

THE FOREST-FIELD ECOTONE OF DYSART WOODS, BELMONT COUNTY, OHIO¹

EZEKIEL A. TOYE² AND WARREN A. WISTENDAHL

Department of Botany, Ohio University, Athens, Ohio 45701

ABSTRACT

The two tracts of forest constituting Dysart Woods, a mature oak forest, are bordered by secondary-growth forests and by fields which have been removed from agricultural use at different times. The vegetation along the margins of the mature forest and along the adjacent fields was studied to determine the existing vegetation and the trend of the migration of trees into the fields. Quadrat data for herbs, shrubs, and trees show vegetational trends characteristic of oldfield succession, but which vary from field to field. The arborescent vegetation indicates that the forest should become dominated by *Fagus grandifolia* and *Acer saccharum* as it expands into the fields. *Quercus alba*, a dominant in the forest, appears to lose that status within the expanding margins.

INTRODUCTION

Dysart Woods, a National Natural Landmark of the United States of America, is located in section 33, Smith Township, Belmont County, Ohio. It consists of two tracts of mature forest, the North Woods and the South Woods, which together total approximately 50 acres (fig. 1). The forest is part of a 455-acre field laboratory of Ohio University. Several vegetation types consisting of a mature (virgin) forest, a cut-over forest, second-growth forests, and abandoned fields occupy the 455-acre area.

The South Woods is bordered on three sides by fields, which are undergoing secondary succession after having been taken out of agricultural use from one to 10 years prior to the study. The cut-over forest adjoins this woods on its southeastern side.

The North Woods is bordered in part by fields which were abandoned seven and 25 years ago (McGaughy, 1970, and Stern, 1970, personal communications). These fields also form part of a buffer zone adjacent to the forest and will revert to forest with time. This reversion to forest is the basic reason for studying the vegetation of the margins of the North Woods, the South Woods, and the ecotones in the adjacent fields. In addition, the research represented an attempt to determine the vegetative characteristics of the woodland margins and their adjacent fields in comparison with the composition of the mature forest.

METHODS

Soils and vegetation were sampled in the margins of the forest and in the ecotones in the adjacent fields along 100-m baselines. Twenty 100-m baselines were established in these forest-field ecotones, five within the margin of each of the two woods and five comparable and parallel lines within the fields adjacent to the margins of the wood (fig. 1). The five pairs of baselines in the North Woods ecotone were 120 m apart, and the five pairs in the South Woods ecotone were 135 m apart. Locations of the ends of each of the forest baselines were made permanent by the emplacement of steel pipes. Compass directions of the baselines in the North Woods were as follows: sample area A, N85°E; sample area B, N80°E; sample area C, N17°W; sample area D, S60°W; and sample area E, S55°W. Compass directions of the baselines in the South Woods were: sample area A, S45°E; sample area B, N85°E; sample area C, N41°E; sample area D, S10°E; and sample area E, S10°E.

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²Present address: Government Teachers College, Gusau, Northern Nigeria.

Soils

Soil samples for chemical analyses and seed-content determinations were collected during March and April of 1970. Soils for chemical analyses were obtained from the approximate center of the South Woods, as well as from the margins of the 1-, 7-, 10-, and 25-year-old fields (fig. 1). Topsoil samples from a depth of

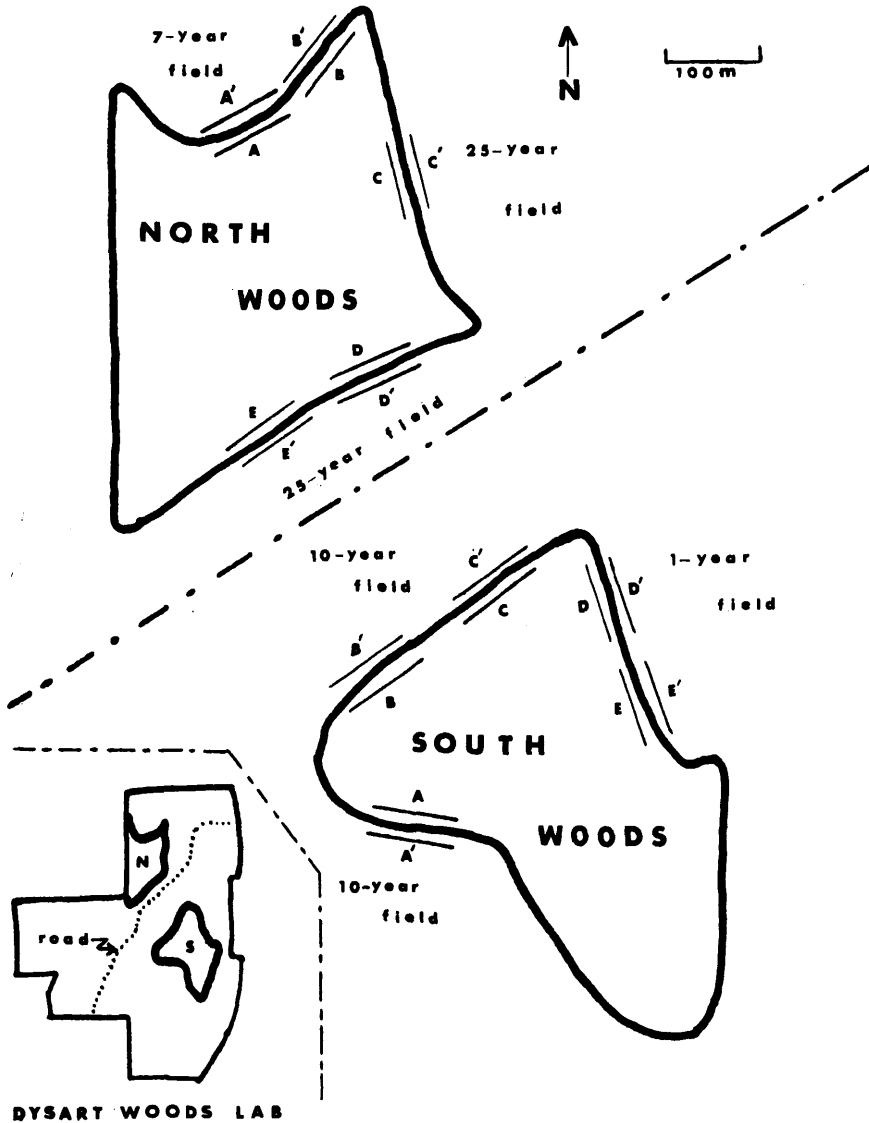


FIGURE 1. Locations of sampling areas in the margins and on adjacent fields of the two tracts of mature forest which comprise Dysart Woods.

10–20 cm and subsoil samples from a depth of 21–40 cm were taken from each site. These samples were sent to the soil-testing laboratory of The Ohio State University, Columbus, for the determination of available phosphorus, exchangeable ions (K, Ca, and Mg), cation-exchange capacity, percent base-saturation, and the calcium-magnesium ratio.

Soil samples for the physical analyses were obtained from the vicinity of each of the 10 pairs of baselines. Only topsoil (from 10–20 cm depth) and subsoil (from 21–40 cm depth) were sampled from the margins of the 1-, 7-, and 10-year-old fields, whereas samples from all three soil horizons—A (topsoil), B (subsoil), and C (parent material)—were taken in the 25-year-old field and the margins of the forest. In all, 26 samples were analyzed for pH, conductivity, saturation percentage, and sand, silt, and clay contents.

Soil pH was determined with a Beckman xeromatic meter using a 1:1 soil-water mixture. The saturation percentage was calculated by slowly adding measured quantities of water to 50 gm of soil (Jackson, 1958). A radiometer conductivity meter (Jackson, 1958) type CDm. 2d., calibrated at 1.5 mmho/cm, was used for the conductivity test, using soil extracts obtained from a 1:1 soil-water mixture. Mechanical analysis of the soil was carried out by the hydrometer method (Bouyoucos, 1951). Soil moisture was measured by determining the loss of weight in a soil dried at 105°C for 72 hours, and is expressed as the percentage of water in the soil on a dry-weight basis.

Soil samples were also collected to determine seed germination from residual seed in the soil. These samples were obtained from the margins of the 1-, 7-, 10-, and 25-year-old fields, as well as from the adjacent margins of the forest. Two 20-cm-x-20-cm plots located 30 cm apart were measured off in each of the 10 sampling locations. These 20 plots were denuded of all vegetation and the surface soil, to a depth of 20 cm, was removed from one of each pair of plots. Surface soil was retained in the other plots, which served as field controls. The surface soil which had been moved from these ten plots was placed in 26-x-54-cm trays, spread evenly, and placed in the greenhouse for a period of three months so that seedling growth could be observed. These trays of soil were watered regularly, and the air temperature was thermostatically controlled at approximately 37°C. The field plots were also observed periodically for the appearance of seedlings.

Vegetation

Ten 10-m-x-10-m quadrats, from which tree data were obtained, were located at 10-m intervals along one side of each of the baselines. Nested within and along one side of each of the larger quadrats was a 2-m-x-10-m quadrat in which saplings and shrubs were sampled. A 0.5-m-x-2-m quadrat, in which data on seedlings, herbs, mosses, and litter were obtained, was located within and at one end of each shrub quadrat.

Trees with diameters greater than one inch (dbh) and their frequencies were recorded by species, diameter, and frequency in each 10-m x 10-m quadrat. In the 2-m x 10-m quadrats, saplings (trees under 1 inch dbh but more than 1 ft tall) were counted by species, and the percentages of cover for each species of shrub and vine were visually estimated. Interstices in the shrub or vine stratum in the quadrats were recorded as percent space. In the smallest quadrats, the percentages of herbaceous cover and of moss cover were estimated in the same way, and the tree seedlings (less than 1 ft tall) were recorded by species, number, and frequency. Litter depth and litter cover were also determined within these smallest quadrats. Relative dominance, relative density, and relative basal area for trees greater than 1 inch dbh were added to obtain importance values (Cottam, 1956). Similarity indices for the three size classes of trees—seedlings, saplings, and trees—occurring in the margins of the forest and in the fields were calculated following the method of Bray and Curtis (1957).

Nomenclature for plant species follows Fernald (1950). Voucher specimens of plants collected from quadrats have been deposited in the herbarium of the Dysart Woods Laboratory, located in the Department of Botany, Porter Hall, Ohio University.

RESULTS

Soils

The pH values of all soil samples range from 5.1 to 6.1 (Table 1). The range in pH of the topsoil samples is 5.4 to 5.8. The 25-year-old field sample is the most acidic, 5.1, whereas the 1-year-old field sample is the least, 6.1. Values for available phosphorus are higher in samples of the topsoil than in those of the subsoil, except in the 25-year-old field. Exchangeable potassium, however, is highest in the 25-year-old field and lowest in the 1-year-old field. Exchangeable calcium in the subsoil of the 7-year-old field is the highest of all soil samples. The topsoil sample of the 25-year-old field shows the greatest cation-exchange capacity.

TABLE 1
Comparison of soil chemical composition in the North and the South Woods ecotones

	North Woods Ectone				South Woods Ectone			
	7-Yr. Field		25-Yr. Field		1-Yr. Field		10-Yr. Field	
	Top-Soil	Sub-Soil	Top-Soil	Sub-Soil	Top-Soil	Sub-Soil	Top-Soil	Sub-Soil
pH	5.8	5.3	5.3	5.1	5.8	6.1	5.4	5.3
Available P (lbs/A)	61	17	23	36	38	32	27	16
Exchangeable ions (lbs/A)								
K	484	330	510	324	426	200	464	291
Ca	2345	3185	2675	2205	2265	2515	2045	2425
Mg	220	217	338	344	257	357	254	348
Cation Exchange Capacity (meq/100g)	18.9	20.8	26.0	30.4	15.9	15.2	18.2	25.2
Base Saturation (%)								
K	3.3	2.0	2.5	1.4	3.4	1.7	3.3	1.5
Ca	21.0	38.3	25.7	18.1	35.6	41.3	28.0	24.1
Mg	4.8	4.3	5.4	4.7	6.7	9.8	5.8	5.8
Ca/Mg ratio	6.4	8.8	4.7	3.8	5.3	4.2	4.8	4.2

There does not seem to be any consistent relationship between soil texture and the soil sample site (Table 2). Similarly, other values for the physical characteristics of the soils differed. The A horizon of the North Woods margin has the highest hygroscopic water value, 3.8, and a saturation percentage of 100. The lowest percentage, 56, are found in the topsoil of the 10-year-old field. The soil sample from the 25-year-old field contains 46.4% sand and has a hygroscopic-moisture retention value of 2.2, a saturation percentage of 90, and the highest value for conductivity, 0.7.

Although the species germinating in the soil samples in the greenhouse were similar to those in the field, germination was earlier, and density was greater, in the greenhouse samples. Some seeds germinated in all of the A-horizon soils samples; however, only two of these were tree species, *Ulmus americana* and *Fraxinus americana*, and they appeared in the A-horizon of the 25-year-old field.

Vegetation

There is a wide range of importance values among the 26 species of trees with diameters greater than 1 inch measured in the margin of the forest (Table 3). *Fagus grandifolia* has higher values in the North Woods than in the South Woods. The reverse is true for *Liriodendron tulipifera*. Although *Fraxinus americana* appears in most of the samples, it has high values for the 25-year-old field and lower values in the forest. *Acer saccharum* is slightly more important in the North Woods than in the South Woods. *Quercus alba*, an important species in both the North

TABLE 2
Comparison of soil physical composition

	Horizon	Sand (%)	Clay (%)	Silt (%)	Hygro-scopie Water (gms)	Saturation (%)	Conductivity (mmho/cm)
North Woods							
Margin (A & B)	A	40	24	36	3.8	100	0.6
	B	43	30	27	1.5	72	0.3
	C	42	26	32	1.6	60	0.2
Margin (C & D & E)	A	48	27	25	4.1	86	0.6
	B	43	36	21	2.2	98	0.3
	C	40	37	23	2.5	62	0.3
25-Year Field (C & D & E)	A	46	27	27	2.2	90	0.7
	B	42	34	24	2.0	70	0.2
	C	42	33	25	2.0	64	0.3
7-Year Field (A' & B')	Top-soil	38	44	18	3.7	68	0.3
	Sub-soil	38	53	9	4.3	76	0.1
South Woods							
Margin (A & B & C)	A	51	23	26	2.9	76	0.9
	B	52	26	22	1.8	72	0.6
	C	55	25	20	1.8	60	0.3
Margin (D & E)	A	49	23	28	2.2	98	0.3
	B	50	24	26	1.1	66	0.4
	C	45	25	30	0.9	48	0.3
10-Year Field (A' & B' & C')	Top-soil	55	23	22	1.3	56	0.3
	Sub-soil	57	22	21	1.0	48	0.3
1-Year Field (D' & E')	Top-soil	46	28	26	2.0	64	0.4
	Sub-soil	42	32	26	1.5	64	0.3

Woods and the South Woods (Lafer and Wistendahl, 1970), is poorly represented in the margin of the South Woods. *Quercus velutina*, *Platanus occidentalis*, *Carya cordiformis*, and *Tilia americana* did not occur in quadrats in the margins of the North Woods, whereas *Cornus florida*, *Quercus rubra*, and *Alnus incana* were not found in the data for margins of the South Woods.

In the sapling data, *Acer saccharum* has the highest density (124) in the North Wood margin (Table 4), but is third in rank (16) in the 25-year-old field, and much lower (1) in the 7-year-old field. Saplings of *Fagus grandifolia*, *Fraxinus americana*, and *Prunus virginiana* have high density values (17 to 23) in the wood margin. *Fraxinus americana* saplings have the highest density (37) in the 25-year-old field, followed by *Crataegus crus-galli* (36), *Crataegus intricata* (12) and *Liriodendron tulipifera* (2).

The occurrence and density of seedlings on the sample areas (Table 4) generally show an increase in forest-margin species that correlates with age of abandonment of adjacent fields. Seedlings outnumber saplings of the same species in most fields, except for *Crataegus* spp. Forest tree species occurring in the fields are mostly those with wind-disseminated seeds, in contrast to non-forest species such as *Crataegus crus-galli*, *Prunus americana*, and *Pyrus malus* which are disseminated by animal-borne seeds. Seedlings of *Juglans nigra* appear in fields as recently as one year after abandonment, but seedlings of *Quercus alba* are present only in the 25-year-old field.

A total of 10 species of shrubs and vines is recorded for all the quadrats of the North Woods and adjacent fields (Table 5). *Parthenocissus quinquefolia* has the greatest average cover value, 11%. All other shrubs and vines have less than 7% cover. No shrubs or vines occur in the quadrat data for the ecotone adjacent to the margin of the South Woods, although 11 species of shrubs and vines occur

TABLE 3
Importance values of trees greater than 1 inch dbh

	North Woods									South Woods					
	Margin					25-Yr. Old				Margin					
	A	B	C	D	E	C'	D'	E'	A	B	C	D	E		
<i>Fagus gradifolia</i>	64	43	90	144	36				24	35			29		
<i>Liriodendron tulipifera</i>	47	43	8			37		70	91	30	24	99	69		
<i>Fraxinus americana</i>	34	26	39	6	39	118	114	66	23	30	8	17			
<i>Acer saccharum</i>	31	20	66	46	93	41	71	49	38	36	24	40	56		
<i>Quercus alba</i>	26	44	41	41	30					4			49		
<i>Cornus florida</i>	29			12	8										
<i>Quercus rubra</i>	21	3													
<i>Prunus virginiana</i>	17	41	6				10		8	29	50	46	16		
<i>Ulmus americana</i>	12	34	22	18		6		42	39	71	12				
<i>U. rubra</i>	11	4	7		6				27	13					
<i>Crataegus crus-galli</i>	6	5				44	65	15	7	3	36	52	8		
<i>Nyssa sylvatica</i>	6	12		12	74								5		
<i>Prunus americana</i>		5	23	14		10			21	9		7	9		
<i>Crataegus pruinosa</i>		4				21	24	7		7	44	10			
<i>Juglans nigra</i>		5						19	6	9	8				
<i>Carya ovata</i>		11							4	7	24		7		
<i>Prunus serotina</i>				6		7	7			7	14				
<i>Acer rubrum</i>					7			33		5	4	8	14		
<i>Alnus incana</i>					6										
<i>Crataegus intricata</i>						16	6				16	20			
<i>Pyrus malus</i>							4		12	3					
<i>Juglans cinera</i>							5			5	17				
<i>Quercus velutina</i>									4				3		
<i>Platanus occidentalis</i>											13		30		
<i>Carya cordiformis</i>											4		4		
<i>Tilia americana</i>													3		
Number of Species	16					14				21					17
Total	22									23					

within the woods margin (Table 5). The forest margins adjacent to the 10-year-old fields contain 11 species of shrubs, but the forest margin adjacent to the 1-year-old field has only six.

Forty-eight species of herbs are listed in the data for the North Woods and adjacent fields (Table 5). A few species, such as *Daucus carota*, *Impatiens biflora*, *Viola papilionacea*, *Aster divaricatus*, and *Medicago sativa*, are found both in margins of the woods and in the fields. Of the 43 species of herbs in the data for the South Woods (Table 5), 17 are found in at least some of the wooded margins, as well as in some of the fields. The list of species for the South Woods samples is similar to that of the North Woods, but the species are not in the same order. Similarity indices based upon densities and upon species are greater for the margins of the North Woods and the adjacent fields, which include the 25-year-old field, than they are for the margins of the South Woods and its adjacent fields (Table 6).

DISCUSSION

At the onset of this study, it was thought that there might be some correlations between the characteristics of the soils of the fields adjacent to the forest and the invasion of trees into these fields. The soils data for the fields and for the forest (Tables 1 and 2) do not show any clearly defined correlations. Studies of the relationship of soils to succession (Bard, 1952) and to forest-tree cover (Fritts and

TABLE 4
Density per 240m² of trees (Tr), saplings (Sa), and seedlings (Se)

	North Woods										South Woods									
	Margins A & B			Margins C & D & E			25-Yr Old (C ¹ & D ¹ & E ¹)			7-Yr Old (A ¹ & B ¹)		Margins A & B & C			Margins D & E			10-Yr Old (A ¹ & B ¹ & C ¹)		1-Yr Old (D ¹ & E ¹)
	Tr	Sa	Se	Tr	Sa	Se	Tr	Sa	Se	Sa	Se	Tr	Sa	Se	Tr	Sa	Se	Sa	Se	Se
	<i>Acer rubrum</i>					1	12	7	2	16			2	19	12	6	3	12	1	
<i>A. saccharum</i>	12	39	30	35	28	124	32	16	106	1		30	41	140	29	54	138	13		64
<i>Alnus incana</i>				1																
<i>Carya cordiformis</i>												1			1					
<i>C. ovata</i>	5	3										10	5	8	2	3	6	1		
<i>Cornus florida</i>	8	5		3	3							1			2					
<i>Crataegus crus-galli</i>	4	4		1		25	36	8	1	1		15	6	8	17	5		9		8
<i>C. intricata</i>						4	12	8				7	3		5	2		2		
<i>C. pruinosa</i>	6			1		10	4				18	1		2			3			
<i>Fagus grandifolia</i>	25	23	24	27	7	8					8	1	12	14	8	12			4	
<i>Fraxinus americana</i>	14	17	36	10	9	20	64	37	124	1	6	17	13	20	2	44	30	46	140	
<i>Juglans cinera</i>						1						2								
<i>J. nigra</i>	1					3				1	12	6	3			1	12	8	8	
<i>Liriodendron tulipifera</i>	12	1		1		17	2			1	6	29	5	4	25	1				
<i>Nyssa sylvatica</i>	4	1		9	1											1				
<i>Platanus occidentalis</i>												3		13						
<i>Prunus americana</i>	2	4		4	8	56	6	1	20	1	48	7	5		4	90	4		24	
<i>P. persica</i>					8		1	8												
<i>P. serotina</i>				1	1	28	2	24	1		5									
<i>P. virginiana</i>	16	17	66	1	1	4	2			5	16	5	332	10	25	222	4			
<i>Pyrus malus</i>						1			16	1	3	1	12	3				4	6	
<i>Quercus alba</i>	8	6	18	7	1			8			2	1	28	12	10	42				
<i>Q. rubra</i>	2	2		1	1								1	8	1	1				
<i>Q. velutina</i>											2	1	8	1	1					
<i>Sassafras albidum</i>				12				16			3			2	42					
<i>Tilia americana</i>													1							
<i>Ulmus americana</i>	19	6	12	7	1	24	8	3	88	18	102	37	15	8	2	30	4		8	
<i>U. rubra</i>	4	2	12	2			1				11	1				1				
Number of species	16	14	7	14	14	10	14	11	12	10	5	21	20	12	17	17	11	12	8	2

Holowaychuk, 1959; Gersper and Holowaychuk, 1971) show that considerable variation in soil characteristics is possible, even in relatively undisturbed forests.

The present study does show some trends which may be related to the length of time since the last agricultural use of the fields. In general, the pH of the soils decreased from 6.1 to 5.1 from the youngest to the oldest fields. Conversely, the cation-exchange capacity increased with time from 15.2 meq/100 g for the 1-year-old field to 30.4 meq/100 g for the 25-year-old field. Although the physical analysis of the soil did not reveal any variations that seemed to correlate with vegetational differences, no characteristics of the soils of the fields adjacent to the forest appeared to be detrimental to the establishment of forest-tree species in the fields. The occurrence of the different tree species in the fields appears to be most closely related to the time since the fields were last used agriculturally, as well as to the fortuitous dissemination of propagules and their successful establishment in the fields.

The value of this study lies in the revelation of the apparent change in the species composition within the forest-field ecotone with time, and the trend toward the expansion of the beech-maple components of the forest rather than of the oaks, which are presently the largest trees within the forest. To demonstrate

TABLE 5

Average cover (C) and Frequency (F) values of shrubs, vines, and herbs within the margins of the forest and on adjacent fields

	North Woods								South Woods							
	Margin		7-Yr Field		Margin		25-Yr Field		Margin		1-Yr Field		Margin		10-Yr Field	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F
Shrubs and Vines																
<i>Campsis radicans</i>			1	5	1	3										
<i>Hydrangea arborescens</i>			3	10	1	3						1	3			
<i>Lindera benzoin</i>	2	5	1	5	1	3										
<i>Parthenocissus quinquefolia</i>	1	5			11	17										
<i>Rhus glabra</i>					1	5	1	3	2	5			3	10		
<i>R. radicans</i>			1	5			1	3	1	5						
<i>Ribes cynosbati</i>			1	5	2	7	3	10	3	5			2	10		
<i>Rosa carolina</i>			3	15	2	7			2	5			2	10		
<i>Rubus ideaus</i>													2	10		
<i>R. strigosus</i>	2	10	7	20					3	15			6	30		
<i>Sambucus canadensis</i>			1	5	3	10							1	3		
<i>Smilax hispida</i>													2	3		
Space	95	100	82	100	78	97	96	100	89	95	100	100	70	95	100	100
Herbs																
<i>Achillea millefolium</i>							1	3	1	5					t	3
<i>Agromonia parviflora</i>					1	3							1	3		
<i>Agrostis alba</i>							3	10	5	15	4	25	6	30		
<i>Ambrosia artemisiifolia</i>					2	7									1	3
<i>Amphicarpa bracteata</i>					1	3										
<i>Andropogon virginicus</i>	1	5							7	25	13	65	5	17		
<i>Antennaria plantaginifolia</i>	t	5							1	5						
<i>Apocynum cannabinum</i>							1	7	t	5					3	10
<i>Aster cordifolius</i>			2	10					t	5			1	7		
<i>A. divaricatus</i>	3	5	2	15			1	3							4	27
<i>Brassica nigra</i>							t	3								
<i>Bromus inermis</i>							12	33			3	10			12	30
<i>Carex rostrata</i>							1	7					t	3		
<i>Cimicifuga racemosa</i>											1	3				
<i>Cirsium arvense</i>					t	3									t	3
<i>Convolvulus sepium</i>							t	3			t	5	2	10		
<i>Dactylis glomerata</i>							3	5	2	10	15	65	5	27	20	77
<i>Daucus carota</i>	3	15	1	10									t	3	3	23
<i>Desmodium canadense</i>											1	10	1	3	1	10
<i>D. glutinosum</i>									1	5						
<i>D. strictum</i>													1	3	1	10
<i>Dianthus armeria</i>	1	5														
<i>Echinochloa pungens</i>							1	3								
<i>Erigeron strigosus</i>							1	3								
<i>Fragaria vesca</i>	1	5							2	65			5	35	3	17
<i>Geranium maculatum</i>	3	15			1	10										
<i>Glechoma hederaceae</i>					1	7									1	3
<i>Impatiens biflora</i>	2	5			5	38	3	13	6	30						
<i>Lamium purpureum</i>					1	3									t	3
<i>Laportea canadensis</i>									t	3						
<i>Medicago sativa</i>			3	15	1	3			1	5	2	5				
<i>Panicum clandestinum</i>							16	85	1	5	39	100	1	7	8	30
<i>P. lanuginosum</i>							1	3							2	10
<i>Phleum pratense</i>							3	13	2	10	10	40	2	10	5	27
<i>Physalis angulata</i>					1	3										
<i>P. heterophylla</i>					1	3										
<i>Pilea pumila</i>							1	3								
<i>Plantago lanceolata</i>															1	7
<i>P. rugelii</i>	2	4			1	3										
<i>Podophyllum peltatum</i>	6	40			23	13							1	10		

TABLE 5—(Continued)

	North Woods						South Woods									
	Margin		7-Yr Field		Margin		25-Yr Field		Margin		1-Yr Field		Margin		10-Yr Field	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F
<i>Potentilla canadensis</i>	1	10	1	5	1	3										
<i>P. recta</i>															1	13
<i>Polygala sanguinea</i>									1	5						
<i>Polystichum acrostichoides</i>	4	15			3	3			1	5			2	13		
<i>Prunella vulgaris</i>							1	7							4	23
<i>Sedum ternatum</i>	3	5							3	5			1	3		
<i>Solanum carolinense</i>					1	3			1	5						
<i>Solidago canadensis</i>							4	13	13	55	3	10	21	80		
<i>Stellaria media</i>					1	3									2	13
<i>Tovara virginiana</i>													1	3	1	3
<i>Trifolium pratense</i>									1	5					5	27
<i>Urtica dioica</i>					1	3			2	10						
<i>Vernonia altissima</i>					1	3							1	3	1	3
<i>Veronica officinalis</i>									2	10						
<i>Viola canadensis</i>					1	3										
<i>V. papilionacea</i>	3	10			1	3	1	3	2	10			3	13		
<i>V. pensylvanica</i>	3	20														
Space		66		67		89		46		72		8		40		20
Mosses	11	20	1	5	5	10	4	10	10	15			10	20		
Litter	70	85	59	80	59	85	65	70	45	85	100	100	36	83	73	100
Depth of litter (cm)		1.4		1.7		1.0		1.2		1.0		2.5		1.2		1.6

t = trace.

TABLE 6

Comparison of the similarity indices in percentages of the seedlings, saplings, and tree species among the different areas in the North and South Woods based on densities, importance values for trees, and number of species

	North Woods			South Woods		
	Margin/ Margin	Margin/ Fields	Fields/ Fields	Margin/ Margin	Margin/ Fields	Fields/ Fields
Seedlings						
Density	30	54	37	69	19	2
No. of Species	59	47	35	70	41	20
Saplings						
Density	58	41	83	55	26	—
No. of Species	79	57	57	92	34	—
Trees						
Importance Value	59	32	60	48	—	—
No. of Species	(43-82)*	(19-46)	(46-78)	(30-66)	—	—
	59	34	56	49	—	—
	(46-71)	(21-45)	(48-64)	(39-61)		

*Variance.

this change, each of the ecotonal areas studied is discussed sequentially, from the most recently abandoned field to the oldest. Emphasis is placed upon the species of trees migrating into the fields, and upon the composition of the tree vegetation of the forest margins. These are compared with a previous study of the tree composition of the forest itself, as made by Lafer and Wistendahl (1970).

The plant cover in the 1-year-old field adjacent to the North Woods is characterized by a dense cover of a number of grasses (Table 5). This field had been mowed for hay until one year prior to the study. Thus, there has been insufficient time for shrubs and trees to appear, although a few seedlings of *Prunus americana* and *Pyrus malus* are found in the field. Barton (1961) listed *Pyrus malus* and *Prunus virginiana* among the seeds possessing high germinative capacity after stratification; also, the litter cover in this field may have enhanced their germination (Mackinney, 1929). Seedlings of other tree species growing adjacent to the field had not become established in this field by this time. Buell *et al.* (1971) have shown that some species of trees appeared in oldfields adjacent to the William L. Hutcheson Memorial Forest within one year after abandonment. They concluded, however, that no uniform pattern of invasion was evident, when they compared their data with those from other studies from over a wide geographical range.

The 7-year-old field adjacent to the North Woods has a greater number of tree species than even the 12-year-old field (Table 4). *Ulmus americana*, a wind-disseminated species, has the highest density of saplings and seedlings in this field. This species should decrease in importance as shade-tolerant forest species, such as *Acer saccharum* and *Fagus grandifolia*, increase in density in the fields (Bard, 1951; Fowells, 1965). The relatively high importance values of these two species in the margins of the adjacent forest suggests that such a shift in dominance may be expected with time. A comparison of similarity indices (Bray and Curtis, 1957) shows a 57% similarity between the saplings in the margins of the North Woods and the adjacent fields (Table 6). The similarity index for saplings is lower in the margins of the South Woods than in the margins of the North Woods, where the adjacent fields have been abandoned for a longer period of time. This further suggests that the similarity of species between forest margin and fields should increase with time as forest species continue to appear in the fields.

The 10-year-old field has the largest number of herbaceous and woody plant species (46) of any of the areas studied. The density of annuals, however, is low compared with perennials, such as *Solidago canadensis*, *Daucus carota*, *Dactylis glomerata*, *Panicum clandestinum*, and *Phleum pratense* (Table 5). This change from annuals to perennials with time has been well established (Keever, 1950; Bard, 1952; Quarterman, 1957). In a 10-year-old field in North Carolina Oosting (1942) found a large number of seedlings which he considered to be from seed buried during cultivation rather than from those disseminated after abandonment. The seed source for some of the perennials in the field reported on here is very likely of similar origin, as indicated by the seed germination study. *Fraxinus americana*, *Acer saccharum*, and *Fagus grandifolia* occur as seedlings or as saplings among the herbaceous vegetation of this 10-year-old field. Although seeds of *Fraxinus americana* are widely disseminated by wind, and its seedlings are shade tolerant, the species occurs only as scattered individuals within mature forests (Harlow and Harrar, 1958). *Acer saccharum* and *Fagus grandifolia* should increase in numbers as more seed are disseminated into the field from the adjacent forest. The proximity of this seed source for these species, as well as for other forest species, probably contributes to the high index of similarity, 70%, between the tree species of the margin of the forest and the tree seedlings in the field (Table 6).

The 25-year-old field has more species of trees in its margin than do any of the other fields (Table 4). The shading effect of the dense canopy of *Crataegus* spp.

contributes to the low number of herbs and shrubs in the understory (Table 5). This field is the only one that possesses trees with dbh values 1 inch or greater (Table 3). *Fraxinus americana* has the highest importance value of all the trees present (Table 3), and the greatest densities of trees, saplings, and seedlings (Table 4). Next in rank in all respects are *Crataegus crus-galli* and *Acer saccharum*, in that order. *Fagus grandifolia*, which has a high importance value in the North Woods, is not represented in the 25-year-old field. There are only a few seedlings of *Quercus alba* present in this field.

The occurrence of large numbers of individuals of *Crataegus* spp. in oldfields can be accounted for, in part, by bird dissemination and by scarification of seeds as they pass through the alimentary canals of birds (Baldwin, 1942; Krefting and Roe, 1949). Once established, *Crataegus* is enhanced by grazing-avoidance of cattle (Westveld, 1949) and by the consequential increase in roosting sites for birds. The 25-year-old field was over-grazed during the first eight years after removal from cultivation (Mrs. McGaughy, personal communication, 1970). Germination of *Crataegus* seed is not immediate following the after-ripening period, but may extend over several years (Crocker, 1906) and thus tend to increase in density with time. In addition, *Crataegus* seems to germinate well in acidic areas (Ekerson, 1913); this 25-year-old field has the lowest pH value of any of the fields studied (Table 1).

The importance values for trees in the margins of the North Woods are in a different order from the values determined by Lafer and Wistendahl (1970) for these trees throughout the Woods. Lafer and Wistendahl (1970) show *Fagus grandifolia* (IV 114), *Quercus alba* (IV 58), and *Acer saccharum* (IV 48) as important species for trees 4 inches dbh or greater. The present study of the margin of the North Woods (Table 3) shows the following species with high importance values: *Fagus grandifolia* (144), *Acer saccharum* (93), *Liriodendron tulipifera* (47), and *Quercus alba* (44). *Quercus alba*, which is second in rank in the Lafer and Wistendahl (1970) study, appears as fourth in the margin of the North Woods. *Liriodendron tulipifera*, which occurs as a large tree in the forest but with a relatively low importance value, shows a low density of saplings in the margin of the forest. *Prunus virginiana*, which has a high density of saplings and seedlings on the margin of the forest, was not ranked at all among the forest trees of the virgin forest by Lafer and Wistendahl (1970), although it may have occurred as trees less than 4 inches dbh. *Fagus grandifolia* and *Acer saccharum* are maintaining high importance values in the margin of the forest as well as in the forest.

For the South Woods, where Lafer and Wistendahl (1970) found high importance values for *Acer saccharum* (99), *Fagus grandifolia* (69), and *Quercus alba* (46) within the forest, *Liriodendron tulipifera* (99), *Ulmus americana* (71), and *Acer saccharum* (56) are the important forest species along the margin of the woods (Table 3). The species with relatively large numbers of seedlings and saplings in the margin of this woods are *Prunus virginiana*, *Fraxinus americana*, and *Acer saccharum* (Table 4). Of the forest species, only *Acer saccharum* is present in all sizes (as seedlings, saplings and trees) and, thus, it should maintain dominance in the margin of the forest. *Prunus virginiana* and *Fraxinus americana* are not likely to attain dominance with the spread of the forest into the fields, because of their intolerance to shade (Harlow and Harrar, 1958). Low densities of seedlings and saplings of *Ulmus americana* seem to preclude its importance with time. Shade-tolerant *Fagus grandifolia* may, however, survive to a tree-stage dominance. Consequently, the *Acer-Liriodendron-Ulmus* community of the South Woods margin possesses the potential of developing toward a *Fagus-Acer* community similar to that of the forest, except with fewer individuals of *Quercus alba*.

A shift in dominance in mature, or so-called virgin, forests elsewhere from *Quercus alba* to *Acer saccharum* and *Fagus grandifolia* has been indicated by the

results of a number of studies of mature forests within the eastern deciduous forest (Monk, 1961a; Monk, 1961b; Dix, 1957; Cain, 1932). Cain (1932) in a study of Donaldson's Woods, Indiana, found that *Quercus alba*, the dominant species, did not seem to be reproducing. Minckler (1957) indicated that oak seedlings were only partially shade-tolerant, and are normally succeeded by more shade-tolerant species such as *Fagus grandifolia* and *Acer saccharum*. Because *Fagus grandifolia* will reproduce both by seed and by root sprouts (Ward, 1961) and because *Acer saccharum* shows a high degree of tolerance to shade (Baker, 1950), it is likely that *Fagus grandifolia* and *Acer saccharum* will not only occupy the margins of the forest but will also be the dominant or most important species in the fields as the forest increases and develops. The low density of seedlings and saplings of *Liriodendron tulipifera* may be attributed to the low viability of embryos of this species (Wean and Guard, 1940). Also, Phillips (1962) indicated that *Liriodendron tulipifera* seedlings could survive through their first three years in clear-cut forest until a 50% overstory developed, but would not survive in uncut stands. Thus, *Liriodendron tulipifera* would remain as a member of the forest community as it develops in adjacent fields, but would be represented by only a few individuals. *Prunus virginiana*, whose fruits are mostly disseminated by birds, is characteristically a tree of oldfields and occurs only in small numbers within the mature forest (Lafer and Wistendahl, 1970). Where *Acer saccharum*, *Liriodendron tulipifera*, and *Prunus virginiana* occur together as young trees, *Acer saccharum* should become the dominant species with time and *Liriodendron tulipifera* and *Prunus virginiana* should remain as components of the forest.

SUMMARY

The forest-field ecotones of Dysart Woods differ vegetationally as a consequence of both time and land-use histories. Although the arborescent species within the ecotone are mostly those characteristic of oldfield succession, there is a trend toward the development of a beech-maple forest with time. The low occurrence of *Quercus alba* as seedlings indicates that this species should become less important within the mature forest than it is now as the forest expands in area. The presence of *Fagus grandifolia* and *Acer saccharum* as dominants in Ohio forests of the past has been indicated by Gordon (1969) and the dominance of these two species in present-day forest in glaciated northeastern Ohio (Cuyahoga County) has been clearly shown by Schlesinger (1971). Although Dysart Woods is presently a mature oak forest within unglaciated Ohio, developmental trends in the forest-field ecotone indicate that beech and maple should dominate the forest as it migrates into the adjacent fields.

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