Butler University Botanical Studies

Volume 10 Article 22

A Five-Acre Forest Survey at Shades State Park (Indiana). A Study of Sampling Methods

Charles L. Trotter

Butler University Botanical Studies

(1929-1964)

Edited by

Ray C. Friesner

The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

Requests for use of materials, especially figures and tables for use in ecology text books, from the *Butler University Botanical Studies* continue to be granted. For more information, visit www.butler.edu/herbarium.

A FIVE-ACRE FOREST SURVEY AT SHADES STATE PARK (INDIANA). A STUDY OF SAMPLING METHODS[1]

By CHARLES L. TROTTER

Various methods have been used to represent the vegetation of a given area on the printed page. In dealing with an area as vast as a forest, only a representative sample of the entire vegetation can be studied conveniently. Therefore sampling methods used must be extensive enough to include at least all the important species in the woods that would be included if the entire forest could be tabulated. A sampling method should show with reasonable accuracy a representation of the number of species present, abundance, stem sizes, and the regularity of their distribution.

It is the purpose of this paper to give what is believed to be the first percentage composition data of the Shades State Park forest, and to study and compare the results obtained by using different sampling patterns in the five acre survey.

LOCATION AND TOPOGRAPHIC FEATURES OF SHADES STATE PARK

The entrance to Shades State Park lies about five miles north of Waveland, Indiana, on State Road 234. The park covers an area of 1,952 acres in Montgomery, Fountain, and Parke counties. Most of the area is in the southwest corner of Montgomery county; the tract under study lies entirely within Sec. 11, T. 17 N., R. 6 W. of Montgomery county.[2]

Montgomery county, and consequently Shades State Park, occurs in the Tipton Till Plain. Dryer (4) has described this same large area as "The Central Till Plain." According to Malott (6) "The Tipton Till Plain is characteristically a slightly modified ground moraine

[1] A portion of a thesis submitted in partial fulfillment of the requirements for the Bachelor of Arts degree, Magna cum Laude, Butler University.

[2] 39° 56′ 06″ N. Lat. crosses 87° 03′ 49″ W. Long. at the southern edge of the area sampled.

plain, and over wide areas is monotonously flat." Digression from this monotony occurs at Shades State Park. "In Fountain, Montgomery, and Parke counties considerable relief exists where the main streams have dissected the plain," (6). Between the streams, however, the till plain is "well preserved and is fairly representative," (6). "Sugar Creek in southwestern Montgomery and northern Parke counties is deeply entrenched in and below the massive resistant Mansfield sandstone, and sheer cliffs of 100 ft. or more are present," (6). "In the 'Shades of Death' (2) park and the Turkey Run State Park, Sugar Creek and its tributaries exhibit wild and rugged scenery," (6). A maximum entrenchment of over 200 ft. occurs in those areas. Complete topographic maps of the Alamo Quadrangle of Indiana (containing Shades) may be purchased for 10c by writing U. S. Geological Survey, Department of Interior, Washington 25, D. C.

According to the Purdue University Agricultural Experimental Station, Special Circular for January 1944, (3) the dominant soil types in the area studied include "Fincastle, Russel, and Cope Silt Loams and Brookston Clay Loam." Medium to heavy leaching has occurred; the subsoil is moderately permeable on sloping land and slowly permeable in flat depressions. At Shades, the deep leaf litter characteristic of a deciduous forest is present, but moderate gully erosion occurs on a few slopes.

METHODS

Weeks before the tabulation work was carried out, the author and others went into the area to be studied and laid out 144 10-meter quadrats. Stakes were driven at the corners of the quads and white string was stretched around appropriate stakes. The quadrats were then numbered at their southwest corners until, at the time of tabulation, 144 quadrats were delimited and systematically numbered on the forest floor. Quadrat number 61 was omitted from the tabulations because 143 10-meter x 10-meter areas total five acres.

All stems 1 inch DBH. or larger were measured with wooden calipers. Stems below 1 inch DBH. but at least 3 ft. in height were tabulated. Figure 1 shows six types of 10% sampling patterns (A-F), one 28% sampling pattern (G), and one 34.6% sampling pattern (H). The latter pattern consisted of 50 quadrats distributed evenly over the five acre tract.

SIGNIFICANT DATA

The total results are presented in tables I-IX,[3] which, because of their bulk, are somewhat unwieldy. Table I shows abundance, size classes, and per cent F. I. for the total number of species in the five acre stand; tables II-IX,[3] present the same sociological features for the various patterns. From these we shall select data which have the most significant bearing on the problem of accuracy of sampling methods.

A summary of variations in per cent F.I. of trees 2 inches DBH. or larger is presented in table X.[3] This table does not include sampling pattern H, the purpose of which is to show how closely the results of a 34 per cent pattern consisting of uniformly distributed quadrats corresponds with the results of the entire five acres with regard to total vegetation and crown cover. These comparisons may be made by perusal of figure 2 and tables I and IX.[3]

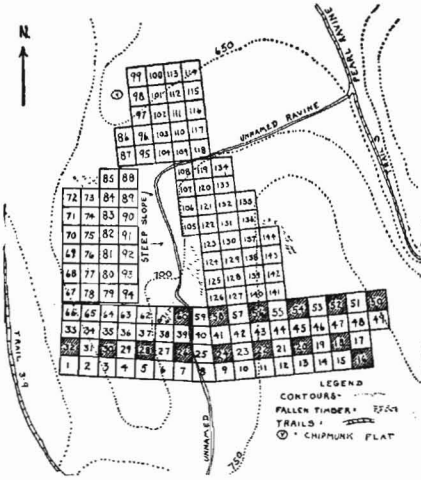
Table X highlights two important facts. First: species which show frequency indices between 10.4 (*Ulmus americana*) and 52.0 (*Fraxinus americana*) in the results of the five acre plot (table I), are absent in varying numbers in all the 10% sampling patterns, but all appear in the 28% sampling pattern (figure I-G). Secondly: F.I. varies with different sampling patterns for most species, especially for *Fagus grandifolia*. Variation is least in the 28% sampling pattern.

The forest is of the beech-mixed hardwoods type which Potzger (7) and Potzger and Friesner (8) have considered climax for Indiana. It is present on mesophytic habitats all over the state. While Fagus has 50% of the large size stems, 13 other species participate in the crown cover. Here, as in nearly all forest stands comparable to the type at Shades Park, *Acer saccharum* plays only a somewhat secondary role in the crown cover but reproduces prodigiously (table I). This stand is also typical for the Indiana climax forest in the absence of a well expressed shrub layer.

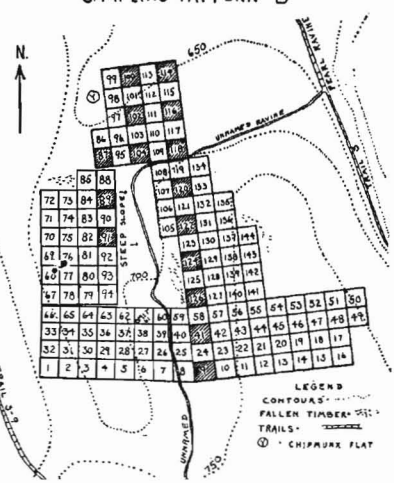
At Shades Park, the occurrence of ten species in five acres whose F.I. do not exceed 10% (table I) is attributed to what has been

[3] These are table numbers of the original manuscript which is available on loan from the Butler University Botanical Library. Only tables I and X are presented in this paper.

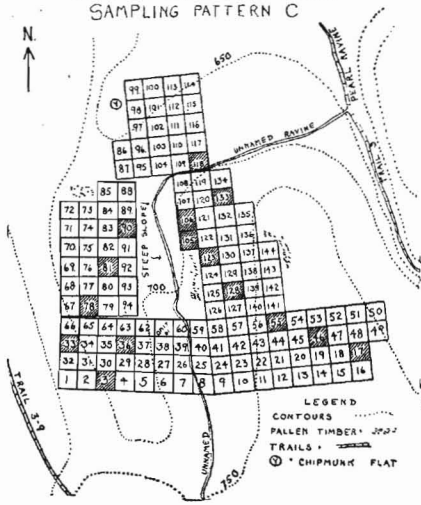
SHADED AREAS COMPRISE
SAMPLING PATTERN A



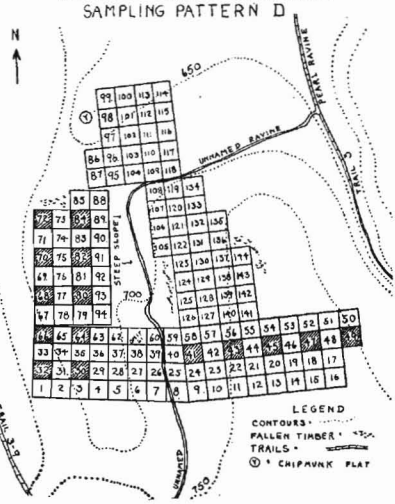
SHADED AREAS COMPRISE
SAMPLING PATTERN B



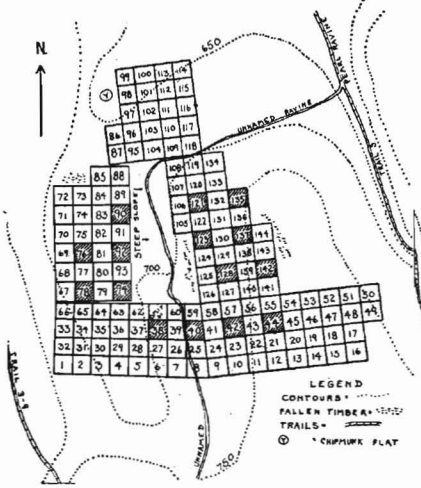
SHADED AREAS COMPRISE
SAMPLING PATTERN C



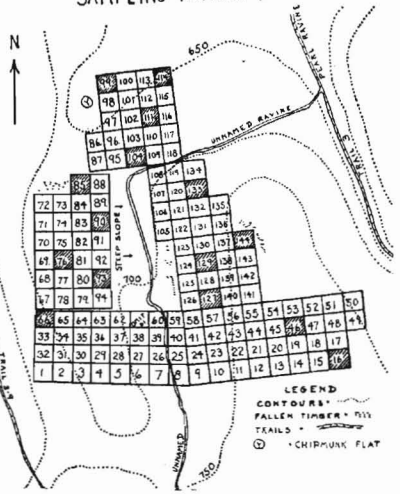
SHADED AREAS COMPRISE
SAMPLING PATTERN D



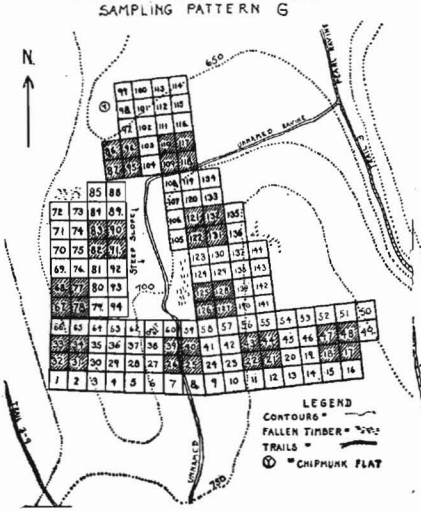
SHADED AREAS COMPRISE
SAMPLING PATTERN E



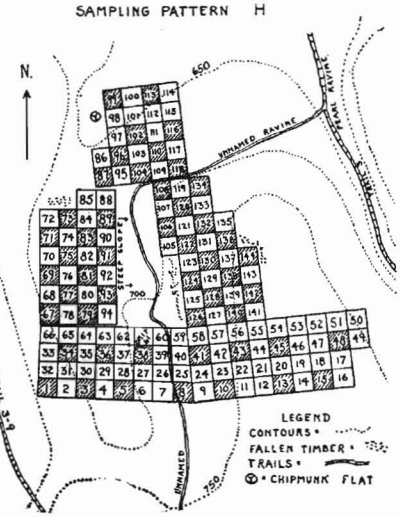
SHADED AREAS COMPRISE
SAMPLING PATTERN F



SHADED AREAS COMPRISE
SAMPLING PATTERN G



SHADED AREAS COMPRISE
SAMPLING PATTERN H



aptly termed a "mosaic of habitat," resulting in a mosaic of microclimate. While the topography of the area is somewhat rugged, some spots are very moist and subject to inundation in spring. Here Platanus and Ulmus, definitely out of place in a mesophytic habitat, find expression. On dry places on the slopes, oaks and hickories ecize and join beech and tulip poplar in the crown cover. For indication of crown control, abundance of stems 10 inches DBH. or larger was used (figure 2) because it was assumed that stems of this diameter had successfully overcome competition for light and now participated in the crown cover.

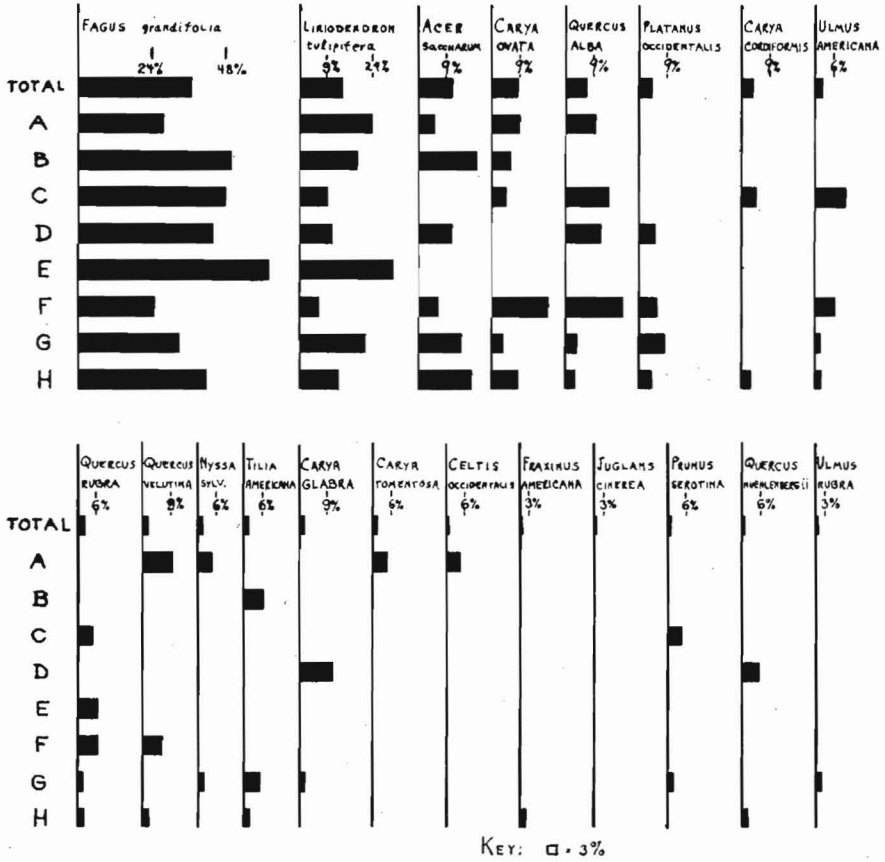
Pattern C (figure 1-C) covers all the types of habitat in the five acre stand, starting on the hill to the east and moving northwest across the ravine, southwest to the top of the hill at quadrat 33 and then back across the valley. As a result of microclimatic variations, the vegetation in pattern C shows species from the somewhat hydrophytic Ulmus (10%) to the xerophytic species *Carya cordiformis* (4.8%) and *Carya ovata* (4.9%) as indicated in figure 2. Sample E avoids the moist land by the valley and stays fairly well to the hilltops and slopes (figure 1-E). Only three species participate in the crown cover of this sample: Fagus (62%), Liriodendron (31%), and *Quercus rubra* (7%), (figure 2). Thus, whether the "mosaic of habitat" is used or carefully avoided, the type of vegetation reflects topographic selection.

DISCUSSION

Foremost among the distinguishing criteria of a mature forest is the comparatively great number of large stems. Only after decades of undisturbed growth and reproduction does a wood become mature to the extent that, although prodigious reproduction occurs in some species, only that species which is most able to adapt itself to prevailing conditions, i.e., to ecize, will survive. This results in a sort of natural selection which is controlled primarily by the macroclimate, but is varied within certain macroclimatically controlled areas by the microclimate of topographic differences which Potzger (7) has shown to be present in the rugged parts of Indiana. In a study of forest types in the Versailles State Park area, Potzger (7) shows that "Indiana is a very sensitively balanced climatic region where comparatively small differences in soil moisture induce striking differ-

FIGURE 2

PERCENT OF TOTAL STEMS 10" OR LARGER DBH IN ENTIRE 5 ACRES AND IN EACH SAMPLING PATTERN



ences in forest cover types." Results of the present study (figure 2) lend some credence to that statement.

Auten (1) considers slightly more than 200 stems per acre 2 inches DBH. or larger as indicative of a mature stand. At Shades State Park, in the present 5-acre study, there were 200 stems 2 inches DBH. or larger per acre, a fact which provides one of the best evidences that the stand is not only mature but that it has not experienced disturbances by man. As a forest matures, Griffin (5) has shown that "competition initiates elimination of numbers of individuals until an equilibrium is established between the carrying capacity of a given habitat and the number of stems in such an area."

That the 10% sampling patterns used are not always uniform in indicating crown cover is shown somewhat by the foregoing but more in detail by careful perusal of figure 2 correlated with topographic conditions for each sampling pattern (figure 1, A-F). While no attempt will be made to account for every variation in the results of the different sampling patterns, we should note that some species which have frequency indices between 10.4 and 52.0% in the five acre stand (table I) are eliminated in varying numbers in the six 10% sampling patterns. This, is, of course, what one would expect of a species which has a low F.I. in a given stand. Such species play only a minor role in the total crown cover (figure 2).

Validity of 10% sampling patterns when one is not dealing exclusively with crown cover is not altogether a different story. When based on trees 2 inches or larger DBH. (table X), species which reproduce excessively in spots, but which obviously have high mortality rates, i.e. *Fraxinus americana* and *Nyssa sylvatica*, are eliminated. The results of sampling patterns C and D more closely approach the true 5-acre tabulations than do the other 10% patterns (table X).

In the present study it is clear that a widely scattered selection of quadrats for a 10% sampling pattern does not necessarily result in a more accurate representation than a pattern arranged in a line. In fact, in the present study the pattern comprised of widely scattered quadrats (figure 1-F) results in the least accurate representation of the five acre stand of any 10% pattern used. From figure 2-F, it is evident that *Carya ovata*, *Carya glabra*, and *Quercus alba* all have

frequency indices more than twice the value they attain in the five acre stand (table I), while *Fagus grandifolia, Liriodendron tulipifera,* and *Acer saccharum* show much less abuandance than they actually show in the five-acre tabulation. Nevertheless, it is apparent (table X) that as a whole, where varying topographical features are included, the 10% sampling patterns except F give a fairly good representation of the important associates in the 5-acre stand. It is quite possible that less variation in results obtained by different 10% sampling patterns would be experienced in stands where topography is less variable. No doubt a uniform topography would automatically eliminate many of the unimportant species showing low frequency indices.

Variation in topographic complexity should no doubt be compensated by increased coverage by sampling units in this study. There is a definite increase in accuracy of representation (figure 2, G and H) when quadrats are enlarged and more area is included in a sampling pattern or when 34.6% of the 5-acres is tabulated by means of evenly distributed 10-meter quadrats. Sampling pattern G (figure 2,), which covers 28% of the 5 acres and consists of ten 20-meter x 20-meter quadrats, does not climinate rather important species, such as *Acer saccharum, Quercus alba* and *Carya ovata* from the crown cover. It results in a representation more closely approaching the total five acre tablations of the species with 9% or greater representation than any of the 10% sampling patterns (figure 2). The results (table IX and figure 2-H) of sampling pattern H (figure 1-H) more closely approach the total 5-acre tabulations than any other pattern used. Frequency indices of species listed in table IX and those of the same species in table I are strikingly comparable. Although sampling pattern H fails to show *Nyssa sylvatica, Carya glabra, C. tomentosa, Juglans cinerea,* and *Celtis occidentalis* in the crown cover (figure 2-H), it gives an accurate picture of the tree crown cover, as comparison with figure 2—Total will quickly indicate.

It is apparent then, that in the present study, 28% or 34% sampling patterns, even though they more closely approximate results of the total tabulation, do not include all species; a few unimportant ones are eliminated, and their elimination by these more inclusive patterns attests to their unimportance. Obviously the best distribution of quadrats over the area is that whose results most clearly ap-

proach the percentages shown in the area as a whole, i. e. when the entire stand is tabulated—in this case, distributions H (34%) and G (28%).

SUMMARY

1. A five-acre forest stand at Shades State Park was divided into 143 10-meter x 10-meter quadrats, and tabulations of all woody species occuring in the 5 acres were recorded.

2. Eight sampling patterns were derived to test their accuracy in recording the known 5-acre results. Six 10% patterns (figure 1, A-F), one 28% pattern (figure 1-G) and one 34% pattern (figure 1-H) were used.

3. All 10% sampling patterns, except E, and perhaps C, present a fairly accurate picture of the forest cover at Shades State Park.

4. Species showing frequency indices between 10.4% and 52% in the 5-acre tabulation (table 1) were eliminated in varying numbers in the results of the 10% sampling patterns when results were based on stems 2 inches DBH. or larger (table X).

5. The 10% sampling pattern comprised of widely scattered quadrats (figure 1-F) resulted in less accurate representation than the more regular 10% patterns.

6. The results (figure 2, G and H, and tables VIII and IX) of the 28% and 34% sampling patterns (figures 1, G and H) show a closer correlation with tabulations of the 5-acre stand than any of the 10% patterns used.

7. It is suggested that in a forest stand of less topographical variation, the results of any 10% sampling pattern would perhaps closely correlate with the total tabulation.

ACKNOWLEDGMENTS

The author is indebted to Dr. J. E. Potzger for suggestion of the problem, supervision in laying out the quadrats and for critical reading of the thesis, and to Dr. R. C. Friesner for supervision of the tabulation work and critical reading of the thesis. The author is grateful to his colleagues, Johanna Jones, William Harris and Robert Petty, for help with the field work.

LITERATURE CITED

1. AUTEN, JOHN T. Notes on old growth forests in Ohio, Indiana and Illinois. U. S. Dept. Agric. Forest Service Tech. Note 49. 1941.
2. BARRETT, EDWARD. The Beautiful Shades. 41st Ann. Rep. Indiana Geol. Survey. 1916. (cited by Malott, 6).
3. BUSHNELL, T. M. The Story of Indiana Soils. Purdue Univ. Agric. Exp. Sta. Spec. Circ. 1944.
4. DRYER, CHARLES R. Geography of Indiana. 1912. (cited by Malott, 6).
5. GRIFFIN, CHARLES DONALD. A study of abundance of stems per acre in relation to age of staud. Butler Univ. Bot. Stud. 8:219-232. 1948.
6. MALOTT, C. A. Physiography of Indiana; Handbook of Indiana Geology. Indiana Dept. Conserv. 1922.
7. POTZGER, JOHN E. Forest types in the Versaillcs State Park area, Indiana. Amer. Midl. Nat. 43:729-741. 1950.
8. ——— and R. C. FRIESNER. What is climax in Central Indiana? A five-mile quadrat study. Butler Univ. Bot. Stud. 4:181-195. 1940.

TABLE I

Tabulation of Woody Species on Five Acres at Shades State Park: Diameter Classes in Inches DBH.

Trees	Diameter Classes Inches DBH. Below 1	1-2	3-5	6-9	10-15	16-20	Above 20	Total	F.I.
Acer saccharum	2,101	1,013	198	23	7	5	9	3,355	100.0
A. rubrum	14							14	4.8
Asimina triloba	229	2						231	17.5
Carpinus caroliniana	28	38	13	1				80	24.4
Carya cordiformis	8	1	4	8	4	1	1	27	13.0
C. glabra	4	2	1	1	3			11	4.8
C. ovata	11	4	6	6	11	3	1	42	18.0
C. tomentosa				1	1	1		3	1.3
Celtis occidentalis	9	2			1			12	4.8
Cornus florida	106	40	42					188	39.0
Fagus grandifolia	23	58	43	11	16	17	37	205	70.0
Fraxinus americana	151	38	3			1		193	52.0
Juglans cinerea							1	1	
Liriodendron tulipifera	5	1	3	4	14	12	1	40	15.0
Morus rubra	11	1						12	7.0
Nyssa sylvatica	505	20	1	3	2		1	532	19.5
Ostrya virginiana	105	26	5	3				139	34.0
Platanus occidentalis					2	5	1	8	4.2
Prunus serotina	11	1			1			13	4.2
Quercus alba	9	5	3	1	7	3	2	30	13.0
Q. muehleubergii	1	1	1				1	4	2.8
Q. rubra	29	1	1	11	4			46	14.0
Q. velutina				1			3	4	2.0
Sassafras variifolium	12	3	7	3				25	11.8
Tilia americana	115	5	4	4	2	1		131	16.7
Ulmus americana	3	4	2	4	4			17	10.4
U. rubra	31	1	4	2			1	39	18.8
Total								5,402	
Shrubs									
Celastrus scandens	8							8	2.1
Cornus alternifolia	27	2						29	6.2
Dirca palustris	7							7	2.8
Hamamelis virginiana	26							26	8.4
Lindera benzoin	209	5						214	18.1
Parthenocissus quinquefolia	1							1	
Ribes cynosbati	1							1	
Sambucus canadensis	6							6	1.3
Smilax tamm. v. hispida	21							21	10.4
Viburnum acerifolium	45							45	9.0
Vitis sp.	1	1	1					3	1.3
Total								361	
Total Trees Plus Shrubs								5,763	

TABLE X*

Comparison of F. I. of Tree Species
Two Inches DBH. or Larger According to 8 Patterns of Sampling
In a Five Acre Stand at Shades State Park

Species: Trees only	Entire Five Acres	Sampling Patterns "A"	"B"	"C"	"D"	"E"	"F"	"G"
Acer saccharum	90.0	86.7	80.0	100.0	93.3	93.3	80.0	92.5
Carpinus caroliniana	14.6		26.3	20.0	13.0	13.0	13.0	12.5
Carya cordiformis	9.8			6.6		6.6	6.6	2.5
C. ovata	15.3	20.0	6.6	6.6	6.6	13.0	26.3	17.5
Cornus florida	22.2	6.6	33.0	6.6	26.3	13.0	40.0	25.0
Fagus grandifolia	64.3	60.0	53.3	66.6	53.3	93.3	53.3	57.5
Fraxinus americana	6.3		6.6		13.0	6.6	13.0	2.5
Liriodendron tulipifera	14.6	20.0	20.0	13.0	33.3	13.0	6.6	20.0
Nyssa sylvatica	4.9	6.6		6.6	6.6			2.5
Ostrya virginiana	8.3	6.6		6.6	13.0	6.6	20.0	7.5
Quercus alba	10.4	20.0	6.6	13.0	13.0		20.0	10.0
Q. rubra	9.0	13.0		6.6	13.0	13.0	13.0	12.5
Sassafras variifolium	7.0	20.0		13.0	6.6		20.0	2.5
Tilia americana	5.6		13.0	6.6				12.5
Ulmus americana	8.3		6.6	13.0	6.6		13.0	10.0
U. rubra	5.6		6.6		6.6	6.6		7.5

* Shows only those trees which had a F. I. or 10 or over in table I.