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STRUCTURE AND COMPOSITION OF GINN WOODS, AN OLD-GROWTH FOREST IN EAST-CENTRAL INDIANA

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ABSTRACT: The structure and composition of Ginn Woods, a deciduous forest community in east-central Indiana, was examined, and its status as an old-growth stand was evaluated. Woody stems $\geq$ 10 cm dbh were sampled using the point-centered quarter method. Woody stems < 10 cm dbh and at least 2 m tall were sampled using 0.01 ha circular plots. Data were collected from three areas having some differences in land-use history and soil moisture regimes. Shade-tolerant species dominate the understory and overstory. *Acer saccharum* has the highest overstory density, understory density, and total basal area of any species in all but the most poorly drained areas. *Fagus grandifolia* or *Tilia americana* rank second in most of these categories. Subdominant species at the site include: *Aesculus glabra*, *Celtis occidentalis*, *Fraxinus americana*, *Prunus serotina*, *Quercus rubra*, and *Ulmus rubra*. *Acer saccharinum*, *Acer rubrum*, *Carya laciniosa*, *Fraxinus pennsylvanica*, *Platanus occidentalis*, and *Populus deltoides* are prominent in localized areas, where soil drainage is the poorest. Canopy recruitment reflects a history of natural windthrows with minimal impact from human activities. Shade tolerant dominants show a descending monotonic size-class distribution that is typical of uneven-aged stands that are replacing themselves. Shade-intolerant species show little or no recruitment, and their importance should continue to decease. Across the site, total canopy stem density (dbh $\geqslant$ 10 cm) ranged from 282 to 339 stems/ha, and basal area ranged from 36 to 39 m^2/ha. These data indicate that Ginn Woods is an old-growth forest. This 61-ha forest ranks as the second largest old-growth forest in Indiana.

KEYWORDS: Indiana, old-growth, beech-maple forest, plant community, succession.

INTRODUCTION

A variety of definitions and criteria have been used to distinguish old-growth forests from less mature successional stands. Most definitions of old-growth forest are based on tree age, lack of human disturbance, forest community structure, and successional stage of the forest. No consensus exists on old-growth criteria based on tree age and degree of anthropogenic disturbance. Old-growth forests are more readily defined by community structural characteristics. On this basis, old-growth forests are generally dominated by old trees, contain a con-

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siderable amount of dead woody biomass, have multiple growth layers, have large trees for the growing conditions, have well-developed herbaceous layers, have a mosaic of variable-sized canopy gaps, and are dominated by late successional species (Leverett, 1996).

Strict quantitative criteria are difficult to use to define old-growth forests due to the variable effects of regional climate, local site conditions, and disturbance regime on community composition and structure. Typically, the criteria in a particular region are based on a variety of quantitative and qualitative forest parameters that combine functional, structural, and historical attributes. The criteria for identifying old-growth mesophytic forests in Indiana and the surrounding states have been summarized by Parker (1989) and Martin (1992). Their criteria can be used to evaluate beech-maple forests, but a lower diversity of canopy species should be expected for beech-maple forests than for other mesophytic forests in the region (Runkel, 1996).

Ginn Woods is one of the largest remaining tracts of old-growth forest in east-central Indiana (McClain, 1985; Ruch, *et al.*, 2000). However, Ginn Woods has not been included in studies of the old-growth forests of Indiana (Parker, 1989; Brothers, 1993; Spetich, *et al.*, 1997). No quantitative studies of the woody plant community in Ginn Woods have been published. In contrast, the Davis-Purdue Research Forest, located only about 45 km from Ginn Woods, has been the subject of several published studies (Parker and Leopold, 1983; Parker, *et al.*, 1985; Parker and Sherwood, 1986; Parker and Ward, 1987; Ward and Parker, 1989; Spetich and Parker, 1998). After a brief visit, Lindsey, *et al.* (1969) rated Ginn Woods as a high quality educational resource, but they did not recognize it as an old-growth forest. In this paper, we describe the distribution and abundance of woody plants within Ginn Woods and evaluate its status as an old-growth forest.

STUDY SITE

Ginn Woods is a 65-ha tract of woodland owned by Ball State University and managed by the Department of Biology. The site is located approximately 25 km north of Muncie, Indiana (SW¼, Sec. 18, and NW¼, Sec. 19, T22N, R10E; Figure 1). Ginn Woods consists of three separately purchased tracts of land. The tract originally known as Ginn's Woods was purchased by John Ginn in 1832 as a United States Land Grant shortly after Delaware County was first settled. The woods remained in the Ginn family until its purchase by Ball State University in 1971. The portion of the original tract known as North Woods (approximately 25 ha) had a slightly different disturbance history from South Woods (approximately 20 ha). According to the Ginn family, North Woods (Figure 1) has been neither grazed nor burned and has not been logged since its acquisition. South Woods was not grazed but has been moderately disturbed. In 1924, some timber was removed for the construction of a house. In addition, a few white oaks were cut by a stave mill company, but, for some unknown reason, the logs were not removed. Ginn's Woods was designated a classified forest in Decem-

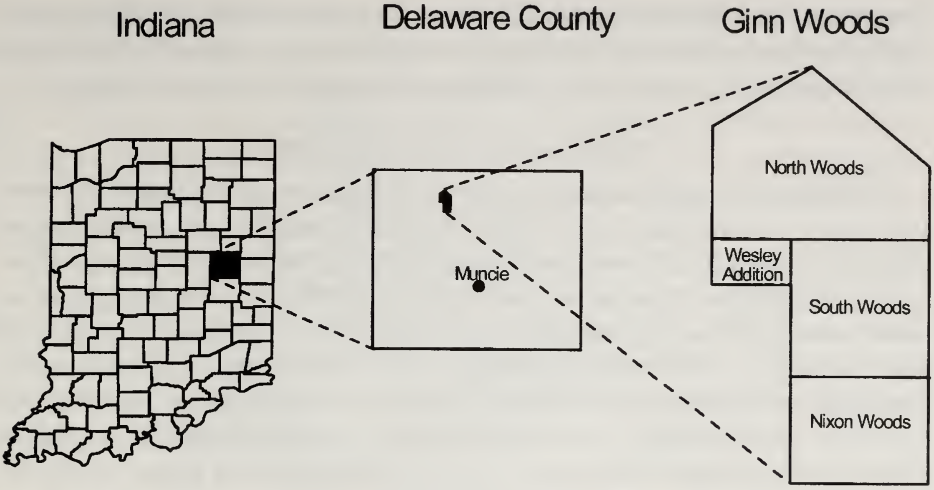

Figure 1. Map of Ginn Woods and the location of Ginn Woods in Delaware County, Indiana.

ber 1929. The State Forester at that time, Charles C. Deam, stated on the application form that the woods had no indication of insect or disease damage and no anthropogenic disturbance. Deam stated that Ginn's Woods was a virgin forest (McClain, 1985).

Ball State University purchased two other tracts of land shortly after the acquisition of the original Ginn's Woods. Nixon Woods (approximately 16 ha; Figure 1), which abuts the southern end of South Woods, was acquired in 1974. No record of past use has been found for Nixon Woods. However, in the 1971 proposal to purchase this tract, Nixon Woods was reported to have larger trees than those found in Ginn's Woods and little evidence of human disturbance (McClain, 1985). The evidence of fencing around Nixon Woods, which is absent from the rest of the study area, suggests that grazing may have occurred in Nixon Woods at some time. The third and final tract purchased was the Wesley Addition or Wesley Wet Area (Figure 1; Ruch, *et al.*, 2000). This 4-ha former agricultural field was purchased to preserve the integrity of North Woods. These four tracts are now known collectively as Ginn Woods. Ginn Woods is managed as a research natural area.

Ginn Woods lies in the Bluffton Till Plain Section of the Central Till Plain Natural Region, an area formerly covered by an extensive beech-maple forest (Homoya, *et al.*, 1985). The soils in Ginn Woods are derived from glacial parent material and vary from somewhat poorly drained to very poorly drained soils (Huffman, 1972). McClain (1985), who studied the soils in North Woods, described the dominant soils as Blount (Aeric Ochraqualfs, fine, illitic, mesic), Glynwood (Aquic Hapludalfs, fine, illitic, mesic), and Lenawee Soils (Mollic Haplaquepts, fine, illitic, mesic). These soils comprise approximately 80%, 15%, and 5% of the study site, respectively. The poor internal drainage of these soils results in a seasonally high water table of less than 40 cm for most of the study area (McClain, 1985). Seasonal ponding typically occurs on the low-lying portions of the Blount Soils through early spring and on the Lenawee Soils through mid-summer.

MATERIALS AND METHODS

Overstory. The point-centered quarter method was used to sample the overstory trees (Cottam and Curtis, 1956). Systematic sampling was used to insure uniform coverage of the woods, excluding the Wesley Wet Area (Figure 1). Transects were spaced at 50 m intervals and oriented from west to east. Sample points were located at 25 m intervals along the transects, and sampling began 25 m in from the edge. At each sample point, four quarters were defined using the direction of the measuring tape and an imaginary line extending perpendicular to the tape at each sampling point. In each quarter, the stem closest to the sampling point that was greater than or equal to 10 cm dbh (diameter at breast height, 1.4 m from the ground) was identified, and its dbh (to the nearest 0.1 cm) and distance from the sampling point (to the nearest 0.1 m) were recorded.

These data were summarized to obtain information on the woods' composition and structure. Stem density per hectare, basal area (dominance) per hectare, and frequency per hectare were calculated for each species along each transect (Cottam and Curtis, 1956). Our initial analysis of the data from the individual transects indicated that species' composition and structure were very homogeneous within each area of Ginn Woods (Schoultz, 1997). Therefore, the transect data were combined to give an overall value for each section of Ginn Woods. Species' importance values were calculated as the average of the sum the relative dominance, relative frequency, and relative density in each area of Ginn Woods (Barbour, *et. al.*, 1987).

Stem density was calculated for the 5 most dominant species (based on importance value) in each section of Ginn Woods. Size-class densities of the remaining species were summed. The size-class distributions were used to infer whether or not a particular species was replacing itself. A species that is reproducing vigorously will often have a high density in its smaller size classes (Ziegler, 1995). Our size-class distributions were compared to the three basic size-structure curves: descending monotonic, multimodal, and decreaser (Leak, 1964; Lorimer, 1985; Whipple and Dix, 1979; Ziegler, 1995). A descending monotonic curve, which has a higher density in the smaller size classes and a decrease in density with an increase in diameter, is typical of uneven-aged stands that are replacing themselves. A multimodal curve identifies a species that reproduces in pulses separated by periods of low/no reproduction. The decreaser curve is similar to the descending monotonic curve except that few to no stems are present in the smaller size classes due to the low recruitment rate of the species.

Understory. One hundred and fifty 0.01 ha circular plots (radius = 5.64 m) were randomly located along the transects. Fifty plots were located within each of the three regions of Ginn Woods. Within the circular plots, the number of woody stems of each species was recorded. The saplings were divided into two size classes; size class 1 contained woody plants ≥ 2 meters in height and < 5 cm dbh; and size class 2 contained woody plants 2 ≥ meters in height with a dbh ≥ 5cm but < 10 cm. Understory plots were categorized as either occurring in gaps or under a closed canopy. Plots were considered to be in canopy gaps when ≥ 50% of the plot was under a canopy gap. Canopy gaps were defined as openings in the canopy created by the death of canopy species.

Nomenclature for all species follows Gleason and Cronquist (1991) with two exceptions. Due to the presence of several individuals exhibiting intermediate traits, *Acer nigrum* and *Acer saccharum* were lumped together as *Acer saccharum.* Since *Quercus shumardii* and *Quercus rubra* could not distinguished from each other on some of the transects, they were lumped together as *Quercus rubra* throughout the site.

RESULTS

Overstory. A total of 28 overstory species (dbh ≥ 10 cm) were recorded in this study (Table 1) at 142, 85, and 67 sample points in North, South, and Nixon Woods, respectively. *Acer saccharum* ranked highest in all importance value categories and is clearly the most dominant species in Ginn Woods. *Fagus grandifolia* ranked second in all categories in North Woods. A distinct break in importance value occurred between *F. grandifolia* and *A. saccharum* and the remaining (subdominant) species in North Woods. *Tilia americana* ranked third in importance value (3.73%) followed by six species with values between 2.4% and 2.8% (*Quercus rubra*, *Ulmus rubra*, *Celtis occidentalis*, *Carya ovata*, *Ulmus americana*, and *Fraxinus americana*). No other species had an importance value above 2.0. Total overstory stem density was 304, 329, and 282 per ha in North, South, and Nixon Woods, respectively (Table 2).

North Woods has 24 overstory species. *Acer saccharum* had the highest density in all size-classes up to 70 cm dbh in North Woods (Figure 2). The density of *Fagus grandifolia* stems was roughly equal to that of all other species combined (with the exception of *A. saccharum*) up to 60 cm dbh. The high recruitment in the smaller size-classes indicates that *A. saccharum* and *F. grandifolia* are reproducing well and will replace themselves. Stems ≥ 80 cm dbh are infrequent. *Tilia americana* and *Ulmus rubra* have size-class distributions that approximate a multimodal curve (Figure 2). They have two or more peaks in density, which indicates that these species may reproduce in pulses. *Quercus rubra* peaks in the 70-80 cm dbh size class, and the absence of stems in the smaller size classes suggests that this species is not replacing itself and may eventually disappear from the study site (Figure 2). Only *A. saccharum* had stems ≥ 90 cm dbh in North Woods.

South Woods has 26 overstory species and ranks highest in total basal area and total density (Table 1). *Acer saccharum* has a slightly lower density and basal area here than in North Woods. The importance of *Fagus grandifolia* is much lower in South Woods. *Tilia americana*, *F. grandifolia*, *Populus deltoides*, and

Table 1. Stand table for overstory trees in the three sections of Ginn Woods.

Species	North Woods				South Woods				Nixon Woods			
	Frequency[1]	Basal Area[2]	Density[3]	IV[4]	Frequency	Basal Area	Density	IV	Frequency	Basal Area	Density	IV
Acer negundo	0.5	0.0	0.9	0.3	0.8	0.1	1.9	0.5	0.6	0.0	0.9	0.4
Acer rubrum	0.3	0.2	0.6	0.3	0.4	0.0	1.0	0.3	1.2	0.0	1.9	1.9
Acer saccharinum	0.5	0.0	1.8	0.9	2.4	3.3	8.7	4	1.2	1.3	8	2.2
Acer saccharum	38.2	19.6	162.2	48.3	32.5	16.3	145.0	40.6	36.0	17.0	149.6	43.5
Aesculus glabra	2.4	0.6	4.9	1.7	2.8	0.1	6.7	1.9	6.3	0.5	11.2	4.3
Carpinus caroliniana	0.3	0.0	0.6	0.2	0.4	0.0	1.0	0.3	0.0	0.0	0.0	0.0
Carya glabra	1.4	0.6	2.7	1.2	0.4	0.7	1.0	0.2	0.0	0.0	0.0	0.0
Carya lacinioca	0.3	0.1	0.6	0.3	1.3	0.0	2.9	1.3	0.6	0.0	1.8	1.0
Carya ovata	3.2	0.9	7.1	2.6	1.7	0.6	3.9	1.4	3.8	0.4	6.7	2.6
Celtis occidentalis	3.7	0.8	6.5	2.6	3.0	0.4	8.0	2.0	3.9	0.3	7.9	2.7
Fagus grandifolia	23.4	6.2	62.5	20.0	10.4	2.4	27.7	7.3	7.4	1.6	17.1	6.1
Fraxinus americana	3.8	0.4	7.3	2.4	6.2	1.3	15.4	5.3	5.6	1.9	12.1	4.9
Fraxinus nigra	0.7	0.0	1.2	0.4	0.4	0.1	1.0	0.3	0.6	0.0	1.0	0.3
Fraxinus pennsylvanica	2.3	0.5	4.9	1.7	1.7	0.4	4.8	1.4	4.8	0.5	9.2	3.6
Gymnocladus dioica	0.3	0.0	0.4	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Juglans nigra	0.8	0.2	1.6	0.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Liriodendron tulipifera	0.0	0.0	0.0	0.0	0.5	0.0	0.9	0.3	0.6	0.2	1.0	0.4
Morus rubra	0.0	0.0	0.0	0.0	0.4	0.1	1.0	0.3	0.0	0.0	0.0	0.0
Platanus occidentalis	0.0	0.0	0.0	0.0	1.6	1.2	3.9	1.9	0.0	0.0	0.0	0.0
Populus deltoides	0.0	0.0	0.0	0.0	5.4	1.9	14.2	6.6	2.0	3.2	3.9	2.3
Prunus serotina	2.0	0.3	4.2	1.5	2.2	0.7	17.1	1.7	0.0	0.2	0.0	0.0
Quercus alba	1.6	0.9	2.6	1.6	0.8	0.9	2.0	1.1	0.0	0.0	0.0	0.0
Quercus macrocarpa	0.6	0.4	1.0	0.9	2.7	1.7	5.6	2.7	0.0	0.3	0.0	0.0
Quercus muehlenbergii	0.4	0.2	0.5	0.3	0.8	0.6	0.6	1.0	0.0	0.0	0.0	0.0
Quercus rubra	2.3	1.8	5.0	2.8	1.4	0.4	2.8	0.9	7.9	4.2	17.9	11.4
Tilia americana	3.6	2.1	9.1	3.7	12.0	4.0	35.9	11.4	10.4	3.6	20.8	9.2
Ulmus americana	3.7	0.3	7.9	2.5	1.7	0.3	5.0	1.2	3.1	0.1	8	1.7
Ulmus rubra	3.4	0.5	8.7	2.7	6.0	1.5	20.9	5.0	4.2	0.3	9.2	2.6
Totals	100.0	37.0	305.0	100.0	100.0	39.0	339.0	100.0	100.0	36.0	282.0	100.0

[1] Frequency = ((the number of samples in which the species occurred)/(the total number of samples)) * 100.
[2] Basal Area = m^2/ha.
[3] Density = The number of stems/ha.
[4] Importance Value = IV = (relative basal area + relative frequency + relative density)/3.

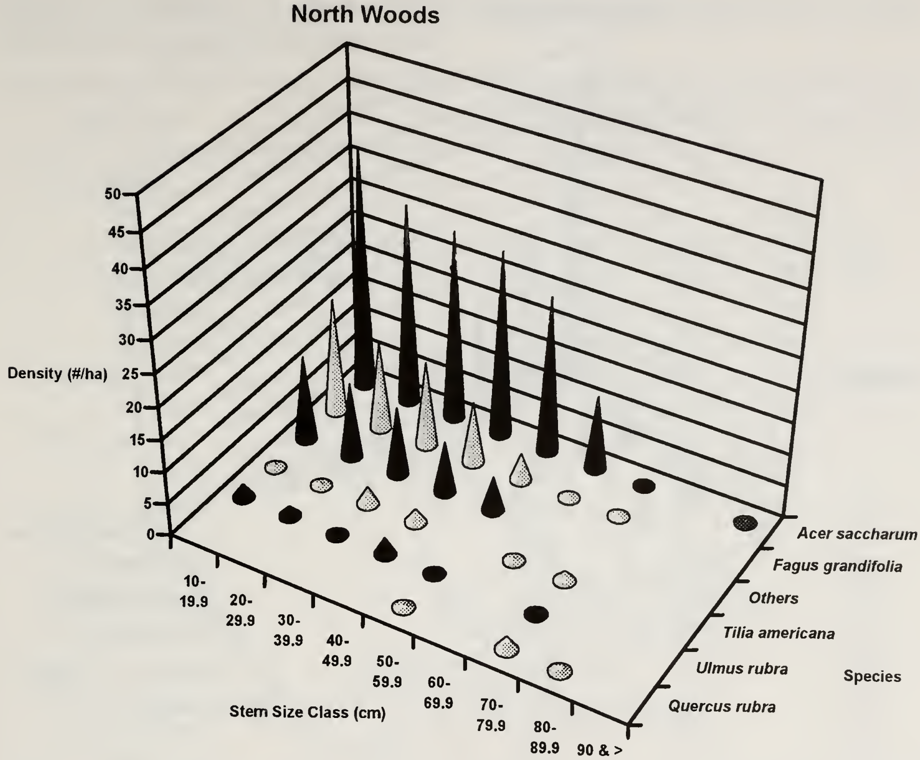

Figure 2. Overstory stem size-class distribution for North Woods. The stem size-class density for the top five species is based on importance value. The remaining species are grouped as "others." See Table 1 for the names of the other species. Light and dark shading is used to as an aid in interpreting the data.

Ulmus rubra all have importance values ≥ 5.0. In South Woods, the elevation is slightly lower than in North Woods, and the overall soil moisture is higher. Where ponding remains the longest during the growing season, wet-site species such as *Acer saccharinum*, *Acer rubrum*, *Carya laciniosa*, *Fraxinus pennsylvanica*, *Platanus occidentalis*, and *Populus deltoides* are locally dominant. In South Woods, the size-class distribution of *A. saccharum* (Figure 3) has higher recruitment in the smallest dbh size class and lower densities above 30 cm dbh than in North Woods (Figure 2). No stems ≥ 90 cm dbh were sampled in South Woods.

The overstory of Nixon Woods consists of 18 tree species (Table 1). As in the other two sections of Ginn Woods, *Acer saccharum* is the most dominant species with an importance value approximately four times greater than that of *Quercus rubra*, the second ranking species. *Quercus rubra* only has stems in size classes ≥ 30 cm dbh (Figure 4), and, despite a lower frequency and density than *Tilia americana*, its larger basal area gives it a higher importance value (Table 1). *Quercus rubra* is followed by *T. americana*, *Fagus grandifolia, Fraxinus*

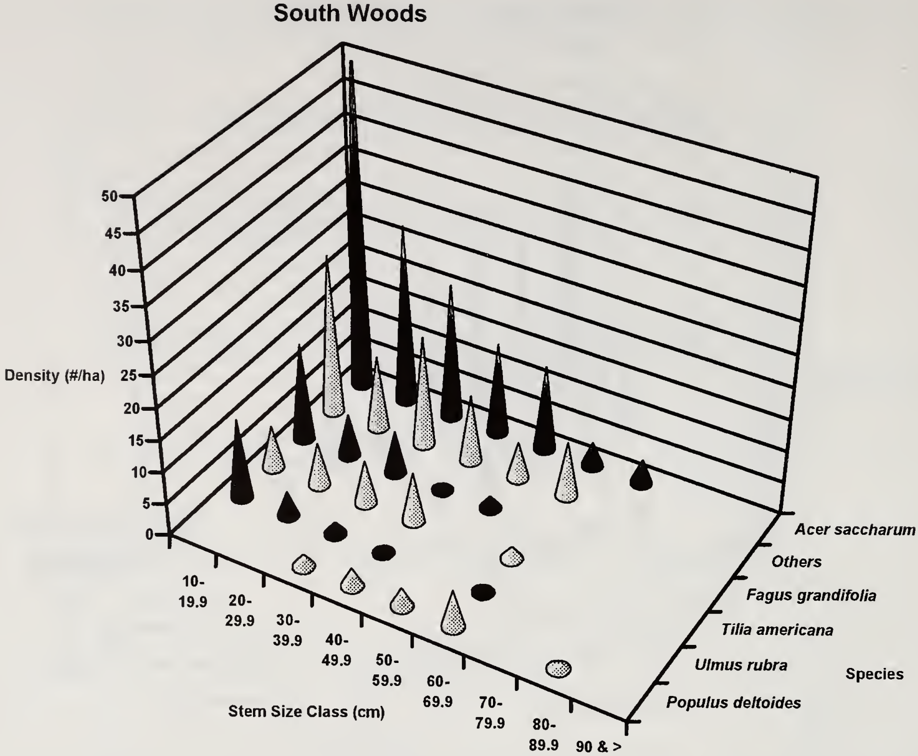

Figure 3. Overstory stem size-class distribution for South Woods. The stem size-class density for the top five species is based on importance value. The remaining species are grouped as "others." See Table 1 for the names of the other species. Light and dark shading is used as an aid in interpreting the data.

americana, and *Aesculus glabra* in importance value. Only *Acer saccharum* shows a strong descending monotonic curve; *Fagus grandifolia, Fraxinus americana*, and *T. americana* approximate a multimodal curve; *Quercus rubra* has a decreaser curve with no recruitment in the smaller size-classes. *Acer saccharum* has the highest density of any species < 70 cm dbh and makes up approximately 50% of the total density in this dbh range (Figure 4). *Quercus rubra* is the predominant species above 70 cm dbh and the only species measured with a dbh > 90 cm.

Understory. The total stem density for size class 2 in Nixon Woods is approximately twice that of either North or South Woods, while the stem density in size class 1 is roughly equivalent in all three areas (Table 2). Shade-tolerant species are dominant throughout Ginn Woods in understory size classes 1 (Figure 5) and 2 (Figure 6). The higher stem density for size class 2 in Nixon Woods is due to the relatively high densities of *Acer saccharum* and *Ulmus rubra* (Figure 6). *Acer saccharum* makes up at least one-third of all the stems in size classes 1 and 2, except in size class 1 in Nixon Woods (Figures 5 and 6). *Ulmus rubra* and *Aesculus glabra* rank second in prominence in the understory (Figures 5 and 6) but

Table 2. Stem density (number/ha) for the woody plants in the understory and overstory in the three sections of Ginn Woods.

Size Class	North Woods	South Woods	Nixon Woods
Understory			
⩾ 2 m tall and < 5 cm dbh (Class 1)	2336	2672	2688
⩾ 2 m tall and 5 cm dbh < 10 cm (Class 2)	130	160	316
Totals	2466	2832	3004
Overstory			
10.0 - 19.9 cm	72.0	116.1	73.6
20.0 - 29.9 cm	59.1	57.1	55.7
30.0 - 39.9 cm	57.0	56.1	57.8
40.0 - 49.9 cm	51.6	37.7	41.0
50.0 - 59.9 cm	36.5	30.9	21.0
60.0 - 69.9 cm	16.0	21.3	20.0
70.0 - 79.9 cm	8.6	8.7	7.4
80.0 - 89.9 cm	2.7	1.0	2.1
> 90.0 cm	0.5	0.0	3.2
Totals	304.0	328.8	281.8

are much less dominant in the overstory (Table 1). *Asimina triloba* and *Lindera benzoin* are prominent components in size class 1, especially in Nixon Woods (Figure 5). Both are understory species that are not likely reach overstory status. *Fagus grandifolia* has its highest density in size class 2 in North Woods (Figure 6) and is found at low densities in size class 1 throughout Ginn Woods (Figure 5). Thirteen percent of all understory plots (20/150) were located in a canopy gap.

DISCUSSION

Overall, Ginn Woods is a maple-beech-basswood forest. *Acer saccharum* is the most dominant species throughout Ginn Woods in all understory and overstory size classes up to 60 cm dbh. *Fagus grandifolia* ranks second in North Woods and is supplanted by *Tilia americana* in South and Nixon Woods. *Quercus rubra*, *Tilia americana*, *Liriodenderon tulipifera*, *Fraxinus americana*, *Ulmus rubra*, *Celtis occidentalis*, and *Prunus serotina* are subdominants commonly found in beech-maple woods (Lindsey and Escobar, 1976). *Acer saccharinum*, *Acer rubrum*, *Carya laciniosa*, *Fraxinus pennsylvanica, Platanus occidentalis*, and *Populus deltoides* are locally dominant where extended ponding occurs. The

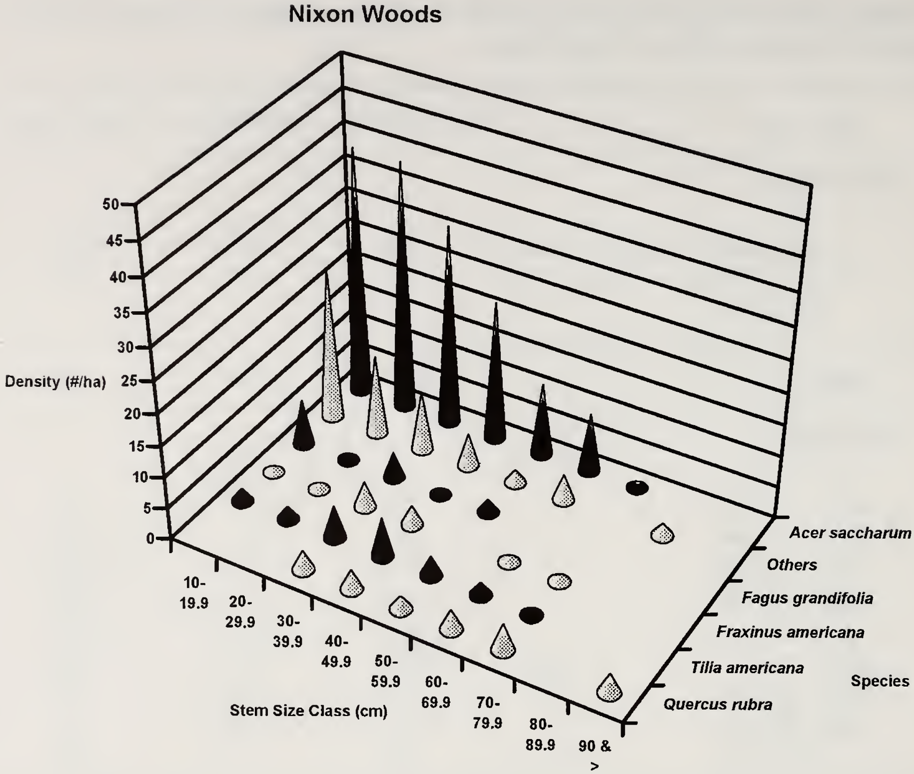

Figure 4. Overstory stem size-class distribution for Nixon Woods. The stem size-class density for the top five species is based on importance value. The remaining species are grouped as "others." See Table 1 for the names of the other species. Light and dark shading is used as an aid in interpreting the data.

successional maturity of Ginn Woods is evident in the dominance of shade-tolerant species in the understory and overstory. Conversely, shade-intolerant species, such as *Quercus rubra*, show little regeneration and should continue to decline in importance without large-scale disturbance.

Should Ginn Woods be considered an old-growth forest? The lack of many very large trees (as is common in other old-growth forests in Indiana) may have been the primary reason that Lindsey, *et al.* (1969) did not consider Ginn Woods to be an old-growth forest. Certainly, the lack of published studies on Ginn Woods would limit its consideration as an old-growth forest in regional studies (Parker, 1989; Brothers, 1993; Spetich, *et al.*, 1997). Several criteria have been used to identify old-growth forests. Based on criteria adapted from Parker (1989), Martin (1992), and Runkle (1996), we believe that Ginn Woods has the structure, composition, and disturbance history that qualifies this stand as an old-growth forest (Table 3).

Ginn Woods has a high diversity of woody and herbaceous species. Over 380 species of vascular plants, including 72 species of woody plants, were

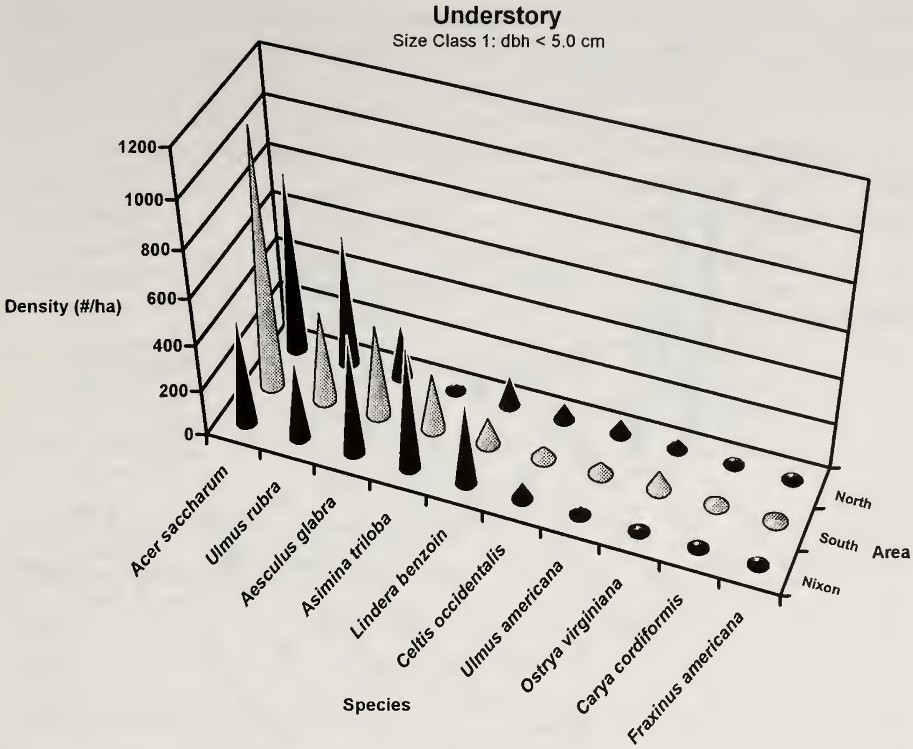

Figure 5. Understory size class 1 sapling density. Size class 1 stems are ⩾ 2 m in height and < 5.0 cm dbh in each section within Ginn Woods. The species are ranked in order from left to right based on their average density across sections. Light and dark shading is used as an aid in interpreting the data.

documented for Ginn Woods (Ruch, *et al.*, 2000). Late-successional plants dominate all size-class categories throughout Ginn Woods. The primary cause of disturbance in Ginn Woods is windfalls, and canopy gaps are fairly frequent. Our initial estimate of canopy gap coverage is 13%, but this feature requires further study. A mosaic of different-aged canopy gaps is found that are primarily populated by shade-tolerant species. The amount of coarse woody debris, while not quantified in this study, is relatively high compared to other old-growth forests in Indiana (pers. obs.). Limited tree harvest, such as those that occurred in South and possibly Nixon Woods, would not prevent these stands from being considered as old-growth in all but the strictest definitions of old-growth (Runkle, 1996)

Edaphic conditions may limit the maximum stem size of trees in Ginn Woods more severely than in other old-growth forests in Indiana. An examination of the root structure of windthrows in Ginn Woods revealed that most of these trees were shallowly rooted and toppled before reaching diameters in excess of 70 cm (Gedler, 1998). This growth pattern is probably the result of a seasonally high water table coupled with a soil structure that prevents the establishment of a deep root system. While trees in excess of 90 cm dbh are uncommon, the density of

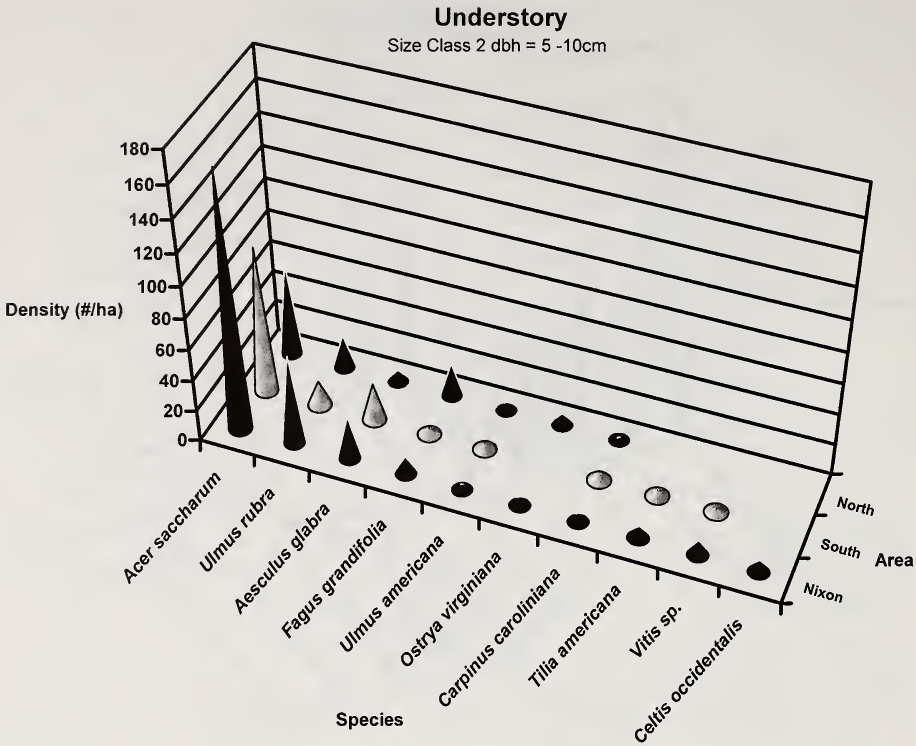

Figure 6. Understory size class 2 sapling density. Size class 2 stems are ≥ 5cm dbh and < 10 cm dbh in each section within Ginn Woods. Species are ranked in order from left to right based on their average density across sections. Light and dark shading is used as an aid in interpreting the data.

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stems in Ginn Woods exceeds the criteria of ≥ 7 stems ≥ 75 cm dbh per hectare suggested by Runkle (1996). Overstory basal area and overstory density (Table 1) fall within expected levels for old-growth forests (Table 3). These structural characteristics, along with a documented history of minimal human disturbance, clearly verify that Ginn Woods is an old-growth forest.

Studies at the Davis-Purdue Research Forest have provided important insights into old-growth forest community dynamics (Parker and Leopold, 1983; Parker, *et al.*, 1985; Parker and Sherwood, 1986; Parker and Ward, 1987; Ward and Parker, 1989; Spetich and Parker, 1998). The proximity of Ginn Woods to the Davis-Purdue Research Forest invites comparison. All of the woody species listed from the Davis-Purdue Research Forest also occur in Ginn Woods (Ruch, *et al.*, 2000). Considerable overlap occurs in the types of soils found between the two sites (McClain, 1985; Spetich and Parker, 1998), and shade-tolerant subdominants, such as *Acer saccharum*, have shown significant recruitment and growth over the last 60 years at the Davis-Purdue Research Forest (Ward and Parker, 1989).

Table 3. Old growth characteristics for each section of Ginn Woods based on criteria adapted from Parker (1989), Martin (1992), and Runkle (1996). A check mark indicates that the characteristic was found in that section of Ginn Woods. A question mark indicates that no data were available for that variable.

Old-Growth Characteristic	Explanation	North Woods	South Woods	Nixon Woods
High diversity	Both woody and herbaceous plants	✓	✓	✓
Old-growth plants prominent	Late successional species	✓	✓	✓
All aged structure	Many size classes; major disturbance rare	✓	✓	✓
Mosaic of canopy gaps	Gaps of all ages	✓	✓	✓
Deadwood biomass	Relatively high	?	?	?
Large trees	> 80 cm dbh	✓	✓	✓
Old trees	> 150 years	?	?	?
Overstory basal area	25 m^2/ha	✓	✓	✓
Overstory density	~ 250 trees/ha	✓	✓	✓
Little human disturbance	Last 80 to 100 years	✓	✓	?

Some interesting differences have also been found. The Davis-Purdue site has been classified as a lowland depressional forest (Lindsay and Schmelz, 1970). *Quercus* spp. form much of the overstory (Ward and Parker, 1989), and several years of cattle grazing may have had a strong influence on the development of the Davis-Purdue Research Forest. Future research is needed to determine how site specific factors, succession patterns, disturbance history, and landscape dynamics produced the similarities and differences between the Davis-Purdue Research Forest and Ginn Woods.

Ginn Woods is a valuable educational and scientific resource. Presettlement Indiana had about 8 million ha of forest (Jackson, 1997). Only about 800 ha of old-growth forest survives. The average size of old-growth stands in Indiana is only about 19 ha (Spetich, *et al.*, 1997). According to the list of old-growth forests in Indiana compiled by Spetich, *et al.* (1997), the 65 ha of old-growth forest at Ginn Woods would make the site the second largest old-growth forest in Indiana. Future studies and the establishment of long-term monitoring plots would add more information to our understanding of plant community dynamics in old-growth forests.

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