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A Vegetational Analysis of the Bowles Woods of the Miami-Whitewater Forest, Hamilton County, Ohio

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Introduction

The Bowles Woods of the Miami-Whitewater Forest, Hamilton County, Ohio has been proposed for dedication as an Ohio Natural Area (Figure 1). The Woods was described in Kelvin (1970) as "the nearest approach to a virgin beech climax forest found in this part of Ohio". Also for the Miami-Whitewater Forest, Durrell (1970) reported "large areas of mixed mesophytic forest with trees up to two feet in diameter common on uplands, slopes and terraces". This was undoubtedly the Bowles Woods. Larger scale studies, i.e. Gordon (1966, 1969), Braun (1950), and Kuchler (1964), have placed Hamilton County in mixed mesophytic, western mesophytic, or oak-hickory forest associations. Sears (1925) considered the presettlement vegetation of southwestern Ohio to be oak and beech-oak. For the most part, these descriptions of the vegetation of southwestern Ohio were not based on detailed field samples and their analyses. This lack of agreement on the forest types in Hamilton County needs to be clarified. For that reason, this study was initiated in an effort to present a detailed and accurate vegetational description of the Bowles Woods.

Description of the Environment

The Bowles Woods is on the eastern edge of the broad valley of the Whitewater River, a remnant of Pleistocene glaciation, and there are some scattered deposits of Illinoian till in the area. The bedrock of Ordovician limestones and calcareous shales is the controlling factor in terms of substrate; the glacial deposits are of little consequence. Sinkholes are abundant at certain levels (Durrell 1970) indicating some internal drainage.

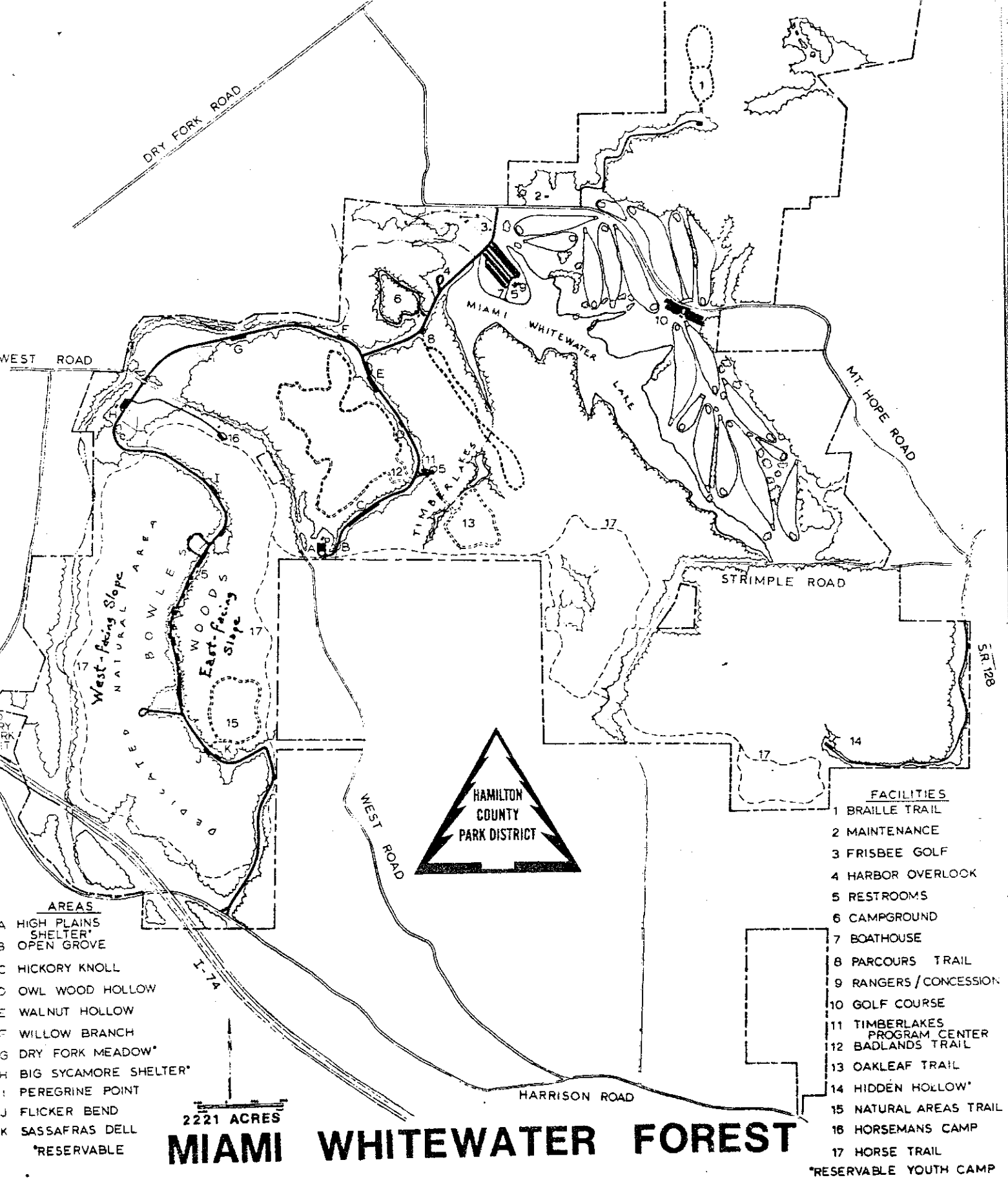


Figure 1. The location of the Bowles Woods of the Miami-Whitewater Forest, Hamilton County, Ohio.

The Bowles Woods occupies a ridge and upland slope complex where contrasting aspects increase environmental diversity. The west-facing slope and ridge varies from ≈240 m (786 feet) to ≈198 m (650 feet) in elevation. This slope is extremely steep and terminates on an upland terrace. The east-facing slope and ridge is more rolling and elevations range from ≈240 m (786 feet) to ≈213 m (700 feet). The soils in the Bowles Woods are the Cincinnati silt loam and the Eden silty clay loam (Lerch, et al. 1982).

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 1985. Trees were sampled in 0.04 hectare circular plots. A total of 40 plots was sampled, 20 on each the W-facing and E-facing slopes. All trees with diameter breast height (dbh) ≥ 10 cm (≥ 4 inches) were measured. Trees ≥ 30 cm (≥ 12 inches) dbh were considered as canopy and those smaller subcanopy. All plots were spaced at 30-m intervals in parallel lines across the slopes in an E-W direction.

The relative frequency (RF), relative density (RD), relative dominance (RDo) and importance value (IV) were determined for each tree species. Trees/hectare (t/ha) and basal area/ha (m^2/ha) were also determined.

Soil moisture and soil pH were determined with a Kelway Soil Tester. These values were obtained near the center of each plot and to a depth of ≈ 10 cm. Notes on tree falls, standing dead trees, and canopy openings were made throughout the study.

The similarity coefficient as determined by Bray and Curtis (1957) was applied for determining vegetational similarity between the W-facing and E-facing slopes and between the Bowles Woods and other forests in the area. This is expressed as $C = (2w)/(a + b)$, where a = the sum of the importance values of all trees in one stand, b = a similar value for a second stand, and w = the sum of the lesser values for only those species which are in common to the two stands. The Shannon-Wiener function was used to measure species diversity. This function is expressed as: $H' = -\sum_{i=1}^{S} p_i \log_2 p_i$ where p_i is the sampling probability.

Results

Results of the sampling and analyses for the W-facing, E-facing, and total forest are presented separately.

There was a total of 13 species of trees on the W-facing slope and ridge complex. Sugar maple (Acer saccharum) was the most important species on the slope with an IV of 136.58 (Table 1). Its major associates and their IVs are northern red oak (Quercus rubra) 50.73, white ash (Fraxinus americana) 22.43, shagbark hickory (Carya ovata) 18.78, black cherry (Prunus serotina) 16.88, chinquapin oak (Q. muehlenbergii) 11.83, black oak (Q. velutina) 11.49, and white oak (Q. alba) 10.80. Although sugar maple was the most important tree in terms of RF, RD and IV, it ranked behind the combined RDo of the oak-hickory component, 37.87 to 43.30, respectively.

There were 318.63 t/ha and a basal area of 32.12 m^2/ha on the W-facing slope. Approximately 43% of the trees present were in the canopy class and 57% in the subcanopy. Overall species diversity was not high, H' = 1.73, however, canopy diversity alone was much higher at 2.74. Subcanopy diversity was low at 0.31.

Soil pH had a narrow range, 6.6 - 7.0, and averaged 6.8.

Soil moisture precentage ranged from 5% to 55%, and averaged 22.88%. This percentage varied with location, but no apparent trends could be determined.

There was a total of 12 tree species on the E-facing slope and ridge with sugar maple ranking first in IV at 126.51 (Table 2). The major associate trees were white ash 64.55, white oak 25.16, beech (Fagus grandifolia) 24.17, shagbark hickory 11.76, and slippery elm (Ulmus rubra) 10.49. Sugar maple ranked first in all sampling categories and its RDo was greater than the combined oak-hickory component, 32.67 to 25.00.

There were 239.59 t/ha and a basal area of 32.26 m^2/ha on the E-facing slope. Approximately 55% of the trees were canopy and 45% subcanopy. Diversity for all tree species was 1.94 compared to 2.55 for the canopy and 0.47 for the subcanopy.

Soil pH ranged from 5.8 to 7.0 and averaged 6.69. Soil moisture ranged from 10% to 85%, averaging 36.38%. Prior to the beginning of the sampling, there had been 21 consecutive days without rain. There were only two mild rainshowers during two of the sampling days, but these did not substantially alter soil moisture.

The coefficient of similarity between the two slopes was 67.09%; for canopy trees only it was 62.59%. There were 79 t/ha fewer on the E-facing than W-facing slope, but the average basal area per tree was higher, 1346 cm^2 to 1008 cm^2, respectively. Thus, total basal area was essentially the same for the two slopes. The basal area contribution by the canopy was greater on the E-facing slope. Size class distributions for all trees on each slope followed the inverted J-curve (Figures 2 & 3). These figures may be misleading because if the contribution of sugar maple is omitted the other species follow the bell-curve indicationg poor replacment.

There were 15 tree species present in the sampling plots and two other tree species, basswood (Tilia americana) and black gum (Nyssa sylvatica), were observed in the Woods. For the entire Bowles Woods, sugar maple was the leading species in terms of RF, RD, RDo and IV (Table 3). Black cherry, chinquapin oak and black walnut were found only in sample plots on the W-facing slope while beech and bitternut hickory were confined to the E-facing slope, however, by lumping the slopes the species composition and the influence of aspect are obscured. The RDo of sugar maple and the combined oak-hickory RDo, so different when considering the slopes separately, are nearly equal at 35.27 and 34.11, respectively.

There were 279.11 t/ha, 48% were canopy and 52% subcanopy. Overall basal area was 32.19 m^2/ha. Species diversity for the entire forest was low at 1.94, but canopy diversity 2.78 was higher than for either slope taken separately. Subcanopy was low 0.43 due to the dominance of sugar maple. A comparison of the canopy and subcanopy for the slopes and the entire forest is presented in Table 4.

Some small gaps in the canopy were produced by standing dead trees, blow downs, and/or trees with the tops broken out. In fact, 27.5% of the sample plots contained one or more of the above types of disturbance. Black cherry, a gap phase tree, was the central tree of most of the blow downs on the W-facing slope.

Discussion

Instead of beech (Melvin 1970) or mixed mesophytic (Durrell 1970), the Bowles Woods of the Miami-Whitewater Forest should be classed as sugar maple-oak. Gordon (1966, 1969) mapped and identified oak-sugar maple for the counties immediately north and east of Hamilton County. Forsyth (1970) postulated that the distribution of Gordon's oak-sugar maple forests may relate to the fairly thick

surficial deposits of loess laid down by the prevailing wind from outwash-filled valleys. Dissection and erosion tend to negate the influence of glaciation and loess at the Bowles Woods. Gordon (1969) stated that, "Ordovician limestone and shales form the bedrock in the Cincinnati region. . . .Oak-sugar maple forest cover is shown on the natural vegetation map where glacial till contains such rock fragments. Elsewhere, the western mixed mesophytic forest and beech-sugar maple forest prevailed at the time of settlement." Gordon, however, did not show this forest fype [oak-sugar maple] for western Hamilton County, the site of the Bowles Woods.

Aspect certainly is important in determining species composition and the relative basal area contribution, as well as, density for the Bowles Woods. There was a greater contribution of the oak-hickory component relative to sugar maple on the W-facing slope. This could be expected because this is a more xeric exposure and the oaks are more tolerant to such conditions. Beech, a mesic species, was confined to the E-facing slope.

Basal area for either slope and for the entire forest exceeded the 30 m^2/ha proposed as an indicator for old-growth climax forests (Held and Winstead 1975). Density varied with slope, but the average of 279.11 t/ha fits Martin's (1983) hypothetical $\leq$ 300 t/ha for old-growth forests.

Canopy diversity, 2.78, for the entire forest was almost identical to the $2.77 \pm .09$ calculated by Monk (1967) for the Western Mesophytic Forest Region. Diversity values for all trees are substantially lower than for the canopy alone because of the nearly total dominance of sugar maple in the subcanopy. Observations on the seedling-sapling stratum seems to confirm that reproduction and tree replacement is largely by sugar maple and not by the oaks and hickories. The bell-curves formed by plotting the size class

class distributions for the associates of sugar maple further point to their poor replacement at this time. Small canopy openings apparently are not sufficient to provide space and light for the shade intolerant species to become established. A regression line was plotted for the tree data and the correlation coefficient (r) was computed for the graph. The r value was -.952 and this was used to compute the coefficient of determination as $100r^2$. The $100r^2$ was 90.63. Schmelz and Lindsey (1965) reported that values approaching 100 are indicative of low disturbance. This value is comparable to those determined by Schmelz and Lindsey (1965) for the best examples of little disturbed old-growth forests in Indiana.

As a conclusion, the Bowles Woods of the Miami-Whitewater Forest is a sugar maple-oak forest similar to the oak-sugar maple forests identified elsewhere in Ohio (Gordon 1966, 1969). This is an old-growth forest as determined by basal area, density, and $100r^2$. Aspect and its influence on soil moisture plays a major role in determining species distributions, densities and basal area even though soils and geology are the same.

Table 1. Vegetation of the Bowles Woods – the West-facing Slope and Ridge Complex.

	N	RF	RD	RDo	IV
Acer saccharum	183	27.78	70.93	37.87	136.58
Quercus rubra	27	15.28	10.47	24.98	50.73
Fraxinus americana	10	9.72	3.88	8.83	22.43
Carya ovata	8	11.11	3.10	4.57	18.78
Prunus serotina	7	8.33	2.71	5.84	16.88
Quercus muehlenbergii	5	6.94	1.94	2.95	11.83
Quercus velutina	4	4.17	1.55	5.77	11.49
Quercus alba	4	5.56	1.55	3.69	10.80
Ulmus rubra	3	2.78	1.16	2.68	6.62
Carya glabra	3	2.78	1.16	1.34	5.28
Juglans nigra	2	2.78	0.78	0.89	4.45
Fraxinus quadrangulata	1	1.39	0.39	0.44	2.22
Ostrya virginiana	1	1.39	0.39	0.14	1.92
	258	100.01	100.01	99.99	300.01

Table 2. Vegetation of the Bowles Woods - the East-facing Slope and Ridge Complex.

	N	RF	RD	RDo	IV
Acer saccharum	125	29.41	64.43	32.67	126.51
Fraxinus americana	26	20.59	13.40	30.56	64.55
Quercus alba	8	8.82	4.12	12.22	25.16
Fagus grandifolia	12	10.29	6.19	7.69	24.17
Carya ovata	5	5.88	2.58	3.30	11.76
Ulmus rubra	4	5.88	2.06	2.55	10.49
Carya cordiformis	3	4.41	1.55	2.91	8.87
Quercus rubra	4	4.41	2.06	1.91	8.38
Quercus velutina	2	2.94	1.03	3.22	7.19
Fraxinus quadrangulata	2	2.94	1.03	1.42	5.39
Ostrya virginiana	2	2.94	1.03	0.11	4.08
Carya glabra	1	1.47	0.52	1.44	3.43
	194	99.98	100.00	100.00	299.98

Table 3. Vegetation of the Bowles Woods - the total forest.

	N	RF	RD	RDo	IV
Acer saccharum	308	28.57	68.14	35.27	131.98
Fraxinus americana	36	15.00	7.96	19.72	42.68
Quercus rubra	31	10.00	6.86	13.42	30.28
Quercus alba	12	7.14	2.65	7.96	17.75
Carya ovata	13	8.57	2.88	3.93	15.38
Fagus grandifolia	12	5.00	2.65	3.86	11.51
Quercus velutina	6	3.57	1.33	4.49	9.39
Prunus serotina	7	4.29	1.55	2.91	8.75
Ulmus rubra	7	4.29	1.55	2.62	8.46
Quercus muehlenbergii	5	3.57	1.11	1.47	6.15
Carya glabra	4	2.14	0.88	1.38	4.40
Carya cordiformis	3	2.14	0.66	1.46	4.26
Fraxinus quadrangulata	3	2.14	0.66	0.93	3.73
Ostrya virginiana	3	2.14	0.66	0.12	2.92
Juglans nigra	2	1.43	0.44	0.44	2.31
	452	99.99	99.98	99.98	299.95

Table 4. A comparison of canopy and subcanopy for the W-facing and E-facing slopes and the entire forest - Bowles Woods.

	Canopy			Subcanopy		
	W-facing	E-facing	Entire Forest	W-facing	E-facing	Entire Forest
Acer saccharum	37.84	40.57	39.17	95.92	93.18	94.89
Quercus rubra	23.42	1.89	12.90	0.68	2.27	1.28
Fraxinus americana	8.11	24.53	16.13	0.68	0	0.43
Carya ovata	7.21	4.72	5.99	0	0	0
Prunus serotina	5.41	0	2.76	0.68	0	0.43
Quercus muehlenbergii	3.60	0	1.84	0.68	0	0.43
Quercus velutina	3.60	1.89	2.76	0	0	0
Quercus alba	3.60	7.55	5.53	0	0	0
Ulmus rubra	2.70	3.77	3.23	0	0	0
Carya glabra	1.80	0.94	1.38	0.68	0	0.43
Juglans nigra	1.80	0	0.92	0	0	0
Fraxinus quadrangulata	0.90	1.89	1.38	0	0	0
Ostrya virginiana	0	0	0	0.68	2.27	1.28
Fagus grandifolia	0	9.43	4.61	0	2.27	0.85
Carya cordiformis	0	2.83	1.38	0	0	0
Total	99.99	100.01	99.98	100.00	99.99	100.02

Figure 2. Plot of size-class distributions of trees on the W-facing slope, Bowles Woods of the Miami-Whitewater Forest.

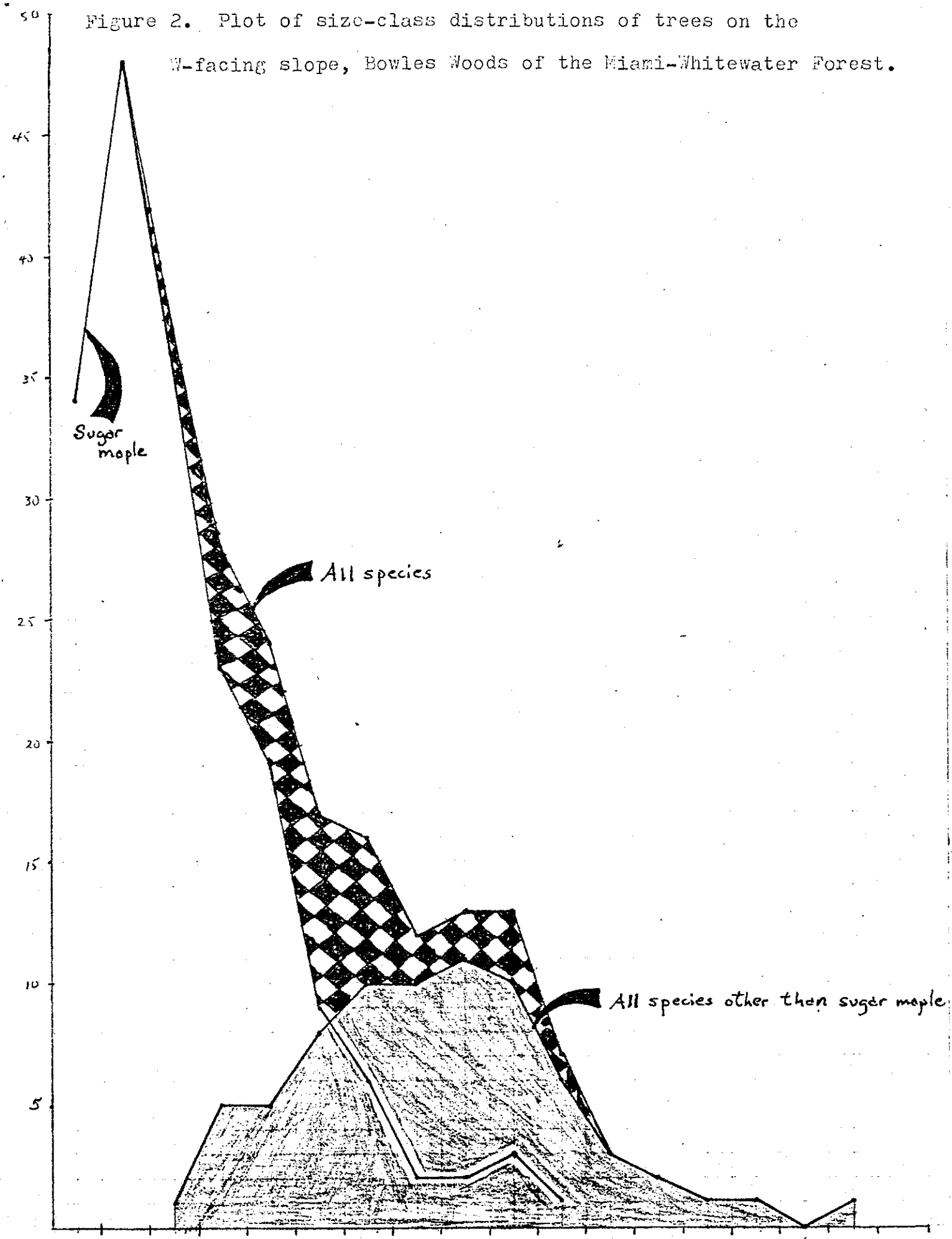
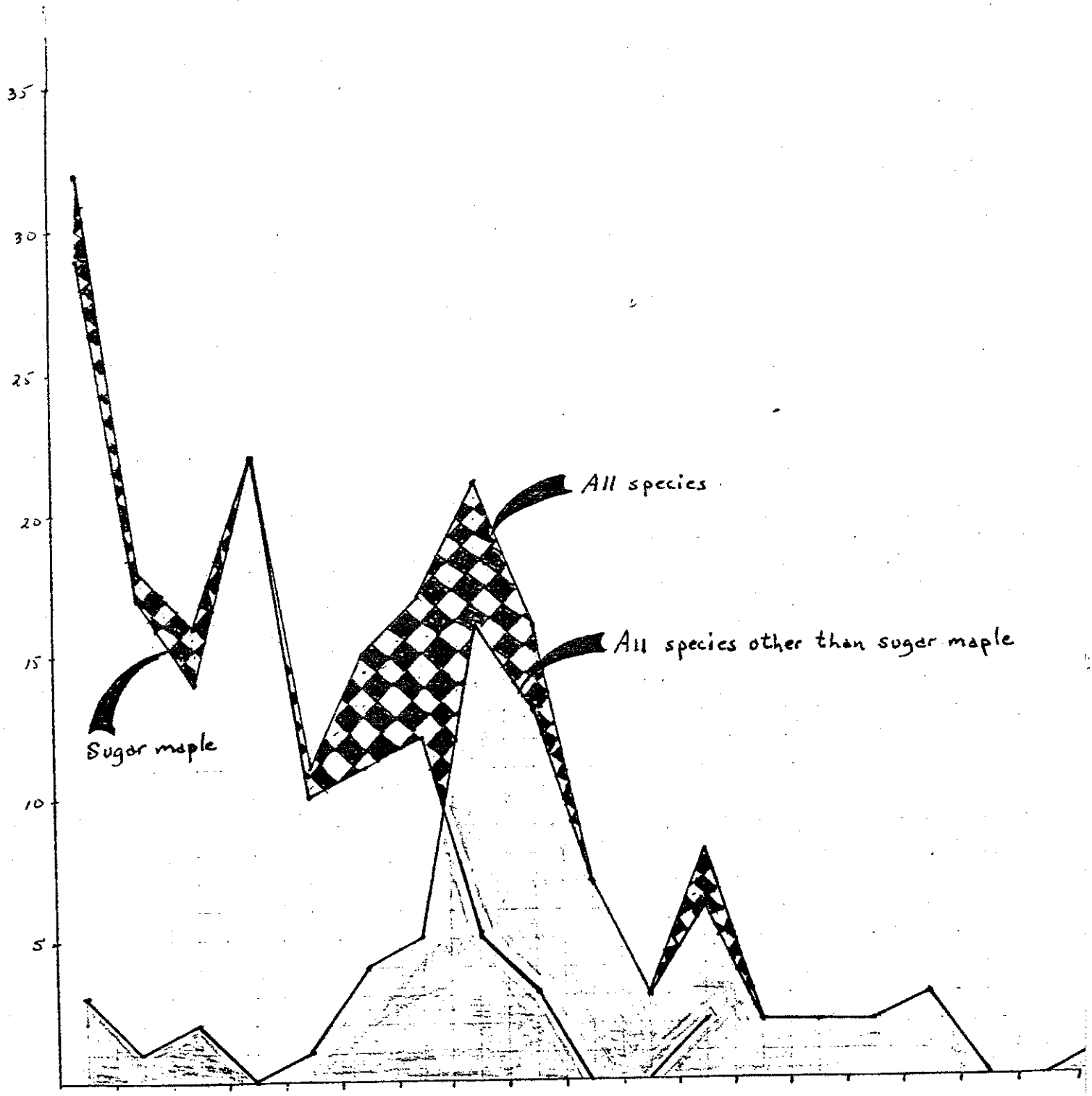


Figure 3. Plot of the size-class distributions of trees on the ...-facing slope, Bowles Woods of the Miami-Whitewater Forest.



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