COMPARISON OF ECOLOGICAL CHARACTERISTICS OF THREE REMNANT OLD-GROWTH WOODLOTS IN BELMONT COUNTY, OHIO

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Abstract—Dysart Woods, North and South, and Collins Woods are small remnant old-growth stands with an old-growth cohort that has a significant oak component (> 50 percent) and includes mixed mesophytic species, such as yellow-poplar and white ash. All three stands are transitional to a northern hardwood type (sugar maple/American beech). Collins Woods is bounded on two sides by a surface mine highwall (20-60 feet high), and on another side by a reclaimed surface mine. Dysart Woods's stands are surrounded by second-growth hardwood forest and agricultural fields. We sampled trees larger than 2 inches dbh and measured woody regeneration. In addition, we conducted a 100 percent inventory of all large trees in the old-growth cohort. We found all three stands to be remarkably similar. For example, the basal area of trees at Collins Woods was 123.3 feet square/acre as compared to 101.2 and 102.5 for the South and North Woods at Dysart Woods. The oak component of the old-growth cohort at Collins Woods was 50.3 percent. For Dysart South and North, oak composition was 61.7 percent and 60.7 percent. Yellow-poplar made up 10.3 percent and 9.8 percent of Dysart South and North and 21 percent of the old-growth cohort at Collins Woods. The average dbh of old-growth trees at Collins Woods was 34.4 inches compared to 33.9 inches and 35.1 inches for the Dysart stands. Collins Woods, like Dysart Woods, had virtually no oak regeneration and the overall diameter distribution indicated a reverse J-shaped curve for all three stands with sugar maple predominating in the smaller diameter classes, and oaks and yellow-poplar in the larger classes. The species diversity of Collins Woods was slightly less than that at Dysart Woods, when expressed as Shannon's H', but about the same in species richness. Measures of health and vigor of the stands were very comparable. The estimated overall mortality rate for old-growth trees at Collins Woods was 1.49 percent/year as compared to 1.56 percent and 1.85 percent at the two stands at Dysart. The tree vigor rating, using the USDA, Forest Service vigor codes, (1 as vigorous and 7 as dead), averaged 2.05, 1.94 and 2.37 for Dysart South and North and Collins Woods, respectively.

The degree of similarity among the three stands suggests that they may have been part of a large contiguous forest. In spite of their different histories, the successional changes in these three stands have produced remarkably similar results. These stands represent what many present-day central hardwood forests could look like in about 200 years, if left relatively undisturbed.

INTRODUCTION

Old-growth central hardwood forests are interesting and valuable both from a natural history standpoint as well as examples of the successional process that affects them. The dynamics of these remnant old-growth stands provide clues as to the potential fate of many present-day stands that, like most old-growth remnants, developed from disturbances such as fire. The present study documents the current condition of three remnant old-growth stands in east-central Ohio. The composition of the old-growth cohort (the largest and oldest trees) is suggestive of a disturbance origin, but the gradual replacement of these stands by shade tolerant climax species is an on-going process that is documented in this study. These case studies, in addition to illustrating the process of succession, provide insight into the timing of changes in undisturbed forests.

DESCRIPTION OF THE SITE

The stands at Dysart Woods are old-growth remnants located approximately 5 miles south of St. Clairsville, Ohio, off state Route 9 and are spatially separated by about 1000 feet. The stands at Dysart Woods are surrounded by second-growth hardwoods except for one side of the North Woods, which is an agricultural meadow. Collins Woods is about 13 miles northwest of Dysart Woods, in Belmont County, Ohio, about 3 miles northwest of Morristown. This woodlot is surrounded on 3 sides by former surface mining activity and has highwalls of approximately 60 feet high or higher on the north and east borders. Mining operations that created these highwalls were conducted in the early to mid 1970s. All three woodlots are remnant old-growth stands that are estimated to be in the age range of approximately 300 years. Collins Woods has been purchased by The Nature Conservancy and is preserved as an example of what was most likely an extensive forest cover type about the time of European settlement of eastern Ohio while Dysart Woods is managed by Ohio University. Stands like Collins and Dysart Woods probably owe their origin to disturbance by fire which favors the regeneration of oaks and shade-intolerant species like yellow-poplar (*Liriodendron tulipifera*).

METHODS

The extent of the old-growth forests in the three stands was determined as the area inside the drip line of the area containing large old trees. Dysart North was found to be approximately 15 acres and the South Woods is about 13.5 acres in size while Collins Woods was 8.3 acres.

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A sampling grid was established over each stand in order to locate approximately 16 plots per stand. At each sample location a 0.1-acre circular plot was established. At plot center, a 10 BAF prism was used to estimate the basal area. The plot was classified as to the Society of American Foresters' cover type present (Eyre 1980). In addition, the slope position, aspect and slope percent were determined. All trees 2 inches dbh and larger were measured in the 0.1-acre plots. For each tree, its species, crown class, live crown ratio, USFS vigor rating[2], expected longevity and total height was evaluated and recorded.

In conjunction with the 0.1-acre plots, two 6-foot-radius understory plots were established, one at plot center and another midway between plot center and the perimeter of the 0.1-acre plot on a random azimuth. The percent of the regeneration plot covered by all vegetation (broken down by percent coverage of woody, herbaceous and fern) was estimated for each 6-foot-radius plot. In addition, all tree seedlings (< 2 inches dbh) in the plots were counted by species and size class (< 6 inches, 6 inches-4 feet, > 4 feet).

Finally all large trees in the "old-growth cohort" (27.5 inches dbh and larger) in each stand were measured (100 percent sample). This size limit was selected subjectively because it seemed to include all the large old trees (particularly oaks and yellow-poplar). Each tree was numbered and dbh, total height, live crown ratio, crown radius, vigor class and expected longevity (estimated as < 10 years, 10-20 years or > 20 years) was recorded. In addition to the large live trees, large standing dead trees were also measured by species for dbh and estimated years dead (based on bark and limb condition). All the large trees were located with laser survey equipment to determine their precise location within the stand so that they could be mapped and plotted.

Tree data from 0.1-acre plots and 100 percent samples were combined to produce the diameter distribution by species (number of trees by diameter). For the large trees (> 27.5 inches dbh), only the 100 percent sample data were used.

Seedling data were compiled by species to document the numbers of seedlings by species and size class, which should indicate the regeneration potential of the various species.

Data from the various samples were used to compute importance values of the tree species. Importance value is the sum of relative density, relative frequency and relative dominance. These are obtained as the number of stems of a species relative to the total number of stems, the number of plots containing the species relative to the total number of plots and the basal area of a species relative to the total basal area. This information was compared to importance values reported in previous studies of Dysart Woods.

[2] Vigor codes: 1-healthy/vigorous, 2-slight dieback, 3-moderate dieback, 4-slight decline, 6-moderate decline, 6-severe decline, 7-dead.

We used data for total number of species present and total individuals per species to develop measures of diversity in each stand (species richness and Shannon-Weiner index). These measures could be used to compare the diversity of the three stands and to compare them with other forests.

Finally, the data from standing dead trees and estimated longevity of large live trees were used to estimate the rate of mortality (percent per decade). This was done by averaging the class midpoints for estimated longevity for old-growth trees (e.g., 0-10 years = 5 years) and doing the same for estimated years dead for large standing dead trees. Thus, two estimates of rate of mortality were obtained (one based on expected longevity of live old-growth trees and the other based on standing dead trees). These two estimates were then averaged to obtain the value that was presented in subsequent discussions.

RESULTS

Overall

Collins Woods was very similar to the stands at Dysart Woods (Table 1) with an old-growth cohort of oaks and mesophytic hardwoods that is being gradually replaced by northern hardwoods [American beech (*Fagus grandifolia*)/ sugar maple (*Acer saccharum*)]. There were a few large stumps at Collins Woods that indicated limited selective logging had occurred in the past, similar to Dysart Woods, but in general most of the old-growth trees were left. The most unique feature of Collins Woods was the fact that the area had been circumscribed by contour surface mining, and along one side (approximately 800 feet), the highwall remained intact while on another side reclamation by back-filling, recontouring and seeding had been done.

The forested site at Collins Woods was an upper slope, primarily on a west-facing aspect with an average slope inclination of about 18 percent. West-facing aspects and upper slope positions, as occurred at Collins Woods, are typically associated with poorer growing sites (Hicks and Frank 1984). Dysart woods had a wider variety of aspects and slope positions, some of which are associated with better quality sites. The diameter distribution of trees at Collins Woods was a reverse J-shaped distribution, similar to the Dysart Woods stands (Figs. 1-3).

Regeneration

Like Dysart Woods, Collins Woods showed little or no oak regeneration—no oak seedlings were found in our survey. As with the Dysart stands, Collins Woods had abundant sugar maple, beech and elm (*Ulmus* spp.) regeneration (Figs. 4, 5). Unlike the Dysart stands, elms at Collins Woods have not grown into the small sapling-size class. Perhaps the higher overstory density at Collins Woods, as reflected by higher basal area, is responsible for shading out the elms before they reach sapling size. A variety of other woody regeneration occurred at Collins Woods, including bitternut hickory (*Carya cordiformis*), hophornbeam (*Ostrya virginiana*) and spicebush (*Lindera benzoin*). Seedling numbers at Collins Woods resembled more closely the North Woods at Dysart Woods, although Collins Woods had fewer maples and beech seedlings than

Table 1—Summary data for Dysart (North and South) and Collins Woods

Variable	Dysart Woods		
	South Woods	North Woods	Collins Woods
Basal area			
(live)(sq. ft./ac.)	101.25	102.50	123.30
SAF cover (pct. of plots)			
Type 54[a]	87.50	81.25	27.80
Type 60	0	12.50	55.50
Type 27	12.50	6.25	16.70
Slope percent (average)	16.75	16.40	17.80
Aspect class (pct. of plots)			
1 (N)	0	25.00	0
2 (NE)	0	0	0
3 (E)	31.25	0	0
4 (SE)	6.25	6.25	0
5 (S)	12.50	25.00	0
6 (SW)	37.50	.625	11.11
7 (W)	12.50	0	83.33
8 (NW)	0	37.50	5.55
Slope position (pct. of plots)			
Ridge	0	6.25	0
Upper slope	31.25	43.75	38.90
Lower slope	37.50	37.50	61.10
Hollow/bottom	31.25	12.50	0

[a] SAF cover type: 54=yellow-poplar; 60=white oak; 27=northern red oak.

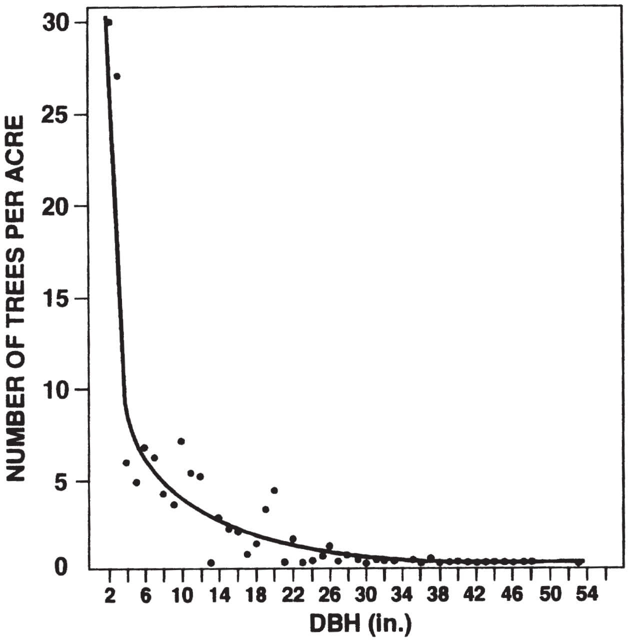

Figure 1—Diameter distribution of all trees > 2 inches dbh, South Woods, Dysart Woods.

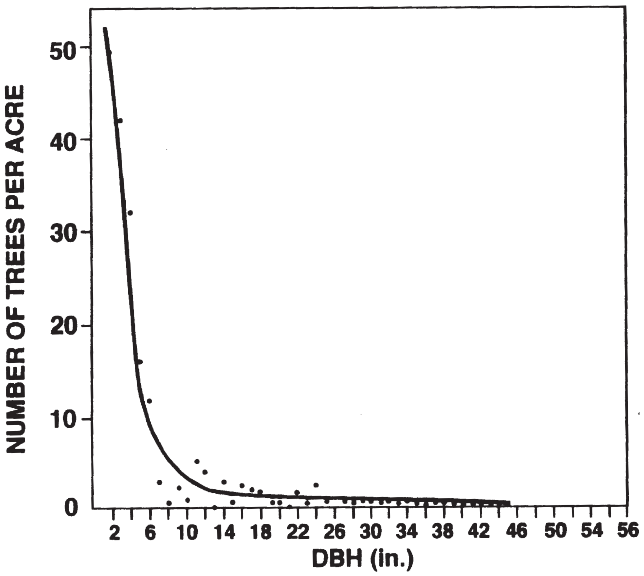

Figure 2—Diameter distribution of all trees > 2 inches dbh, North Woods, Dysart Woods.

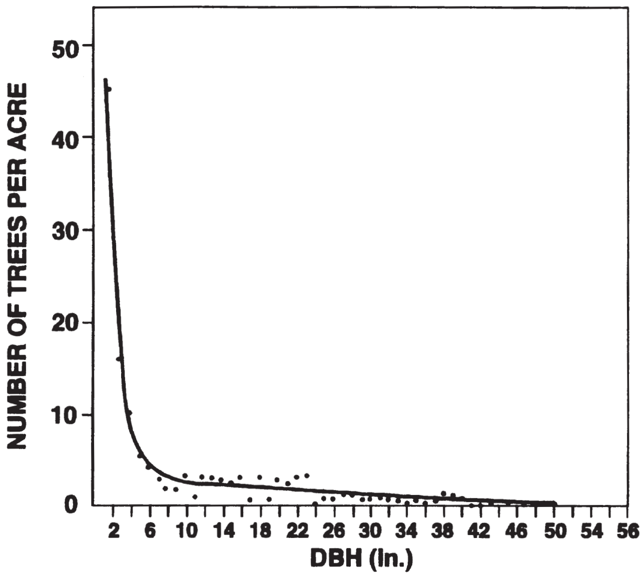

Figure 3—Diameter distribution of all trees > 2 inches dbh, Collins Woods.

either of the Dysart stands. This may reflect the effect of higher basal area and greater shade at Collins Woods or possibly other factors such as a higher deer density.

Overstory

Almost 70 percent of the overstory plots at Collins Woods were classed as northern hardwoods types (beech/maple and sugar maple), whereas the majority of plots at Dysart Woods were classed as mesophytic hardwoods. The large number of beech and sugar maple at Collins Woods that are in the diameter range of 10 to 27 inches is the basis for classifying the Collins Woods plots as northern hardwoods. Of the approximately 35 trees per acre in the 10-27-inch diameter range, 33 of them were beech or maples.

The importance values of species at Collins Woods (relative density + relative dominance + relative abundance) were very similar to those of Dysart stands. For example, sugar maple had an importance value at Collins Woods of 187.5 (Table 2). Its importance values for the South Woods and North Woods at Dysart Woods were 176.6 and 162.9, respectively. The ranking of importance value at Collins Woods was sugar maple, American beech,

Table 2—Relative densities (RD), relative frequencies (RF), relative dominance (RDo) and importance values (IV) for tree species sampled at Dysart and Collins Woods

	Dysart Woods														
	South Woods					North Woods					Collins Woods				
Species	RD	RF	RDo	IV	Rank	RD	RF	RDo	IV	Rank	RD	RF	RDo	IV	Rank
Sugar maple	46.95	100	29.63	176.58	1	55.04	90	17.89	162.93	1	69	100	18.5	187.5	1
American beech	14.24	70	23.04	107.28	2	13.51	80	29.27	122.78	2	15	67	15.1	85.6	2
Elms	17.37	50	3.29	70.66	3	6.65	40	3.25	49.90	4	2	22	3.6	27.6	5
Black cherry	6.37	40	0	46.51	4	4.11	40	0	44.11	6	1	11	0.1	12.1	13
White oak	3.06	20	19.75	42.81	5	1.72	40	26.02	67.74	3	1	17	15.6	33.6	4
White ash	3.24	30	1.65	34.89	6	1.61	20	3.25	24.86	9	1	11	3.5	15.5	10
Blackgum	2.24	20	4.94	27.18	7	1.87	20	1.63	23.50	10	1	11	0.4	12.4	12
Yellow-poplar	1.20	20	3.29	24.49	8	2.08	10	4.88	16.96	13	3	17	2.5	22.5	7
Northern red oak	1.78	10	1.64	13.42	9	1.61	20	4.88	26.49	8	2	39	25.0	66.0	3
Shagbark/shell Bark/bitternut Hickory	1.16	10	1.65	12.81	10	1.51	20	1.63	23.14	11	2	11	1.3	14.3	11
Flowering dogwood	0.72	10	0	10.72	11	4.26	30	0	34.26	7	1	6	0.1	7.1	15
Red maple	1.27	0	6.58	7.85	12	1.72	40	3.25	44.97	5	2	17	3.3	22.3	8
Black walnut	<0.01	0	0	<0.01	13	—-	—	—-	—-		—	—-	—-	—-	
Blue beech/ Hophornbeam	—-	—-	—-	—-		3.12	20	0	23.12	12	1	22	0.2	23.2	6
Serviceberry	—-	—-	—-	—-		0.32	10	0	10.32	15	—	—-	—-	—-	
Sourwood	—-	—-	—-	—-		—-	—	—-	—-		—	—-	—-	—-	
Hackberry	—-	—-	—-	—-		0.32	10	0	10.32	15	—	—-	—-	—-	
Basswood	—-	—-	—-	—-		0.52	10	0	10.52	14	—	—-	—-	—-	
Black oak	—-	—-	—-	—-		—-	—	—-	—-		2	11	6.0	19.0	9
Sassafras	—-	—-	—-	—-		—-	—	—-	—-		1	6	1.1	8.1	14

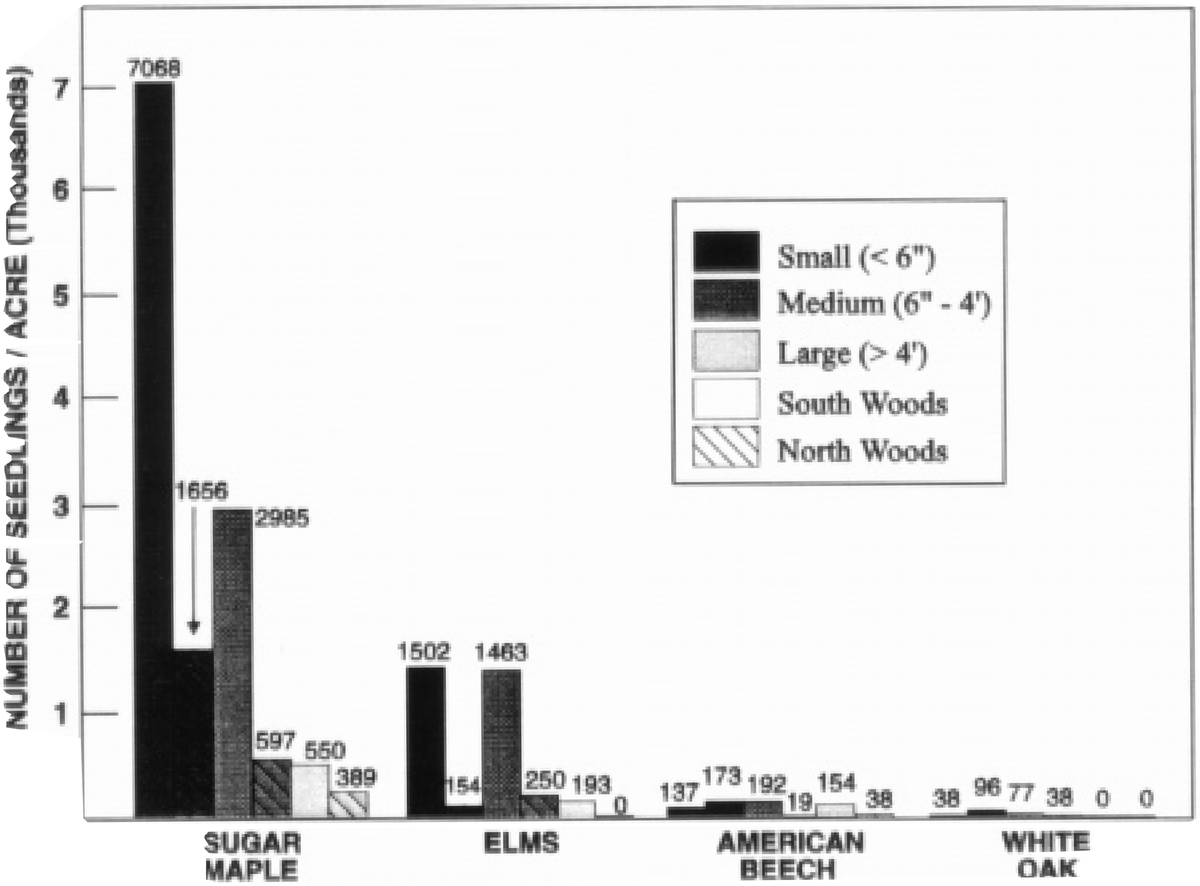

Figure 4—Number of seedlings per acre by species and height class for the North and South Woods, Dysart Woods.

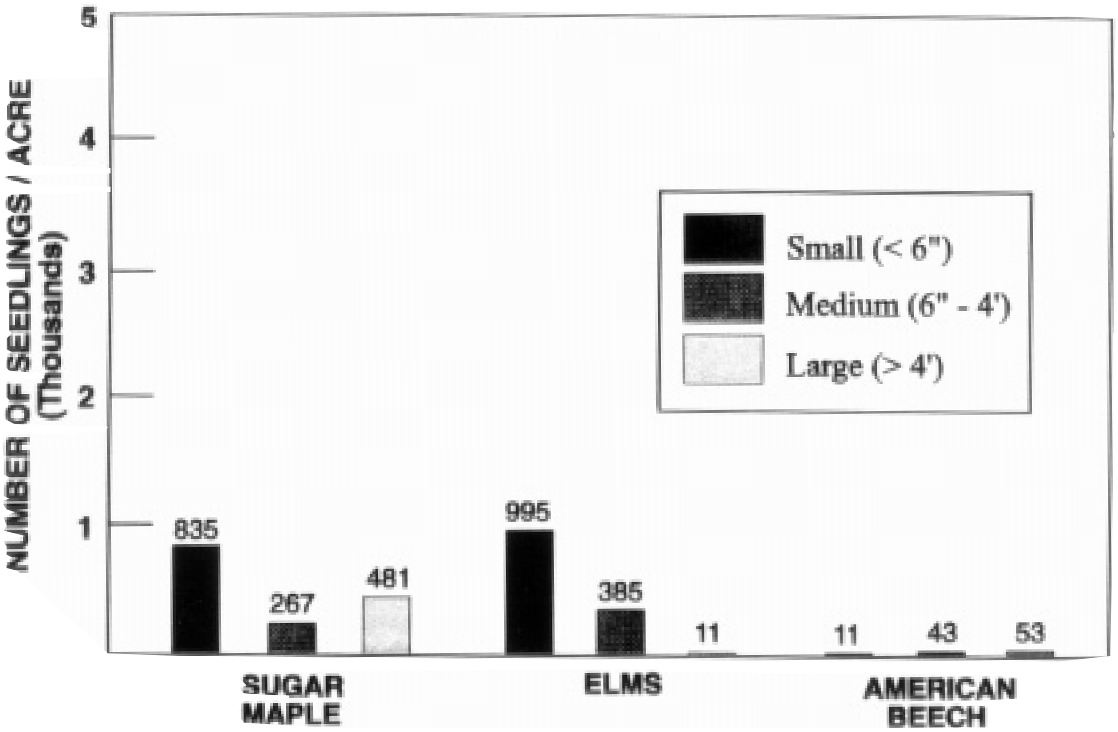

Figure 5—Number of seedlings per acre by species and height class for Collins Woods.

northern red oak (*Quercus rubra*), white oak (*Quercus alba*) and elm, whereas 4 of the top 5 species at Dysart North and South were the same, and sugar maple and American beech were the first- and second-ranked species at all these stands.

Previous studies performed at Dysart Woods (Benner 1971, Lafer 1968, Smith 1979) reported importance values. Figures 6 and 7 show the change over time of the relative ranking of species by importance values. In general, sugar maples and beech were ranked 1 and 2, while oak declined and elms increased. The species diversity at Collins Woods, as measured by Shannon's H' was lower than that of Dysart Woods (Table 3). But diversity based on species richness was very similar among the three stands.

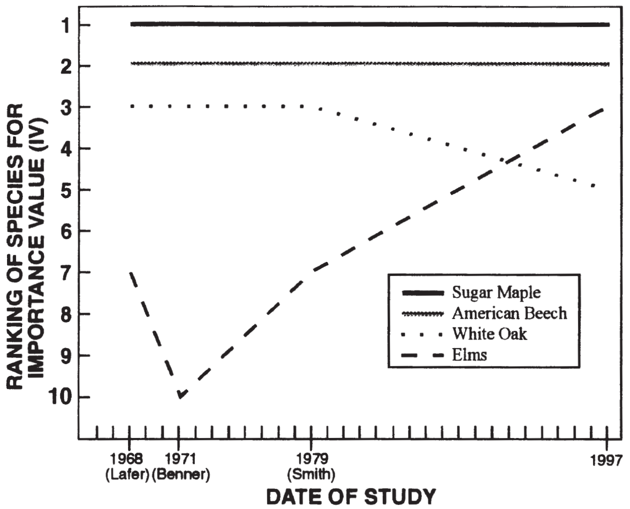

Figure 6—Relative ranking of species by importance values over 31 years for the South Woods, Dysart Woods.

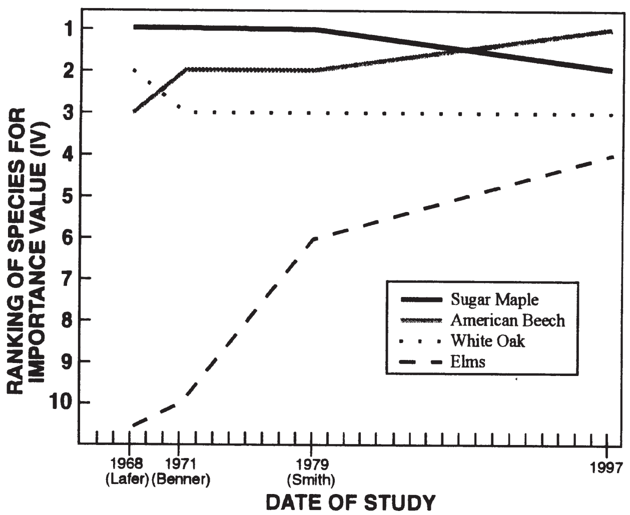

Figure 7—Relative ranking of species by importance values over 31 years for the North Woods, Dysart Woods.

Old-Growth

There was an average of 9.7 large trees per acre at Collins Woods as compared to 7.9 and 8.0 at Dysart South and North (Table 4). The average dbh of old-growth trees was very similar among all three stands but trees at Dysart Woods were, on average, about 15-20 feet taller, probably indicating an inherently better overall growing site at Dysart Woods. This difference in height is not related to any effect of mining over the past 30 years since old-growth trees, even on the best of sites, grow very little in height. For example, growth curves for yellow-poplar presented by Carmean and others (1989) indicate that trees on average sites grow about two feet per year. By age 100, yellow-poplar trees on these sites typically grow less than one foot per year, and by 250-300 years of age, trees have virtually ceased height growth due to the natural slowing with age. Thus the greater height at Dysart Woods most likely resulted from a steeper growth curve during the first 100 years of life rather than any occurrences in recent years. Collins Woods had a higher proportion of northern red oak and yellow-poplar and a lower proportion of white oak.

Comparing measures of forest health and vigor for the three stands, we found that they were very comparable. The overall rate of mortality (percent per year) for the large trees at Collins Woods was estimated to be 1.49 percent, whereas Dysart South and North were estimated to be 1.85 percent and 1.56 percent, respectively. The USDA, Forest Service vigor code averaged 2.37 (1 being most vigorous and 7 being dead) for Collins Woods (Table 5). The two stands at Dysart Woods averaged 1.94 and 2.05.

DISCUSSION AND CONCLUSIONS

The old-growth component of the forest at Collins and Dysart Woods regenerated in the late 17th or early 18th century. Many authors have linked oak regeneration to fire (Abrams 1992). It is acknowledged by a number of writers (Curtis 1959, Pallardy and others 1988) that presettlement fires, either caused by lightning or set by native people, were an important disturbance that led to the regeneration of oaks over vast areas. Native American populations were decimated by disease that was introduced by early European explorers which led to a lower incidence of fire. In the absence of fire, oaks regenerate poorly, mostly because they are unable to compete in the understory of established stands (Norwacki and others 1990).

Dysart and Collins Woods are old-growth "islands" that have persisted in spite of landscape changes, such as reduced fire, land clearing, subsistence farming and logging, that occurred throughout the central hardwood region.

The diameter distribution and structure of the stands gives important clues as to the origin of the various cohorts present. For example, the white oaks have a diameter distribution typical of an even-age stand in spite of the fact that the aggregate distribution of all species has the reverse J-shaped distribution typical of all-age stands. Stout (1991) observed a similar phenomenon on a much wider scale that characterizes so-called "transition" stands, currently covering a large area in the Allegheny Plateau of

Table 3—Species diversity [species richness and Shannon-Weiner Index (H')] for Collins Woods, Dysart Woods and other old-growth central hardwood forests

Forest	Shannon-Weiner H' $(H'=-1\sum_{i=1}^{n} pi \ln pi)$	Species richness		Reference
		No./0.1 ac.	Total no.	
Collins Woods	1.25	—-	15	Present study
Dysart, South	1.69	4.0	13	Present study
Dysart, North	1.72	5.8	18	DeSelm and Sherman (1982)
Savage Gulf (TN)	3.70	—-	22	Monk (1967)
Beech-white oak	2.77	—-	—	Bryant (1987)
Ault Park (OH)	2.83	—-	21	Bryant (1987)
California Woods (OH)	3.11	—-	20	Bryant (1987)
Caldwell Park (OH)	3.35	—-	21	Bryant (1987)
Winton Woods (OH)	2.18	—-	15	Bryant (1987)
Bowles Woods (OH)	1.94	—-	15	Bryant (1987)
Melborne Forest (OH)	3.07	—-	17	Bryant (1987)
Davis-Purdue (IN)	2.50	—-	30	Ward and Parker (1987)

Table 4—Summary data for attributes of live large trees (> 27.5 inches d.b.h.) for Dysart Woods (South and North) and Collins Woods

Species	Dysart Woods[a]								Collins Woods[a]			
	South Woods				North Woods							
	Total no. trees	RD[b]	D.b.h.	Ht.	Total no. trees	RD[b]	D.b.h.	Ht.	Total no. trees	RD[b]	D.b.h.	Ht.
			In.	Ft.			In.	Ft.			In.	Ft.
White oak	55	51.4	35.3	120.9	59	48.4	37.5	121.4	18	22.2	36.9	100.8
Northern red oak	11	10.3	36.2	123.5	13	10.6	38.1	122.6	20	24.8	37.3	108.6
Black oak	0	0	—	—	2	1.7	29.0	117.0	3	3.7	31.7	102.0
Sugar maple	8	7.5	29.8	121.3	3	2.5	32.3	116.7	7	8.6	29.6	104.6
Red maple	1	0.9	32.0	121.3	1	0.8	32.0	88.0	0	0	—	—
American beech	18	16.8	30.9	101.0	17	13.9	30.0	106.0	12	14.8	29.9	98.9
Yellow-poplar	11	10.3	31.2	115.0	12	9.8	34.2	134.7	17	21.0	34.7	110.7
White ash	3	2.8	34.7	136.4	12	9.8	31.9	123.1	1	1.2	29.0	110.0
Blackgum	0	0	—	—	1	0.8	28.0	120.0	0	0	—	—
Shagbark hickory	0	0	—	—	2	1.7	30.5	128.0	0	0	—	—
Elm	0	0	—	—	0	0	—	—	3	3.7	32.7	108.3
Total/overall	107[c]	100	33.9	122.3	122[c]	100	35.1	120.5	81[c]	100	34.4	105.1

[a] All figures are averages.
[b] Relative density (percent).
[c] Number of large trees per acre—South Woods @ 13.43 ac. = 7.97 large trees/ac., North Woods @ 15.18 ac. = 8.04 large trees/ac., and Collins Woods @ 8.36 ac. = 9.69 large trees/ac.

Table 5—Health/vigor indices for Dysart and Collins Woods

Health/vigor indices	Dysart, North	Dysart, South	Collins Woods
Estimated tree mortality[a] (pct./yr.)	1.56	1.85	1.49
Average[b] USFS vigor rating	2.05	1.94	2.37

[a] Based on all trees in the old-growth cohort.
[b] Vigor assessed on a scale of 1-7, where 1=healthy and 7=dead.

Pennsylvania. These stands contain representatives of oak-hickory as well as northern hardwood types, and the oak component is generally in the larger diameter classes and possesses a normal or bell-shaped distribution.

The diameter distribution of the American beech component of the stands in Dysart Woods provides some interesting questions. In both stands, beech displays a reverse J-shaped distribution, typical of shade-tolerant species, but with a wave of larger diameter trees. This suggests that a cohort of beech ingrowth responded to a disturbance that produced fairly substantial canopy gaps about 75-150 years ago. Disturbances, such as drought, insect or disease attacks, ice or wind damage, could trigger such a phenomenon. Beech is representative of so-called “role-2” species (Shugart 1987) and is shade tolerant enough to regenerate in dense shade (Harcombe and others 1982) and capable of responding to canopy gaps as they develop.

The diameter distribution of sugar maple in all stands was typical of the reverse J-shaped distribution expected of shade-tolerant species in an all-age stand. However, the larger number of overtopped saplings in the Dysart North Woods compared to the South Woods seems to suggest that the regeneration of sugar maple in the two stands has become dissynchronous, and this relates to some fairly recent disturbance events that are not common to both stands. A ground fire would be a likely explanation but no charcoal or fire scars on trees was evident to point to such an occurrence and no reports of fires were found in published accounts of the history of Dysart Woods. An alternative explanation might be a different woodland grazing regime for the two stands.

The regeneration inventory of the stands reinforces our conclusions regarding the occurrence of a gradual shift from oaks to a maple-beech forest. This is a process that is on-going throughout the central hardwood region. Loftis (1989) indicates that the process is best described by combining the concepts of “initial floristics composition” and “vital ecological attributes” of species. That is to say that propagules of all the species present today were present when the stands first developed, but the shifts in dominance over time reflect a change in conditions that favor some species over others. Currently, the balance has shifted toward sugar maple and American beech and away from oaks and yellow-poplar. This transition from oaks to maples and other northern or mesophytic hardwoods is a trend that is well documented in old-growth forests throughout the central hardwood region (Downs and Abrams 1991, Schlesinger 1989). The interesting phenomenon relating to greater overall abundance of regeneration (especially sugar maple) in the Dysart South Woods may be part of the same process that has caused the reverse to be true of trees in the sapling size class (2 inches-6 inches dbh). In-other-words, the dense low shade created by the cohort of maples and beech in the sapling size class may be preventing regeneration, even of shade-tolerant species, in the North Woods. The high shade from canopy-level trees in the South Woods has allowed better seedling establishment there. Elms are apparently producing more seedlings and saplings now than were reported in past studies of Dysart Woods, but due to their intermediate status in shade tolerance and their susceptibility to disease, they will probably not become significant contributors to any future overstory.

The remarkable similarity between the old-growth components of the three stands indicates that strong forces are at work driving the ecosystem changes that have taken place. These stands were probably historically part of a single large stand but even so, in spite of differences in average aspect and soils (Lafer 1968) the resulting old-growth cohorts have maintained a high degree of similarity. The dissynchrony in regeneration between the two Dysart stands, however, indicates that it is the intrinsic characteristics of the system rather than particular disturbance events that drive the process.

Regarding species diversity, Dysart and Collins Woods is on the low end of the scale for old-growth forests with values for the Shannon-Weiner index of 1.69 and 1.72. There are two reasons for the mathematically low values. First, these stands have relatively low woody species richness compared to other old-growth forests reported in the central hardwood region (Table 3) and secondly, as Loucks (1970) proposes, northern hardwood types become dominated by sugar maple which reduces their diversity.

The process of oak replacement by maple and beech can be illustrated by plotting the change in ranking of importance values of species over the past 30 years (Figs. 6 and 7). As can be seen on these two figures, white oak is generally declining in rank whereas sugar maple is either increasing or maintaining. In both stands, sugar maple is now the top ranked species and American beech is in second position. An interesting rise in the importance value ranking of elms is primarily related to a large influx of sapling-sized trees—many of which are presently showing symptoms of declining vigor.

The future of these stands, barring a major disturbance event, is likely to continue on a course where large senescent oaks and yellow-poplars are replaced by sugar maple and American beech trees presently in subordinate canopy positions. Stresses, such as drought, air pollution/acid deposition, insects [gypsy moth (*Lymantria* *dispar*), etc.] and diseases (beech bark disease, Dutch elm disease, dogwood anthracnose, etc.) will play a role in the future of Collins and Dysart Woods, and these factors, although unpredictable, will probably alter the course of events by affecting the balance in competitive advantage among species.

Perhaps one of the greatest values of these remnant old-growth stands is the fact that they offer a glimpse into the future. The central hardwood region, following logging, fires and agricultural abandonment since the turn of the century, has rebounded with millions of acres of second-growth forests dominated by oaks and mesophytic hardwood species (MacCleery 1992). Stands like Collins and Dysart Woods give a good indication of what these forests will look like in 200 years with minimal disturbance (fire exclusion and limited cutting). They also, when viewed in the context of a collective whole of remnant deciduous forests, illustrate that some rather consistent processes (vital ecological attributes) are moving these stands in the same direction and these same forces will probably shape today's second-growth forests in a similar way.

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