

Vegetation of the Boone County Cliffs Nature Preserve, a Forest on a Kansan Outwash Deposit in Northern Kentucky

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ABSTRACT

Four distinct local communities were recognized and related to aspect and disturbance at the 20.24-hectare Boone County Cliffs Nature Preserve on Kansan outwash deposits in northern Kentucky. The dominant tree species in each community were: *Acer saccharum*, *Quercus muhlenbergii*, *Q. rubra*, and *Ulmus rubra* in the maple-oak-elm community; *Ulmus rubra*, *Acer saccharum*, *Fraxinus americana*, *Quercus muhlenbergii*, *Q. rubra*, and *Robinia pseudo-acacia* in the elm-maple-locust community; *Acer saccharum*, *Tilia americana*, *Fagus grandifolia*, and *Fraxinus americana* in the maple-basswood-beech community; and *Acer saccharum*, *Fagus grandifolia*, *Fraxinus americana*, *Quercus rubra*, and *Q. alba* in the maple-beech-oak community. The vegetation of the forest differs greatly from the hydromesophytic forests of the Illinoian till plain, but compares somewhat to the slope and ravine forests on other Illinoian deposits.

INTRODUCTION

Several authors have reported on the vegetation of the glaciated tristate area of northern Kentucky (Nelson 1918, Braun 1950, Keith 1968, Held and Winstead 1976), southwestern Ohio (Braun 1916, 1917, 1936, 1950; Cobbe 1943), and southeastern Indiana (Gordon 1936, Chapman 1942, Keller 1946, Beals and Cope 1964). All those studies concerned vegetation on Illinoian till except that of Keith (1968) who did not differentiate between the various Pleistocene drift deposits. No reports are available for the areas of Kansan outwash recently identified in northern Kentucky (Ray 1966, 1974) that filled ancient and abandoned tributaries to the Ohio River.

In this paper, the vegetation on Kansan outwash at the Boone County Cliffs Nature Preserve is compared with that of areas of Illinoian till. The Preserve, purchased by the Kentucky Chapter of The Nature Conservancy, is known locally as the Cliffs or Enchanted Valley. Sutton (1877, 1879) referred to the area as the Middle Creek Conglomerate.

THE STUDY AREA

The 20.24-ha Boone County Cliffs Nature Preserve lies off Middle Creek Road ap-

proximately 14.2 km west of Burlington, in western Boone County, Kentucky. While old growth forest predominates the Preserve, some logging occurred about 60 years ago and some trees were selectively cut just prior to acquisition by The Nature Conservancy (however, my data were collected prior to that most recent logging).

Elevations in the Preserve range from 198 to 259 m above mean sea level. Large conglomerate cliffs and boulders outcrop on the slopes (Fig. 1). Ray (1974) stated that the Middle Creek conglomerate is composed of cemented sand, gravels, and cobbles of limestone and a few crystalline rocks and quartzite. The area that includes the conglomerate is now deeply eroded, especially by Middle Creek, to narrow valleys with rugged precipitous walls 18.3 m or more high. Soils are Jessup silt loam and Cynthiana flaggy clay loam (Weisenberger et al. 1973) and are derived from weathering of the conglomerate and colluvial action.

Wet areas resulting from the seepage of water from the interior of the conglomerate rock are abundant and present throughout the year. A springfed stream passes through the ravine that separates the north- and south-facing slopes.

The climate is temperate and humid. The average temperature is 12.2 C and the aver-



FIG. 1. Large conglomerate outcrop on the south-facing slope of the Boone County Cliffs Nature Preserve, Boone County, Kentucky.

age annual rainfall is 101.6 cm (Weisenberger et al. 1973).

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METHODS AND MATERIALS

Vegetation was sampled from March 1972 to October 1976. Trees were sampled in 0.04-ha circular plots, saplings in 0.01-ha circular plots, and seedlings in 0.004-ha circular plots. Shrubs were sampled in the latter 2 sized plots.

Woody plants with diameters breast height (dbh) of 8.9 cm (3.5 inches) or greater were classed as trees. Seedlings and

saplings were placed in appropriate size classes determined 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 high 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 8.9 cm (2.5–3.5 inches) in diameter. A total of 29 plots for each vegetational category was sampled. Plots were spaced at 33-m intervals along straight-line transects through the communities sampled.

The relative frequency (RF), relative density (RD), relative dominance (RDo), and importance value (IV) for each tree species were determined. Numbers of seedlings, saplings, and shrubs per hectare were determined.

TABLE 1.—THE NUMBER (N), RELATIVE FREQUENCY (RF), RELATIVE DENSITY (RD), RELATIVE DOMINANCE (RDo), AND IMPORTANCE VALUE (IV) OF ALL TREE SPECIES AT THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

	N	RF	RD	RDo	IV
<i>Acer saccharum</i>	216	17.31	40.91	20.83	79.05
<i>Ulmus rubra</i>	72	8.33	13.64	11.84	33.81
<i>Fraxinus americana</i>	43	11.54	8.14	10.01	29.69
<i>Fagus grandifolia</i>	14	5.77	2.65	12.23	20.65
<i>Quercus rubra</i>	22	7.69	4.17	8.11	19.97
<i>Quercus muhlenbergii</i>	33	3.85	6.25	7.26	17.36
<i>Tilia americana</i>	16	3.85	3.03	7.51	14.39
<i>Celtis occidentalis</i>	16	4.49	3.03	2.36	9.88
<i>Robinia pseudo-acacia</i>	12	3.85	2.27	3.41	9.53
<i>Liriodendron tulipifera</i>	9	5.13	1.70	2.49	9.32
<i>Carya cordiformis</i>	8	3.85	1.52	3.73	9.10
<i>Juglans nigra</i>	9	3.21	1.70	1.98	6.89
<i>Quercus alba</i>	6	1.92	1.14	2.82	5.88
<i>Ulmus americana</i>	6	2.56	1.14	2.12	5.82
<i>Cercis canadensis</i>	12	2.56	2.27	0.47	5.30
<i>Carpinus caroliniana</i>	7	3.21	1.33	0.27	4.81
<i>Carya ovata</i>	7	2.56	1.33	0.37	4.26
<i>Fraxinus quadrangulata</i>	7	1.92	1.33	0.64	3.89
<i>Ostrya virginiana</i>	5	1.92	0.95	0.19	3.06
<i>Aesculus glabra</i>	2	1.28	0.38	0.14	1.80
<i>Platanus occidentalis</i>	1	0.65	0.19	0.73	1.56
<i>Gymnocladus dioica</i>	2	0.64	0.38	0.30	1.32
<i>Carya glabra</i>	1	0.64	0.19	0.08	0.91
<i>Acer negundo</i>	1	0.64	0.19	0.07	0.90
<i>Cornus florida</i>	1	0.64	0.19	0.03	0.86
Totals	528	100.00	100.02	99.99	300.01

Because of local differences in habitat, such as aspect and disturbance, the forest was divided into 4 sampling areas: south-facing slope, ridge atop the south-facing slope, north-facing slope, and ridge atop the north-facing slope. No quantitative determinations of herbs were made, however, notes on the herbaceous composition were taken. Soil samples were taken from 20 sites and the soil texture was determined with a hydrometer.

Nomenclature for all plant species follows Mohlenbrock and Voigt (1959).

ANALYSIS OF COMMUNITIES

Distinct local communities were recognized and probably were related to aspects

and disturbances. The 4 community types were: maple-oak-elm on the south-facing slope, elm-maple-locust on the ridge atop the south-facing slope, maple-basswood-beech on the north-facing slope, and maple-beech-oak on the ridge atop the north-facing slope. In addition to the major community types, a small stand of *Liriodendron tulipifera* was present in the ravine between the slopes. A list of the kinds of trees in the entire Preserve is presented in Table 1, and the average basal area values for the dominant tree species in each community are listed in Table 2.

Average values for soil samples at 20 locations throughout the Preserve were: sand (40.37%), clay (23.21%), and silt (36.42%). Local differences regarding soil

TABLE 2.—AVERAGE BASAL AREA (CM²) FOR INDIVIDUAL TREES OF 8 SPECIES IN THE 4 COMMUNITIES AT THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

	South-facing slope	South ridge	North-facing slope	North ridge
<i>Acer saccharum</i>	270.84	197.18	229.43	472.72
<i>Quercus rubra</i>	1,549.87	421.44	902.94	1,653.01
<i>Fraxinus americana</i>	1,006.33	553.86	856.95	687.70
<i>Ulmus rubra</i>	321.21	540.06	1,259.10	
<i>Quercus muhlenbergii</i>	848.95	365.07		
<i>Robinia pseudo-acacia</i>	476.53	994.98		
<i>Tilia americana</i>			1,642.11	497.10
<i>Fagus grandifolia</i>			3,511.57	2,389.85

textures probably were not great enough to modify plant distributions.

Maple-Oak-Elm Community

The south-facing slope was the driest habitat in the Preserve due to its exposure. The upper half of the slope was decidedly xeric. *Acer saccharum* (IV 61.42) was the most prominent tree, although being most abundant on the lower portions of the slope

(Table 3). Oaks, *Quercus muhlenbergii* (IV 43.82) and *Q. rubra* (IV 28.30), ranked second and third, respectively, while *Q. alba* (IV 5.16) ranked thirteenth. Combined, the oaks had an importance value of 77.28. Other important associated trees included *Ulmus rubra*, *Juglans nigra*, *Fraxinus americana*, and *Celtis occidentalis*. *Fraxinus quadrangulata* was confined to the upper slope, especially rooted in the large

TABLE 3.—THE NUMBER (N), RELATIVE FREQUENCY (RF), RELATIVE DENSITY (RD), RELATIVE DOMINANCE (RDo), AND IMPORTANCE VALUE (IV) OF ALL TREE SPECIES ON THE SOUTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

Species	N	RF	RD	RDo	IV
<i>Acer saccharum</i>	51	13.46	32.90	15.60	61.42
<i>Quercus muhlenbergii</i>	23	7.69	14.84	21.29	43.82
<i>Quercus rubra</i>	8	9.62	5.16	13.52	28.30
<i>Ulmus rubra</i>	18	7.69	11.61	6.30	25.60
<i>Juglans nigra</i>	9	9.62	5.81	6.89	22.32
<i>Fraxinus americana</i>	8	7.69	5.16	8.78	21.63
<i>Celtis occidentalis</i>	10	5.79	6.45	5.80	18.02
<i>Liriodendron tulipifera</i>	6	9.62	3.87	2.82	16.31
<i>Ulmus americana</i>	5	5.77	3.23	4.71	13.71
<i>Carya cordiformis</i>	2	3.85	1.29	6.83	11.97
<i>Cercis canadensis</i>	7	3.85	4.52	1.27	9.64
<i>Robinia pseudo-acacia</i>	2	3.85	1.29	1.04	6.18
<i>Quercus alba</i>	1	1.92	0.65	2.59	5.16
<i>Platanus occidentalis</i>	1	1.92	0.65	2.55	5.12
<i>Acer negundo</i>	1	1.92	0.65	0.24	2.81
<i>Fraxinus quadrangulata</i>	1	1.92	0.65	0.17	2.74
<i>Carpinus caroliniana</i>	1	1.92	0.65	0.09	2.66
<i>Aesculus glabra</i>	1	1.92	0.65	0.07	2.64
Totals	155	100.00	100.03	100.02	300.05

TABLE 4.—SEEDLINGS (SIZE CLASSES 1, 2) AND SAPLINGS (SIZE CLASSES 3, 4, 5) PER HECTARE OF ALL SHRUB AND TREE SPECIES ON THE SOUTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

	Size class				
	1	2	3	4	5
Shrubs					
<i>Staphylea trifolia</i>	164.65	136.21	21.93		
<i>Lindera benzoin</i>	3,265.88	3,101.31	406.17	186.61	
<i>Asimina triloba</i>	1,180.09	741.00	43.89		
Seedlings-saplings					
<i>Acer saccharum</i>	686.09	356.77	164.67	32.93	10.97
<i>Quercus rubra</i>	82.33	54.88	43.89	43.89	
<i>Fraxinus americana</i>		137.21	65.87	10.97	
<i>Cercis canadensis</i>	439.09	164.67	186.61	43.89	
<i>Ostrya virginiana</i>	439.09	54.88	10.97		
<i>Carya cordiformis</i>	137.21				
<i>Carpinus caroliniana</i>	27.44		21.93	10.97	
<i>Acer negundo</i>	109.77	54.88			
<i>Fraxinus quadrangulata</i>	219.53	137.21	32.93		
<i>Prunus serotina</i>	164.65	27.44	21.93		
<i>Fagus grandifolia</i>	27.44			10.97	
<i>Platanus occidentalis</i>		27.44			
<i>Liriodendron tulipifera</i>	164.65			10.97	
<i>Ulmus rubra</i>	301.88	109.77			
<i>Celtis occidentalis</i>	82.33	27.44			
<i>Aesculus glabra</i>			21.93	10.97	
<i>Qercus muhlenbergii</i>			10.97		

conglomerate outcrops that were difficult to sample.

Cercis canadensis was the major understory tree. Shrubs, *Lindera benzoin*, *Asimina triloba*, and *Staphylea trifolia*, were most abundant on the lower slope and near the stream, yet *A. triloba* did extend upslope wherever water seepage occurred.

Of the canopy trees, seedlings and saplings of *A. saccharum* were the most abundant (Table 4). Seedlings and saplings of most of the dominant trees were present, but only *A. saccharum* reached tree replacement size.

Elm-Maple-Locust Community

The ridge atop the south-facing slope was cleared approximately 60 years ago and an old farm road crossed the ridge. Remnants of the early successional stages, *Ulmus*

rubra and *Robinia pseudo-acacia*, were still present and ranked first (IV 91.48) and fourth (IV 33.02), respectively (Table 5). *A. saccharum*, *F. americana*, and the oaks, *Q. muhlenbergii* and *Q. rubra*, were other important trees, however, those 4 species were smaller there than elsewhere in the Preserve reflecting a more recent establishment. Entire black locust trees and portions of others were dead and dying. The replacement of *R. pseudo-acacia* by *A. saccharum*, *F. americana*, and the oaks was in advanced condition. Those latter species were of Class 5 (Table 6). *U. rubra* was reproducing, but *R. pseudo-acacia* was not. *F. quadrangulata* was most abundant near the edge of the conglomerate cliffs and its seedlings and saplings extended throughout the ridge.

An understory of *Cercis canadensis* was developing under the new canopy. *Asimina*

TABLE 5.—THE NUMBER (N), RELATIVE FREQUENCY (RF), RELATIVE DENSITY (RD), RELATIVE DOMINANCE (RDo), AND IMPORTANCE VALUE (IV) OF ALL TREE SPECIES ON THE RIDGE ATOP THE SOUTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

Species	N	RF	RD	RDo	IV
<i>Ulmus rubra</i>	50	16.67	33.56	41.25	91.48
<i>Acer saccharum</i>	38	16.67	25.50	11.45	53.62
<i>Fraxinus americana</i>	15	13.89	10.07	12.69	36.65
<i>Robinia pseudo-acacia</i>	10	11.11	6.71	15.20	33.02
<i>Quercus muhlenbergii</i>	10	5.56	6.71	5.58	17.85
<i>Quercus rubra</i>	6	8.33	4.03	3.86	16.22
<i>Carya cordiformis</i>	3	5.56	2.01	2.28	9.85
<i>Celtis occidentalis</i>	3	5.56	2.01	2.10	9.67
<i>Fraxinus quadrangulata</i>	5	2.78	3.36	2.55	8.69
<i>Carya ovata</i>	2	5.56	1.34	0.81	7.70
<i>Cercis canadensis</i>	4	2.78	2.68	0.41	5.87
<i>Gymnocladus dioicus</i>	2	2.78	1.34	1.45	5.57
<i>Carya glabra</i>	1	2.78	0.67	0.38	3.83
Totals	149	100.03	99.99	100.00	300.02

TABLE 6.—SEEDLINGS (SIZE CLASSES 1, 2) AND SAPLINGS (SIZE CLASSES 3, 4, 5) PER HECTARE OF ALL SHRUB AND TREE SPECIES ON THE RIDGE ATOP THE SOUTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

	Size class				
	1	2	3	4	5
Shrubs					
<i>Asimina triloba</i>	41.15		49.40		
<i>Staphylea trifolia</i>	205.83		16.47		
<i>Symphoricarpos orbiculatus</i>	411.67				
<i>Rubus</i> sp.	1,770.15				
Seedlings-saplings					
<i>Acer saccharum</i>	247.00	82.33	312.87	214.07	32.93
<i>Quercus muhlenbergii</i>	82.33		131.73	16.47	16.47
<i>Quercus rubra</i>	82.33		214.07	32.93	16.47
<i>Ulmus rubra</i>	823.33	82.33	65.87	16.47	16.47
<i>Cercis canadensis</i>	82.33		181.13	32.93	16.47
<i>Ostrya virginiana</i>	123.50		16.47		
<i>Fraxinus quadrangulata</i>	1,111.50	782.17	230.53		
<i>Fraxinus americana</i>	164.65	41.15	115.27		
<i>Carya cordiformis</i>	370.50	123.50	16.47		
<i>Celtis occidentalis</i>	946.83	247.00	131.73		
<i>Acer negundo</i>	41.15	41.15	16.47		
<i>Ulmus americana</i>	41.15				
<i>Juniperus virginiana</i>	41.15				
<i>Aesculus glabra</i>			16.47		
<i>Gymnocladus dioicus</i>			32.93		
<i>Carya glabra</i>			16.47		

TABLE 7.—THE NUMBER (N), RELATIVE FREQUENCY (RF), RELATIVE DENSITY (RD), RELATIVE DOMINANCE (RDo), AND IMPORTANCE VALUE (IV) OF ALL TREE SPECIES ON THE NORTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

Species	N	RF	RD	RDo	IV
<i>Acer saccharum</i>	61	19.05	50.00	16.73	85.78
<i>Tilia americana</i>	14	11.90	11.48	27.49	50.87
<i>Fagus grandifolia</i>	5	7.14	4.10	20.99	32.23
<i>Fraxinus americana</i>	11	7.14	9.02	11.27	27.43
<i>Ulmus rubra</i>	4	7.14	3.28	6.02	16.44
<i>Carpinus caroliniana</i>	6	9.52	4.92	0.94	15.38
<i>Carya cordiformis</i>	3	4.76	2.46	4.98	12.20
<i>Quercus rubra</i>	3	4.76	2.46	3.24	10.46
<i>Liriodendron tulipifera</i>	2	4.76	1.64	2.50	8.90
<i>Ostrya virginiana</i>	4	4.76	3.28	0.65	8.69
<i>Celtis occidentalis</i>	3	4.76	2.46	1.01	8.23
<i>Ulmus americana</i>	1	2.38	0.82	2.92	6.12
<i>Aesculus glabra</i>	1	2.38	0.82	0.45	3.65
<i>Carya ovata</i>	1	2.38	0.82	0.35	3.55
<i>Fraxinus quadrangulata</i>	1	2.38	0.82	0.26	3.46
<i>Cornus florida</i>	1	2.38	0.82	0.12	3.32
<i>Cercis canadensis</i>	1	2.38	0.82	0.08	3.28
Totals	122	99.97	100.02	100.00	299.99

triloba and *Staphylea trifolia* were present where slight depressions in soil allowed water accumulation. Remnants of the past clearing association, *Symphoricarpos orbiculatus* and *Rubus* sp. persisted in the tracks of the farm road.

Maple-Basswood-Beech Community

The vegetation of the north-facing slope was a mixed mesophytic association with *A. saccharum* (IV 85.78), *Tilia americana* (IV 50.87), and *Fagus grandifolia* (IV 32.23) as the dominant trees (Table 7). *F. americana* and *U. rubra* were major associates. The understory was composed of *Carpinus caroliniana* and *Ostrya virginiana*.

The shrub layer was composed of *Lindera benzoin*, *Asimina triloba*, and *Staphylea trifolia*. All of those species ranged high up the slope and were not confined to seepage areas. A few individuals of *Hydrangea arborescens* were present, but were not recorded from sample plots. Of the dominant tree species, replacement to tree size was by *A. saccharum*, *T. americana*, and *F. americana*, however, saplings up to Class 3

of *Fagus grandifolia* were present (Table 8).

Maple-Beech-Oak Community

The ridge atop the north-facing slope was also dominated by *A. saccharum* (IV 127.53), with major associated canopy trees being *F. grandifolia* (IV 59.30), and *F. americana* (IV 39.78) (Table 9). *Q. rubra* and *Q. alba* ranked fourth and fifth, respectively, but as a composite the oaks had an importance value of 44.17.

The trees were widely spaced and there was no well-defined subcanopy or shrub layer. Seedlings and saplings of *A. saccharum* and *F. grandifolia* were present to tree replacement size (Table 10).

Shortly after that ridge community was sampled, many of the oaks were logged.

Hummock of Tulip Poplar

Near the head of the stream that passed through the ravine was a small stand of *Liriodendron tulipifera*. The soil was deeper there than elsewhere in the Preserve.

TABLE 8.—SEEDLINGS (SIZE CLASSES 1, 2) AND SAPLINGS (SIZE CLASSES 3, 4, 5) PER HECTARE OF ALL SHRUB AND TREE SPECIES ON THE NORTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

	Size class				
	1	2	3	4	5
Shrubs					
<i>Asimina triloba</i>	2,223.00	2,037.75	61.75		
<i>Lindera benzoin</i>	185.25	185.25	37.05		
<i>Staphylea trifolia</i>	339.63	123.50	24.70		
Seedlings-saplings					
<i>Acer saccharum</i>	617.50	648.38	135.85	86.45	24.70
<i>Tilia americana</i>	185.25	123.50	12.35		12.35
<i>Fraxinus americana</i>	61.75	92.63			12.35
<i>Carpinus caroliniana</i>	61.75	30.88	12.35		
<i>Fagus grandifolia</i>	92.63	61.75	61.75		
<i>Ulmus rubra</i>	185.25	123.50			
<i>Quercus rubra</i>		30.88			
<i>Cercis canadensis</i>	92.63		61.75	12.35	
<i>Acer negundo</i>	92.63			12.35	
<i>Liriodendron tulipifera</i>	30.88				
<i>Carya cordiformis</i>	61.75				
<i>Fraxinus quadrangulata</i>		30.88			
<i>Aesculus glabra</i>		61.75			

That stand apparently was the seed source of the tulip poplars of the slopes.

DISCUSSION

No comparable studies of vegetation on Kansan outwash have been reported, although Keith (1968) undoubtedly included

some areas in his study; however, because of the weathered nature of the areas he sampled, he made no distinctions between till deposits. Since there is more literature for vegetation of Illinoian till available comparisons are to that area.

When all sampling areas are combined, the forest of the Boone County Cliffs

TABLE 9.—THE NUMBER (N), RELATIVE FREQUENCY (RF), RELATIVE DENSITY (RD), RELATIVE DOMINANCE (RDo), AND IMPORTANCE VALUE (IV) OF ALL TREE SPECIES ON THE RIDGE ATOP THE NORTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

Species	N	RF	RD	RDo	IV
<i>Acer saccharum</i>	66	23.08	64.71	39.74	127.53
<i>Fagus grandifolia</i>	9	23.08	8.82	27.40	59.30
<i>Fraxinus americana</i>	9	23.08	8.82	7.88	39.78
<i>Quercus rubra</i>	5	7.69	4.90	10.53	23.12
<i>Quercus alba</i>	1	7.69	4.90	8.46	21.05
<i>Liriodendron tulipifera</i>	1	3.85	0.98	4.18	9.01
<i>Carya ovata</i>	4	3.85	3.92	0.44	8.21
<i>Tilia americana</i>	2	3.85	1.96	1.27	7.08
<i>Ostrya virginiana</i>	1	3.85	0.98	0.09	4.92
Totals	102	100.02	99.99	99.99	300.00

TABLE 10.—SEEDLINGS (SIZE CLASSES 1, 2) AND SAPLINGS (SIZE CLASSES 3, 4, 5) PER HECTARE OF ALL SHRUBS AND TREE SPECIES ON THE RIDGE ATOP THE NORTH-FACING SLOPE OF THE BOONE COUNTY CLIFFS NATURE PRESERVE, BOONE COUNTY, KENTUCKY

	Size class				
	1	2	3	4	5
Seedlings-saplings					
<i>Acer saccharum</i>	494.00	247.00	131.73	49.40	131.73
<i>Fagus grandifolia</i>	329.33	41.17	279.93	32.93	16.47
<i>Ostrya virginiana</i>	617.50	370.50	148.20		16.47
<i>Cornus florida</i>	41.17		65.87	131.73	
<i>Carya cordiformis</i>	247.00	82.33	49.40		
<i>Quercus rubra</i>	205.83	164.67	98.80		
<i>Fraxinus americana</i>	164.67				
<i>Fraxinus quadrangulata</i>	82.33	41.17	16.47		
<i>Ulmus rubra</i>	494.00		16.47		
<i>Celtis occidentalis</i>		41.17			
<i>Sassafras albidum</i>		41.17			

Nature Preserve shows some similarities as well as striking differences to those on Illinoian till, in particular the Dinsmore's Woods (Held and Winstead 1976). In both forests, *Acer saccharum* ranked first in importance value, 79.05 at the Preserve to 91.94 at Dinsmore's Woods. *Fraxinus americana* ranked third at the Preserve (IV 29.69) and second at Dinsmore's Woods (IV 44.48) while *Ulmus rubra* ranked second at the Preserve (IV 33.81) and fourth at Dinsmore's Woods (IV 22.93). The Preserve forest was decidedly more mesic than Dinsmore's Woods when the respective importance values of the following species are compared: *Fagus grandifolia*, 20.65 to 6.91; *Tilia americana*, 14.39 to 5.17; *Quercus rubra*, 19.71 to 7.81; and *Liriodendron tulipifera*, 9.32 to 0. The importance values for *Q. muhlenbergii*, 17.36 to 5.38; *Q. alba*, 5.88 to 17.87; and *Celtis occidentalis*, 9.88 to 29.88, reflect other differences. Keith (1968) felt that a high importance for *C. occidentalis*, such as that at Dinsmore's Woods indicated a disclimax. Basal area values were very similar, 27.2 m²/ha at the Preserve to 28.1 m²/ha at Dinsmore's Woods. The differences between the forests probably are the results of different soils, weathered conglomerate, and colluvium at the Preserve and a Wisconsin loess cap at

Dinsmore's Woods, in conjunction with a greater number of microhabitats at the Preserve.

Local habitat factors result in distinct communities at the Preserve with only 3 tree species, *A. saccharum*, *F. americana*, and *Q. rubra*, in each of the 4 community types. Cobbe (1943) noted the establishment of local communities at Cabin Run, Ohio, as a result of microenvironmental differences.

The vegetation of the south-facing and north-facing slopes was quite different at the Preserve. Braun (1917) noted that slopes of the same steepness but of different direction show great differences in the character of the vegetation even though both are on conglomerate rock substrate. The south-facing slope, the driest habitat, was occupied by a maple-oak-elm association. Cobbe (1943) also found the south-facing slope to be less mesophytic and dominated by *A. saccharum*. Braun (1950) noted that the drier slopes and exposed river bluffs of the Illinoian deposits in Kentucky display remnants of an oak-ash-maple forest. The prominence of *Q. muhlenbergii*, the most xeric of the white oak group (Curtis 1959), on the south-facing slope is evidence of the dryness. Mesic shrubs, *Asimina triloba*, *Lindera benzoin*, and

Staphylea trifolia, were abundant on the lower slope and in seepage sites. Braun (1917) noted the occurrence of constantly wet places on conglomerate slopes resulting from a gradual seepage of water from the interior of the rock.

Presently, the disturbed south-facing ridge is occupied by an elm-maple-locust association. The ridge was undergoing advanced succession toward a maple-oak-elm community. The systematic replacement of *Robinia pseudo-acacia* by *Acer* and *Quercus* was readily visible. Many individuals of black locust were dead or dying and that species was not reproducing. Braun (1916) found that black locust did not retain its early importance after other trees were started, and was seldom found within the oak forest. Along with black locust on the top of bluffs in southwestern Ohio were *U. rubra*, *Fraxinus quadrangulata*, and *Q. muhlenbergii* (Braun 1916). *U. rubra* was reproducing to tree replacement size and apparently was maintaining itself as a member of the developing maple-oak-elm community.

The north-facing slope was occupied by a mixed mesophytic association of maple-basswood-beech. Cobbe (1943) found the north slope of Cabin Run ravine to be the most mesophytic community with a dense canopy of *Fagus grandifolia*, *Tilia americana*, *Liriodendron tulipifera*, *Q. alba*, and *Juglans nigra*. Cobbe also recorded *A. saccharum* in the understory along with *F. americana*, *U. rubra*, *Ostrya virginiana*, and *Carpinus caroliniana*. Both *A. saccharum* and *F. americana* were more abundant in the subcanopy than the canopy at the Preserve. Cobbe (1943) stated that a large number of individuals but of small basal area indicated that those trees were not important in the canopy.

The position of *L. tulipifera* in each of the slope associations deserves special mention. Cobbe (1943) found *L. tulipifera* to be most prevalent in the wide protected ravine of Cabin Run, much like its site of abundance at the Preserve, and noted that it reproduced only in openings offered by the death of canopy trees. Overthrow of

large canopy trees is a common occurrence on the slopes of the Preserve and possibly is one of the reasons why trees do not reach larger size. The severe slope angles and the sandy nature of the soils will not support large trees. When such trees overturn, *L. tulipifera* from its seed source in the ravine, invades the newly created openings or gaps.

The ridge atop the north-facing slope was occupied by a maple-beech-oak association. Braun (1916) and Cobbe (1943) recorded *F. grandifolia* from the tops of hills, ridges, and knolls, and along with beech on the tops of the hills, are other trees, the most important of which are *A. saccharum*, *Carya laciniosa*, *Q. alba*, and *Q. rubra* (Braun 1916). Such an assemblage is similar to that at the Preserve. The trees were more widely spaced on the ridge than elsewhere in the Preserve and the shrub and subcanopy layers were very sparse. Cobbe (1943) noted that the beech ridge communities were open with no layering. Saplings of *A. saccharum* and *F. grandifolia* reach tree replacement size, but the oaks were not reproducing, especially *Q. alba*. Held and Winstead (1976) also observed poor reproduction by white oak.

The flora of the Preserve is similar to that reported by Cobbe (1943) and Braun (1917) for the glaciated slope areas in southwestern Ohio. I have recorded over 300 species of vascular plants in the Preserve. Conglomerate boulders on the lower slopes are covered with plants. On the drier outcroppings, fewer species are present. The plant successional pattern on those conglomerate cliffs undoubtedly is much like that reported by Braun (1917) on the conglomerate rocks of southern Ohio.

In conclusion, the glaciated portion of Kentucky is limited to a small area in the extreme northern counties, yet those glacial deposits are of significance geologically and vegetationally. The vegetation of the Boone County Cliffs Nature Preserve, on Kansan outwash, differs greatly from the hydromesophytic forests of the Illinoian till plain (Braun 1916, 1936), but compares somewhat to slope and ravine forests on Illinoian till (Cobbe 1943, Held and Winstead 1976).

Braun (1936) reported that where ravines cut through the hydromesophytic flats, a number of species of the mixed mesophytic forest enter, of which tulip poplar and sugar maple are the most important. The ravine and slopes in the Preserve provide numerous microhabitats, and are largely responsible for the similarities observed with the vegetation of dissected Illinoian deposits.

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