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A FLORISTIC AND ECOLOGICAL ANALYSIS OF A PORTION OF
THE MANISTEE NATIONAL FOREST,
OCEANA AND MASON COUNTIES, MICHIGAN

presented by

Timothy Scott Mustard

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John H. Beaman
Major professor

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A FLORISTIC AND ECOLOGICAL ANALYSIS OF A PORTION OF THE MANISTEE NATIONAL FOREST, OCEANA AND MASON COUNTIES, MICHIGAN

By

Timothy Scott Mustard

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ABSTRACT

A FLORISTIC AND ECOLOGICAL ANALYSIS OF A PORTION OF THE MANISTEE NATIONAL FOREST, OCEANA AND MASON COUNTIES, MICHIGAN

By

Timothy Scott Mustard

A portion of the Manistee National Forest within the tension zone of Michigan is examined floristically and ecologically. This secondary forest, approximately 75 years old, is dominated by red oak (*Quercus rubra*). Original land survey records of the presettlement forest indicate a *Pinus strobus* dominance with *Fagus grandifolia* and *Tsuga canadensis* also important. Comparisons are made between the presettlement forest and that of today. Because of disturbance factors, it is suggested that the forest will indefinitely remain a red oak-dominated association. A total of 364 species of vascular plants was collected, including three grass taxa representing range extensions into the tension zone of Michigan's Lower Peninsula. A spectral analysis of the vegetation indicates a hemicryptophytic phytoclimate characteristic of temperate deciduous forests.

ACKNOWLEDGMENTS

Many people have contributed toward the completion of this study and I am very grateful for all of their help. I am indebted to my major professor, Dr. John H. Beaman for his guidance in the preparation of this thesis. I wish to thank Dr. Stephen N. Stephenson for his suggestions on ecological sampling methods and treatment of the data and for his help in determining several difficult grass specimens. I would also like to thank John J. Pipoly and Daniel M. Mustard for their help in the collection of the field data and my parents who rendered their financial and personal support in my field work. Dr. Raymond H. Hollensen and Kathleen A. Hollensen lended much of their valuable time in the computer analysis of the data. I am very grateful for their efforts.

I am especially grateful to my wife, Mary, for her loving support, help in the field and in the typing and proofing of this manuscript.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Northern Michigan has long been considered a vegetational ecotone (Harvey, 1919; Nichols, 1935; Braun, 1950; Elliott, 1953; and others). The northern half of the Lower Peninsula and all of the Upper Peninsula has been considered to comprise a transitional forest in which species of the northern coniferous forest intermingle with species of the northern elements of the deciduous forest. This transitional forest has been discussed more extensively than has any other forest formation in North America.

Sargent, in 1884, classified the forests centering on the Great Lakes as the northern pine belt, characterized by the presence of *Pinus strobus*, a classification followed by Shimper (1903). Transeau (1905) described the region as the northeastern coniferous formation. Harshberger's (1911) St. Lawerence-Great Lake region roughly corresponds to the areas treated by the above authors.

The region has also been termed the northern hardwood forest (Frothingham, 1915); the northern mesophytic-evergreen forest (Shreve, 1917); the northeastern transition forest (Nichols, 1918); the Great Lake forest (Weaver and Clements, 1929); the Hemlock-White Pine-northern hardwoods forest (Nichols, 1935); and the Great Lake section of the Hemlock-White Pine-northern hardwoods region (Braun, 1950).

The point has been raised that no one plant association stands out to the exclusion of all others as being the climatic climax

(Nichols, 1935; Maycock and Curtis, 1960). After an extensive literature review and phytosociological study of 110 forest stands in the northern Great Lakes region, Maycock and Curtis (1960) have concluded that the forests of this region do not comprise a vegetational ecotone between the two community types (northern conifer-southern deciduous forests). Rather, these authors feel the forests are continuous through the region and merely reflect a vegetational gradient whereby the forest becomes predominately coniferous in its northern range and deciduous in its southern range.

The ultimate climax forest type of this region is considered to be a beech-maple-hardwoods climax association by most authors, (Quick, 1923; Graham, 1941; Braun, 1950; Elliott, 1953; Maycock and Curtis, 1960).

With these considerations in mind, a portion of the Manistee National Forest in Oceana and Mason Counties was examined floristically and ecologically in this study to obtain information on forest dynamics within the tension zone of Michigan. Since little work has been done in this region, a review of the past and present forest structure is needed to help elucidate future forest composition. The study area lies at the northern boundary of the tension zone of Potzger (1948). This study may help future workers determine successional sequences and climatic trends within the tension zone. It is also anticipated that the study will aid the U. S. Forest Service in the preparation of an environmental analysis of the area for planning future management activities.

Finally, extensive plant collections are greatly needed in Oceana County and in the Manistee National Forest. Collections made in connection with this study are important contributions toward the preparation of a more accurate flora of Michigan.

GENERAL FOREST DESCRIPTION

The Manistee National Forest is located in the northern Lower Peninsula of Michigan. It contains 532,634 hectares (1,331,585 acres), extending from slightly north of Cadillac in central Wexford County, southward to southern Muskegon and Newaygo Counties (Figure 1). Its location is such that it straddles the tension zone of Potzger (1948) which forms the north-south boundary for many plant and animal distributions and climatological factors (Sommers, 1977).

The area studied lies on the western side of the Manistee National Forest, approximately midway in its north-south dimension, on the Oceana-Mason County border (43^{o} 50' North latitude, 86^{o} 10' West longitude). The research area includes 25 sections (6,475 hectares, 16,000 acres) of forested land, representing 1.2 percent of the total area of the Manistee National Forest (Figures 1 and 2). Fifteen sections occur in Oceana County (14 in Crystal Township; 1 in Colfax Township) and 10 in Mason County (8 in Eden Township; 2 in Logan Township). The majority of Eden Township sections are covered by a highly disturbed, dense swamp forest along the North Branch of the Pentwater River. The rest of the study area consists of a secondary red oak-dominated upland forest. A few scattered cedar swamps occur along streams and in wet ravines. The principle vegetational and geographical features of the study area are shown in Figure 2.

Figure 1. Geographic map of the study area. Inset showing location of the area within the Manistee National Forest.

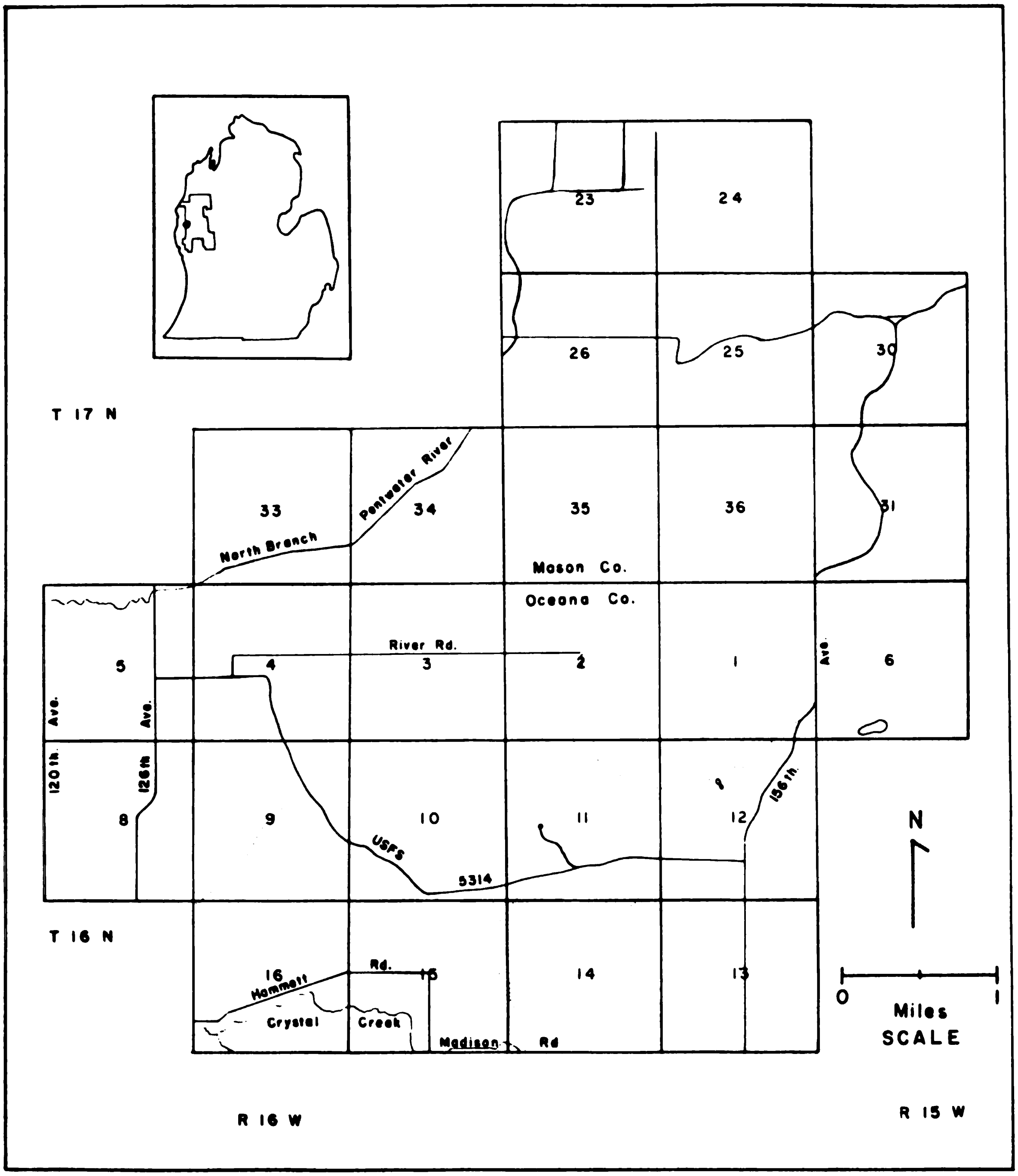
23
24
26
25
30
T 17 N
33
34
35
36
31
Pentwater River
North Branch
Mason Co.
Oceana Co.
River Rd.
5
4
3
2
1
6
Ave.
Ave.
Ave.
120th.
126th
8
9
10
11
12
156th.
USFS
5314
N
T 16 N
16
Rd.
15
14
13
Hammett
Crystal
Creek
Madison
Rd
0
1
Miles
SCALE
R 16 W
R 15 W

Figure 2. Aerial photograph of the study area.

2 cm = 1 mi.

The close proximity to Lake Michigan, the varied topography and its occurrence in the tension zone make this area interesting floristically, with many southern species reaching their northernmost distributions and intermingling with more northern species.

Climate

The ameliorating effect of Lake Michigan on the climate of Oceana and Mason counties has had a strong influence on both the natural vegetation and agriculture. The study area's proximity to Lake Michigan results in moderated temperatures and increased precipitation.

Because of the prevailing westerly winds, spring and early summer temperatures are cooler than would normally be expected at this latitude (43^{o} 50'). Oceana and Mason counties are cooler in spring and early summer than counties in central and eastern Michigan. Fall and winter temperatures are correspondingly milder. For this reason the fruit industry (cherries, apples, peaches, etc.), has flourished in Oceana and Mason counties. The cool spring temperatures retard early blooming of fruit trees and the milder winter temperatures are less likely to damage the flower buds.

The average date of the last freezing temperature in spring is May 21, while the average date of the first frost in autumn is September 30. The growing season averages 132 days annually (Michigan Department of Agriculture, 1971). The mean annual temperature is approximately 47^{o} F.

Precipitation is well distributed throughout the year. The average annual total over a 29-year period (1940-1969) was 82.9 cm

(Michigan Department of Agriculture, 1971). The May to October crop season receives an average of 43.9 cm, or 54 percent of the average annual total. September is generally the wettest month, receiving an average of 8.6 cm, while March, with 4.9 cm, is the driest. Summer precipitation is mainly in the form of afternoon showers and thundershowers. Thunderstorms occur on an average of 36 days a year.

Oceana and Mason counties lie within Michigan's "Lake Snow Belt" (Michigan Department of Agriculture, 1971). The average annual snowfall for Hart, the county seat of Oceana County is 226.3 cm. Ludington, Mason County's seat, averages 182.9 cm of snowfall annually. These totals are almost twice the annual snowfall received over central and southeastern Michigan and reflect the influence of Lake Michigan. Hart usually receives its first snowfall around November 22 and will usually have a six-inch snow depth by December 18.

The tension zone into which the study area falls is an important dividing line for many climatological phenomena which affect forest types in Michigan. Potzger (1948) describes the tension zone of Michigan as a 60-mile wide band extending from Saginaw to Muskegon. It is bounded on the south by Allegan County and on the north by Oceana and Clare counties. Several of the phenomena which differ north and south of the tension zone are: (1) the average date at which daily normals exceed 50° F is April 1 south of the zone and May 1 north of the zone; (2) the number of days with temperatures constantly below freezing are 60 or more north of the zone and 30 southward. (3) the zone separates regions of long winters, where the soil freezes 1 to 2 m, from regions of milder winters where the soil freezes 0.5 to 1 m below the surface; (4) three inches of snow cover

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The influence of the tension zone in limiting the distribution of many plant species is evident across the state. Near Lake Michigan, however the meteorological phenomena are somewhat ameliorated. Many southern species, (e.g. Paspalum ciliatifolium, Quercus velutina), which are normally restricted northward by early frosts and severe winter cold in central Michigan, extend their ranges along the eastern coast of Lake Michigan. Likewise, northern species (e.g. Claytonia caroliniana, Carex ormostachya), which respond adversely to warm spring and summer temperatures, can find suitable habitats in the cooler parts of the state along Lake Michigan. The abundant moisture received in the form of rain and snow and the lower evapotranspiration rates enable more mesic species to occur in the relatively dry habitats present in the upland forest.

Geology and Soils

The bedrock under the study area is almost completely covered to a great depth by glacial drift and therefore, apparently has little effect on vegetation.

According to a geological map of the southern peninsula of Michigan (Martin, 1936), the area is underlain by bedrock of Mississippian Age. The study area is at the boundary of two Mississippian geological formations. Coldwater Shale occurs under the western third of the area and Lower Marshall Sandstone under the eastern two-thirds. Coldwater Shale, being the older of the two formations, consist of red shales and thin limestones (Martin, 1936). It is typically 152 to

303 m thick and, in Crystal and Eden Townships, contains deposits of oil and gas. Lower Marshall Sandstone ranges from 55 to 79 m in thickness and consists of white, gray, green and red sandstones (Martin, 1936).

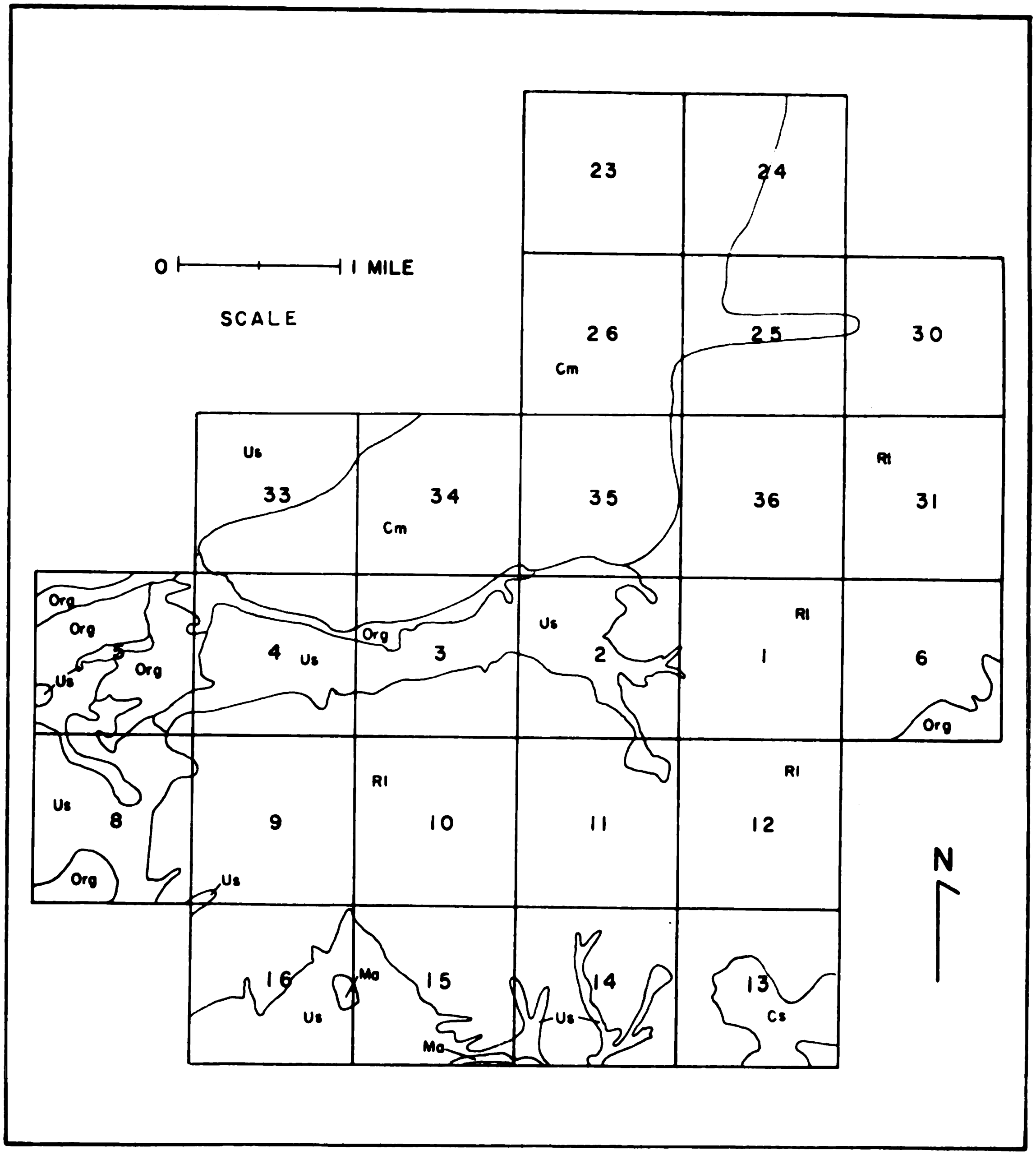
The glacial deposits in the Manistee National Forest are products of the Wisconsin Stage of Pleistocene glaciation. Most of the area examined in this study consists of gently rolling morainal deposits of fine glacial sands of the Rousseau series (Rl in Figure 3). These slightly acidic, well-drained soils typically have black A_1 horizons about 3 cm thick, pinkish gray A_2 horizons extending to 20 cm, dark reddish brown B horizons 20 to 64 cm and a reddish yellow C horizon 64 to 152 cm (USDA soil survey interpretations, 1976).

Several soil wells were dug in the forest to a depth of 1 m, and the resulting soil profiles usually resembled the generalized description given above. On the average the A_0 horizon was black and about 3 cm thick. The A_1 extended to a depth of 7 cm and was also black in color. The light gray A_2 horizon generally was about 6 cm thick, extending down to a depth of 14 cm. The fine reddish sand of the B horizon seemed to extend without interruption to a depth of 1 m (the depth of the soil wells). No clear boundary was ever observed between the B and C horizons.

The vegetation of the majority of the Eden Township sections is a dense swamp forest developed on Carlisle and Tawas mucks (Cm in Figure 3.) These soils have been deposited on an outwash plain (Leverett, 1924) which extends northeastward into Lake County.

The Carlisle series includes deep organic soils which developed from woody materials, which are not well decomposed. The Tawas series

Figure 3. Soil map of study area; soil boundaries adapted from Mokma et al. (1972); Cm, Carlisle and Tawas mucks; Cs, coventry fine sand; Ma, Roscommon mucky sand; Org., organic or poorly drained soils, including Roscommon mucky sand and Deford loamy sand, Wainola loamy fine sand and Au Gres fine sand; Rl, Rousseau and Graycalm fine sands; Us, heterogeneous combination of several minor upland sands, including Croswell and Montcalm sands, Deford loamy sand and Mancelona loamy sand.


0 1 MILE
SCALE
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Us
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Org
3
Us
2
1
Rl
6
Org
Us
8
Org
9
Rl
10
11
Rl
12
Us
16
Ma
Us
15
Ma
14
Us
13
Cs

includes organic soils consisting of well decomposed woody materials (Mokma et al. 1972). Both of these soils are 41 to 130 cm thick, overlying sand or loamy sand, and are very poorly drained. They typically have a black muck surface layer 10 cm thick, over layers of black and dark reddish-brown muck (USDA Soil Survey Interpretations, 1976). The vegetation of this area is a highly disturbed cedar-hemlock swamp with Fraxinus americana, Cornus stolonifera, Salix spp., Betula spp. and Physocarpus opulifolius well represented.

A cedar-hemlock swamp in the southeast quarter of Section 15 and the southwest quarter of Section 14 of Crystal Township is situated on Roscommon mucky sand (Ma in Figure 3), a poorly drained soil type developed on deep sands (Mokma et al. 1972). The surface layer is black loamy sand 10 cm thick. The underlying material is gray and grayish-brown sand extending to a depth of 152 cm (USDA Soil Survey Interpretations, 1976).

Other minor soils (Us in Figure 3) in the area are composed of upland well-drained fine sands similar to those of the Rousseau series.

Physiography

All of the surficial deposits in the Manistee National Forest are products of the Wisconsin stage of Pleistocene glaciation. Most of the area examined in this study consists of gently rolling morainal deposits of fine glacial sands. These hills vary from approximately 212 m to 303 m (700 to 1,000 ft.) above sea level and exert moderate microclimatic influences on the flora. Probably the most obvious of these is the effect of atmospheric drainage whereby cold air flows down from the upland areas and forms pockets in low-lying regions. This pehnomonon was observed in May, 1978, when a late frost severely damaged saplings of Sassafras and Quercus and many of the herbs, such as Pteridium and Aquilegia in low lying areas, but did not affect plants on the adjacent hillsides.

The varied topography also provides suitable habitats for plants of various moisture and temperature regimes. Plants with a preference for warmer, more xeric sites can become established on south- and west-facing slopes, while those with cooler and more mesic tendencies can find suitable habitats on the north- and east-facing slopes.

The large swamp at the northern part of the study area (Crystal Township, Sections 3, 4 and 5; Mason county, Eden Township Sections 14, 23, 24, 26, 33, 34 and 35) lies on top of glacial outwash sediments. This dense swamp rests entirely on what are now mucky sands and poorly drained alluvial deposits (cf. previous section). The difference in glacial deposition has resulted in a markedly different flora than that found on the upland morainal deposits.

Two small bog-like marshes occur in the northwest quarter of Section 12 in Crystal Township (Figure 4). Most of the herbaceous plants found here are unique to these marshes, not being found elsewhere in the study area. These include Carex scoparia, C. lasiocarpa, Eleocharis smallii, Agrostis hyemalis var. tenuis f. setigera, Panicum implicatum, Hypericum boreale, H. canadense, and Viola lanceolata. Although no soil pits were dug at this location, it appears that the soils here must be different from those of the surrounding forest. The marshes are probably remnants of glacial ponds or bogs. Although beyond the scope of this study, it would be interesting to obtain core samples of the sediments for pollen analysis and age determinations.

Figure 4. Oblique aerial view (from 150 m) of two small marshes in Section 12, Crystal Township.

Figure 5. Oblique aerial view (from 150 m) of an old pond or marsh site approximately 400 m northwest of those shown in Figure 4.

Figure 4

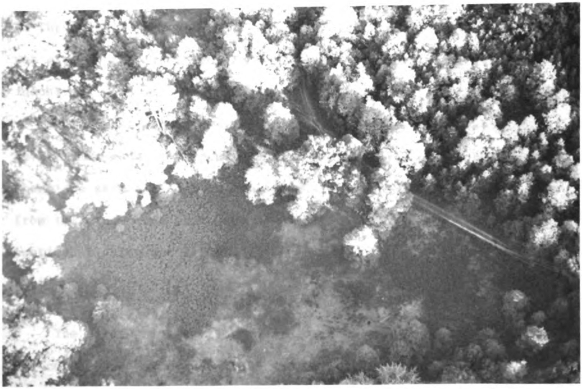

Figure 5

Another suspected glacial pond or marsh lies at the extreme northwest corner of Section 12, approximately 400 m northwest of the above mentioned marshes (Figure 5). This large depression contains a flora of Vaccinium, Comptonia, Pteridium and Danthonia. The soil here consists of a black organic horizon 3.5 cm thick, underlain by gray clay. The sediments are clearly lacustrine in origin. Succession evidently has proceeded at a faster rate in this former marsh than in the other two extant marshes.

Several small streams originate in, or pass through, the study area. They all originate from crystal-clear springs. The streams flow to no major drainage basin; instead they run directly to Lake Michigan or may merge with the North Branch of the Pentwater River which also empties directly into Lake Michigan, via Pentwater Lake.

The North Branch of the Pentwater River was formerly important to the logging industry when white pine logs were sent downstream to the mills. Crystal Creek, once much wider and deeper than now, was also an important source of power and transportation for the industry.

No natural ponds or lakes occur in the study area, although several man-made trout ponds and irrigation ponds may be found. There are several small inland lakes within a radius of ten miles from the study area which are now important recreation areas for boating, fishing and swimming.

POSTSETTLEMENT HISTORY

The first white settlers arrived in Oceana County in the 1830's. The county was surveyed in 1838 and formal organization of the county occured in 1855. The area was settled mainly for its pine timber (Vandenhavel, 1976), but agriculture subsequently became important, especially along Lake Michigan.

The earliest county census showed a population of 496 people in 1840. This figure increased to 1,816 in 1860. Thereafter, the population rapidly increased, attaining 11,699 in 1880, 18,000 in 1894 and 18,739 in 1910 (Vandenhavel, 1976). This rapid population increase and concomitant increase in farming led to the eventual destruction of many of the dense pine forests of the area. By 1894, 2,186 farms had sprung up with 46 percent of the county's acreage converted to farmland. Most of the farms were established along the shore of Lake Michigan and consisted of small orchards of peaches, apples and plums (Anonymous, 1895). Other crops included various grains and truck crops.

No reference could be found as to when the first sawmill became established in the area, but by 1862 log booming was a common practice on the North Branch of the Pentwater River.

The first sawmill in Crystal Township, a small shingle mill, was built in 1871 by John Bean and J. H. Gay (Vandenhavel, 1976). This mill burned in 1874. A larger saw and shingle mill was then built on the site by the firm of Sands and Maxwell. This steam-powered mill had an upright saw and patent edger and had a capacity of 1,000,000 feet of lumber monthly and produced 250,000 shingles per month. Logs were cut in the surrounding forest and skidded by ox team to the mill in winter (Vandenhavel, 1976).

In 1885, the Sands and Maxwell lumber company built another mill in Pentwater (16 km west of the study area). For a period of ten years the mill averaged more than 8,000,000 feet of lumber and 5,000,000 shingles annually. This and nine other mills in the county contributed a total of 250,000,000 feet of lumber and 125,000,000 shingles per year.

Consequently by the early 1900's most of the forest had been ravaged by the white man's axe. Evidence of the lumbering era is shown by the numerous pine stumps throughout the study area. There are also several openings where logs were stockpiled and a former logging trail where logs were skidded in winter to the North Branch of the Pentwater River.

According to Beal (1904), the tree tops and slashings which were left in the wake of the lumberjacks soon dried out and repeated fires swept through the remnants of these once magnificant forests. Although no recorded evidence could be found of early forest fires in the study area, they certainly did occur. This can be inferred by the present forest structure of oaks and aspen, by the average ages of the largest trees (ca. 74 years), and most conclusively by the burned shells of Pinus strobus stumps and the multiple boles indicating a sprout origin for the majority of oak trees. In addition, Dr. Ogden Amstutz, a long-time resident of Oceana County, has said (personal communication) that he remembers a fire which burned at least the extreme southern portion of the study area about 55 years ago.

Human interference still remains a strong force against the natural course of forest succession, maintaining the forest in a disclimax. A productive oil and gas field was discovered under Crystal Township in 1945 (and Eden Township at approximately the same time). Many wells were drilled throughout the study area, resulting in several oil-well openings in the forest. Logging is still an important industry in the area, albeit much less than it was a century ago. The U. S. Forest Service has sold large areas of timber and many hectares have been clear cut (Figure 10) for pulp production.

The U. S. Forest Service stated in a personal communication that "the only additional planned management activities includes harvest and regeneration of mature aspen stands in the north portion of Section 3. Future management activities in adjacent compartments would be dependent upon inventory of the resources and subsequent preparation through interdisciplinary input of an Environmental Analysis".

It is expected that this study will provide useful input for such an analysis.

METHODS

Field Methods

Starting in May, 1977, extensive field collections were made in the study area to determine and document the species present. Collecting trips were made to several different habitats such as ponds, streams, swamps, roadsides and the upland woods. Collections were made in the following sections: Oceana County, Crystal Township, sections 1, 2, 4, 5, 9, 10, 11, 12, 14, 15, 21, 22, 23; Colfax Township, Section 6; Mason County, Eden Township, sections 24 and 33. The specimens were later identified and voucher specimens are deposited in the Beal-Darlington Herbarium of Michigan State University. Duplicates and 35 mm color slides of many of the species are filed in my private collection.

In an effort to characterize and evaluate the forest, quantitative data were collected in a representative upland area in Crystal

Township using several different methods. For tree and shrub species the following methods were used: point-centered quarter (for trees greater than 2.54 cm d.b.h.), line intercept (for canopy cover), 4 x 5 m quadrats in the woods and clear-cut tracts (for seedling and sapling studies) and increment core samples to determine ages of the largest trees.

For the herbaceous species 100 1-m^2 quadrats were used to determine percent cover and density of individuals in the forest.

The point-centered quarter, or point-quarter technique of Cottam et al. (1953) was used to collect data on trees greater than 2.54 cm d.b.h. Six 500-m line transects were established in a north-south orientation at six different locations in an upland forest area selected from aerial photographs. Criteria used in choosing the sites were that the locations were relatively undisturbed and that the vegetation was fairly continuous and constant over the 500 m length. Since the forest in Crystal Township met these criteria, this portion of the study area was chosen for quantitative study. The main road through the area, USFS-5314, was chosen as the starting point for all of the point-quarter transects. The starting point was arbitrarily placed 20 to 25 m into the woods from the road to eliminate the effects of disturbance or increased sunlight. Three line transects were established north of the road in sections 10, 11 and 12, and three south of the road in sections 14 (two lines) and 15. All transects were separated by a distance of at least one kilometer.

Fifty four points were established along each transect using a random numbers table. At every point an imaginary line was drawn perpendicular to the transect in order to divide the point into four quadrants. The nearest tree greater than 2.54 cm d.b.h. in each quadrant was determined. The species of the tree, its distance from the point and its diameter at breast height were recorded. Every point thus yielded data on four different trees. Data on a total of 1,296 trees were recorded using this method.

In order to further characterize the forest, canopy cover determinations were made using a modified line intercept technique of Lindsey (1954) along 20 30-m transects. Four sets of lines were used, each set consisting of five 30-m tape transects. These were established in Crystal Township sections 10, 11, 12 and 15. At each site a 60 m east-west oriented base line was established. Five 30-m tape transects were arranged perpendicular to the base line at 15 m intervals. Along each 30 m transect, the interception distance traversed by the crown of each canopy member and its species were recorded. A total of 123 canopy species was intercepted by the 20 lines.

To determine density and frequency of tree seedlings and saplings, 25 4 x 5 m quadrats were laid out. Five quadrats were established along five different line transects in Crystal Township sections 10, 11, 12, 14 and 15. The quadrats were placed at 25 m intervals along the north-south oriented transects. At each location the 20 m^2 (4 x 5 m) area was marked off using a cloth tape, and the number of individuals of each species contained in the area was recorded. The differentiation of seedling and sapling stages is based on the classification of Cottam (1949). Seedlings are defined as being less than 30 cm tall, while saplings are those individuals more than 30 cm tall, but less than 2.54 cm d.b.h. Trees are here defined as being greater than 2.54 cm d.b.h.

In order to evaluate regeneration of tree and shrub species in clear-cut areas, two clear-cut tracts were chosen and five 4 x 5 m quadrats were established in each. The data were collected in the manner described previously. The two areas selected differed markedly in the advancement of regeneration due to age differences. The first, clear-cut in 1976, is located along USFS-5314 in Section 9 (Figure 10). The other, more mature area was cut in 1972 and is located in Section 3.

To determine the ages of the largest trees in the forest, increment cores from 30 large trees were obtained using a Djos 400 tree borer. Tree rings of several large stumps left from clear-cutting operations were also counted.

Quantitative studies on the herbaceous plants and tree seedlings were performed using 100 1-m^2 quadrats. Four 625-m transects were established (by pacing) in a north-south orientation and 25 quadrats were examined along each transect. Two transects were started from 25 m south of USFS-5314, in sections 11 and 14 and two north of the road in sections 10 and 11.

The 1 x 1 m metal frame was dropped at 25 m intervals and the number of individuals and percent coverage of each herbaceous species recorded. Even though many woodland plants reproduce vegetatively and many shoots may actually belong to the same individual, each above ground shoot was treated as a separate individual. In the case of some grasses and sedges (e.g. Oryzopsis asperifolia) the number of clumps was recorded.

More than 200 35-mm color slides were taken of general forest aspects and representative species. A few typical quadrats and soil wells were also photographed. A pilot was hired in September 1978 to fly me over the forest to obtain the low altitude aerial photographs used in this thesis and to gain a greater perspective of the study area, unattainable from ground-based observations.

Laboratory Methods and Quantitative Procedures

I will now briefly discuss the quantitative procedures used in the analysis of the field data. A discussion of the data of Tables 1 through 11 is included in the following sections.

A computer-assisted analysis of the point quarter data was utilized in this study by using the CEDAR4 program developed by Kathleen A. Hollensen, an undergraduate student at Michigan State University. The CEDAR4 program calculates density, dominance and frequency values for each tree species after the treatment of Cottam et al. (1953). Relative values for the three are also calculated and summed for each species to determine importance values. The importance values for all tree species sum to a constant total of 300. As pointed out by Cain et al. (1956) and Maycock and Curtis (1960), importance values are better indicators of the relative ecological importance of individual species than are any one of its components. Importance values permit a comparison of the values for any species in different stands upon an equal basis. These data were used in describing forest composition in the following sections and are recorded in Table 4.

The point-quarter data were used in size-class studies of the 11 most important tree species. The trees encountered in the point-quarter method were first divided into four size classes; 2.5-9.9 cm, 10.0-22.6 cm, 22.7-40.4 cm and greater than 40.5 cm d.b.h. (diameter at breast height), after Cottam (1949).

Basal area (in dm^2) was calculated for each tree and then summed with other conspecifics of that size class to obtain total basal area for each class.

Relative density, represented here as percentage of the total number of individuals (Cottam et al. 1953), was calculated by dividing the number of conspecific individuals for each size-class by the total number of trees (1,285) encountered in the point-quarter treatment. These data are included in Table 5.

The quantitative data for canopy cover summarized in Table 6 were calculated after Lindsey (1955). In calculating these data, the letter I represents the sum of interception distances for a species on all lines. I_t equals the total interception distance for all species on all lines (615.15 m), L_t the total length of all lines collectively (600 m), and n' the number of lines (20). Then the mean line cover $C_1 = I/n'$, square meter cover per hectare $C_2 = C_4$ (10^4 m^2/ha), relative cover or percent vegetation cover $C_3 = 100\ I/I_t$, and percent ground cover $C_4 = 100\ I/L_t$.

The 4 x 5 m quadrat data for tree seedlings and saplings were analyzed by the HERB3 computer program of K. A. Hollensen according to the methods defined in Cox (1976). Density (number of individuals per unit area), percent frequency (percent occurrence in 25 quadrats), and importance value (here based on a total of 200) are recorded in Tables 7 and 8.

The data for herbaceous plants presented in Table 11 were likewise calculated with the HERB3 program after the treatment outlined in Cox (1976). The treatment differs from that described for the 4 x 5 m quadrats in that percent coverage data were utilized to determine relative dominance values for the herbaceous species and tree seedlings. Importance values in this case are based on a total of 300.

Tree growth increments were determined after the methods outlined in Cox (1976), and a spectral analysis of the flora basically follows treatments discussed by Thieret (1977), Buell and Wilbur (1948), and Raunkiaer (1934).

In an effort to characterize the presettlement forest, records of the General Land Office Survey of 1838 were examined from transcriptions filed at the Lands Division of the Department of Natural Resources, in Lansing. Many authors have discussed the use of these data in the analysis of presettlement forests (Kenoyer, 1934, 1940, 1943; Cottam, 1949; Bourdo, 1956; Hushen, et al. 1966; Lorimer, 1977; Kapp, 1978).

The instructions to the surveyors in 1838 were to mark ("blaze") two witness trees, closest to the corner post and in different quadrants, at every section and quarter-section corner. The species of tree, its estimated diameter in inches and the direction and distance in links from the corner posts were to be recorded. In addition, the surveyors were instructed to place a double blaze on each tree intersected by a section line and record the identities and estimated diameters of these "line trees". General notes were often included in the records on the nature of the forest and land type or quality, such as "Land hilly; Pine, Beech, Maple, Hemlock". These data were copied from the records for 15 sections in Crystal Township. Since this township was the site for my quantitative forest studies, it was chosen as the sample area for characterization of the presettlement forest. The location and diameter of the 201 individual trees were plotted on a township grid map for use in further evaluation of the data.

As pointed out by Bourdo (1956) cases of fraud and bias in the collection of field data have been noted, but as he and others (Kenoyer, 1930; McIntosh, 1962; Delcourt and Delcourt, 1974) have shown, this bias is generally not statistically significant. Nevertheless Bourdo (1956) and Lorimer (1977) admonish each worker to establish the validity of his or her data by the application of probability theory. Surveyors' biases toward a certain species and tree size can be determined by computing mean distance from corner posts to their respective bearing trees. Bias studies were performed on the Crystal Township data according to the methods of Bourdo and no significant bias was detected.

In order to evaluate the data for forest composition, the data were plotted on a grid map of the northern half of Crystal Township. A soils map (Mokma, et al. 1972) was superimposed over this and the trees separated according to their occurrence on general soil types of well drained fine sands or poorly drained organic soils (indicating upland forest and swamp habitats respectively). For all tree species of each soil type total basal area (dm^2) was calculated by summing the basal area of all conspecifics. The relative density (percent occurrence), relative dominance (percent total basal area) and importance values (based on a total of 200) were then calculated after Hushen et al. (1966) and are presented in Tables 1 and 2 and Figures 6 and 7.

RESULTS AND DISCUSSION

In order to fully understand and describe modern floristic associations one must be familiar with the past history of the flora. Only then can one begin to fully understand the floristic composition of modern forests.

Post-Pleistocene Forest

The development of vegetation in what is now the Manistee National Forest actually began in early post-glacial times. The first tree species to become established on the barren sands following the retreat of the Wisconsin glacier were *Picea glauca* and *Abies balsamea* (Potzger, 1948; Benninghoff and Hibbard, 1961; Dorr and Eschmann, 1970). The cool moist climate at this time (13,000-10,000 years B.P.) supported a taiga forest and seems to have inhibited the establishment of *Pinus* (Cushing, 1965; Dorr and Eschman, 1970). As the climate became slightly warmer and drier the forest was dominated by *Pinus banksiana* (8,000 years B.P.) and soon afterward (by 7,000 years B.P.) by *Pinus strobus* (Zumberge and Potzger, 1956; Dansereau, 1947; Dorr and Eschman, 1970). A further warming and drying of the climate allowed the broad leaved hardwood species such as *Quercus*, *Fagus* and *Ulmus* to move northward into the region about 4,000 years B.P. (Potzger, 1948; Cushing, 1965; Dorr and Eschman, 1970).

Potzger (1948) performed a pollen study of 13 bogs in the tension zone of Michigan's Lower Peninsula. Three of the bogs are located in Oceana County, approximately 19 km southwest of the study area. In his established limits of the tension zone he observed *Quercus* pollen representation of 50-60 percent in the southern limits (Allegan County).

Further north, along Highway 46, the representation dropped to 20-40 percent. In Oceana County Quercus pollen composed 20-30 percent of the total and in Clare County, along his northern border of the zone, representation was 10-20 percent. These figures show the expected decline from the southern stations to the northern stations and indicate the importance of Quercus in the ancient pine forest. Dorr and Eschman (1970) note the importance of Quercus and Fagus in the presettlement forest as much as 4,000 years ago. Due to the dense pine forests established prior to the invasion of the broad-leaved genera and the colder temperatures found in northern Michigan, Quercus and other broad leaved genera remained subordinate to Pinus. These trees were probably sub-canopy components under the stately white pines, but due to shading effects, climate and the longer life span of the latter, they were unable to compete as climax dominants in the forest. Consequently, following heavy lumbering activities and subsequent fires in the late 19th century the broad leaved trees assumed dominance in the resulting disclimax forest.

Presettlement Forest

The structure of the presettlement forest of the recent past can be inferred from data calculated from the records of the General Land Office Survey of 1838. As described earlier in this paper (under laboratory methods) these records were used to construct tables showing the relative density, relative dominance and importance values for presettlement forest species on well drained sandy soils and poorly drained organic soils (Tables 1 and 2).

The overwelming dominance of white pine, Pinus strobus is evident from the data presented in Table 1. The importance value for Pinus strobus (101.7) is over two and a half times that for Fagus grandifolia (38.4), the second most important species. Third in importance was Tsuga canadensis, eastern hemlock. Tsuga did not appear to be common on sandy upland sites, rather it tended to favor more mesic sites, as it does today in the study area.

Quercus rubra ("black oak" of the surveyors), Acer rubrum and Acer saccharum, respectively the fourth, fifth and sixth most important species of the presettlement forest, represent a group of trees of secondary importance in the forest. Due to their shade tolerance, both red maple and sugar maple were probably important constituents of the understory sapling and seedling strata. All three were probably common members of the "sub-canopy" under the white pines. The importance of Quercus rubra is evident from Table 1. Its importance increased greatly in the modern forest following release from competition with white pine. Figure 6 shows relative density and relative dominance values plotted as percentages for the six most important tree species on upland soils in the presettlement forest. The importance of white pine is strikingly apparent from this graph. Based on these facts, the upland presettlement forest of Crystal Township is equivalent to Kapp's (1978) beech-pine-hardwoods.

Table 2 lists the relative density, relative dominance and importance values for tree species on organic soils. As might be expected, white cedar, Thuja occidentalis, and eastern hemlock, Tsuga canadensis, are the two most important trees in swamps of the presettlement forest. Tilia americana, which actually has a higher importance value than

Table 1. Presettlement forest of 1838 on sandy soil.

Species	Number of Individuals	Total Basal Area (dm^2)	Ave. Basal Area	Relative Density	Relative Dominance	Importance Value
Pinus strobus	63	1906.6	30.3	36.0	65.7	101.7
Fagus grandifolia	52	253.3	4.9	29.7	8.7	38.4
Tsuga canadensis	24	165.4	6.9	13.7	5.7	19.4
Quercus rubra	10	274.4	27.4	5.7	9.5	15.2
Acer rubrum	16	135.3	8.5	9.1	4.7	13.8
Acer saccharum	10	108.9	10.9	5.7	3.8	9.5
Quercus alba	2	34.3	17.2	1.1	1.2	2.3
Pinus resinosa	1	16.4		0.6	0.6	1.2
Ulmus americana	1	7.3		0.6	0.3	0.9
Total	175	2901.9				

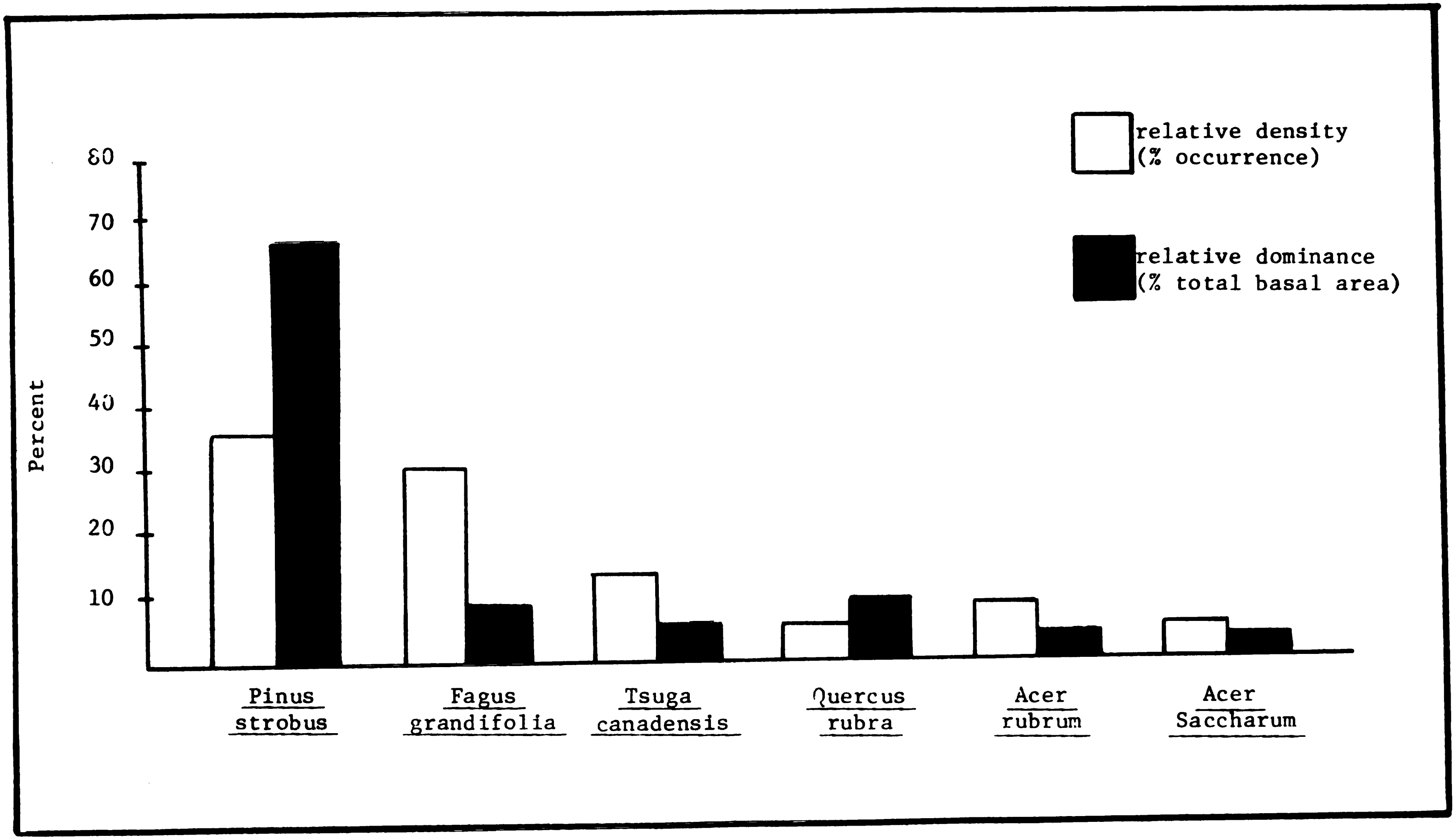

Figure 6. Presettlement Forest of 1838 on sandy soils

Table 2. Presettlement forest of 1838 on organic soils.

Species	Number of Individuals	Total Basal Area (dm^2)	Ave. Basal Area	Relative Density	Relative Dominance	Importance Value
Thuja occidentalis	9	76.8	8.5	34.6	28.3	62.9
Tsuga canadensis	7	33.9	4.8	26.9	12.5	29.4
Tilia americana	2	74.8	37.4	7.7	27.5	35.2
Acer saccharum	2	39.1	19.6	7.7	14.4	22.1
"Balsam"	2	11.8	5.9	7.7	4.3	12.0
Fraxinus americana	1	20.3		3.8	7.5	11.3
Fagus grandifolia	2	7.3	3.7	7.7	2.7	10.4
Ulmus americana	1	7.3		3.8	2.6	10.2
Total	26	271.3				

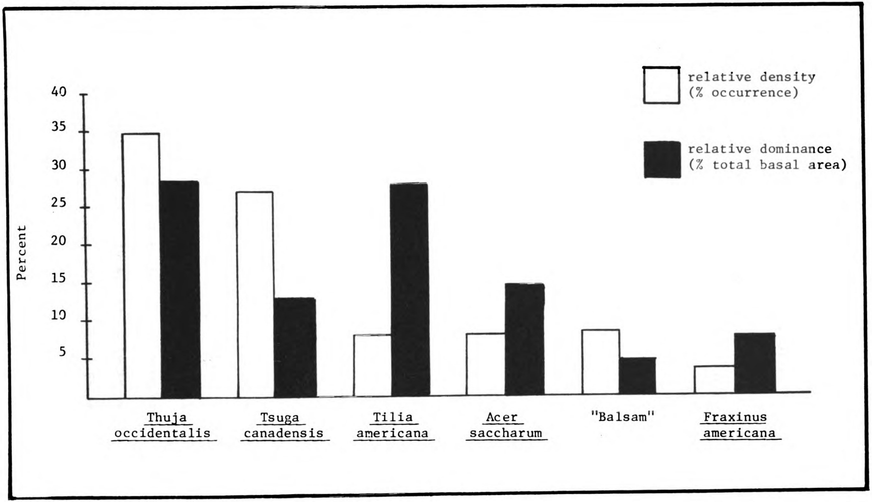

Figure 7. Presettlement forest of 1838 on organic soils

Tsuga, has been placed third in importance. The high importance value for Tilia is an anomalous situation arising from the presence of two very large trees, one 76.2 cm d.b.h., the other 61 cm d.b.h., and the small sample size of 26 individuals.

Acer saccharum is important on organic soils, unlike its representation on upland sandy soils, being represented by several large trees averaging 50 cm d.b.h.

The scientific name of the tree labelled "Balsam" cannot be ascertained from the habitat data or from the literature (Hushen, et al. 1966). The name given by the surveyors could apply to balsam poplar (Populus balsamifera L.) or balsam fir (Abies balsamea (L.) Mill.), both of which would be expected on organic soils in a swamp habitat. The relative density and relative dominance values for tree species on organic soils are summarized in Figure 7.

Comparison of Presettlement Forest and Present Forest

If the upland forest data of 1838 are compared with the point-quarter analysis of the modern forest (150 years later), several dramatic differences in forest composition are noted (see Table 3), the most notable being the extreme reduction in the importance of Pinus strobus. In 1838 Pinus had an importance value of 101.7 (based on a total of 200). One hundred fifty years later, following the selective cutting of white pine and subsequent fires, white pine's importance value dropped to 19.4. It is today represented by numerous individuals in the understory of the upland forest. Its former significance is also attested by the presence of numerous stumps left from logging operations of the late nineteenth century (Figure 9).

Table 3. A comparison of the vegetation of the study area in 1838 with that of 1978.

Species	1838			1978		
	Relative Density	Relative Dominance	Importance Value	Relative Density	Relative Dominance	Importance Value
Pinus strobus	36.0	65.7	101.7	15.7	3.7	19.4
Fagus grandifolia	29.7	8.7	38.4	9.3	4.6	13.9
Tsuga canadensis	13.7	5.7	19.4	0.0	0.0	0.0
Quercus rubra	5.7	9.5	15.2	20.1	54.4	74.5
Acer rubrum	9.1	4.7	13.8	13.9	6.6	20.5
Acer saccharum	5.7	3.8	9.5	5.7	4.9	10.6
Quercus alba	1.1	1.2	2.3	8.0	14.1	22.1
Pinus resinosa	0.6	0.6	1.2	0.0	0.0	0.0
Ulmus americana	0.6	0.3	0.9	0.0	0.0	0.0
Populus grandidentata	0.0	0.0	0.0	14.6	9.2	23.8

Fagus and *Tsuga* likewise show reductions, undoubtedly due to changes in forest composition. *Fagus* is well represented in the smaller size classes and in the canopy of the extant forest, while *Tsuga* occurs as a few scattered relicts, not encountered in the point-quarter treatment. Even though *Tsuga* is often thought to be a successful component of the forests of northern Michigan (Whitford, 1901; Graham, 1941; Elliott, 1953) it was not encountered in any of the quantitative treatments. According to Graham (1941), eastern hemlock may have been reduced as a result of exposure after the elimination of white pine. Eastern hemlock has been shown to have poor reproductive potential following the cutting of old growth stands (Coffman, 1978). In addition, eastern hemlock was selectively removed from this area for tan bark and shingle production (Anonymous, 1985) and many of the "white pine stumps" remaining today may in fact be those of eastern hemlock.

Quercus rubra, *Acer rubrum* and *Quercus alba* show substantial increases in importance, all being canopy dominants in the modern forest. Suprisingly, *Acer saccharum* shows only a slight increase in importance. *Pinus resinosa* is present in the modern forest but was not encountered in the point-quarter analysis.

Populus grandidentata was not referred to by the surveyors in 1838. This may be due to the surveyor's reluctance to blaze aspen trees because of their relatively short life spans (Cottam, 1949; Bourdo, 1956). Even if this is the case, *Populus* can be assumed to have had little importance in the presettlement pine forest. After logging and subsequent burning, the forest conditions considerably favored the establishment of *Populus trees*.

Present Forest

The present secondary or disclimax forest association is shown quantitatively to be dominated by the *Quercus rubra* complex (*Quercus rubra*, *Quercus rubra* var. *borealis* and *Quercus velutina*). Due to the difficulty in the recognition of these taxa in the field, they were all treated as the same taxon. *Quercus velutina*, being near its northern distributional limit (Little, 1971), is very poorly represented in the upland forest. All three taxa are likely hybird-izing in the Manistee National Forest.

Other important canopy and understory members are *Populus grandidentata*, *Acer rubrum*, *Pinus strobus* and *Fagus grandifolia* (see Figures 8 and 9).

The dominance of *Quercus rubra* in the study area is not unusual. Northern red oak has been shown to be the dominant tree on upland sandy soils following disturbance by logging or fires in northern Michigan by other authors (Gates, 1930; Elliott, 1953).

The oldest tree encountered in the forest was a red oak which measured 63.5 cm d.b.h. and was estimated to be 74 years old by core increment analysis. A large red oak 72.4 cm d.b.h. had 61 growth rings to its rotted center and was the largest extant tree found in the study area. Another red oak, 61.7 cm d.b.h. and a white oak (*Quercus alba*), 49.0 cm d.b.h. were both found to be approximately 73 years old, indicating the oldest trees now in the forest probably date from the time of the last major fire, in approximately 1904-05. The average sized canopy trees, however, range from 50 to 60 years old. This is true for all the larger canopy and understory trees examined. As was reported by Dr. Ogden Amstutz (personal communication),

Figure 8. Interior view of upland forest, section 11, Crystal Township. Large trees are Quercus rubra; understory predominately Acer rubrum and Fagus grandifolia; herbaceous layer dominated by Pteridium aquilinum.

Figure 9. Interior view of upland forest, section 12, Crystal Township. Quercus alba pictured at left and right; Quercus rubra near center, multiple boles indicating obvious sprout origin. Note stumps and young trees of Pinus strobus.

Figure 8

Figure 9

a lightning fire burned through the area approximately 55 years ago. Although no written account of the extent of the fire could be found, it is assumed that this fire killed the understory trees and did little harm to the larger canopy members (i.e. the 73-74 year-old components). The relatively even aged canopy members averaging 22 to 40 cm. d.b.h. (size class 3 in Table 5) represent the new growth following that fire.

The extreme dominance of the Quercus rubra complex in the Manistee National Forest study area is shown in Table 4 and 6. As shown by the point-quarter data, Quercus rubra has an importance value of 95.16, over two and a half times greater than that of the second most important species, Populus grandidentata (37.28). It comprises 60 percent of the total canopy cover, over four times that of Quercus alba (Table 6). Table 5 shows red oak well represented in all size classes, indicating its ability to reproduce and maintain its dominance for some time. In addition, the presence of many large red oaks is evidenced by the high relative density and basal area values for trees greater than 40.5 d.b.h. Forty-one red oak trees were assigned to this size class, representing 15 percent of the total red oak trees encountered in the point-quarter analysis.

Populus grandidentata is second in importance according to the point-quarter technique (Table 4), third in the size class ordination (Table 5) where the species are ranked according to relative dominance values, and fifth in percent crown cover values (Table 6). The reason for the differential placement is inherent in the nature of the analyses and in the fact that Populus is, by habit, a smaller tree. It is therefore represented by numerous individuals in the smaller size

Table 4. Point-quarter data for density, dominance, frequency and importance values for 11 woody species 2.54 cm or greater d.b.h.

Species	Number of Individuals	Average Dominance (cm^2)	Density (ha)	Relative Density	Dominance	Relative Dominance	Frequency	Relative Frequency	Importance Value
Quercus rubra	260	623.96	229.71	20.14	14.33	54.38	.56	20.63	95.16
Populus grandidentata	189	145.50	166.98	14.64	2.43	9.22	.37	13.42	37.28
Acer rubrum	180	109.08	159.03	13.94	1.74	6.58	.41	15.22	35.74
Pinus strobus	206	53.23	182.00	15.96	0.97	3.68	.32	11.84	31.47
Quercus alba	103	409.29	91.00	7.98	3.73	14.13	.25	9.25	31.35
Fagus grandifolia	120	114.72	106.02	9.30	1.22	4.62	.25	9.13	23.04
Sassafras albidum	129	45.79	113.97	9.99	0.52	1.98	.29	10.49	22.46
Acer saccharum	73	199.71	64.49	5.66	1.29	4.89	.19	6.88	17.42
Prunus serotina	11	85.36	9.72	0.85	0.08	0.32	.03	0.90	2.07
Amelanchier sp.	10	11.63	8.84	0.78	0.01	0.04	.03	1.13	1.94
Fraxinus americana	4	96.95	3.53	0.31	0.03	0.13	.01	0.45	0.89

Table 5. Size classes of upland forest trees. Species arranged in decreasing order of relative dominance.

Species	Number of individuals	Size class 1 2.5-9.9 cm		Size class 2 10.0-22.6 cm		Size class 3 22.7-40.4 cm		Size class 4 > 40.5 cm		Relative Dominance
		Relative Density	Basal Area (dm^2)	Relative Density	Basal Area (dm^2)	Relative Density	Basal Area (dm^2)	Relative Density	Basal Area (dm^2)	
Quercus rubra	260	5.45	21.52	5.60	154.72	5.99	588.44	3.19	860.96	54.4
Quercus alba	103	2.49	9.81	2.57	52.79	2.26	228.16	0.70	130.20	14.1
Populus grandidentata	189	7.24	23.26	6.46	180.83	1.01	68.84			9.1
Acer rubrum	180	10.04	30.04	2.96	62.53	0.93	68.21	0.08	32.95	6.5
Acer saccharum	73	3.35	11.91	1.48	32.13	0.62	49.68	0.23	52.05	4.9
Fagus grandifolia	120	5.84	16.14	2.88	64.59	0.54	42.66	0.08	14.30	4.6
Pinus strobus	206	12.84	45.99	3.11	59.19	0.08	4.48			3.7
Sassafras albidum	129	9.03	37.57	0.93	14.69	0.08	6.82			2.0
Prunus serotina	11	0.39	0.95	0.47	8.44					0.3
Amelanchier spp.	10	0.78	8.40							0.3
Fraxinus americana	4	0.23	1.03	0.08	2.85					0.1
Total	1285		206.62		632.76		1057.29		1090.46	

Table 6. Canopy cover values for upland forest trees.

Species	Number of Individuals	Interception Distance (I)	Mean Line Cover (C_1)	m^2 Cover/ha (C_2)	% Relative Cover (C_3)	% Ground Cover (C_4)
Quercus rubra	70	363.00	18.15	6,050	59.01	60.50
Quercus alba	21	86.05	4.30	1,434	13.99	14.34
Acer rubrum	12	74.00	3.70	1,233	12.03	12.33
Fagus grandifolia	5	39.80	1.99	663	6.47	6.63
Populus grandidentata	7	25.30	1.27	422	4.11	4.22
Acer saccharum	3	13.60	0.68	227	2.21	2.27
Sassafras albidum	2	4.80	0.24	80	0.78	0.80
Fraxinus americana	2	4.50	0.23	75	0.73	0.75
Prunus serotina	1	4.10	0.21	68	0.67	0.68
Total	123	615.15				

classes. The high relative density and frequency values which it possesses determine its higher rank in the point-quarter treatment. The fact that it has a smaller trunk and canopy diameter than white oak, red maple and beech accounts for its lower placement in Tables 5 and 6.

As shown by the quadrat data (Tables 7 and 8), Populus grandidentata is poorly represented in the seedling and sapling strata, indicating its inability to reproduce in the shade of the upland forest. As succession proceeds further, its eventual demise in the upland community is certain. The oldest living individuals were found to be approximately 50 years old. Many rotted stumps remain from older individuals. It should be noted that Populus is the first tree species to reinvade clear-cut tracts and assume dominance. Populus is being regenerated in these large clear-cut stands for pulpwood production. The trees are harvested at about 45 years of age (U. S. Forest Service, personal communication).

Acer rubrum, Pinus strobus and Quercus alba are third, fourth and fifth respectively in importance in the point-quarter treatment (Table 4). These species are common in all size classes (Table 5), with the exception of Pinus, which exists as smaller understory trees. Thus, it is poorly represented in the third size class (22.7-40.4 cm) and is not represented in the fourth class (greater than 40.5 cm). The canopy cover determinations show Quercus alba with its generally wider crown to be the second most dominant canopy member with 14.34 percent ground cover, closely followed by Acer rubrum (12.33 percent). Pinus strobus was not encountered as a canopy component in this study.

Fagus grandifolia and Acer saccharum are sixth and eighth respectively in importance according to the point-quarter analysis. Both are well represented in the seedling and sapling strata (Table 7 and 8). Beech is common in the canopy and subcanopy layers, while sugar maple is poorly represented in the canopy (Table 6).

Sassafras albidum, being a smaller tree, is only occasionally found in the canopy, usually in disturbed areas, or in openings in the oak canopy. It has the third highest value for relative density and the second highest value for total basal area in the first size class (2.5 to 9.9 cm). The quadrat data (Tables 7 and 8) show its importance in the seedling and sapling strata. The oldest Sassafras trees were approximately 73 years old. The outer growth rings usually become very closely spaced and difficult to count, indicating senescent growth in these old individuals.

Prunus serotina, Amelanchier spp., Fraxinus americana, Hamamelis virginiana and Ostrya virginiana were all encountered in the understory and in the seedling and sapling strata to varying degrees. None assume prominence in any of the strata over large areas, although Hamamelis may be locally important.

To evaluate future successional trends, twenty five 4 x 5 m quadrats were established to determine density, frequency and importance values for tree seedlings and saplings. These data are summarized in Tables 7 and 8. In the 500 m^2 sample area a total of 1,701 tree seedlings and 132 saplings were encountered. The density value for tree seedlings is $3.4/m^2$ and that for saplings, $0.26/m^2$. There are nearly thirteen times as many seedlings as saplings, representing a reduction in the number of seedlings to saplings of 92 percent.

Since the contribution of vegetative reproduction was not considered, these numbers do not truly reflect the number of individuals (seedlings) produced from seed. Nevertheless, similar ratios of seedlings to saplings have been observed by others (Clayberg, 1930; Buell and Cantlon, 1951).

Table 7. Density, frequency and importance values for tree and shrub seedlings based on 500 m^2 sample area.

Species	Density	% Frequency	Importance Value
Acer rubrum	.67	88	29.06
Quercus rubra	.54	92	25.85
Viburnum acerifolium	.75	36	24.95
Quercus alba	.49	84	23.57
Sassafras albidum	.40	96	22.43
Prunus spp.	.19	68	13.45
Amelanchier spp.	.11	60	10.29
Fagus grandifolia	.09	52	8.62
Hamamelis virginiana	.06	24	4.42
Acer saccharum	.07	20	4.22
Fraxinus americana	.03	16	2.75
Populus grandidentata	.002	04	0.54

Acer rubrum was found to be the dominant species in both strata with an importance value of 29.06 for seedlings and 7.43 for saplings. Red maple, long considered to be an indicator of more mesic habitats, is now known to exhibit a wide range of ecological tolerances (Elliott, 1953). Its abundance in all strata in the sandy upland forest is therefore not surprising. The reduction in density from seedlings (.67) to saplings (.08) represents a difference or a seedling "mortality rate" of 88 percent. Since the number of individuals reaching the sapling stage was not followed through time, a true death rate, or mortality rate, could not be calculated. It cannot be known if the seedling population is the same today as it was several years ago when the present saplings were represented in the seedling layer. Fluctuations in seed crop size are regular phenomena which may also contribute to differences. It has been shown, however (Hett, 1971), that in years of heavy seed production with a high initial input of seedlings, mortality of seedlings is high. Seed crop size does not seem to influence the number of seedlings established. Thus a relatively constant input of seedlings is maintained through time. With this in mind it can further be assumed that general microclimatic conditions have remained relatively constant for the past 20 years. Therefore, it may be safe to assume that the present seedlings of _Acer rubrum_, for instance, will result in a similar density of saplings shown by the present red maple saplings. In other words an approximate density reduction of 88 percent should be expected in the present generation of seedlings.

Red oak and white oak (_Quercus rubra_ and _Q. alba_) are very common in the seedling layer, less so in the sapling layer, indicating a density reduction of 98 percent and 96 percent respectively. It has been noted (Korstian, 1927; Parmelee, 1953) that a small percentage of oak seedlings reach the sapling stage due to a variety of factors, including insect predation and shade intolerance. This would tend to favor the hypothesis that the forest will eventually assume a beech-maple climax association with the concomitant elimination of the oaks. As indicated by the size class studies (Table 5,) this replacement is undoubtedly many years in the future, if in fact it occurs at all.

Viburnum acerifolium, a small shrub, is abundant in the seedling and sapling layers, being placed third in importance for both strata. Due to its ability to reproduce vegetatively, Viburnum often forms dense colonies, resulting in its high importance values in Tables 7 and 8.

Table 8. Density, frequency and importance values for tree and shrub saplings based on 500 m^2 sample area.

Species	Density	% Frequency	Importance Value
Acer rubrum	.08	44	7.43
Sassafras albidum	.03	32	4.56
Viburnum acerifolium	.04	24	3.93
Amelanchier spp.	.02	16	2.36
Quercus alba	.02	16	2.36
Fagus grandifolia	.01	16	2.25
Quercus rubra	.01	12	1.66
Hamamelis virginiana	.01	8	1.35
Prunus spp.	.01	8	1.13
Acer saccharum	.02	4	1.03
Populus grandidentata	.01	4	0.70
Fraxinus americana	.002	4	0.54
Pinus strobus	.002	4	0.54

Sassafras albidum is very common as seedlings and saplings in the forest. The reason for this is due, in part, to its ability to sprout vegetatively. Sassafras becomes abundant in open disturbed sites, such as along roads and in windthrow openings, as well as in older clear-cut stands.

Fagus grandifolia and Acer saccharum again show lesser importance than seedlings and saplings of any of the above species. Fagus is more important than Quercus rubra in the sapling layer (importance values of 2.25 and 1.66 respectively), while Acer saccharum has a lower importance value than either (1.04). Fagus shows a seedling mortality rate or density reduction of approximately 80 percent, equal to that of Acer rubrum. Acer saccharum shows a density reduction of 61 percent. A greater percentage of beech and maple seedlings are reaching the sapling stage than either of the oaks, indicating a slight tendency toward a beech-maple forest.

As can be seen from Tables 7 and 8), Populus grandidentata is very poorly represented as seedlings and saplings, emphasizing the eventual demise of Populus if the normal course of succession is followed.

Pinus strobus does not appear to be reproducing in the present forest. No cone bearing trees were observed in the many collecting trips to the area. However, a few older individuals in the cedar swamps were observed with cones. A few saplings were observed in the upland forest (Table 8), but no seedlings were encountered in the quadrat studies.

To study the effects of clear-cutting on the forest vegetation and to understand general successional tendencies, two clear-cut tracts were examined using five 4 x 5 m quadrats in each. The resulting small sample size contributes to some sampling error appearing in the data. It was therefore decided to evaluate the changes in forest composition in general terms, rather than relying on the data to show definitive trends. Further studies are greatly needed on forest regeneration both in the Manistee National Forest and in other forests of eastern North America. It was beyond the scope of this study to provide such an analysis, but it is hoped that this preliminary study will show the necessity for further research in forest regeneration.

The youngest, or more recently cut, of the two clear-cut tracts occurs in Section 9. This stand, which was clear-cut in 1976, is shown in Figure 10. It is dominated by young saplings of Populus grandidentata, most of which are approximately two meters tall. The other clear-cut area occurs in Section 3 and was established in 1972. The vegetation here is dominated by Populus grandidentata saplings and trees.

Populus grandidentata, being an early successional species shows a significant increase in importance values for seedlings and saplings in the Section 9 clear-cut area (Tables 9 and 10). This rapid increase is due to vegetative reproduction from remaining stumps, although some seed germination is undoubtedly contributing to the effect. As these stands mature, the density and importance of Populus can be expected to decline due to mortality and inter- and intraspecific competition (Gates, 1930). This is reflected in the data gathered by the 4 x 5 m quadrats and is plotted in Figure 11. It should be noted that the data points represented here are not absolute. Due to statistical sampling error some deviation may be expected in the location of these points. The graphs are included merely to illustrate the observed trends in forest regeneration.

As Figure 11 shows, seedlings and saplings of Populus tremuloides show a similar concave curve to that of P. grandidentata. The importance values drop to zero in the woods and in the Section 3 clear-cut tracts. As Gates (1930) points out, P. tremuloides is better adapted to wetter habitats, although it is frequently found in sandy

Figure 10. Clear-cut stand in Section 9, Crystal Township; the area was cut in 1976 and is dominated by saplings of Populus grandidentata.

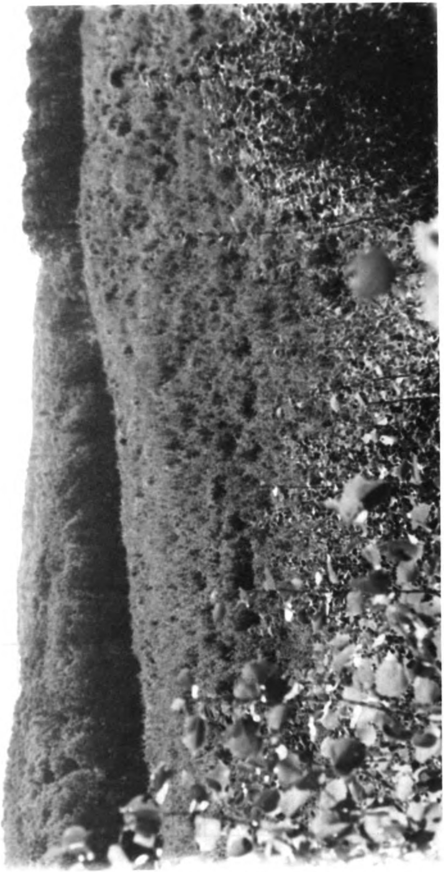

Table 9. Comparison of density, frequency and importance values for tree seedlings in the upland forest and in two clear-cut stands.

	Density			% Frequency			Importance Value		
Species	Woods	Clear Cut Sec. 9	Clear Cut Sec. 3	Woods	Clear Cut Sec. 9	Clear Cut Sec. 3	Woods	Clear Cut Sec. 9	Clear Cut Sec. 3
Acer rubrum	.67	.17	.11	88	60	80	29.06	15.26	8.95
Acer saccharum	.07			20			4.22		
Amelanchier spp.	.11	.18	.08	60	40	40	10.29	12.70	4.96
Fagus grandifolia	.09		.01	52		20	8.62		1.89
Populus grandidentata	.002	.24	.01	4	60	20	0.54	17.91	1.89
Populus tremuloides		.06			40			8.16	
Prunus spp.	.19		.42	68		80	13.45		15.05
Quercus alba	.49	.51	.02	84	100	40	23.57	34.02	3.78
Quercus rubra	.54	.09	.37	92	60	100	25.85	12.23	15.76
Sassafras albidum	.40	.09	2.25	96	60	80	22.43	12.23	51.07

Table 10. Comparison of density, frequency and importance values for tree saplings in the upland forest and in two clear-cut stands.

	Density			% Frequency			Importance Value		
Species	Woods	Clear Cut Sec. 9	Clear Cut Sec. 3	Woods	Clear Cut Sec. 9	Clear Cut Sec. 3	Woods	Clear Cut Sec. 9	Clear Cut Sec. 3
Acer rubrum	.08	.06	.07	44	20	40	7.43	5.21	4.77
Acer saccharum	.02			4			1.03		
Amelanchier spp.	.02	.06	.02	16	40	40	2.36	8.16	3.78
Fagus grandifolia	.01			16			2.25		
Populus grandidentata	.01	.74	.32	4	60	100	0.70	36.85	14.77
Populus tremuloides		.15			40			11.56	
Prunus spp.	.01		.19	8		60	1.13		8.82
Quercus alba	.02	.40	.02	16	20	20	2.36	4.46	2.09
Quercus rubra	.01	.20	.15	12	20	100	1.66	10.52	11.43
Sassafras albidum	.03		.36	32		80	4.56		13.87

areas. *Populus tremuloides* would appear to be unable to compete with *P. grandidentata* and other late-successional species in the sandy habitats present in the study area.

Two other taxa show concave curves for importance values. These are *Amelanchier* spp. and *Quercus alba*. Four species of *Amelanchier* were collected in the study area. It was difficult to identify seedlings and saplings based on vegetative characteristics so they were listed only by genus. It may be assumed however, that most of these individuals are probably *A. arborea*, a frequent member of the upland forest understory.

The strong pulse in importance of *Quercus alba* seedlings of Section 9 (Figure 11) may be due to a heavy seed crop of the previous year being released from shading and competition by the overstory. A high mortality rate is expected in seedlings due to increased sunlight, drying and other microclimatic influences. This is shown by *Q. alba*, and more convincingly by *Acer rubrum*, *Acer saccharum* and *Fagus grandifolia*. All three taxa are well represented in the seedling and sapling layers of the upland forest (Tables 7 and 8). *Fagus grandifolia* and *Acer saccharum*, being components of more mesic forests, respond adversely to clear-cutting. No seedlings or saplings of these two were observed in either of the clear-cut stands. *Acer rubrum*, being a more tolerant species, is well represented in the clear-cut stands. It has an importance value of 5.21 in Section 9 and 4.77 in Section 3.

Sassafras albidum seedlings and saplings appear to exhibit a slight lag period when an area is clear-cut. Whether this is real or a result of sampling error will have to be determined by further study. Since *Sassafras* reproduces vegetatively to a great extent, it may

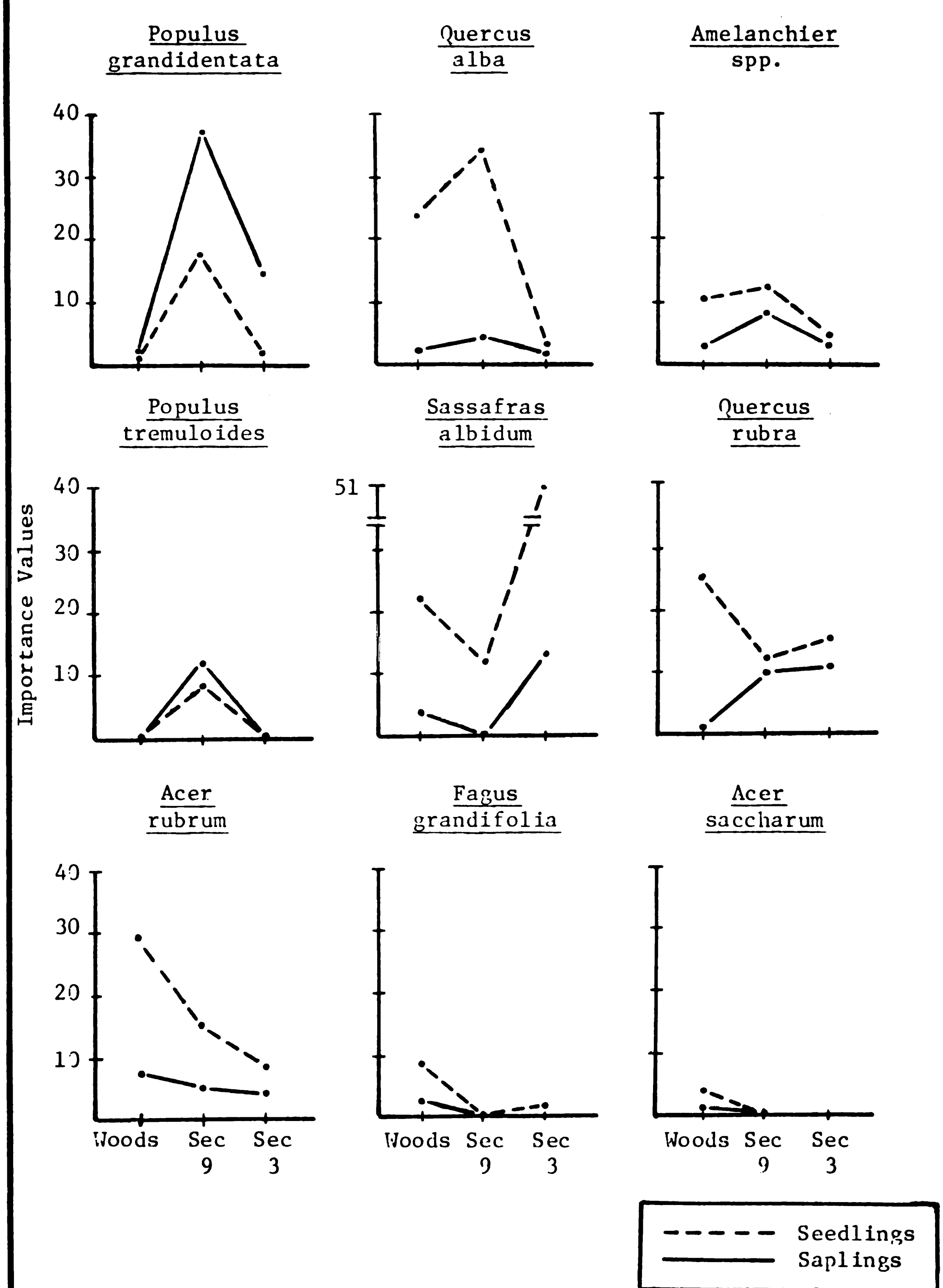

Figure 11. Comparison of importance values for tree seedlings and saplings in the upland forest and in two clear-cut areas.

require some time before it becomes a successful competitor in clear-cut stands. Once it becomes established it rapidly proliferates, forming dense colonies, as it does in Section 3.

Quercus rubra, the dominant canopy member of the upland forest, is able to reproduce after cutting by stump sprouts (Beal, 1888) and is an important invader in sandy upland soils (Gates, 1930). The increase in importance of Q. rubra saplings (figure 11) is due primarily to stump sprouting. It would be interesting to observe further succession in these areas to determine the percentage of stump sprouts that reach sexual maturity and become canopy components. As noted above, these clear-cut stands are to be managed for continued pulp production. The aspens are to be harvested at approximately 45 years of age (U.S. Forest Service, personal communication).

The comparative data for the herbaceous stratum of the upland forest are summarized in Table 11. Carex pensylvanica is overwelmingly the dominant herbaceous species with an importance value of 89.27. Carex often forms dense stands in the open forest. It is often a codominant with Danthonia spicata in openings created in the forest, especially in former marshes. Carex shows a remarkable range of light tolerance, being found in full sun and deep shade. Density for Carex is based on the number of above-ground shoots and may not actually represent the true number of individuals per unit area. It is nevertheless a ubiquitous plant in the forest.

Bracken fern, Pteridium aquilinum, is second in importance in the 1 m^2 quadrat studies, with an importance value of 39.83 (Table 11). Like Carex pensylvanica, Pteridium often forms dense stands, especially in open areas. Nearly pure stands result in clear-cut tracts under

Table 11. Density, dominance, frequency and importance values for herbaceous plants based on a 100 m^2 sample area.

Species	Density	Dominance	% Frequency	Importance Value
Carex pensylvanica	21.96	15.40	63	89.27
Pteridium aquilinum	2.01	13.81	65	39.83
Vaccinium angustifolium	1.48	2.59	21	11.78
Gaultheria procumbens	2.02	0.66	30	11.64
Rubus spp.	0.32	0.66	16	4.92
Desmodium nudiflorum	0.41	0.38	7	2.94
Oryzopsis asperifolia	0.19	0.44	9	2.90
Solidago sp.	0.22	0.24	10	2.84
Danthonia spicata	0.41	0.23	2	1.73
Epifagus virginiana	0.33	0.40	1	1.63
Maianthemum canadense	0.08	0.05	5	1.23
Aralia nudicaulis	0.07	0.25	2	0.96
Comptonia perigrina	0.06	0.13	3	0.93
Epigaea repens	0.07	0.04	3	0.81
Corallorhiza odontorhiza	0.04	0.02	2	0.47

the young aspens. In the upland forest the combined shade of the canopy vegetation and Pteridium fronds greatly affects the ground layer vegetation. Only the most shade tolerant plants such as mosses, Carex pensylvanica and seedlings of red maple, sugar maple and beech can survive under these conditions.

Vaccinium angustifolium, a small shrubby plant, is third in importance (11.78) while Gaultheria procumbens is a close fourth (11.64). Gaultheria is often found in rotting pine stumps in the forest. It would be interesting to calculate its importance in the "stump flora" of the Manistee National Forest.

Danthonia spicata, with an importance value of 1.73 in the forest, becomes dominant in many grassy openings. It often occurs with Carex pensylvanica and Comptonia perigrina in these openings. It is also common in clear-cut areas.

These and the other species listed in Table 11 are important constituents of the herbaceous or seedling layer of the upland forest. They are, of course, in competition with tree seedlings and undoubtedly affect seedling mortality rates. Many species, such as Pteridium, Carex and Gaultheria are nearly ubiquitous throughout the study area.

The drier soils of the upland forest are noticeably lacking in the spring "wildflowers" characteristic of beech-maple forests of southern Michigan. These plants are present in swamps and low moist ground in the study area. A beech-maple forest in Section 21, 1 km southwest of the study area, supports a rich vernal flora. Many species common to southern Michigan such as Trillium grandiflorum, Dicentra spp., Dentaria spp., Caulophyllum thalictroides, Uvularia grandiflora, etc. are all common in this 16 hectare woodlot. A notable exception is Claytonia virginica which is extremely common in southern Michigan woodlots but does not occur in this one. It does occur in Crystal Township, Section 4, 4.8 km to the north. The more northern Claytonia caroliniana is extremely common in the Section 21 woodlot. This species is not found south of the tension zone (Voss, 1968) in Michigan. Voss reported finding a mixed population of the two species in a woodlot near Shelby, Michigan, 19 km southwest of the study area. Since both occur within a short distance of each other in Crystal Township, mixed populations should be expected here as well. Further field collections may substantiate this claim.

It would be interesting to quantitatively study the isolated woodlots adjacent to the study area to determine floristic variations between these and the study area. It is expected that the data presented in this paper will aid other researchers in performing such quantitative comparisons.

In summary, the Manistee National Forest study area has been shown to be a Quercus rubra-dominated forest, approximately 75 years old, secondarily derived from a dense white pine forest. Associated species are Populus grandidentata, Acer rubrum, Pinus strobus, Quercus alba and Fagus grandifolia.

The seedling/herbaceous layer is dominated by Carex pensylvanica, Pteridium aquilinum, Acer rubrum, Quercus rubra, Viburnum acerifolium, Quercus alba and Sassafras albidum. The sapling/shrub layer is dominated by Acer rubrum with Sassafras albidum, Viburnum acerifolium, Amelanchier spp., Quercus alba and Fagus grandifolia well represented. The percentage of oak seedlings that reach the sapling stage is much less than that for beech maple. However, due to the preponderance of sexually mature oaks, it will be some time before the oak seedlings and saplings are dominated by those of beech and sugar maple.

What is the expected climax association for the Manistee National Forest? It is thought by several workers that the ultimate climax is a beech-maple dominated association in this area (Whitford, 1901; Quick, 1923; Clayberg, 1930; Braun, 1950; Elliott, 1953; Maycock and Curtis, 1960). As pointed out by Clayberg (1930), Graham (1941), Parmelee (1953), and Maycock and Curtis (1960), this climax may be more hypothetical than real. In northern forests large scale catastrophe (fire, windthrow, insect infestation, etc.) is prevalent and prevents succession from reaching the climax stage. Local disturbance, edaphic factors and microclimatic conditions tend to favor one or another forest types, resulting in a mosaic of "climax" associations in northern Michigan (Maycock and Curtis, 1960). These authors believe the diverse forest types of Michigan represent a vegetational continuum from deciduous hardwood forest in the south to coniferous in the north. They have observed (p. 31) that "no group of species occupies a center of action to the exclusion of all other groups". A particular assemblage of species is the result of a variety of environmental factors. The codominant taxa occur in varying proportions as a result of their different but overlapping ecological adaptations. The assemblage of species on more mesic sites, for instance, will naturally differ in the relative amounts of each species than those on more xeric sites. Parmelee (1953) states that it is not the species present as much as the relative amount of each which characterizes the climax forest. As Parmelee (1953) and Harvey (1919) contend, oak upland forests are the stable, mature "climax" forest type on the sites where they are found. Parmelee, in particular, maintains that since oak forests in southern Michigan have been able to perpetuate themselves since the pine era, their ability to maintain themselves indefinitely is clearly attested.

This is also true for the Manistee National Forest study area. On those sites which presently support an oak association, the oaks should continue to be dominant. Red oak, the dominant tree today, was important in the presettlement forest of 1838 (Table 1). After release from competition with the pines, red oak was better adapted to the resulting environmental conditions than sugar maple or beech and hence assumed dominance at this site. This is not to say that beech and maple are not capable of being climax dominants in this region. Whitford (1901), Elliott (1953) and Overlease and Overlease (1976) have shown that beech-maple forests are common in northern Michigan; therefore, the climate can support such a forest type. However, given the soil type and past history of the study area, a beech-maple dominance is not favored here. The apparent low reproductive ability of the oaks compared to red maple, sugar maple and beech obviously does not preclude them from successful competition. Parmelee (1953) observed the same phenomenon in his southern Michigan oak forests, but as stated earlier, he has demonstrated the ability of _Quercus_ to maintain its dominance indefinitely. Based on these facts, and in light of the selective cutting and clear-cutting operations now underway in the study area, I predict a continued red oak dominated association as the climax forest type of this area.

LIFE FORM SPECTRUM

A spectral analysis of the vegetation of the Manistee National Forest study area was performed after the treatments outlined in Thieret (1977), Buell and Wilbur (1948), McDonald (1937) and Raunkiaer (1934).

The classification of life forms follows that of Raunkiaer (1934). His system is based on the position of the perennating buds. Raunkiaer found that the proportion of plants with their buds near or below the surface of the ground increases with progressively drier or colder conditions. Briefly defined, his life form classification consists of five main groups: Phanerophytes (Ph) bear their perennating buds at least 25 centimeters above the soil surface. Trees, shrubs and most vines would be placed in this catagory. Chamaephytes (Ch) bear their buds above the soil surface but lower than 25 centimeters. Chamaephytes are usually low or trailing woody plants and are common in boreal floras. The herbaceous plants of the Manistee National Forest fall into the last three catagories. Those whose perennating buds are at or in the soil surface are Hemicrypotophytes (H). Cryptophytes (Cr) bear their buds well below the soil surface, and Therophytes (Th) are annuals, which bear their perennating buds in seeds.

To determine the life form spectrum of the study area a checklist was made of all the species (native and introduced) collected and identified in the flora. Each species was then assigned to a particular life form based on the treatments of Buell and Wilbur (1948), McDonald (1937) and Gibson (1963). When certain species were not included in these treatments it was necessary to consult the standard manuals (e.g. Gleason and Cronquist, 1963) for species descriptions in order to assign them to a particular life form. The percentage of the total flora was then calculated for each life form catagory. These data are presented in Table 12, along with the spectra for other areas in North America for comparison.

Raunkiaer (1934) recognized four types of phytoclimate: phanerophytic, chamaephytic, hemicryptophytic and therophytic. He did not recognize a cryptophytic phytoclimate since cryptophytes are not characteristic of any one area. He devised the "Normal Spectrum" (Ph 46, Ch 9, H 26, Cr 6, Th 13) which is based on 1,000 randomly-selected species of the world's flora. He suggested that every regional life-form spectrum has at least one life-form class with a percentage significantly higher than that of the normal spectrum. The Manistee National Forest spectrum (Ph 16, Ch 4, H 53, Cr 20, Th 7) has a hemicryptophytic percentage about double that of normal, indicating a hemicryptophytic phytoclimate characteristic of temperate grasslands and deciduous forests. The cryptophytic percentage is more than three times that of normal, but since Raunkiaer did not recognize such a phytoclimatic classification, the present floral spectrum cannot be assigned to this class.

In conclusion, the flora of the Manistee National Forest study area is similar in its life form spectrum and phytoclimate to that of other areas in eastern North America. The higher percentage of chamaephytes would suggest a slight affiliation with the boreal flora to the north.

TABLE 12. Life-form spectrum for the Manistee National Forest study area, the Normal Spectrum and the spectra for other selected areas in North America (after Thieret, 1977).

	Ph	Ch	H	Cr	Th
Normal Spectrum (Raunkiaer, 1934)	46.0	9.0	26.0	6.0	13.0
Manistee National Forest (This paper)	16.3	3.8	52.6	20.3	7.0
Michigan (Thieret, 1977)	14.2	2.2	51.6	22.1	9.2
Kentucky (Gibson, 1963)	17.6	1.4	52.6	16.6	11.8
Indiana (McDonald, 1937)	15.3	1.7	50.3	19.6	13.0
Illinois (Hansen, 1952)	15.5	1.6	50.2	19.8	12.9
Iowa (McDonald, 1937)	14.8	1.0	48.6	20.9	14.2
Minnesota (Thieret, 1967)	13.0	3.0	49.0	22.0	13.0
Southern District of Mackenzie (Thieret, 1963)	11.9	7.7	55.7	18.7	5.1

CHECKLIST OF VASCULAR PLANTS

The following checklist of vascular plants represents specimens collected within the area shown in Figure 1. All collection numbers cited represent Timothy S. Mustard specimens deposited in the Beal-Darlington Herbarium of Michigan State University.

Three taxa cited in this checklist were observed in the study area but are not represented by voucher specimens. These are *Phytolacca americana*, *Scirpus cyperinus* and *Habenaria lacera*.

The terms relating to abundance follow those of Voss (1972, P. 24). They are defined as follows:

> Rare: occurring in small numbers wherever found and often absent in the expected habitats.
> Local: occurring in a very restricted habitat or region, but may be common when found.
> Occassional: Sporadic in occurrence throughout the region.
> Frequent: intermediate in abundance between occasional and common; likely to be found if one looks for it.
> Common: widespread and reasonably plentiful throughout its range in appropriate habitats, where easily found.
> Abundant: very common, likely to form dense stands.

The flowering dates indicated for some species represent the earliest flowering date supported by the voucher specimens. It is expected that such a listing of specific flowering dates will aid future workers in making additional collections in the Manistee National Forest.

The systematic arrangement of plant families is as follows: Pteridophytes and Gymnosperm higher taxa, Cronquist et al. (1966); Angiosperms, Cronquist (1968); genera and species of each family are arranged alphabetically.

Nomenclature for the pteridophytes and dicotyledons is according to Gleason and Cronquist (1963), except where otherwise noted.

That for gymnosperms and monocotyledons is according to Voss (1972).

The checklist includes 77 families, 220 genera and 364 species. Of this number 309 species are native, 54 are introduced and one is planted.

According to Beaman (1970), 151 vascular plant families occur in Michigan. The study area has 51 percent of the total families represented. Over 10 percent of the species of vascular plants present in Michigan are found in this area.

The four largest families are Asteraceae with 26 genera and 42 species, Poaceae with 23 genera and 38 species, Cyperaceae with 5 genera and 27 species and Rosaceae with 11 genera and 21 species. The largest genus is *Carex* with 21 species. Five other genera have five or more species. These are *Viola* (7), *Solidago* (6), *Panicum* (6), *Polygonum* (6) and *Aster* (5).

Three plants, all grasses, are especially noteworthy because of their range extensions into the study area. *Cynosurus echinatus* L. has only been collected once before in Michigan, near Kalamazoo (Stephenson, 1967). *Paspalum ciliatifolium* Michx. has not, to my knowledge, been collected north of Kent County. This collection extends the known range of *Paspalum* approximately 100 km northward. The third grass, *Agrostis hyemalis* (Walter) BSP. var. *tenuis* (Tuck.) Gleason f. *setigera* (Fern.) E. Voss, is well represented in Michigan's Upper Peninsula (Voss, 1972). It has previously been known to occur only in Mecosta County in the northern Lower Peninsula.

These documented range extensions show the need for further botanical collecting in the Manistee National Forest.

Lycopodiophyta
Lycopodiales

LYCOPODIACEAE

Lycopodium clavatum L. 834. Local, occurring in small colonies throughout the upland forest.

Lycopodium lucidulum Michx. 717. Occasional in cedar swamps.

Lycopodium obscurum L. 322. Occasional in cedar swamps.

Lycopodium tristachyum Pursh. 566, 816. Frequent in open areas of the upland forests.

Equisetophyta
Equisetales

EQUISETACEAE

Equisetum arvense L. 636b. Locally abundant in an open swamp along Crystal Creek.

Equisetum hyemale L. 636a. Locally abundant in an open swamp along Crystal Creek.

Equisetum scirpoides Michx. 947, 1015. Frequent in cedar swamps, occasional in clear-cut areas.

Polypodiophyta
Ophioglossales

OPHIOGLOSSACEAE

Botrychium multifidum (Gmel.) Rupr. 891. Rare, one plant was found in an open wooded habitat in Section 11, Crystal Township.

Botrychium virginianum (L.) Sw. 452, 461. Local, in cedar swamps.

Filicales

OSMUNDACEAE

Osmunda cinnamomea L. 463. Common in wet open swamps.

Osmunda claytoniana L. 316. Local, in open cedar swamps.

Osmunda regalis L. var. spectabilis (Willd.) Gray. 522. Occasional in open swamps.

POLYPODIACEAE

Adiantum pedatum L. 315. Occasional in cedar swamps.

Athyrium filix-femina (L.) Roth. var. michauxii Mett. 405, 521. Occasional in open swamps.

Gymnocarpium dryopteris (L.) Newm. 468. Occasional in cedar swmaps.

Matteuccia struthiopteris (L.) Todaro var. pensylvanica (Willd.) Mort. 1003. Rare, a small population occurs in the floodplain of the North Branch of the Pentwater River.

Onoclea sensibilis L. 496. Common in wet soil throughout the study area.

Polystichum acrostichoides (Michx.) Schott. 495. Occasional in cedar swamps.

Pteridium aquilinum (L.) Kuhn. 474. Abundant throughout the upland forest, especially in clearings. The dominant herbaceous plant of the forest.

Thelypteris hexagonoptera (Michx.) Weatherby. 529. Rare, a small population occurs in an open area of a cedar swamp in Section 14, Crystal Township.

Thelypteris noveboracensis (L.) Nieuwl. 383. Local in distribution. A large population of several hundred individuals occurs in an open area of a cedar swamp in Section 14, Crystal Township.

Pinophyta
Coniferales

PINACEAE

Picea pungens Engelm. 927. A small plantation occurs around a woodland marsh in the northwestern corner of Section 12, Crystal Township.

Pinus resinosa Ait. 988. Occasional throughout the forest, commonly found in plantations established by the U. S. Forest Service.

Pinus strobus L. 669. Common throughout the upland forest. The dominant tree of the presettlement forest.

Tsuga canadensis (L.) Carr. 515. Common in cedar swamps, rare in the upland forest.

CUPRESSACEAE

Juniperus communis L. 819. Rare, two small shrubs were discovered at the base of a large red oak tree in Section 15, Crystal Township.

Thuja occidentalis L. 527. 637. Dominant tree in cedar swamps throughout the Manistee National Forest.

Magnoliophyta
Magnoliopsida
Magnoliidae
Magnoliales

LAURACEAE

Lindera benzoin (L.) Blume. 952 (flowering May 6.) Frequent in swamps and wet wooded habitats.

Sassafras albidum (Nutt.) Nees. 272 (flowering May 6), 670, 981. Abundant in the understory and seedling strata of the upland forest.

ARISTOLOCHIACEAE

Asarum canadense L. 313, 963 (flowering May 7). Local, in cedar swamps within the study area.

Nymphaeales

NYMPHAEACEAE

Nuphar advena (Ait.) Ait. f. 1038 (flowering June 15). Abundant in a large pond in Section 6, Colfax Township.

Ranunculales

RANUNCULACEAE

Anemone canadensis L. 996 (flowering June 9). Local, in open swamps in the study area.

Anemone quinquefolia L. var. interior Fern. 360, 959 (flowering May 6). Frequent in cedar swamps and moist areas of the forest.

Aquilegia canadensis L. 382 (flowering May 28). Common in open areas of the upland forest, especially in clear-cut tracts and along roadsides.

Caltha palustris L. 237, 457, 944 (flowering May 6). Locally abundant in open swamps and along streams.

Clematis virginiana L. 711 (flowering August 13). Common in open swamps.

Coptis trifolia (L.) Salisb. 301. Frequent in cedar swamps.

Hepatica acutiloba DC. 940, 945 (flowering May 6). Common in cedar swamps and moist areas of the forest.

Hepatica americana (DC.) Ker. 903 (flowering April 22). Occasional in cedar swamps.

Ranunculus abortivus L. 296 (flowering May 14). Rare, in open swamps.

Ranunculus recurvatus Poir. 297 (flowering May 14). Rare, one plant was discovered in an open swamp along Crystal Creek.

Ranunculus septentrionalis Poir. 289. Occasional in open swamps.

Thalictrum polygamum Muhl. 1001 (flowering June 9). Occasional in open swamps.

BERBERIDACEAE

Podophyllum peltatum L. 957. Rare, one population was discovered in a *Fagus*-*Acer rubrum* stand in moist sandy loam in Section 4, Crystal Township.

MENISPERMACEAE

Menispermum canadense L. 352, 1002. Occasional in open swamps and wet wooded habitats.

Hamamelidae
Hamamelidales

HAMAMELIDACEAE

Hamamelis virginiana L. 374, 582, 823 (flowering September 16). Frequent understory component in the upland forest.

Urticales

ULMACEAE

Ulmus americana L. 458, 679. Formerly common in swamps, now represented by a few young trees in open swamp forests.

URTICACEAE

Boehmeria cylindrica (L.) Sw. 738. Local, in swamps.

Laportea canadensis (L.) Wedd. 506, 710. Occasional in swamps and wet wooded habitats.

Pilea pumila (L.) Gray. 653 (flowering July 27). Rare, one small population was found along a shaded two track road in Section 1, Crystal Township.

Urtica dioica L. 739. Rare, a few plants occur in the dense floodplain of the North Branch of the Pentwater River.

Myricales

MYRICACEAE

Comptonia perigrina (L.) Coult.[1] 389, 986. Abundant in clearings and along roadsides throughout the forest.

Fagales

FAGACEAE

Fagus grandifolia Ehrh. 273 (flowering May 7), 393, 565. Common canopy member of the upland forest. Well represented in the seedling and sapling strata.

Quercus alba L. 783, 814. Common canopy tree of the upland forest. Well represented in the seedling and sapling strata.

Quercus rubra L.[2] 596, 597, 1023. Dominant canopy tree of the upland forest.

Quercus rubra L. var. borealis (Michx. f.) Farw. 523, 1022. Occasional in the canopy of the upland forest.

Quercus velutina Lam. 784, 872, 1202. Occasional in the canopy of the upland forest, probably hybridizing with the Q. rubra complex.

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[1]Sensu Fernald (1950), p. 525.

[2]Sensu Fernald (1950), p. 546.

BETULACEAE

Alnus incana (L.) Moench subsp. rugosa (Du Roi) Clausen[3]. 734, 920. Local, two populations were discovered in the study area, both at the edges of large ponds.

Betula alleghaniensis Britt.[4] 454. Frequently encountered in cedar swamps and in the floodplain of the North Branch of the Pentwater River.

Betula papyrifera Marsh. 953. Occasional in cedar swamps and in the Pentwater River floodplain. More common northward in the Manistee National Forest.

Carpinus caroliniana Walt. 282, 347. Very common in open areas of a cedar swamp in the southeastern corner of Section 15, Crystal Township.

Ostrya virginiana (Mill.) K. Koch. 317. Common in swamps, occasional in the upland forest of the study area.

Caryophyllidae
Caryophyllales

PHYTOLACCACEAE

Phytolacca americana L. Sight record. Occasional in open disturbed areas.

CARYOPHYLLACEAE

Cerastium vulgatum L. 306. Rare, growing in a moist thicket along Crystal Creek, Section 15, Crystal Township.

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[3]Sensu Furlow (1974). p. 324.

[4]Sensu Britton (1904), p. 166.

Dianthus armeria L. 483 (flowering June 17). Local, in disturbed grassy habitats.

Lychnis alba Mill. 440 (flowering June 11). Frequent in disturbed areas and along roads in the Manistee National Forest.

Saponaria officinalis L. 622 (flowering July 25). Frequent along roads in and around the Manistee National Forest.

Stellaria longifolia Muhl. 399 (flowering May 28). Rare, a few plants were found in an open disturbed area of a cedar swamp in Section 15, Crystal Township.

PORTULACACEAE

Claytonia virginica L. 942 (flowering May 6). Frequent in open swamps and wet soil in the study area. C. caroliniana Michx. (Mustard 938) was discovered 3 miles south of the C. virginica collection, outside of the study area. Voss (1968) reported finding mixed populations and possible hybrids of these taxa at Shelby, 19 km southwest of the study area. Although no mixed populations were discovered, they are to be expected in this region.

CHENOPODIACEAE

Chenopodium album L. 674. Common agricultural weed in Oceana county. Occasionally found in open sandy clearings and clear-cut areas in the Manistee National Forest.

Polygonales

POLYGONACEAE

Polygonum aviculare L. 858. Occasional in sandy openings and two-track roads.

Polygonum hydropiper L. 853. Frequent in cedar swamps.

<u>Polygonum hydropiperoides</u> Michx. <u>1195</u> (flowering July 29). Abundant in shallow water at the edge of a large pond in Section 6, Colfax Township.

<u>Polygonum persicaria</u> L. <u>723</u>. Occasional in disturbed grassy habitats.

<u>Polygonum punctatum</u> Ell. <u>741</u>. Frequent in the floodplain of the North Branch of the Pentwater River.

<u>Polygonum tenue</u> Michx. <u>116</u>. Occasional along roads in the study area.

<u>Rumex acetosella</u> L. <u>373</u>, <u>1055</u>. Frequent in a variety of habitats, from dry sandy soil to low wet ground.

<u>Rumex crispus</u> L. <u>365</u>. Occasional in open swamps and nearby fields.

<u>Rumex obtusifolius</u> L. <u>493</u>. <u>827</u>. Occasional in open swamps.

Dilleniidae
Theales

HYPERICACEAE

<u>Hypericum boreale</u> (Britt.) Bickn. <u>1189a</u> (flowering July 29). Common in a small woodland marsh, in Section 12, Crystal Township.

<u>Hypericum canadense</u> L. <u>1189b</u> (flowering July 29). Common in a small woodland marsh in Section 12, Crystal Township. It appears that this taxon and the above are hybridizing in this marsh. Further collections are needed to determine if this is true.

<u>Hypericum perforatum</u> L. <u>570</u> (flowering July 23). Common along roads, in sandy oil-well openings and other disturbed habitats.

<u>Hypericum punctatum</u> Lam. <u>652</u> (flowering July 27). Rare, a small population was discovered along a sandy two-track road in Section 1, Crystal Township.

Triadenum virginicum (L.) Raf. 732 (flowering August 14). Rare, a few plants were discovered growing in a bog-like habitat at the edge of a small pond in section 4, Crystal Township.

Malvales

TILIACEAE

Tilia americana L. 713, 1050. Occasional in open swamps and forests.

MALVACEAE

Malva moschata L. 877 (flowering September 23). Rare, growing at the border of a swamp and cornfield; Section 15, Crystal Township.

Violales

VIOLACEAE

Viola blanda Willd. 958 (flowering May 6). Occasional in wet open areas and in cedar swamps.

Viola cucullata Ait. 295 (flowering May 15). Frequent in cedar swamps.

Viola eriocarpa Schw. 293 (flowering May 14). Occasional in open swamps.

Viola lanceolata L. 1013 (flowering June 10). Common along the edge of a small woodland marsh in Section 12, Crystal Township.

Viola pubescens Ait. 983 (flowering May 20). Frequent in the upland forest.

Viola rostrata Pursh. 329 (flowering May 14). Occasional on dry shaded hillsides and swamp borders.

Viola sororia Willd. 967 (flowering May 20). Common in clear-cut tracts.

CISTACEAE

Helianthemum canadense (L.) Michx. 394 (flowering May 28). Common in sandy two-track roads and sandy clearings throughout the study area.

Salicales

SALICACEAE

Populus grandidentata Michx. 536, 1029. Dominant saplings in clear-cut areas. Common as a canopy tree in the upland forest.

Populus tremuloides Michx. 534, 638, 890, 1031. Common in clear-cut areas and open swamps.

Salix discolor Muhl. 955, 919 (flowering May 5), 930. Common in swamps and on the banks of streams and ponds.

Salix humilis Marsh. 292. Occasional in open swamps.

Capparales

BRASSICACEAE

Arabidopsis thaliana (L.) Heyn. 978 (flowering May 20), 989. Occasional in open sandy habitats.

Arabis drummondii Gray. 975 (flowering May 20), 1183. Occasional in open sandy habitats.

Barbarea vulgaris R.Br. 298 (flowering May 14). Occasionally found in open swamps. A common agricultural weed in Oceana County.

Berteroa incana (L.) DC. 443 (flowering June 11), 476, 998. Very common along USFS-5314 and other roads in the Manistee National Forest. Occasional in swamps.

Cardamine bulbosa (Schreb.) BSP. 278 (flowering May 7). Common in a wet meadow along Crystal Creek, in the southeastern corner of Section 15.

Dentaria diphylla Michx. 307 (flowering May 14), 993. Occasional in cedar swamps. D. laciniata Muhl. (Mustard 934) was not discovered in the study area, although it occurs 1 km southwest of the area in a beech-maple woodlot in Section 21, Crystal Township.

Lepidium campestre (L.) R. Br. 348. Rare, a few plants were discovered in a disturbed woodlot north of Elmwood School.

Rorippa islandica (Oeder) Borbas. 656 (flowering July 27). Rare, a small population was found along a sandy two-track road in Section 1 of Crystal Township.

Ericales

ERICACEAE

Chimaphila umbellata (L.) Bart. var. cisatlantica Blake. 568. Frequent on dry hillsides in the forest.

Epigaea repens L. 578, 921 (flowering May 5), 995. Occasional on dry hillsides in the forest.

Gaultheria procumbens L. 594, 1210 (flowering August 12). Abundant throughout the upland woods, clear-cut tracts and swamps. Frequent in decaying Pinus strobus stumps.

Monotropa hypopithys L. 471 (flowering June 16), 719, 776, 793, 1176. Frequent throughout the upland woods. Occasional in cedar swamps. Red and yellow forms observed.

Monotropa uniflora L. 581 (flowering July 23). Occasional in upland areas of the forest, more common in cedar swamps.

Pyrola virens Schweigg. 1177. Rare, a few plants were discovered in a clear-cut area in Section 3, Crystal Township in a dense Populus grandidentata stand.

Vaccinium angustifolium Ait. 434, 577, 972 (flowering May 20). Abundant throughout the upland forest, often forming dense colonies.

Primulales

PRIMULACEAE

Lysimachia ciliata L. 700, 742 (flowering August 14). Occasional in open swamps in the study area.

Lysimachia thyrsiflora L. 1040 (flowering June 15). Common along the edge of a large pond in Section 6, Colfax Township.

Trientalis borealis Raf. 311 (flowering May 14). Occasional in cedar swamps.

Rosidae
Rosales

GROSSULARIACEAE

Ribes cynosbati L. 359. Rare, a few plants occur along Crystal Creek.

SAXIFRAGACEAE

Chrysoplenium americanum Schw. 400 (flowering May 28). Abundant in wet, open cedar swamps.

Mitella diphylla L. 305 (flowering May 14), 381. Common in cedar swamps.

Parnassia glauca Raf. 730 (flowering August 14). Rare, a small population was discovered in a small bog-like pond in Section 4, Crystal Township.

Tiarella cordifolia L. 277 (flowering May 7), 369, 990. Common in cedar swamps.

ROSACEAE

Agrimonia gryposepala Wallr. 513, 519 (flowering July 2). Occasional in open swamps.

Amelanchier arborea (Michx. f.) Fern. 374, 616, 833, 976. Frequent in the understory of the upland forest.

Amelanchier laevis Weig. 987 (flowering May 20). Rare, one tree was discovered along a road in the study area.

Amelanchier sanguinea (Pursh) DC. 642. Rare, one tree was discovered in the understory of the upland forest.

Amelanchier spicata (Lam.) K. Koch. 956 (flowering May 6), 1032. Rare in the oak-dominated uplands.

Crataegus mollis (T. & G.) Scheele. 283, 722. Occasional in dry open areas of the forest.

Fragaria virginiana Duchesne. 361, 966 (flowering May 20). Common in clear-cut areas and open sunny spots in the forest.

Geum allepicum Jacq. var. strictum (Ait.) Fern. 479. Occasional in wet open swamps.

Geum canadense Jacq. 488 (flowering June 17), 491, 600. Frequent in cedar swamps and wet open ground.

Geum rivale L. 401 (flowering May 28). Local in open cedar swamps.

Physocarpus opulifolius (L.) Maxim. 743. Common in the large floodplain along the North Branch of the Pentwater River.

Potentilla argentea L. 467 (flowering June 14), 1037. Frequent in open sandy ground and along roads.

Potentilla recta L. 477 (flowering June 17). Frequent in disturbed areas in the forest.

Potentilla simplex Michx. 364 (flowering May 27). Frequent in open shaded swamps.

Prunus serotina Ehrh. 281, 508, 640. Occasional canopy tree in the upland forest, more common in the seedling/sapling layers.

Rosa blanda Ait. 402 (flowering May 28). Rare, a few shrubs occur at the edge of an open swamp in Section 15, Crystal Township.

Rubus allegheniensis Porter. 345 (flowering May 27), 573. Abundant along roads and in abandoned oil-well clearings throughout the forest.

Rubus flagellaris L. 1046 (flowering June 15). Local, in dry openings in the forest.

Rubus pubescens Raf. 310 (flowering May 14), 451. Frequent in cedar swamps, especially near springs.

Rubus strigosus Michx. 456 (flowering June 13), 512, 735. Local, in moist or dry open habitats.

Spiraea alba DuRoi. 736 (flowering August 14). Occasional in moist open areas and roadside ditches.

FABACEAE

Amphicarpa bracteata (L.) Fern. 708. Locally abundant in an open swamp along Crystal Creek.

Desmodium nudiflorum (L.) DC. 589, 790. Common throughout upland areas of the forest, often becoming abundant in clear-cut tracts.

Desmodium paniculatum (L.) DC. 590, 590a. Common in clear-cut areas and along roadsides in the study area. This and the above species may be hybridizing in clear-cut tracts (Mustard 590a).

Lespedeza hirta (L.) Hornem. 614, 788. Common along roads and in sandy clearings throughout the forest.

Lespedeza intermedia (Wats.) Britt. 659 (flowering July 27). Rare, a small population was discovered along a sandy two-track road in Section 1, Crystal Township.

Medicago lupulina L. 403. Frequent in disturbed areas throughout the study area.

Melilotus alba Desr. 812. Common along roads and in other disturbed habitats.

Trifolium hybridum L. 1054. Rare, in the floodplain of the North Branch of the Pentwater River.

Trifolium pratense L. 441. Common along roads and in clearings throughout the Manistee National Forest study area.

Vicia cracca L. 469, 572, 703. Frequent on dry open hillsides and in sandy openings throughout the study area.

ONAGRACEAE

Circaea alpina L. 406 (flowering May 29), 531. Frequent in open swamps.

Epilobium ciliatum Raf. 563 (flowering July 23), 695, 850, 1214. Occasional in wet swamps.

Oenothera biennis L. 598 (flowering July 14). Occasional in swamps, clearings and roadsides.

Celastrales

AQUIFOLIACEAE

Ilex verticillata (L.) Gray var. verticillata. 505 (flowering July 2), 687. Rare, in a disturbed swamp north of Elmwood School.

Euphorbiales

EUPHORBIACEAE

Euphorbia maculata L. 1207. Abundant in a sandy two-track road in a clear-cut area in Section 9, Crystal Township.

Rhamnales

RHAMNACEAE

Ceanothus americanus L. 668, 1180 (flowering July 29). Abundant in a clear-cut tract in Section 9, Crystal Township. Occasional in the upland forest.

VITACEAE

Parthenocissus quinquefolia (L.) Planch. 509, 530. Common vine of open swamps.

Vitis aestivalis Michx. 539, 784. Occasional vine in the upland forest.

Vitis vulpina L. 1051 (flowering June 16). Occasional in the floodplain of the North Branch of the Pentwater River.

Sapindales

ACERACEAE

Acer rubrum L. 466, 649, 926. Very common canopy member of the upland forest. Common also in the seedling and sapling strata.

Acer saccharinum L. 629. Rare, reaching its northern distribution in the Manistee National Forest.

Acer spicatum Lam. 321. Rare, in cedar swamps.

ANACARDIACEAE

Rhus copallina L. 486. Common on dry open hillsides in the forest.

Rhus typhina L. 680. Common along the borders of the forest and in open disturbed fields.

Toxicodendron radicans (L.) Kuntze. 696. Abundant in an open swamp along Crystal Creek. Specifically the taxon in the study area is T. radicans ssp. negundo (Greene) Gillis.[5] According to Dr. W. T. Gillis (personal communication) my specimen shows characteristics of the more northern T. rydbergii (Small ex Rydb.) Greene, indicating an exchange of genes between the two taxa in the tension zone of Michigan.

Geraniales

OXALIDACEAE

Oxalis stricta L. 475 (flowering June 17), 658. In open woods and along roads in the study area.

GERANIACEAE

Geranium robertianum L. 995 (flowering June 9). Rare, in the flood-plain of the North Branch of the Pentwater River.

BALSAMINACEAE

Impatiens biflora Walt. 560. (flowering July 23). Abundant in wet swamps and along streams throughout the study area.

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[5]Sensu W. T. Gillis (1971), p. 228.

Polygalales

POLYGALACEAE

Polygala paucifolia Willd. 275. (flowering May 7). Common in cedar swamps and moist habitats in the forest.

Umbellales

ARALIACEAE

Aralia nudicaulis L. 319. Frequent in cedar swamps, less common in the upland forest.

Panax trifolium L. 274 (flowering May 7). Rare, in cedar swamps.

APIACEAE

Cicuta maculata L. 740. Rare in the floodplain of the North Branch of the Pentwater River.

Cryptotaenia canadensis (L.) DC. 351, 489. Common in swamps throughout the study area.

Daucus carota L. 558. Common along roadsides and in open fields, in the study area.

Pastinaca sativa L. 1035. Occasional in wet open habitats.

Sanicula marilandica L. 376. Occasional in cedar swamps.

Asteridae
Gentianales

GENTIANACEAE

Gentiana andrewsii Griseb. 775 (flowering September 4). Locally abundant in open swamps.

APOCYNACEAE

Apocynum androsaemifolium L. 482 (flowering June 17). Occasional in disturbed areas and along fence rows, usually occurring with Rhus typhina.

ASCLEPIADACEAE

Asclepias incarnata L. 516 (flowering July 2), 702. Frequent in open swamps and meadows.

Asclepias syriaca L. 725. Common along roads and in sandy openings throughout the forest.

Asclepias tuberosa L. 1179 (flowering July 15). Common along USFS-5314 and other roads in the forest.

Polemoniales

SOLANACEAE

Physalis heterophylla Nees. 571 (flowering July 23). Common on dry open hillsides and in abandoned oil-well openings.

Solanum carolinense L. 747 (flowering August 14). Frequent in Comptonia openings and in open, dry sandy habitats.

Solanum dulcamara L. 366, 497 (flowering June 17). Common in open swamps and low wet ground.

HYDROPHYLLACEAE

Hydrophyllum virginianum L. 349 (flowering May 27). Rare in swamps and wet woods.

Lamiales

BORAGINACEAE

Cynoglossum officinale L. 1014 (flowering June 10). Rare, one population was discovered in a clear-cut area in Section 10, Crystal Township.

Echium vulgare L. 1184 (flowering July 29). Common in clear-cut areas, sandy two-track roads and in sandy openings throughout the Manistee National Forest.

VERBENACEAE

Verbena hastata L. 559. Common in open swamps and along streams, usually in full sun.

Verbena urticifolia L. 748. Occasional in the floodplain of the North Branch of the Pentwater River.

PHRYMACEAE

Phryma leptostachya L. 609 (flowering July 24). Occasional in swamps.

LAMIACEAE

Leonurus cardiaca L. 829. Rare in the study area; a few plants were found along the edge of a swamp in Section 15, Crystal Township.

Lycopus americanus Muhl. 599 (flowering July 24). Abundant in open swamps.

Lycopus uniflorus Michx. 1188 (flowering July 29). Common along the edge of a small woodland marsh.

Mentha arvensis L. 602 (flowering July 24), 1215. Abundant in open swamps.

Mentha piperita L. 821 (flowering September 16). Rare, a flourishing population occurs in and along Crystal Creek in Section 15, Crystal Township.

Monarda fistulosa L. 1200 (flowering July 29). Occasional in open habitats in the forest.

Monarda punctata L. var. villicaulis Penn. 569 (flowering July 23). Common in sandy openings and along roads throughout the study area.

Prunella vulgaris L. 487 (flowering June 17), 514, 654. Common in swamps, less frequent in shaded areas of the upland forest.

Satureja vulgaris (L.) Fritsch. 481 (flowering June 17), 524, 557. Common in open swamps.

Scutellaria lateriflora L. 564 (flowering July 23). Occasional in cedar swamps.

Plantaginales

PLANTAGINACEAE

Plantago lanceolata L. 625 (flowering July 26). Rare in the study area. Common in nearby lawns and fields.

Scrophulariales

OLEACEAE

Fraxinus americana L. 444, 643, 697, 808, 954. Occasional in swamps and in the canopy layer of the upland forest; more frequent in the seedling and sapling strata.

SCROPHULARIACEAE

Chelone glabra L. 631 (flowering July 26), 721. Frequent in wet open habitats.

Melampyrum lineare Desr. var. americanum (Michx.) Beauv. 539. Common throughout the upland forest.

Melampyrum lineare Desr. var. lineare. 624. Frequent in the upland forest.

Pedicularis canadensis L. 438, 968 (flowering May 20). Common in clear-cut tracts and open forested areas.

Verbascum blattaria L. 1201 (flowering July 29). Occasional in dry open habitats in the forest.

Verbascum thapsus L. 1185 (flowering July 29). Frequent along roads and in open sandy habitats.

Veronica americana (Raf.) Schw. 409 (flowering May 29). Local, in shallow water or muddy habitats in swamps.

Veronica arvensis L. 478, 979 (flowering May 20). Occasional in clear-cut areas and other disturbed sites in the forest.

Veronica serpyllifolia L. 299. Rare, a small population was discovered in a swamp in Section 15, Crystal Township.

OROBANCHACEAE

Conopholis americana (L.) Wallr. 1021 (flowering June 12). Occasional throughout the upland forest.

Epifagus virginiana (L.) Bart. 794, 795 (flowering September 16). Frequent throughout the upland forest where it is parasitic on Fagus grandifolia.

LENTIBULARIACEAE

Utricularia vulgaris L. 1045 (flowering June 15). Common in shallow water in a large pond in Section 6, Colfax Township.

Campanulales

CAMPANULACEAE

Lobelia cardinalis L. 729 (flowering August 14). Local, in wet mucky soil.

Lobelia kalmii L. 733 (flowering August 14). Rare, a few plants were collected at the edge of a small pond in Section 4, Crystal Township.

Lobelia siphilitica L. 610 (flowering July 24), 852. Occasional in cedar swamps.

Rubiales

RUBIACEAE

Galium aparine L. var. echinospermum (Wallr.) Farw. 350. Occasional in a moist disturbed woodlot north of Elmwood School.

Galium pilosum Ait. 1178 (flowering July 29), 1181. Frequent in dry open areas, especially in clear-cut tracts, in the forest.

Galium trifidum L. var. tinctorium (L.) T. & G. 1043, 1194. Common along the edges of ponds and marshes.

Galium triflorum Michx. var. triflorum. 372, 490, 634. Frequent in cedar swamps.

Mitchella repens L. 424, 459 (flowering June 13). Common in cedar swamps and moist areas in the forest.

Dipsacales

CAPRIFOLIACEAE

Lonicera sp. 464. Rare, one sterile plant was discovered in a cedar swamp in Section 15, Crystal Township.

Sambucus canadensis L. var. canadensis. 507. Common in low, wet, open ground.

Symphoricarpos albus (L.) Blake var. albus. 621. Rare, one small colony was discovered on a north facing shaded slope near the Crystal Lookout Tower.

Viburnum acerifolium L. 537. Abundant shrub throughout the upland forest area. Dominant in some localities.

Viburnum lentago L. 287, 626. Frequent shrub of open swamps and low wet ground.

Viburnum opulus L. var. americanum Ait. 997. Common shrub in the floodplain of the North Branch of the Pentwater River.

Asterales

ASTERACEAE

Achillea millefolium L. 511. Common along roads and in clearings throughout the forest.

Ambrosia artemisiifolia L. 675 (flowering August 13), 811. Frequent in clear-cut tracts and sandy openings in the forest.

Antennaria neglecta Greene var. attenuata (Fern.) Cronq. 271, 974, 994. Common along roads, in sandy clearings and in clear-cut tracts. Occasional in the forest.

Artemisia campestris L. 705, 818. Frequent on dry open hillsides in the forest.

Arctium minus Schk. 709. Frequent in sandy clearings and occasionally found in open swamps.

Aster laevis L. 777 (flowering September 16). Occasional in open sandy habitats.

Aster lateriflorus (L.) Britt. 632, 689. Common in cedar swamps and moist areas of the forest.

Aster puniceus L. 707 (flowering August 13), 826. Occasional in low wet ground.

Aster sagittifolius Willd. 780 (flowering September 16). Common in open swamps, in clear-cut areas and along roads in dry sand.

Aster simplex Willd. var. ramosissimus (T. & G.) Cronq. 693, 822. Common in mucky sand along Crystal Creek.

Bidens cernua L. 706. Rare, a small population was discovered in an open swamp along Crystal Creek.

Centaurea maculosa Lam. 613. Common in dry sandy openings and along roads throughout the forest.

Chondrilla juncea L. 1212 (flowering August 12). Common along USFS-5314, in dry sand with open exposure.

Chrysanthemum leucanthemum L. 355, 1030. Frequent along roads and in sandy openings in the Manistee National Forest.

Cichorium intybus L. 1182. Common along roads throughout the forest.

Cirsium arvense (L.) Scop. 561. Local, in low wet ground.

Cirsium vulgare (Savi) Tenore. 691. Local, in wet open swamps.

Erigeron philadelphicus L. 480, 504, 657. Common along roads and in dry disturbed areas of the forest.

Erigeron strigosus Muhl. 801, 810. Occasional along roads and in openings.

Eupatorium maculatum L. 604, 712, 1206. Abundant in low wet ground.

Eupatorium perfoliatum L. 603. Abundant in low wet ground.

Eupatorium rugosum Houtt. 608. Common in cedar swamps.

Gnaphalium obtusifolium L. 682. Occasional in disturbed open habitats.

Helianthus divaricatus L. 619, 671. Abundant along roads in the forest.

Hieracium aurantiacum L. 701. Common in sandy openings and clear-cut tracts.

Hieracium pratense Tausch. 354, 388, 718, 857. Abundant in sandy roads and clearings throughout the forest.

Krigia virginica (L.) Willd. 395, 1028. Occasional in sandy clearings and two-track roads.

Lactuca biennis (Moench) Fern. 690. Rare, one plant was collected in a disturbed portion of the woods north of Elmwood School.

Lactuca canadensis L. 620 (flowering July 25). Rare, one plant was collected along USFS-5314.

Matricaria matricarioides (Less.) Porter. 446. Occasional in open sandy spots in clear-cut tracts.

Prenanthes alba L. 831. Occasional along roads.

Prenanthes altissima L. 778. Rare, one plant was collected in the oak-dominated uplands.

Rudbeckia hirta L. 746. Occasional along roads in the study area.

Senecio obovatus Muhl. 380. Common in cedar swamps, usually around springs.

Solidago caesia L. 792. Occasional along shaded roads and in openings in the forest.

Solidago canadensis L. 676. Common along roads and in open habitats.

Solidago flexicaulis L. 611. Occasional in open swamps and marshes.

Solidago graminifolia (L.) Salisb. 627, 699. Common in an open swamp along Crystal Creek.

Solidago puberula Nutt. 684. Occasional in open sunny habitats.

Solidago rugosa Mill. 686, 698. Frequent in open moist habitats.

Taraxacum officinale Weber. 828, 969. Frequent in clear-cut tracts and dry sandy openings in the forest.

Tragopogon dubius Scop. 439 (flowering June 11). Common along roads and in sandy openings throughout the study area.

Liliopsida
Alismatidae

POTAMOGETONACEAE

Potamogeton natans L. 1044. Common in a large pond in Section 6, Colfax Township.

Commelinidae
Juncales

JUNCACEAE

Juncus brevicaudatus (Engelm.) Fern. 1199 (flowering July 29). Rare, several plants were collected at the edge of a woodland marsh.

Juncus effusus L. 543. Common in open swamps and marshes.

Juncus tenuis Willd. 661, 745, 1186. Common in sandy clearings and sandy two-track roads.

Cyperales

CYPERACEAE

Carex annectens (Bickn.) Bickn. 518. Frequent in an open swamp along Crystal Creek.

Carex bromoides Willd. 291. Occasional in an open swamp along Crystal Creek.

Carex cephalophora Willd. 358. Occasional in open moist woods.

Carex cristatella Britt. 520. Occasional in an open swamp along Crystal Creek.

Carex digitalis Willd. 580. Occasional in moist habitats in the forest.

Carex hystericina Willd. 407. Frequent in open swamps.

Carex interior Bailey. 1041. Common cespitose sedge in a wet cedar swamp, Section 6, Colfax Township.

Carex intumescens Rudge. 854. Frequent in cedar swamps.

Carex lasiocarpa Ehrh. 1011. Common in a small woodland marsh.

Carex laxiflora Lam. 357. Frequent in an open swamp along Crystal Creek.

Carex leptonervia Fern. 303. Occasional in open swamps.

Carex lupulina Willd. 377. Common in open cedar swamps.

Carex muhlenbergii Willd. 1027. Rare, a few plants were collected in a sandy two-track road in a clear-cut tract.

Carex ormostachya Wieg. 494. Occasional in cedar swamps.

Carex pensylvanica Lam. 922, 984. Abundant throughout the study area, becoming dominant in open clearings and late successional marshes.

Carex plantaginea Lam. 950. Frequent in swamps and other moist habitats.

Carex rosea Willd. 356. Rare, in moist open woods north of Elmwood School.

Carex rugosperma Mack. 398. Rare, one population was discovered in a sandy oil-well clearing.

Carex scoparia Willd. 1190, 1217. Abundant in a small woodland marsh and in the Pentwater River floodplain.

Carex stipata Willd. 290, 346. Common in an open swamp along Crystal Creek.

Carex vulpinoidea Michx. 1216. Frequent in the swamp forest along the North Branch of the Pentwater River.

Cyperus filiculmis Vahl. 1187. Rare, a few plants were collected in a sandy two-track road.

Cyperus schweinitzii Torr. 809. Rare, a few plants were collected along Hammett road at the edge of the forest.

Dulichium arundinaceum (L.) Britt. 1039, 1196. Frequent at the edge of a large pond in Section 6, Colfax Township.

Eleocharis smallii Britt. 1012, 1193. Abundant in a small woodland marsh.

Scirpus atrovirens Willd. 485, 542. Common in open swamps.

Scirpus cyperinus (L.) Kunth. Sight record. Occasional in open swamps.

POACEAE

Agropyron repens (L.) Beauv. 673, 803. Occasional in sandy openings in the forest.

Agropyron trachycaulum (Link) Malte. 787, 1175. Frequent in clear-cut areas, less common in the forest.

Agrostis gigantea Roth. 540, 683. Frequent in open sandy habitats in the forest.

Agrostis hyemalis (Walter) BSP. var. tenuis (Tuck.) Gleason. 799, 804, 1192. Local, in open sandy habitats. In addition to the above taxon, the form setigera (Fern.) E. Voss [Mustard 1192], was collected within the study area 29 July 1978. This form, which bears a slender awn from the back of the lemma, is well represented in Michigan's Upper Peninsula. Voss (1972) states that this form is known from Isle Royale, the Keweenaw peninsula and Marquette County. The only known collections of A. hyemalis var. tenuis f. setigera in the Lower Peninsula occur in Mecosta County and now Oceana County. It is interesting to note that both occur near the northern boundary of the tension zone of Potzger (1948).

Agrostis stolonifera L. 651. Frequent in the upland forest.

Andropogon scoparius Michx. 704, 817. Occasional on open hillsides.

Andropogon virginicus L. 53, 813. Occasional in dry sandy openings.

Aristida basiramea Vasey. 797. Occasional in sandy clearings and in two-track roads.

Bromus inermis Leyss. 806. Occasional in sandy openings and along roads in the study area.

Cenchrus longispinus (Hackel) Fern. 1218. Frequent in sandy openings in the forest.

Cinna arundinacea L. 824. Occasional in open cedar swamps.

Cynosurus echinatus L. 442. Rare, two plants were found in the upland forest in Section 10, Crystal Township. This represents the second collection record for Michigan. It was first collected by Dr. S. N. Stephenson in 1967 near Wintergreen Lake in the Kellogg Bird Sanctuary, (Stephenson, 1967).

Dactylis glomerata L. 390. Frequent in open grassy areas and along roads in the forest.

Danthonia spicata (L.) R. & S. 646, 895. Abundant in open grassy areas and clear-cut tracts.

Elymus virginicus L. 737. Rare, a few plants were discovered in the dense swamp forest along the North Branch of the Pentwater River.

Eragrostis cilianensis (All.) Mosher. 724, 1208. Frequent in sandy two-track roads and clear-cut areas.

Eragrostis spectabilis (Pursh) Steudel. 681. Occasional in sandy clearings and along roads in the forest.

Glyceria canadensis (Michx.) Trin. 1197. Rare, a small population was discovered at the edge of a large pond in Section 6, Colfax Township.

Glyceria grandis S. Wats. 54. Rare, a small population was discovered along Crystal Creek.

Glyceria striata (Lam.) Hitchc. 371, 523, 688. Abundant in wet open swamps.

Leersia oryzoides (L.) Swartz. 562. Common in wet cedar swamps and along streams.

Leptoloma cognatum (Schult.) Chase. 574, 802. Frequent in oil-well clearings and other sandy habitats in the study area.

Muhlenbergia frondosa (Poiret) Fern. 832. Rare, one large population was discovered in a sandy oil-well opening.

Muhlenbergia mexicana (L.) Trin. 650. Occasional in the upland forest.

Muhlenbergia schreberi J. F. Gmelin. 655. Rare, a small population was discovered along a two-track road in Section 1, Crystal Township.

Oryzopsis asperifolia Michx. 971, 982. Very common throughout the upland forest and especially in clear-cut tracts.

Panicum columbianum Scribner. 387, 428. Frequent in open sandy habitats.

Panicum dichotomum L. 426, 644, 800, 1209. Common in open sandy areas, clear-cut tracts and under oaks in the upland forest.

Panicum implicatum Britt. 1191. Rare, a few plants were found at the edge of a small woodland marsh.

Panicum latifolium L. 425, 667. Frequent in open sandy habitats.

Panicum linearifolium Britt. var. werneri (Britt.) Fern. 1025. Occasional in clear-cut areas and open sandy habitats.

Paspalum ciliatifolium Michx. var. stramineum (Nash) Fern. 805. Rare, a few plants were found in an old field in the study area. This collection extends the known Michigan range approximately 100 km northward (cf. Voss, 1972).

Phalaris arundinacea L. 820, 1036. Common in low wet ground.

Phleum pratense L. 677. Common along roads and in openings in the forest.

Poa compressa L. 397, 789, 798. Common in the upland forest and in clear-cut areas.

Poa pratensis L. 392, 970. Frequent in dry open habitats.

Sporobolus cryptandrus (Torr.) Gray. 859. Rare, a few plants were collected along a sandy two-track road.

Typhales

SPARGANIACEAE

Sparganium chlorocarpum Rydb. 1198 (flowering July 29). Common in shallow water at the edge of a large pond in Section 6, Colfax Township.

TYPHACEAE

Typha latifolia L. 832. Common around ponds and in wet ditches.

Arecidae
Arales

ARACEAE

Arisaema triphyllum (L.) Schott. 309 (flowering May 14). Common in cedar swamps and wet woods.

Calla palustris L. 1042 (flowering June 15). Frequent at the edge of a large pond in Section 6, Colfax Township.

LEMNACEAE

Lemna minor L. 924. Common in a large pond in Section 6, Colfax Township.

Liliidae
Liliales

LILIACEAE

Asparagus officinalis L. 1018 (flowering June 11). Occasional in open areas and along roads in the study area. Presumably dispersed by birds.

Clintonia borealis (Ait.) Raf. 135 (flowering May 29). Frequent in a small cedar swamp in Section 5, Crystal Township.

Erythronium americanum Ker. 327, 928 (flowering May 5). Common in swamps throughout the Manistee National Forest study area.

Lilium michiganense Farw. 728. Rare, three plants were discovered along the North Branch of the Pentwater River.

Maianthemum canadense Desf. 300 (flowering May 14). Abundant throughout the study area in swamps, moist areas of the upland woods and in decaying pine stumps.

Medeola virginiana L. 384 (flowering May 28). Occasional in a cedar-hemlock swamp in Section 14, Crystal Township.

Polygonatum pubescens (Willd.) Pursh. 302 (flowering May 14). Rare, a few plants were found in an open swamp in Section 15, Crystal Township.

Smilacina racemosa (L.) Desf. 666, 1049 (flowering June 16). Rare, a few plants were found in the upland forest.

Trillium grandiflorum (Michx.) Salisb. 308, 932 (flowering May 5). Frequent in open swamps and moist wooded areas.

Uvularia grandiflora Sm. 937 (flowering May 5), 992. Occasional in cedar swamps and mesic forested habitats.

IRIDACEAE

Iris versicolor L. 1000 (flowering June 9). Frequent along the banks of the North Branch of the Pentwater River.

Orchidales

ORCHIDACEAE

Cypripedium acaule Ait. 567. Frequent throughout the upland forest.

Cypripedium calceolus L. var. pubescens (Willd.) Correll. 1005 (flowering June 10). Common in a small cedar swamp in Section 5, Crystal Township.

Corallorhiza maculata Raf. 662 (flowering July 27). Rare, one plant was found growing along a shaded two-track road.

Corallorhiza odontorhiza (Willd.) Nutt. 744 (flowering August 14), 779, 791. Common in late summer throughout the forest.

Goodyera pubescens (Willd.) R. Br. 606 (flowering July 24), 1006. Local, small populations may be found in cedar swamps throughout the study area.

Habenaria hyperborea (L.) R. Br. 615 (flowering July 24). Local, small populations may be found in cedar swamps throughout the study area.

Habenaria lacera (Michx.) Lodd. Sight record (flowering August 4). Rare, one plant was observed, but not collected, in a cedar swamp in Section 14, Crystal Township.

Habenaria psycodes (L.) Spreng. 601 (flowering July 24), 633. Common in open areas of a cedar swamp along Crystal Creek.

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