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Vegetational Communities on an Abandoned Farm in Van Buren County, Michigan

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VEGETATIONAL COMMUNITIES ON AN ABANDONED FARM IN VAN BUREN COUNTY, MICHIGAN

by

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INTRODUCTION

Several studies have been made of xeric forests in southern Michigan which have developed through secondary succession following the cutting of the presettlement vegetation. Brewer et al. (1973) described such an area in Allegan County, Michigan which was dominated by presettlement pine and is now dominated by oak. The oak forests of the Harvey Ott Preserve in Calhoun County, Michigan have been described by Catana (1967). Studies of the oak forests in the Haven Hill area in southeastern Michigan have been made by Thompson (1953). In addition to these studies of xeric forests in southern Michigan, extensive studies of xeric forests in southern Wisconsin have been made by Curtis (1971).

These studies of xeric forest communities have dealt with relatively large areas. The minimum size community studied by Brewer et al. (1973) was 8 acres and the minimum area studied by Curtis (1971) was 15 acres. The studies of xeric forest communities in southwestern Michigan by Catana (1967) and Brewer et al. (1973) dealt with publicly owned property which had not been disturbed since cutting of the presettlement vegetation.

In this study xeric communities much smaller than those previously mentioned are described. Several small communities in close proximity to one another but with different vegetational compositions are described. These communities are on privately owned property and have been disturbed since the presettlement vegetation was cut.

The objective of this study is to describe these communities and determine why they are so different in terms of present vegetation. Past aerial photographs, age structure of the stands, and environmental factors are discussed in an attempt to explain these differences in vegetation. The future successional trends of these areas based on present understory and environmental factors are also discussed.

STUDY AREA

Location

This study site is a 45-acre parcel located in the S½ of the N½, and the S½ of the S½ of the NE¼, both in the SW¼ of Sec. 27, T 1S, R 13W, Pine Grove Township, Van Buren County, Michigan. Along the northern boundary of this parcel the vegetational boundaries do not coincide with the property boundary, therefore, some of the study plots extend slightly north of the above stated area.

Physiography

Surface features of the study area are associated with the activities of the Lake Michigan lobe of the Wisconsin ice sheet which receded west-northwesterly across Van Buren County (Terwilliger 1954). The eastern part of this property lies along the western edge of Kendall Ridge, the easternmost of the three ridges which make up the Valparaiso Morainic System in northeastern Van Buren County. The western and part of the central portion of the study area lie in the area between Kendall Ridge and Gobles Ridge which was occupied by ponded water long after glacial activities had ceased.

Total relief on the property is approximately 10 m. The area that was occupied by ponded water is approximately 237 m above mean sea level. The rest of the area varies between 238 and 247 m above mean sea level.

Soils

The soils of this study area were mapped between 1950 and 1955 by the Van Buren County Soil Conservation Service. Three soil types were found on the study area, Houghton muck, Oshtemo sandy loam, and Spinks loamy sand (Fig. 1, page 5). Houghton muck which occurs in the western and north central portions of the study area is characterized by the United States Department of Agriculture Soil Conservation Service (1965) as a deep organic soil derived from grasses, sedges, reeds, and other non-woody material. This type of soil occurs in nearly level areas where the water table is at or near the surface unless drained. In the south central portion of the study area the soil is Oshtemo sandy loam. It is characterized (USDA-SCS 1965) as a well-drained soil with a sandy or loamy surface layer over sandy loam to sandy clay loam, which in turn is underlain with calcareous, stratified sand and gravel at a depth of 1 to 1.5 m. This type of soil normally occurs on outwash plains and moraines. The soil of the eastern portion of the study area is Spinks loamy sand which is characterized (USDA-SCS 1965) as a well-drained soil with a sandy surface layer over alternate layers of sand and loamy sand or light sandy loam, all over sand. The soil type is found on low dunes, lake plains, and moraines.

Climate

According to climatological data recorded at Bloomingdale, Michigan, located 7 miles west of the study area, the average annual precipitation in northeastern Van Buren County is 91 cm; during the

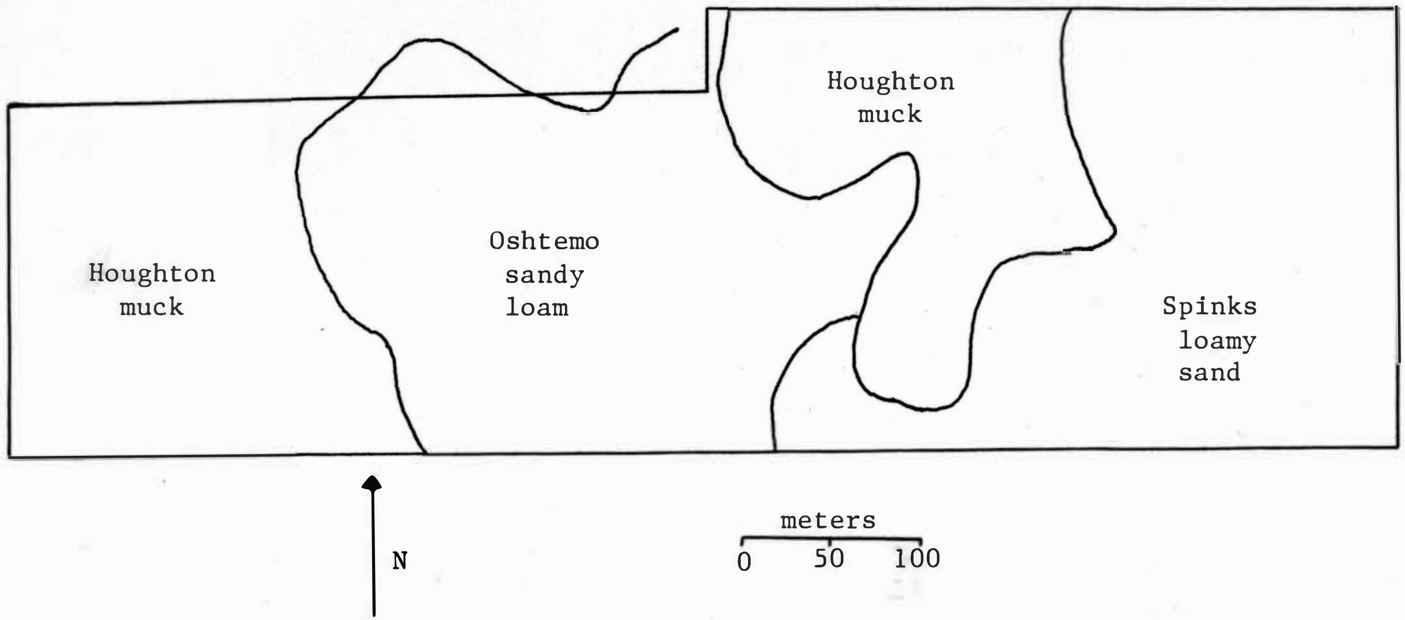


Fig. 1. Soil types on the study area as mapped by the Van Buren County Soil Conservation Service.

period 1956 to 1970 it ranged from 70.9 to 106.2 cm (USCOMM-NOAA 1956-1970). The lowest precipitation occurs during the winter when precipitation averages around 6.0 cm per month and precipitation highs occur in the late spring when precipitation averages around 9.5 cm per month.

The mean annual temperature is 10^{o} C with temperatures averaging 21^{o} C during the summer and -3^{o} C during the winter. The growing season (mean length of period between last spring frost and first autumn frost) is approximately 155 days.

Vegetational History

Van Buren County is in the beech-maple region described by Braun (1950). This region is characterized by beech-maple on the more mesic sites and various oak and oak-hickory communities on the more xeric sites. Kenoyer's (1934) reconstruction of the original vegetation of southwestern Michigan based on the original land survey records indicate that the study area was covered by oak-hickory and oak-pine at the time of settlement.

According to the original land survey of section 27, Pine Grove Township, the west and northwest parts of this section were covered by a pine-tamarack swamp at the time of settlement. This pine-tamarack swamp presumably included the west portion of the study area. Witness trees for the rest of section 27 were white oaks (*Quercus alba*) with a few black oaks (*Q. velutina*) and hickories (*Carya* sp.). This indicates that the lowland sites of section 27

were covered by pine (Pinus sp.) and tamarack (Larix larcina) while the upland sites were covered by oak and hickory.

A later survey in 1849 of the E½ of the NW¼ of Sec. 27 mentions several mature beech (Fagus grandifolia) trees growing just north of the study area. This indicates that beech were probably growing on the more mesic upland sites in this general area.

The entire study area appears to have been logged off at one time and a few old charred stumps indicate that at least parts of the area were also burned. At least one-sixth of the area has been under agriculture. Old fences on the study area indicate that other parts of the area have been pastured at one time.

At the present time the lowland areas, some of which contain standing water during parts of the year, in the west and north central parts of the study area are covered by grasses and shrubs. The upland portions of the study area are covered by mature trees except for the following areas: an area of bromegrass (Bromus inermis) and alfalfa (Medicago sativa) in the southeast portion of the study area that was under agriculture until 1972, a semi-open sand blowout and red pine (Pinus resinosa) plantation in the northwest part of the study area, and a semi-open old field in the south central part of the study area that was abandoned in the late 1930's or early 1940's.

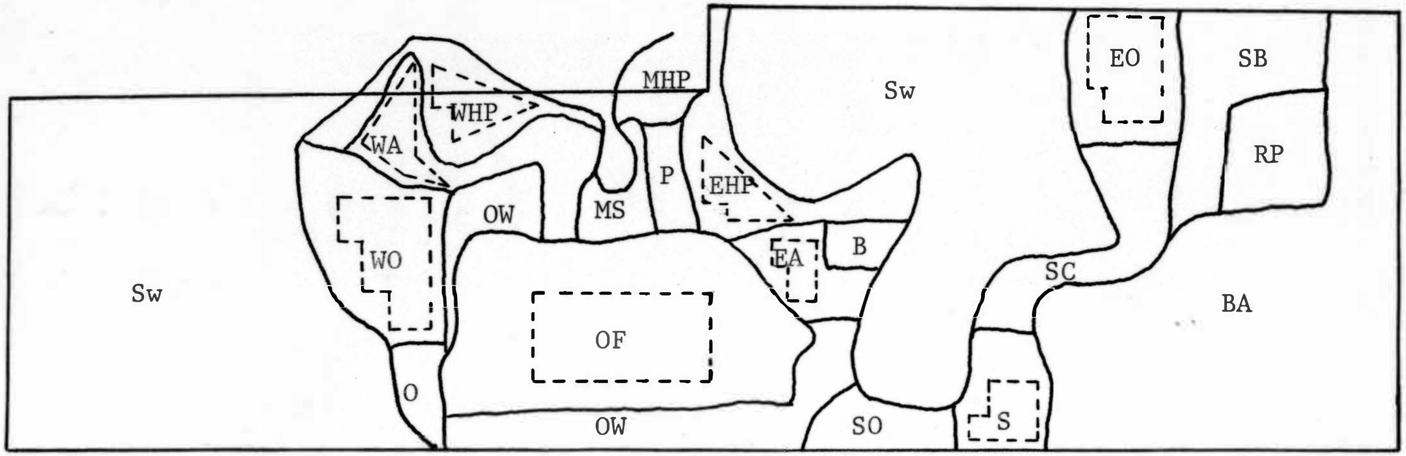
METHODS

Preliminary Survey

A permanent grid was established on the study area in June 1972 using a Suunto compass and steel tape. The grid consisted of steel stakes placed 50 m apart in the north-south and east-west directions. Following the establishment of the grid, the various plant communities were delineated on the basis of visual homogeneity and were mapped in reference to the grid markers (Fig. 2, page 9).

Of the various plant communities shown in Fig. 2 (page 9), eight were chosen for intensive study. These eight communities were chosen on the basis of several factors. First, even though all the communities on the study area were small, an attempt was made to choose the larger of these communities. Secondly, communities were chosen which were free from recent disturbance. In addition, the communities which showed the greatest amount of visual homogeneity were chosen. Finally, an attempt was made to include a variety of communities to illustrate the range of vegetation types present on the study area.

In each of the eight communities an area for intensive study was marked out using a Suunto compass and steel tape (Fig. 2, page 9). These study plots were kept as large as possible with at least a 5 to 10 m margin being excluded along the edge of each community.



VEGETATION TYPES

B	Beech	P	Pine
BA	Bromegrass-Alfalfa	RP	Red Pine
EA	East Aspen	S	Sassafras
EHP	East Hardwood-Pine	SB	Sand Blowout
EO	East Oak	SC	Sumac-Cherry
MHP	Mixed Hardwood-Pine	SO	Sassafras-Cherry
MS	Mixed Shrubs	Sw	Swamp
O	Oak	WA	West Aspen
OF	Old Field	WHP	West Hardwood-Pine
OW	Oak-Walnut	WO	West Oak

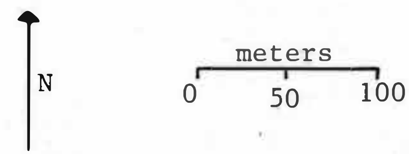


Fig. 2. Present vegetation on the study area. Study plots are delineated by the dotted lines.

Vegetation Analysis

Within each of the eight study plots all canopy trees, 10 cm dbh (diameter-breast height) or greater, were counted by species and their dbh recorded. Random, nested, circular quadrats were used to sample the understory trees and seedlings. Quadrats 20 m^2 were used to sample the understory trees of 2.5 to 9.9 cm dbh. Tree seedlings were sampled using 2 m^2 quadrats. The seedlings were separated into those less than 0.3 m tall and those 0.3 m or taller but less than 2.5 cm dbh. Adequacy of sampling was determined by plotting the cumulative mean densities for the 2 or 3 most abundant species against the number of samples (Greig-Smith 1964). This procedure was applied to both understory and seedling samples. Prominent herbaceous and nonarborescent woody vegetation in each community was noted but not sampled. These procedures were carried out in July and August 1972. Plant names follow Fernald (1950).

Increment cores were taken of canopy trees in the spring of 1973. Each of the eight study plots were subdivided into three or four areas depending on the shape of the study plot. In each subdivision all individuals of species with fewer than 8 individuals were cored. For the species with greater than 8 individuals per subdivision a random sample of 6 to 8 individuals was cored. The cores were taken approximately 45 cm above the ground. In the lab all cores except those with easily distinquished rings were stained with phloroglucinol (Patterson 1959). A binocular microscope was used to count the number of rings.

Environmental Factors

Light intensity readings were taken between 12:30 and 2:30 EDT on clear days in August 1973. The readings were taken 1.4 m above the ground using a Weston sunlight illumination meter with a Viscor filter. These light intensity readings were taken at the same random sampling points that were used for the vegetation sampling. Additional light readings were taken in full sunlight before and after the readings in each community.

Soil samples were taken from each of the eight areas in August 1973. The samples were taken from 3 to 6 systematically chosen points in each area. At each point a sample was taken at a depth of 15 to 30 cm and at a depth of 45 to 60 cm. The samples were placed in sealed plastic bags for transportation to the lab.

In the lab, the pH of each sample was measured colorimetrically. The samples were then air dried. The texture of each soil sample was determined by the Bouyoucos-hydrometer method (Bouyoucos 1936).

Differences in pH values and differences in soil texture were tested by analysis of variance. Pairwise comparisons (Snedecor and Cochran 1968) were also made to determine which pairs of areas were different in terms of soil pH and also in terms of soil texture. These tests were made using an IBM 370 computer.

Slope angle and exposure were measured at the vegetation sampling points during July and August 1973. The exposure direction was measured with a compass. The slope was then measured using an Abney level and steel tape.

Aerial Photographs

Aerial photographs have been taken of the study area in 1938, 1950, 1955, 1960, and 1967. These photographs were obtained from the U. S. Soil Conservation Service in stereopairs at a 1:20000 scale. These five sets of photographs were used to obtain information on the successional change on the eight areas since 1938. A University of Michigan photo interpreter's scale (Carow 1954) was used to obtain estimates of crown closure.

RESULTS

Vegetation

Old Field

One of the most recently disturbed of the eight study plots is the old field located in the south central part of the study area (Fig. 2, page 9). This area is still largely dominated by grasses and herbaceous vegetation. Among the more prominent grasses are broomsedge (Andropogon virginicus), poverty oatgrass (Danthonia spicata), and porcupine grass (Stipa spartea). A common biennial in the area is wild carrot (Daucus carota). Among the numerous perenials are common St. Johnswort (Hypericum perforatum), gray goldenrod (Solidago nemoralis), tall goldenrod (S. altissima), woodland sunflower (Helianthus divaricatus), panicled tick-trefoil (Desmodium paniculatum), and common strawberry (Fragaria virginiana). Small shrubs on the area include black raspberry (Rubus occidentalis) and winged sumac (Rhus copallina).

A summary of the tree species present on this area is found in Table 1 (page 14) with relative density and relative dominance values of overstory and understory vegetation found in Table 2 (page 15). Black cherry (Prunus serotina) is the most important overstory tree on the area. Other trees present on the area in order of abundance are sassafras (Sassafras albidum), black oak, white pine (Pinus strobus), and black walnut (Juglans nigra).

Table 1. Structure of the old field vegetation. Densities are expressed per 1000 m^2. The size of the study plot is 5000 m^2.

	Less than 2.5 cm dbh		More than 2.5 cm dbh		
Species	Less than 30 cm tall	More than 30 cm tall	2.5–10 cm	10–25 cm	> 25 cm
Acer rubrum	0	0	5.0	0	0
Cornus florida	25	0	47.5	0	0
Juglans nigra	25	0	0	0	0
Pinus strobus	0	0	2.5	0.8	0.2
Prunus serotina	300	0	5.0	9.4	0
Quercus velutina	425	125	0	1.0	0.2
Sassafras albidum	3450	1100	52.5	2.0	0
Totals	4225	1225	112.5	13.2	0.4

Table 2. Relative density and relative dominance values for the understory and overstory species of the old field.

Species	2.5-10.0 cm dbh Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.	> 10.0 cm dbh Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.
Acer rubrum	4.4	3.7	8.1			
Cornus florida	42.2	29.5	71.7			
Juglans nigra				1.4	0.7	2.1
Pinus strobus	2.2	5.4	7.6	7.2	13.6	20.8
Prunus serotina	4.4	9.3	13.7	68.2	57.9	126.1
Quercus velutina				8.7	17.8	26.5
Sassafras albidum	46.8	52.1	98.9	14.5	10.0	24.5

The understory size class is dominated by sassafras with some black cherry, red maple *(Acer rubrum)*, and white pine also present. Flowering dogwood *(Cornus florida)* is also prominent in the understory. Sassafras is the most abundant seedling found on this area.

A summary of the ages of the trees found on this area as determined by core samples is found in Table 3 (page 17). The mean ages of four of the tree species, black walnut, black cherry, black oak, and sassafras, are very similar ranging from 22 to 24.5 years. White pine appears to be somewhat younger with a mean age of 16.33 years.

Sassafras Area

The sassafras stand is located in the southeast part of the study area (Fig. 2, page 9). A summary of the tree species data is found in Table 4 (page 18) and a summary of relative densities and dominances is found in Table 5 (page 19). Sassafras is the most important overstory tree found on this area. Following it closely in dominance but with a much lower density is large-toothed aspen *(Populus grandidentata)*.

Sassafras is the most abundant understory species, with flowering dogwood next in abundance. Sassafras is also the most abundant seedling species and black cherry ranks second.

Small woody vegetation present on the area included Virginia creeper *(Parthenocissus quinquefolia)*, poison ivy *(Rhus radicans)*, grape (*Vitis* sp.), and dewberry *(Rubus hispidus)*. Among the few herbaceous plants found on the area are sweet cicely (*Osmorhiza* sp.), goldenrod (*Solidago* sp.), aster (*Aster* sp.), and wild lily of the valley *(Maianthemum canadense)*.

Table 3. Summary of the ages of the overstory trees in the old field.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Juglans nigra	1	22.0		
Pinus strobus	6	16.3	3.8	12-21
Prunus serotina	29	23.9	2.1	19-27
Quercus velutina	3	24.0	1.0	23-25
Sassafras albidum	8	24.5	0.8	23-25

Table 4. Structure of the sassafras stand. Densities are expressed per 1000 m^2. The size of the study plot is 1150 m^2.

Species	Less than 2.5 cm dbh		More than 2.5 cm dbh		
	Less than 30 cm tall	More than 30 cm tall	2.5-10 cm	10-25 cm	> 25 cm
Acer rubrum	0	67	6.7	0	0
Cornus florida	300	200	36.7	0	0
Carya ovalis	167	67	0	0	0
Hamamelis virginiana	33	67	0	0	0
Pinus strobus	0	0	3.3	0	0
Populus grandidentata	0	0	6.7	8.7	4.3
Prunus serotina	2067	767	3.3	0.9	0
Quercus alba	0	0	3.3	1.7	0
Q. velutina	33	33	10.0	1.7	0
Sassafras albidum	2200	800	100.0	76.5	0.9
Ulmus rubra	0	33	0	0	0
Totals	4800	2034	170.0	89.5	5.2

Table 5. Relative density and relative dominance values for the understory and overstory species of the sassafras area.

Species	2.5–10.0 cm dbh			> 10.0 cm dbh		
	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.
Acer rubrum	3.9	1.0	4.9			
Cornus florida	21.5	8.5	30.0			
Pinus strobus	2.0	1.9	3.9			
Populus grandidentata	3.9	4.6	8.5	13.8	45.9	59.7
Prunus serotina	2.0	0.8	2.8	0.9	0.5	1.4
Quercus alba	2.0	0.5	2.5	1.8	1.5	3.3
Q. velutina	5.9	4.3	10.2	1.8	2.8	4.6
Sassafras albidum	58.8	78.4	137.2	81.7	49.3	131.0

The ages of the trees found in this area are summarized in Table 6 (page 21). The sassafras trees with a mean age of 33.25 years are generally older than the other trees. The four other species, large-tooth aspen, black cherry, white oak, and black oak, have approximately the same mean ages, 21.33 to 25.0 years; however, the range of large-toothed aspen is considerably greater, 14 to 32 years.

West Aspen Area

The west aspen stand is located in the northwest part of the study area (Fig. 2, page 9). In Table 7 (page 22) is found a summary of the tree species data for this area; relative densities and dominances are summarized in Table 8 (page 23). Large-toothed aspen is the predominant tree in the overstory on this area; no other species approaches large-toothed aspen in terms of either density or dominance. The density of dead but still standing aspens is 10.8 per 1000 m^2. The dbh of these dead aspens ranges from 13.3 to 33.0 cm.

The understory is dominated by understory shrubs, flowering dogwood and witch hazel (*Hamamelis virginiana*), which conprise 82.1 per cent of the individuals in this layer. The most abundant potential overstory species in this layer is white pine. Understory shrub species also dominate the large and small seedling classes.

Small woody species found on the area include Virginia creeper, staghorn sumac (*Rhus typhina*), dewberry, maple-leaved viburnum (*Viburnum acerifloium*), and common blackberry (*Rubus allegheniensis*). False Solomon's seal (*Smilacina* sp.) and wild lily of the valley are

Table 6. Summary of the ages of the overstory trees in the sassafras area.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Populus grandidentata	12	21.3	5.1	14-32
Prunus serotina	1	25.0		
Quercus alba	2	25.0	1.4	24-26
Q. velutina	2	23.0	1.4	22-24
Sassafras albidum	24	33.4	4.9	26-41

Table 7. Structure of the west aspen stand. Densities are expressed per 1000 m^2. The size of the study plot is 1390 m^2.

Species	Less than 2.5 cm dbh		More than 2.5 cm dbh		
	Less than 30 cm tall	More than 30 cm tall	2.5-10 cm	10-25 cm	> 25 cm
Acer rubrum	321	321	0	0	0
Cornus florida	464	893	146.4	0	0
Hamamelis virginiana	357	179	17.9	0	0
Nyssa sylvatica	0	0	0	0.7	0
Pinus strobus	0	0	28.6	0	0
Populus grandidentata	0	0	0	23.0	20.9
Prunus serotina	607	36	3.6	0.7	0
Quercus alba	214	71	3.6	0	0.7
Q. rubra	214	36	0	1.4	0
Q. velutina	71	0	0	4.3	0
Sassafras albidum	143	0	0	2.2	0
Totals	2391	1536	200.1	32.3	21.6

Table 8. Relative density and relative dominance values for the understory and overstory species of the west aspen area.

	2.5-10.0 cm dbh			> 10.0 cm dbh		
Species	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.
Cornus florida	73.2	81.6	154.8			
Hamamelis virginiana	8.9	3.2	12.1			
Nyssa sylvatica				1.3	0.9	2.2
Pinus strobus	14.3	11.6	25.9			
Populus grandidentata				81.4	85.0	166.4
Prunus serotina	1.8	1.1	2.9	1.3	0.6	1.9
Quercus alba	1.8	2.5	4.3	1.3	7.1	8.4
Q. rubra				2.7	0.8	3.5
Q. velutina				8.0	3.5	11.5
Sassafras albidum				4.0	2.1	6.1

common in the area. Less abundant are bracken (*Pteridium aquilinum*), sweet cicely, and Solomon's seal (*Polygonatum* sp.).

Tree ages for this area are summarized in Table 9 (page 25). Large-toothed aspens are among the youngest trees on the area with a mean age of 32.33 years. The oldest tree on the area is a white oak determined to be at least 49 years old. The mean ages of the other five species range from 37.33 to 41.0 years.

East Aspen Area

The east aspen stand is located northeast of the old field (Fig. 2, page 9). The data for the tree species of this stand are summarized in Table 10 (page 26). Relative density and dominance values appear in Table 11 (page 27). As in the west aspen stand large-toothed aspen is the predominant overstory species; no other species approaches it in terms of density or dominance.

Red maple is predominant in the understory with understory shrubs, witch hazel and flowering dogwood, comprising much of the rest of the understory. Most abundant in the seedling class is black cherry followed by flowering dogwood and red maple.

Poison ivy and Virginia creeper are common in this area. Other small woody species present are dewberry, prickly ash (*Xanthoxylum americanum*), and grape. Herbaceous vegetation is poorly represented both in terms of numbers and variety with only Solomon's seal and wild lily of the valley being observed.

The tree age data for this area are summarized in Table 12 (page 28). Large-toothed aspen ages range from 10 to 26 years with a

Table 9. Summary of the ages of the overstory trees in the west aspen area.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Nyssa sylvatica	1	41.0		
Populus grandidentata	18	32.3	4.8	25-38
Prunus serotina	1	39.0		
Quercus alba	1	49.0		
Q. rubra	2	39.0	1.4	38-40
Q. velutina	6	37.3	4.5	29-42
Sassafras albidum	3	40.7	0.6	40-41

Table 10. Structure of the east aspen stand. Densities are expressed per 1000 m^2. The size of the study plot is 680 m^2.

Species	Less than 2.5 cm dbh: Less than 30 cm tall	Less than 2.5 cm dbh: More than 30 cm tall	More than 2.5 cm dbh: 2.5-10 cm	More than 2.5 cm dbh: 10-25 cm	More than 2.5 cm dbh: > 25 cm
Acer rubrum	346	231	153.8	2.9	0
Betula lutea	0	0	0	5.9	0
Cornus florida	500	269	76.9	0	0
Carya ovalis	38	0	0	0	0
Hamamelis virginiana	154	115	92.3	0	0
Pinus strobus	0	0	19.2	4.4	0
Populus grandidentata	0	0	23.1	51.5	2.9
Prunus serotina	923	154	0	5.9	0
Quercus alba	0	38	3.8	1.5	0
Q. rubra	0	0	7.7	0	0
Q. velutina	38	0	7.7	1.5	0
Sassafras albidum	38	154	11.5	2.9	0
Totals	2037	961	396.0	76.5	2.9

Table 11. Relative density and relative dominance values for the understory and overstory species of the east aspen area.

Species	2.5-10.0 cm dbh Rel. Den.	2.5-10.0 cm dbh Rel. Dom.	2.5-10.0 cm dbh Rel. Den. + Rel. Dom.	> 10.0 cm dbh Rel. Den.	> 10.0 cm dbh Rel. Dom.	> 10.0 cm dbh Rel. Den. + Rel. Dom.
Acer rubrum	38.5	41.2	79.7	3.7	2.5	6.2
Betula lutea				7.4	6.7	14.1
Cornus florida	19.2	19.3	38.5			
Hamamelis virginiana	23.0	14.7	37.7			
Pinus strobus	4.8	6.4	11.2	5.6	3.6	9.2
Populus grandidentata	5.8	7.9	13.7	68.6	74.6	143.2
Prunus serotina				7.4	7.1	14.5
Quercus alba	1.0	1.1	2.1	1.8	2.0	3.8
Q. rubra	1.9	1.2	3.1			
Q. velutina	2.9	4.5	7.4	1.8	1.2	3.0
Sassafras albidum	2.9	3.7	6.6	3.7	2.3	6.0

Table 12. Summary of the ages of the overstory trees in the east aspen area.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Acer rubrum	2	17.5	0.7	17-18
Betula lutea	3	17.7	6.3	11-21
Pinus strobus	3	21.3	6.1	16-28
Populus grandidentata	18	19.7	6.3	10-26
Prunus serotina	4	22.8	2.2	20-25
Quercus alba	1	25.0		
Q. velutina	1	23.0		
Sassafras albidum	2	26.0	1.4	25-27

mean of 19.67 years. Five species, white pine, black cherry, white oak, black oak, and sassafras, have mean ages greater than large-toothed aspen but their maximum ages are similar to that of large-toothed aspen.

West Oak Area

The west oak stand is located in the west central part of the study area (Fig. 2, page 9). The summary of the vegetation data of this area is given in Table 13 (page 30). Relative densities and dominances are found in Table 14 (page 31). This stand is dominated by black oak. The largest black oak is a 81.25 cm dbh, open grown tree located in the center of the stand. No other species approaches black oak in terms of density or dominance.

Flowering dogwood is very predominant in the understory comprising 84 per cent of the individuals in this layer. Among the potential overstory trees in the understory, black oak and white oak are of about equal importance. Flowering dogwood is also the predominant species in the seedling class. It is followed by black cherry, white oak, and witch hazel.

Small shrubs and vines observed in the west oak stand were Virginia creeper, dewberry, maple-leaved viburnum, prickly ash, common greenbrier (*Smilax rotundifolia*), and hawthorn (*Crataegus* sp.). As with the east aspen area, very little herbaceous vegetation is present with only false Solomon's seal and wild lily of the valley being observed.

Table 13. Structure of the west oak stand. Densities are expressed per 1000 m^2. The size of the study plot is 2920 m^2.

Species	Less than 2.5 cm dbh		More than 2.5 cm dbh		
	Less than 30 cm tall	More than 30 cm tall	2.5-10 cm	10-25 cm	> 25 cm
Acer rubrum	93	56	3.7	0.7	0
Cornus florida	630	926	155.6	0	0
Carya ovalis	18	0	0	0	0
Fagus grandifolia	0	0	0	1.0	0
Hamamelis virginiana	222	74	7.4	0	0
Juglans nigra	0	0	0	0.3	0
Nyssa sylvatica	0	0	0	0.3	0
Pinus strobus	0	37	0	0	0
Prunus serotina	389	130	0	1.4	0
Quercus alba	296	56	11.1	1.4	0.3
Q. rubra	0	0	0	0	0.7
Q. velutina	18	0	7.4	18.8	17.8
Sassafras albidum	18	37	0	0.3	0
Totals	1684	1316	185.2	24.2	18.8

Table 14. Relative density and relative dominance values for the understory and overstory species of the west oak area.

Species	2.5-10.0 cm dbh			> 10.0 cm dbh		
	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.
Acer rubrum	2.0	0.7	2.7	1.6	1.1	2.7
Cornus florida	84.0	86.8	170.8			
Fagus grandifolia				2.4	1.3	3.7
Hamamelis virginiana	4.0	1.4	5.4			
Juglans nigra				0.8	0.5	1.3
Nyssa sylvatica				0.8	0.6	1.4
Prunus serotina				3.2	1.8	5.0
Quercus alba	6.0	4.5	10.5	4.0	4.2	8.2
Q. rubra				1.6	0.5	2.1
Q. velutina	4.0	6.6	10.6	84.8	89.8	174.6
Sassafras albidum				0.8	0.2	1.0

The tree age summary of the west oak stand is found in Table 15 (page 33). There is little difference in the ages of the various tree species; most of mean ages fall between 38 and 43 years.

East Oak Area

The east oak stand is located in the northeast part of the study area (Fig. 2, page 9). The data for tree vegetation of this stand are summarized in Table 16 (page 34) with the relative density and dominance values given in Table 17 (page 35). This stand contains the largest diversity of tree species of any of the stands. This stand, unlike the west oak stand, is dominated by red oak (*Quercus rubra*). Like the west oak stand this area also contains a large, centrally located, open grown tree, a 70.1 cm dbh red oak. Black oak is second to red oak in terms of density and dominance.

Understory shrubs although common in this area are less abundant than in the west oak area. Among the potential overstory species in the understory, pignut hickory (*Carya ovalis*) and red oak are the most abundant. Red maple is the most abundant species in the seedling class. It is followed closely by red oak.

Among the small shrubs and vines present on the area are common blackberry, maple-leaved viburnum, red raspberry (*Rubus strigosus*), Virginia creeper, common greenbrier, and grape. Only two herbaceous plants, wild lily of the valley and Solomon's seal, are present in noticeable numbers.

The mean ages of the trees present in the east oak area range from 30 to 49 years (Table 18, page 36). The mean ages of the four

Table 15. Summary of the ages of the overstory trees in the west oak area.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Acer rubrum	1	48.0		
Fagus grandifolia	3	38.0	6.2	28-45
Juglans nigra	1	39.0		
Nyssa sylvatica	1	43.0		
Prunus serotina	4	34.8	6.8	27-43
Quercus alba	5	42.2	17.3	31-71
Q. rubra	2	36.5	2.1	35-38
Q. velutina	24	38.6	2.8	32-44
Sassafras albidum	1	35.0		

Table 16. Structure of the east oak stand. Densities are expressed per 1000 m^2. The size of the study plot is 2550 m^2.

	Less than 2.5 cm dbh		More than 2.5 cm dbh		
Species	Less than 30 cm tall	More than 30 cm tall	2.5–10 cm	10–25 cm	> 25 cm
Acer rubrum	750	250	5.0	2.0	0.8
Betula lutea	0	0	0	1.2	0
Cornus florida	50	25	20.0	0	0
Carya ovalis	50	50	20.0	4.3	0.4
Fagus grandifolia	0	25	0	0.4	0
Hamamelis virginiana	50	0	30.0	0	0
Nyssa sylvatica	0	0	0	0.4	0.4
Pinus strobus	0	0	2.5	0	0
Prunus serotina	350	25	2.5	1.2	0
Quercus alba	0	0	0	0.4	0
Q. rubra	700	50	12.5	20.4	7.1
Q. velutina	75	0	0	3.5	4.7
Sassafras albidum	450	225	10.0	3.9	0
Ulmus rubra	0	0	0	0.8	0
Totals	2477	650	102.5	38.5	13.4

Table 17. Relative density and relative dominance values for the understory and overstory species of the east aspen area.

Species	2.5-10.0 cm dbh			> 10.0 cm dbh		
	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.
Acer rubrum	5.0	1.9	6.9	5.3	5.7	11.0
Betula lutea				2.3	2.4	4.7
Cornus florida	20.0	13.7	33.7			
Carya ovalis	20.0	30.0	50.0	9.1	5.0	14.1
Fagus grandifolia				0.8	0.3	1.1
Hamamelis virginiana	27.5	22.1	49.6			
Nyssa sylvatica				1.5	1.1	2.6
Pinus strobus	2.5	1.1	3.6			
Prunus serotina	2.5	1.7	4.2	2.3	1.3	3.6
Quercus alba				0.8	0.2	1.0
Q. rubra	12.5	24.4	36.9	53.0	52.8	105.8
Q. velutina				15.8	26.6	42.4
Sassafras albidum	10.0	5.1	15.1	7.6	4.1	11.7
Ulmus rubra				1.5	0.5	2.0

Table 18. Summary of the ages of the overstory trees in the east oak area.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Acer rubrum	2	42.5	2.1	41-44
Betula lutea	2	37.5	0.7	37-38
Carya ovalis	12	42.1	4.0	34-48
Fagus grandifolia	1	49.0		
Nyssa sylvatica	2	36.0	15.7	25-47
Prunus serotina	3	44.0	1.0	43-45
Quercus alba	1	30.0		
Q. rubra	24	39.1	3.0	31-44
Q. velutina	13	41.8	5.4	34-51
Sassafras albidum	10	43.8	4.0	35-49
Ulmus rubra	2	46.0	1.4	45-47

most abundant species, red oak, black oak, pignut hickory, and sassafras, range from 39.1 to 43.8 years.

West Hardwood-Pine Area

The west hardwood-pine stand is located in the north central part of the study area (Fig. 2, page 9). In Table 19 (page 38) is a summary of the tree vegetation of this area. Relative densities and dominances are given in Table 20 (page 39). Sassafras is the most abundant species in this stand; however, it is surpassed in dominance by white pine, white oak, and black oak.

Understory shrubs, flowering dogwood and witch hazel, are again very common in the understory. White pine and white oak are the most abundant potential overstory species in this layer. Red maple is the most abundant species in the seedling class. It is followed by flowering dogwood and black cherry.

This stand is second only to the old field in herbaceous vegetation. Herbaceous species observed were sweet cicely, Solomon's seal, false Solomon's seal, and wild lily of the valley. Virginia creeper and partridge berry (*Mitchella repens*) are also found in this area.

Tree ages for this area are summarized in Table 21 (page 40). In this area there is a large range in the mean ages of species, 29.7 to 47 years. There is also a large range in the ages of some individual species with red maple ranging from 14 to 52 years and white pine ranging from 15 to 64 years.

Table 19. Structure of the west hardwood-pine stand. Densities are expressed per 1000 m^2. The size of the study plot is 1280 m^2.

Species	Less than 2.5 cm dbh: Less than 30 cm tall	Less than 2.5 cm dbh: More than 30 cm tall	More than 2.5 cm dbh: 2.5-10 cm	More than 2.5 cm dbh: 10-25 cm	More than 2.5 cm dbh: > 25 cm
Acer rubrum	1292	731	7.7	0.8	1.6
Cornus florida	269	1154	73.1	0	0
Fagus grandifolia	0	38	0	0.8	0
Hamamelis virginiana	192	231	15.4	0	0
Pinus strobus	0	77	19.2	8.6	3.9
Prunus serotina	923	115	0	0	0.8
Pyrus malus	0	0	0	0.8	0
Quercus alba	346	192	11.5	0.8	1.6
Q. rubra	0	38	0	0	0.8
Q. velutina	38	0	0	1.6	2.3
Sassafras albidum	385	231	7.7	14.8	0
Totals	3445	2807	134.6	28.2	11.0

Table 20. Relative density and relative dominance values for the understory and overstory species of the west hardwood-pine area.

	2.5-10.0 cm dbh			> 10.0 cm dbh		
Species	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.	Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.
Acer rubrum	5.7	3.5	9.2	6.0	3.0	9.0
Cornus florida	54.3	52.8	107.1			
Fagus grandifolia				2.0	1.8	3.8
Hamamelis virginiana	11.4	4.5	15.9			
Pinus strobus	14.3	15.6	29.9	32.0	34.0	66.0
Prunus serotina				2.0	3.3	5.3
Pyrus malus				2.0	0.7	2.7
Quercus alba	8.6	10.6	19.2	6.0	25.9	31.9
Q. rubra				2.0	3.3	5.3
Q. velutina				10.0	15.0	25.0
Sassafras albidum	5.7	13.0	18.7	38.0	13.0	51.0

Table 21. Summary of the ages of the overstory trees in the west hardwood-pine area.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Acer rubrum	3	34.7	19.2	14-52
Fagus grandifolia	1	47.0		
Pinus strobus	13	29.7	13.2	15-64
Prunus serotina	1	40.0		
Pyrus malus	1	30.0		
Quercus alba	3	32.3	5.7	29-39
Q. rubra	1	36.0		
Q. velutina	4	31.2	2.1	29-33
Sassafras albidum	14	36.6	4.5	32-46

East Hardwood-Pine Area

The east hardwood-pine stand is located in the north central part of the study area (Fig. 2, page 9). The tree vegetation data of this stand are summarized in Table 22 (page 42) with relative densities and dominances given in Table 23 (page 43). American beech is the most important tree in this stand. It is followed very closely in terms of dominance by white pine. Quaking aspen (*Populus tremuloides*) is second to American beech in terms of density. The density of dead aspens in this stand is 3.3 per 1000 m^2.

In the understory, witch hazel and flowering dogwood are again most abundant. Important potential overstory trees in this layer are white pine and red oak. There is a very large number of seedlings in this stand; most of these seedlings are red maples. Black cherry seedlings are also very abundant.

Small woody species present in this area are Virginia creeper, grape, partridge berry, and common greenbrier. Only one herbaceous species, wild lily of the valley, was noted on the area; it was, however, quite abundant.

The tree ages are summarized in Table 24 (page 44). The mean ages of American beech, black cherry, and black oak are very similar, ranging from 37.2 to 39.8 years. White oak has a lower mean age, 31.25 years, and a much larger range, 20 to 63 years. Quaking aspen is the youngest species in the stand with a mean age of 24.7 years.

Table 22. Structure of the east hardwood-pine stand. Densities are expressed per 1000 m^2. The size of the study plot is 910 m^2.

Species	Less than 2.5 cm dbh		More than 2.5 cm dbh		
	Less than 30 cm tall	More than 30 cm tall	2.5–10 cm	10–25 cm	> 25 cm
Acer rubrum	9500	700	2.5	0	0
Betula lutea	0	0	0	1.1	0
Cornus florida	300	275	65.0	0	0
Carya ovalis	25	25	0	0	0
Fagus grandifolia	0	25	0	13.2	4.4
Hamamelis virginiana	450	150	87.5	0	0
Nyssa sylvatica	0	0	5.0	0	0
Pinus strobus	25	200	37.5	2.2	2.2
Populus tremuloides	25	0	0	7.7	0
Prunus serotina	2700	75	0	4.4	1.1
Quercus alba	25	0	2.5	0	1.1
Q. rubra	150	50	20.0	0	0
Q. velutina	125	0	0	3.3	2.2
Sassafras albidum	50	75	10.0	0	0
Totals	13375	1575	230.0	31.9	11.0

Table 23. Relative density and relative dominance values for the understory and overstory species of the east hardwood-pine area.

Species	2.5-10.0 cm dbh Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.	> 10.0 cm dbh Rel. Den.	Rel. Dom.	Rel. Den. + Rel. Dom.
Acer rubrum	1.1	0.3	1.4			
Betula lutea				2.6	0.6	3.2
Cornus florida	28.2	45.8	74.0			
Fagus grandifolia				41.0	30.5	71.5
Hamamelis virginiana	38.0	24.8	62.8			
Nyssa sylvatica	2.2	3.3	5.5			
Pinus strobus	16.4	13.8	30.2	10.3	30.1	40.4
Populus tremuloides				17.9	7.2	25.1
Prunus serotina				12.8	8.4	21.2
Quercus alba	1.1	0.5	1.6	2.6	4.1	6.7
Q. rubra	8.7	6.6	15.3			
Q. velutina				12.8	19.1	31.9
Sassafras albidum	4.3	4.9	9.2			

Table 24. Summary of the ages of the overstory trees in the east hardwood-pine area.

Species	No. of Trees	Mean Age	Std. Dev.	Range
Betula lutea	1	31.0		
Fagus grandifolia	6	39.8	3.3	35-44
Pinus strobus	4	31.2	23.5	20-63
Populus tremuloides	7	24.7	4.6	18-31
Prunus serotina	4	39.2	4.3	35-45
Quercus alba	1	43.0		
Q. velutina	5	37.2	8.9	22-45

Environmental Factors

Light Intensity

The light intensity data for the eight stands are summarized in Table 25 (page 46). As would be expected, the highest light intensities were recorded from the old field. The light intensities of the other seven areas are similar, ranging from 2.2 to 4.3 per cent of full sunlight.

Soil pH

A summary of the soil pH data is found in Table 26 (page 47). There is a significant difference ($p = .05$) in the pH values of the upper soil samples (15-30 cm) of the various stands. A pairwise comparison reveals that the sassafras stand has a significantly higher pH ($p = .05$) than the other stands. The west hardwood-pine stand also has a significantly higher pH than the east hardwood-pine stand.

There is also a significant difference ($p = .05$) in the pH values of the lower soil samples (45-60 cm). A pairwise comparison shows that both the sassafras and the east oak stands have significantly higher pH values ($p = .05$) than the other six stands.

Soil Texture

The soil texture data are summarized in Table 27 (pages 48, 49). In terms of percent sand in the upper soils, there is a significant difference ($p = .05$) among the various stands. Based on the pairwise comparisons, the upper soils of the sassafras and east oak areas are

Table 25. Light intensities recorded from the eight study plots in August 1973 and expressed as a percentage of full sunlight.

Area	Mean	Std. Dev.	Range
Old Field	61.5	40.5	3.8-100.0
Sassafras	2.2	2.6	0.1- 8.8
West Aspen	4.3	3.3	1.3- 14.7
East Aspen	2.2	3.0	0.6- 11.9
West Oak	4.2	2.9	1.2- 13.2
East Oak	3.4	2.2	1.3- 10.1
West Hardwood-Pine	2.5	1.7	1.2- 7.4
East Hardwood-Pine	3.3	2.3	1.0- 8.4

Table 26. Summary of the soil pH data collected from the eight study plots.

Area	Sample Size	Upper Sample			Lower Sample		
		Mean	Std. Dev.	Range	Mean	Std. Dev.	Range
Old Field	3	5.3	0.1	5.2-5.4	5.2	0.2	5.0-5.4
Sassafras	5	6.4	0.4	5.8-6.6	6.2	0.5	5.6-6.6
West Aspen	5	5.3	0.2	5.0-5.6	5.3	0.2	5.2-5.6
East Aspen	4	5.2	0.0	5.2-5.2	5.3	0.1	5.2-5.4
West Oak	5	5.2	0.1	5.2-5.4	5.2	0.1	5.0-5.4
East Oak	6	5.2	0.3	5.0-5.6	5.9	0.6	5.4-6.6
West Hardwood-Pine	5	5.4	0.2	5.2-5.6	5.3	0.2	5.2-5.6
East Hardwood-Pine	4	5.1	0.1	5.0-5.2	5.4	0.2	5.2-5.6

Table 27. Summary of the soil texture data of the eight study plots. Soil texture is expressed as the percentage of different size particles.

Area	Particle[1] Size	Sample Size	Upper Sample Mean	Upper Sample Std. Dev.	Upper Sample Range	Lower Sample Mean	Lower Sample Std. Dev.	Lower Sample Range
Old Field	Sand	3	81.7	4.0	78.2-86.0	84.2	5.8	77.7-88.8
	Silt	3	12.7	4.5	8.6-17.5	9.1	3.2	6.7-12.7
	Clay	3	5.6	1.4	4.3- 7.0	6.7	2.6	4.5- 9.6
Sassafras	Sand	5	85.7	3.2	82.2-90.5	88.6	2.2	86.1-91.9
	Silt	5	7.4	2.1	4.2- 9.4	6.7	1.3	4.1- 7.4
	Clay	5	6.9	1.1	5.3- 8.4	5.4	1.3	4.0- 6.5
West Aspen	Sand	5	80.9	3.8	77.3-85.7	82.0	2.2	79.6-84.2
	Silt	5	11.5	3.8	6.7-14.6	11.2	1.4	8.9-12.8
	Clay	5	7.6	0.8	6.2- 8.3	6.8	1.4	5.8- 8.7
East Aspen	Sand	4	77.1	7.0	70.9-83.8	75.3	11.4	68.4-88.4
	Silt	4	14.2	4.0	11.6-17.8	14.9	7.9	5.8-20.2
	Clay	4	8.7	3.0	5.8-11.6	9.8	3.5	5.8-12.2

[1] Sand = 2.0-0.05 mm, silt = 0.05-0.002 mm, clay = < 0.002 mm.

(con't)

Table 27. Continued.

Area	Particle Size	Sample Size	Upper Sample			Lower Sample		
			Mean	Std. Dev.	Range	Mean	Std. Dev.	Range
West Oak	Sand	5	76.3	2.1	74.5-79.8	76.3	3.7	71.7-81.0
	Silt	5	14.6	2.2	11.0-17.0	15.7	3.2	12.0-20.2
	Clay	5	9.1	1.1	8.0-10.6	8.1	1.4	5.7- 9.1
East Oak	Sand	6	86.7	3.3	84.6-93.5	85.7	4.0	80.8-92.8
	Silt	6	6.9	2.2	2.8- 8.9	7.4	2.3	3.1- 9.1
	Clay	6	6.4	1.5	3.7- 8.1	6.8	2.0	4.1-10.1
West Hardwood-Pine	Sand	5	75.9	0.6	75.2-76.8	77.2	2.7	74.7-81.2
	Silt	5	14.7	1.6	13.3-16.7	14.5	1.9	13.2-17.7
	Clay	5	9.4	1.8	8.1-11.3	8.2	2.2	5.6-11.7
East Hardwood-Pine	Sand	4	77.2	4.0	74.5-83.1	78.8	4.8	73.7-85.2
	Silt	4	13.9	4.5	7.4-17.8	13.1	4.7	7.4-18.9
	Clay	4	8.9	1.9	6.2-10.8	8.0	0.8	7.4- 9.2

significantly more sandy ($p = .05$) than the east aspen, west oak, west hardwood-pine, and east hardwood-pine areas. The east oak area is also significantly more sandy than the west aspen area. The upper soils of the west hardwood-pine stand in addition to being significantly less sandy than the sassafras and east oak stands are also significantly less sandy than the old field and west aspen stands.

The lower soil samples of the various stands are different ($p = .05$) in terms of percent sand. Pairwise comparisons show that the lower soil samples of the east oak and sassafras areas are significantly more sandy ($p = .05$) than the east aspen, west oak, west hardwood-pine, and east hardwood-pine areas with the sassafras area also being significantly more sandy than the west aspen area. The old field lower soils are also significantly more sandy than the east aspen, west oak, and west hardwood-pine areas.

Slope Angle

The slope angle data are summarized in Table 28 (page 51). Of the eight stands sassafras is found on the steepest slope. Intermediate slopes are found in the east hardwood-pine, east oak, west oak, and west aspen areas. The least amount of slope is found in the old field, east aspen, and west hardwood-pine areas.

Exposure

Three of the stands, west oak, east oak, and sassafras, have a west exposure. Both the east and west hardwood-pine areas have a east-

Table 28. Amount of slope, expressed in degrees, found on the eight study plots.

Area	Mean	Std. Dev.	Range
Old Field	6.1	3.4	2-12
Sassafras	18.2	4.9	11-24
West Aspen	13.0	5.0	3-19
East Aspen	8.3	4.4	0-14
West Oak	11.9	4.6	0-18
East Oak	15.4	5.7	7-25
West Hardwood-Pine	6.9	4.3	2-14
East Hardwood-Pine	14.6	5.9	7-28

northeasterly exposure. The other three stands, east aspen, west aspen, and old field, have a northern exposure.

Aerial Photographs

Aerial Photographs of 1938

According to the 1938 aerial photographs the old field and east aspen areas were under agriculture during 1938. There is no evidence of trees or shrubs in either of these areas at that time. About all that can be said about the sassafras area due to the poor quality of the 1938 photographs is that it was not under agriculture at this time. Some small trees or shrubs appear to be present on the area.

The west oak, east oak, west aspen, and west hardwood-pine areas appear basically similar on the 1938 aerial photographs. All of these areas were largely open with some small to medium sized trees and shrubs. The east and west oak areas also had a few larger trees. Crown closure on these four areas was about 20 to 25 per cent.

The east hardwood-pine area had a greater number of trees and shrubs in 1938 than the other areas. Crown closure on this area appears to be about 50 per cent but little can be determined about the size of the vegetation because of the poor quality of the photographs.

Aerial Photographs of 1950

By 1950 the old field and the east aspen areas were no longer under agriculture. In the old field small trees and shrubs were scattered throughout the field. Crown closure was about 5 per cent.

At this time the east aspen stand is evident as a small dense stand. The total size of this stand appears smaller than it is at the present time. Trees can be clearly seen in the sassafras area on the 1950 photographs. Crown closure appears to be about 65 per cent on this area.

On the west oak, east oak, west aspen, and west hardwood-pine areas there was a considerable increase in the number and size of the trees by 1950. In the west aspen area crown closure had increased to about 65 per cent. On the other three areas crown closure had increased to 50 to 55 per cent. On the east hardwood-pine area the change from 1938 to 1950 was not as noticeable. Crown closure had increased to 60 to 65 per cent.

Aerial Photographs of 1955, 1960, and 1967

From 1950 to 1967 there were no major changes on any of the areas. In the old field there was an increase in number and size of the shrubs with crown closure increasing to 25 per cent by 1967. In the east aspen area there was an apparent increase in the size of the stand during this period. There was also an increase in the size of the tree crowns during this period.

For the other six stands the only noticeable change was an increase in crown closure. By 1967 crown closures had reached 90 per cent in the sassafras, west aspen, west oak, and east oak areas. The crown closure appeared to be about 80 per cent in the west and east hardwood-pine areas by 1967.

DISCUSSION

Stand Ages

When the maximum ages of the various species in the study areas are considered, there appear to be two distinct periods when the areas were released from some factor which was inhibiting the establishment or growth of tree species. For two of the areas, the old field and east aspen, the factor which was inhibiting tree species was agriculture. The 1938 aerial photographs reveal that both of these areas were under agriculture and part of the same field at this time. This field had definitely been abandoned by the time the 1950 aerial photographs were taken. The maximum tree ages in the old field are between 25 to 27 years (Table 3, page 17) and the maximum tree ages in the east aspen are also between 25 and 27 years (Table 12, page 28). This would seem to place the date of abandonment of this field from agriculture somewhere in the early 1940's.

It must be remembered, however, that when cores samples are taken some distance above ground level as they were in this study (45 cm), tree ages will generally be underestimated (Studhatter et al. 1963). Henry and Swan (1974) found on the basis of tree core samples taken at 23 cm and at ground level that beech tree ages were underestimated by an average of 5 years and red maple ages by an average of 3 years. It is therefore apparent that the tree ages reported in this study are underestimates. The amount by which they are underestimated

is probably related to species of the tree and environmental conditions at the site.

The trees of the other six areas are older than those in the old field and east aspen stand. None of the trees cored in the sassafras area appear to have been present before approximately 1930 (Table 6, page 21). The situation is very similar in the west aspen stand where, with the exception of one older white oak, all the species have maximum ages between 38 and 42 years (Table 9, page 25). This would indicate that in the west aspen area essentially none of the present trees were established before approximately 1930.

A similar trend exists with the other four areas; however, they tend to be a little older than the two areas just mentioned. In the west oak area there are two old trees, a 71 year old white oak and a 81.25 cm dbh black oak which was not aged. Excluding these two trees the maximum ages of six of the species found on this area are between 43 and 46 years (Table 15, page 33). This would indicate that before the mid-1920's only a few of the existing trees were present. In the west hardwood-pine area it also appears that before the mid-1920's only a couple of the existing trees had become established (Table 21, page 40). This situation is again similar in the east hardwood-pine area where there is one older white pine and then a number of species with maximum ages of 43 to 45 years (Table 24, page 44).

The east oak area trees appear to be slightly older than those on the three areas just mentioned. The maximum ages of almost all the species range between 38 and 51 years (Table 18, page 36). This

indicates that some of the trees on this area may have been established by the early 1920's.

These six stands can not be considered even aged stands since there is always a relatively large range of ages. However, the similarity of maximum ages of species within and among these six areas would seem to indicate that something happened in the period 1920 to 1930 which suddenly allowed trees to become established on these areas.

One possible release factor which could explain the situation just described is that the areas were cut over in the early 1920's. This would be consistent with the presence of multiple trunk oaks in areas such as the east oak stand. If these areas were cut over this recently, however, one would expect to see more old stumps and other evidence of the cutting. If the areas were cut then burned it would be difficult to explain how the few older oaks and white pines escaped the fire. Another possible explanation would be that the areas were under agriculture until the early 1920's. Again it would be hard to explain the few older trees which would have most likely been removed during agriculture. In addition, the slopes on some of these areas would have made them poor choices for agriculture.

A third possibility is that the areas were grazed until the early 1920's. Light to moderate grazing might have allowed an occasional tree to become established but would have prevented any large scale establishment of woody species. This possibility would be consistent with the remnants of old fences in some areas.

Differences in Present Condition

Old Field

The old field is different from the other areas studied in many ways. This area has the lowest density of trees and the least amount of canopy coverage. In addition, no other area is dominated by black cherry to the extent that the old field is. These differences appear to be at least partially related to the differences in disturbance history. None of the other areas with the exception of the east aspen area appear to have been disturbed as recently as the old field. In addition, none of the areas, again with the exception of the east aspen area, may have ever been under agriculture.

The dominance of black cherry in this area (Table 2, page 15) is not surprising considering its ability to dominate secondary succession (Fowells 1965). Bard's (1952) study of old field succession in the Piedmont of New Jersey reports a density of only 3 black cherries per 2500 m^2 at 40 years after abandonment. Bazzaz (1968) reported a density of black cherry of 0.25 per acre on 25 year old fields with no black cherries being observed in the 40 year old fields. The differences in abundance of black cherry in the old field of this study and some of those reported in the literature may be related to a difference in available seed source which some authors consider to be an important factor in old field succession (Ashby and Weaver 1970).

The high importance of sassafras (Table 2, page 15) is not surprising either considering its ability to restock abandoned farmland by root sprouting (Fowells 1965, Bazzaz 1968, Duncan 1935). White

pine which is also present on this area is also able to function as a pioneer species in secondary succession (Fowells 1965).

Sassafras Area

This area is unique among the areas studied in terms of the density of sassafras (Table 4, page 18). This area does differ significantly from many of the other areas in terms of soil pH (Table 26, page 47) and soil texture (Table 27, pages 48, 49). However, since most of the species found on the various study areas can grow under a variety of soil pH and soil texture conditions, it seems rather unlikely that these soil differences have been a major factor in the high density of sassafras on this area. This seems especially true considering that the east oak area has soil pH and soil texture conditions similar to the sassafras community, yet has a very different vegetation.

Duncan (1935) and Bazzaz (1968) report that dense stands of sassafras often arise on abandoned agricultural fields. Sassafras is a common fence row species in some areas and pieces of roots often are severed and scattered during plowing and disking. These pieces of root have the ability to send up sprouts. Dense stands of sassafras can arise in this way after a field is abandoned. Whether this is the way the sassafras area developed is not known; however, this would seem to be a logical possibility.

West Aspen Area

The west aspen area is heavily dominated by large-toothed aspen, but the surrounding areas are not. This peculiar situation could have developed in one of several ways. One possibility is that a previous aspen stand or even a few aspen trees occupied this area earlier and were destroyed with a resulting sucker stand developing. Another possibility is that a few aspen seedlings became established, and since aspens are able to produce suckers at a very early age (Andrejak and Barnes 1969), a stand developed with a few trees of seedling origin and many other trees of sucker origin. A third possibility is that some disturbance occurred on this area resulting in the exposure of bare mineral soil and a seedling stand developed. The presence of charred stumps on this area indicates that this area was burned at one time. This would have resulted in the exposure of a mineral soil seedbed for aspen seedlings. However, charred stumps also occur in surrounding areas which again makes it difficult to explain why this area developed into aspen and the surrounding areas did not. In addition, it is not possible to determine whether this area burned at the time this aspen stand developed or whether it burned many years before.

In the spring of 1973 aspen trees on this area were noted leafing out at different times suggesting the presence of at least several different aspen clones. This would, however, be consistent with any of the three suggested development patterns. With the evidence presently available it is not possible to state just how

this stand developed nor why it is different from the surrounding areas.

East Aspen Area

Since the east aspen area appears to have had the same disturbance history as the old field area, the question arises as to why these areas are presently so different in terms of vegetation. These areas have a similar soil pH (Table 26, page 47), exposure, and slope (Table 28, page 51). The lower soil of the old field area (Table 27, page 48) is coarser than that of the east aspen; however, this should not have inhibited large-toothed aspen establishment. The old field area apparently is suitable for aspen seedling establishment since several 1 m high aspens were observed on recently disturbed soil in the old field at least 50 m from any other aspens.

Andrejak and Barnes (1969) reported a seedling population of aspens developing in an abandoned field in southeastern Michigan. The population of seedling aspens which they described had no aspen trees adjacent to it. The east aspen population did, however, have aspen present adjacent to it at the time of establishment.

The most logical explanation for the origin of the east aspen stand appears to be that it developed by suckers from trees on the border of the field. Both the presence of older adjacent aspens and the lack of aspens in the rest of the old field would seem to support this explanation.

West Oak Area

The west oak stand seems to be unique when compared to published accounts of oak stands in southern Michigan in that it is very highly dominated by black oaks. The oak stands in Allegan County, Michigan described by Brewer et al. (1973) contain a mixture of black oaks and white oaks with black oak dominating the larger size classes and white oak dominating the smaller tree classes. The oak forests of Haven Hill, Michigan are also dominated by white and black oaks (Thompson 1953). The oak stands on the Ott Preserve in Calhoun County described by Catana (1967) also contain mixtures of oak species with white and black oak dominating in one stand, white, black, and red oak being equally important in another stand, and black and red oak dominating in yet another stand.

The reason for the relatively high density of black oak in this stand may be related to seed source. The large, open grown, black oak in the center of this stand probably provided a large seed source in the early to mid-1920's. The large white oak is smaller and may not have been producing acorns at this time, at least not in very large numbers. It thus seems logical that available seed source may have been a factor in the present high density of black oaks on this area.

East Oak Area

The east oak stand is more similar to other oak stands described in the literature in terms of relative densities of the oak species (Table 17, page 35). Although red oak dominates this stand, it does

not dominate it to the extent that black oak dominates the west oak stand. The east oak stand contains in addition to the red oaks many black oaks and pignut hickories. Although oak stands dominated by red and black oaks appear from the literature to be less common than stands dominated by white and black oak, some do exist. One of the oak stands described by Catana (1967) was dominated by black and red oak with white oak being considerably less abundant. Larsen (1953) described an oak woods in southern Wisconsin being invaded by red maple in which black and red oak dominated.

The dominance of the east oak area by red oak and the dominance of the west oak area by black oak seems to be inconsistent with certain physical differences between these two areas. The soils of the east oak area are significantly more sandy than the soils of the west oak area (Table 27, page 49). In addition, the slope is greater in the east oak area (Table 28, page 51). Both of these factors would suggest that there is less available moisture in the east oak area. Red oak, however, is a more mesic species than black oak (Curtis 1971, Colvin and Eisenmenger 1943).

The dominance of red oak in this stand may be related to a seed source factor. Near the center of the stand is a large, open grown, red oak which was probably producing seed in the early to mid-1920's. This could have resulted in a large red oak seed supply and subsequently, the dominance of red oak in the present stand.

West Hardwood-Pine Area

The west hardwood-pine area appears to have a rather unique vegetational composition (Table 19, page 38) when compared both with the other areas on this property and with the published literature on plant communities in southern Michigan. One of the five upland vegetation societies of Kent County, Michigan described by Livingston (1903) was an oak-pine-sassafras society. This vegetation type may be somewhat similar to what is growing on the west hardwood-pine area. Livingston described this type as growing on the driest sites and on areas once covered with pine.

In comparison with the other areas studied, the west hardwood-pine area would appear to be a relatively mesic area. The soil texture is less coarse than most of the other areas (Table 27, pages 48, 49). The amount of slope on this area is among the least (Table 28, page 51) and the exposure is east-northeast. In spite of these facts, the vegetation does not appear to be more mesic than that of the other areas.

There appears to be no explanation why this area is so different from the other areas in terms of vegetation. A difference in seed source is certainly possible but there is no obvious evidence of it.

East Hardwood-Pine Area

Like the west hardwood-pine area the east hardwood-pine area appears unique. The two most abundant species (Table 23, page 43) include the most shade intolerant tree on the property, quaking aspen,

and the most shade tolerant tree on the property, American beech. The situation is complicated further by the fact that the quaking aspen trees are younger than the beech trees. It is possible that the aspens are the remnants of an older stand of quaking aspen. The presence of a number of dead aspens would tend to support this.

No mention was found in the literature of communities with vegetational compositions similar to the east hardwood-pine area. Bingham (1945) mentions pine-hardwood forests occurring in Oakland County, Michigan; however, the hardwood species present were quite different from those found in this area.

The number of beech trees present on this site would suggest that this area is more mesic than the other study areas. The soil texture on this site is less coarse than some of the other sites (Table 27, page 48, 49) and the east-northeast slope would be more favorable in terms of moisture than either of the oak areas or the sassafras area. These factors would suggest that the east hardwood-pine site might be more mesic than some of the other sites.

Seed source may have been a factor in the vegetational development of this area. This area is very close to the mature beech stand (Fig. 2, page 9) which means that a good beech seed source may have been available. The moderate number of oaks may be related to the fact that there is no evidence of nearby oak trees that would have been producing seed 40 to 50 years ago.

On both the east and west hardwood-pine areas the age structure of white pines is similar to the condition mentioned by Brewer et al. (1973) for the white pines in Allegan County, Michigan. They did not

work directly with tree ages in their study; however, they found, "...some large trees, few or no middle size trees, and on most areas a fair number of small trees." A similar situation was observed in this study; there were a few white pine trees 60+ years old (Tables 21, 24, pages 40, 44), very few white pines down to age 30, and white pines age 15 to 30 years were rather numerous. The lack of pines 45 to 60 years old is not unexpected since there are no other species with trees in this interval either. However, other trees are fairly numerous in the age interval 30 to 45 years. Brewer et al. (1973) mention the following three possible explanations for the white pine size distribution they found: "(1) poor success of trees of intermediate age ... (2) the recent arrival of pines at seed-producing age; and (3) a recently terminated period of conditions unfavorable to white pine reproduction or growth." One or a combination of these factors have probably influenced white pine size and age distribution in this study area also.

Future Successional Trends

Predicting Succession

Braun (1950) states that "... perpetuation of the existing type is indicated by the essential accordance of canopy and understory layers.... Lack of accordance of canopy and understory is always indicative of change, of development, or succession." She also states that the lower vegetation layers are less significant since many individuals will be eliminated by competition. Jackson and Petty (1971)

suggest a similar method of obtaining successional information. They suggest comparing the relative importance of species in different size classes.

Both of these methods are based on the assumption that there is good correlation between size and age of all species. Whitford (1951) found that white oak was of relatively uniform size in any one age class; however, with black oak there was a high variation in size among even aged trees. Gates and Nichols (1930) point out that understory trees may appear youthful when in fact they are suppressed. On the basis of these facts it is apparent that caution must be used when one uses size class information to make inferences about succession.

Old Field

The low total density of trees (Table 1, page 14) and the relatively high light intensity (Table 25, page 46) would suggest that none of the species on this area are suffering from moisture or light competition except possibly where the vegetation is highly clumped. Black cherry which presently dominates the overstory is not represented as well as sassafras is in the understory (Table 2, page 15). This would suggest a future increase in the relative importance of sassafras at the expense of black cherry. The high density of sassafras in the understory and seedling classes is probably related to its root sprouting ability (Fowells 1965). Gant and Clebsch (1975) report that sassafras can maintain itself in the mature forest stage. They suggest that some alleopathic interference on surrounding

vegetation may be allowing it to maintain itself. If this is true one would expect sassafras to maintain itself in this area for a considerable period of time.

Considering the coarse soil on this area and the fact that oak or oak-hickory was the pre-settlement vegetation in this area, one would expect an eventual succession to oak or oak-hickory. At the present time there is no evidence of a trend toward oak in the near future. Potzger and Potzger (1950) point out that the invasion of oak and hickory during secondary succession may be delayed because squirrels are not attracted to the area. This could possibly account for the low abundance of oaks on this area. The presence of a few black oak trees on the area at the present time would suggest a good potential seed source once these trees begin producing abundant acorn crops.

In summary, it appears that sassafras will become increasingly important in the canopy in the near future with black oak possibly increasing in importance in the more distant future.

Sassafras Area

The extremely low light intensity (Table 25, page 46) in the sassafras area would suggest that all species in the understory and particularly the seedling classes are being suppressed because of lack of light. The density of sassafras in the understory and seedling classes (Table 4, page 18) is probably related to its root sprouting ability and possibly also to the alleopathic interference suggested by Gant and Clebsch (1975). Since sassafras does not attain a very

large size in Michigan (Smith 1952) and since it is an intolerant tree (Baker 1949), one would expect it to begin dying out soon after it is overtopped by taller trees. However, the low density of other tree species in both the understory and overstory of this area suggest that this will occur very slowly. Black oak and red maple would appear to be the species in the understory most likely to replace the sassafras.

Large-toothed aspen the second most important tree in this stand is a short-lived intolerant species (Smith 1952) and can be expected to begin dying out in the next 20 to 25 years. This could result in some gaps in the canopy. The high density of sassafras in the understory would suggest that it is the species most likely to replace the large-toothed aspen. This could further lengthen the amount of time that this area is dominated by sassafras.

In summary, it appears that the conversion of this area from sassafras to a more tolerant species such as oak or possibly red maple will be very slow unless some canopy disturbance occurs.

West Aspen Area

Large-toothed aspen which is presently the most important species on the area definitely appears to be dying out. Both the number of dead aspen trees, 10.8 per 1000 m^2, and the lack of large-toothed aspen in the understory and seedling classes support this.

The number of potential overstory trees in the understory is very low (Table 7, page 22). The low density of traditional aspen replacement species such as oaks and maples (Graham et al. 1963)

may be due to the high density of understory shrubs, witch hazel and particularly flowering dogwood. Curtis (1971) reports that shrubs can intercept a large fraction of the light that penetrates the canopy and thus have a profound effect on tree germination.

The species most likely to respond to the opening of the aspen overstory would be white pine, followed by white oak and black cherry. If the aspen canopy deteriorates rapidly, it may be some time before another full canopy develops due to the scarcity of replacement trees and the abundance of understory shrubs which will continue to hinder germination and growth of seedlings.

East Aspen Area

Large-toothed aspen, the most important tree in the overstory, does not appear to be reproducing well (Table 10, page 26). In contrast to the west aspen stand, however, the aspen canopy in this area could remain for a number of years. Graham et al. (1963) state that aspen stands may begin to deteriorate any time after 35 years, although some aspen stands remain healthy much longer than 35 years. This stand should thus remain healthy for another 10 years.

Potential replacement trees are much more common in the understory of this stand than in the west aspen stand. This is due particularly to the high density of red maple in the understory. Oaks are also more abundant in the understory of this stand. Oaks and red maple are the chief species invading aspen stands in northern Lower Michigan according to Graham et al. (1963). It, therefore, seems very likely that succession on this area will be from large-toothed

aspen to red maple with a mixture of oaks and possibly some white pine. The high number of more tolerant individuals in the understory might also suggest that the aspens may begin to deteriorate relatively early due to competition when these more tolerant individuals reach the overstory canopy.

West Oak Area

It would appear that the west oak stand will undergo no significant canopy changes in the near future. The low density of potential overstory trees in the understory (Table 13, page 30) and the relatively young age of the black oaks are the basis for this statement. The phenomenon of dense growths of understory shrubs inhibiting tree germination and growth of tree species (Curtis 1971) appears to be occurring in this stand also.

Brewer et al. (1973) found some evidence of increasing dominance of white oaks due to death of black oaks in the oak stands in Allegan County, Michigan. There is no evidence of the black oaks dying in this area. However, the fact that white oaks are more abundant than black oaks in both the understory and seedling classes (Table 13, page 30) would suggest that white oaks may become more important in the future.

Of the other potential replacement species present, red maple, red oak, and American beech, only red maple is reproducing, and it is reproducing at a very low rate. The reproduction of red oak and American beech may increase in the future, however, as the present trees mature and produce more seed.

East Oak Area

It appears that little change will occur in the overstory composition of the east oak area in the near future. Red oak which dominates the overstory appears to be reproducing relatively well (Table 16, page 34). The subdominant black oak is absent from the understory and only poorly represented in seedling class and will, therefore, probably decrease in overstory importance with time. Two species which are likely to increase in overstory importance are red maple and pignut hickory.

Larsen (1953) described an oak forest in southern Wisconsin dominated by red oak and black oak which was being invaded by red maple. A few red maples which seeded in originally with the oaks began to produce dense growths of seedlings around them after the canopy matured. The dense growths of seedlings spread out wiping out the typical oak understory as they spread. A situation such as this was not observed in the east oak area; however, the condition of the canopy vegetation seems in many ways similar to that described by Larsen. The canopy is dominated by red and black oaks and there are a few red maples which became established at about the same time as the oaks. This area appears to have the potential of being invaded by red maple but at the present time it can not be determined whether it will happen.

The possibility of this stand changing to beech-maple in the distant future should be considered since this area is presently dominated by red oak, the most mesic of the oak species. The coarse

soil texture (Table 27, page 49) and the west exposure may tend to make this possibility remote.

West Hardwood-Pine Area

In spite of the fact that there is a large number of understory shrubs (Table 20, page 39) which is effecting the relative density of the other species, sassafras does not appear to be doing as well in the understory as in the overstory. Considering the intolerance of sassafras and the fact that it does not attain a very large size in this region, it will be suffering from competition for light in the near future. However, as suggested by Gant and Clebsch (1975) it may be able to maintain itself for a somewhat longer period of time due to possible alleopathic inhibition.

With the exception of flowering dogwood, white pine is the most abundant species in the understory, and it would appear that it will increase in the overstory in the future. White oak, although relatively scarce in the overstory, is quite abundant in the understory and will likely become increasingly important in the overstory in the future. One other species which appears likely to increase in the overstory is red maple which is quite abundant in the understory and particularly in the seedling classes.

The more mesic species of the overstory, red oak and American beech, show no signs of increasing in the overstory. Both are absent in the understory and scarce in the seedling class. As mentioned before, however, this area appears to be one of the most mesic areas studied. With the increasing maturity of the present trees and

subsequent increase in seed production, these species may become more abundant. However, there is no indication of their increase at the present time.

In summary, it appears that there will be a decrease in the importance of sassafras in the canopy on this area and an increase in the importance of white pine, white oak, and red maple.

East Hardwood-Pine Area

The quaking aspens in this stand appear to be dying out. The relatively high density of dead aspens, 3.3 per 1000 m^2, and their lack of reproduction (Table 22, page 42) would seem to indicate that aspen will be absent from the canopy in another 10 years. The loss of the aspen may not create much of a gap in the canopy since the space may rapidly be taken up by surrounding trees.

If any gaps do occur in the canopy, the species most likely to take advantage of it would appear to be white pine and red oak (Table 23, page 43). Excluding flowering dogwood and witch hazel, white pine is the most abundant understory species and seems likely to increase in overstory importance in the future. Red oak, although absent in the overstory, is quite abundant in the understory and being one of the most tolerant of the potential canopy trees in the understory would seem likely to reach the canopy.

Red maple, although very abundant in the seedling class, is very scarce in the understory. Therefore, it does not appear that it will become an important canopy tree in the near future.

American beech, the most important tree in the overstory, does not appear to be reproducing to a very great extent. These beech are probably just beginning to produce seed which would partially explain the lack of reproduction. Some root sprouts would be expected, however, since in most stands reproduction by root sprouts is more common than by seedlings (Curtis 1971). The number of beech trees already present on this area would indicate that this area is suitable for beech. The scarcity of sprouts or seedlings can not be completely explained.

In summary, it appears that the quaking aspen will decrease in the canopy. Species which apparently will increase in the canopy are white pine, red oak, and possibly red maple. The future of American beech is uncertain.

CONCLUSIONS

There appear to be two periods when the eight sites considered in this study were released from human activities and were able to develop woody vegetation. It is apparent from aerial photographs and maximum tree ages that the old field and east aspen communities were released from agriculture in the early 1940's. The activity which most likely prevented establishment of woody vegetation on the other six areas was grazing. The presence of some old fences, steep slopes in some areas, and the presence of only a few older trees are factors supporting this explanation. These areas appear to have been released from grazing in the 1920's.

One of the factors which influenced the development of different vegetational communities on these areas was difference in seed source. The difference between the old field and east aspen communities is probably due to the fact that the east aspen site had aspen growing adjacent to it at the time of abandonment. The adjacent aspen probably caused the development of a sucker stand on the east aspen site. Other areas where seed source was probably an important factor are the east oak and west oak communities. The west oak area has a large, open grown, black oak in the center, and it is now dominated by black oak. The east oak area has a large, open grown, red oak in the center, and it is now dominated by red oak. In the other areas seed source differences may have been a factor but the differences are not as obvious.

The future successional trends of these areas seem to be toward more overstory oaks. In most of the areas oaks are among the more important species in the understory. The trend toward more oaks is consistent with the presettlement vegetation of this area and with the sandy soils of these areas. Based on the present understories, other species which are likely to become more important in the future are red maple and white pine. There is little evidence of these areas being dominated in the future by more mesic species such as American beech. There are some overstory beech trees especially in the east hardwood-pine area but the species is very rare in the understory and seedling layers.

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