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STAND STRUCTURE AND COMPOSITION OF A NATURAL MIXED HARDWOOD FOREST

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Abstract

A complete inventory of a 60-acre natural mixed hardwood forest was conducted to study its stand structure and composition. The current status of the woodland was compared with data from the 1963 inventory. In the present stand the leading dominant is sugar maple. Hackberry, slippery elm, white ash and basswood follow in order of Importance Value Index. The relative species composition did not change significantly after the impact of the Dutch elm disease, but most species showed an increase in number of trees and basal area. The total stand had a basal area of 120.8 square feet (trees 2.6 inch diameter and larger), with 231.6 trees per acre. Sugar Maple can be expected to maintain its dominance in the future as it represents approximately one third of all individuals in the seedling and sapling stage.

Forests in central Illinois once were found mainly along watercourses and in isolated patches known as "Prairie Groves" that were separated from the main bodies of timber (Boggess 1964). With settlement many of these forest lands were converted to agricutlrual use, with only a few remnants remaining. The University of Illinois acquired several of these woodlands maintaining them as natural areas for research and educational purposes. The two major remnants of the "Big Grove" near Urbana, Illinois are Brownfield Woods and Trelease Woods. Brownfield Woods has been owned by the University of Illinois since 1939 and Trelease Woods since 1917. Results of an analysis of the stand composition of Brownfield Woods was reported previously (Miceli et. al. 1977). This paper summarizes the results of a 100% inventory of Trelease Woods conducted in 1976. Both of the woodlands are classified as mesophytic upland forests.

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Trelease Woods is a 60-acre woodland located northeast of Urbana, Illinois in the SW¼ of Section 1, Range 9E, Township 19N, Champaign County Illinois. Topography is flat with elevation differences of less than 5 m. The major soil orders are Mollisols and Alfisols which are developed in shallow loess (3 feet or less) over glacial till (Bailey et. al., 1964). The Mollisols predominate with the weakly developed transition Alfisols occurring in only a few areas of the woodland.

PAST WORK

The first inventory of Trelease Woods was completed in 1922 as a tree count by species (McDougall, 1922). In 1935 a study on plot size requirements was conducted giving results on stand composition (Marberry 1936) and in 1940 this study was continued including additional plots (Vestal and Heermans 1945). Boggess conducted the first 100% inventory in 1963 examining the effect of Dutch elm disease occurring in the early 1950's on the forest. All references to past results are based on Boggess (1964).

METHODS

In designing the inventory the measurement system of Boggess (1964) was followed since a comparison with the 1963 inventory was desired. The area is subdivided in 96, 50-meter square blocks. For measurement purposes each block was subdivided into quarters (quadrats) by running a line diagonally from each corner post. All woody vegetation 2.6 inches dbh and above was measured to the nearest 0.1 inch by species. The saplings (0.6 to 2.5 diameter class) were measured in two 5 x 5 meter subplots in each block distributed systematically over the area. Tree seedlings were sampled in 2 x 2 meter plots located randomly in one corner of the 25 m^2 plot. Seedlings of woody species less than 0.6 inch in diameter were tallied by height in two classes (1) less than 1 foot and (2) greater than 1 foot.

In sampling reproduction and shrub species a total of 192 plots of 5 x 5 m and the same number of 2 x 2 m plots were measured, doubling the number used in 1963. This corresponds to a sampling intensity of 2% and 0.3% respectively, only a small sample of the entire area, which should be considered in evaluating results.

Tree data reported by diameter class, basal area, frequency and density in Table 1 and a comparison of earlier inventories in terms of basal area is shown in Table 2. Table 3 shows the density and frequency of seedlings and saplings by height or diameter class. The Importance Value Index is also shown in Table 1 and is calcualted as the sum of the relative density and the relative dominance for each species as in Boggess (1964).

RESULTS AND DISCUSSION

A total of 13,733 trees of 2.6 inch diameter or larger were measured resulting in an average number of 231.6 trees/acre. This compares to a total of 148.9 trees/acre in the 1963 inventory. The

Table 1. Number of Trees, Basal Area Per Acre, Importance Value Index, and Average Diameter for Leading Dominants.

	Diameter Class																	
	3-6		7-12		13-24		25-36		37+		Total		Percent		Average	Importance value	Frequency %	Frequency %
Species	BA	No.	BA	No.	BA	No.	BA	No.	BA	No.	BA	No.	BA	No.	diameter	index	quadrats	blocks
Sugar Maple	3.4	36.5	5.5	11.8	20.9	12.1	5.0	1.2	0.3	.	35.1	61.6	29.0	26.6	10.2	55.7	90.9	99.0
White Ash	0.6	5.3	1.4	3.1	8.2	4.1	4.4	1.1	0.4	0.1	15.0	13.6	12.4	5.9	14.2	18.3	61.8	95.8
Hackberry	1.4	12.2	4.9	10.7	3.1	2.3	2.8	0.6	1.1	0.1	13.4	26.0	11.1	11.2	9.7	22.3	80.7	96.9
Red Oak	.	0.1	.	0.1	1.2	0.5	7.1	1.4	2.9	0.4	11.2	2.4	9.3	1.0	29.5	10.3	27.3	64.6
Basswood	1.2	11.9	1.9	4.4	3.2	1.8	1.1	0.3	.	.	7.4	18.4	6.2	7.9	8.6	14.1	58.3	90.6
Slippery Elm	2.3	22.3	3.5	8.5	0.7	0.5	0.5	0.1	.	.	6.9	31.4	5.7	13.6	6.3	19.3	85.9	100.0
Black Walnut	0.4	3.9	0.8	1.8	2.4	1.2	3.0	0.7	.	.	6.6	7.6	5.5	3.3	12.6	8.7	44.3	78.1
Bur Oak	0.2	1.9	0.1	0.3	1.2	0.6	3.4	0.7	1.3	0.2	6.2	3.5	5.1	1.5	18.0	6.7	28.6	56.3
Buckeye	0.8	9.2	0.5	1.3	3.9	2.2	0.6	0.2	.	.	5.8	12.8	4.8	5.5	9.1	10.3	69.3	97.9
Blue Ash	0.2	2.6	0.5	1.2	0.9	0.5	0.7	0.2	.	.	2.4	4.4	2.0	1.9	9.9	3.9	40.6	72.9
American Elm	0.4	4.0	1.1	2.5	0.4	0.3	.	.	.	.	1.9	6.8	1.6	2.9	7.2	2.9	40.4	79.2
Hawthorn	0.6	5.8	0.6	1.7	0.2	0.1	.	.	.	.	1.4	7.7	1.1	3.3	5.8	4.5	31.0	59.4
Pawpaw	1.1	20.8	.	.	.	.	.	.	.	.	1.1	20.8	0.9	9.0	3.2	9.9	46.1	69.8
Chinquapin Oak	.	.	.	.	0.2	0.1	0.5	0.1	0.3	.	1.1	0.2	0.9	0.1	29.1	1.0	3.1	11.5
Kentucky Coffee Tree	0.1	1.3	0.2	0.5	0.5	0.3	0.2	0.1	.	.	1.0	2.1	0.9	0.9	9.4	1.8	17.2	42.7
Shagbark Hickory	0.2	1.4	0.2	0.7	0.5	0.3	0.1	.	.	.	1.0	2.4	0.8	1.0	8.8	1.8	18.2	41.7
Blue Beech	0.7	7.2	0.1	0.2	.	.	.	.	.	.	0.7	7.4	0.6	3.2	4.2	3.8	37.8	65.6
Sycamore	.	.	.	.	.	.	0.3	0.1	0.4	.	0.7	0.1	0.6	0.1	33.0	0.6	1.6	6.3
Green Ash	.	0.3	0.1	0.2	0.4	0.2	0.1	.	.	.	0.7	0.7	0.6	0.3	13.4	0.8	7.8	25.0
Silver Maple	.	.	.	.	.	.	0.3	0.1	.	.	0.4	0.1	0.3	0.1	23.2	0.3	0.5	2.1
Bitternut Hickory	.	0.2	.	.	0.2	0.1	.	.	.	.	0.2	0.3	0.2	0.1	11.7	0.3	4.4	15.6
Honey Locust	.	0.2	.	.	.	.	0.1	.	.	.	0.2	0.3	0.1	0.1	11.6	0.3	3.4	10.4
Others	0.1	0.6	0.1	0.1	0.1	0.1	0.1	.	0.2	.	0.4	1.0	0.3	0.5				
Total	13.7	147.7	21.5	49.1	48.2	27.3	30.3	6.9	6.9	0.8	120.8	231.6	100.0	100.0				

Table 2. Number of Trees and Basal Area Per Acre (sq. ft.) in 1940, 1963 and 1976 for 12 Species.

Species	1940		1963		1976	
	Number trees	Basal area (sq. ft.)	Number trees	Basal area (sq. ft.)	Number trees	Basal area (sq. ft.)
Sugar Maple	39.2	34.6	37.8	27.5	61.6	35.1
American Elm	16.0	21.9	4.2	0.8	6.8	1.9
Slippery Elm	8.6	11.4	17.0	3.0	31.4	6.9
Basswood	10.4	11.6	12.0	6.0	18.4	7.5
White Ash	9.4	8.5	10.4	12.0	13.6	15.0
Buckeye	7.1	7.5	7.9	4.6	12.8	5.8
Red Oak	2.8	8.5	2.8	11.2	2.4	11.2
Blue Ash	4.8	3.0	2.9	2.6	4.4	2.4
Hackberry	4.1	3.1	20.9	8.5	26.0	13.4
Black Walnut	3.0	5.5	4.0	4.9	7.6	6.6
Bur Oak	1.5	3.5	1.6	5.0	3.5	6.2
Chinquapin Oak	1.2	2.2	0.4	1.4	0.2	1.1
Total	108.1	121.3	121.9	87.5	188.7	113.1

Table 3. Density/acre and frequency (%) of woody species less than 2.6 inch dbh by height or diameter class.

Scientific Name	Common Name	Height Class (<0.6" dbh) <1'	>1'	Total	% Frequency	Diameter Class Density 1" & 2"	Frequency %
Acer saccharum	Sugar maple	368.9	790.5	1159.4	28.1	175.4	33.3
Fraxinus americana	White ash	.	.	.	.	0.8	0.5
Celtis occidentalis	Hackberry	5.3	100.1	105.4	4.2	19.4	10.4
Quercus rubra	Red oak	84.3	15.8	100.1	5.2	3.4	1.6
Tilia americana	Basswood	10.5	.	10.5	1.0	14.3	4.2
Ulmus rubra	Slippery elm	5.3	42.2	47.5	4.7	19.4	7.3
Juglans nigra	Black walnut	.	5.3	5.3	0.5	1.7	1.0
Quercus macrocarpa	Bur oak	10.5	.	10.5	1.0	6.7	3.1
Aesculus glabra	Buckeye	131.8	205.5	333.3	20.3	38.8	15.6
Fraxinus quadrangulata	Blue ash	5.3	36.9	42.2	3.6	11.0	5.2
Ulumus americana	American elm	.	.	.	.	5.1	2.6
Crataegus mollis	Hawthorn	.	10.5	10.5	1.0	5.1	2.6
Asimina triloba	Pawpaw	147.5	442.7	590.2	21.9	192.2	29.2
Quercus muehlenbergii	Chinquapin oak	147.5	58.0	205.5	12.5	5.1	2.6
Gymnocladus dioicus	Kentucky coffee tree	5.3	31.6	36.9	2.1	5.1	2.1
Carya ovata	Shagbark hickory	10.5	.	10.5	1.0	.	.
Carpinus caroliniana	Blue beech	10.5	79.1	89.6	2.6	35.4	5.2
Fraxinus pennsylvanica	Green ash	.	.	.	.	0.8	0.5
Carya cordiformis	Bitternut hickory	.	5.3	5.3	0.5	.	.
Gleditsia triacanthos	Honey locust	.	.	.	.	0.8	0.5
Lindera benzoin	Spicebush	94.8	353.1	447.9	14.6	59.9	10.4
Prunus serotina	Black cherry	.	.	.	.	0.8	0.5
Carya laciniosa	Shellbark hickory	10.5	10.5	21.0	2.1	0.8	0.5
Cornus racemosa	Dogwood	.	21.1	21.1	0.5	1.7	0.5
Prunus virginiana	Chokecherry	63.2	79.1	143.3	0.5	.	.
Zanthoxylum americanum	Prickly ash	.	5.3	5.3	0.5	0.8	0.5
Total				3401.3		604.5	

largest increase was in the 3-6 inch diameter class from 94.0 to 147.8 trees/acre. The stand basal area also increased since 1963, approaching the 1940 level (93.1 to 120.8 square feet per acre). Table 1 shows population characteristics for the 22 major species representing more than 99.5% of the entire stand in terms of basal area and number of trees/acre. The remaining 0.5% consisted of one cottonwood tree of 40.9 inch diameter, previously not recorded, and several small trees whose classifications were questionable.

Sugar maple (Acer saccharum Marsh.) is the by far most abundant species in the stand. The relative basal area of sugar maple has remained the same since 1963 but the absolute values increased from 27.5 to 35.1 square feet reaching the 1940 level (Table 2). Sugar maple is well distributed, occurring in 349 quadrats with a frequency of 90.9%. Sugar Maple also has by far the highest importance value index with 55.7 (Table 1).

In terms of basal area, white ash (Fraxinus americana L.) is the second most important species with a basal area of 15.0 $ft.^2$ or 12.4%. This represents 13.6 trees per acre or 5.9% of the total number of trees. The distribution by diameter class is relatively equal for classes from 3- to 24-inches, but shows a major drop for the 25- to 36-inch class. The average diameter is 14.2 inches. White ash is also well distributed over the forest occurring in 95.8% of the blocks and 61.8% of the quadrats.

The third ranked species in terms of basal area is Hackberry (Celtis occidentalis L.) with a basal area of 13.4 square feet of 11.1% of the total. Its diameter distribution is skewed toward the lower values with the highest frequency in the 3- to 6-inch diameter class. The average diameter of 9.7 inches reflects the large percentage of small trees. Hackberry is distributed well over the forest with a frequency of 96.9% of the blocks and 80.7% of the quadrats.

Fourth in rank order is red oak (Quercus rubra L.) with 11.2 square feet basal area or 9.3%. Red oak has the highest percentage of all species in the 37+ inch diameter class, and the largest average diameter with 29.5 inches. Basswood (Tilia americana L.) and slippery elm (Ulmus rubra Muhl.) are next in terms of basal area, with both species having a large percentage in the lower diameter classes. The number of trees per acre is relatively high for both species resulting in above-average importance values of 14.1 and 19.3, respectively. Slippery elm is dominantly represented among smaller diameter classes with the second highest number of trees in the 3- to 6-inch class (after sugar maple), and very few in the 25- to 36-inch class. The importance value index for slippery elm is third with 19.3 based on the large number of trees and the relative dominance. It is well distributed in the forest and was found in all 96 blocks and in 330 quadrats (85.9% frequency).

These six species represent more than 73% of the basal area of the entire stand.

A graphic representation of the stand density is shown in Figure 1 where number of trees per acre by diameter class is shown for the major species.

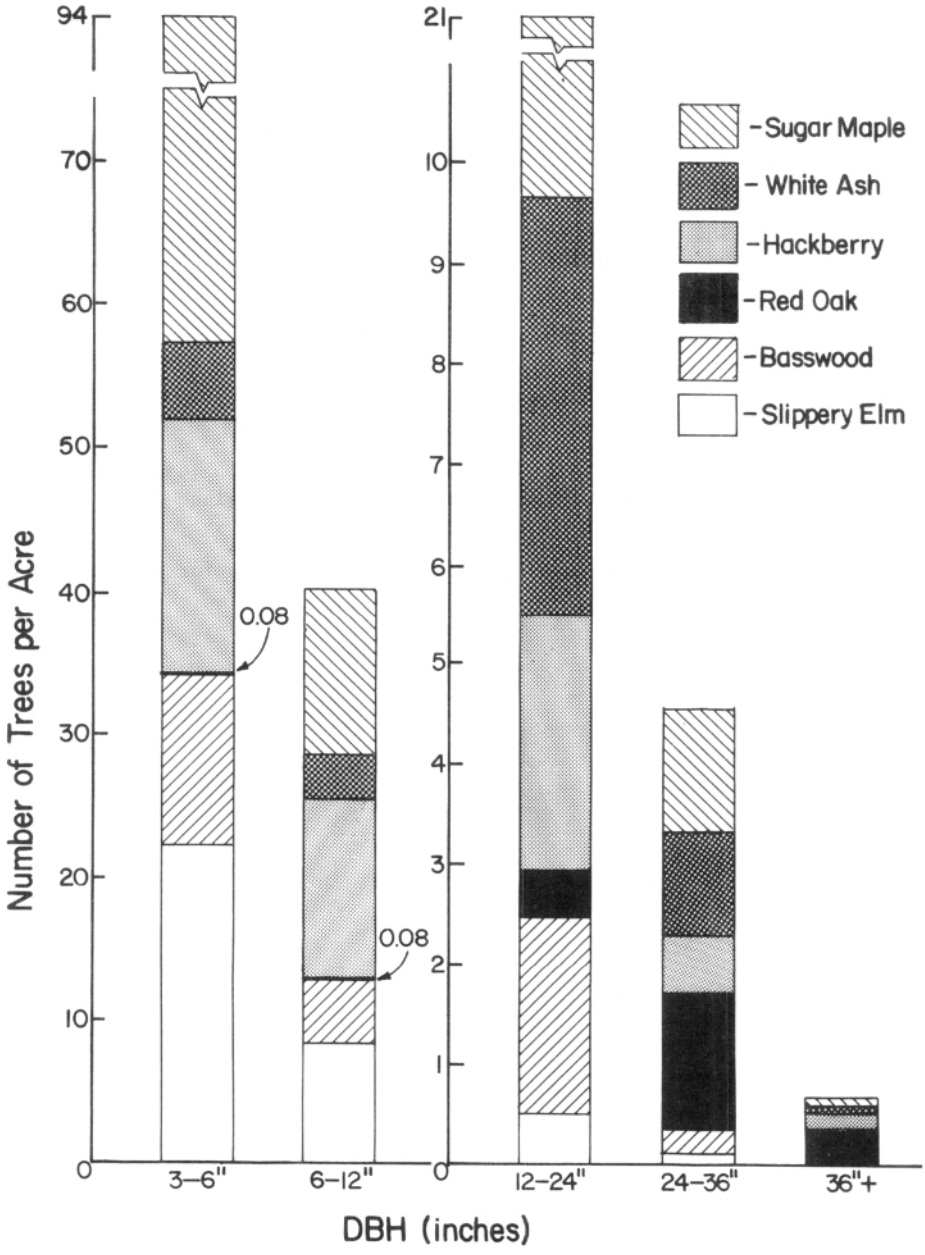
The understory is dominated by sugar maple with 1159.4 seedlings per acre (less than .6 inch diameter) and 175.4 saplings per acre between 0.6 and 2.5 inch diameter (Table 3). Sugar maple seedlings were found in 28% of all plots, saplings in 33% of all plots. Pawpaw is next in density with 590.2 seedlings and 192.2 saplings, follows by spicebush with 447.9 seedlings and 60 saplings per acre. Buckeye and chinquapin oak also show a relative high density in the seedling stage. Other tree species have a considerable lower number of seedlings and saplings.

The most remarkable changes in stand composition since the 1963 inventory are the increases in number of trees per acre and basal area per acre. Sugar maple increased from 27.5 square feet basal area in 1963 to 35.1, with a shift toward smaller diameter classes and an increase in number of trees/acre from 37.8 to 61.6 (Table 2). Slippery elm more than doubled in basal area from 3.0 to 6.9 square feet and increased its number of trees/acre from 18.0 to 31.4. American elm shows a small increase from 0.8 $ft.^2$ to 1.9 $ft.^2$. Hackberry also shows a remarkable increase in basal area and a corresponding shift toward larger diameter classes. Bur oak shows an increased basal area, but its diameter distribution is shifting toward the smaller diameter classes as the old large trees die. The average diameter decreased from 23.9 inches to 18.0 inches is due to the mortality of the larger diameter classes and increase number of the smaller individuals in the smaller classes. The number of large trees increased significantly since the last inventory. A total of 22 trees of more than 36.5 inch diameter were measured in 1963 whereas in 1976 47 trees were recorded.

The decline in basal area and number of trees per acre resulting from the high mortality due to Dutch elm disease was reversed during the last 13 years, with areas once occupied by american elm now occupied by a variety of species. Slippery elm gained most in relative terms with an increase in importance value from 15.3 to 19.3. However, sugar maple showed the largest increase in absolute numbers and the third largest in relative terms after slippery elm and black walnut. Pawpaw invaded the spaces previously occupied by elms increasing in number of trees per acre from 9.1 in 1963 to 20.8 in 1976.

It seems remarkable that the relative species composition of the forest was not significantly altered due to a natural catastrophy such as the Dutch elm disease but that most species simply increased in number of trees and basal area to occupy the available niche and maintain their standing in the forest.

In the present stand sugar maple is the leading dominant with 29% of the total number of trees. It is likely that it will maintain its dominant position in the future because of its importance in the seedling stage (34% of total individuals) and in the sapling stage (29% of total individuals).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Number of Trees per Acre
3–6"
6–12"
12–24"
24–36"
36"+
DBH (inches)
- Sugar Maple
- White Ash
- Hackberry
- Red Oak
- Basswood
- Slippery Elm

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