra	2	1.89	0.64	0.93	3.46
Celtis occidentalis	3	1.89	0.96	0.35	3.20
Ulmus americana	2	1.89	0.64	0.56	3.09
Ailanthus altissima	1	0.94	0.32	1.03	2.29
Carya cordiformis	1	0.94	0.32	0.88	2.14
Ostrya virginiana	1	0.94	0.32	0.10	1.36
Cornus florida	1	0.94	0.32	0.04	1.30
Totals	311	100.01	99.98	99.98	299.97

Table 2. A comparison of the composition and trees/hectare (t/ha) for canopy trees (≥12 inch dbh) and subcanopy trees (≥4 <12 inch dbh) for the Winton Woods Forest, Hamilton County, Ohio.

	Canopy		Subcanopy	
	%	t/ha	%	t/ha
Fagus grandifolia	32.43	37.05	7.98	10.04
Acer saccharum	17.59	20.07	83.44	104.98
Fraxinus americana	31.08	35.51	1.23	1.55
Prunus serotina	5.41	6.18	1.23	1.55
Juglans nigra	4.05	4.63	0	0
Ulmus rubra	1.35	1.54	1.84	2.31
Quercus alba	2.70	3.08	0.61	0.77
Quercus rubra	1.35	1.54	0	0
Nyssa sylvatica	2.03	2.32	0	0
Celtis occidentalis	0	0	1.84	2.31
Ailanthus altissima	0.68	0.78	0	0
Ulmus americana	0.68	0.78	0.61	0.77
Carya cordiformis	0.68	0.78	0	0
Ostrya virginiana	0	0	0.61	0.77
Cornus florida	0	0	0.61	0.77

Figure 2. Plot of trees in 4 inch (10 cm) dbh size classes using size class midpoints. Comparison is made to the regression line.

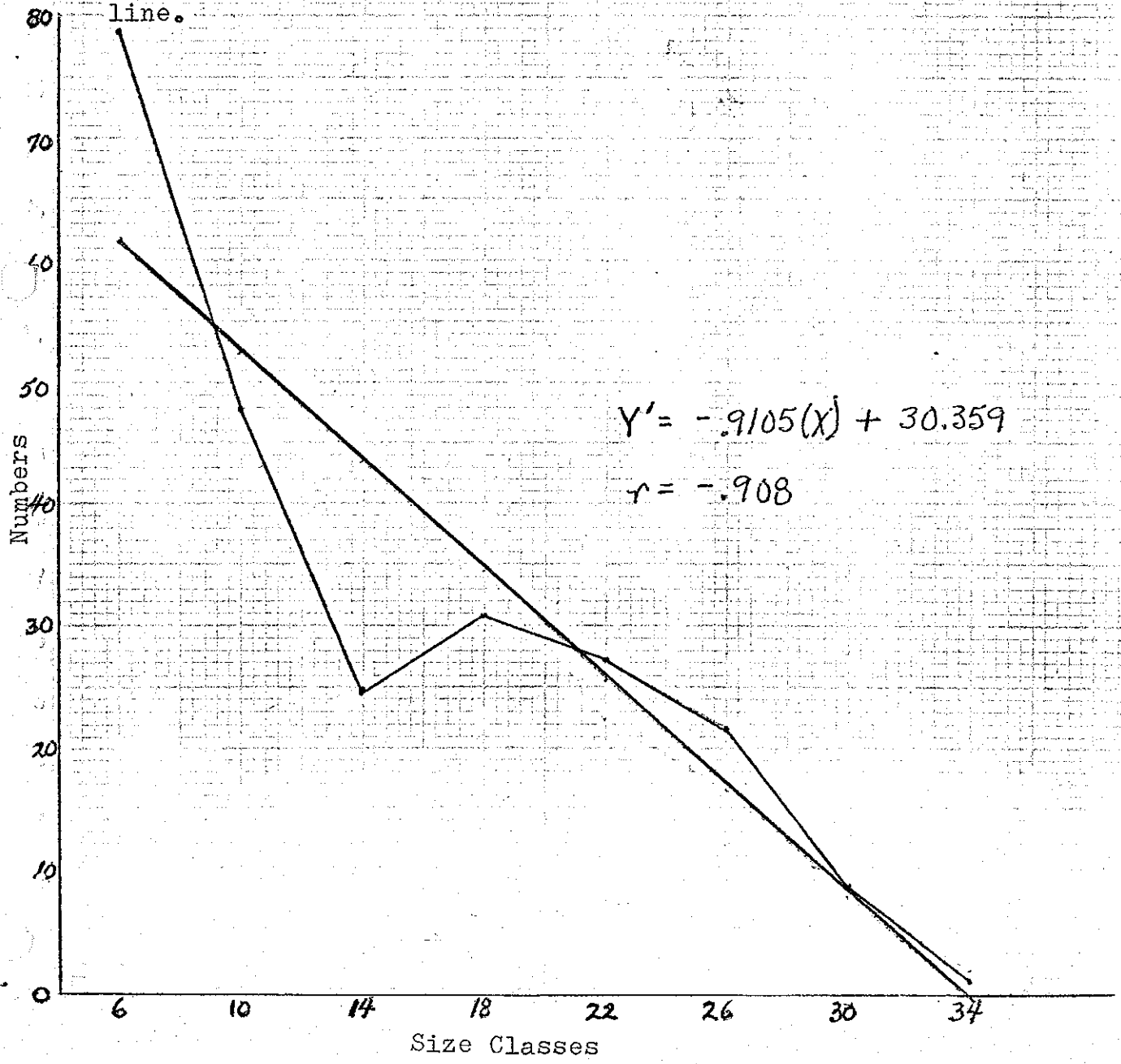

Table 3. Seedlings-saplings and shrubs per hectare at the Winton Woods Forest, Hamilton County, Ohio.

	Seedlings		Saplings		
Size class	1	2	3	4	5
Acer saccharum	8085.13	82.33	309.60	98.80	46.10
Prunus serotina	1547.86	16.46			
Fraxinus americana	823.33				
Fagus grandifolia	32.93		6.59		
Ulmus rubra	889.20	32.93	52.69		
Cornus florida	230.53		6.59		
Quercus rubra	49.40				
Carya cordiformis	115.27				
Nyssa sylvatica	65.87				
Ulmus americana	32.93				
Celtis occidentalis	98.80				
Morus rubra	16.46				
Aesculus octandra		16.46	6.59		
Ostrya virginiana		16.46	6.59	6.59	
Pyrus sp.	16.46				
Ailanthus altissima	16.46				
		Shrubs			
Asimina triloba	2437.07	49.40	46.11		
Lindera benzoin	98.80				
Rosa sp.	115.27				
Euonymus atropurpurea	16.46				
Sambucus canadensis	16.46				
Lonicera tartarica	115.27				
Viburnum sp.	32.93				
Rubus sp.	82.33				
Unidentified	32.93				

Literature Cited

Abrell, D.B. and M.T. Jackson. 1977. A decade of change in an old-growth beech-maple forest in Indiana. Amer. Midl. Nat. 98: 22-32.

Braun, E.L. 1916. The physiographic ecology of the Cincinnati region. Ohio Biol. Surv. 2: 115-211.

_____. 1917. The vegetation of conglomerate rocks of the Cincinnati region. Plant World 20: 380-392.

_____. 1921. Composition and source of the flora of the flora of the Cincinnati region. Ecology 2: 161-180.

_____. 1936a. Forests of the Illinoian till plain of southwestern Ohio. Ecol. Monogr. 6: 90-149.

_____. 1936b. Notes on root behavior of certain trees and shrubs of the Illinoian till plain of southwestern Ohio. Ohio J. Sci. 36: 141-146

_____. 1950. Deciduous Forests of Eastern North America. The Blakiston Co. Philadelphia, Pa. 596 pp.

_____. 1951. Plant distribution in relation to the glacial boundary. Ohio J. Sci. 51: 139-146.

_____. 1969. An ecological survey of the vegetation of Fort Hill State Memorial. Ohio Biol. Surv. (new series) 3: 1-134.

_____ and L. Jones. 1926. Ohio. pp. 354-372 in V.E. Shelford (ed.). Naturalist's Guide to the Americas. The Williams & Wilkins Co. Baltimore, Md. 761 pp.

Bray, J.R. and J.T. Curtis. 1957. Ordination of the upland forest communities of southern Wisconsin. Ecol. Monogr. 27: 325-349.

Cobbe, T.J. 1943. Variations in the Cabin Run Forest, a climax area in southwestern Ohio. Amer. Midl. Nat. 29: 89-105.

Curtis, J.T. 1959. The Vegetation of Wisconsin. Univ. Wisc. Press, Madison, Wisc. 657 pp.

Diehl, G.A. 1933. Forest types of Hamilton County, Ohio. M.S. thesis, Univ. Cincinnati. 20 pp.

Giesler, S. 1926. Soil reactions in relation to plant successions in the Cincinnati region. Ecology 7: 163-184.

Held, M.E. and J.E. Winstead. 1975. Basal area and climax status in mesic forest systems. Ann. Bot. 1147-1148.

Herrick, J.A. 1974. The natural areas project: A survey of data to date. Ohio Biol. Surv. Infor. Cir. 1. 60 pp.

Hoye, M.E., J.V. Perion and C.H. Perino. 1978. Secondary vegetation and successional sequences within Shawnee Lookout Park, Hamilton County, Ohio. Castanea 44: 208-217.

Irwin, N.M. 1929. The Cedar Cliffs Prairie opening of the Cincinnati region. Proc. Ohio Acad. Sci. Spec. Pap. 21: 203-233.

Lerch, N.K., W.F. Hale, and D.D. Lemaster. 1982. Soil survey of Hamilton County, Ohio. USDA, SCS. U.S. Govt. Print. Off. Washington, D.C. 217 pp.

Lindsey, A.A., W.B. Crankshaw and S.A. Qadir. 1965. Soil relations and distribution map of the vegetation of presettlement Indiana. Bot. Gaz. 126: 155-163.

Monk, C.D. 1967. Tree species diversity in the eastern deciduous forest with particular reference to north central Florida. Amer. Nat. 101: 173-187.

Pielou, E.C. 1974. Population and Community Ecology. Gordon and Breach Co. New York.

Romme, W.H. and W.H. Martin. 1982. Natural distrubance by tree-falls in an old-growth mixed mesophytic forest: Lilley Cornett Woods, Kentucky. in R.N. Muller (ed.). Central Hardwood Conference IV Proceedings. pp. 367-383.

Runkle, J.R. 1981. Gap regeneration in some old-growth forests of the

eastern United States. Ecology 62: 1041-1051.

_____. 1982. Patterns of disturbance in some old-growth mesic forests of eastern United States. Ecology 63: 1533-1546.

Schmelz, D.V. and A.A. Lindsey. 1965. Size-class structure of old-growth forests in Indiana. Forest Sci. 11: 258-264.

Sears, P.B. 1925. The natural vegetation of Ohio, I. A map of the virgin forest. Ohio J. Sci. 25: 139-149.

Thompson, I. 1939. Geographical affinities of the flora of Ohio. Amer. Midl. Nat. 21: 730-751.

Vankat, J.L., W.H. Blackwell, Jr. and W.E. Hopkins. 1975. The dynamics of Hueston Woods and a review of the question of the successional status of the southern beech-maple forest. Castanea 40: 290-308.

Withrow, A.P. 1932. Life forms and leaf size classes of certain plant communities of the Cincinnati region. Ecology 13: 12-35.