STRUCTURE AND COMPOSITION OF THE OLD-GROWTH FORESTS OF HAMILTON COUNTY, OHIO AND ENVIRONS[1/]

William S. Bryant[2/]

Abstract.--The old-growth forests preserved in the parks of Hamilton County, Ohio were systematically sampled. These forests were compared to those present at the time of settlement as reconstructed from the 1788 Symmes Purchase Survey. The present day forests compare favorably in composition and dominant species to those present at the time of settlement. The forests in the parks include mixed-mesophytic, beech-maple, sugar maple-oak (mixed hardwoods) and pin oak. In terms of basal area (m^2/ha), density (trees/ha), diversity (H'), and coefficient of determination ($100r^2$), the current forests represent some of the finest examples of old-growth remnants in the lower Midwest.

Keywords: presettlement forests, forest types, southwest Ohio

INTRODUCTION

The best examples of little-disturbed, old-growth forests in Hamilton County, Ohio are now found in its parks, preserves, and on the older estates. Although some of these scattered remnants have been variously mentioned in the literature, i.e. Braun and Jones (1926), Melvin (1970), Durrell (1970), and Herrick (1974), there have been few studies of their vegetation. Only Diehl's (1933) superficial study of county-wide vegetation, Braun's (1950) study of Ault Park, and the Hoye, et al. (1978) paper on succession at Shawnee Lookout Park have presented quantitative information. The fact that the parks have been preserved for a fairly long time and their forests protected from major human disturbance gives them great potential for study.

What is the structure and composition of the old-growth forests that now occupy the parks and are these forests comparable to those that covered Hamilton County at the time of settlement? Although the original survey notes for the Symmes Purchase of 1788, most of which is Hamilton County, have long been available for study, these have not been used for vegetational reconstruction. Sears (1925) used General Land Office data in the preparation of his map of the virgin forests of Ohio, however, the records for the lower portion of the Symmes Purchase were not available to him in a form suitable for his analysis. A more recent map and discussion of Ohio's vegetation during pioneer times (Gordon 1966, 1969) made use of more recent literature in those interpretations. Neither Sears nor Gordon cited Dr. Daniel Drake's (1815) book on the Cincinnati area which contained a short section on the botany of the Miami Country (the Symmes Purchase). By his own admission, Drake recognized his limitations as a botanist, yet his catalogue and lists of the dominant trees in the forests at that time are rather thorough.

Over 100 years elapsed following the publication of Drake's book and the beginnings of Dr. E. Lucy Braun's botanical and ecological studies in southwest Ohio. In a number of papers, Braun (1916, 1917, 1921, 1935, 1936a, 1936b, 1950, 1951, 1969) and her students: Giesler (1926), Segelken (1929), Irwin (1929), Withrow (1932), Diehl (1933), Thompson (1939) and Cobbe (1943) reported on various aspects of the flora and vegetation. These papers were largely descriptive and not designed to give detailed quantitative information on the structure and dynamics of the vegetation. It seems unusual that so little mention of the parks was made by the above investigators especailly in view of the fact that the city of Cincinnati had been quite farsighted in setting aside parklands. In fact, the 1907 Kessler Plan for Parks and Parkways served as Cincinnati's first comprehensive plan and was in effect for over 40 years (Hurley 1982). This plan recommended the development of several parks throughout the city to take advantage of the natural hillside vistas of the basin of the Ohio River.

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2/Professor and Chairman, Biology Department, Thomas More College, Crestview Hills, KY 41017

This paper reports on my studies to try and determine the following: (1) What is the structure and composition of the old-growth forests of the parks and preserves? (2) What was the original vegetation of Hamilton County as revealed by the 1788 Symmes Purchase Survey field notes and by Drake's early writings? (3) How do the forests that now occupy the parks compare to those in 1788? and (4) How do the current forests compare to those mentioned by Braun and her students for southwest Ohio and to those in adjacent states?

Fourteen forested sites were visited and from those sampled the 6 that best represent the vegetational complex in the county were selected for presentation here (Fig. 1). Three of the forests are in the Cincinnati Park system, 2 in the Hamilton County Park District, and one is on the Ohio River floodplain in Campbell County, Kentucky. The latter was selected for inclusion because it was originally cited by Braun (1916) as being the largest and best example of a depression forest in the Cincinnati Region. The two smaller depression forests that she mentioned for Hamilton County are no longer extant.

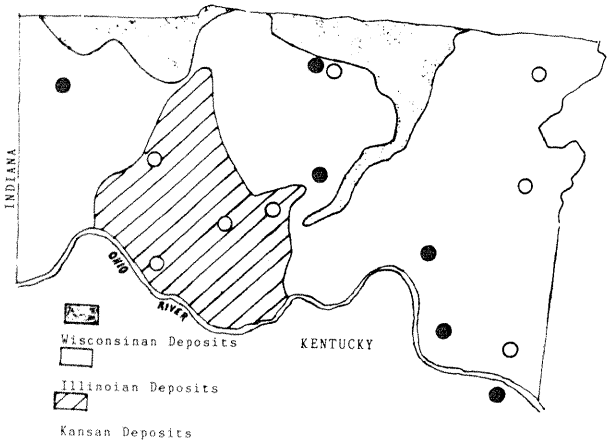

Figure 1.--The location of the forests sampled in Hamilton County, Ohio and an outline of the major glacial deposits. Solid circles are those forests reported in this paper.

The Environment

Hamilton County is about 107,350 hectares in size and is located in extreme southwestern Ohio. It is bordered on the West by southeastern Indiana and on the South by the Ohio River and adjacent northern Kentucky. Fenneman (1916) placed Hamilton County in the Till Plains section of the Central Lowland Physiographic Province but found it to be less typical of the Till Plains in Ohio and Indiana because of its proximity to important drainage lines where small tributary valleys are numerous and deep. Within the county are deposits of Kansan, Illinoian and Wisconsin glacial materials (Ray 1974) which overlie the bedrock of limestone and calcareous shale of Ordovician age.

The main local physiographic features are gently rolling glacial uplands, steep hillsides along the major streams, extensive glacial river terraces and outwash plains, and floodplains (Lerch, et al. 1982). Relief in the county varies from 293 m to 139 m. Stream dissection has produced many deep steep-sided valleys on the glacial deposits and exposed the underlying bedrock (Forsyth 1970). The soils reflect the glacial and erosional history of the county (Lerch, et al. 1982).

The forest sites selected for detailed analysis are reflective of the soils, geology and topography of Hamilton County and exemplify the habitat diversity:

Ault Park forest is located on a north-facing slope cut by a number of short ravines. Soils are the Pate silty clay loam, a colluvial soil, and the Eden silty clay loam on the upper slopes.

California Woods Nature Preserve is on a dissected outwash terrace near the junction of the Little Miami and Ohio Rivers. Soils are the Casco loam, Princeton sandy loam, Bonnell silt loam, Cincinnati silt loam, and Eden silty clay loam.

Caldwell Park is an upland slope forest in the Mill Creek Valley and is cut by many steep-sided ravines. The Cincinnati silt loam and Bonnell silt loam are the dominant soils.

Winton Woods (Greenbelt Forest) is a rolling to flat upland dotted with a few sinkholes. Soils are the Rossmoyne silt loam which is underlain by a fragipan and the Bonnell silt loam.

Bowles Woods of the Miami-Whitewater Forest consists of a ridge and slope complex. The soils include the Cincinnati silt loam and the Eden silty clay loam. In places the Ordovician limestone bedrock outcrops and sinkholes are abundant.

Melbourne Forest appears to be a flat plain on the Ohio River floodplain and experiences ponding and seasonally poor drainage. The soil mosaic includes the Newark, Avonburg, and Rossmoyne soils which are poorly drained and the Wheeling and Ashton soils which are well-drained and formed from recent alluvium (Weisenberger, et al. 1973).

The climate of Hamilton County is continental with cold winters and hot summers. The average winter temperature is 0.5 C and the average summer temperature is 23 C (Lerch, et al. 1982). Annual precipitation is 101.6 cm with 53% of that falling during the growing season.

METHODS

The vegetation of the selected forests was sampled in 0.04 hectare circular plots randomly spaced throughout the forests, except for Melbourne where 0.07 ha plots were employed. All trees $\geq$10 cm at diameter-breast-height (dbh) were measured within the plots. Data for each forest were analyzed to relative frequency, relative density, relative dominance and importance value. Trees were considered to be canopy ($\geq$30 cm dbh) and subcanopy ($\geq$10 cm dbh <30 cm dbh) following Abrell and Jackson (1977).

Density (trees/ha), basal area (m^2/ha), and species diversity (H') were determined for each forest. Species diversity patterns were calculated using the Shannon-Wiener index: $H' = -\sum_{i=1}^{S} p_i \log_2 p_i$, where S is the number of species and p_i is the

proportion of each species in the forest (Shannon and Weaver 1949). Stem counts were plotted against their size classes on semilog paper and a regression line was fitted to the plotted data using the methods of Schmelz and Lindsey (1965). The coefficient of determination ($100r^2$), which defines how much the variation of the dependent variable (density) is accounted for by the variation of the independent variable (diameter), was used as an index of the degree of past disturbance of the stand structure still detectable at the time of study, a high value indicating little disturbance (Schmelz and Lindsey 1965).

The original field notes for the 1788 Symmes Purchase survey were obtained from the Cincinnati Historical Society. The trees listed by the surveyors were tabulated and their percentages in the overall forest determined. No attempt was made to locate the original trees in the field.

RESULTS

Vegetational Reconstruction

Because the 1788 survey of the Symmes Purchase was on private lands it was not laid off in townships nor did it follow the rectangular plan (Bourdo 1956). The surveyors recorded trees as landmarks and in their notes made some brief descriptions of the landscape. Only one portion of the survey, that along the Ohio River, failed to list the trees present. A total of 651 trees was included in the survey (Table 1). Species in the genera Quercus, Acer, Fraxinus, Fagus and Carya were clearly the dominants. Sugar maple (Acer saccharum) was the most commonly mentioned species followed by white oak (Quercus alba), hickory (Carya spp.) and beech (Fagus grandifolia). Ulmus, Juglans, Aesculus, and Celtis were major associates. The surveyors noted that "swamps", "wetlands" and "bottoms" were present as well as sinkholes, Indian fortifications and one prairie.

Twenty-seven years after the Symmes survey, Drake (1815) wrote, "The beech, white oak, sugar tree and some kinds of walnut, hickory and ash, are the most numerous of any trees in the Miami country." He further wrote, "the most valuable timber trees are the white flowering locust, white, black, lowland chestnut and bur oaks, black walnut, wild cherry, yellow poplar, blue and white ash, mulberry, honey locust, shell bark hickory, coffee nut and beech; all of which, except the first, are common throughout the Miami country. Many other species, such as the sweet buckeye, sassafras, sugar tree, linden tree and boxelder are seldom used for timber.....The most elegant flowering trees and shrubs are the following, which excel in the order of their enumeration: dogwood, red bud, white flowering locust, crab apple, honeysuckle, black haw, the different species of roses, plumbs and haws, the buckeyes and yellow poplar; most of which are common, and for that reason are seldom transplanted into our streets and gardens."

Table 1.--Percentage composition of the forests of the Symmes Purchase based on the 1788 surveyors' field notes. Tree names are those listed in the survey.

Species	%	Species	%
Quercus		Gleditsia	
a/White oak	14.90	Honey locust	0.61
Pin oak	0.15	Robinia	
Black oak	4.15	Locust	1.38
Swamp oak	0.15	Ulmus	
Red oak	0.31	g/Elm	4.45
Oak	0.46	Celtis	
	20.12	Hackberry	2.00
Acer		Platanus	
Sugar tree	16.59	Sycamore	1.38
b/Maple	1.38	Tilia	
Boxelder	0.46	h/Basswood	0.46
	18.43	Liquidambar	
Fagus		Gum	0.15
Beech	12.75	Nyssa	
Fraxinus		Pepperage	0.31
White ash	4.61	Betula	
Blue ash	3.69	Birch	0.15
c/Ash	4.30	Ostrya or Carpinus	
Hoop ash	1.38	Ironwood	0.77
Black ash	0.15	Viburnum	
	14.13	Black haw	0.15
Carya		Morus	
d/Hickory	14.90	Mulberry	0.46
Juglans		Staphylea	
Black walnut	1.08	Bladdernut	0.15
White walnut	0.77	Cornus	
e/Walnut	1.38	Dogwood	0.77
	3.23	Boxwood	0.15
Aesculus			0.92
f/Buckeye	3.07		

a/May include Chinquapin oak.
b/Probably includes Red and Silver maples.
c/May include Green ash.
d/No distinction is made to species, but Shagbark, Pignut, and Bitternut occur in Hamilton County.
e/Probably is Black walnut.
f/Includes both Yellow and Ohio buckeyes.
g/Probably includes American and Slippery elms.
h/May include White and American basswoods.

Forests of the Parks and Preserves

The results of the investigations of the forests of the parks and preserves are presented in Tables 2-7.

Ault Park

In 1926, Braun and Jones described the Ault Park forest as a "fairly good beech forest" and they further noted that the undergrowth was considerably destroyed through recreational activities and "park improvements". Later, Braun (1950) in a more

detailed account described this as a mixed mesophytic forest essentially like those of the Mixed Mesophytic Forest Region since Aesculus octandra and Tilia heterophylla were among the dominants.

A total of 570 trees, representing 21 species, was recorded from the 45 sampling plots. Sugar maple had the highest importance value (IV 78.05) followed by white basswood (Tilia heterophylla), white ash (Fraxinus americana), beech (Fagus grandfolia), and yellow or sweet buckeye (Aesculus octandra) (Table 2). Those 5 species accounted for nearly 80% of the basal area. The combination of dominants and their associates is characteristic of the mixed mesophytic forest association and is in agreement with the conclusions of Braun (1950). Basal area totalled 34.27 m^2/ha and density 313 trees/ha (Table 8).

Table 2.--Relative frequency (RF), relative density (RD), relative dominance (RDo) and importance value (IV) of tree species at Ault Park, Hamilton County, Ohio.

Tree species	RF	RD	RDo	IV[a/]
Acer saccharum	21.03	44.04	12.98	78.05
Tilia heterophylla	15.42	15.79	21.12	52.33
Fraxinus americana	11.21	8.42	18.26	37.89
Fagus grandifolia	10.75	6.14	18.41	35.30
Aesculus octandra	10.28	8.77	7.48	26.53
Quercus rubra	3.74	3.68	5.40	12.82
Juglans nigra	4.67	1.75	4.23	10.65
Celtis occidentalis	5.14	2.63	2.53	10.30
Carya cordiformis	3.27	1.58	0.99	5.84
Ulmus rubra	2.34	1.23	1.64	5.21

a/ Species with IV <5.00 are Prunus serotina, Fraxinus quadrangulata, Quercus shumardii, Q. macrocarpa, Q. velutina, Q. muehlenbergii, Robinia psdudoacacia, Ailanthus altissima, Ulmus americana, Acer negundo, and Cercis canadensis.

California Woods Nature Preserve

The forest of the California Woods Nature Preserve, a.k.a. Cincinnati Water Works Woods, was described as a climax deciduous forest (Braun and Jones 1926) and as mixed mesophytic (Durrell 1970). This is undoubtedly the forest that Braun (1916) described as her second stage ravine community as part of a successional sequence in ravine development.

There was a total of 407 trees representing 20 species in the 31 sampling plots. Sugar maple (IV 77.66), beech (IV 42.29), tulip poplar (Liriodendron tulipifera, IV 35.27), yellow buckeye (IV 20.61), red oak (Quercus rubra, IV 16.36), and hackberry (Celtis occidentalis, IV 14.06) were the leading dominants in this mixed mesophytic community (Table 3). Basal area was highest of any forest sampled at 39.16 m^2/ha and density totalled 324 trees/ha (Table 8).

Table 3.--Relative frequency (RF), relative density (RD), relative dominance (RDo) and importance value (IV) of tree species at California Woods Nature Preserve, Hamilton County, Ohio.

Tree species	RF	RD	RDo	IV[a/]
Acer saccharum	19.02	42.65	17.59	79.26
Fagus grandifolia	11.66	10.54	20.09	42.29
Liriodendron tulipifera	7.98	7.84	19.45	35.27
Aesculus octandra	9.20	6.62	4.79	20.61
Quercus rubra	5.52	3.19	7.65	16.36
Celtis occidentalis	6.75	4.90	3.96	15.61
Fraxinus americana	6.13	3.43	4.50	14.06
Tilia heterophylla	4.91	3.92	4.12	12.95
Carya cordiformis	4.91	3.92	4.05	12.88
Prunus serotina	4.29	2.94	3.80	11.03
Juglans nigra	3.68	2.70	2.78	9.16
Platanus occidentalis	1.23	1.23	3.55	6.01
Quercus muehlenbergii	2.45	1.23	1.37	5.05

a/ Species with IV<5.00 are Q. alba, Ulmus rubra, Cornus florida, Carya ovata, Carpinus caroliniana, Robinia pseudoacacia, and Nyssa sylvatica.

Caldwell Park

Caldwell Park has been referred to as a mixed mesophytic climax forest on a dissected Illinoian glacial terrace (Durrell 1970) and as a wild virgin woodland (Melvin 1970). A total of 234 trees in 29 plots was measured in this forest. This is a beech-maple segregate of the mixed mesophytic forest with beech and sugar maple nearly equal in IV, 68.24 and 66.67, respectively (Table 4). Their associates include tulip poplar, black cherry (Prunus serotina), white ash, hackberry, American elm (Ulmus americana), and white oak (Q. alba). Density (199 trees/ha) was lowest of any forest sampled which contributed to a lower basal area (26.05 m^2/ha), however, species diversity was high (Table 8).

Table 4.--Relative frequency (RF), relative density (RD), relative dominance (RDo) and importance value (IV) of tree species at Caldwell Park, Hamilton County, Ohio.

Tree species	RF	RD	RDo	IV[a/]
Fagus grandifolia	17.55	15.81	34.88	68.24
Acer saccharum	20.61	34.62	11.44	66.67
Liriodendron tulipifera	7.63	4.70	17.90	30.23
Prunus serotina	8.40	9.83	9.45	27.68
Fraxinus americana	5.34	5.13	6.52	16.99
Celtis occidentalis	6.87	5.13	4.02	16.02
Ulmus americana	4.58	2.99	4.45	12.02
Quercus alba	5.34	2.99	2.87	11.20
Quercus rubra	3.05	2.14	3.74	8.93
Asimina triloba	2.29	4.70	0.43	7.42

a/ Species with IV <5.00 are Aesculus octandra, Ulmus rubra, Cornus florida, Carya cordiformis, Ailanthus altissima, Quercus muehlenbergii, Q. macrocarpa, Fraxinus quadrangulata, Juglans nigra, Tilia heterophylla, Cercis canadensis, Acer negundo, and Nyssa sylvatica.

Winton Woods (Greenbelt Forest)

The forest at Winton Woods has been variously described as a climax beech woods and as a mixed mesophytic climax woods (Durrell 1970). A total of 311 trees in 32 plots was sampled here. Based on the low species diversity relative to mixed mesophytic stands, the Winton Woods forest is beech-maple (Table 8). There was a total of 15 species and 240 trees/ha in the forest with sugar maple (IV 101.25), beech (IV 76.17), and white ash (IV 59.43) clearly the dominant species (Table 5). Of the 28.85 m^2/ha basal area, 82% was contributed by beech, ash, and maple. This forest had the lowest $100r^2$ value indicating that some influence of past disturbance is still detectable.

Bowles Woods of the Miami-Whitewater Forest

Melvin (1970) stated that the Bowles Woods is the nearest approach to a virgin beech forest found in southwest Ohio, yet Durrell (1970) noted that large areas of mixed mesophytic forest occur here. Forty plots with a total of 452 trees was sampled. Bowles Woods may best be described as a sugar maple-oak or mixed hardwood forest. Collectively, the oaks and hickories (IV 87.61) rank second to sugar maple (IV 131.98) (Table 6). Aspect influences species

Table 5.--Relative frequency (RF), relative density (RD), relative dominance (RDo) and importance value (IV) of tree species at Winton Woods (Greenbelt), Hamilton County, Ohio.

Tree species	RF	RD	RDo	IV[a/]
Acer saccharum	29.25	52.09	19.91	101.25
Fagus grandifolia	21.70	19.61	34.86	76.17
Fraxinus americana	16.98	15.43	27.02	59.43
Prunus serotina	8.49	3.22	5.24	16.95
Juglans nigra	5.66	1.93	3.79	11.38
Ulmus rubra	4.72	1.61	1.06	7.39
Quercus alba	1.89	1.61	2.54	6.04

a/ Species withIV<5.00 are Nyssa sylvatica, Quercus rubra, Celtis occidentalis, Ulmus americana, Carya cordiformis, Ailanthus altissima, Cornus florida, and Ostrya virginiana.

distributions in this forest with oaks and hickories being most prominent on the W-facing slope and beech confined to the E-facing areas. Lumping of the data for the forest obscures these differences. Canopy diversity was relatively high, but subcanopy diversity was the lowest of any forest sampled pointing out the near total dominance of one species, sugar maple (Table 8).

Melbourne Forest

Braun (1916) noted that in the Cincinnati Region, "the depression forest is an uncommon type occurring in undrained situations on the floodplain and that its trees, pin oak, swamp white oak, and red maple, are most typical of these undrained situations". She further wrote that the largest depression forest was the Melbourne Forest and that here the trees were of different ages and diameter classes, with some of the pin oaks being especially large. A total of 416 trees in 15 plots was taken in this stand. Of the 17 tree species recorded from the plots, pin oak (Q. palustris, IV 86.09) is still the dominant species. Its associates include red maple (A. rubrum), ash (F. americana and F. pennsylvanica), slippery elm (U. rubra), tulip poplar, boxelder (A. negundo) and black cherry (Table 7). Density was the highest of any forest sampled which may have contributed to the high basal area (Table 8). Subcanopy diversity was higher than for the canopy which may indicate some change in composition is occurring, however, the $100r^2$ was the highest of any of the forests sampled (Table 8).

Table 6.--Relative frequency (RF), relative density (RD), relative dominance (RDo) and importance value (IV) of tree species at Bowles Woods of the Miami-Whitewater Forest, Hamilton County, Ohio.

Tree species	RF	RD	RDo	IV[a/]
Acer saccharum	28.57	68.14	35.27	131.98
Fraxinus americana	15.00	7.96	19.72	42.68
Quercus rubra	10.00	6.86	13.42	30.28
Quercus rubra	7.14	2.65	7.96	17.75
Carya ovata	8.57	2.88	3.93	15.38
Fagus grandifolia	5.00	2.65	3.86	11.51
Quercus velutina	3.57	1.33	4.49	9.39
Prunus serotina	4.29	1.55	2.91	8.75
Ulmus rubra	4.29	1.55	2.62	8.46
Quercus muehlenbergii	3.57	1.11	1.47	6.15

a/ Species with IV<5.00 are *Carya glabra*, *Carya cordiformis*, *Fraxinus quadrangulata*, *Ostrya virginiana*, and *Juglans nigra*.

Table 7.--Relative frequency (RF), relative density (RD), relative dominance (RDo) and importance value (IV) of tree species at the Melbourne Forest, Campbell County, Kentucky.

Tree species	RF	RD	RDo	IV[a/]
Quercus palustris	12.37	26.68	47.04	86.09
Acer rubrum	12.37	19.95	11.84	44.16
Fraxinus americana and *F. pennsylvanica*	12.37	13.94	8.61	34.92
Ulmus rubra	13.40	13.22	5.85	32.47
Liriodendron tulipifera	8.25	5.05	11.33	24.63
Acer negundo	13.40	7.21	3.36	23.97
Prunus serotina	6.19	3.13	4.14	13.46
Celtis occidentalis	4.12	1.92	1.33	7.37
Robinia pseudoacacia	4.12	1.44	1.07	6.63
Platanus occidentalis	3.09	2.40	0.73	6.22
Quercus bicolor	3.09	1.20	1.53	5.82

a/ Species with IV<5.00 are *Sassafras albidum*, *Fagus grandifolia*, *Gleditsia triacanthos*, *Carya* sp., and *Ulmus americana*.

Species Diversity

In general, diversity was highest in the mixed mesophytic stands especially for the canopy (H' = 3.16, 3.24, and 3.64). Canopy diversity was higher than for that of the subcanopy in all forests except for the pin oak stand. The lower subcanopy diversity for the upland stands reflects the major role of the shade-tolerant sugar maple in that stratum.

Table 8.--Density (trees/ha), basal area (m^2/ha), diversity (H') and coefficient of determination ($100r^2$) for 6 selected forests in Hamilton County, Ohio.

Forest	Trees/ha	BA/ha	H' Canopy	H' Subcanopy	H' Total	$100r^2$
Ault Park	313	34.27	3.24	1.94	2.83	97
California Woods	324	39.16	3.64	2.03	3.11	92
Caldwell Park	199	26.07	3.16	2.71	3.35	91
Winton Woods	240	28.85	2.48	1.06	2.18	72
Bowles Woods	279	32.19	2.78	0.43	1.94	90
Melbourne Forest	396	30.91	2.60	2.98	3.07	99

Regression Analysis

A regression line was plotted for each forest using the methods of Schmelz and Lindsey (1965) including the log transformation. The coefficient of determination for all forests except Winton Woods exceeded 90% indicating that these stands are relatively free of major disturbances or had nearly recovered from any past perturbations (Table 8).

DISCUSSION

The climax forest 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 southwest 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), or oak-sugar maple (Gordon 1966, 1969), and willow-cottonwood-soft maple (Diehl 1933). Gordon (1966, 1969) recognized a mixed mesophytic western type for Hamilton County which is after Braun's (1950) western mesophytic type. Forsyth (1970) noted that the presence of till and gravel and dissection exposing bedrock has created many different microenvironmental differences due to variation in slope and soil conditions and substrates. Thus in the valleys the

tree association is best mapped as mixed mesophytic, but the clayey shale may create both dry and wet environments which restrict certain plants (Forsyth 1970). Mixed mesophytic forests are fairly widespread in Hamilton County in areas of intermediate edaphic conditions (Withrow 1932) and are prominent in the areas of Kansan glacial outwash deposits in northern Kentucky (Bryant 1978).

In general, the forests now present in the parks are little disturbed as judged by their $100r^2$. Indeed, the coefficients of determination for all forests with the exception of Winton Woods are comparable to the best examples of climax forests in Indiana (Schmelz and Lindsey 1965). The Winton Woods forest has not recovered thoroughly from some past disturbance, but more likely, small scale natural disturbances serve to keep this forest in a perturbed condition. Gaps caused by overthrown trees were found in 28% of the plots there and these gaps may be partially attributed to the soil. 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 on these till plain soils (Braun 1936b) combined with wind action contribute to the overthrow.

In terms of density and basal area all of the forests approach or exceed the $\approx$300 trees/ha (Martin 1983) and the 30 m^2/ha (Held and Winstead 1975) suggested for climax forests in the Midwest. Diversity followed Monk's (1967) findings and is highest in the mixed mesophytic stands followed by the mixed hardwoods and then beech-maple. The pin oak type was not considered by Monk, but diversity was high. Subcanopy diversity was lower than canopy diversity in all forests except for pin oak. Apparently some changes are occurring in the Melbourne Forest that need to be determined. Otherwise, the low subcanopy diversity can be attributed to the dominance in this stratum by sugar maple (Loucks 1970).

The tree species that were predominant in the presettlement forests of Hamilton County occupy similar positions in the forests today. In 1788, 86.78% of the species recorded by the surveyors were in the genera Fagus, Acer, Quercus, Carya, Fraxinus, Ulmus and Celtis. Now 82.58% of the trees are in those genera. Lindsey et al. (1965) found that the presettlement forests of southeastern Indiana adjacent to Hamilton County were Fagus-Quercus-Acer-Carya dominated with an abundance of upland ash too. In terms of structure and composition, the forests in the parks of Hamilton County appear to be quite similar to those at the time of settlement. Species that were not recorded by the surveyors, black cherry, tulip tree, coffee tree, sassafras and bur oak, perhaps because of bias (Bourdo 1956) were listed by Drake (1815). The surveyors listed hackberry, gum, birch, red oak, ironwood and elm which Drake did not list so a check was in place. It appears that white oak is of lower importance now than in the presettlement forests. Some individual trees may have been removed by logging, but it is also probable that chinquapin oak (Q. muehlenbergii) was lumped with white oak, thus giving it a higher percentage. Although sugar maple was the species most frequently mentioned by the surveyors, it appears to have increased in importance since that time. This trend of increasing sugar maple importance in the Midwest has been reported by many workers, e.g. Loucks (1970). Pin oak was represented by only one individual in the 1788 survey, yet Braun (1916, 1936a) and Diehl (1933) mentioned its prominence on the Illinoian till plains of southwest Ohio as well as on the floodplains. Pin oak is restricted to certain habitats and thus is localized in its distribution. It is the dominant species at Melbourne, but was not encountered elsewhere.

Soils, aspect, substrate and drainage are important in the complex of factors that determine the forest types and species distributions in Hamilton County. The location of the county in regards to the distribution of the major forest types in the eastern United States adds to the complexity associated with the forests here. Braun's (1950) vegetational map shows Hamilton County to be near the junction of the mixed mesophytic, western mesophytic, oak-hickory, and beech-maple forests. Kuchler's (1964) map shows oak-hickory, beech-maple, and mixed mesophytic in and adjacent to the Hamilton County area. The forests that now occupy the parks and preserves reflect the vegetational diversity of the area and appear to be representative of the forests that were present at the time of settlement.

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