THE PHYTOSOCIOLOGY OF THE UPLAND SECOND GROWTH HARDWOODS OF MISSAUKEE COUNTY, MICHIGAN

By

Jack Calkins Elliott

A DISSERTATION

Submitted to the School of Graduate Studies of Michigan

State College of Agriculture and Applied Science

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

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THE PHYTOSOCIOLOGY OF THE UPLAND SECOND GROWTH HARDWOODS OF MISSAUKEE COUNTY, MICHIGAN

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AN ABSTRACT

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The phytosociology of ninety-eight stands of second growth upland hardwoods in Missaukee County, Michigan was determined by an analysis of quantitative data recorded in 546 one hundred square meter quadrats. The objectives of the study were (1) to record quantitatively the composition of the upland second growth hardwood stands in Missaukee County, (2) to compare this composition with the composition of other stands as reported from the Lake Forest, and (3) to compare this composition with the vegetational pattern of the primeval forest as interpreted from the original land survey field notes of 1854. The quantitative data were obtained by the quadrat method of sampling. Stands were selected on the basis that they be representative of relatively undisturbed natural upland types. The characteristics of the soils within the stands were considered. The quantitative data were analyzed and structural and synthetic characters for the community established. Statistical treatment of the quantitative data to establish significant differences between percentages have been summarized and the ecological implications considered. Lociations, as represented by the six soil series, were described. Comparisons between the composition of the stands in Missaukee County and the composition of selected stands as reported from the Lake Forest were drawn. The primeval forest of the county was mapped and the differences in the composition of the forest between the two periods of time pointed out.

It has been established, on the basis of (1) the quantitative structural characteristics of the concrete community (density, frequency and basal area); (2) the qualitative characters which became evident from an analysis of the quantitative data (sociability, dispersion and vitality); and (3) the synthetic characters of the abstract community (presence, constance and coefficient of community), that the present composition of the second growth upland hardwood stands in Missaukee County is representative of a disclimax stage in plant succession, within an area which supports a mixed conifer-northern hardwood forest formation. The primary dominant canopy species was *Acer saccharum*. Secondary dominants were *Fagus grandifolia*, *Ulmus Thomasi*, *U. americana* and *Tilia americana*. Incidental dominants were *Fraxinus americana*, *Acer rubrum*, *Quercus rubra var. borealis*, *Q. alba*, *Tsuga canadensis*, *Prunus serotina*, *Ulmus rubra*, *Betula lutea*, *Betula papyrifera*, *Pinus Strobus*, *P. resinosa*, *Thuja occidentalis* and *Fraxinus nigra*. The sub-dominant species of the understory were *Ostrya virginiana*, *Prunus pensylvanica*, *Populus grandidentata*, *P. tremuloides* and *Amelanchier sp.*.

The disclimax status of the forest community is established on the basis of the ecological significance of the primary, secondary and incidental dominants of the ninety-eight stands of upland second growth hardwoods. Man has been the principal disturbing agent. It is suggested that the high abundance and frequency values of *Ulmus Thomasi* within the county be considered as an indication of a northward extension of its range. The considerably less acreage of forest now than at the time of the original land survey is pointed out as well as the composition differences.

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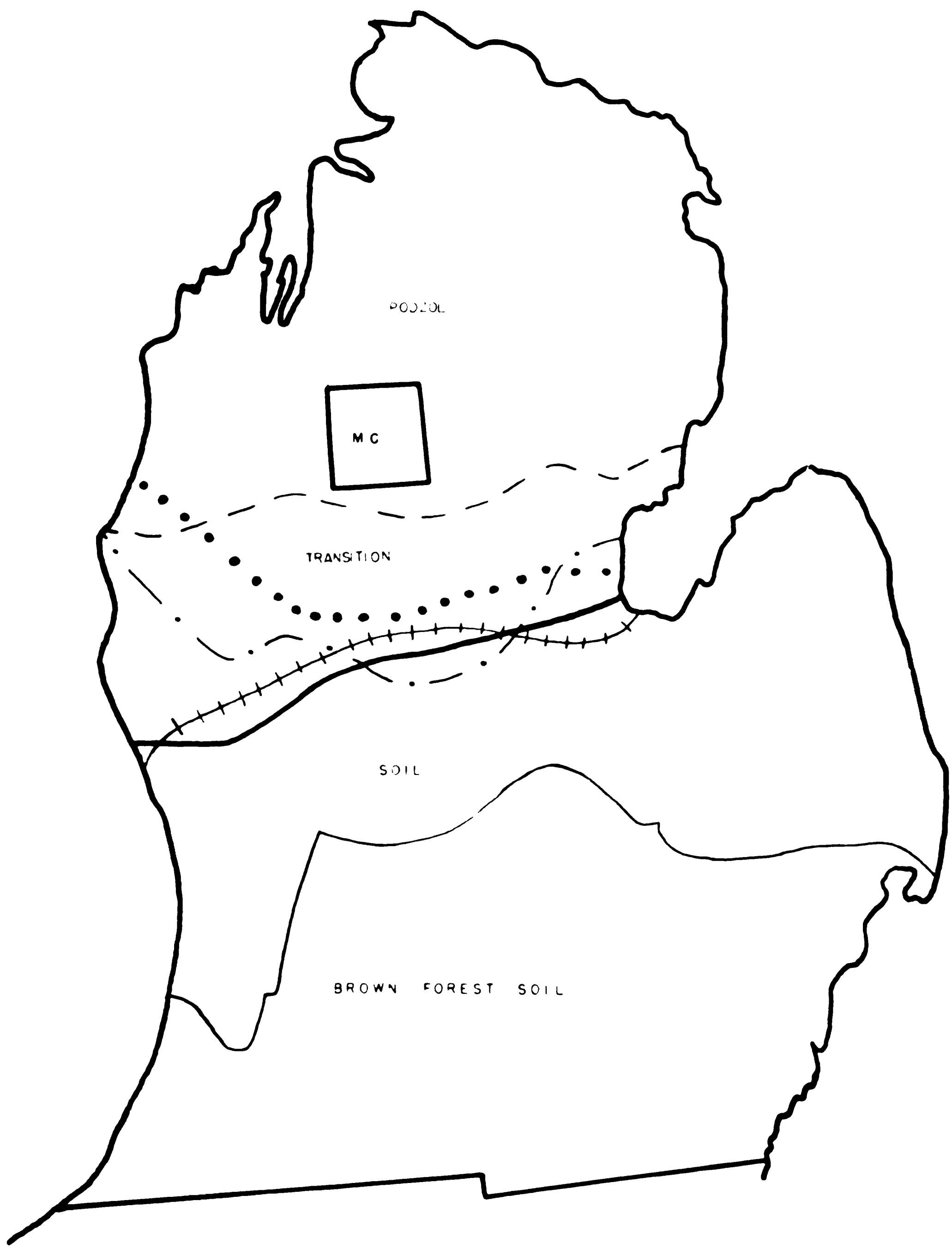
INTRODUCTION

There are two expressions of climax forest vegetation within the state of Michigan. One is the deciduous forest formation in the southern part of the lower peninsula. The other is the mixed conifer-northern hardwood forest formation in the upper part of the lower peninsula and throughout the upper peninsula.

The boundary between these two climax forests is not sharply defined and is represented by a zone of tension, or ecotone. This boundary is narrow due to critical changes in the controlling environmental conditions. Braun (1950, P. 338), Potzger (1948, 1946), Darlington (1945), Veatch (1932), Gleason (1924), Quick (1923), Livingston (1905, 1903), and Beal and Wheeler (1892), as well as others, have pointed out the presence of this tension zone between these two great forest formations. Here the relics of the northeastern conifer forest mix with the northern elements of the deciduous forest. The line of tension is usually described as being located near the latitude of 43 degrees North (Fig. 1). More commonly it is described as a line running from Saginaw on the eastern edge of the state to Muskegon on the western margin. Southward from this line lies the Hardwood Country or the Deciduous Forest formation; northward lies the Hemlock-White Pine-Northern Hardwood Forest Formation.

The portion of the Hemlock-White Pine-Northern Hardwood forest north of the tension zone forms a part of the mixed conifer-northern hardwood forest of northeastern North America, and it has been dis-



- - - - Spruce
· · · · · · Jack Pine
-·-·-·- Oak-Hickory
· · ++ Norway Pine
——— · White Pine
——— N. Boundary of Beech-Maple Region

Fig. 1. **Map of Lower** Michigan showing boundary between the Beech-Maple and Hemlock-White Pine-Northern Hardwoods regions, and its relation to tree ranges and soils. (After Braun, 1950 and Veatch, 1932)

cussed by ecologists and plant geographers more voluminously than has any other forest formation on the North American continent. A number of descriptive names have emerged from their studies which have been used to typify the region. The region to be described in the present paper lies within the Northern Hardwood region of Frothingham (1915); as well as in the Northeastern Transition Forest region of Nichols (1918, 1935) and The Great Lakes or South Canadian Forests of Hardy (1920). It likewise falls within the St. Lawrence-Great Lakes region claimed by Harshberger (1911) and is included in the Lake Forest region of Weaver and Clements (1929, P. 496). In Braun's Deciduous Forests of Eastern North America (1950, P. 337), the area is characterized as the Hemlock-White Pine-Northern Hardwood region.

While a transition zone between two large vegetation cover types has always presented a tantalizing aspect of vegetational characteristics, few of the many papers which have been published dealing with these forest formations offer quantitative studies describing the forest composition of the region in such a way that the data can be used for comparative purposes.

Opportunities for such studies on undisturbed stands within the northern part of the lower peninsula of Michigan are now nearly non-existent. In an effort to piece together a part of the picture of the present composition of the forest formation just north of the tension zone, a quantitative study was made of the upland second growth hardwood stands in Missaukee County, Michigan. The primary objectives of the study were: first, to record quantitatively the composition of the upland second growth hardwood stands within the county; second, to compare the present composition of the upland second growth hardwood stands within the county with the composition of other communities as reported from within and near the Lake Forest formation; and third, to compare the present composition of the upland second growth hardwood stands with the vegetational pattern as revealed from an interpretation of the field notes and maps of the original land survey of the county which was completed in 1854.

REVIEW OF THE LITERATURE

A. Ecological Concepts

The foundations of plant ecology were first established by Kerner (1863). Since that time these original concepts have been expanded, augmented, and refined considerably by European and American workers. The results of these years of development and building were ably brought together and summarized during the Conference on Plant and Animal Communities, which was held at Cold Spring Harbor, Long Island, New York, August 29 to September 2, 1938.

At that time, Conard (1939) brought together in his paper, Plant Associations on Land, the salient teachings of the various schools which have had special influence upon the description and classifications of associations. Six schools were included in his considerations: 1) The Zurich-Montpellier School: It had for its field laboratory the magnificent plant mosaic of central Europe and the Alps, where the conspicuous feature was the stability of vegetation when left undisturbed. From this field laboratory was developed the concept of the association, defined by its floristic composition, as a unit actually found in nature, and upon which all phytosociological study centered. 2) The Scandinavian School: Working with the vegetation of marginal lands, which was conspicuously different from the luxuriant vegetation of central Europe, the school developed two "oft repeated emphases: (a) the soil is the product of vegetation, and is independent of the nature of the substratum; (b) the fundamental unit of vegetation is the layer or synusia" (Conard 1939, p. 4). 3) The Danish School: Influenced by the nature of its geographical location and political organization, and under the impetus of Raunkiaer, the group developed the statistical method of phytosociological treatments. 4) The Russian School: Conard (1939, p. 6) quotes Sukatchew (1934) in summary with the statement that, "Russian phytosociologists were primarily interested in the Steppe vegetation and its relation to forests." The Russians have been credited with being the first to recognize the relation of soils to climate and vegetation (Glinka 1914). Conard (1939) mentions further (p. 6), "It is most regretable that much of their work is inaccessible to other people because of the barrier of language." To this inaccessibility, today we must add additional barriers. 5) The Chicago School: The concept of succession dominated the Chicago School, where the principal objective in the study of vegetation was an explanation of the causes and processes of vegetational change. 6) The Nebraska School: Like the Chicago School under the leadership of Cowles, the Nebraska School under the inspiration of Clements, developed the concept of succession, with its extensive terminology. In conclusion, Conard (1939, p. 7) makes a plea for a standardization of terminology: "- -a very great advantage would occur if we could find a best method for the study, and especially the description of vegetation. At least an internationally accepted terminology would help."

Gleason (1939), during the conference, defended The Individualistic Concept of the Plant Association. According to him (p. 9) the fundamental question basic to all ecological work is, "What is a plant association?" In answer to his question he presented three basic theories, chosen from the voluminous literature, as typifying the principal thinking, with an explanation that other viewpoints may be regarded as variants from the three basic theories. The theories were (p. 93):

> 1. The association is an organism, or quasi-organism, not composed of cells like an individual plant or animal, but rather made up of individual plants and animals held together by a close bond of interdependence; an organism or quasi-organism, with properties different from but analogous to, the vital properties of an individual, including phenomena similar to birth, life, and death, as well as constant structural features comparable to the structures of an individual.
>
> 2. The association is not an organism, but a series of separate similar units, variable in size but repeated in numerous examples. As such it is comparable to a species, which is composed of variable individuals. Under this view the association is considered by some to be a concrete entity, merely divided into separate pieces, while by others the association as a whole is regarded as a mental concept, based upon the common character of all of the pieces, and capable of typification by one or more of these pieces which most nearly approach the average or ideal conditions.
>
> 3. The vegetation is a temporary and fluctuating phenomena, dependent, in its origin, its structure, and its disappearance, on the selective action of the environment, and on the nature of the surrounding vegetation. Under this view the association has no similarity to an organism and is scarcely comparable to a species.

In defense of the third theory, the so called Individualistic Concept, Gleason (1939) presented a series of theses the principal points of which were: (1) every species of plant has reproductive powers in excess of its own needs; (2) every species of plant has some method of migration; (3) the environment in any particular station is variable; and (4) the development of a vegetative unit depends upon one or the other of these two conditions: the appearance of new ground, or the disappearance of the existing association. By way of clarifying and pointing up these theses he presented the following two general statements (p. 103):

> First, an association, or better one of those detached pieces of vegetation which we may call a community, is a visible phenomenon. As such it has dimensions and area, and consequently boundary. While its area may be large, the community is nevertheless a very tangible thing, which may be mapped, surveyed, photographed, and analyzed. Over this area it maintains a remarkable degree of structural uniformity in its plant life. Homogeneity of structure, over a considerable extent, terminated by definite limits, are the three fundamental features on which the community is based. Without these three features, Grisebach would never have published his statement of a century ago; without them, all of our studies of synecology would never have been developed. Also, besides its extent in space, every community has a duration in time. Uniformity, area, boundary, and duration are the essentials of a plant community.
>
> Second, every community occupies a position in two series of environmental variation. In the space series, as the community exists <u>here</u>, in this spot, it is part of a space-variation, and its environment differs from the adjacent communities. In the time series, as the community exists <u>now</u>, at this time, it is part of a time-variation and in its environment differs from the communities which preceded it or will follow it.

An an example in proof of his statements he cited the beech-maple climax forest in Michigan. Of this he said (p. 106): "Within the state of Michigan, the beech-maple climax forest, always considered to be a definite, well distinguished association-type, exhibits profound changes from one end of the state to the other."

An analysis of Gleason's Individualistic Concept of the Plant Association would seem to indicate that it is the most conspicuous expression of the space relationship of plants; that it is dependent only upon the coincidence of environmental selection and migration over measurable areas; and that it usually exists for a considerable length of time.

The climax and its complexities have been ably discussed and summarized by Cain (1939). In his paper, he brought together the numerous concepts concerning a workable definition of a plant community, and listed the references for such detailed discussions of the problem. In another section of the paper, (p. 150), he presented in a clear cut manner, A Brief Conspectus of Clements' Concepts and Terminology. In the fourth section of the paper (p. 152), The Complexity of the Climax, Cain (1939) has brought together statements from most of the active French, German, English, Swedish, Russian, and American plant ecologists which point out the varying views as well as serving as a complete summary for the considerable literature on the subject. He has, in his concluding statements (p. 175), pointed out the difficulties of classification which have arisen from the lack of a standardized terminology with the following statement:

> . . . .Clement's disposition of the variation within the climax, (or climax regions), through the concepts of faciations, lociations, through subclimax, proclimax and serclimax, through seration and through preclimax and postclimax presents a scientifically and philosophically sound system. A description of all the stable (climax) communities of a region might necessitate dealing with all of the above concepts. A very large number of investigators have chosen not to follow Clements in this but to treat all such cover types as associations. The plant sociologists go even further and include successional communities (associes) under the term. This may have some justification if the seral nature of the communities is not proven. The result, however, is to include many different things under the term, whereas Clements has a different term for a different thing.

That appears to be the crux of the problem: . . .to include many different things under a single term; or to employ a different term for a different thing. It would seem that the latter course would make for better understanding of descriptive accounts, and would best serve in leading to a standardization of the terminology.

Since the Cold Spring Harbor Conference, discussions of terminology and ways of best describing vegetation have continued to appear in the literature. A symposium held at Boston, Massachusetts, in December 1946, considered the problem of Origin and Development of Natural Floristic Areas with Special Reference to North America. At that time, considerable attention was given to distribution patterns and the problem of ancient dispersals. According to Camp (1946, p. 126) the common objective for this series of papers was:

> . . .the constant searching for a more complete knowledge of the influential historical events and causitive biological factors underlying the dynamic phenomena operative in the everychanging vegetational mantle of this world on which we live.

At that time, Cain (1946) brought out the close relationship between floristic and vegetational geography, and at the same time questioned the "objective reality" (p. 198) of the plant association. He placed considerable emphasis upon the employment of natural areas conceived in terms of collective data of many sorts, rather than single factors or single points of view. At this point, it would seem that Cain has absorbed some of the Individualistic Concept of Gleason (1939) and the Concept of Holism of Egler (1942, 1951).

McIntosh and Curtis (1950) have proposed the concept of a Vegetational Continuum for the hardwood stands of southwest Wisconsin. The Continuum Concept would abolish the term "association", at least in its present accepted usage. In certain aspects, this concept tends to support Gleason's (1926, 1939) idea of the Individualistic Concept of the Plant Association as well as to embody some of the connotations carried by Brauns' (1935 a-b, 1950) Association Segregate. Egler (1951) regards this concept as being one of the better ones of the first half-century of American Ecology.

The terminology of forest ecology, as previously mentioned, has a decided lack of uniformity in usage. Cognizance of this is taken by Braun (1950) when she devotes a chapter (Chap. 2, 10-27) to Forest Ecology and Terminology so that the terms as used in her Deciduous Forests of Eastern North America may be defined. Her terminology which is related to the units of vegetation is largely Clementsian with certain modifications, such as, "association-segregates"; "associes"; "consocies".

The various approaches to the study of vegetation in the light of floristic mapping, life-form statistics, and ecological classifications have been reviewed by Dansereau (1951) in a paper which proposed a new system for the description and recording of vegetation upon a structural basis. He suggested six series of criteria for use: 1) life-form; 2) size; 3) function; 4) leaf shape; 5) leaf texture; and 6) coverage. It would seem that his system is an attempt to combine certain principles of the Individualistic Concept theory of Gleason (1926-1939) with some of the doctrines of Clements (1936) plus an admixture of dynamic cytogenetics.

B. The Mixed Conifer-Northern Hardwood Forests of the Northeastern United States

It was noted in the introduction that the mixed conifer-northern hardwood forests of the northeastern United States have been a much discussed forest formation. As a consequence the literature is very extensive.

Frothingham (1915, p. 1) described the northern hardwood forests as occupying "the fresh, well drained, fertile soils of the northern pine region." He pointed out the distinguishing differences between the northern and southern hardwood forests, mentioning several important tree species which are common to both, as well as showing the principal differences between them. According to him (p. 1), the northern hardwood forest is distinguished by the presence of yellow birch, white pine, and eastern hemlock, and the absence of yellow poplar, red gum, sycamore, as well as several other more southern species. The northern hardwood forest, with some twenty important species of hardwoods, is more simple in composition than the southern hardwood forest, "which has fully ninety-five species of local or general commercial value." The northern hardwood forest is usually divided into two regions: 1) the eastern mountain region and 2) the Great Lakes region, with the latter mostly within the area of Wisconsin glaciation. Frothingham (1915, p. 21) said that the greater abundance of basswood and elm is perhaps the most striking characteristic of this forest formation in the Lake States.

Both Nichols (1935) and Cain (1935) have reviewed the extensive literature of the Hemlock-White Pine-Northern Hardwood region of eastern North America. According to Nichols (1935) the region, which lies between the northern conifer forest to the north and the deciduous forest region to the south, has a "climatic climax" forest comprising a mixture of evergreen coniferous and deciduous broadleaf trees. He placed these trees into four groups with reference to their geographical distribution (p. 419-420):

> 1. Species whose centers of north-south distribution lie north of the region and which are widely distributed northward, being constituents of the northern conifer climax, namely the balsam fir and the white spruce.
>
> 2. Species whose centers of north-south distribution lie within the region, whose range as a whole extends but little beyond it, and which are members of the climatic climax in no other region, notable the hemlock, eastern white pine, and yellow birch.
>
> 3. Species whose centers of north-south distribution lie within the region or immediately south of it, but which range well to the south, there entering more or less into the composition of the deciduous forest climax, notably the sugar maple and the basswood.
>
> 4. Species whose centers of north-south distribution lie far to the south, and which are widely distributed as constituents of the deciduous forest climax, among others the beech and the white ash.

Nichols (1935, p. 420) further calls attention to the fact that the region has been commonly treated as a part of the northern conifer region from an ecological standpoint; but that it differs from it especially in the comparatively minor importance in the climax of the trees in his group one. It is more closely related to the deciduous forest region, as indicated by the prominence of trees in the climax from his groups three and four. He said (p. 420):

> Much may be said, however, in favor of treating this region as a distinct ecological unit, in itself. In addition to the climax species of group 2, numerous other trees and shrubs are prominent in the vegetation here which are not only more or less 'endemic' but also distinctive in their ecological characteristics. . . .Also various southern hardwood species are conspicuously absent here and, when present, tend to become replaced, in the course of succession, by hemlock and northern hardwoods.

According to Nichols (1935, p. 407) the forest formation has the following characteristic species: hemlock, sugar maple, beech, yellow birch, eastern white pine, basswood, American elm, white ash, red oak, black cherry, red spruce, balsam fir, white spruce, red maple, and Norway pine. He indicated that it is the climax favored by climate and generally develops on the better soils throughout the eastern hemlock region, "except where natural conditions have been modified by fire and man" (p. 407).

In studies of the beech-maple climax forests of southern Michigan, Cain (1935, p. 510) called attention to Frothingham's distinguishing differences between the northern and southern hardwood forests. He also mentioned papers by Zon and Garner (1930) and Danna (1931) which dealt with the northern forests as a whole (p. 510).

A brief post glacial history of the Lake Forest formation has been presented by Potzger (1946). He discussed the controversies as to what constitutes a climax forest, showing the opinions to be divided into two major groups: ". . .one considers (it) the pine-hemlock, the other the hemlock deciduous forest" (p. 228-230). The latter group, which includes Potzger, would consider Pinus on sandy soil to be post-climax, or edaphic climax.

The most recent as well as the most comprehensive treatment of this forest formation is to be found in the book, Deciduous Forests of

Eastern North America by E. Lucy Braun (1950). Here the author has presented detailed descriptions of the original forest patterns as well as the composition of the virgin forests. She has analyzed and compared the climax communities, traced the expansions and contractions of the formation and its segregation into types, and has demonstrated the generic relation of its several parts.

According to Braun (1950 p. 337) the Hemlock-White Pine-Northern Hardwoods Region, "extends from northern Minnesota and extreme southeastern Manitoba through the upper Great Lakes region and eastward across southern Canada and New England, including, toward the southeast much of the Appalachian Plateau in New York and Northern Pennsylvania. She found that the region is characterized by pronounced alternations of coniferous, deciduous, and mixed forest communities. For the primary deciduous forest communities she reports that (p. 337): "sugar maple, beech, and basswood; sugar maple and beech; or sugar maple and basswood are the usual codominants, and yellow birch, white elm, and red maple more or less frequent associates." Two general types of coniferous communities occur at intervals almost throughout the region (p. 337): ". . .those of more or less dry sandy plains and ridges where white pine, red or Norway pine, and jack pine prevail; those of poorly drained areas, bogs and muskegs, where black spruce, arbor vitae (northern white cedar), and larch prevail." The most characteristic communities of the region, the ones from which the name Hemlock-White Pine-Northern Hardwood is derived, are composed of hemlock, sugar maple, beech, basswood, and yellow birch, in which there is or was an admixture of white pine. In speaking of the boundaries of the region Braun (1950, p. 338) said:

> The boundaries of the region are ill-defined, for this is a great tension zone between encroaching more southern species and retreating more northern species. It is a region of interpenetrating climaxes, but a region distinct in the grouping of its climax dominants and in its dry soil physiographic climaxes.

For the person interested in the past, present, and probable future of this much discussed forest formation, as well as for the entire history and development of the deciduous forests of eastern North America, Braun's (1950) Deciduous Forests of Eastern North America is a revealing source book.

There are numerous papers which deal with the northern hardwood or associated types and variants in local areas of the main forest formation. Bergman (1928) and Daubenmire (1936) have considered the forest composition and its interrelations in Minnesota. Jennings (1927); Illick and Frontz (1928); Morey (1936); Hough (1936, 1937, 1943); Hough and Forbes (1943) have all reported on extensive studies for the state of Pennsylvania. Esten (1932) has reported on a study of the maple-beech association in Indiana. Eggler (1936) discussed the maple-basswood association of northern Wisconsin and Stearns (1949, 1951) has reported on the sugar maple-hemlock-yellow birch association in northern Wisconsin. Stearns (1951) noted that the conclusions reached by the workers in Pennsylvania were very similar to those found for northern Wisconsin. He found that the composition of the sugar maple-hemlock-yellow birch association, determined on the basis of dominance was (p. 263): "*Acer saccharum*, 28%; *Tsuga canadensis*, 23.8%; *Betula lutea*, 24.9%; *Tilia americana*, 13.8%; *Pinus strobus*, 4.8%; *Ulmus americana*, 2%." The remaining three percent was made up of minor species which included ironwood, blue beech, white ash, and balsam fir.

C. The Mixed Conifer-Northern Hardwood Forest Formation In Michigan

Some of the earliest and most descriptive accounts of the original vegetation and successional patterns in Michigan were written by Beal (1888, 1889, 1890, 1903) and Beal and Wheeler (1892). It is interesting to note that the work of these two botanists is seldom mentioned in any of the general accounts which discuss the forest formations of which Michigan is a part.

In his paper, Observations of the Succession of Forests in Northern Michigan, Beal (1888, p. 75) said:

> During the past summer, I have had many opportunities of examining large tracts of land in Northern Michigan, where there were many kinds of coniferae and various species of deciduous trees. In a trip by wagon from Lake Huron to Lake Michigan, I started with this subject strongly impressed upon my mind. I have spent considerable time besides visiting the forests and burned districts, and looking at the second growth and observing what was there growing. For example at Harrison, near the center of Clare County, there is an admirable chance to study this subject. The soil varies considerably, though most of it is sandy.
>
> In imagination let me conduct you to a fine virgin forest two to three miles southeast of the village. The land is rolling and thickly timbered with tall trees. We shall find much thrifty white pine and Norway pine, and in places considerable hemlock. There are scattering trees of red maple, white and black and red oak, a little beech, and small white ash, some hazel, witchhazel, maple leaved viburnum, New Jersey Tea, mountain maple, large toothed aspen, now and then a dwarfed plant of huckleberry, blackberry, dew berry, eagle fern, sweet fern, dogwoods, choke cherry, black and pin cherries, June berry, and other shrubs and perennial herbs which are deep rooting. In some places the undergrowth is quite thick, but often the large trees are too thick to permit many small trees to grow, at least well enough for them to thrive and cover the ground. The leaves are usually well

packed to the ground, as they were when the snow melted last spring. When the land was sandy all of the leaves were dry enough to burn, and about July 25th fire had spread over a considerable tract of this land.

There are evidences that the fire has run through these woods on several occasions, killing the young timber and all of the undergrowth to the surface of the ground and often damaging and killing some of the larger trees. There are very few young pines and hemlocks, though cones are found in abundance. The thick layer of deciduous leaves on the ground leaves little opportunity for the delicate seeds of the coniferae to produce trees.

Let us look for some young deciduous trees.

Here are a few slender oaks of two or three species, some that are eighteen feet high and less than an inch and a half in diameter near the ground; yes, and there is now and then one that has died to the ground, apparently smothered from want of light, but a few spindling sprouts are coming up showing that life still holds out. On digging a few of these slender oaks we find that some of them come from clumped roots or 'grubs' of various sizes showing that the present growth in the first, second, third, or fourth sprout which has apparently come in succession from the same foundation; some of these old sprouts are now represented only by dead stumps, some of which are charred near to the ground. By counting the rings of growth near to the ground in the last sprout, or if small, the bud rings, we may tell very accurately how long since a fire killed the last sprout.

The remainder of the paper continues to cite examples, both in this type of forest stand and in the jack pine plains, showing the manner of forest succession from clumped roots. These forests, described in their successional patterns by Beal (1888), are the secondary beech-maple or maple-beech sprout forests of Braun (1950, p. 341). Beal's paper is exceedingly well illustrated with pictures of both 'grubs' and standing timber which show the manner in which certain tree species became so long-lived against fire. With fire losses now reduced to practically zero in this area of the state, there can be little doubt that many of the present stands of second growth timber have had their origin in a manner such as that described by Beal (1888).

In Michigan Flora (1892), Beal and Wheeler discussed at some length the interrelations of climate and soil upon the vegetation of the state. They pointed out, in their descriptions of the Traverse Region, the fact that in the upland hardwoods there was a falling out of many of the southern species with the northern ones taking their place (p. 16): ". . .or if found growing farther south, here for the first time become frequent." They described (p. 16) deep forests of hemlock and yellow birch mixed with a "fine tall growth of striped maple", and note that sugar maple and basswood are also abundant in this region, commenting on their immense size (p. 16): ". . .in fact, it would be difficult to find finer groves of maple in any other part of the state."

The paper also contains a detailed description of the "pine country proper" (p. 16). According to the authors, this country was composed largely of sand hills and plains, either scantily furnished with vegetation, or densely covered with pine forests. Jack pine was credited with being the usual timber of the sand barrens and there was included a long list of the flora of the jack pine plains (p. 19-21) which consisted of representatives of "thirty families, of fifty-four genera, and of seventy species." In speaking of the pine lands and hardwoods together, Beal and Wheeler (1892, p. 16) said: "Such is the character of the sylva down to latitude 43 degrees, but in the western part of the state, owing perhaps to moister climate, or to favorable soil, hemlock-spruce is more abundant and reaches farther south, nearly or quite to the Indiana line, and the same is true of the white pine."

Darlington (1943) has reviewed the floristic and ecological studies in Michigan since 1900. According to this author that part of the lower peninsula south of the Grand River is the best known botanically. However, he pointed out (p. 37) that "the founding of the biological station by the University of Michigan at Douglas Lake marked the start of intensive botanical and ecological surveys of the Traverse region." Darlington (1943, p. 36-43) called attention to the fact that ecological work in the lower peninsula of Michigan has been mostly concerned with the investigation of former types of forest cover, with the relation of soils to vegetation, and with areas which have suffered little from disturbance as bogs and sand dunes.

An inventory reporting upon the conditions found within the Michigan Forest Reserve was published by Sherrard (1902). He reported that the original magnificent stands of white and Norway pine had been succeeded, following lumbering, in the following ways (p. 405): 1) oak flats, 32%; 2) oak ridges, 11%; 3) jack pine barrens, 39%; 4) swamp, 11%; 5) hardwood land, 6%. This estimate of the comparative representation of the various tree stands was further subdivided to indicate the species in order of representation:

1. Oak Flats
    a. Scarlet Oak
    b. Aspen and Pine
    c. Norway Pine
    d. White Pine
    e. Pin Cherry
    f. Birch

2. Oak Ridges
    a. White and red oak together more than 60%
    b. The remainder as in 1 above

3. Jack Pine Barrens
    a. Jack Pine, 88%
    b. Scarlet Oak
    c. Norway Pine
    d. Aspen
    e. Red Oak
    f. White Pine
    g. White Oak

4. Swamps
   a. Tamarack, cedar, spruce, and balsam together making up more than 80%

5. Hardwood Lands
   a. Beech and Hard Maple together form 80%
   b. Hemlock 11%
   c. On Cut-over hardwood lands Pin Cherry holds the first place in the second growth for the time being, while the representation of Maple and Beech together is reduced to 28%

The Michigan Forest Reserve covered some 60,000 acres in ten townships in the western half of Roscommon County and two townships in Crawford County. It is now a part of the Higgins Lake and Houghton Lake State Forests. Sherrard (1902) indicated that the hardwood timber was but poorly represented in the original forests on the reserve.

In a paper based upon the principles of Cowle's Physiographic Ecology, Whitford (1901) reported upon the generic development of the forests of northern Michigan. As a result of his study of the life history of the vegetation at four sites of different physiographic formations, he concluded that in each series the climax plant growth was a deciduous-hemlock combination. The manner of the intermingling of the northern elements with those of the southern elements in generic development is especially well done.

Livingston (1903) attempted to reconstruct (p. 39), "as accurately as possible," the plant societies which occupied Kent County at the time of settlement. He found that the vegetation of the area fell naturally into two groups (p. 39): "that growing on what is commonly termed dry ground and that found in moist or swampy places." He was able to separate each of the two groups into several societies, noting that (p.45): "they often merge gradually into one another, so that in some localities it appears that there is a mixture of several of them." According to Livingston (1903, p. 45) the vegetation of the upland fell into five societies, which he characterized on the basis of trees, shrubs, and herbaceous plants as follows: 1) Beech-Maple Society; 2) Maple-Elm Society; 3) Oak-Hickory Society; 4) Oak-Hazel Society; 5) Oak-Pine-Sassafrass Society." The distribution for these societies is shown on a map of the county with their locations identified by various shadings. He placed considerable emphasis upon the importance of the edaphic factor in accounting for the distribution of the societies within the county. He suggested the hypothesis (p. 54): "The decisive factor in plant distribution over a small glaciated area is, in most cases, the moisture retaining power of the soil."

A continuation of the problem of the relation of soil to vegetational distribution was carried out by Livingston (1905) with a study of the relation of the soils to natural vegetation in Roscommon and Crawford Counties. Here he found that the uplands were vegetated with four types of societies (p. 28-30): 1) hardwoods; 2) white pine; 3) Norway pine; 4) jack pine. Acer, Fagus and Tsuga made up three quarters of the hardwood type of forest with one or another of the three being dominant. He listed (p. 28) the following trees as characteristic: "*Acer saccharum*, *Fagus grandifolia*, *Tsuga canadensis*, *Ulmus americana*, *U. racemosa*, *U. fulva*, *Abies balsamea*, *Betula lutea*, some *Picea candensis* and *P. mariana*, often scattered *Pinus Strobus* of enormous size."

The white pine type was the typical "pinery", according to Livingston (1905, p. 28). He noted, however, the presence of both

Norway pine and frequent hardwoods in this type. At the time of his investigations, the pines had been lumbered and consequently little of the type remained. The aspect of the white pine type, according to the author (p. 28) "gives vast stretches where there are no trees at all, fires having killed the young conifers as well as a scattering of hardwoods. In some regions there are dwarfed Quercus alba, Q. rubra, Acer rubrum, and a number of shrubs." Reference was made here in describing this part of the area to the papers of Beal (1888) and Sherrard (1902). The Norway pine type, like the white pine type, had given way to lumbering and fires. The most open type and that occurring on the most sterile soils was the jack pine type. According to Livingston (1905, p. 29) the only species of trees here were Pinus divaricata (Pinus Banksania), Quercus coccinea, Prunus virginiana, and seedlings of Populus grandidentata: "all but the pin oak are scarcely more than shrubs."

Livingston (1905, p. 28-32) divided the lowland vegetation into three types: 1) open meadow; 2) tamarack-arborvitae; 3) mixed swamp. He found that all three types were much nearer their original condition than the upland types. He illustrated the patterns of distribution for the various kinds of vegetation on a county map. An analysis of the map reveals that the hardwood type is always found on soils containing considerable amount of clay and covered with a fairly thick leaf litter and humus layer. Where pine occurs on soils containing the same, or nearly the same clay content as those of the hardwood type, the physiography of the area accounts for greater altitude and better drainage. After a lengthy discussion concerning soil characteristics and their effect upon plant distribution Livingston (1905, p.40) concludes that:

> . . .The main factor in determining the distribution of forests on the uplands of this region is that of the size of the soil particles, the sorting of which dates back almost entirely to the glacial epoch. The size of the particles determines the amount of air and moisture in the soil, and this in turn determines the amount of humus formation, and the growth of the nitrifying organisms, and perhaps also to a certain extent the amount of soluble salts in the surface layers.

Thus the author is back to his Kent County hypothesis of the "moisture retaining power of the soil" (Livingston 1903, p. 55).

In commenting upon the relation between the vegetation of Kent County and this region, he indicated that he considered climate to be a major factor of plant distribution, for he said (p. 39):

> . . .the presence of hickory and the better growth of black, red, and white oaks in the more southern area is an indication of a more southern flora.

He noted (p. 40) that the hardwood forests of the two areas were very nearly the same in character and suggested that perhaps a study of the transition zone between the two areas would be useful in working out the exact relations of the various societies.

The Missaukee County study concerns an area just west of that studied by Livingston in 1905. It will add another piece of the necessary information for a working out of these relationships for the different communities.

The composition of the beech-maple association has been studied in detail by Clayberg (1920); Quick (1923); Gleason (1924); Woollett and Sigler (1928); McIntire (1931); Dice (1931); Westveld (1933); Cain (1935); Potzger (1946); and Braun (1950).

The region studied by Clayberg (1920) lies in Emmet and Charlevoix Counties. He found (p. 43) that the "normal type" of forest occurring on the uplands before clearing had the following composition: "70-90% sugar maple; 5-30% beech. Hemlock is a constant tree also, running as high as 25% in some localities." Other trees occurred in varying but small proportions. Among the more prominent were: basswood, black ash, mountain maple, silver maple, ironwood, white birch, yellow birch, choke cherry, red maple, American elm, and slippery elm (p.43).

Clayberg (1920, p. 45-46) distinguished two variants from his normal type. He found on the hilly ground, which was both drier and more open, a variation which he described as the xerach type of variant. Here either beech or maple was dominant. In a detailed description of the XerarchTree Society, the author states (p.49) that the aspen-white birch-pin cherry society varies much in general form and specific content with the result that (p. 49): "three types (consocies) are found." While the variations are described for each consocies it is stated (p.49) that the dominant trees are: "Populus tremuloides Michx., P. grandidentata Michx., and Prunus pennsylvanica L." In the valleys and on low ground he distinguished a hydrach variant, with linden (basswood) and yellow birch being characteristic trees (p. 45).

It is Clayberg's (1920, p.50) contention that the forest itself in this area is static in species, but dynamic as to individuals. In commenting on Livingston's (1903) studies in Kent County, Clayberg (1920, p. 51) noted that the oak and hickory played a more important role in the forest succession in Kent County, and that while three of Livingston's societies contained both oak and maple in the Charlevoix and Emmet County region, the four primary types were mutually exclusive.

He seems to have overlooked the important fact that the Kent County study is to the south of the tension zone, while his study was north of it.

Quick (1923) made an extensive study of the distribution of the climax association in southern Michigan. As a result of a comparative study of the percentage frequency of the trees in sixteen stands, which were divided into six regions within the lower peninsula, (Fig. 29) he listed the dominant trees in the association as (p. 222): Acer saccharum, Betula lutea, Carya cordiformis, Fagus grandifolia, Ostrya virginiana, Quercus rubra, Tilia americana, and Ulmus americana. He noted (p. 222) that maple and beech make up 60% of the association, with the others making up 30%. The remaining 10% was composed of a number of different species of trees which varied in kind in different parts of the state.

Region 4, which occupies all of the western and central part of the lower peninsula north of the Grand River, includes Missaukee County. Quick's sampling stations within this region were three in number. Geographically (Fig. 29) they were located south of Missaukee County, in the southern part of this region. He found that the climax forest occupied high and well-drained soils as well as low and boggy ones and that it was dense and had much humus in both situations (p. 231). His results indicate the following tree species to be dominant within this area (p. 231): Acer saccharum, Betula lutea, Carya cordiformis, Fagus grandifolia, Fraxinus americana, Ostrya virginiana, Quercus rubra, Tilia americana, Tsuga candensis, and Ulmus americana. The addition of Tsuga canadensis to the dominant trees of the association within the region, in contrast to its absence from the association dominants in the southern part of the lower peninsula as a whole, is indicative of a tendency toward a northern aspect for this location. Quick (1923, p. 231) likewise mentioned the occasional occurrence of Pinus Strobus and Larix laricina within the region, relegating them to relic status within the association. He noticed (p. 231) that in the southern border of the region some species of more southern ranges occurred: "Juglans cinerea at Mosley; Plantanus occidentalis at Mill Creek; and Ulmus racemosa at Hart."

It was Quick's conclusion (p. 239) that the beech-maple climax association was an ecological association for the southern peninsula of Michigan, and that the differences which were evident between the climax forests of the northern and southern portions of the peninsula were not sufficient to warrant a division into two areas, each having a different climax. He indicated (p. 239) a belief that the organic matter of the soil was an important factor in determining the development of the climax association, with the inorganic factor not acting as a limiting one and that the water relations were important only in the early stages of development. Quick (1923, p. 238) would allocate historical factors to a place of considerable importance in explaining the present distribution of the climax association. He said (p. 238) that the "lagging" of certain species in the central region of the state may be due to their having entered from one or more corners and to their not having yet completed their invasion of the entire region. Quick (p. 238) indicated that many of the areas at present unoccupied by the climax association will become so in the future after sufficient time has elapsed to allow for the modification of the present soil.

The character of the second growth hardwood stands found in the northwestern part of the lower peninsula depends almost entirely upon the nature of the original cutting and subsequent action of fire according to Buttrick (1923, p.4). He has classified these second growth hardwoods, depending upon the manner in which the original timber was removed and what subsequently happened, as follows (p. 5):

1. Culled lands
2. Clean cut lands unburned or largely unburned
3. Culled or clean cut lands heavily burned over
4. Cleared lands allowed to revert back to forests
5. Cut, cleared, or burned lands resulting in pure, or nearly pure stands of aspen

He described the manner of succession in which the second growth hardwoods have once again taken over the lands, complete with comparative tables of volume and yields of varied-aged stands in Antrim, Kalkaska, and Leelanau Counties. According to this study, elm, basswood, maple, beech,hemlock were the principal trees of the second growth stands.

The structure of the maple-beech association in northern Michigan was made up of twenty-three species according to a study by Gleason (1924). Their role in the structure of the association was distinguished both by their wide distribution among the areas studied and their "high frequency indexes" within an area. The species as listed by Gleason (1924, p. 293) were:

Trees

<u>Acer saccharum</u>
<u>Betula lutea</u>
<u>Fagus grandifolia</u>
<u>Tilia americana</u>
<u>Ulmus americana</u>

Shrubs

<u>Acer spicatum</u>
<u>Cornus alternifolia</u>
<u>Ribes Cynosbati</u>
<u>Sambucus racemosa</u>

Herbs

Adiantum pedatum	Milium effusum
Aralia nudicaulis	Osmorhiza Claytoni
Arisaema triphyllum	Polygonatum biflorum
Aspidium spinulosum	Smilacina racemosa
Carex intumescens	Tiarella cordifolia
Caulophyllum thalictroides	Trillium grandiflorum
Galium triflorum	Viola scabriuscula

The area studied by Gleason (1924) consisted of a portion of Antrim, Otsego, Charlevoix and Emmet Counties. This paper is one of the very few which gives a full statement of the structure of this important association. As a result of his studies, Gleason suggested the following general theory (p. 296):

> The hemlock forest represents the mesophytic climax of the various successional series of the northern type of vegetation, and the veteran hemlocks of the northern type of hardwood forest are the last generation of trees of this earlier association. Succession by hardwood forests is a modern process, which in some places has not yet been completed in respect to the secondary species, and the present veteran trees of sugar maple and beech represent, in some places at least, the first generation of dominant species of this association.

In conclusion (p. 296) he noted that the hardwood forest of this region was dominated by sugar maple, with beech, elm, and basswood as important codominants, with the proportion of each depending upon the available soil moisture.

Wollett and Sigler (1928, p. 21) report that the typical trees in the revegetation of Beech-Maple areas in the Douglas Lake region are: Acer saccharum, Betula lutea, Fagus grandifolia, Tilia glabra, Ulmus americana, with Ostrya virginiana and Tsuga canadensis being abundant at times. Their studies considered the reforestation of beech-maple forests in areas where there had been: 1) lumbering without fire; 2) burned over areas; 3) pastured areas; and 4) abandoned cultivated areas (p. 22-23). They were also able to compare the processes of reforestation on these areas with the composition of two virgin forest stands. Their findings (p. 28) revealed that the unburned lumbered areas returned to beech-maple association by means of a "coppice" development, that the burned areas involved several successional stages and a considerably longer time for reforestation. Both the pastured and abandoned lands were still more complicated with successional stages before the process was completed. In their comparisons of the virgin forest stands with the reforested areas (p. 24.-25), they found that the latter stands had 6.8% beech and 67.3% maple, while the composition of the old-age stands showed 21.2% beech and 35.9% maple. It is interesting to note that they consider the presence of Betula papyrifera, Pinus Strobus and Quercus borealis as "prominent relics in the composition of the virgin forests" (p. 24).

There have been numerous papers published in which the original forest cover has been reconstructed on the basis of soil maps (Veatch 1928, 1931, 1941). In his 1928 paper, Veatch has mapped the state of Michigan to show the type of original forest as reconstructed from soil maps. According to this map (p. 119) Missaukee County was originally covered by three different forest types: 1) Pine: Norway, white, jack pines. Oaks. 2) Hardwood-Conifer: Sugar maple, beech, yellow birch, hemlock. Norway and white pine local bodies or in mixture with the hardwoods. 3) Hardwood-Conifer: Elm, ash, basswood, red maple; locally sugar maple-beech. Conifers, white pine, hemlock, balsam fir, spruce. In a classification of agricultural land and land types of Michigan, Veatch (1941) has included in the table of soil types under the subdivision of land character, a description of the original forest cover as well as some notes on the state of the vegetational covering at the time of publication. The publication is a valuable part of a field kit as it serves as a source for checking areas for first reconnaissance as well as offering opportunities for interesting comparisons following the completion of the quantitative studies.

There are four principal combinations of forest types in which species of oak occur on the sandy soils of northern Michigan according to Kittredge and Crittenden (1929). They reported that the distribution of the four types of oak forests corresponds very closely with the distribution of certain soil types (p. 11). These forest types in relation to the soils are: 1) jack oak type; Grayling, Ottawa, and some on Roselawn sands; 2) jack oak-white oak type; Roselawn sands chiefly, but occasionally on Roselawn sandy loam and Grayling sand. 3) white oak-black oak type; Plainfield and Coloma sands,and to a lesser extent on Rubicon sand and Ottawa fine sand. 4) red oak type; Roselawn sand and sandy loam, Rubicon and Kalkaska sand, Plainfield fine sand, Emmet sandy loam. According to the authors (p. 45):

> . . .the 1,300,000 acres of so-called 'scrub oak' lands in the northern part of the lower peninsula of Michigan were originally covered with a mixed forest of large Norway pine and white pine with a numerous although subordinate representation of oaks. Logging and repeated fires have eliminated the pines. The oaks alone have persisted by their ability to sprout after each fire.

According to Gates (1930), the most important secondary association within the lower peninsula is the Aspen Association. He indicated that it is an association which is able to revegetate nearly every type of site following the removal of the virgin forest. The association, Gates reports, (1930, p. 238-241), is dominated by _Populus grandidentata_ on the sandy upland soils, by Prunus pensylvanica on the clay upland soils, and Populus tremuloides on the lowland soils.

The Land Economic Survey has recognized four distinct upland hardwood types for upper Michigan (Mc Intire 1931, p.240). They were:

M	-	hardmaple, beech, elm, basswood, yellow birch
Mb	-	hardmaple, beech, yellow birch
Me	-	hardmaple, elm, basswood, yellow birch
My	-	hardmaple, yellow birch

Within the table the species are arranged in the order of their usual occurrence for the stand. Hard maple and yellow birch are present in each of the four types, with hard maple first in abundance. McIntire (1931, p. 241) pointed out that the indicators were beech, elm, and basswood which gave character to the association by their presence or absence. He recognized the virgin associations in northern Michigan as definite in character and comparatively simple in composition, with the second growth stands, which had been only cut over, retaining many of the characteristics of the original forest. He found, however, that the problem of forest typing is a more intricate one in marginal areas where the composition of the original forest was composed of two or more types, and where both logging and fires have been a disturbing factor. The need for an understanding of the basic association of the region in order to construct a type classification is emphasized as follows (p. 245): ". . .a common fault in type mapping is the tendency to place too much emphasis on the area under treatment in the construction of the type classification. A correct type map cannot be made of any given tract without first considering the associations of the entire physiographic unit in which it occurs."

Dice (1931), in his Preliminary Classification of the Major Terrestrial Ecological Communities of Michigan, Exclusive of Isle Royale, divided the state into three biotic provinces. From south to north they were: Ohioan Biotic Province; Alleghanian Biotic Province; and the Canadian Biotic Province, which is confined, within the state, to Isle Royale.

The boundary between the Ohioan and Alleghanian provinces is an east-west line extending from Lake Huron to Lake Michigan and marks a possible geographical location for the boundary of the tension zone in Michigan's lower peninsula. Dice (1931, p. 220) indicated that the position of this boundary line was an arbitrary one somewhat indefinite in location and that it should be interpreted to indicate more or less the central location for a broad belt of intergradation. A complete description of the numerous communities, with their successional stages was drawn for both provinces. According to the author, these were developed from the literature and his own field observations. The principal ecological characteristic of the Alleghanian province, which includes Missaukee County, was the extensive development of pines (Pinus Strobus, P. resinosa and P. banksiana). According to Dice (1931, p. 225) the association formed a very important successional stage which is "sometimes long maintained, and which perhaps in some situations may never be followed by hardwood forests." The author indicated that the hardwood forest was dominated by hard maple, with beech, hemlock, yellow birch, basswood and elm found in association in varying abundance (p. 226).

In a comprehensive study of twenty-four soil types upon which the northern hardwood forest occurs in the upper peninsula of Michigan, Westveld (1933) found that the relations between soil characteristics and forest composition and growth were (p. 49) "sufficiently conclusive to establish general principles for forest land classification and silvicultural practices." The extensive literature pertinent to soil as an important factor of the forest site is reviewed here (p. 4-6). The author reported that the soils which support a natural deciduous forest growth have a relatively wide range of texture and that the difference in the soil types were great enough to cause differences in the composition and rate of growth of various species which occurred in the stands (p. 23-39). An analysis of his comparative yield tables (p. 30-33) indicates that the soil types are very definitely related to yields. The record showed twenty species of trees within the area studied, with nine of these being well represented on most all soil types. They were: sugar maple, beech, yellow birch, American elm, basswood, hemlock, balsam fir, ironwood, and red maple. Westveld (1933, p. 34) called attention to the fact that white pine was more common originally, but that early cutting had removed all traces of it from the stands in some instances.

One of the more complete quantitative studies of the maple-beech association in Michigan has been presented by Cain (1935). On the basis of the results of his quadrat studies, he concluded (p. 512) that: "Warren's Woods fits best type 57 of the Society of American Foresters." This study represents an area well south of the tension zone, near Three Oaks, in Berrien County, Michigan.

The hemlock-hardwood forests of the upper peninsula of Michigan are usually designated by the forester as "mixed hardwoods", by the ecologists as the "northern hardwood climax" or "yellow birch-maple climax", and by the layman as "the virgin hardwoods of the Upper Peninsula", according to Graham (1941, p. 355). On the basis of his investigations in the climax forest of the upper peninsula of Michigan, he reported that in the mixed hardwood forests growing on clay and sandy clay soils in the western end of the upper peninsula, only four species of trees possessed the qualities demanded of climax species. They were hemlock, sugar maple, basswood, and balsam fir. Yellow birch and white pine did not exhibit a high degree of tolerance nor did they reproduce, and consequently could not qualify as climax species (p. 371).

Kenoyer (1929, 1933, 1939) has experienced considerable success in mapping plant associations as interpreted from original land surveys. He reported (1928, p. 214) that for Kalamazoo County a careful checking of the forest remnants now present indicated that almost without exception the boundaries of the association had remained unchanged for the past one hundred years.

As the result of a pollen study within the tension zone of lower Michigan, Potzger (1948, p. 163) was able to conclude:

> . . .the vegetation has experienced more fluctuations and minor changes along the tension line than to the north and south of it, and that some climatic factors exert a progressively increased sharp control to bring about marked 'tapering off' changes within comparatively small latitudinal distances.

The conclusions which have been reached by most of the authors whose papers are cited above are brought together and summarized by Braun (1950) in her magnificent description of the deciduous forests of eastern North America.

According to Braun (1950, p. 340): "the vegetational unity of the Hemlock-White Pine-Northern Hardwood region is emphasized by the nature of the climax communities which vary almost as much locally as regionally." She divides this forest formation into four sections, (p. 340-341): 1) the Great Lakes section, approximately the northern half of the Great Lake section of the physiographers together with a strip across Ontario; 2) the Superior Upland, corresponding somewhat with the physiographic province of that name; 3) the Minnesota section, which is the northeastern part of the Western Young Drift section of physiographers, together with some contiguous area to the north and east; and 4) the Laurentian Upland section, defined by Braun (1950) as a Canadian area extending from eastern Lake Superior eastward to the valley of the St. Lawrence River. Northern lower Michigan and eastern upper Michigan fall within The Great Lakes section as delimited by this author. In describing the area she says (p. 341): "beech-maple as a forest type or as an ecological climax community is as well illustrated in the northern part of the Lower Peninsula of Michigan or in the eastern end of the Upper Peninsula as it is in northern Ohio or southern Michigan. However maple is generally more abundant than beech in the more northern communities and usually has a higher frequency. Hence the name 'maple-beech' so often used is particularly applicable here." She found (p. 342) that the sandy outwash plains of glacial topography afforded suitable habitats for the pine forests and that the morainal ridges and swells of the rolling moraines, "if the soils are fine grained and loamy, are occupied by deciduous forest communities, or mixtures of deciduous species with hemlock and perhaps white pine."

Braun (1950, p. 343) lists the following tree species as composing the pine forests of Michigan: "Pinus Banksiana, P. resinosa, P. Strobus." She states (p. 343) that they may be found singly or in combination and that each of them reaches its southern limit or "less continuous range" in the transition soil region of Veatch (Fig. 1). Sugar maple, beech, basswood, and yellow birch are considered to be the most abundant deciduous trees. Other species more or less frequent are listed as (p. 351): red maple, white elm, and red oak. She states that (p. 352):

> . . .all statistical data for the hardwood forests of this section illustrate the overwhelming dominance of sugar maple and beech, not only in the forest canopy, but in the lower layers as well; the almost universal occurrence of hemlock, sometimes as codominant; and the abundance of hophornbeam (Ostrya) among the smaller trees.

It is the belief of this author that (p. 347):

> . . .Successional development in the several pine communities will lead, ultimately, to the establishment of the regional climax forest of hemlock and northern hardwoods, or of hardwoods alone. This development is exceedingly slow, taking centuries for its completion and is possible only in the absence of fire. It may take place on any type of soil, but is more rapid on the fine-grained soils, and slower on the sandy soils.

It is evident from this review of the literature that this large geographical area, known as the Hemlock-White Pine-Northern Hardwoods region, or Lake Forest, supports a climax forest of mixed conifers and northern hardwoods; and that local sections or the larger areas are faciations and lociations altered in their composition as a result of various physiographic, edaphic and disturbance factors.

DESCRIPTION OF THE AREA STUDIED

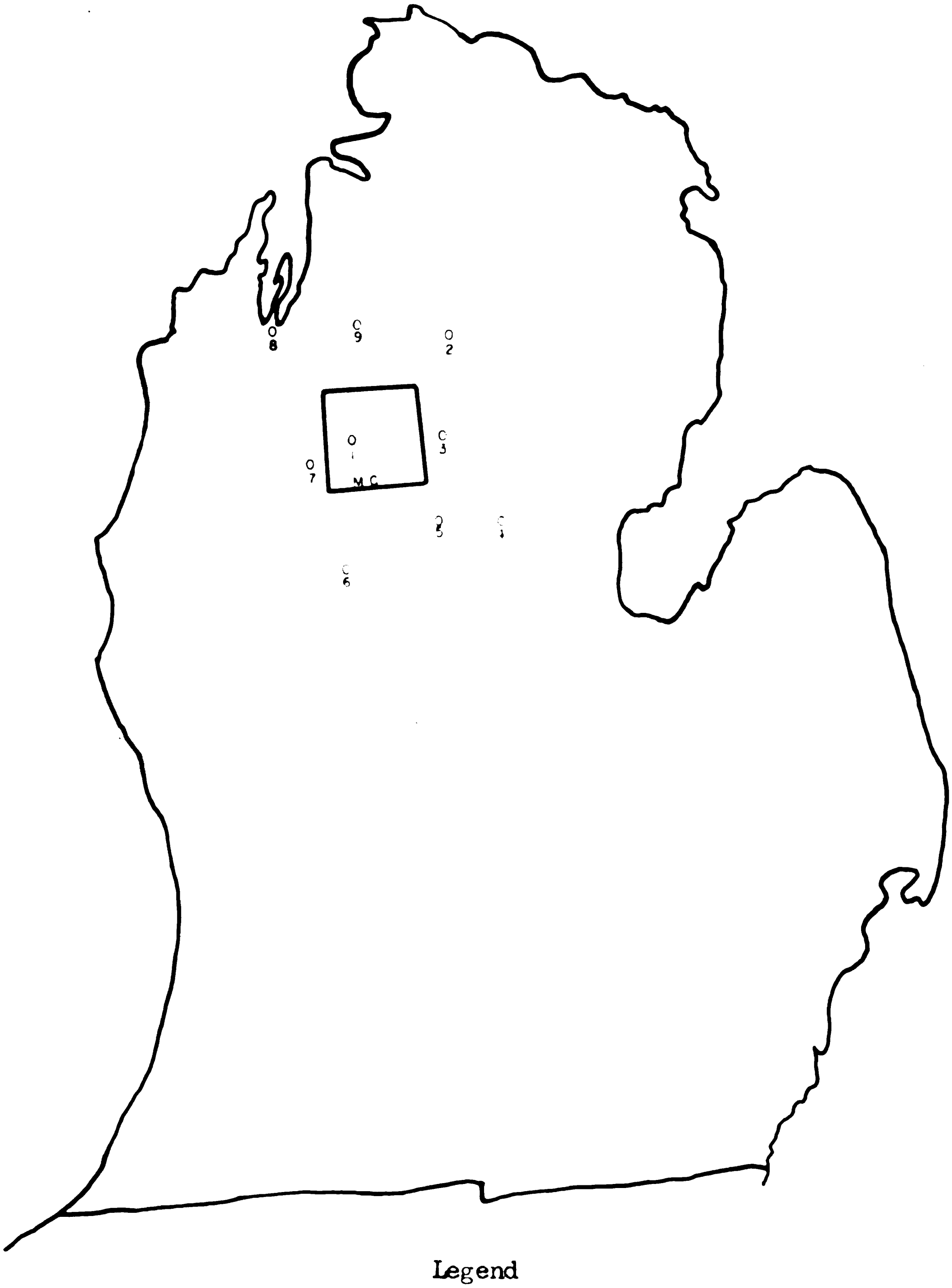
A. Location

Missaukee County is located in the north-central part of the lower peninsula near the geographical center of Michigan. The northwest corner of the county is eighteen miles southeast of the south shore of Grand Traverse Bay and forty-two miles west of the eastern shore of Lake Michigan. The eastern county line is six miles west of the western end of Houghton Lake (Fig. 2).

B. Physiography

The topography of Missaukee County is composed of a series of morainic ridges, outwash aprons and till plains. The most prominent topographic features in the county are the ridges comprising the two morainic systems (Fig. 3).

The southwest corner of the county is covered by a ridged deposit which marks the northern limits of the Lake Michigan-Saginaw Interlobate tract (Leverett 1915). Its topography is largely of the knob-basin type with elevations on the moraines averaging about 1,350 feet. The Lake Border moraine enters the county from the west, after bending around the northern end of the Lake Michigan-Saginaw Interlobate Tract, and runs northeastward across the center and northeastern part of the county, finally joining the West Branch moraine in Oscoda County. Threading out from the main body of this moraine, near the center of the county, is a ridge running southeast across the county. The ridge, known as the



Legend

(MC) Missaukee County; (1) Lake City; (2) Grayling; (3) Houghton Lake; (4) Gladwin; (5) Harrison; (6) Evart; (7) Cadillac; (8) Traverse City; (9) Kalkaska.

Fig. 2. Map of Lower Michigan showing the location of Missaukee County and the weather stations from which climatological data was assembled.

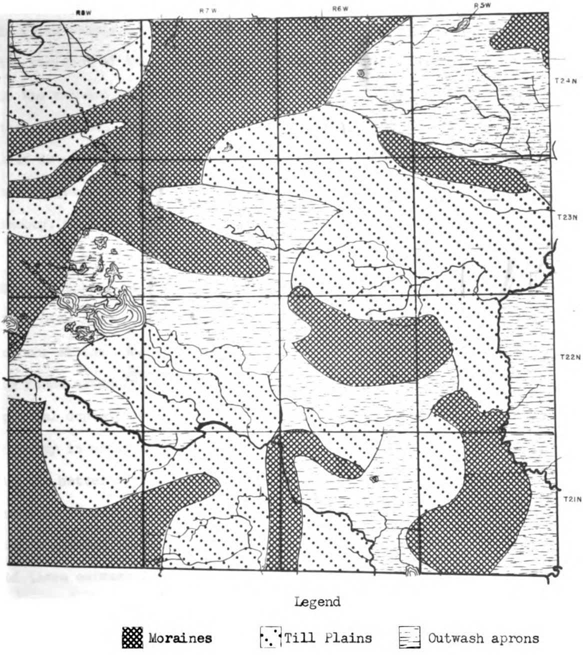


Fig. 3. Surface Geology of Missaukee County
(After Leverett, 1915.)

Harrison-Lake City ridge, joins the West Branch Moraine near Harrison in Clare County. The Lake Border moraine is a recessional one, marking the position of the Cary Ice during a halt in its retreat. The relief on the moraine above the surrounding plains varies from fifty to more than 500 feet. Within the morainic boundary, however, the average relief is about one hundred feet. The topography of the broad summit of the ridges varies from slightly undulating and rolling to rough and knobby, where the elevations change quickly in short distances.

East and north of the northern terminus of the Lake Michigan-Saginaw Interlobate Tract, as well as east and north of the Harrison-Lake City ridge, are large areas of till plains. In the northeast corner of the county, and near the base of the morainic systems are to be found extensive outwash aprons. The till plains are composed of glacial deposits which were laid down under the ice sheet. Their topography is undulating to rather rolling. The soils of these areas make up the better agricultural areas of the county. The outwash aprons are made up of stratified glacial drift which was deposited by the melt-water streams during periods when the ice was shrinking. The surface of these outwash aprons is flat to undulating. Their soil is relatively poor, especially for agricultural purposes, as the materials are mostly a mixture of silt, sand and gravel. There is evidence within the county to indicate that certain phases in both the till plains and outwash aprons are comparable to the "composite plains" as characterized by Stewart (1948, p. 221) for Wexford County.

C. Drainage

There are three drainage basins within Missaukee County (Fig. 4). The lake area in Lake and Caldwell townships together with Hopkins Creek and its tributaries forms that part of the Manistee River drainage basin within the county. In the very northeastern corner of the county, Cannon Creek and Grass Lake drain into the Au Sable River drainage basin. The greater part of the county is served by the Muskegon River drainage basin. In the northeastern part, Willow Run, Haymarsh, Dead Stream, and Addis Creeks all join the Muskegon River just east in Roscommon County. West Branch and Butterfield Creeks, in the central and eastern portion of the county, join the Muskegon River as it flows southward through the eastern part of Missaukee County. The Clam River, with its numerous tributaries, drains the southern part of the county and joins the Muskegon River to the south in Clare County.

D. Climate

Missaukee County is located within an area in which the climatic factors have favored the development of a forest formation: Whitford (1901), Seelye (1917), Quick (1923), Gates (1926), Darlington (1945), Potzger (1946, 1948) and Braun (1950). The temperature is moderate, the rainfall, which is amply distributed throughout the year, is also moderate, and snowfall is usually abundant, remaining on the ground for some length of time.

While the major variations of macroclimatic factors are sufficiently large to bring about a change in the expression of the forest formation from a deciduous forest climax in the southern part of the state to a

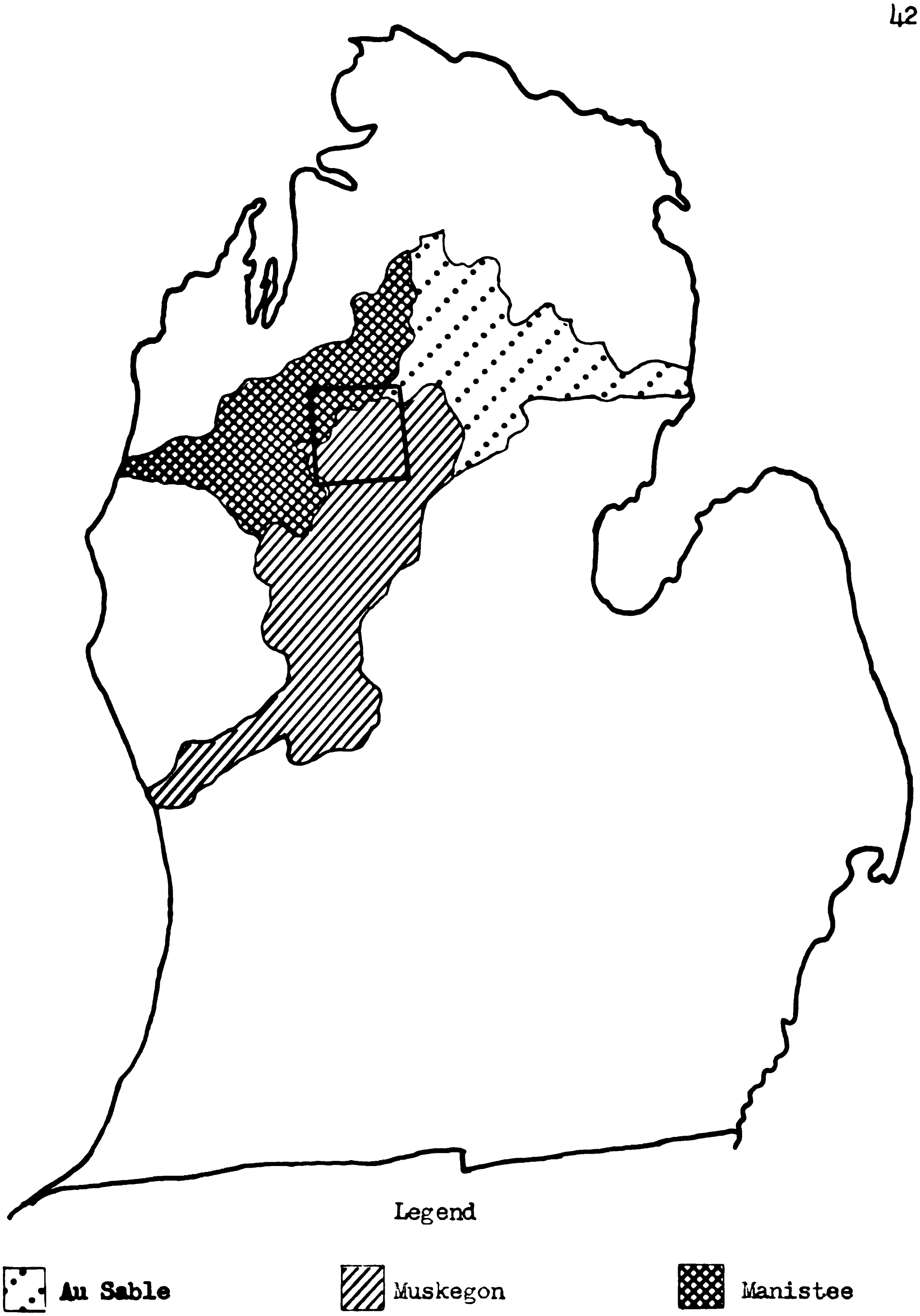


Fig. 4. Map of Lower Michigan showing drainage basins serving Missaukee County.

mixed conifer-northern hardwood forest climax in the northern part of the state, they are not varied enough to account for any major vegetational changes within Missaukee County. Livingston (1905, p. 40), Quick (1923, p. 215), and Cain (1944, p. 12-13) have all noted that meteorological conditions are of little value in explaining differences in vegetation for smaller regions, although they no doubt are very significant in explaining vegetational differences between larger areas.

Table I presents a climatic summary for the weather station at Lake City, Missaukee County, as well as including similar data for the nearest weather stations in all major compass directions. The location of these stations is shown on the map at Fig. 2. Comparison of the climatic factors expressed in the table reveals that Missaukee County is nearly average for the stations considered, as regards temperature and length of the growing season. The county receives slightly less rain annually than the other stations considered. This difference, however, is not believed to be large enough to be a critical factor as regards the distribution of the forest formation within the total area.

The physiography of Missaukee County is of such nature that the "microclimate of edaphic factors" (Potzger 1948, p. 162) would undoubtedly affect the vegetational expression, sometimes favoring the species characteristic of the southern deciduous forest climax and at other times favoring species characteristic of the mixed conifer-northern hardwood climax forest. Small fluctuations in temperature and moisture, factors which would be influenced by such microclimatic-edaphic differences, would find expression here while not being evident within the boundaries of the major communities. The determination of such micro-

TABLE I - A

CLIMATIC SUMMARY FOR WEATHER STATIONS
IN AND NEAR MISSAUKEE COUNTY*

Station	1	Temperature in °F. a	Temperature in °F. b	x +	y −	1	Killing Frost Av. Dates c	Killing Frost Av. Dates d	2
Lake City Missaukee County	26	19.3	68.3	106	-41	17	May 26	Sept 26	123
Grayling Crawford County	46	17.4	66.1	106	-41	40	May 27	Sept 19	115
Houghton Lake Roscommon County	32	19.8	67.4	107	-48	22	June 11	Sept 3	84
Gladwin Gladwin County	32	20.1	68.7	105	-39	20	May 13	Sept 23	133
Harrison Clare County	23	19.8	69.1	103	-36	24	May 13	Oct 3	143
Evart Osceola County	24	21.2	69.1	102	-42	18	May 21	Sept 23	125
Cadillac Wexford County	39	18.4	67.5	104	-36	26	May 27	Oct 6	146
Traverse City Grand Traverse County	48	22.0	69.6	105	-33	36	May 15	Oct 11	149
Kalkaska Kalkaska County	22	17.6	67.8	106	-35	24	May 23	Sept 25	125

1. Length of record in years
   a. January average temperature
   b. July average temperature
   c. Last killing frost in the spring
   d. First killing frost in the fall
   +x. Maximum temperature recorded
   -y. Minimum temperature recorded
2. Length of growing season - days

* Adapted from Climate of Michigan in Climate and Man, USDA Yearbook 1941 and expanded by use of Climatological Data for Michigan; U. S. Dept. of Commerce Weather Bureau, 1942 - 1950

TABLE I - B

SUMMARY OF PRECIPITATION DATA FOR WEATHER STATIONS
IN AND NEAR MISSAUKEE COUNTY*

Station	Average monthly precipitation (inches)													
	A	1	2	3	4	5	6	7	8	9	10	11	12	B
Lake City Missaukee County	24	1.47	1.65	1.50	1.96	2.52	2.65	2.50	2.25	2.94	2.33	1.79	1.29	24.65
Grayling Crawford County	47	1.56	1.32	1.70	2.56	3.37	2.89	3.41	2.90	3.43	3.16	2.73	1.70	30.73
Houghton Lake Roscommon County	32	1.34	1.21	1.99	2.52	2.74	2.77	2.38	2.73	2.92	2.97	2.37	1.45	27.40
Gladwin Gladwin County	30	1.44	1.37	1.88	2.32	3.59	2.21	2.78	2.61	3.74	2.90	1.99	1.68	28.24
Harrison Clare County	29	1.15	1.40	1.96	2.26	2.84	2.49	2.78	2.90	2.44	2.27	2.29	1.67	26.45
Evart Osceola County	25	1.70	1.23	2.07	2.14	3.20	2.84	3.81	2.80	2.84	3.11	2.48	1.51	29.73
Cadillac Wexford County	30	1.50	1.54	1.73	2.38	2.77	2.73	2.61	2.90	3.61	2.83	2.48	1.45	28.53
Traverse City Grand Traverse County	40	1.78	1.59	1.74	1.99	2.71	2.10	2.81	2.59	2.88	2.85	2.65	1.78	27.47
Kalkaska Kalkaska County	25	1.49	1.23	1.94	2.20	2.94	2.60	3.07	3.19	3.30	2.87	2.40	1.95	29.18

A. Length of record in years
B. Annual rainfall

* Adapted from Climate of Michigan in Climate and Man, USDA Yearbook 1941 and expanded by use of Climatological Data for Michigan; U. S. Dept. of Commerce Weather Bureau 1942-1950

climatic factors and their expressions upon the vegetational distribution within the area would require a long period of controlled field experiments much beyond the scope of this study. All that can be done here is to take notice of their probable existence, and attempt to correlate plausible explanations where an analysis of the composition of the vegetation seems to indicate that such factors are operative.

E. Soils

The soils of the northern part of Michigan are a part of the great soil group known as the podzols. Those of Missaukee County were developed from the material deposited by the great ice sheet of the Tazwell and Cary substages of the Wisconsin stage of Pleistocene glaciation. Some evidence of pre-Wisconsin glacial activity may be interpreted from the compact clay drift which is found beneath the Tazewell surface in certain parts of the county. Thus the area may be considered as comparatively young physiographically in view of the fact that the last glacier is considered by geologists to have receded from this part of the state about 25,000 years ago.

References to the northern part of the lower peninsula of Michigan invariably brings forth the comment, "Oh, that's all sand up there." This popular connotation rests upon a sound foundation, as that part of the state has been classified largely as third and fourth class agricultural land because of the large proportion of sandy soils present (Millar 1948).

The natural land divisions for the county, as mapped by Veatch and Schneider (1948, p. 23), are shown in Fig. 5. Division A is composed

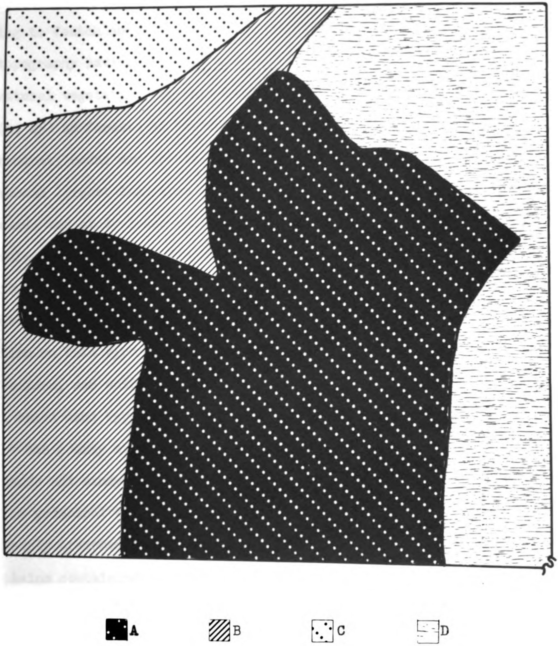
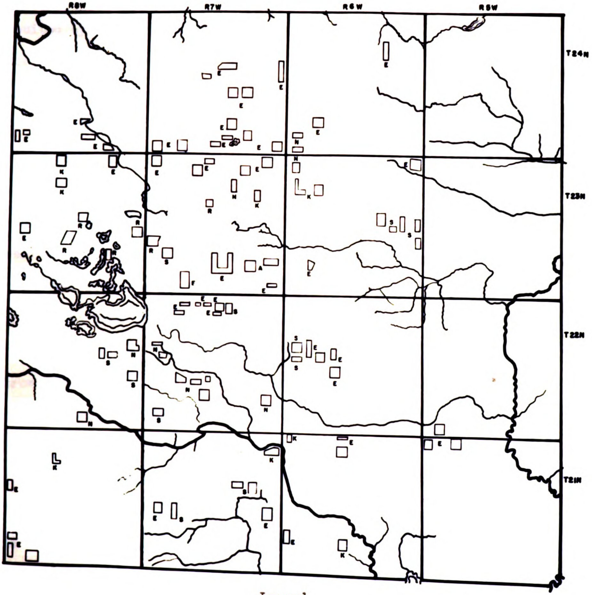


Fig. 5. Map of Missaukee County showing Natural Land Divisions (After Veatch and Schneider, 1948.)

predominately of sandy loam and loam soils over reddish clay. According to Veatch and Schneider, such land types are characterized by a topography having flat and undulating plains with low hills. The natural vegetation for this land type is described by the mappers (p. 25) as forests of "hard-maple, beech, elm, basswood, white pine, hemlock; cedar and spruce in the swamps." Division B makes up the second largest land type in the county. Its soils are predominately sands and sandy loams while associated with them are smaller areas which are like the soils of Division A. Topographically, Division B is rolling and hilly with some flat plains which may be either dry or wet. Veatch and Schneider (p. 25) have classified the natural vegetation on this type as: "forests; upland hardmaple, beech, mixed hardwood, hemlock, and white pine. Swamps - cedar, spruce, tamarack, and fir." A third land type, Division C, is restricted to the northwest corner of the county along the Manistee River. The soils of this type are sands and sandy loams which have dry sands and gravel beneath them. The principal topographic feature is a high dry plain which has been deeply trenched by the Manistee River. There are some small swamps plains containing low ridges and hillocks of sand. This land type, according to the mappers (p.27) has a natural vegetation composed of forests of white and red pine on the dry plains, with swamp hardwoods and conifers on the wet lands. The eastern portion of the county is characterized by Veatch and Schneider (p. 25) as a natural land division with predominant dry acid sands of low fertility with large and small bodies of peats. Its topography is level pitted plains, hilly highland, lakes, and a few large swamps. The natural vegetation of such a natural land division, according to Veatch and Schneider (p. 25), is forest with red and jack pines dominant and white pine, oaks, and aspen in lesser abundance. This natural land division is shown on the map (Fig. 5) as Division D.

Michigan soil types developed from glacial drift usually show considerable heterogenity over a comparatively small area. Missaukee County is no exception. The legend of an unpublished Land Type Map of Missaukee County* lists no less than twenty-two major soil types. Associated with each major soil type are numerous minor types so that the final picture for the soil becomes a very heterogenous affair. Comparisons of the sample plots with the soil series were made after the sampling areas in the county had been selected. It was then found that six different soil series were represented within the ninety-eight stands of second growth upland hardwoods selected for quantitative study (Fig. 6). Therefore a description of the general characteristics and profile development of the soils will be limited to these six. These descriptions are based upon field notes taken in the stands during the summer of 1950 and the descriptions of The Established Soil Series by the Division of Soil Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, copies of which are on file with The Soils Department, Michigan State College. The six soil series represented in this study are: 1) Arenac; 2) Emmet; 3) Kalkaska; 4) Nester; 5) Selkirk; and 6) Roselawn.

*Land Type Map, Missaukee County. Agricultural Experiment Station. Michigan State College. Conservation Institute and Soil Science Section, Department of Conservation, State of Michigan; USDA, Bureau of Plant Industry, Div. of Soil Survey. 1942.



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▯ **Stand Location;** A - Arenac Soil Series; E - Emmet Soil Series; K - Kalkaska Soil Series; N - Nester Soil Series; S - Selkirk Soil Series; R - Roselawn Soil Series.

Fig. 6. **Map of** Missaukee County showing the location of the ninety-eight **stands** of second growth upland hardwoods and their relation to the six soil series.

According to The Division of Soil Survey (1939) the Arenac series consists of podzols which have been developed in sands deposited by winds and water over heavy clay. The A_{00} layer of the A horizon of the profile was the most variable in the nineteen quadrats on Arenac sandy loam. It ranged from bare sand at the forest floor in some plots to others having a leaf litter more than one inch thick. Where the leaf litter was completely absent the profile showed no humus layer, when the layer of leaf litter was present there was a weakly developed brown raw humus. The A_2 portion of the horizon was well developed, showing strong podzol characteristics. This layer, which was strongly leached, was a loamy sand, ligh-lavender in color and varied from three to nine inches in thickness. The upper layer of the B horizon was loamy sand, slightly acid in reaction and pale coffee brown in color. Its thickness varied from eight to twelve inches, with the deepest layer found in sites having the thickest A_{00} layer. The B_2 layer was more sandy than loamy and averaged six inches in thickness. It showed the same degree of acid reaction as did the B_1. The deepest layer of the B horizon was extensively developed, ranging from a foot to a foot and a half thick. It was yellow sand, neutral in reaction. There were some sample plots which contained, in addition to the yellow sand, a slightly mottled rusty-brown sand. The parent material is a calcareous clay, which was probably water laid, as these tracts are physiographically outwash aprons.

The largest number of sample plots were located on the Emmet sandy loam of the Emmet Soil Series. This series includes podzols developed on sandy glacial drift, which is coarse for the most part. The solum varies from a medium to strongly acid and the parent material is slightly calcareous, according to the Division of Soil Survey (1943). The profile varies within the plots, especially in regard to the A_{00} layer. In some stands it was nearly four inches thick, while at other places it was exceedingly thin. In nearly every plot, there was a typical mull humus layer in the A_0 portion which was about two inches thick. The zone of eluviation was a loose loamy sand mostly pale-lavender in color, and usually eight inches deep. Three layers were distinguishable in the B horizon. The B_1 was a sandy loam mostly light brown. However, in some instances this layer tended towards a yellowish color. While variable in thickness within the plots, its average depth was ten inches. The B_2 layer had the greatest variation in color characteristics within the sampling area. In some instances, it was a brownish-gray with a slight tendency towards mottling. At other places, the color was reddish-brown. The loamy sand was without structure, just slightly acid, and four to five inches thick. The B_3 layer, which was almost two feet thick, possessed a greater clay content with the sand resulting in a coarse, somewhat blocky, structure. This layer was slightly to medium acid in reaction. A moderately compact, slightly calcareous glacial till formed the C horizon. The Division of Soil Survey (1943) indicates that the $CaCo_3$ content of this horizon varies from 5-15%.

Kalkaska sandy podzols make up the third soil series. The Division of Soil Survey (1950) describes the series as being composed of sandy podzols developed on glacial outwash plains. They are sands of mixed composition possessing both silicate and limey materials. In the samples used in this study, there was an A_{oo} layer which varied from less than one-half to four inches thick. The Ao layer was composed largely of organic debris in various stages of decomposition tending toward humus, but less than humus. Its average depth was an inch. The lowest layer of the A horizon was made up of a pinkish-gray, fine sand which averaged nearly a foot in depth. Digging "soil wells" through this area was hampered by the accumulation of many secondary roots from the tree and shrub species. A fine loamy sand, dark brown in color and medium acid in reaction formed the B_1 layer of the B horizon. The layer was approximately ten inches thick and tended to show a granular structure in many of the plots. The B_2 portion was a dry brown loamy sand, varying to a yellowish-brown sand, which was more moist. The layer was like the B_1 in structure, thickness and reaction. The C horizon was a light-brown to yellowish sand and varied from dry to slightly moist with many small stones in it.

According to The Division of Soil Survey (1946), the Nester Series consists of podzols developed in moderately heavy, pinkish-brown glacial till, which is somewhat calcareous, with a solum acid in reaction. The A_{oo} layer of the profile was composed of freshly fallen leaves together with other forest debris and averaged two inches in thickness. The Ao layer, about one inch thick, was made up of undecomposed organic debris. In the A_1 layer of the horizon characteristics of a mull humus were easily identifiable. This layer, in these stands, was nearly two inches thick. Below, in the zone of eluviation, there was a light-gray loam about four inches thick. The upper layer of the B horizon consisted of a yellowish-brown loam some three inches thick. The B_1 layer was a fairly compact gritty clay loam, reddish in color and two feet deep. The B_2 layer, while not sharply defined, was thicker than the preceding layer. The C horizon was composed of a gritty, pebbly clay till, limey in character, which has a reddish-pink cast.

The Selkirk Series is composed of imperfectly drained soils which have been developed over reddish or pinkish calcareous till or lacustrine clay, in the podzol region, according to the records of the Established Soil Series prepared by the Division of Soil Survey (1946). The stands of second growth hardwoods occurring within this soil series were on Selkirk silt loam. A consolidated soil profile for the type encountered here consisted of an A_{00} layer averaging three inches in thickness. The A_1 layer, a dark gray humus layer, slightly acid in reaction, was typical of a mull humus. It was slightly thicker than the A_{00} layer. A podzol characteristic was evident in the A_2 layer, which was silt loam, light-gray in color, and medium acid in reaction. Two layers were distinguishable in the B horizon, both giving visible evidence of imperfect drainage. The B_1 was a silty clay loam reddish to yellow-brown, and very coarse structured. Its thickness was very variable throughout the seventy-two quadrats, being from two to seven inches. The yellowish color of this silty clay was lacking in the B_2 horizon. Instead, there was a gray silt along with a reddish clay. The layer was quite impervious and quite acid in reaction. Like the B_1 layer, it was also variable in thickness, averaging eight inches. The parent material was a silty clay which, in some locations, was very pebbly.

Roselawn, the sixth soil series, is characterized by The Division of Soil Survey (1946) as including podzols developed on light-textured glacial drift composed largely of quartzone material. The A_{00} horizon

of the soil profile for the Roselawn sand, which represents this series within the area studied, was variable in thickness and amount. In its greatest depth, it was hardly more than an inch, while in many stands the forest floor had a sparse covering. The A_o was mostly little-decomposed organic debris, one and one-half to two inches thick. In some instances, this graded into an A_1 layer only slightly more decomposed; in other stands, where the A_{oo} was heaviest, and the A_o was much decomposed, the A_1 horizon contained a humus layer characteristic of the mor type. The illuvial portion of the A horizon was incoherent sand of a light-gray color, which varied from four to ten inches in depth. A light-yellow loamy sand, eight inches thick, formed the B_1 layer. The B_2 layer was not sharply defined; however, it tended to lose the loamy characteristic and become quite loose sand. The yellow color characteristic was weaker here also. The parent material, which is only about one and one-half feet from the surface, is sand for the most part. In some sample plots gravel was also found in the C horizon, while two "soil wells" evidenced a reddish clay pocket in the gravel material.

F. History

Missaukee County was legally established in 1840; however, the county government was not organized until 1871. The county was named for an Ottawa chief, who was one of the signers of the treaties of 1831 and 1833. The name Missaukee means "large mouth of a river." (Quaife, 1940).

At the first meeting of the Board of Supervisors, June 6, 1871, which was held at "the Parley farm, a couple of miles northeast of

Falmouth"; (Stout, 1934), the following tax assessments were made:

Pine land - $4.00 an acre
First-class farm land - $2.00 an acre
Pine stump - $1.25 an acre

In April 1877, the present county seat, Lake City, received its name. Previous to this date it was known as Reeder. At that time, mail was received by stage from Fife Lake. Forest fires were very frequent, destroying timber, taking lives, threatening the settlements, and nearly interrupting the mail service as indicated in the following quotation from Stout (1934): "April 1877. . .the stage had difficulty in getting through because of fire, and reported driving through a blazing strip half a mile wide". The establishment of county government coincides with the starting of pine logging on a large scale. The value of the pine lands at that time is reflected in the Supervisors' tax assessment. Commercial pine logging, within the county, centered at Jennings on the west bank of Crooked Lake. Watson Brothers were the largest operators in the county. In the summer of 1877, they reported having 75-80 million feet of pine logs in West Branch township, as well as a big drive in Butterfield township.

The harvest from the pine lands was nearly completed by 1896. Stout reports that The Lapham Mill finished its cut and was wrecked at that time and that Sands' Mill cut their last log. Only small scale operations, largely for local consumption, have been in operation within the county since then. As the end of the harvest approached, serious forest fires were more numerous. Lake City people were aroused to the danger in 1887. During the dry summer of 1891, there were extensive fires throughout the general area of the "pine plains", with considerable damage resulting in Missaukee County. The worst fire in the history of the county is recorded as having occurred on the 20th of May, 1893. At that time nearly all of the personnel of a logging camp lost their lives during a fire which consumed nearly all of the timber and slash in section 11 of Forest township. Only a year later the town of McBain was almost destroyed as forest fires raged through the southern part of the county. The following summer Moorstown, in the northeastern part of the county, met a similar fate. With the passing of time since the extensive logging operations, the number and intensity of the forest fires has decreased sharply, until now, under the supervision of the Michigan State Department of Conservation, there is scarcely any yearly fire loss.

Hardwood logging started as a small scale operation, furnishing the building materials for the business and residential sections of the numerous towns which became the trading and recreational centers of the county during the time of commercial pine logging. Many of the larger operators closed out their lumbering operations in the county with the complete devastation of the virgin hardwood stands.

Titus (1945, p. 7) has described the vanishing forests for the northern part of the lower peninsula as follows:

> By the fifties logging of Michigan pine was an industry just starting. In forty years only a remnant of the pine was left. Towns started, thrived and disappeared as the harvest of nearby stands waxed and waned. First by forties, then by sections and finally by whole townships what had been forests last autumn was chopping this spring, with flash fires raging to cap the destruction man had started. No longer was there work for those to do who settled in the vicinity, nor need for the towns they had built.

History has recorded that a land boom followed the logging opera- in the northern part of the lower peninsula. Missaukee County experienced the full force of the railroaders, loggers, and others who tried in every way to increase settlement on the cutovers. As forfeiture for non-payment of taxes became a probability, the holders of large cutover areas could no longer hang on in hopes of realizing a return from their acres. Then came the "speculative gentry" who purchased great tracts from tax conscious owners and added their excitement to the land boom. Below is a sample of one of the representative sales efforts; it was taken from a statement of a railroad company with acres for sale and no doubt having an interest in the future of the territory (Titus 1945, p. 9):

> Lands timbered with maple, beech, basswood and ash are everywhere regarded as fertile and well adapted to agriculture. A large part of these lands are of this character. In other parts the soil is more sandy. Plains quite free from timber and nearly ready for the plow are also to be found. These lands though offered at low prices ($10.00 to $25.00 an acre) possess the same qualities of soils as some of the best of England and the United States, and wherever lands of this kind have been subjected to intelligent husbandry adapted to their character, they have produced well, and with less labor than the heavier soils. It may be said in general that the lands are adapted to all crops grown in this latitude.
>
> Specimens from these lighter soils have been subjected to numerous examinations, by eminent soil chemists, for the purpose of determining their productive ingredients, and in every case an abundance of lime, feldspar, and mica as well as silica or common sand has been found to exist. As these last named minerals contain a large percentage of potash, the only thing which this variety of soil seems to lack is vegetable matter. A good supply of this latter will make it exceedingly fertile, and can easily be supplied by turning under blue grass sod.

At the height of the boom, lean, droughty, insect-infested, frost-bitten pine lands could be purchased for $10.00 an acre. For $25.00 an acre one could buy hardwood hills with slopes so steep that their fertile soils would go to the bottom after a year's cultivation, and the water table so deep that the cost of a well would be exorbitant.

Most of the early settlers had little money. Very seldom did they start on their new adventure with any resources to help take up the shock of even a temporary set-back. Thus, when crops failed time and again, and the woods offered no more employment, the log cabins and tar papered shacks were abandoned. Soon bracken and sweet fern invaded the unworked fields while aspen and pin cherry crept down off the hills to take over the clearings. These are the dark spots of the settlement picture.

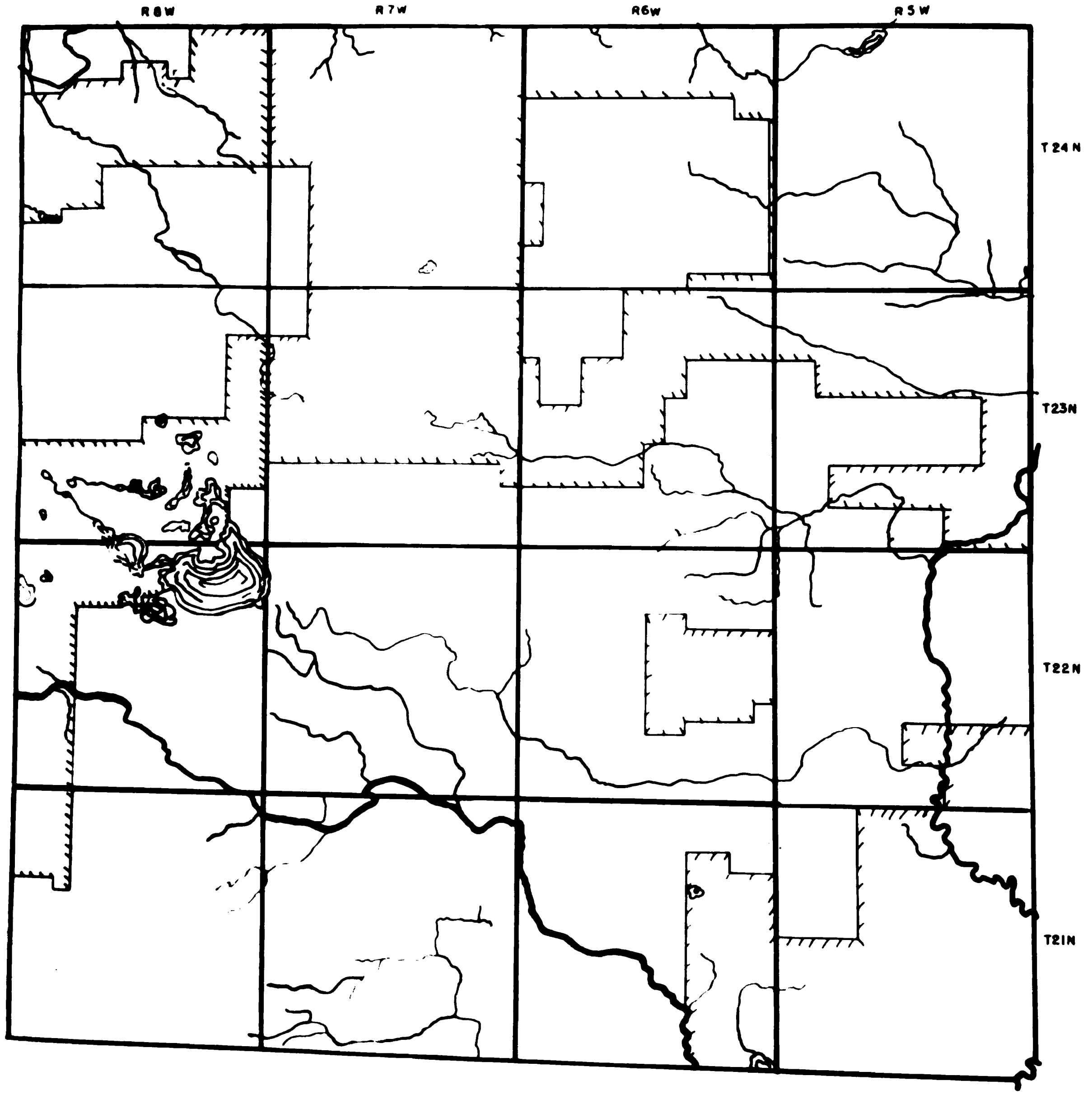
A long sequence of federal and state legislative actions has now corrected such abuses as indicated above and with new approaches to the problems, augmented by sound land policy developments, efforts are being successfully carried forward to reclaim the "Land Nobody Wanted" (Titus, 1945). In speaking of the changes which have occurred in the northern or "wild land" portion of the lower peninsula of Michigan, Andrews and Bromley (1941, p. 30) state:

> The most striking change in the forest conditions is the reduction in area of stands from 0-3 inches in diameter breast high and the increase in the area of those from 3-9 inches in diameter. In particular, the increase from 35,000 to 150,000 acres of stands containing 6-9 inch trees gives promise of early merchantability of considerable areas of timber of value for lumber, pulp, ties, fuel, and other products. These merchantable supplies should support new wood-using industries which will add much to the property and stability of the region, especially if new uses can be developed for the large quantity of low-grade material for which there is little demand.
>
> With effective fire protection the forest is growing taller and denser. Although the area as a whole is now only about half stocked, the question is being raised whether continued increase in the density of stocking, particularly in the stands of conifers, may not have an unfortunate influence upon the wildlife. Careful study of the biological factors and of the economic values involved is essential for an intelligent solution of this problem.

Since the turn of the century the number of inhabitants of Missaukee County has been decreasing. The Federal census figures for 1900 reported a population of 10,606. Ten years later this figure was reported as 9,004. In 1930 it had dropped to 6,922. There was an increase during the next ten years, no doubt as a result of people returning "home to the farm" from the cities during the depression years. The population for the ten year period was reported as 8,029. During the years of World War II and the "return of prosperity" a decrease in population is again reflected, with the latest census figures, 1950, being reported as 7,458.

According to Hill (1930), Missaukee County occupies two types of agricultural regions. Most of the county is included in the "Potato Region". He classified the type of farming within this region as (p. 374): "potato, hay, pasture, cattle". A small portion of the northwest corner of the county is included in the "Forestry and Forage Region" (p. 374). Beagle (1948) has computed human fertility ratios for seventeen types of farming areas as reported by Hill (1939). His figures indicate that the human fertility ratios among the rural-farm residents of The Northern Potato and Dairy Type of Farming (including Missaukee County) are the highest in the state.

The boundaries of the state forests for the county, as of June, 1950, are shown in Fig. 7. A large percentage of the privately owned land is maintained as hunting reserves, with the remainder in agricultural use. Cultural practices of the county are of such a nature that few, if any, stands of timber are long undisturbed. Almost every woodlot is open to cattle seeking refuge from sun or rain. The woodlots likewise serve as a source of supply for fuel to implement coal, oil,



Legend

Boundaries of State Forests

Fig. 7. Map of Missaukee County showing the boundaries of State Forests as of June, 1950. (After Michigan Department of Conservation, 1951.)

and bottled gas supplies during the long cold winters. Such cultural habits added much to the difficulty in the selection of the stands of second growth upland hardwoods for this study.

METHODS

A. General

The selection of the stands of upland second growth hardwoods for this study was made on the basis of the following criteria: (1) that they represent natural stands (i.e., not artificially planted); (2) that they be as little disturbed as possible (i.e., fire, grazing and extensive cutting); and (3) that they be representative of the upland land type. As was noted under the discussion of the history of the county, the selection of stands to exclude disturbances from both grazing and extensive cutting was most difficult due to certain cultural practices within the county. A woodlot which shows no browse line and which is not used to supplement winter fuel supplies is an exception to the rule here. Because of these factors, it was decided to treat quantitatively only the tree and shrub layers composing the stands selected.

Actual selection of stands was made during a reconnaissance through the county. Stands meeting the criteria were sampled quantitatively. In this manner, ninety-eight stands were chosen and data from 546 one hundred square meter quadrats recorded. The geographical distribution within the county (Fig. 6) was believed adequate to give an accurate picture of the upland type of second growth hardwoods.

B. Field Methods

In this study, the quadrat method of sampling, as defined by Weaver and Clements (1938, p. 10-13) was used. The method has been used previously in the general area with satisfactory results by Gates (1912, 1926, 1930); Woollett and Sigler (1928); Westveld (1933); and Cain (1935). Rectangular quadrats, 20 meters by 5 meters on a side, were placed in each stand. Because of the different sizes of the stands (woodlots), varying numbers of quadrats were used in each to insure adequate sampling. The quadrats were placed far enough within the canopy to avoid bordering effects. As the topography of the area is morainic, with outwash aprons and till plains, the rectangular shaped quadrat was selected in order to best sample slope effect.

All trees and shrubs, one foot or taller, were counted and recorded on standardized data sheets which listed the species on the basis of the following five size classes: Size Class Two, .09 in. DBH or less; Size Class Three, 1.0-3.5 in. DBH; Size Class Four, 3.6-9.5 in. DBH; Size Class Five, 9.6-15.5 in. DBH; Size Class Six, 15.6 in. DBH and above. The size class in which each tree or shrub belonged was determined by measuring the diameter of the species breast high (DBH) with a diameter tape. Specimen nomenclature is that of Gray's Manual of Botany, Eighth Edition, Fernald (1950). Records were kept of the conditions of the forest floor and the presence of herbaceous species noted. The presence of any unusual physical appearance in a stand was also noted as well as any pertinent and interesting remarks contributed by the owner. The soils were sampled by means of "soil wells" which were dug into the C horizon. One face of the well was scraped clean and measurements and descriptions recorded. Soil reactions were measured by using a "Soil-Tex" kit. A "soil well" was dug in each stand except in those on moraines. Here the wells were placed on the crest, the slope, and near the base.

C. Treatment of Data

1. Structural Characters

a. Quantitative Description. The present composition of the upland second growth hardwoods in Missaukee County, as revealed by the data from 546 one hundred square meter quadrats, is described quantitatively in terms of frequency, density, and basal area as defined below. These data, obtained by quadrat studies, indicate the numbers of individuals, their sizes, and the space that they occupy. Together they are the sociological characters of the individual stand or concrete community.

Frequency is an expression of percentage of sample plots in which the species occurs (Oosting 1948, p. 58). Frequency is used here in the usual sense as the percentage of the total number of quadrats sampled in which the species was found.

Density, as used in this study, is a quantitative measure of the species abundance expressed on a percentage basis. It is determined by dividing the actual number of trees of a species by the total number of trees of all species within the sampling area.

Basal area, one of the concepts of dominance, designates the important species from the viewpoint of size. This concept can add much to an evaluation in terms of bulk and size that cannot be visualized

through the other quantitative characters. The actual number of square feet occupied by the various species are of interest for they serve to indicate the bulk of the arboreal vegetation present. In order to facilitate comparisons with other studies, the totals for basal area are presented in terms of square feet per acre. A second concept concerned with the expression of dominance is the DFD Index (Curtis, 1947). This index is the sum of the percentage of density (D), frequency (F), and basal area (D). By combining size, relative number, and distribution of individuals into a single expression, the DFD Index becomes an effective means of indicating the relative importance of each species in the stand.

The quantitative description of the composition is presented on a two-fold basis: (1) the upland type as an entity; and (2) the upland type as characterized by the composition of the hardwoods for each of the six soil series. Summary tables, bar graphs, phytographs, photographs, and maps are used in helping to convey these descriptions.

b. Qualitative Data. Qualitative characters indicate the manner in which species are grouped or distributed, or describe stratification, periodicity, vitality and similar conditions. Generally they are not derived from quadrat studies but are rather based upon the knowledge gained from long familiarity and observation of the community. However, when the quantitative analysis of the quadrat data has been completed, many of the qualitative characters are included in the picture. From such an analysis, the qualitative characters of sociability, dispersion, and vitality become apparent. Sociability evaluates the degree that individuals of a species are grouped or how they are distributed in a stand. Dispersion is a statistical expression which is usually applied to sociability. Normal dispersion implies a randomized distribution such as might be expected by chance. Irregular dispersion (hyper-dispersion) results in crowded individuals in some areas and their complete absence from others. A dispersion which is more regular in arrangement than would be expected by chance is known as hypodispersion. This arrangement is characteristic of artifically planted areas. Quantitative density-frequency values usually yield characters of dispersion noticeable in the data. Vitality concerns the vigor and prosperity attained by the different species. Dominants decreasing in numbers and reproducing feebly usually indicate future changes in the composition of the community. Rapidly increasing numbers of species previously of little importance may suggest the new dominants to come.

2. Synthetic Characteristics

a. Presence. One of the more useful synthetic characters used for considering a community in the abstract is that of presence. It involves the degree of regularity with which a species occurs in the stands observed. Generally the presence of each species is expressed by the percentage of the stands in which it occurred on a five-degree scale of presence classes:

1. Rare (1-20% of the stands)
2. Seldom Present (21-40% of the stands)
3. Often Present (41-60% of the stands)
4. Mostly Present (61-80% of the stands)
5. Constantly Present (81-100% of the stands)

b. <u>Constance</u>. Constance is an expression relative to the presence of a species in different examples of a community and is based on the species in a unit area in each community rather than in the entire extent. Constance values are usually expressed on a five-degree scale similar to that showing presence classes. This value bears a relation to the abstract community very much like that of frequency in the concrete community.

c. <u>Fidelity</u>. This character indicates the degree with which a species is restricted to a particular community. Fidelity is frequently spoken of as exclusiveness. Braun-Blanquet and Pavillard (1925) have recognized five classes:

Fid. 1. Strangers

Fid. 2. Indifferents

Fid. 3. Preferants

Fid. 4. Selectives

Fid. 5. Exclusives

Characteristic species of a community are considered to be those which attain a fidelity value between three and five. Fidelity values which have been accurately determined are considered to contribute strongly to the recognition and classification of a community. However, because these kinds of studies are so few in the United States, insufficient data have been accumulated to allow accurate statements of fidelity for the species of most communities. Such values established within the extent of one area might indicate the characteristic species for it. However, there are insufficient available data to establish which of these species could be considered as characteristic for the

more extensive community of the larger area: (i.e. Acer saccharum in Missaukee County; but no data on which to evaluate its fidelity standing for the deciduous forest of eastern North America).

3. Comparisons with Other Studies

Comparisons of the composition of the second growth upland hardwoods in Missaukee County, as established by this quantitative study, with other studies in Michigan, Wisconsin and Minnesota were made by use of the Frequency Index Community Coefficient (FICC) as conceived by Gleason (1920). In one instance (Stearns, 1951) quantitative data were presented which gave a DFD Index (Curtis, 1947) for the species composing the forest formation under study. It was therefore possible, in this case, to draw comparisons from these criteria of dominance.

4. The Original Forest Distribution in Missaukee County, as Interpreted from the Original Land Survey Field Notes and the Present Day Composition of the Upland Second Growth Hardwood Stands

The distribution of forests in Missaukee County at the time of the original land survey was determined in the manner of Kenoyer (1929, 1933, 1939). He described the method as follows (1933, p. 107):

> The surveyor blazed two trees at each station corner and at the midpoint of each section boundary line, stating in his field notes the kind, size, and location with reference to the stake. When records of the species are inserted in their proper locations on a county map it is easy to outline the area occupied by each plant association. Since the located points are in general a half-mile from one another it is possible to draw the boundary line of the association within a half-mile of the exact location.

In Missaukee County, the surveyor also noted in his field notes the kind and size of all the trees falling on the section lines. With these plotted on the county map, in addition to the information given above, the boundary lines of the original plant communities take on an added sharpness. Comparisons with the boundaries of the original forest communities, as interpreted from the original field notes, are then made with the boundaries of the present second growth upland hardwood communities as established by this study.

OBSERVATIONS AND RESULTS

A. The Second Growth Upland Hardwoods of the County

The data gathered from 546 one hundred square meter quadrats, representing ninety-eight stands of second growth upland hardwoods in Missaukee County, indicate that, although there is some variation of the composition between stands, there is sufficient homogeneity to establish a typical grouping of species: the *Acer saccharum - Fagus grandifolia* (Maple-Beech) association, which may be considered as the normal climax forest association for the northern portion of Michigan's lower peninsula.

In describing and comparing the aborescent and shrubby vegetation in numerous stands of second growth upland hardwood, a first logical step is to list all of species present in the individual stands. This is a distinct aid in determining characteristic species and formulating concepts in regard to uniformity and variation of the community. This material has been brought together in Table II.

Among the canopy tree species, *Acer saccharum* and *Fagus grandifolia* are constantly present for nearly all the stands, the former being present in 93% of the stands, and the latter in 86%. *Ulmus americana*, *Tilia americana*, and *Fraxinus americana* were often present, when rated on the usual five-degree scale of presence classes. Their percentage of presence in the stands was as follows: *Ulmus americana* and *Tilia americana*, 57%; *Fraxinus americana*, 43%. Other canopy tree species and their presence class for the stands were: Class 2 (seldom present), *Prunus*

93	94	9
x	x	
x	x	
	x	
x		
x		
	x	
x		
x		
	x	
x		
x	x	

93	94	95	96	97	98	Total	Percent	Class	Canopy Tree Species
x	x	x	x	x	x	93	95	5	Acer saccharum
x	x	x		x	x	84	86	5	Fagus grandifolia
	x	x		x		56	57	3	Ulmus americana
x		x			x	34	35	2	Ulmus Thomasi
x						32	33	2	Ulmus rubra
	x	x	x	x	x	56	57	3	Tilia americana
x						38	40	2	Prunus serotina
				x		42	43	3	Fraxinus americana
						1	1	1	Fraxinus nigra
						29	30	2	Acer rubrum
						19	19	1	Betula lutea
						9	9	1	Betula papyrifera
				x		15	15	1	Quercus rubra var borealis
						5	5	1	Quercus alba
		x	x			36	37	2	Tsuga canadensis
						5	5	1	Pinus Strobus
						3	3	1	Pinus resinosa
						4	4	1	Thuja occidentalis
									Understory Tree Species
x		x	x		x	57	58	3	Ostrya virginiana
	x	x				22	22	2	Populus grandidentata
x						3	3	1	Populus tremuloides
x	x	x		x		40	41	3	Prunus pensylvanica
						8	8	1	Amelanchier sp.
						1	1	1	Crataegus sp.
		x				6	6	1	Rhus typhina
									Shrub Species
						4	4	1	Acer spicatum
						8	8	1	Corylus cornuta
		x		x		12	12	1	Cornus alternifolia
						2	2	1	Ribes cynosbati
						1	1	1	Rosa sp.
						3	3	1	Sambucus pubens
				x		6	6	1	Viburnum acerifolium
						1	1	1	Spiraea sp.

serotina, 40%; Tsuga canadensis, 37%; Ulmus Thomasi, 35%; U. rubra, 32%; Acer rubrum, 30%. Class 1 (rare), Betula lutea, 19%; Quercus rubra var. borealis, 15%; Betula papyrifera, 9%; Pinus Strobus and Quercus alba, 5%; Thuja occidentalis, 4%; Fraxinus nigra, 1%.

Ostrya virginiana and Prunus pensylvanica have the largest presence percentage (class 3) for the understory trees in the ninety-eight stands, as follows: Ostrya virginiana, 58%; Prunus pensylvanica, 41%. The understory tree species fitting the criteria for presence class 2 were limited to a single one, Populus grandidentata, 28%. The species in presence class one were: Amelanchier sp., 8% and Populus tremuloides, 3%.

The shrubby layer within the second growth upland hardwood stands of Missaukee County was composed of ten different species. Each of these was only rarely present within the stands, having a percentage of less than twenty. Cornus alternifolia was present most often, 12%; Corylus cornuta followed with 8% and Viburnum acerifolium and Rhus typhina were next with 6%. The presence percentage for Acer spicatum was four. Representatives of the genera Sambucus, 3%; Ribes, 2%; Crataegus, 1%; Rosa, 1%; and Spiraea, 1%, complete the list.

A presence diagram, based upon a composite of the stands within the county, is shown in Fig. 8. It is quite a normal one in that it shows no secondary maximum due to the relatively small number of constantly present species. Normally most communities have a very high proportion of species present in class one (rare), and tend to have declining amounts in succeeding classes. An inspection of the diagram shows that such is generally the case for this study as based upon the presence values for the tree and shrub species composing the ninety-eight stands.

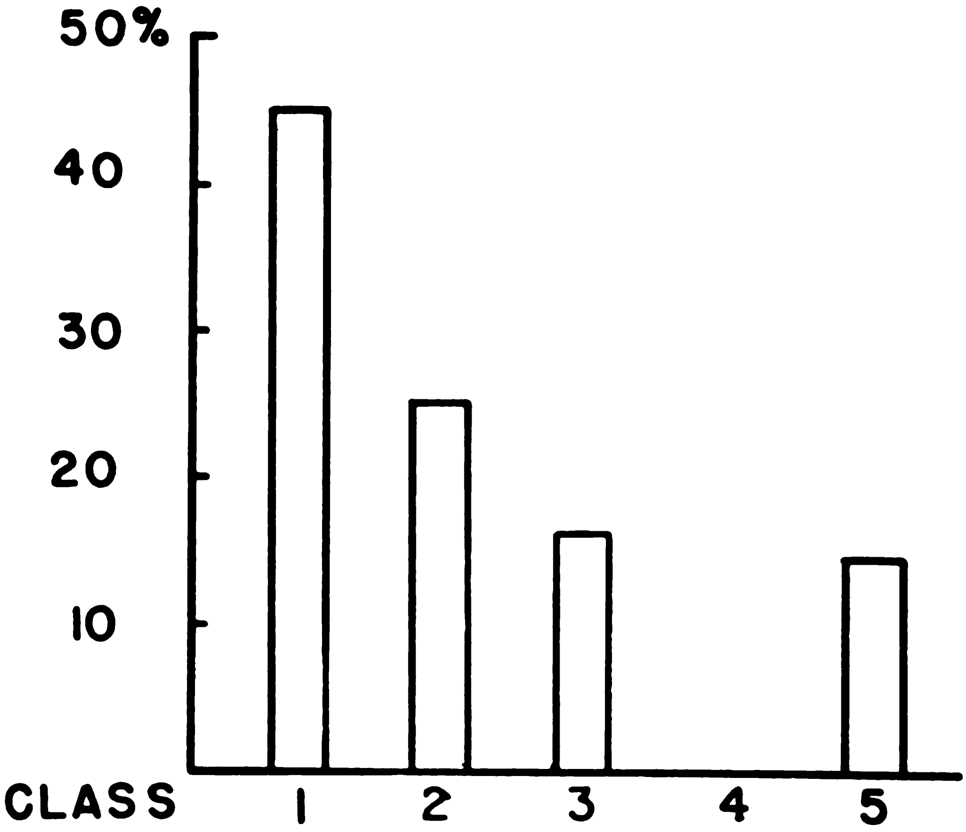


Fig. 8. Presence diagram for the tree and shrub species in the ninety-eight stands of second growth upland hardwoods. Class 1, Rare, 1-20%; Class 2, Seldom Present, 21-40%; Class 3, Often Present, 41-60%; Class 4, Mostly Present, 61-80%; Constantly Present, 81-100%.

Forty-five percent of the tree and shrub species are rarely present (class one); twenty-five percent are seldom present (class two); sixteen percent are often present (class three); there were no species which could be listed as mostly present (class four); fourteen percent were constantly present (class five).

The quantitative results for the quadrat studies are shown in Tables III, IV, V, and Figs. 9 and 10. On the basis of the DFD Index (Curtis 1947), the composition of the aborescent second growth upland hardwoods for the county, arranged in decreasing order of dominance, is as follows: Acer saccharum, Fagus grandifolia, Ulmus americana, Ulmus Thomasi, Tilia americana, Ostrya virginiana, Fraxinus americana, Prunus pensylvanica, Acer rubrum, Quercus rubra var. borealis, Populus grandidentata, Tsuga canadensis, Prunus serotina, Ulmus rubra, Betula lutea, Quercus alba, Betula papyrifera, Amelanchier sp., Populus tremuloides, Pinus Strobus, Thuja occidentalis, Pinus resinosa, and Fraxinus nigra.

The shrubby layer is composed of the following species: Cornus alternifolia, Corylus cornuta, Viburnum acerifolium, Rhus typhina, Acer spicatum, Ribes cynosbati, Sambucus pubens, Crataegus sp., Spiraea sp., and Rosa sp.. The dominance value for these species was established by using a modification of the DFD Index. Only percent density and percent frequency were considered in the quantitative study of the shrubs and thus their potential dominance was taken as the sum of these two percentages.

It is customary to characterize a vegetational community by assigning the names of the two dominant species to it. An analysis of tables

TABLE III

SUMMARY DATA FOR THE TREE SPECIES BASED ON 546 ONE HUNDRED SQUARE METER QUADRATS IN THE NINETY EIGHT STANDS OF UPLAND SECOND GROWTH HARDWOODS IN MISSAUKEE COUNTY, MICHIGAN

Tree Species	TOTALS						
	Frequency		Density		Basal Area		
	No.	%	No.	%	Ft²/A	%	DFD
Acer saccharum	514	94.14	11,184	60.59	42.55	35.83	1
Fagus grandifolia	277	50.73	1,485	8.04	15.05	12.67	2
Ulmus americana	179	32.78	695	3.76	15.35	12.92	3
Ulmus Thomasi	123	22.53	731	3.96	12.94	10.89	4
Tilia americana	141	25.82	522	2.83	7.41	6.24	5
Ostrya virginiana	142	26.01	514	2.78	2.00	1.68	6
Fraxinus americana	104	19.05	368	1.99	3.53	2.97	7
Prunus pensylvanica	90	16.48	620	3.36	.30	.25	8
Acer rubrum	72	13.19	720	3.90	2.57	2.16	9
Quercus rubra var. borealis	59	10.81	323	1.75	3.85	3.24	10
Populus grandidentata	57	10.44	460	2.49	2.55	2.15	11
Tsuga candensis	64	11.72	147	.80	2.39	2.01	12
Prunus serotina	58	10.62	133	.72	2.92	2.46	13
Ulmus rubra	58	10.62	190	1.03	2.52	2.12	14
Betula lutea	31	5.68	60	.33	.64	.54	15
Quercus alba	15	2.75	101	.55	.77	.65	16
Betula papyrifera	16	2.93	55	.29	.43	.36	17
Amelanchier sp.	9	1.65	64	.35	.04	.03	18
Populus tremuloides	8	1.47	37	.20	.16	.13	19
Pinus Strobus	7	1.28	23	.12	.38	.32	20
Thuja occidentalis	7	1.28	17	.09	.19	.16	21
Pinus resinosa	3	.55	7	.04	.14	.12	22
Fraxinus nigra	2	.37	4	.03	.03	.02	23
Total			18,460	100.00			

TABLE IV

SUMMARY DATA FOR THE TREE SPECIES BY SIZE CLASSES BASED ON 546 ONE HUNDRED SQUARE METER QUADRATS IN THE NINETY EIGHT STANDS OF SECOND GROWTH UPLAND HARDWOODS IN MISSAUKEE COUNTY, MICHIGAN

Tree Species	SIZE-CLASS TOTALS																			
	2				3				4				5				6			
	Frequency		Density		Frequency		Density		Frequency		Density		Frequency		Density		Freq.		Dens.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Acer saccharum	420	76.92	6057	66.64	470	86.80	3327	65.74	402	73.63	1580	45.78	131	29.99	180	23.93	34	6.23	40	29.20
Fagus grandifolia	148	27.11	722	7.94	142	26.01	383	7.57	133	24.36	237	6.87	95	17.40	116	16.07	26	4.76	27	19.71
Ulmus americana	42	7.69	198	2.17	65	11.90	147	2.90	115	21.06	217	6.29	73	13.37	113	15.65	19	3.48	20	14.60
Ulmus Thomasi	37	6.78	184	2.02	62	11.36	159	3.14	96	17.58	264	7.65	57	10.44	107	14.82	9	1.65	17	12.41
Tilia americana	42	7.69	140	1.54	52	9.52	104	2.05	97	17.77	218	6.32	37	6.78	47	6.51	10	1.83	13	9.49
Ostrya virginiana	43	7.88	160	1.86	95	17.40	215	4.25	81	14.84	125	3.62	5	.91	5	.69				
Fraxinus americana	29	5.31	120	1.32	46	8.42	91	1.80	65	11.90	135	3.91	20	3.66	22	3.05				
Prunus pensylvanica	76	13.92	551	6.06	31	5.68	67	1.32	2	.37	2	.06								
Acer rubrum	45	8.24	322	3.54	51	9.34	240	4.74	45	8.24	150	4.35	7	1.28	8	1.11				
Quercus rubra*	21	3.85	74	.81	27	4.95	88	1.74	48	8.79	135	3.91	13	2.38	23	3.19	2	.37	3	2.19
Populus grandidentata	33	6.04	282	3.11	17	3.11	44	.87	40	7.33	115	3.33	16	2.93	17	2.35	1	.18	2	1.46
Tsuga canadensis	19	3.48	72	.79	13	2.38	26	.51	23	4.21	31	.90	11	2.02	12	1.66	7	1.28	6	4.38
Prunus serotina	9	1.65	14	.16	14	2.56	24	.47	35	6.41	56	1.62	25	4.58	34	4.71	11	2.02	5	3.65
Ulmus rubra	11	2.02	62	.68	23	4.21	37	.73	35	6.41	66	1.91	17	3.11	23	3.19	2	.37	2	1.46
Betula lutea	3	.55	6	.07	12	2.20	18	.36	23	4.21	32	.93	3	.55	4	.55				
Quercus alba	8	1.47	41	.45	9	1.65	25	.49	11	2.02	31	.90	3	.55	4	.55				
Betula papyrifera					11	2.02	21	.42	13	2.38	34	.99								
Amelanchier sp.	7	1.28	44	.48	5	.91	19	.38	1	.18	1	.03								
Populus tremuloides	3	.55	14	.16	4	.73	15	.30	5	.91	8	.23								
Pinus Strobus	4	.73	9	.10	1	.18	5	.10	1	.18	4	.12	2	.37	4	.55	1	.18	1	.73
Thuja occidentalis	1	.18	3	.04	4	.73	5	.10	4	.73	6	.18	1	.18	3	.42				
Pinus resinosa	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]

TABLE V

SUMMARY DATA FOR THE SHRUB SPECIES BASED ON 546 ONE HUNDRED SQUARE METER QUADRATS FROM THE NINETY-EIGHT STANDS OF SECOND GROWTH UPLAND HARDWOODS IN MISSAUKEE COUNTY, MICHIGAN

Shrub Species	TOTALS				
	Frequency		Density		
	No.	%	No.	%	DF
Cornus alternifolia	27	4.95	259	44.34	1
Corylus cornuta	16	2.93	128	21.91	2
Viburnum acerifolium	9	1.65	59	10.10	3
Rhus typhina	7	1.28	42	7.19	4
Acer spicatum	6	1.10	37	6.14	5
Ribes cynosbati	3	.55	25	4.28	6
Sambucus pubens	3	.55	19	3.25	7
Crataegus sp.	3	.55	10	1.71	8
Rosa sp.	1	.18	18	1.20	9
Spiraea sp.	1	.18	5	.86	10
			591	100.00	

III and IV, which are arranged in order of decreasing dominance as indicated by the DFD Index, reveals that Acer saccharum is by far the most dominant tree species in the second growth upland hardwoods of Missaukee County. This species has percentage of frequency of 94.14, being present in five hundred fourteen of the 546 quadrats. The percentage of density was 60.59, there being 11,118 stems of this species in the grand total of 18,460 stems for all tree species. The basal area, expressed as square feet per acre, was 45.55 or 35.83%. The 546 one hundred square meter quadrats studied quantitatively in the county represents a total of 13.49 acres.

The tree species accorded second rank in the dominance scale is Fagus grandifolia: percentage frequency, 50.73; percentage of density, 8.04; and percentage of basal area, 12.67.

On the basis of the above figures, the community may be characterized as an Acer saccharum - Fagus grandifolia (maple-beech) association. An inspection of Table IV indicates that these two species fulfill the criteria for dominant trees in a climax forest community since they are present in all size classes, indicating successful ecesis, establishment, and maintenance. The Table reveals further that Acer saccharum is not only the most dominant tree species on the basis of the final totals, but that it also exceeds the other tree species in every size class. Fagus grandifolia ranks second throughout all the size classes in respect to both density and frequency. However, the two species of the genus Ulmus closely approach the beech in all size classes in respect to both percent frequency and density and in some size classes, their percentage of basal area is greater than that of beech.

III and IV, which are arranged in order of decreasing dominance as indicated by the DFD Index, reveals that Acer saccharum is by far the most dominant tree species in the second growth upland hardwoods of Missaukee County. This species has percentage of frequency of 96.44, being present in five hundred fourteen of the [illegible] quadrats. The percentage of density was 60.59, there being 11,115 stems of this species in the grand total of 18,460 stems for all tree species. The basal area, expressed as square feet per acre, was [illegible] or [illegible].63%. The 5[illegible] one hundred square meter quadrats studied quantitatively in the county represents a total of 13.49 acres.

The tree species accorded second rank in the dominance scale is Fagus grandifolia: percentage of frequency, 50.73; percentage of density, 8.04; and percentage of basal area, 12.67.

On the basis of the above figures, the community may be characterized as an Acer saccharum - Fagus grandifolia (maple-beech) association. An inspection of Table IV indicates that these two species fulfill the criteria for dominant trees in a climax forest community since they are present in all size classes, indicating successful ecesis, establishment, and maintenance. The Table reveals further that Acer saccharum is not only the most dominant tree species on the basis of the final totals, but that it also exceeds the other tree species in every size class. Fagus grandifolia ranks second throughout all the size classes in respect to both density and frequency. However, the two species of the genus Ulmus closely approach the beech in all size classes in respect to both percent frequency and density and in some size classes, their percentage of basal area is greater than that of beech.

The presence of Tilia americana, in all size classes, and Fraxinus americana and Betula lutea in all but the largest size classes is characteristic of the typical composition of the northern hardwood deciduous forest formation. The representation of Tsuga canadensis and Pinus Strobus in all five of the size classes; Thuja occidentalis in four of the five classes; and Pinus resinosa in three of the five size classes, adds the necessary elements to constitute a mixed conifer-northern hardwood deciduous forest formation.

Phytographs for the first eight dominant (DFD Index) canopy tree species for the second growth upland hardwoods of the county are presented in Fig. 9. This type of diagram, devised by Lutz (1930), is intended to portray the relative importance of the tree species within a community. Any differences which appear in expressing the relative importance of a tree species on the basis of the DFD Index and a phytograph are discussed is a later section. An inspection of the phytographs clearly shows that the community may be characterized as a Maple-Beech (Acer saccharum - Fagus grandifolia) association on the basis of the two dominant tree species.

The importance of the understory tree species is presented by means of phytographs in Fig. 10.

While there was no quantitative study made of the herbaceous vegetation because of the intense pasturing and frequent cutting within the woodlots, the following species were noted during the study: Allium tricoccum, Caulophyllum thalictroides, Comptonia peregrina, var. asplenfolia, Galium triflorum, Geranium Robertianum, Hepatica acutiloba, Hieracium aurantiacum, Lycopodium complanatum, Mitchella repens, Osmorhiza Claytoni, Polygonatum biflorum, Oxalis Acetosella, Pteridium

aquilinum, *Thalictrum dioicum*, *Solidago sp.*, *Trillium grandiflorum*, *Viola pensylvanica*, *V. pubescens*, and *V. canadensis*. This list duplicates, for the most part, those published by Quick (1923, p. 225) and Gleason (1924, p. 290).

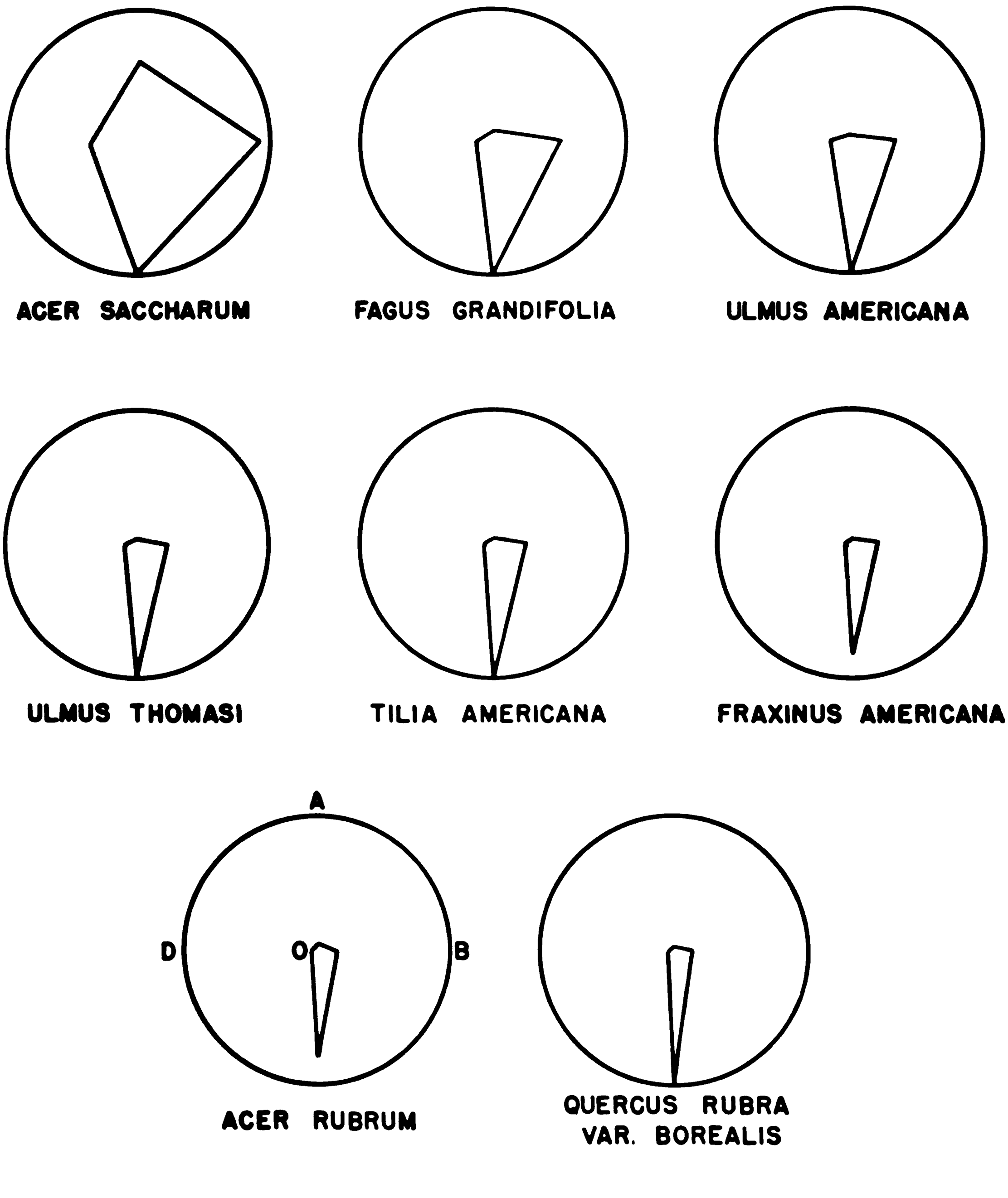


Fig. 9. Phytographs for the first eight dominant (DFD Index) canopy tree species in the ninety-eight stands of second growth upland hardwoods of Missaukee County. Radius O-A, Percentage of Density; O-B, Percentage of Frequency; O-C, Percentage of Size Class; O-D, Percentage of Basal Area.

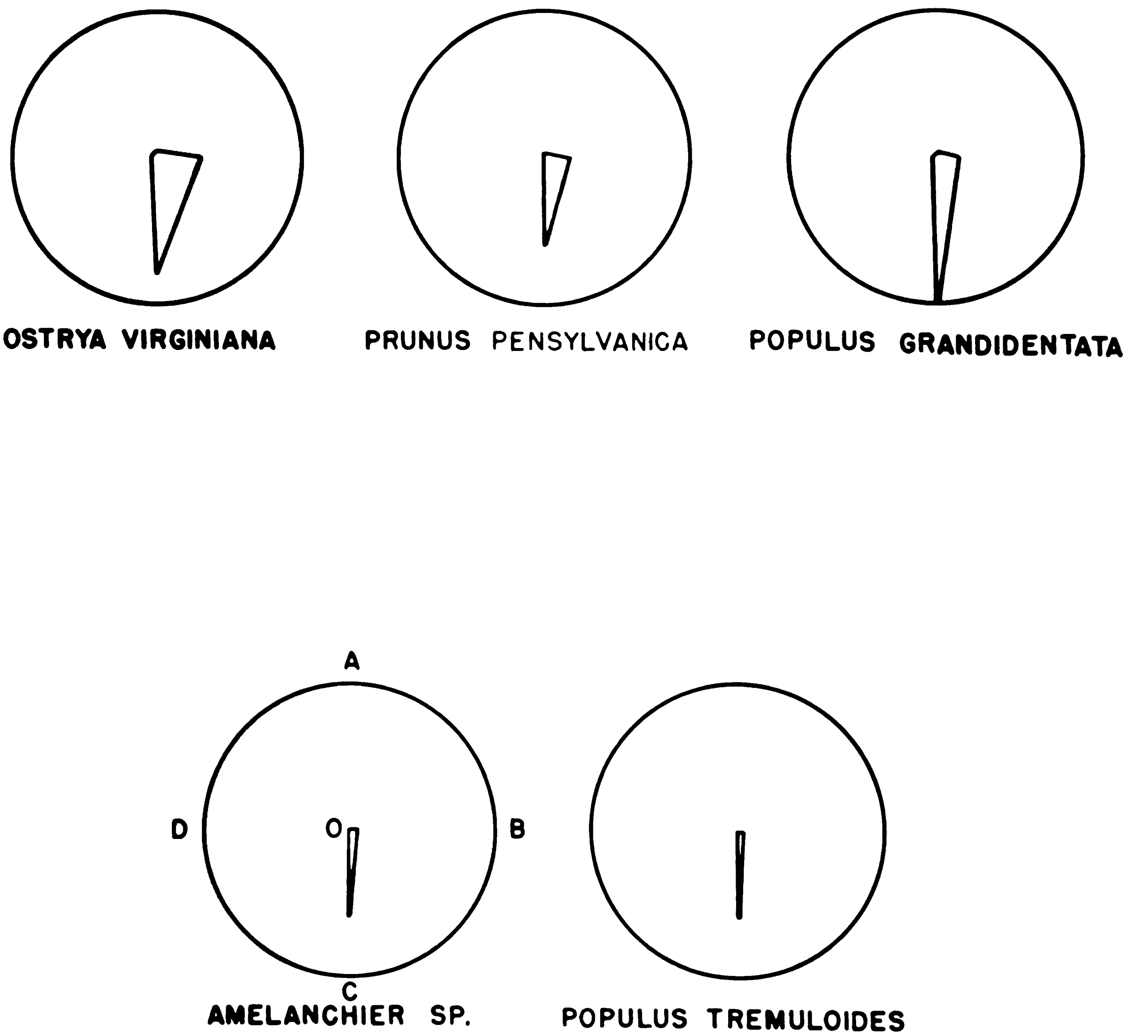


Fig. 10. Phytographs for the understory tree species in the ninety-eight stands of second growth upland hardwoods in Missaukee County. Radius O-A, Percentage of Density; O-B, Percentage of frequency; O-C, Percentage of Size Classes; O-D, Percentage of Basal Area.

B. The Second Growth Upland Hardwoods of the County in Relation to the Six Soil Series

If one groups the ninety-eight stands of upland second growth hardwoods of Missaukee County into arbitrary plots on the basis of the six soil series upon which they occur it is possible to see certain differences in the composition of the communities as they occur on the various soil series.

The quantitative data for this grouping are presented in Tables VI to XXI. An analysis of the data shows that *Acer saccharum* is the dominant tree species in five of the six soil series. The single exception occurs on The Roselawn Soil Series. According to Veatch (1943, p. 43) this soil series supported Norway, white pine and oaks in its virgin condition. Since lumbering and fire, the coniferous element has all but disappeared and deciduous trees such as *Quercus rubra var. borealis*, *Acer rubrum*, *Quercus alba*, and *Acer saccharum* form the second growth arborescent vegetation. A complete analysis for the data of the 23 one hundred square meter quadrats representing this soil series is presented in Tables VI and VII. In the summary totals, *Quercus rubra var. borealis* was accorded first rank on the DFD Index scale. *Acer rubrum* was in second position, *Quercus alba*, third, *Acer saccharum*, fourth, and *Fagus grandifolia*, fifth. The total list of tree species on the Roselawn sand numbered sixteen. Both *Acer saccharum* and *Fagus grandifolia*, the dominant tree species for the deciduous forest formation in this area, are present in considerable abundance in the first four size classes.

B. The Second Growth Upland Hardwoods of the County in Relation to the Six Soil Series

If one groups the ninety-eight stands of upland second growth hard-woods of Milwaukee County into [illegible] on the basis of the six soil series upon which they occur it is possible to see certain differences in the composition of the arborescent [illegible] as they occur on the various soil series.

The quantitative data for this formation are presented in Tables VI to XXI. An analysis of the data shows that Acer saccharum is the dominant tree species in five of the six soil series. The single exception occurs on the Roselawn Soil Series. According to Veatch (1943, p. 43) this soil series supported Norway, white pine and oaks in its virgin condition. Since lumbering and fires, the coniferous element has all but disappeared and deciduous trees such as Quercus rubra var. borealis, Acer rubrum, Quercus alba, and Acer saccharum form the second growth arborescent vegetation. A complete analysis for the data of the 23 one hundred square meter quadrats representing this soil series is presented in Tables VI and VII. In the summary totals, Quercus rubra var. borealis was accorded first rank on the DFD index scale. Acer rubrum was in second position, Quercus alba, third, Acer saccharum, fourth, and Fagus grandifolia, fifth. The total list of tree species on the Roselawn sand numbered sixteen. Both Acer saccharum and Fagus grandifolia, the dominant tree species for the deciduous forest formation in this area, are present in considerable abundance in the first four size classes.

TABLE VI

SUMMARY DATA FOR THE TREE SPECIES IN 23 ONE HUNDRED SQUARE METER QUADRATS OF SECOND GROWTH UPLAND HARDWOODS IN MISSAUKEE COUNTY LOCATED ON THE ROSELAWN SOIL SERIES

Tree Species	TOTALS						
	Frequency		Density		Basal Area		
	No.	%	No.	%	Ft^2/A	%	DFD
Quercus rubra var. borealis	22	95.65	177	18.87	49.14	55.80	1
Acer rubrum	16	69.75	287	30.59	4.32	4.91	2
Quercus alba	11	47.83	94	10.02	14.72	16.70	3
Acer saccharum	7	30.43	182	19.40	3.03	3.44	4
Fagus grandifolia	5	21.74	78	8.31	.82	.93	5
Prunus pensylvanica	5	21.74	27	2.88	.28	.32	6
Tilia americana	3	13.04	11	1.17	5.62	6.38	7
Pinus Strobus	3	13.04	9	.96	3.90	4.44	8
Populus grandidentata	3	13.04	39	4.00	2.19	2.49	9
Ostrya virginiana	3	13.04	13	1.39	.68	.77	10
Pinus resinosa	2	8.70	6	.62	.28	.32	11
Ulmus americana	1	4.35	4	.43	1.75	1.99	12
Prunus serotina	1	4.35	3	.32	.80	.91	13
Ulmus rubra	1	4.35	3	.32	.34	.44	14
Amelanchier sp.	1	4.35	4	.43			15
Fraxinus americana	1	4.35	1	.11	.14	.16	16
Totals			938				

TABLE VII

SUMMARY DATA FOR THE TREE SPECIES BY SIZE CLASS BASED ON
23 ONE HUNDRED SQUARE METER QUADRATS FROM THE
SECOND GROWTH UPLAND HARDWOODS OF MISSAUKEE COUNTY
ON THE ROSELAWN SOIL SERIES

Tree Species	SIZE CLASS TOTALS																			
	2				3				4				5				6			
	Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.	
	No.	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Quercus rubra*	10	43.47	45	8.67	13	56.52	49	19.07	18	78.26	67	48.57	8	34.78	16	69.56				
Acer rubrum	15	65.22	170	32.76	16	69.57	108	42.02	4	17.39	9	6.52								
Quercus alba	7	30.43	39	7.52	9	39.13	25	9.73	9	39.13	23	19.57	2	8.70	3	13.04				
Acer saccharum	7	30.43	144	27.74	7	30.43	29	11.28	3	13.04	9	6.52								
Fagus grandifolia	5	21.74	55	10.59	5	21.74	22	8.56	1	4.35	1	.72								
Prunus pensylvanica	4	17.39	19	3.66	2	8.70	8	3.11												
Tilia americana					1	4.35	2	.72	3	13.04	7	5.07	1	4.35	2	8.70				
Pinus Strobus	3	13.04	7	1.34									1	4.35	1	4.35	1	4.35	1	100.00
Populus grandidentata	2	8.70	23	4.43	3	13.04	7	2.70	3	13.04	9	6.52								
Ostrya virginiana	2	8.70	8	1.54	3	13.04	4	1.57	1	4.35	1	.72								
Pinus resinosa	2	8.70	5	.96					1	4.35	1	.72								
Ulmus americana					1	4.35	1	.39	1	4.35	2	1.45	1	4.35	1	4.35				
Prunus serotina									1	4.35	3	2.17								
Ulmus rubra					1	4.35	1	.39	1	4.35	2	1.45								
Amelanchier sp.	1	4.35	4	.77																
Fraxinus americana					1	4.35	1	.39												
Totals			519	55.33			257	27.40			138	14.71			23	2.45			1	.11

*Quercus rubra var. borealis

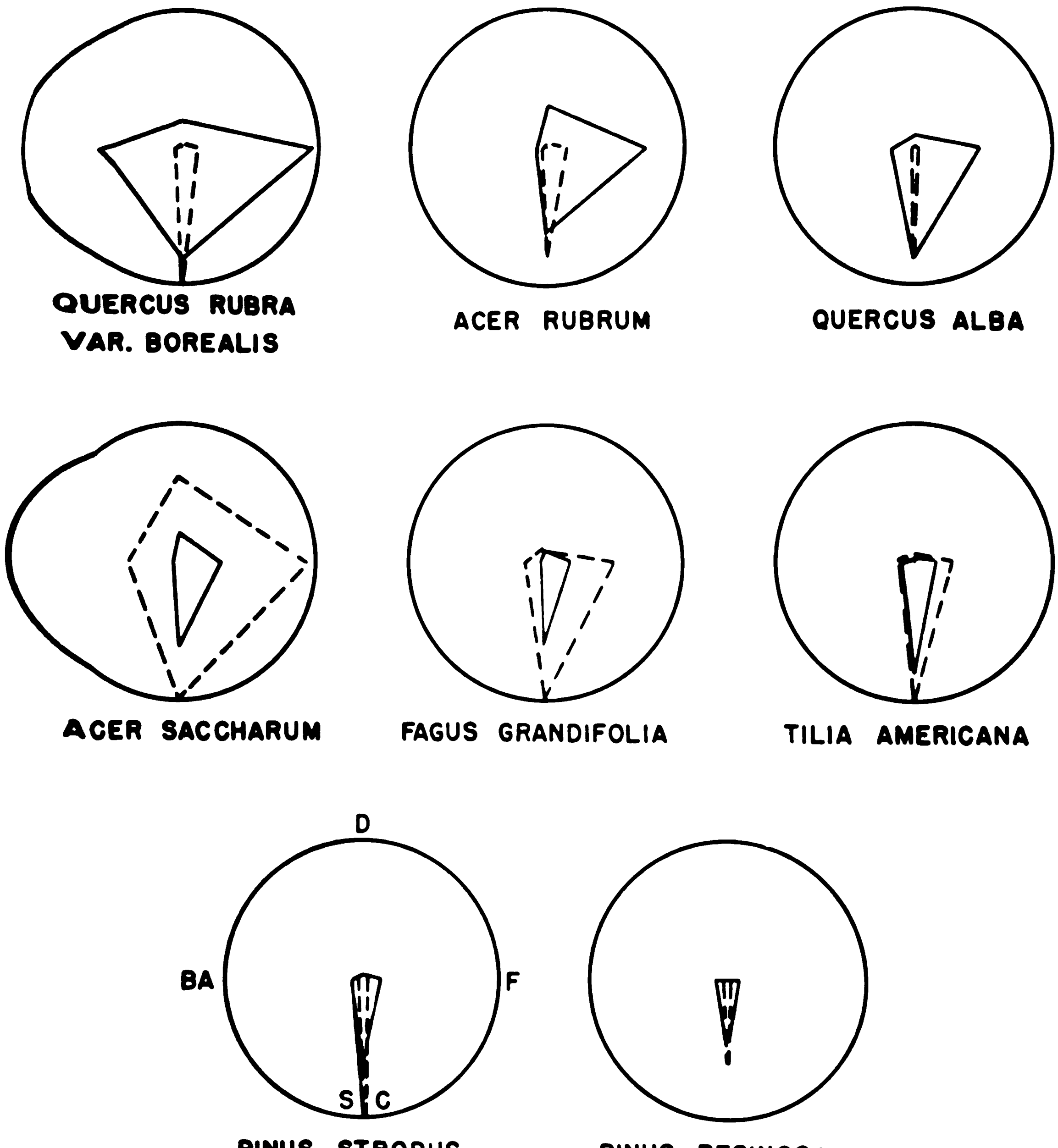


Fig. 11. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the first eight dominant (DFD Index) canopy tree species on the Roselawn Soil Series. (----) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

Pinus Strobus,(DFD-8), and *P. resinosa*, (DFD-11), indicate the ranking of the coniferous element for this soil series. As is shown in Table VII, *Pinus Strobus* was represented by seven trees in the smallest size class and a single tree in size class five and six. *P. resinosa* was absent from both the smallest and largest size classes, with one tree being recorded in each of size classes three and five, and two individuals in size class four.

On the basis of size class representation for all of the sixteen tree species recorded on the Roselawn Soil Series, those of size class two, (DBH under one inch and at least one foot tall), are dominant, composing 55% of the total. Those trees of size class three made up 27% of the total; size class four, 15%; size class five, 2%; and size class six, .11%.

The quantitative data here presented for the Roselawn Soil Series would seem to indicate that the forest composition may be considered to represent a *Quercus rubra var. borealis* - *Acer rubrum* lociation* within the *Acer saccharum* - *Fagus grandifolia* association, which is the climax forest association for this part of the state.

Phytographs for the first eight dominant (DFD Index) canopy tree species on the Roselawn Soil Series are presented in Fig. 11. They serve as a basis for comparing dominance of these tree species on this soil series with the composite of the county, as well as with the other lociations found within the other soil series. Fig. 12 represents, by means of phytographs, the composition of the understory tree species on the Roselawn Soil Series. They likewise afford a basis for comparing

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*Lociation: "Local variations, generally due to edaphic causes." Braun (1950).

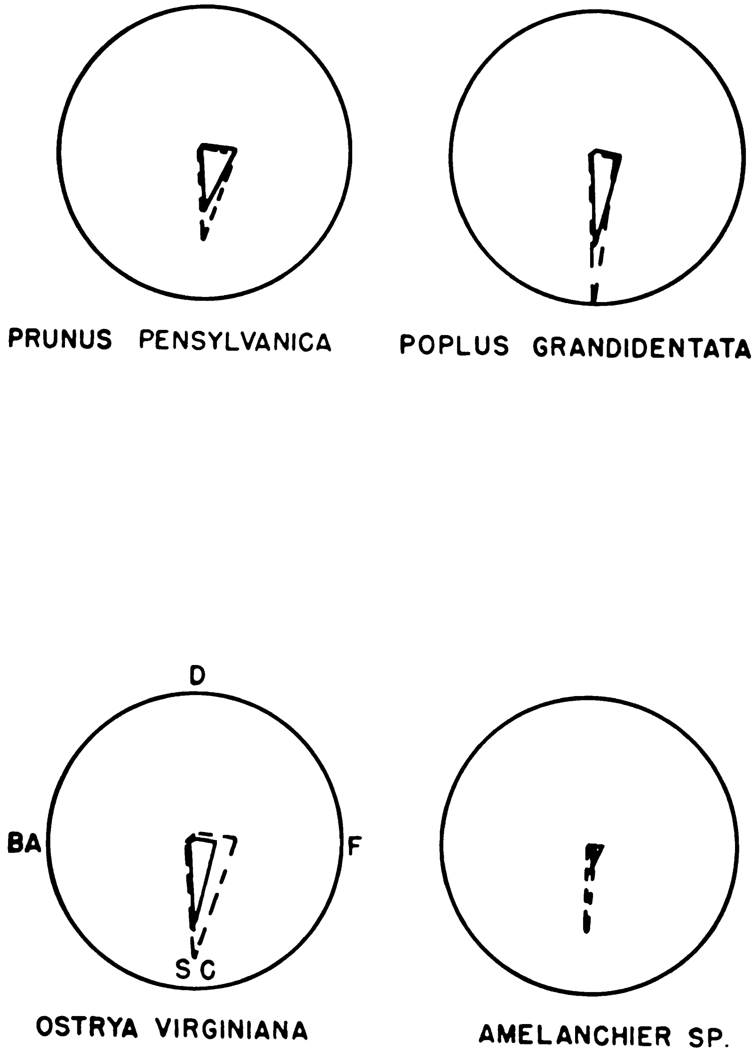


Fig. 12. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the understory tree species on the Roselawn Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

dominance on the soil series with the other aspects. Only three different shrub species appeared in the quantitative data for the quadrat studies on this soil series. The details of these data are shown in Table VIII.

On the five other soil series, Acer saccharum always attained dominance as indicated by both DFD Index values and phytographic interpretations. The tree species attaining second ranking and lower were not always the same, however.

The data showing the results of the quantitative analysis for the 19 one hundred square meter quadrats representing the Arenac Soil Series are presented in Tables IX and X. Comparative phytographs similar to those for the Roselawn Soil Series are presented in Figs. 13 and 14.

DFD Index values, Table IX, indicate that the Arenac Soil Series supports an Acer saccharum - Ulmus Thomasi lociation within the area under study. Acer saccharum is the only tree species on this soil series to be represented in all size classes. Both Ulmus Thomasi and Fagus grandifolia are present in the first four size classes, while Ulmus americana is absent from both size class two and six. The coniferous element of a mixed conifer-northern hardwood deciduous forest formation is represented by a lone relic specimen of Tsuga canadensis in size class six.

Ostrya virginiana, the dominant understory tree species, is well represented in this lociation, having a DFD Index value of five. Prunus pensylvanica is the only other understory tree species present for the soil series (DFD-8). The shrubby species are completely absent from the quadrat studies here.

TABLE VIII

SUMMARY DATA FOR THE SHRUB SPECIES BASED ON 23 ONE HUNDRED SQUARE METER QUADRATS IN THE SECOND GROWTH UPLAND HARDWOODS OF MISSAUKEE COUNTY ON THE ROSELAWN SOIL SERIES

Shrub Species	TOTALS				
	Frequency		Density		
	No.	%	No.	%	DF
Corylus cornuta	4	17.39	25	67.58	1
Viburnum acerifolium	1	4.35	7	18.92	2
Cornus alternifolia	2	8.70	5	13.52	3
Totals			37		

TABLE IX

SUMMARY DATA FOR THE TREE SPECIES BASED ON
19 ONE HUNDRED SQUARE METER QUADRATS FROM
THE UPLAND SECOND GROWTH HARDWOODS
OF MISSAUKEE COUNTY ON THE
ARENAC SOIL SERIES

Tree Species	TOTALS						
	Frequency		Density		Basal Area		
	No.	%	No.	%	Ft^2/A	%	DFD
Acer saccharum	19	100.00	316	66.81	42.43	33.76	1
Ulmus Thomasi	8	42.11	55	11.63	14.27	11.36	2
Ulmus americana	7	36.84	29	6.13	54.06	21.50	3
Fagus grandifolia	6	31.58	16	3.38	13.68	10.83	4
Ostrya virginiana	7	36.84	16	3.38	2.42	1.93	5
Fraxinus americana	4	21.05	4	.85	3.86	3.07	6
Tilia americana	3	15.79	12	2.54	5.12	4.07	7
Prunus pensylvanica	2	10.53	10	2.11			8
Acer rubrum	2	10.53	9	1.90	.17	.14	9
Tsuga canadensis	1	5.26	1	.21	3.40	2.70	10
Quercus rubra var borealis	1	5.26	4	.85	1.31	1.04	11
Prunus serotina	1	5.26	1	.21	1.42	1.13	12
Totals			473	100.00			

TABLE X

SUMMARY DATA FOR THE TREE SPECIES BY SIZE CLASS BASED ON 19 ONE HUNDRED SQUARE METER QUADRATS FROM THE SECOND GROWTH UPLAND HARDWOODS OF MISSAUKEE COUNTY ON THE ARENAC SOIL SERIES

Tree Species	SIZE CLASS TOTALS																			
	2				3				4				5				6			
	Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Acer saccharum	13	68.42	128	72.73	18	94.74	109	74.68	17	89.47	74	64.91	4	21.05	4	11.43	1	5.26	1	50.00
Ulmus Thomasi	4	21.05	22	12.50	3	15.79	11	7.54	8	42.11	17	14.91	3	15.79	5	14.29				
Ulmus americana					2	10.53	4	2.74	6	31.58	12	10.53	7	36.84	13	37.14				
Fagus grandifolia	1	5.26	2	1.14	3	15.79	5	3.42	2	10.53	2	1.75	6	31.58	7	20.00				
Ostrya virginiana	1	5.26	4	2.27	4	21.05	7	4.79	4	21.05	5	4.39								
Fraxinus americana					1	5.26	1	.68	1	5.26	1	.88	2	10.53	2	5.71				
Tilia americana	2	10.53	4	2.27	2	10.53	5	3.42					2	10.53	3	8.57				
Prunus pensylvanica	2	10.53	10	5.68																
Acer rubrum	2	10.53	6	3.41	2	10.53	3	2.05												
Tsuga candensis																	1	5.26	1	50.00
Quercus rubra*					1	5.26	1	.68	1	5.26	3	2.63								
Prunus serotina													1	5.26	1	2.86				
Total			176	37.21			146	30.87			114	24.10			35	7.40			2	.42

*Quercus rubra var. borealis

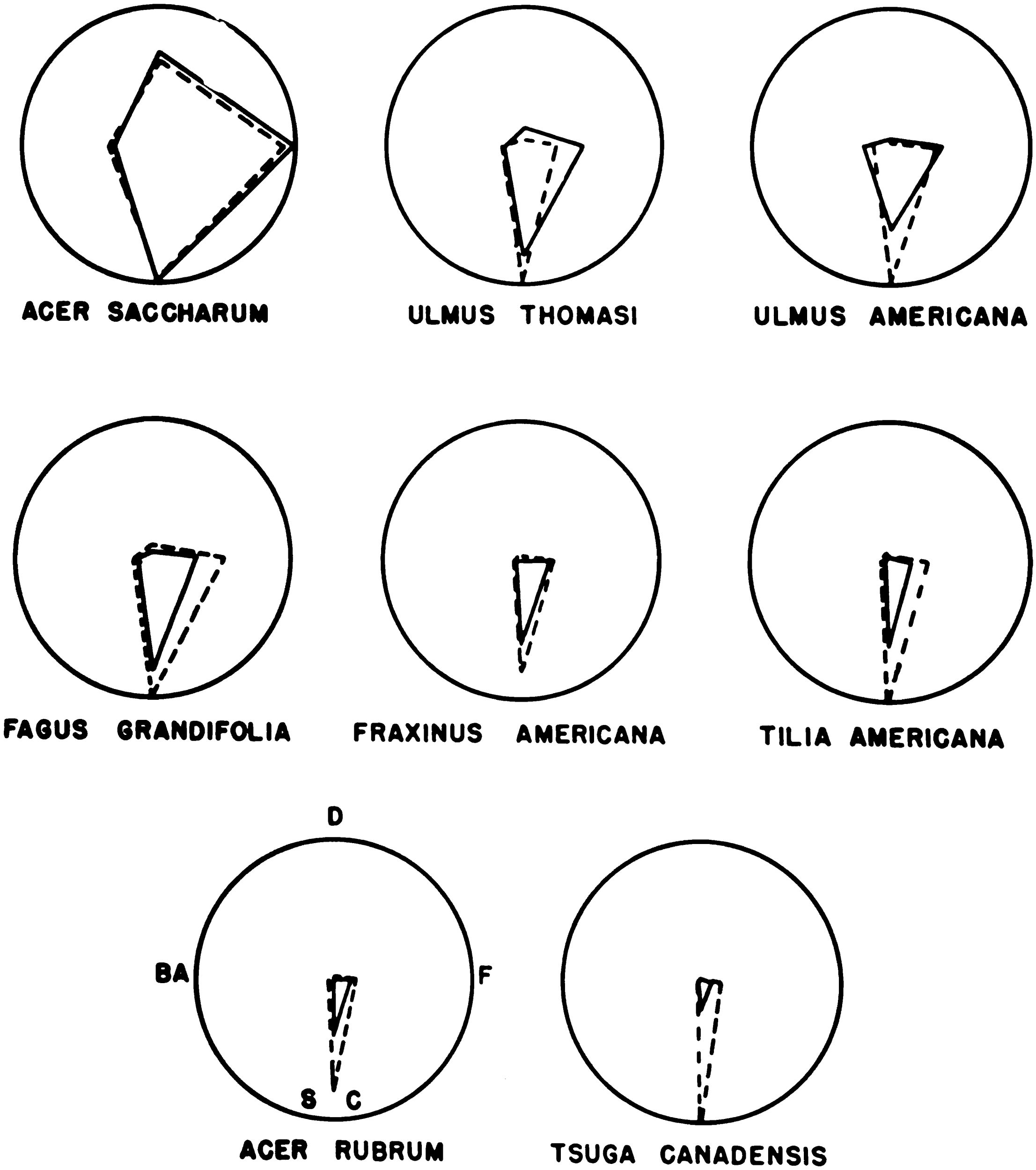


Fig. 13. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the first eight dominant (DFD Index) canopy tree species on the Arenac Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

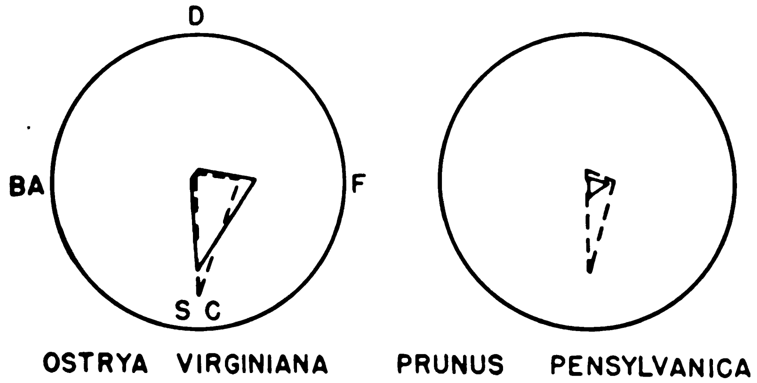


Fig. 14. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (———) the understory tree species on the Arenac Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

Thirty seven percent of all of the tree species on the Arenac Soil Series belonged in size class two; 31% were classified in size class three; 24% in size class four; 7% in size class five; and .5% in size class six.

The upland second growth hardwoods, as represented by the 322 one hundred square meter quadrats on the Emmet Soil Series, are similar to the forest formation for the county in that they constitute an Acer saccharum - Fagus grandifolia association. There were nineteen different tree species recorded in the quadrats for this soil series. Of the 11,918 trees recorded in the quadrat studies on the Emmet Soil Series, 52% fell in size class two; 29% belonged in size class three; 16% were of size class four; 3%, size class five; and .5% in size class six. The quantitative results of the quadrat studies are presented in Tables XI, XII, and XIII. A graphic representation of some of the tree species occurring on the Emmet Soil Series, as indicated by phytographs, is presented in Figs. 15 and 16. A comparison of the phytographs in Fig. 15 with the data of Table XI shows agreement as to the two methods of expressing dominance in this instance.

Other canopy tree species, in addition to Acer saccharum and Fagus grandifolia, manifesting high DFD Index values for the Emmet Soil Series were: Ulmus americana, (3); Tilia americana, (4); Fraxinus americana, (6); and Ulmus Thomasi, (8). Three of the understory tree species ranked high on the DFD Index scale are: Ostrya virginiana,(5); Prunus pensylvanica, (7); and Populus grandidentata, (9). As was the case in the Arenac Soil Series, the only representative of the conifers was Tsuga canadensis. However, unlike the situation on the Arenac Soil Series, it was represented here in all five size classes, Table XII. The shrubby layer of

TABLE XI

SUMMARY DATA FOR THE TREE SPECIES BASED ON 322 ONE HUNDRED SQUARE METER QUADRATS FROM THE UPLAND SECOND GROWTH HARDWOODS IN MISSAUKEE COUNTY ON THE EMMET SOIL SERIES

Tree Species	TOTALS						
	Frequency		Density		Basal Area		
	No.	%	No.	%	Ft^2/A	%	DFD
Acer saccharum	318	98.70	8004	67.16	40.7	39.00	1
Fagus grandifolia	175	54.30	1049	8.80	14.4	14.00	2
Ulmus americana	125	38.80	485	4.07	16.4	16.00	3
Tilia americana	101	31.30	392	3.29	7.6	7.00	4
Ostrya virginiana	78	21.10	348	2.92	1.7	2.00	5
Fraxinus americana	65	20.10	265	2.22	2.9	3.00	6
Prunus pensylvanica	62	19.20	328	2.75	.5	.50	7
Ulmus Thomasi	39	12.10	236	1.98	7.1	7.00	8
Populus grandidentata	35	10.80	252	2.11	2.1	2.00	9
Prunus serotina	31	9.60	71	.60	3.0	3.00	10
Ulmus rubra	32	9.60	101	.84	2.5	2.00	11
Quercus rubra var. borealis	29	9.00	112	.94	2.1	2.00	12
Acer rubrum	26	8.00	164	1.38	1.2	1.00	13
Tsuga candensis	21	6.50	28	.23	1.3	1.00	14
Betula lutea	12	3.70	23	.19	.5	.50	15
Populus tremuloides	5	1.50	31	.26	.1		16
Amelanchier sp.	5	1.50	21	.17			17
Quercus alba	3	.90	4	.03	.1		18
Betula papyrifera	2	.60	4	.03			19
Total			11,918	100			

TABLE XII

SUMMARY DATA FOR THE TREE SPECIES BY SIZE CLASS BASED ON
322 ONE HUNDRED SQUARE METER QUADRATS IN THE
SECOND GROWTH UPLAND HARDWOODS
OF MISSAUKEE COUNTY ON THE
EMMET SOIL SERIES

Tree Species	SIZE CLASS TOTALS																			
	2				3				4				5				6			
	Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.	
	No.	%	No.	%	No	%	No.	%	No.	%	No.	%	No	%	No	%	No	%	No	%
Acer saccharum	279	86.60	4512	73.23	303	99.00	2433	70.90	236	73.20	964	50.40	54	16.40	75	21.70	16	4.90	20	28.60
Fagus grandifolium	99	30.70	499	8.10	96	29.90	299	9.00	85	26.30	170	8.90	53	16.20	68	19.70	12	3.70	13	18.50
Ulmus americana	34	10.50	151	2.54	46	14.20	94	2.70	80	24.80	148	7.70	48	14.90	71	20.50	15	4.60	15	21.40
Tilia americana	34	10.50	123	2.00	40	12.10	85	2.50	64	19.80	154	8.10	20	6.20	24	6.90	6	1.80	6	8.60
Ostrya virginiana	28	8.60	139	2.26	53	16.20	134	3.90	46	14.20	74	3.90	1	.30	1	.30				
Fraxinus americana	20	6.20	91	1.48	35	10.80	79	2.30	44	13.60	88	4.60	7	2.10	7	2.00				
Prunus pensylvanica	49	14.50	268	4.35	28	8.60	58	1.60	2	.60	2	.20								
Ulmus Thomasi	10	3.10	67	1.09	23	7.10	55	1.60	24	7.40	72	3.80	21	6.50	38	11.00	3	.90	4	5.70
Populus grandidentata	20	6.20	141	2.29	12	3.70	35	1.00	21	6.50	71	3.70	4	1.20	4	1.40				
Prunus serotina	5	1.20	7	.11	9	2.70	16	.50	11	3.40	20	1.10	14	4.30	23	6.70	4	1.20	5	7.10
Ulmus rubra	7	2.10	30	.49	10	3.10	18	.50	18	.55	34	1.80	11	3.40	17	4.90	2	.60	2	2.90
Quercus rubra*	8	2.40	26	.42	9	2.70	34	.90	22	6.80	44	2.30	3	.90	5	1.40				
Acer rubrum	14	4.30	66	1.07	16	4.90	53	1.50	17	5.20	43	2.20	2	.60	2	.60				
Tsuja candensis	7	2.10	12	.20	3	.90	4	.20	3	.90	3	.30	7	2.10	7	2.00	2	.60	2	2.90
Betula lutea	1	.30	4	.06	4	1.20	5	.20	9	2.70	12	.60	1	.30	2	.60				
Populus tremuloides	2	.60	13	.21	3	.90	13	.30	2	.60	5	.30								
Amelanchier sp.	2	.60	5	.08	3	.90	16	.50												
Quercus alba	1	.30	2	.03					1	.30	1	.03	1	.30	1	.30	2	.60	3	4.30
Betula papyrifera									2	.60	4	.20								
Totals			6162	51.71			3431	28.79			1909	16.02			346	2.90			70	.59

*Quercus rubra var. borealis

TABLE XIII

SUMMARY DATA FOR THE SHRUB SPECIES BASED ON 322
ONE HUNDRED SQUARE METER QUADRATS FROM THE
UPLAND SECOND GROWTH HARDWOODS
ON THE EMMET SOIL SERIES

Shrub Species	Frequency		Density		DF
	No.	%	No.	%	
Cornus alternifolia	8	2.40	66	39.76	1
Rhus typhina	6	1.80	33	19.88	2
Viburnum acerifolium	5	1.50	28	16.87	3
Ribes cynosbati	3	.90	25	15.06	4
Rosa sp.	1	.30	7	4.22	5
Corylus cornuta	1	.30	4	2.40	6
Sambucus pubens	2	.60	2	1.20	7
Crataegus sp.	1	.30	1	.60	8
Total			166		

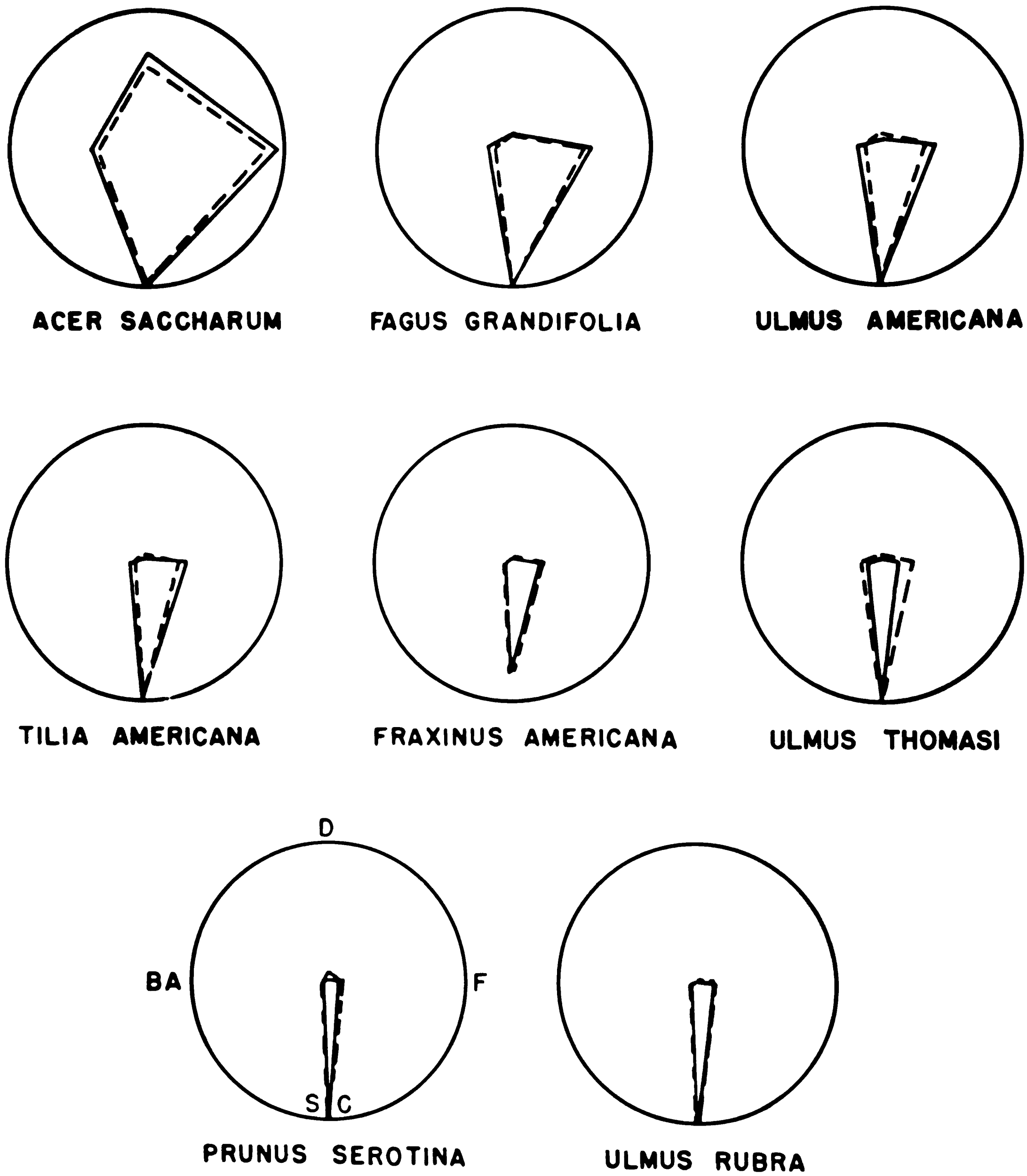


Fig. 15. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the first eight dominant (DFD Index) canopy tree species on the Emmet Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

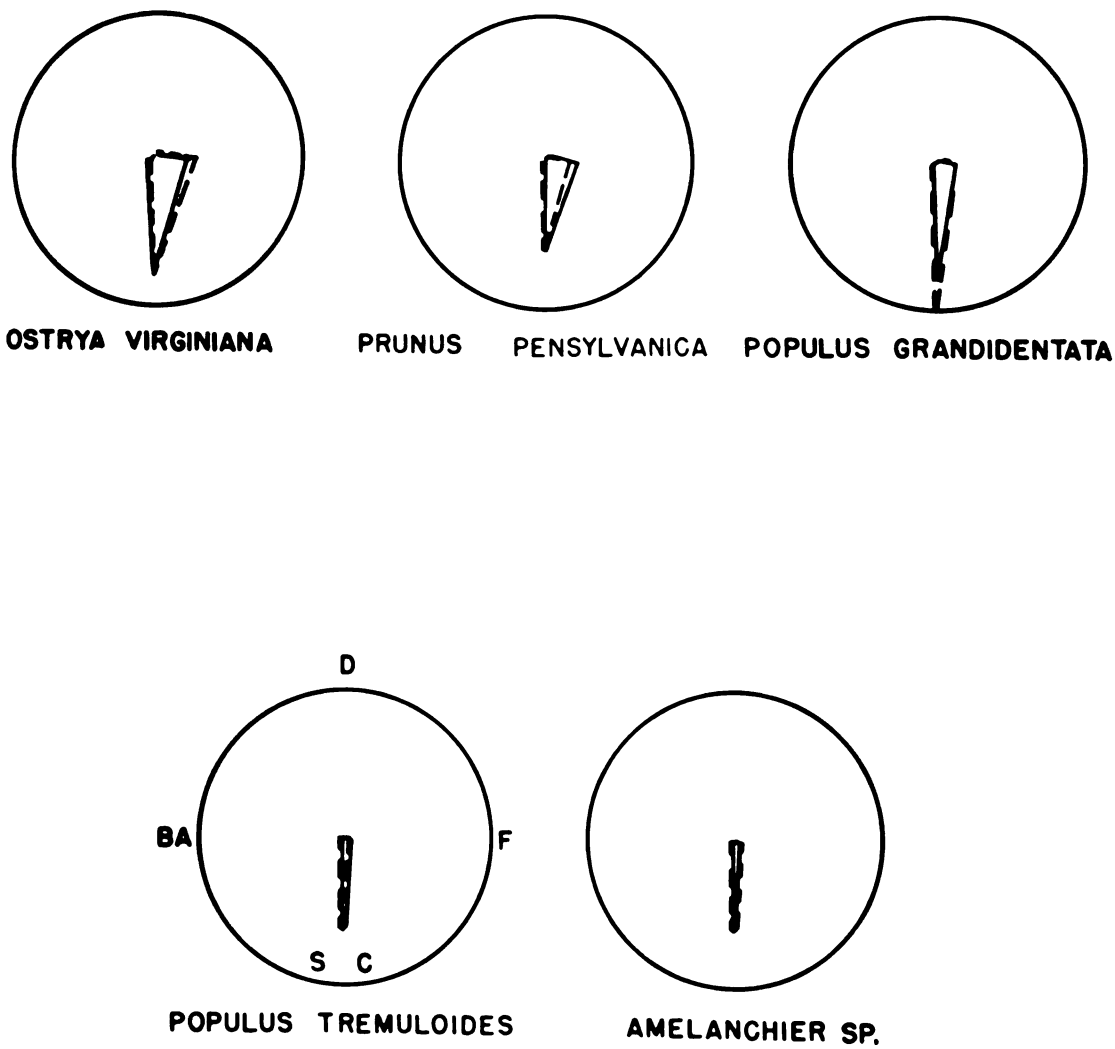


Fig. 16. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the understory tree species on the Emmet Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

vegetation for this soil series was composed of eight different species (Table XIII) with Cornus alternifolia having the highest ranking on the DF scale.

The summary of the quantitative data for the 29 one hundred square meter quadrats representing the Kalkaska Soil Series is presented in Tables XIV and XV. These data indicate that the Kalkaska Soil Series has an Acer saccharum - Ulmus Thomasi lociation within the Acer saccharum - Fagus grandifolia association of the forest formation. Other canopy tree species and their order of dominance as indicated by the DFD Index are: Fagus grandifolia, (3); Ulmus americana, (5); Prunus serotina, (6); Tilia americana, (7); Tsuga canadensis, (9); and Fraxinus americana, (11). Tsuga canadensis again represents the only coniferous element for the soil series. There is but a single tree, which is in size class four, Table XV. The percentage of trees in the various size classes recorded on the Kalkaska Soil Series follow: Size class two, 42%; size class three, 25%; size class four, 23%; size class five, 7%; and size class six, 3%. Ostrya virginiana (DFD-4) is the most dominant tree of the understory. Two other tree species Prunus pensylvanica (DFD-8) and Populus grandidentata (DFD-10) complete the understory layer. The Kalkaska Soil Series was devoid of any shrub species for the quadrats studied.

Phytographs for the first eight dominant (DFD Index) canopy tree species on the Kalkaska Soil Series are presented at Fig. 17. These phytographs offer a basis for comparison for these tree species on the soil type with the same tree species as represented by a composite of the six soil series. Comparisons may also be made for the expression vegetation for this soil series was composed of eight different species (Table XIII) with Cornus alternifolia having the highest ranking on the IF scale.

The summary of the quantitative data for the 25 one hundred square meter quadrats representing the Kalkaska Soil Series is presented in Tables XIV and XV. These data indicate that the Kalkaska Soil Series has an Acer saccharum - Ulmus Thomasi association within the Acer saccharum - Fagus grandifolia association of the forest formation. Other canopy tree species and their order of dominance as indicated by the DFD Index are: Fagus grandifolia, (3); Ulmus americana, (5); Prunus serotina, (6); Tilia americana, (7); Tsuga canadensis, (9); and Fraxinus americana, (11). Tsuga canadensis again represents the only coniferous element for the soil series. There is but a single tree, which is in size class four, Table XV. The percentage of trees in the various size classes recorded on the Kalkaska Soil Series follow: Size class two, 42%; size class three, 25%; size class four, 23%; size class five, 7%; and size class six, 3%. Ostrya virginiana (DFD-4) is the most dominant tree of the understory. Two other tree species Prunus pensylvanica (DFD-8) and Populus grandidentata (DFD-10) complete the understory layer. The Kalkaska Soil Series was devoid of any shrub species for the quadrats studied.

Phytographs for the first eight dominant (DFD Index) canopy tree species on the Kalkaska Soil Series are presented at Fig. 17. These phytographs offer a basis for comparison for these tree species on the soil type with the same tree species as represented by a composite of the six soil series. Comparisons may also be made for the

TABLE XIV

SUMMARY DATA FOR THE TREE SPECIES BASED ON 29 ONE HUNDRED SQUARE METER QUADRATS FROM THE UPLAND SECOND GROWTH HARDWOODS OF MISSAUKEE COUNTY ON THE KALKASKA SOIL SERIES

Tree Species	SUMMARY TOTALS						
	Frequency		Density		Basal Area		
	No.	%	No.	%	Ft^2/A	%	DFD
Acer saccharum	29	100.00	547	75.44	70.05	45.60	1
Ulmus Thomasi	16	55.17	70	9.66	40.70	26.60	2
Fagus grandifolia	15	51.72	44	6.07	18.66	12.20	3
Ostrya virginiana	10	34.48	17	2.34	1.77	1.20	4
Ulmus americana	5	17.25	22	3.03	13.77	9.00	5
Prunus serotina	7	24.14	8	1.10	2.94	1.90	6
Tilia americana	3	10.34	5	.69	4.69	3.00	7
Prunus pensylvanica	1	3.44	7	.97			8
Tsuga candensis	1	3.44	1	.14	.48	.30	9
Populus grandidentata	1	3.44	1	.14	.42	.20	10
Fraxinus americana	1	3.44	2	.28			11
Ulmus rubra	1	3.44	1	.14	.02		12
Total			725				

TABLE XV

SUMMARY DATA FOR THE TREE SPECIES BY SIZE CLASS BASED ON 29 ONE HUNDRED SQUARE METER QUADRATS FROM THE UPLAND SECOND GROWTH HARDWOODS IN MISSAUKEE COUNTY ON THE KALKASKA SOIL SERIES

Tree Species	SIZE CLASS TOTALS																			
	2				3				4				5				6			
	Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.	
	No	%	No.	%	No	%	No.	%	No	%	No.	%	No	%	No	%	No	%	No	%
Acer saccharum	15	51.72	225	83.06	25	86.20	149	83.24	24	82.76	116	69.05	16	55.17	22	44.00	4	13.79	5	23.80
Ulmus Thomasi	2	6.59	8	2.61	4	13.79	11	6.15	11	37.93	24	14.27	10	34.48	17	34.00	3	10.30	10	47.63
Fagus grandifolia	5	17.24	23	7.49	2	6.89	2	1.12	6	20.69	9	5.36	6	20.69	6	12.00	4	13.79	4	19.50
Ostrya virginiana					5	17.24	10	5.58	5	17.24	7	4.17								
Ulmus americana	1	3.44	9	2.93	1	3.44	4	2.23	2	6.89	5	2.98	1	3.44	3	6.00	1	3.44	1	4.76
Prunus serotina					1	3.44	2	1.12	4	13.79	4	2.37	2	6.89	2	4.00				
Tilia americana	1	3.44	3	.99					1	3.44	1	.60					1	3.44	1	4.76
Prunus pensylvanica	1	3.44	7	2.27																
Tsuga canadensis									1	3.44	1	.60								
Populus grandidentata									1	3.44	1	.60								
Fraxinus americana	1	3.44	2	.65																
Ulmus rubra					1	3.44	1	0.56												
Totals			307	42.34			179	24.69			168	23.17			50	6.90			21	2.90

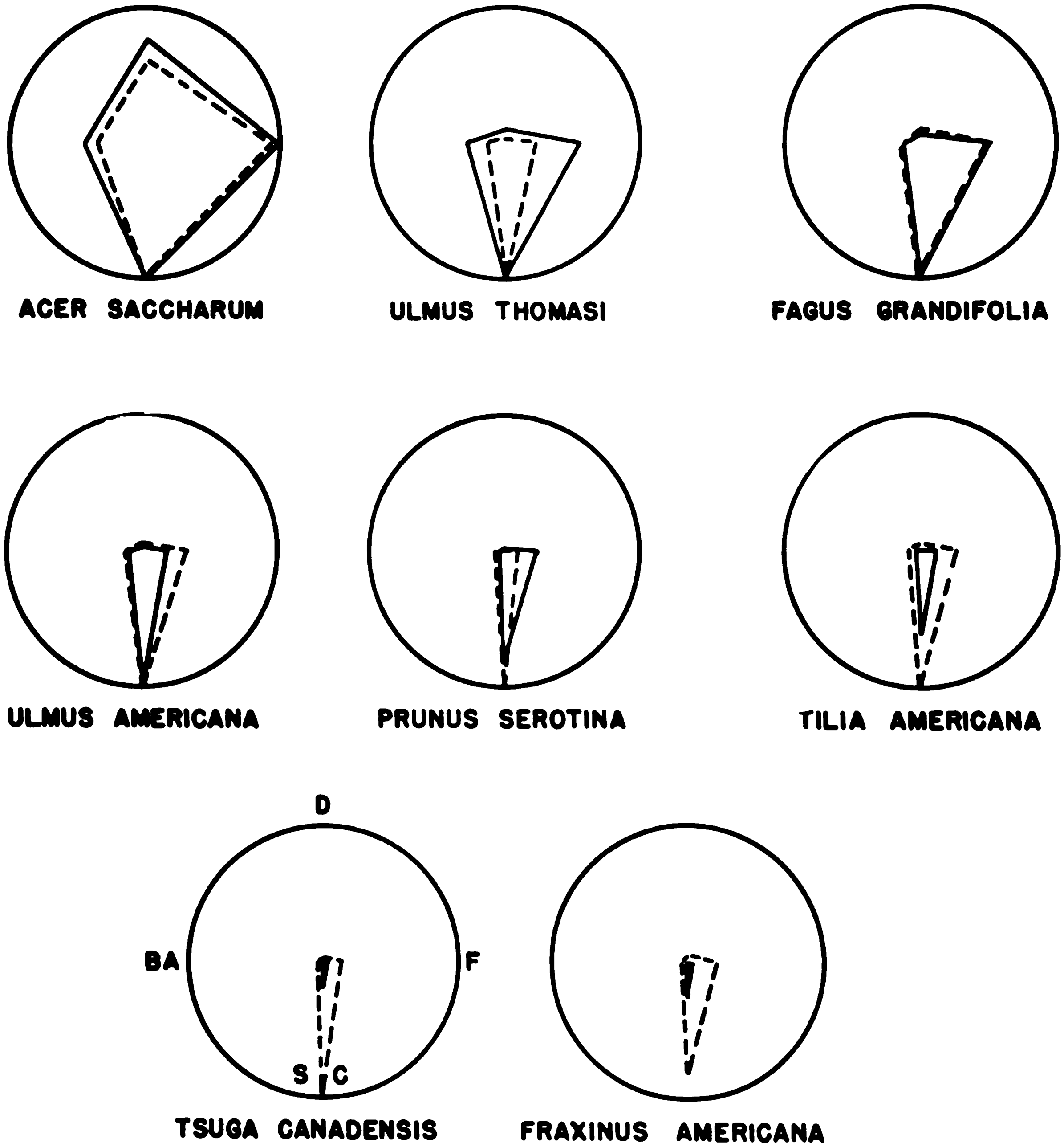


Fig. 17. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the first eight dominant (DFD Index) canopy tree species on the Kalkaska Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

of dominance as indicated by the size of the trapezium for each tree species in the figure and the DFD Index value as shown in Table XIV. The composition of the understory layer of tree species and their comparative dominance with the composite for the county is shown by means of phytographs in Fig. 18.

The Nester Soil Series was represented by 79 one hundred square meter quadrats. There were nineteen different species of trees recorded with Acer saccharum and Fagus grandifolia being accorded first and second place dominance on the basis of the DFD Index. Thus the Nester Soil Series presents a maple-beech association. Other canopy tree species attaining high values on the DFD Index were: Ulmus americana, (3); Ulmus Thomasi, (5); Tilia americana, (6); and Tsuga canadensis, (7). Forty-five percent of all the trees recorded in the 79 quadrats on this soil series fell in size class two; 24% of them were of size class three; 25% of them belonged in size class four; 5% in size class five; and .5% in size class six (Table XVI).

The character of the mixed conifer-northern hardwood deciduous forest formation was attained on the Nester Soil Series by the presence of Pinus Strobus, Tsuga canadensis, and Thuja occidentalis. As is shown in Table XVII, Tsuga canadensis is present in all size classes; Pinus Strobus has no representatives in either size class two or six; Thuja occidentalis was recorded in size classes three, four and five.

Phytographs for the first eight dominant (DFD Index) canopy tree species on the Nester Soil Series are presented in Fig. 19. They may be used as a basis for comparing dominance criteria as expressed in this manner with that of the DFD Index scale. Fig. 20 presents, by means of phytographs, the composition of the understory tree species for the soil

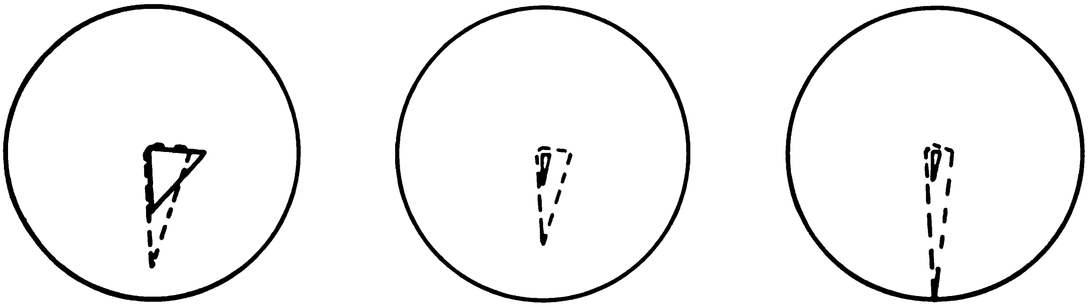


Fig. 18. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the understory tree species on the Kalkaska Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

TABLE XVI

SUMMARY DATA FOR THE TREE SPECIES BASED ON
79 ONE HUNDRED SQUARE METER QUADRATS
FROM THE UPLAND SECOND GROWTH HARDWOODS
OF MISSAUKEE COUNTY ON THE
NESTER SOIL SERIES

	TOTALS						
	Freq.		Dens.		Basal Area		
Tree Species	*No	%	No.	%	Ft²/A	%	DFD
Acer saccharum	74	93.60	1159	48.05	38.68	33.82	1
Fagus grandifolia	39	49.30	157	6.51	9.03	7.90	2
Ulmus americana	26	32.90	95	3.94	9.48	8.29	3
Ostrya virginiana	28	34.10	89	3.68	3.73	3.29	4
Ulmus Thomasi	20	25.10	103	4.27	12.26	11.37	5
Tilia americana	23	29.10	57	2.36	7.88	6.80	6
Tsuga canadensis	22	27.80	44	1.82	5.25	4.59	7
Populus grandidentata	15	18.90	155	6.43	5.48	4.79	8
Fraxinus americana	16	20.20	62	2.57	6.02	5.26	9
Prunus pensylvanica	13	16.40	182	7.55			10
Prunus serotina	15	18.90	35	1.45	3.39	3.00	11
Acer rubrum	10	12.60	118	4.89	4.99	4.33	12
Ulmus rubra	12	15.00	15	.62	1.36	1.19	13
Betula papyrifera	9	11.40	38	1.58	1.84	1.61	14
Betula lutea	10	12.60	15	.62	.55	.48	15
Thuja occidentalis	4	4.90	12	.49	.97	.85	16
Pinus Strobus	3	3.50	9	.37	1.41	1.23	17
Populus tremuloides	3	3.50	22	.91	.53	.50	18
Amelanchier sp.	3	3.50	29	1.20	.05	.03	19
Quercus rubra var. borealis	3	3.50	12	.49	.50	.44	20
Fraxinus nigra	2	2.00	4	.17	.25	.22	21
Total			2412				

TABLE XVII

SUMMARY DATA FOR THE TREE SPECIES BY SIZE CLASS BASED ON
79 ONE HUNDRED SQUARE METER QUADRATS FROM THE
SECOND GROWTH UPLAND HARDWOODS
OF MISSAUKEE COUNTY ON THE
NESTER SOIL SERIES

Tree Species	SIZE CLASS TOTALS																			
	2				3				4				5				6			
	Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Acer saccharum	53	67.00	537	49.50	61	77.20	345	61.82	59	74.70	243	39.07	26	32.90	31	26.50	3	3.50	3	27.27
Fagus grandifolia	20	25.10	83	7.63	18	22.70	32	5.73	19	24.10	23	3.70	12	15.00	16	13.68	3	3.50	3	27.27
Ulmus americana	5	6.30	27	2.48	11	13.90	20	3.58	18	22.70	37	5.95	8	10.00	10	8.54	1	1.20	1	9.09
Ostrya virginiana	8	10.10	13	1.19	24	29.90	50	8.96	13	16.40	23	3.70	3	3.50	3	2.50				
Ulmus Thomasi	2	2.00	9	.83	10	12.60	17	3.05	13	22.70	59	9.49	7	8.80	18	15.38				
Tilia americana	4	4.90	8	.74	4	4.90	5	.90	17	21.50	31	4.98	8	10.10	10	8.54	2	2.00	3	27.27
Tsuga canadensis	10	12.60	18	1.66	5	6.30	11	1.97	7	8.80	12	1.93	2	2.20	2	1.66	2	2.00	1	9.09
Populus grandidentata	10	12.60	114	10.48	2	2.00	2	.35	12	15.00	28	4.50	11	9.37						
Fraxinus americana	6	7.50	20	1.84	4	4.90	4	.72	11	13.90	34	5.74	4	4.90	4	3.33				
Prunus pensylvanica	13	16.40	181	16.65	1	1.20	1	.18												
Prunus serotina	3	3.50	6	.55	3	3.50	5	.90	12	15.00	20	3.22	4	4.90	4	3.33				
Acer rubrum	6	7.50	41	3.77	5	6.30	25	4.48	9	11.40	52	8.36								
Ulmus rubra					5	6.30	16	1.08	8	10.10	8	1.29	1	1.20	1	.83				
Betula papyrifera					7	8.80	16	2.87	7	8.80	22	3.54								
Betula lutea	1	1.20	1	.09	4	4.90	5	.90	6	7.50	7	1.13	2	2.00	2	1.66				
Thuja occidentalis					4	4.90	5	.90	2	2.00	4	.64	1	1.20	3	2.50				
Pinus Strobus					1	1.20	4	.72	1	1.20	3	.47	1	1.20	2	1.66				
Populus tremuloides	1	1.20	1	.09	1	1.20	2	.35	3	3.50	3	.47								
Amelanchier sp.	2	2.00	28	2.58																
Quercus rubra*					2	2.00	2	.35	3	3.50	9	1.45	1	1.20	1	.83				
Fraxinus nigra					1	1.20	1	.18	2	2.00	3	.47								
Totals			1087	45.07			558	23.14			622	25.79			117	4.85			11	.50

*Quercus rubra var. borealis

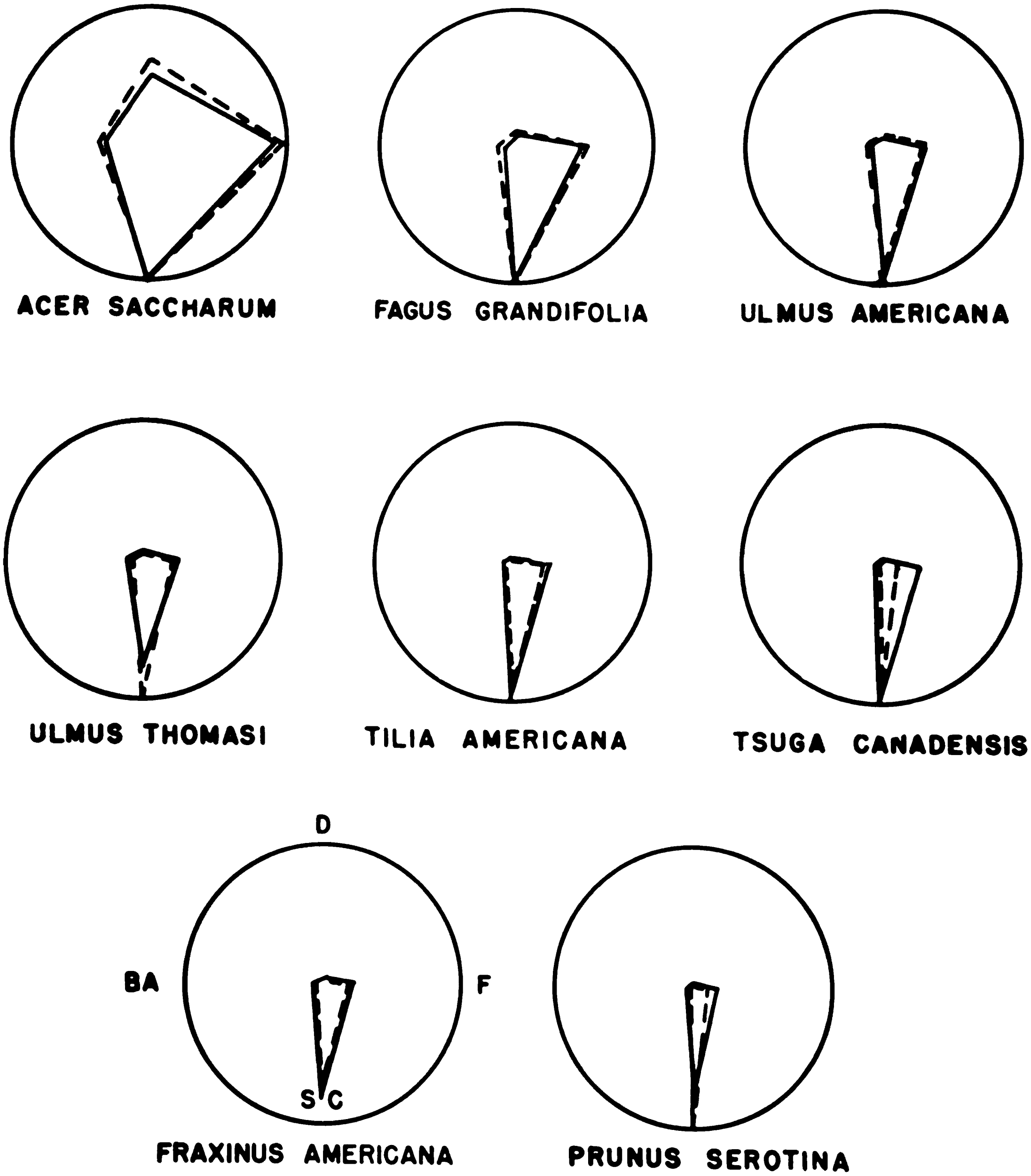


Fig. 19. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the first eight dominant (DFD Index) canopy tree species on the Nester Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

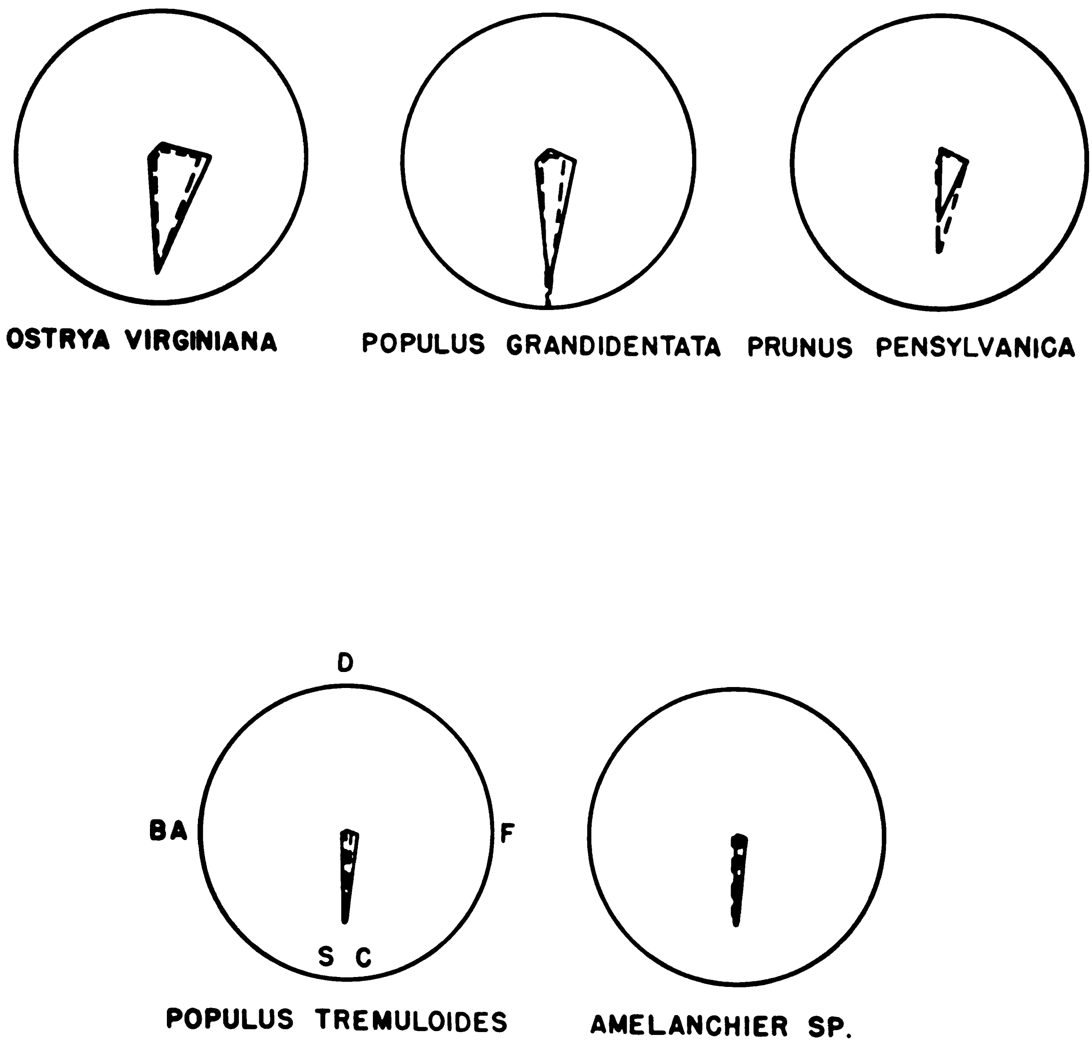


Fig. 20. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the understory tree species on the Nester Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

series. There were five different species making up the understory here. Ostrya virginiana was the dominant attaining a DFD value of four on the scale for all the trees. The remaining four were in the following order of DFD Index dominance: Populus grandidentata, (8); Prunus pensylvanica, (10); Populus tremuloides, (17); and Amelanchier sp., (18). The shrubby layer of vegetation was composed of eight different species, Table XVIII.

There were 72 one hundred square meter quadrats representing the Selkirk Soil Series. An examination of the quantitative data presented at Table XIX indicates that the upland second growth hardwoods growing upon this soil series are representative of an Acer saccharum - Ulmus Thomasi lociation. According to the data presented in Table XX, 42% of all the trees were of size class two; 24% were of size class three; 25% belonged to size class four; 7% to size class five; and 2% were in size class six. Tsuga canadensis, Pinus Strobus, P. resinosa, and Thuja occidentalis constitute the coniferous element of the forest formation for this soil series. An examination of the data presented in Table XX indicates that Tsuga canadensis is here present in all size classes; Pinus Strobus only in size class two; P. resinosa in size class six only; and Thuja occidentalis in size class two and four.

One of the concepts of dominance is indicated for the canopy and understory tree species by phytographs in Figs. 21 and 22. The phytographs may also be used for comparing dominance, as expressed in this way, with the same character as indicated by the DFD Index values in Table XIX. The quantitative data for the shrub layer of vegetation for the Selkirk Soil Series are presented in Table XXI.

series. There were five different species making up the understory here. Ostrya virginiana was the dominant attaining a DFD value of four on the scale for all the trees. The remaining four were in the following order of DFD Index dominance: Populus grandidentata, (9); Prunus pensylvanica, (10); Populus tremuloides, (11); [illegible] sp., (18). The shrubby layer of vegetation was composed of [illegible] different species, Table XVIII.

There were 72 one-hundred square meter quadrats representing the Selkirk Soil Series. An examination of the quantitative data presented at Table XIX indicates that the upland second growth hardwoods growing upon this soil series are representative of an Acer saccharum - Ulmus Thomasi lociation. According to the data presented in Table XX, 42% of all the trees were of size class two; 24% were of size class three; 25% belonged to size class four; 7% to size class five; and 2% were in size class six. Tsuga canadensis, Pinus Strobus, P. resinosa, and Thuja occidentalis constitute the coniferous element of the forest formation for this soil series. An examination of the data presented in Table XX indicates that Tsuga canadensis is here present in all size classes; Pinus Strobus only in size class two; P. resinosa in size class six only; and Thuja occidentalis in size class two and four.

One of the concepts of dominance is indicated for the canopy and understory tree species by phytographs in Figs. 21 and 22. The phytographs may also be used for comparing dominance, as expressed in this way, with the same character as indicated by the DFD Index values in Table XIX. The quantitative data for the shrub layer of vegetation for the Selkirk Soil Series are presented in Table XXI.

TABLE XVIII

SUMMARY DATA FOR THE SHRUB SPECIES BASED ON 79 ONE HUNDRED SQUARE METER QUADRATS FROM THE SECOND GROWTH UPLAND HARDWOODS OF MISSAUKEE COUNTY ON THE NESTER SOIL SERIES

Shrub Species	TOTALS				
	Freq.		Dens.		
	No	%	No.	%	DF
Cornus alternifolia	9	100.00	130	55.80	1
Corylus cornuta	7	8.80	53	22.46	2
Acer spicatum	3	3.50	30	12.71	3
Crataegus sp.	2	2.00	9	3.81	4
Rhus typhina	1	1.20	9	3.81	5
Spiraea sp.	1	1.20	5	2.12	6
Total			236		

TABLE XIX

SUMMARY DATA FOR THE TREE SPECIES BASED ON
72 ONE HUNDRED SQUARE METER QUADRATS FROM
THE SECOND GROWTH UPLAND HARDWOODS
IN MISSAUKEE COUNTY ON THE
SELKIRK SOIL SERIES

Tree Species	Freq. No	Freq. %	Dens. No	Dens. %	Basal Area Ft²/A	Basal Area %	
Acer saccharum	67	93.06	976	48.63	56.63	34.50	DFD
Ulmus Thomasi	40	55.56	267	13.30	27.30	16.63	1
Fagus grandifolia	38	52.78	141	7.03	21.29	12.97	3
Acer rubrum	18	25.00	142	4.08	8.31	5.06	4
Tsuga canadensis	19	26.39	73	3.64	6.12	3.73	5
Ulmus americana	15	20.83	60	2.99	11.57	7.05	6
Fraxinus americana	17	23.61	34	1.69	5.00	3.03	7
Ostrya virginiana	16	22.22	31	1.54	1.48	.90	8
Ulmus rubra	12	16.67	70	3.49	5.08	3.09	9
Tilia americana	8	11.12	45	2.24	9.26	5.64	10
Prunus serotina	10	13.89	15	.75	3.03	1.85	11
Betula lutea	9	12.50	22	1.10	1.75	1.07	12
Prunus pensylvanica	7	9.72	66	3.29			13
Betula papyrifera	5	6.94	13	.65	.83	.51	14
Quercus rubra var. borealis	4	5.56	18	.90	1.90	1.16	15
Populus grandidentata	3	4.17	13	.65	2.97	1.82	16
Thuja occidentalis	3	4.17	5	.25	.40	.24	17
Amelanchier sp.	2	2.79	10	.50			18
Pinus resinosa	1	1.39	1	.05	.93	.57	19
Quercus alba	1	1.39	3	.15	.30	.18	20
Pinus Strobus	1	1.39	2	.10			
Totals			2007				

TABLE XX

SUMMARY DATA FOR THE TREE SPECIES BY SIZE CLASS BASED ON
72 ONE HUNDRED SQUARE METER QUADRATS FROM THE
UPLAND SECOND GROWTH HARDWOODS
OF MISSAUKEE COUNTY LOCATED
ON THE SELKIRK SOIL SERIES

Tree Species	Size Class Totals																			
	2				3				4				5				6			
	Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.		Freq.		Dens.	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Acer saccharum	53	73.61	481	57.38	56	77.78	262	53.58	63	87.50	174	34.87	31	43.06	48	32.21	10	13.89	11	34.38
Ulmus Thomasi	19	26.39	78	99.31	22	30.56	65	13.29	35	48.61	92	18.44	16	22.22	29	19.46	3	4.17	3	9.38
Fagus grandifolia	18	25.00	60	7.16	18	25.00	23	4.71	20	27.78	32	6.41	18	25.00	19	12.75	7	9.72	7	21.87
Acer rubrum	8	11.12	39	4.66	12	16.67	51	10.43	15	20.83	46	9.22	5	6.94	6	4.03				
Tsuga canadensis	2	2.79	42	4.27	5	6.94	11	2.25	12	16.67	15	3.01	2	2.79	3	2.01	2	2.79	2	6.24
Ulmus americana	2	2.79	5	.59	4	5.56	24	4.91	8	11.12	13	2.60	8	11.12	15	10.07	2	2.79	3	9.38
Fraxinus americana	2	2.79	7	.84	5	6.94	6	1.23	9	12.50	12	2.40	7	9.72	9	6.04				
Ostrya virginiana	4	5.56	5	.59	6	8.33	10	2.04	12	16.67	15	3.01	1	1.39	1	.67				
Ulmus rubra	4	5.56	32	3.81	6	8.33	11	2.75	8	11.12	22	4.41	5	6.94	5	3.36				
Tilia americana	1	1.39	2	.24	5	6.94	7	1.43	12	16.67	25	5.01	6	8.33	8	5.37	1	1.39	3	9.38
Prunus serotina	1	1.39	1	.12	1	1.39	1	.20	7	9.72	9	1.80	4	5.56	4	2.68				
Betula lutea	1	1.39	1	.12	4	5.56	8	1.64	8	11.12	13	2.61								
Prunus pensylvanica	7	9.72	66	7.87																
Betula papyrifera					4	5.56	5	1.02	4	5.56	8	1.60								
Quercus rubra*	3	4.17	3	.36	2	2.79	2	.41	4	5.56	12	2.40	1	1.39	1	.67				
Populus grandidentata	1	1.39	4	.47					3	4.17	6	1.21	1	1.39	1	.67	1	1.39	2	6.24
Thuja occidentalis	1	1.39	3	.36					2	2.79	2	.40								
Amelanchier sp.	2	2.79	7	.84	2	2.79	3	.61												
Pinus resinosa																	1	1.39	1	3.13
Quercus alba									1	1.39	3	.60								
Pinus Strobus	1	1.39	2	.24																
Totals			838	41.75			489	24.36			499	24.86			149	7.42			32	1.59

*Quercus rubra var. borealis

TABLE XXI

SUMMARY DATA FOR THE SHRUB SPECIES BASED ON 72 ONE HUNDRED SQUARE METER QUADRATS FROM THE UPLAND SECOND GROWTH HARDWOODS OF MISSAUKEE COUNTY LOCATED ON THE SELKIRK SOIL SERIES

Shrub Species	TOTALS				
	Frequency		Density		
	No	%	No	%	DF
Cornus alternifolia	8	11.12	58	40.00	1
Corylus cornuta	4	5.56	46	31.72	2
Viburnum acerifolium	3	4.17	24	16.55	3
Sambucus pubens	1	1.39	17	11.72	4
Totals			145		

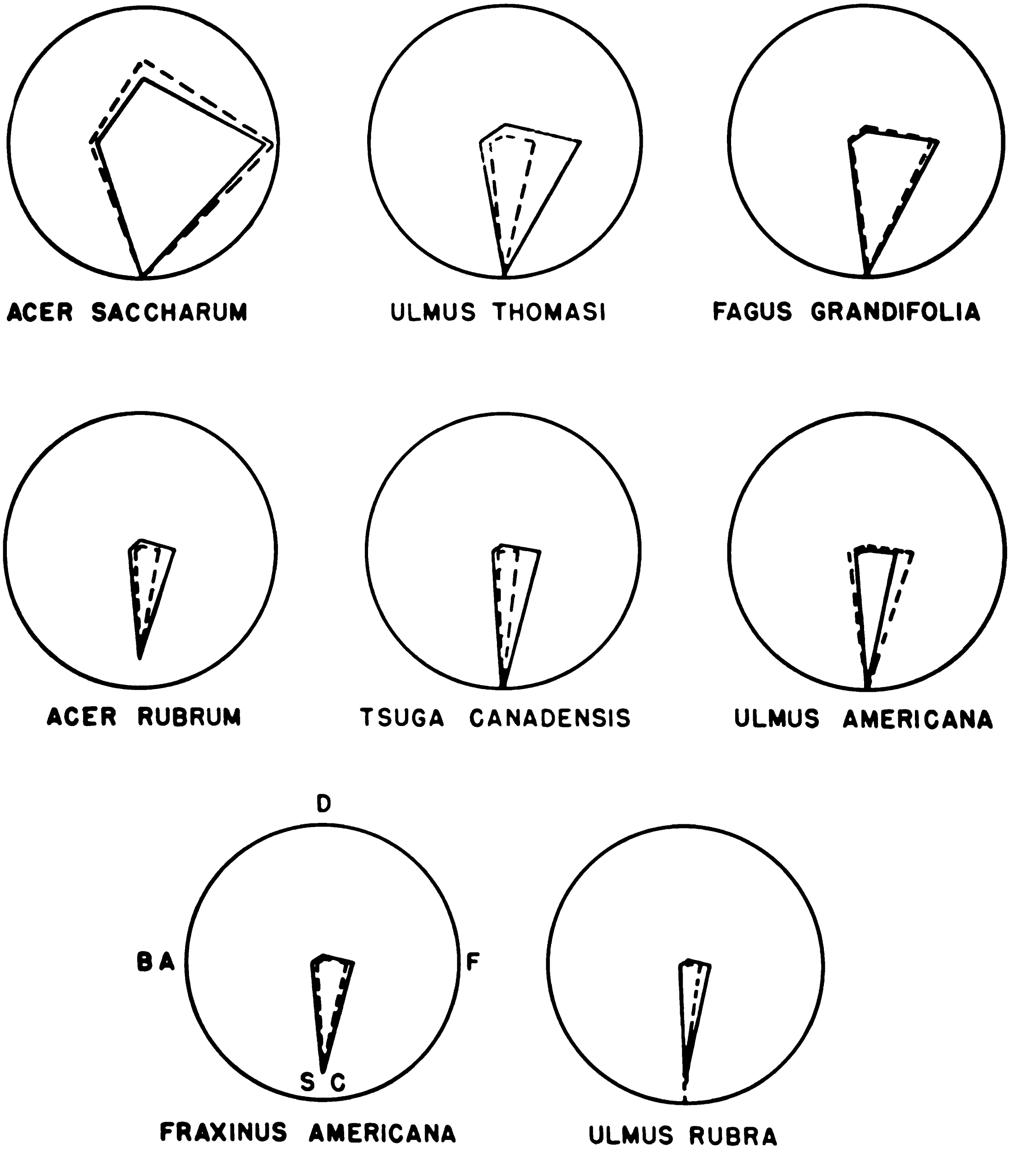


Fig. 21. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the first eight dominant (DFD Index) canopy tree species on the Selkirk Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

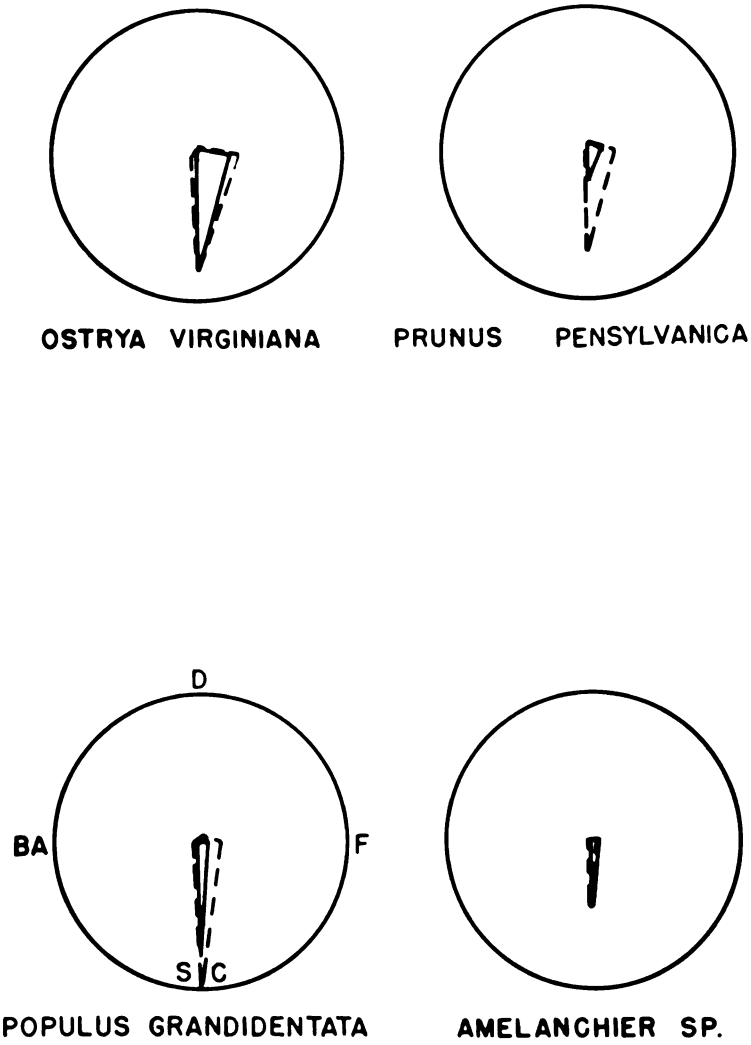


Fig. 22. Phytographs showing comparative density (D), frequency (F), size classes (SC) and basal area (BA). (——) the understory tree species on the Selkirk Soil Series. (- - -) the same tree species as represented by a composite of the six soil series within the ninety-eight stands.

One of the significant facts, which is revealed by an examination of Tables VI to XXI, is that in many instances the percentage of frequency, density and basal area for one species of tree is much greater on one soil series than it is on another. In order to establish whether these differences in percentages were the result of mathematical chance or the result of some other factor, or combinations of factors, the percentages noted above for each of the canopy tree species occurring on each of the six soil series within the county were tested by means of statistical treatment: Significance of Difference Between Percentages. This treatment employed the equation $\frac{P_1 - P_2}{P_1 - P_2}$ with P representing the percent frequency, density, and basal area for each of the canopy tree species on each of the soil series. A percentage difference greater than a plus or minus 2.5 indicates that factors other than mathematical chance are accountable for the differences. Complete absence of a tree species from a soil series is here considered to indicate the greatest significance. A summation of the significance of difference between the percentages of frequency, density and basal area for each of the canopy tree species between the six soil series is presented in Table XXII. The details of the statistical treatments are presented in the Appendix, Tables LXII to LXXV.

An analysis of the data presented in Table XXII reveals the following differences:

1. Between the Arenac Soil Series and the Emmet Soil Series:
    a. The percent frequency of *Ulmus Thomasi* is greater than mathematical chance in favor of the Arenac Soil Series.

TABLE XXII

SUMMARY OF SIGNIFICANCE OF DIFFERENCE IN PERCENTAGES OF FREQUENCY, DENSITY, AND BASAL AREA BETWEEN SOIL SERIES

SOIL SERIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	:FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB	FDB
Arenac - Emmet	000	000	000	+00		000	000	000		000			000		000			
Arenac - Kalkaska	000	000	000	000		000	000	000							000			
Arenac - Nester	000	000	00+	000		000	000	000		000			000		-00			
Arenac - Roselawn	++0	000	+0+			000	000	000		--0			-0-					
Arenac - Selkirk	000	000	00+	000		000	000	000		000			000		-00			
Emmet - Kalkaska	000	000	+00	-0-	000	+00	000	-00							000			
Emmet - Nester	0+0	000	000	000	000	000	000	000		000	000	-00	000		-00			
Emmet - Roselawn	+++	+0+	+0+		000	+00	000	+00		--0			-0-	-0-				
Emmet - Selkirk	0-0	000	000	--0	000	+00	000	000		-00	000	000	000	000	-00			
Kalkaska - Nester	0+0	000	000	+00	000	-00	000	-00							-00			
Kalkaska - Roselawn	+++	+0+	000		000	000	000	000										
Kalkaska - Selkirk	0+0	000	000	000	000	000	000	-00							-00			
Nester - Roselawn	+++	+00	+00		000	+00	000	+00		-00			-0-			000		
Nester - Selkirk	000	-00	000	-00	000	+00	000	000		000	000	000	000		000	000		000
Roselawn - Selkirk	---	-0-	-00		000	000	000	-00		+00			+0+	+00		000		

F - % of Frequency; D - % of Density; B - % of Basal Area; 0 - indicates significance of difference of percentages not greater than mathematical chance; + - indicates significance of difference of percentages greater than mathematical chance in favor of soil series listed first; - indicates significance of difference of percentages greater than mathematical chance in favor of the soil series listed second.

1. Acer saccharum
2. Fagus grandifolia
3. Ulmus americana
4. Ulmus Thomasi
5. Ulmus rubra
6. Tilia americana
7. Prunus serotina
8. Fraxinus americana
9. Fraxinus nigra
10. Acer rubrum
11. Betula lutea
12. Betula papyrifera
13. Quercus rubra var. borealis
14. Quercus alba
15. Tsuga candensis
16. Pinus strobus
17. Pinus resinosa
18. Thuja occidentalis

b. The following canopy tree species were absent from the Arenac Soil Series but present on the Emmet Soil Series:

1.) *Ulmus rubra*

2.) *Betula lutea*

3.) *Betula papyrifera*

4.) *Fraxinus americana*

2. Between the Arenac Soil Series and the Kalkaska Soil Series:

a. There were no significances of difference greater than mathematical chance between the percentages of frequency, density and basal area between the canopy tree species on these two soil series.

b. Species of canopy trees present on the Arenac Soil Series and absent from the Kalkaska Soil Series were:

1.) *Acer rubrum*

2.) *Quercus rubra var. borealis*

c. Species of canopy tree species absent from the Arenac Soil Series and present on the Kalkaska Soil Series:

1.) *Ulmus rubra*

3. Between the Arenac Soil Series and the Nester Soil Series:

a. The percent frequency of *Tsuga canadensis* is greater than mathematical chance in favor of the Nester Soil Series.

b. The percent of basal area for *Ulmus americana* is greater than mathematical chance in favor of the Arenac Soil Series.

c. Canopy tree species which were present on the Nester Soil Series and absent from the Arenac Soil Series:

1.) Ulmus rubra

2.) Fraxinus americana

3.) Betula lutea

4.) Pinus Strobus

5.) Thuja occidentalis

4. Between the Arenac Soil Series and the Roselawn Soil Series

a. The percent frequency and percent density of Acer saccharum is greater than mathematical chance in favor of the Arenac Soil Series.

b. The percent frequency and percent basal area of Ulmus americana is greater than mathematical chance in favor of the Arenac Soil Series.

c. The percent frequency and density of Acer rubrum is greater than mathematical chance in favor of the Arenac Soil Series.

d. The percent frequency and density of Acer rubrum is greater than mathematical chance in favor of the Roselawn Soil Series.

e. The percent frequency and percent basal area for Quercus rubra var. borealis is greater than mathematical chance in favor of the Roselawn Soil Series.

f. Canopy tree species present on the Arenac Soil Series and absent from the Roselawn Soil Series:

1.) Ulmus Thomasi

2.) Tsuga canadensis

g. Canopy tree species absent from the Arenac Soil Series and present on the Roselawn Soil Series:

1.) _Pinus resinosa_

2.) _Pinus Strobus_

3.) _Quercus alba_

4.) _Ulmus rubra_

5. Between the Arenac Soil Series and the Selkirk Soil Series

   a. The percentage of basal area for _Ulmus americana_ is greater than mathematical chance in favor of the Arenac Soil Series.

   b. The percentage of frequency for _Tsuga candensis_ is greater than mathematical chance in favor of the Selkirk Soil Series.

   c. Canopy tree species absent from the Arenac Soil Series and present on the Selkirk Soil Series:

   1.) _Ulmus rubra_

   2.) _Betula papyrifera_

   3.) _Betula lutea_

   4.) _Quercus alba_

   5.) _Pinus Strobus_

   6.) _Pinus resinosa_

   7.) _Thuja occidentalis_

6. Between the Emmet Soil Series and the Kalkaska Soil Series

   a. The percentage of frequency for _Ulmus americana_ and _Tilia americana_ is greater than mathematical chance in favor of the Emmet Soil Series.

   b. The percentage of frequency and basal area for _Ulmus Thomasi_ is greater than mathematical chance in favor of the Kalkaska Soil Series.

   c. Canopy tree species present on the Emmet Soil Series and absent from the Kalkaska Soil Series:

1.) *Acer rubrum*

2.) *Betula lutea*

3.) *Betula papyrifera*

4.) *Quercus rubra, var. borealis*

5.) *Quercus alba*

7. Between the Emmet Soil Series and the Nester Soil Series

   a. The percentage of density for *Acer saccharum* is greater than mathematical chance in favor of the Emmet Soil Series.

   b. The percentage frequency of *Betula papyrifera* and *Tsuga canadensis* is greater than mathematical chance in favor of the Nester Soil Series.

   c. Canopy tree species present on the Emmet Soil Series and absent from the Nester Soil Series were:

      1.) *Quercus alba*

   d. Canopy tree species present on the Nester Soil Series and absent from the Emmet Soil Series:

      1.) *Fraxinus nigra*

      2.) *Pinus Strobus*

      3.) *Thuja occidentalis*

8. Between the Emmet Soil Series and the Roselawn Soil Series

   a. The percentage of frequency, density and basal area for *Acer saccharum* is greater than mathematical chance in favor of the Emmet Soil Series.

   b. The percentages of frequency and basal area for both *Fagus grandifolia* and *Ulmus americana* are greater than mathematical chance in favor of the Emmet Soil Series.

c. The percent frequency of <u>Tilia americana</u> and <u>Fraxinus americana</u> is greater than mathematical chance in favor of the Emmet Soil Series.

d. The percentages of frequency and density for <u>Acer rubrum</u> are both greater than mathematical chance in favor of the Roselawn Soil Series.

e. The percentages of frequency and basal area for both <u>Quercus rubra var. borealis</u> and <u>Quercus alba</u> are greater than mathematical chance in favor of the Roselawn Soil Series.

f. Canopy tree species present on the Emmet Soil Series and absent from the Roselawn Soil Series were:

1.) <u>Ulmus Thomasi</u>

2.) <u>Betula lutea</u>

3.) <u>Betula papyrifera</u>

4.) <u>Tsuga canadensis</u>

g. Canopy tree species present on the Roselawn Soil Series and absent from the Emmet Soil Series:

1.) <u>Pinus Strobus</u>

2.) <u>Pinus resinosa</u>

9. Between the Emmet Soil Series and the Selkirk Soil Series

a. The percentage of density for <u>Acer saccharum</u> is greater than mathematical chance in favor of the Emmet Soil Series.

b. The percentage of frequency for <u>Tilia americana</u> is greater than mathematical chance in favor of the Emmet Soil Series.

c. The percentage for density and frequency of <u>Ulmus Thomasi</u> is greater than mathematical chance in favor of the Selkirk Soil Series.

d. The percentage of frequency for _Acer rubrum_ and _Tsuga canadensis_ is greater than mathematical chance in favor of the Selkirk Soil Series.

e. Canopy tree species absent from the Emmet Soil Series and present on the Selkirk Soil Series were:

1.) _Pinus Strobus_

2.) _Pinus resinosa_

3.) _Thuja occidentalis_

10. Between the Kalkaska and the Nester Soil Series

a. The percent density of _Acer saccharum_ is greater than mathematical chance in favor of the Kalkaska Soil Series.

b. The percentage of frequency for _Ulmus Thomasi_ is greater than mathematical chance in favor of the Kalkaska Soil Series.

c. The percentage of frequency for _Tilia americana_, _Fraxinus americana_ and _Tsuga canadensis_ is greater than mathematical chance in favor of the Nester Soil Series.

d. Canopy tree species absent from the Kalkaska Soil Series and present on the Nester Soil Series were:

1.) _Acer rubrum_

2.) _Betula lutea_

3.) _Betula papyrifera_

4.) _Fraxinus nigra_

5.) _Pinus Strobus_

6.) _Quercus alba_

7.) _Quercus rubra var. borealis_

8.) _Thuja occidentalis_

11. Between the Kalkaska Soil Series and the Roselawn Soil Series

    a. The percentages of frequency, density, and basal area for *Acer saccharum* are greater than mathematical chance in favor of the Kalkaska Soil Series.

    b. The percentages of frequency and basal area for *Fagus grandifolia* are greater than mathematical chance in favor of the Kalkaska Soil Series.

    c. There were no canopy tree species present on both soil series which showed any significance of difference of percentages in favor of the Roselawn Soil Series.

    d. Canopy tree species present on the Kalkaska Soil Series and absent from the Roselawn Soil Series were:

        1.) *Ulmus Thomasi*

        2.) *Tsuga canadensis*

    e. Canopy tree species present on the Roselawn Soil Series and absent from the Kalkaska Soil Series:

        1.) *Acer rubrum*

        2.) *Quercus rubra var. borealis*

        3.) *Quercus alba*

        4.) *Pinus Strobus*

        5.) *Pinus resinosa*

12. Between the Kalkaska and Selkirk Soil Series

    a. The percentage of density for *Acer saccharum* is greater than mathematical chance in favor of the Kalkaska Soil Series.

    b. The percentage of frequency for *Fraxinus americana* and *Tsuga canadensis* is greater than mathematical chance in favor of the Selkirk Soil Series.

c. Canopy tree species absent from the Kalkaska Soil Series and present on the Selkirk Soil Series were:

1.) *Acer rubrum*

2.) *Betula lutea*

3.) *Betula papyrifera*

4.) *Pinus resinosa*

5.) *Pinus Strobus*

6.) *Quercus alba*

7.) *Quercus rubra var. borealis*

13. Between the Nester Soil Series and the Roselawn Soil Series

a. The percentages of frequency, density, and basal area for *Acer saccharum* are greater than mathematical chance in favor of the Nester Soil Series.

b. The percentages of frequency and basal area for *Quercus rubra var. borealis* are greater than mathematical chance in favor of the Roselawn Soil Series.

c. Canopy tree species that are present on the Nester Soil Series and absent from the Roselawn Soil Series are:

1.) *Betula lutea*

2.) *Betula papyrifera*

3.) *Fraxinus nigra*

4.) *Tsuga canadensis*

5.) *Thuja occidentalis*

6.) *Ulmus Thomasi*

d. Canopy tree species that are absent from the Nester Soil Series and present on the Roselawn Soil Series:

1.) *Pinus resinosa*

2.) *Quercus alba*

14. Between the Nester and the Selkirk Soil Series

   a. The percentage of frequency for Tilia americana is greater than mathematical chance in favor of the Nester Soil Series.

   b. The percentage of frequency for Fagus grandifolia and Ulmus Thomasi is greater than mathematical chance in favor of the Selkirk Soil Series.

   c. Canopy tree species present on the Nester Soil Series and absent from the Selkirk Soil Series was:

      1.) Fraxinus nigra

   d. Canopy tree species which were present on the Selkirk Soil Series and absent from the Nester Soil Series:

      1.) Pinus resinosa

      2.) Pinus Strobus

15. Between the Selkirk Soil Series and the Roselawn Soil Series

   a. The percentages of frequency, density and basal area for Acer saccharum are greater than mathematical chance in favor of the Selkirk Soil Series.

   b. The percentages of frequency and basal area for Fagus grandifolia are greater than mathematical chance in the favor of Selkirk Soil Series.

   c. The percentages of frequency and basal area for Quercus rubra var. borealis are greater than mathematical chance in favor of the Roselawn Soil Series.

   d. The percentage of frequency for both Acer rubrum and Quercus alba are greater than mathematical chance in favor of the Roselawn Soil Series.

e. The percentage of frequency for both Ulmus americana and Fraxinus americana is greater than mathematical chance in favor of the Selkirk Soil Series.

f. Canopy tree species that were present on the Selkirk Soil Series and absent from the Roselawn Soil Series were:

1.) Betula lutea

2.) Betula papyrifera

3.) Tsuga canadensis

4.) Thuja occidentalis

5.) Ulmus Thomasi

A discussion of the ecological relationships and significance of these statistical findings is to be found in Section B of the section of this report entitled "Discussion" (p. 217).

The following series of photographs show the appearance of the various upland second growth hardwood stands as they appear on the six different soil series. Fig. 23 is of a woodlot within the Arenac Soil Series on an outwash apron. Fig. 24 shows a woodlot on the Emmet Soil Series on an east-facing morainic slope. In Fig. 25 is shown a stand on the Kalkaska Soil Series located on a till plain. The stand of second growth upland hardwoods in Fig. 26 is representative of the Nester Soil Series, also on a till plain. This particular photograph is of the stand sampled quantitatively on the Michigan State College Experiment Station Farm. Fig. 27 is a woodlot within the Selkirk Soil Series on a till plain. Fig. 28 shows a stand of second growth upland hardwoods on the Roselawn Soil Series. The picture was taken near the crest of a westward facing morainic slope.

Fig. 23. Photograph showing a stand of second growth upland hardwoods on Arenac sandy loam within an outwash apron.

Fig. 24. Photograph showing a stand of upland second growth hardwoods on Emmet sandy loam. East facing morainic slope.

Fig. 25. Photograph showing a stand of second growth upland hardwoods on Kalkaska loamy sand in a till plain.

Fig. 26. Photograph showing a stand of upland second growth hardwoods on Nester loam within a till plain.

Fig. 27. Photograph showing a stand of second growth upland hardwoods on Selkirk silt loam on a till plain.

Fig. 28. Photograph showing a stand of second growth upland hardwoods on Roselawn sand. West facing morainic slope.

C. The Composition of the Woody Vegetation in the Ninety-Eight Stands of Second Growth Upland Hardwoods of Missaukee County Compared with the Composition of the Woody Vegetation in other Areas of Michigan, Wisconsin and Minnesota

1. General

Comparisons of the composition of the woody vegetation in the ninety-eight stands of second growth upland hardwoods of Missaukee County with the reported quantitative data for the forest formations in other areas of Michigan, Wisconsin and Minnesota have been worked out along two general lines. In the article (Stearns 1951), which presented the quantitative data to include a DFD Index scale (Curtis 1947), the comparisons were worked out on that basis. In the articles where the quantitative data did not include a DFD Index scale, comparisons were drawn by establishing a Frequency Index Community Coefficient in the manner of Gleason (1920, p. 31-32) and Gates (1949, p. 41).

2. Quick (1923). A Comparative Study of the Distribution of the Climax Association in Southern Michigan

In his report, Quick (1923) presented the percentage frequency of the trees in the climax association in tabular form. The table listed six regions for the southern peninsula of Michigan, with each region being represented by two or more stations where quantitative samplings were taken. These regions and the location of the stations are shown in Fig. 29. Comparisons with the climax association for each of these stations were drawn with the composition of the ninety-eight stands of second growth upland hardwoods in Missaukee County on the basis of a Frequency Index Community Coefficient (FICC). These results are presented in Tables XXIII through XXXIX.

The three stations for which quantitative data were reported in Region 4 were the nearest geographically to Missaukee County. On the basis of the Frequency Index Community Coefficient, the station at Hart (11), when compared, received the highest FICC, 73%. Clare (6) and Mosely (13), the other two stations within the region manifested an FICC of 71% and 63% respectively. The lowest FICC established was with the station at Douglas Lake (10), in Region 6, where the coefficient was only 40%. The station at Vassar (16), in Region 5, likewise gave a very low FICC, 41%. Clifford (7), in the northern part of Region 2, yielded an FICC of 72% and comparisons with Clayton (5), in the southern part of the same region, resulted in an FICC of 70%. This station is the farthest removed from Missaukee County, and consequently might be expected to show a lower FICC as increased distance between compared areas tends to increase floristic differences.

The establishment of a high frequency index community coefficient between two compared areas is usually believed to indicate a close relationship. Most frequently these coefficients, if the two areas are in the same association within the same area, are in excess of eighty. However, it is very possible to find areas close together, which appear similar to the eye, that, upon comparison, yield coefficients which are less than sixty. The various areas in Quick's (1923) study, when compared by means of the Frequency Index Community Coefficient with the data from Missaukee County show a wide range of coefficient values which indicate, when low, very little relationship, and when high, a closer affinity. The significance of these relationships, as well as their indicator value, are considered in detail in Section C of the Discussion (p. 224).

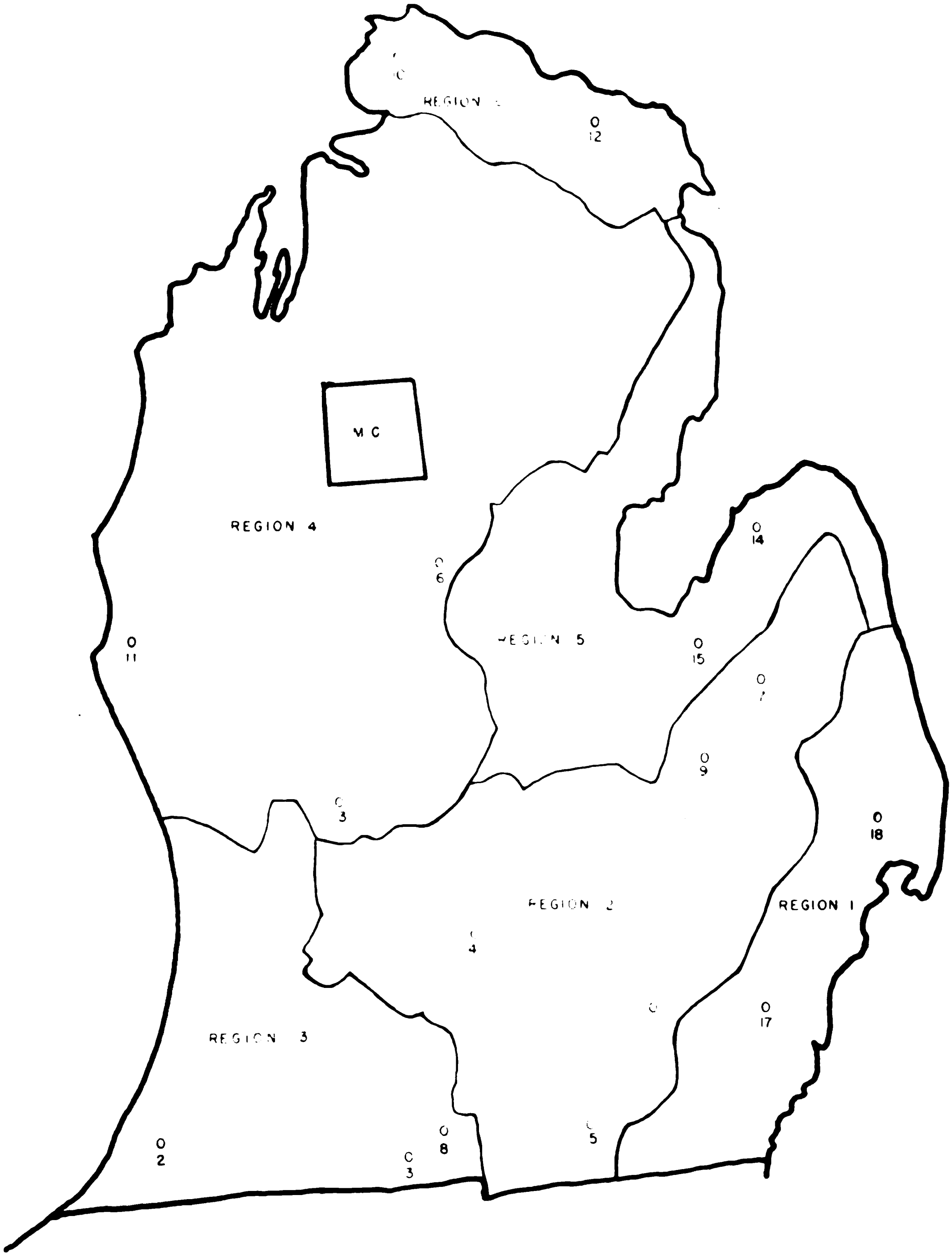


Fig. 29. Map of Lower Michigan showing Quick's (1923) region within the Beech-Maple Climax Association and the location of stands from which quantitative data were compared with the ninety-eight stands of upland second growth hardwoods of Missaukee County (MC).

TABLE XXIII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

Tree Species	1	2	3
Acer rubrum	13		
Acer saccharum		94 22	
Betula lutea	5		
Betula papyrifera	3		
Carya cordiformis			1
Carya ovata			4
Fagus grandifolia		50 20	
Fraxinus americana		19 9	
Juglans cinerea			1
Liriodendron Tulipifera			1
Ostrya virginiana		26 11	
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina	11		
Quercus alba		3 1	
Quercus rubra var. borealis		11 2	
Thuja occidentalis	1		
Tilia americana		26 5	
Tsuga candensis	12		
Ulmus americana		33 12	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	81	344	7

344 + 2 = 172 81 + 172 + 7 = 260 $\frac{172}{260} \times 100 = 66\%$

Frequency Index Community Coefficient is 66%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's region one, Richmond stand, (15).

TABLE XXIV

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	9	
Betula lutea	5			
Betula papyrifera	3			
Carya cordiformis				2
Carya ovata				2
Fagus grandifolia		50	22	
Fraxinus americana		19	6	
Liriodendron Tulipifera				1
Ostrya virginiana	26			
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina	11			
Quercus alba		3	5	
Quercus rubra var. borealis		11	8	
Thuja occidentalis	1			
Tilia americana		26	2	
Tsuga canadensis	12			
Ulmus americana		33	6	
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	107	294		5

$294 \div 2 = 147$ $\quad 107 + 147 + 5 = 259$ $\quad \frac{147}{259} \times 100 = 56\%$

Frequency Index Community Coefficient is 56%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's region one, Wayne station,(17).

TABLE XXV

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	53	
Betula lutea	5			
Betula papyrifera	3			
Carya cordiformis				1
Carya ovata				3
Fagus grandifolia		50	18	
Fraxinus americana		19	6	
Ostrya virginiana		26	1	
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina		11	2	
Quercus rubra var. borealis		11	1	
Quercus alba	3			
Thuja occidentalis	1			
Tilia americana		26	2	
Tsuga canadensis	12			
Ulmus americana		33	6	
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	73	359		4

$359 \div 2 = 179$ $\qquad$ $179 + 73 + 4 = 256$ $\qquad$ $\frac{179}{256} \times 100 = 70\%$

Frequency Index of Community Coefficient is 70%.

1. Percent frequency of trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of trees common to both stands.

3. Percent frequency of trees in Quick's Region Two, Clayton station, (5).

TABLE XXVI

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	8	
Betula lutea	5			
Betula papyrifera	3			
Carya ovata				1
Fagus grandifolia		50	9	
Fraxinus americana		19	14	
Ostrya virginiana		26	7	
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina		11	1	
Quercus alba	3			
Quercus rubra var. borealis		11	4	
Thuja occidentalis	1			
Tilia americana		26	17	
Tsuga canadensis	12			
Ulmus americana	33			
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	106	297		1

$297 + 2 = 148$ $\qquad 106 + 148 + 1 = 255 \qquad \frac{148}{255} \times 100 = 58\%$

Frequency Index of Community Coefficient is 58%.

1. Percent frequency of trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of trees common to both stands.

3. Percent frequency of trees in Quick's Region Two, Ann Arbor station, (1).

TABLE XXVII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 20	
Betula lutea	5		
Betula papyrifera	3		
Carya cordiformis			6
Fagus grandifolia		50 52	
Fraxinus americana		19 4	
Juglans cinerea			1
Ostrya virginiana		26 3	
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina		11 4	
Quercus alba	3		
Quercus rubra var. borealis		11 2	
Thuja occidentalis	1		
Tilia americana		26 2	
Tsuga canadensis	12		
Ulmus americana		33 6	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	72	363	7

$363 + 2 = 181$ $\quad$ $72 + 181 + 7 = 260$ $\quad$ $\frac{181}{260} \times 100 = 69\%$

Frequency Index Community Coefficient is 69%.

1. Percent frequency of trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of trees in Quick's Region Two, Charlotte stand (4).

TABLE XXVIII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 23	
Betula lutea	5		
Betula papyrifera	3		
Carya ovata			3
Fagus grandifolia		50 41	
Fraxinus americana		19 3	
Ostrya virginiana		26 8	
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis		11 4	
Thuja occidentalis	1		
Tilia americana		26 8	
Tsuga canadensis	12		
Ulmus americana		33 5	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	84	351	3

$351 + 2 = 175$ $84 + 175 + 3 = 262$ $\frac{175}{262} \times 100 = 68\%$

Frequency Index Community Coefficient is 68%.

1. Percent frequency of trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of trees common to both stands.

3. Percent frequency of the trees in Quick's Region Two, Davidson station (9).

TABLE XXIX

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	48	
Betula lutea	5			
Betula papyrifera	3			
Fagus grandifolia		50	19	
Fraxinus americana		19	3	
Ostrya virginiana		26	5	
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina		11	1	
Quercus alba	1			
Quercus rubra var. borealis	11			
Thuja occidentalis	1			
Tilia americana		26	6	
Tsuga canadensis	12			
Ulmus americana		33	13	
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	72	367		0

$367 \div 2 = 183$ $72 + 183 = 255$ $\frac{183}{255} \times 100 = 72\%$

Frequency Index Community Coefficient is 72%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Two, Clifford station (7).

TABLE XXX

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 45	
Betula lutea	5		
Betula papyrifera	3		
Fagus grandifolia		50 39	
Fraxinus americana	19		
Juglans cinerea			2
Ostrya virginiana		26 7	
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis	11		
Thuja occidentalis	1		
Tilia americana		26 3	
Tsuga canadensis	12		
Ulmus americana		33 3	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	114	326	2

326 + 2 = 163 114 + 163 + 2 = 279 $\frac{163}{279} \times 100 = 58\%$

Frequency Index Community Coefficient is 58%.

1. Percent frequency of the trees in the ninety-eight stands of second growth hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Three, Coldwater station (8).

TABLE XXXI

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	60	
Betula lutea	5			
Betula papyrifera	3			
Carya cordiformis				2
Fagus grandifolia		50	5	
Fraxinus americana		19	5	
Juglans cinerea				5
Liriodendron Tulipifera				2
Ostrya virginiana	26			
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina		11	4	
Quercus alba		3	2	
Quercus rubra var. borealis		11	4	
Thuja occidentalis	1			
Tilia americana		26	5	
Tsuga canadensis	12			
Ulmus americana		33	6	
Ulmus rubra	23			
Ulmus Thomasi	11			
Totals	96	335		9

$335 + 2 = 167$ $\quad\quad$ $196 + 167 + 9 = 272$ $\quad\quad$ $\frac{167}{272} \times 100 = 61\%$

Frequency Index Community Coefficient is 61%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Three, Bronson station (3).

TABLE XXXII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 38	
Betula lutea	5		
Betula papyrifera	3		
Carya cordiformis			1
Fagus grandifolia		50 29	
Fraxinus americana		19 5	
Liriodendron Tulipifera			2
Ostrya virginiana		26 1	
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina		11 1	
Quercus alba		3 1	
Quercus rubra var. borealis		11 2	
Thuja occidentalis	1		
Tilia americana		26 12	
Tsuga canadensis	12		
Ulmus americana		33 6	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	70	368	3

$368 \div 2 = 184$ $\quad 184 + 70 + 3 = 257$ $\quad \frac{184}{257} \times 100 = 69\%$

Frequency Index Community Coefficient is 69%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Three, Berrien Springs station (2).

TABLE XXXIII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	24	
Betula lutea	5			
Betula papyrifera	3			
Carya ovata				3
Fagus grandifolia		50	43	
Fraxinus americana		19	4	
Juglans cinerea				2
Liriodendron Tulipifera				2
Ostrya virginiana		26	2	
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina		11	1	
Quercus alba		3	2	
Quercus rubra var. borealis		11	3	
Thuja occidentalis	1			
Tilia americana		26	13	
Tsuga canadensis	12			
Ulmus americana		33	2	
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	70	357		7

357 + 2 = 128   70 + 128 + 7 = 205 $\frac{128}{205} \times 100 = 62\%$

Frequency Index Community Coefficient is 62%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Four, Moseley station (13).

TABLE XXXIV

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISON

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 9	
Betula lutea	5		
Betula papyrifera	3		
Fagus grandifolia		50 65	
Fraxinus americana		19 4	
Ostrya virginiana		26 1	
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis		11 4	
Thuja occidentalis	1		
Tilia americana		26 2	
Tsuga canadensis		12 12	
Ulmus americana		33 1	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	72	359	0

$359 \div 2 = 179$ $\qquad$ $72 + 179 = 251$ $\qquad$ $\frac{179}{251} \times 100 = 71\%$

Frequency Index Community Coefficient is 71%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of trees common to both stands.

3. Percent frequency of the trees in Quick's Region Four, Clare station (6).

TABLE XXXV

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	26	
Betula lutea		5	1	
Betula papyrifera	3			
Fagus grandifolia		50	36	
Fraxinus americana		19	2	
Ostrya virginiana		26	1	
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina		11	9	
Quercus alba	3			
Quercus rubra var. borealis	11			
Thuja occidentalis	1			
Tilia americana		26	1	
Tsuga canadensis		12	18	
Ulmus americana		33	5	
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	67	375		0

$375 \div 2 = 188$ $\qquad$ $67 + 188 = 255$ $\qquad$ $\frac{188}{255} \times 100 = 73\%$

Frequency Index Community Coefficient is 73%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Four, Hart station (11).

TABLE XXXVI

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 23	
Betula lutea	5		
Betula papyrifera	3		
Fagus grandifolia		50 68	
Fraxinus americana	19		
Juglans cinerea			2
Ostrya virginiana	26		
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis	11		
Thuja occidentalis	1		
Tilia americana		26 2	
Tsuga canadensis	12		
Ulmus americana	33		
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	173	263	2

$263 + 2 = 131$ $173 + 131 + 2 = 306$ $\frac{131}{306} \times 100 = 41\%$

Frequency Index Community Coefficient is 41%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Five, Vassar station (18).

TABLE XXXVII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	8	
Betula lutea		5	4	
Betula papyrifera	3			
Carya ovata				2
Fagus grandifolia		50	12	
Fraxinus americana	19			
Juglans cinerea				3
Ostrya virginiana	26			
Pinus resinosa	1			
Pinus Strobus	1			
Prunus serotina	11			
Quercus alba	3			
Quercus rubra var. borealis		11	1	
Thuja occidentalis	1			
Tilia americana		26	4	
Tsuga canadensis	12			
Ulmus americana		33	36	
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	124	284		5

$284 \div 2 = 142$ $\qquad 124 + 142 + 5 = 271$ $\qquad \frac{142}{271} \times 100 = 51\%$

Frequency Index Community Coefficient is 51%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Five, Pigeon station (14).

TABLE XXXVIII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 35	
Betula lutea	5		
Betula papyrifera	3		
Fagus grandifolia		50 48	
Fraxinus americana	19		
Ostrya virginiana	26		
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis	11		
Thuja occidentalis	1		
Tilia americana	26		
Tsuga canadensis		12 17	
Ulmus americana	33		
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	187	256	0

256 + 2 = 128   167 + 128 = 315 $\frac{128}{315} \times 100 = 40\%$

Frequency Index Community Coefficient is 40%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods in Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Six, Douglas Lake station (10).

TABLE XXXIX

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 40	
Betula lutea		12 1	
Betula papyrifera	3		
Fagus grandifolia		50 49	
Fraxinus americana	19		
Ostrya virginiana		26 1	
Pinus resinosa	1		
Pinus Strobus	1		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis	11		
Thuja occidentalis	1		
Tilia americana		26 1	
Tsuga canadensis		12 7	
Ulmus americana		33 1	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	97	353	0

$353 + 2 = 176$ $\qquad 176 + 97 = 273$ $\qquad \frac{176}{273} \times 100 = 64\%$

Frequency Index Community Coefficient is 64%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Quick's Region Six, La Rocque station (12).

3. Woollett and Sigler (1928). Revegetation of Beech-Maple Areas in the Douglas Lake Region

Woollett and Sigler (1928) were able to compare a typical virgin beech-maple forest with the reforesting areas. In their report, they presented percent frequency of the tree species for the two types of areas considered. When compared with the Missaukee County stands of second growth upland hardwoods on the basis of a Frequency Index Community Coefficient, the "typical" beech-maple forest yielded a coefficient of 71% and for the reforesting areas, 70%. It is of interest to note that these percentages are considerably larger than the FICC obtained between Quick's Douglas Lake station and Missaukee County. The details of the comparisons with the studies of Woollett and Sigler are presented in Tables XL and XLI.

An examination of Table XL, which compares the mature beech-maple forest of the Douglas Lake area with the Missaukee County stands of second growth upland hardwoods, reveals that it is the presence of such "fire species" as Populus grandidentata, P. tremuloides, and Prunus pensylvanica, as well as a greater number of representatives of Ulmus, which are responsible for the differences in vegetation between the two areas. While the "fire species" are present in both the reforesting areas of the Douglas Lake area (Table XLI) and Missaukee County, such successional species as Fraxinus americana, Quercus alba, Quercus rubra var. borealis, Pinus resinosa and P. Strobus, were absent from the reforesting areas, in the Douglas Lake region. The latter four species would be considered as relic species by Woollett and Sigler (1928, p. 24).

TABLE XL

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum		13 4	
Acer saccharum		94 36	
Betula lutea		5 4	
Betula papyrifera*		3 1	
Fagus grandifolia		50 21	
Fraxinus americana		19 1	
Ostrya virginiana		26 1	
Pinus resinosa	1		
Pinus Strobus*		1 2	
Populus grandidentata	10		
Populus tremuloides	1		
Prunus pensylvanica	16		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis*		11 1	
Thuja occidentalis	1		
Tilia americana#		26 2	
Tsuga canadensis#		12 15	
Ulmus americana		33 3	
Ulmus rubra	11		
Ulmus Thomasi	23		
Totals	77	384	0

384 ÷ 2 = 192 192 + 77 = 269 $\frac{192}{269} \times 100 = 71\%$

Frequency Index Community Coefficient is 71%.

1. Percent frequency of the tree species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the tree species common to both stands.

3. Percent frequency of the tree species in Woollett and Sigler's typical beech-maple forest of the Douglas Lake Region.

*Tree species listed by Woollett and Sigler as prominent relics.
#Tilia americana/Tilia glabra
#Tsuga canadensis/Tsuga americana

TABLE XLI

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Abies balsamea				2
Acer rubrum		13	1	
Acer saccharum		94	67	
Betula lutea		5	1	
Betula papyrifera*		3	4	
Fagus grandifolia		50	7	
Fraxinus americana	19			
Ostrya virginiana		26	1	
Pinus resinosa	1			
Pinus Strobus*	1			
Populus grandidentata		10	3	
Populus tremuloides		1	1	
Prunus pensylvanica		16	2	
Prunus serotina	11			
Quercus alba	3			
Quercus rubra var. borealis*	11			
Thuja occidentalis	1			
Tilia americana#		26	1	
Tsuga canadensis#		12	3	
Ulmus americana		33	2	
Ulmus rubra	11			
Ulmus Thomasi	23			
Totals	81	382		2

$382 \div 2 = 191$ $\qquad$ $191 + 81 + 2 = 274$ $\qquad$ $\frac{191}{274} \times 100 = 70\%$

Frequency Index Community Coefficient is 70%.

1. Percent frequency of the tree species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the tree species common to both stands.

3. Percent frequency of the tree species in Woollett and Sigler's reforesting areas, Douglas Lake Region.

*Tree species listed by Woollett and Sigler as prominent relics.
#Tilia americana/ Tilia glabra
#Tsuga canadensis/ Tsuga americana

As such, they might not be expected to reoccur in reforesting area which no longer support the climax characteristic of these species. However, in Missaukee County, the quantitative data yield sufficient evidence to indicate that they are reproducing and maintaining themselves within the forest community.

4. Gleason (1924). The Structure of the Maple-Beech Association in Northern Michigan

In his study of the Maple-Beech association in northern Michigan, Gleason (1924) presented a frequency index for the composition of the forest cover and species normally associated with the association. These figures and species lists were used to establish a Frequency Index Community Coefficient as a basis of comparison for this area and the ninety-eight stands of second growth upland hardwoods in Missaukee County. The area studied by Gleason is north of Missaukee County. It comprised parts of Antrim, Charlevoix, Emmet, and Otsego Counties. The areas as defined by Gleason were (p. 286-287):

Area one: A square mile of virgin forest on section 13, Town 30 North, Range 5 West, in the extreme eastern end of Antrim County, bordering on Otsego County, about six miles east of Alba.

Area two: A square mile on Section 8, Town 30 North, Range 4 West, near the western edge of Otsego County, about two miles northeast of area one.

Area three: A square mile of section 17, Town 30 North, Range 4 West in Otsego County, adjoining are two on the south.

Area four: A tract almost a square mile in extent on section 35, Town 32 North, Range 4 West, in the eastern end of Charlevoix County, about eight miles north of area two.

Area five: A small tract, not exceeding forty acres in extent, on the land of the State Game Refuge in Emmet County, about nine miles southwest of Mackinaw City.

The Frequency Index Community Coefficients, when established for the different areas with the Missaukee County study, ranged from a low of 36% to a high of 59%. Area one, as compared with Missaukee County, was 44%; area two, 52%; area three, 57%; area four, 57%; and area five, 36%. The details for the FICC comparisons are presented in Tables XLII through XLVI.

An inspection of the tables reveals that there are present in Missaukee County a larger number of such successional tree species as Populus grandidentata, P. tremuloides, Betula papyrifera, Ulmus Thomasi, and U. rubra together with such relic species as Pinus Strobus and P. resinosa. The presence of these tree species in the one area, while absent from the other, is largely accountable for the low FICC values here. A greater percent of frequency for the characteristic climax tree species (Fagus grandifolia, Tilia americana, Fraxinus americana, Tsuga canadensis) in Missaukee County than in the areas of Gleason (1924) must also be considered in interpreting the significance of these FICCs. A more detailed consideration of the significances of these coefficients and their values as indicators is presented in Section C of the Discussion.

5. Cain (1935). Studies on Virgin Hardwood Forests. III. Warren's Woods, A Beech-Maple Climax Forest in Berrien County, Michigan

Warren's Woods is reputedly a virgin forest on the NW one-quarter of Section 27, Range 20 West, Township 7 West. It is held as a state reserve under the Edward K. Warren Foundation of Three Oaks, Berrien

TABLE XLII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 96	
Acer spicatum		1 3	
Amelanchier sp.	2		
Betula lutea		5 4	
Betula papyrifera	3		
Cornus alternifolia		4 1	
Corylus cornuta	3		
Fagus grandifolia	50		
Fraxinus americana	19		
Ostrya virginiana	26		
Pinus resinosa	1		
Pinus Strobus	1		
Populus grandidentata	10		
Populus tremuloides	1		
Prunus pensylvanica		16 1	
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis	11		
Rhus typhina	1		
Ribes sp.		1 4	
Rubus sp.			4
Sambucus pubens		1 9	
Thuja occidentalis	1		
Tilia americana		26 2	
Tsuga canadensis	12		
Ulmus americana		33 13	
Ulmus rubra	11		
Ulmus Thomasi	23		
Viburnum acerifolium		2 1	
Totals	203	329	4

329 + 2 = 165 $\qquad$ 203 + 165 + 4 = 372 $\qquad$ $\frac{165}{372} \times 100 = 44\%$

Frequency Index Community Coefficient is 44%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the species in Gleason's area one.

TABLE XLIII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	88	
Acer spicatum		1	9	
Amelanchier sp.	2			
Betula lutea		5	1	
Betula papyrifera	3			
Cornus alternifolia		4	1	
Corylus cornuta	3			
Fagus grandifolia		50	2	
Fraxinus americana	19			
Ostrya virginiana	26			
Pinus resinosa	1			
Pinus Strobus	1			
Populus grandidentata	10			
Populus tremuloides	1			
Prunus pensylvanica	16			
Prunus serotina	11			
Quercus alba	3			
Quercus rubra var. borealis	11			
Rhus typhina	1			
Ribes sp.		1	8	
Rubus sp.				18
Sambucus pubens		1	32	
Thuja occidentalis	1			
Tilia americana		26	4	
Tsuga canadensis		12	1	
Ulmus americana		33	17	
Ulmus rubra	11			
Ulmus Thomasi	23			
Viburnum acerifolium	2			
Totals	159	390		18

$390 \div 2 = 195$ $159 + 195 + 18 = 372$ $\frac{195}{372} \times 100 = 52\%$

Frequency Index Community Coefficient is 52%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the trees common to both stands.

3. Percent frequency of the trees in Gleason's area two.

TABLE XLIV

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

SPECIES	1	2		3
Acer rubrum	13			
Acer saccharum		94	88	
Acer spicatum		1	5	
Amelanchier sp.	2			
Betula lutea		5	2	
Betula papyrifera	3			
Cornus alternifolia	4			
Corylus cornuta	3			
Fagus grandifolia		50	5	
Fraxinus americana	19			
Ostrya virginiana		26	1	
Pinus resinosa	1			
Pinus Strobus	1			
Populus grandidentata	10			
Populus tremuloides	1			
Prunus pensylvanica	16			
Prunus serotina		11	2	
Quercus alba	3			
Quercus rubra var. borealis	11			
Rhus typhina	1			
Ribes sp.		1	2	
Rubus sp.				21
Sambucus pubens		1	9	
Thuja occidentalis	1			
Tilia americana		26	1	
Tsuga candensis		12	5	
Ulmus americana		33	12	
Ulmus rubra	11			
Ulmus Thomasi	23			
Viburnum acerifolium	2			
Totals	126	392		21

$392 \div 2 = 196$ $\qquad 126 + 196 + 21 = 343$ $\qquad \frac{196}{343} \times 100 = 57\%$

Frequency Index Community Coefficient is 57%.

1. Percent frequency for the species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the species common to both stands.

3. Percent frequency of the species in Gleason's area three.

TABLE XLV

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 74	
Acer spicatum		1 10	
Amelanchier sp.	2		
Betula lutea		5 3	
Betula papyrifera	3		
Cornus alternifolia	4		
Corylus cornuta	3		
Fagus grandifolia		50 49	
Fraxinus americana		19 3	
Ostrya virginiana	26		
Pinus resinosa	1		
Pinus Strobus	1		
Populus grandidentata	10		
Populus tremuloides	1		
Prunus pensylvanica	16		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis	11		
Rhus typhina	1		
Ribes sp.		1 1	
Sambucus pubens		1 23	
Thuja occidentalis	1		
Tilia americana		26 2	
Tsuga canadensis		12 3	
Ulmus americana		33 18	
Ulmus rubra	11		
Ulmus Thomasi	23		
Viburnum acerifolium	2		
Totals	143	426	0

$426 \div 2 = 213$ $\quad 143 + 213 = 356$ $\quad \frac{213}{356} \times 100 = 59\%$

Frequency Index Community Coefficient is 59%.

1. Percent frequency of the species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the species common to both stands.

3. Percent frequency of the species in Gleason's area four.

TABLE XLVI

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 100	
Acer spicatum	1		
Amelanchier sp.	2		
Betula lutea		5 3	
Betula papyrifera	3		
Cornus alternifolia	4		
Corylus cornuta	3		
Fagus grandifolia		50 14	
Fraxinus americana	19		
Ostrya virginiana	26		
Pinus resinosa	1		
Pinus Strobus	1		
Populus grandidentata	10		
Populus tremuloides	1		
Prunus pensylvanica	16		
Prunus serotina	11		
Quercus alba	3		
Quercus rubra var. borealis	11		
Rhus typhina	1		
Ribes sp.	1		
Sambucus pubens	1		
Thuja occidentalis	1		
Tilia americana	26		
Tsuga canadensis	12		
Ulmus americana	33		
Ulmus rubra	11		
Ulmus Thomasi	23		
Viburnum acerfolium	2		
Totals	237	267	0

267 + 2 = 134 $\qquad$ 134 + 237 = 371 $\qquad$ $\frac{136}{371}$ x 100 = 36%

Frequency Index Community Coefficient is 36%.

1. Percent frequency of the species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the species common to both stands.

3. Percent frequency of the species in Gleason's area five.

County, Michigan. According to Braun (1950, p. 318): "In all probability, the forest tract which the largest number of students of forest ecology have looked at as an example of the Beech-Maple association is Warren Woods." During the summer of 1933, Cain (1935) made a quantitative study of twenty-five quadrats of 10 x 10 meters each (p. 502) "scattered regularly in a checkerboard pattern over a little more than ten acres of the upland south of the highway and north of the Galien River." From his data, it was possible to compare this study with that of Missaukee County by establishing a Frequency Index Community Coefficient for the two locations. The result was an FICC of 58%. The details for the comparison are presented in Table XLVII. An inspection of this Table shows that the Warren's Woods area contained numerous species of more southern range: *Carya cordiformis*, *C. ovata*, *Carpinus caroliniana*, and *Liriodendron Tulipifera*. Likewise the shrub species were more numerous in the Warren's Woods, and those species which were common to both areas, usually attained a higher percent frequency within the more southern forest. The more northern aspect of the forest community in Missaukee County is revealed by the presence of such coniferous species as *Pinus Strobus*, *P. resinosa*, and *Tsuga canadensis*. Yet another difference between the composition of the southern expression of the deciduous forest with that in the more northern part of the state is seen in the relative percent frequencies of the two characteristic tree species for the climax association. In Warren's Woods, the percent frequency for *Acer saccharum* was 64; in Missaukee County, it was 94%. *Fagus grandifolia* had a recorded percent frequency within the more southern stand of 100%, while in Missaukee County it was only half that, or 50%.

TABLE XLVII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

SPECIES	1	2		3
Acer rubrum		13	100	
Acer saccharum		94	64	
Amelanchier sp.		1	8	
Asimina triloba				16
Betula lutea	5			
Betula papyrifera	3			
Benzoin aestivale				96
Carpinus caroliniana				76
Carya cordiformis				20
Carya ovata				4
Celtis occidentalis				4
Cornus alternifolia		4	8	
Corylus cornuta		3	40	
Crataegus sp.	1			
Dirca palustris				12
Fagus grandifolia		50	100	
Fraxinus americana		19	24	
Liriodendron Tulipifera				24
Lonicera sp.				28
Ostrya virginiana		26	60	
Pinus resinosa	1			
Pinus Strobus	1			
Populus grandidentata	10			
Populus tremuloides	1			
Prunus pensylvanica		12	16	
Prunus serotina		11	8	
Quercus alba		3	8	
Quercus rubra var. borealis		11	64	
Rhus typhina	1			
Ribes sp.		4	24	
Sambucus pubens		1	32	
Smilax sp.				48
Thuja occidentalis	1			
Tilia americana		26	40	
Tsuga canadensis	12			
Ulmus americana		33	64	
Ulmus rubra		11	16	
Ulmus Thomasi	23			
Viburnum acerifolium		1	52	
Totals	61	1051		328

1051 + 2 = 525 $\qquad$ 61 + 525 + 328 = 914 $\qquad$ $\frac{525}{914} \times 100 = 57\%$

Frequency Index Community Coefficient is 57%.

1. Percent frequency of the species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.
2. Percent frequency of the species common to both stands.
3. Percent frequency of the species in Cain's Warren Woods study.

More consideration of the significance of these differences are presented in Section C of the Discussion.

6. Eggler (1938). The Maple-Basswood Forest Type in Washburn County, Wisconsin

Eggler's study was concerned with three areas of undisturbed hardwood forest in northern Wisconsin. It is to be expected that a Frequency Index Community Coefficient for these areas and the Missaukee County study should yield low percentages because the two areas are some distance removed from one another and a different climax association is characteristic of each. The comparisons, the details of which are presented in Tables XLVIII, XLVIX, and L, bear out this expectation. The Hunt Hill and Long Lake stands in Eggler's study, compared with the stands of second growth upland hardwoods of Missaukee County gave an FICC of 49%. The comparisons between the East Woods stand and those in Missaukee County yielded an even lower percentage, being 42%.

It is interesting to note that Acer saccharum has a much higher percent frequency in the Missaukee County stands than it does in the Wisconsin area, as reported in Eggler's study, and that the Wisconsin codominant, Tilia americana, has a considerably greater percentage of frequency in only the Long Lake stand. Fagus grandifolia, codominant with Acer saccharum in the climax association in Missaukee County, is absent from the Wisconsin areas, as this tree species drops out from the forest formation westward from the northern part of Michigan's lower peninsula. Ulmus appears to be of no importance in the climax community of Washburn County, Wisconsin, but it is one of the important successional species in the second growth upland hardwoods in Missaukee County. Also, there are a larger number of "fire species" present in the Missaukee

TABLE XLVIII

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum		13	17	
Acer saccharum		94	48	
Betula lutea		5	2	
Betula papyrifera	3			
Carya cordiformis				7
Fagus grandifolia	50			
Fraxinus americana	19			
Fraxinus pensylvanica*				20
Ostrya virginiana		26	30	
Pinus resinosa	1			
Pinus Strobus		1	2	
Populus grandidentata		10	2	
Populus tremuloides	1			
Prunus pensylvanica	16			
Prunus serotina	11			
Quercus alba		3	13	
Quercus rubra var. borealis*		11	59	
Thuja occidentalis	1			
Tilia americana		26	34	
Tsuga canadensis	12			
Ulmus americana	33			
Ulmus rubra*	11			
Ulmus Thomasi	23			
Totals	181	396		27

$396 \div 2 = 198$ $\qquad$ $181 + 198 + 27 = 407$ $\qquad$ $\frac{198}{407} \times 100 = 49\%$

Frequency Index Community Coefficient is 49%.

1. Percent frequency of the trees in the ninety-eight stands of second growth upland hardwoods of Missaukee County.
2. Percent frequency of the tree species common to both stands.
3. Percent frequency of the tree species in Eggler's Hunt Hill stand.

*Quercus rubra var. borealis/ Quercus borealis var. maxima
*Fraxinus pensylvanica var. lanceolata/ var. subintegerrima
*Ulmus rubra/ Ulmus fulva

TABLE XLIX

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2		3
Acer rubrum		13	5	
Acer saccharum		94	57	
Betula lutea		5	4	
Betula papyrifera	3			
Carya cordiformis				22
Fagus grandifolia	50			
Fraxinus americana	19			
Fraxinus pennsylvanica*				17
Juglans cinerea				4
Ostrya virginiana		26	51	
Pinus resinosa	1			
Pinus Strobus	1			
Populus grandidentata	10			
Populus tremuloides	1			
Prunus pensylvanica	16			
Prunus serotina	11			
Quercus alba		3	11	
Quercus rubra var. borealis*		11	37	
Thuja occidentalis	1			
Tilia americana		26	57	
Tsuga canadensis	12			
Ulmus americana	33			
Ulmus rubra*		11	1	
Ulmus Thomasi	23			
Totals	170	412		43

$412 \div 2 = 206$ $\quad$ $170 + 206 + 43 = 419$ $\quad$ $\frac{206}{419} \times 100 = 49\%$

Frequency Index Community Coefficient is 49%.

1. Percent frequency of the tree species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the tree species common to both stands.

3. Percent frequency of the tree species in Eggler's Long Lake station.

*Fraxinus pennsylvanica var. lanceolata/ var. subintegerrima
*Quercus rubra var. borealis/ Quercus borealis var. maxima
*Ulmus rubra/ Ulmus fulva

TABLE L

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 55	
Betula lutea		5 5	
Betula papyrifera	3		
Carpinus caroliniana			5
Fagus grandifolia	50		
Fraxinus americana	19		
Fraxinus pennsylvanica*			15
Ostrya virginiana		26 40	
Pinus resinosa	1		
Pinus Strobus	1		
Populus grandidentata	10		
Populus tremuloides	1		
Prunus pensylvanica	16		
Prunus serotina	11		
Quercus alba		3 5	
Quercus rubra var. borealis*		11 20	
Thuja occidentalis	1		
Tilia americana		26 20	
Tsuga canadensis	12		
Ulmus americana	33		
Ulmus rubra*	11		
Ulmus Thomasi	23		
Totals	194	310	20

$310 \div 2 = 155$ $\quad 194 + 155 + 20 = 369$ $\quad \frac{155}{369} \times 100 = 42\%$

Frequency Index Community Coefficient is 42%.

1. Percent frequency of the tree species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. Percent frequency of the tree species common to both stands.

3. Percent frequency of the tree species in Eggler's East Woods station.

*Fraxinus pennsylvanica var. lanceolata/ var. subintegerrima
*Quercus rubra var. borealis/ Quercus borealis var. maxima
*Ulmus rubra/ Ulmus fulva

County stands than in the three areas considered by Eggler. Populus grandidentata is only in the Hunt Hill area of Washburn County, while in Missaukee County, Populus tremuloides and Prunus pensylvanica were also present.

7. Daubenmire (1936). The Big Woods of Minnesota: Its Structure, and Relation to Climate, Fire and Soils

Comparisons between the ninety-eight stands of second growth upland hardwoods in Miss aukee County and the Big Woods of Minnesota as studied by Daubenmire (1936) were drawn on the basis of a Frequency Index Community Coefficient. The results of such an analysis established an FICC of 56%, the details of which are presented in Table LI. According to Daubenmire (p. 247), "This comparative study of the two samples of the Big Woods shows that even though the composition of the sugar maple-basswood community varies, six species are usually the most important and bear the same approximate relationship to each other." The data presented in Table LI indicates that the same six species play an important part in the composition of the Missaukee County community. Further, it is interesting to note that the codominant, Tilia americana, in the Minnesota area had the same percentage of frequency in the Missaukee County locations and that Fagus grandifolia, codominant with Acer saccharum in that community association, was absent from the Minnesota Big Woods.

8. Stearns (1951). The Composition of the Sugar Maple-Hemlock-Yellow Birch Association in Northern Wisconsin

In reporting the quantitative data for the composition of the sugar maple-hemlock-yellow birch association in northern Wisconsin, Stearns (1951)

TABLE LI

FREQUENCY INDEX COMMUNITY COEFFICIENT COMPARISONS

TREE SPECIES	1	2	3
Acer rubrum	13		
Acer saccharum		94 72	
Betula lutea	5		
Betula papyrifera	3		
Celtis occidentalis			2
Fagus grandifolia	50		
Fraxinus americana	19		
Ostrya virginiana		26 10	
Pinus resinosa	1		
Pinus Strobus	1		
Quercus alba	3		
Quercus rubra var. borealis		11 4	
Thuja occidentalis	1		
Tilia americana		26 26	
Tsuga canadensis	12		
Ulmus americana		33 8	
Ulmus rubra*		11 14	
Ulmus Thomasi	23		
Totals	131	344	2

$344 \div 2 = 172$ $\qquad$ $131 + 172 + 2 = 305$ $\qquad$ $\frac{172}{305} \times 100 = 56\%$

Frequency Index Community Coefficient is 56%.

1. Percent frequency of the tree species in the ninety-eight stands of second growth upland hardwoods in Missaukee County.

2. Percent frequency of the tree species common to both stands.

3. Percent frequency of the tree species in Daubenmire's Big Woods of Minnesota.

*Ulmus rubra/ Ulmus fulva

used the DFD Index (Curtis, 1947) and consequently it was possible to compare the second growth upland stands of hardwoods in Missaukee County with this association on that basis (Table LII).

An examination of Stearns' data reveals that the association in Wisconsin conforms more nearly with the accepted concept of a mixed conifer-northern hardwood forest than does the woody vegetation now characteristics of the Missaukee County area. Acer saccharum is the leading dominant on the basis of the DFD Index, for both areas, while Tsuga canadensis ranks second in Stearns' report and twelfth in the Missaukee County study. The second ranking tree species on the DFD Index scale for Missaukee County is Fagus grandifolia. It is not a member of the forest formation in Wisconsin. Ulmus americana, with a DFD Index value of 49.46%, is the third dominant in Missaukee County and drops to seventh in Wisconsin where its reported DFD Index value is 14.5%. Betula lutea, as reported by Stearns, had a DFD Index of 92.2%, and consequently was in third place within the Wisconsin association; in Missaukee County, its DFD Index was 6.5%, placing it in fifteenth position. On the basis of naming an association after the first three dominants as indicated by their DFD Index values, as was done in the Wisconsin study, it would appear that the ninety-eight stands of second growth upland hardwoods of Missaukee County, as shown by these quantitative data, should be characterized as Sugar Maple-Beech-Elm association. Tilia americana is ranked in fourth position in Stearns' study, and fifth in Missaukee County, with Ostrya virginiana appearing in fifth position in Stearns' data, and sixth in that for Missaukee County. Only a single tree species, Abies balsamea, reported in the Wisconsin study is absent

TABLE LII

COMPARISON OF DFD INDEX VALUES

TREE SPECIES	1		2	
	DFD		DFD	
	%	#	%	#
Acer saccharum	190.56	1	158.8	1
Fagus grandifolia	71.44	2	-	
Ulmus americana	49.46	3	14.5	7
Ulmus Thomasi	36.38	4	-	
Tilia americana	34.69	5	74.1	4
Ostrya virginiana	30.47	6	42.7	5
Fraxinus americana	24.01	7		
Prunus pensylvanica	21.19	8		
Acer rubrum	19.25	9		
Quercus rubra var. borealis	15.80	10		
Populus grandidentata	15.08	11	-	
Tsuga canadensis	14.53	12	113.7	2
Prunus serotina	13.80	13		
Ulmus rubra	13.77	14	-	
Betula lutea	6.55	15	92.2	3
Quercus alba	3.95	16		
Betula papyrifera	3.58	17		
Amelanchier sp.	2.03	18		
Populus tremuloides	1.80	19	-	
Pinus Strobus	1.72	20	10.8	8
Thuja occidentalis	1.53	21		
Pinus resinosa	0.71	22		
Fraxinus nigra	0.42	23	-	
Abies balsamea			37.8	6

1. The DFD Index of the tree species for the ninety-eight stands of second growth upland hardwoods of Missaukee County.

2. The DFD Index of the tree species for the Sugar Maple-Hemlock-Yellow Birch Association in Northern Wisconsin as reported by Stearns (1951).

from the data of the Missaukee County study, while there were sixteen tree species included in the quantitative data for Missaukee County that were not found by Stearns.

The presence of Abies balsamea within the Wisconsin association and its absence from the Missaukee County study may be accounted for by the fact that the latter investigation was concerned with upland stands of second growth hardwoods which would exclude this tree species from the community. Many of the sixteen tree species found in this investigation in Missaukee County and not listed by Stearns in his Wisconsin study may be regarded as successional species. As such, it is only natural that they would be included in the data of a study of second growth forest stands which are representative of a disclimax such as are those stands in Missaukee County, and absent from the data of the undisturbed climax stands, such as reported for Wisconsin. Considerations regarding the significance of these comparisons between the stands of second growth upland hardwoods of Missaukee County with those of these and other areas are treated in greater detail in Section C of the Discussion.

D. Forest Distribution in Missaukee County as Interpreted from the Original Land Survey (1837-1854)

The forest vegetation in Missaukee County, as interpreted from the field notes and maps of the original land survey, was a typical Hemlock-Hardwoods Association (Oosting 1948, p. 250). The forests may be divided into four communities: 1) swamp; 2) pine; 3) mixed conifer and northern hardwoods; and 4) northern hardwoods.

A large part of the original survey was completed during 1837-1838. At that time John Brink, Deputy Surveyor, and his crew compiled the records for the following townships: Townships 21 North: Ranges 5, 6, 7, and 8 West; Townships 22 North: Ranges 7 and 8 West; Townships 23 north: Ranges 6, 7, and 8 West. The remaining townships were surveyed during 1852-1854. Township 23 North: Range 5 West was recorded by Arteman Curtis in 1852 and Township 22 North: Ranges 5 and 6 West were surveyed by W. L. Coffenbury during 1853. The northern tier of townships, T 24 N: R5, 6, 7 and 8 West were surveyed by George H. Camnose during 1853-1854. The surveyors recorded in their field notes each section corner by reference to three and sometimes four witness trees with the species, diameter, and the direction and distance from the stake being noted. They also recorded the species, diameter, and distance from the section corner of all the trees falling on the line. By plotting all witness and "line" trees on a county map, one is able to judge with considerable accuracy the nature of the forest and the limits of distribution for the various plant communities. In plotting the data from

Missaukee County upon a county map, a list of thirty-three different common names for the tree species was compiled. There is a good possibility that some of these common names represent duplication of the same species, especially among the pines; however, as only the common names were used by the surveyors, it is impossible to ascertain which might be duplications. Beal (1888, p. 79) has given some indication of the possible duplication of names within the pines:

> . . .The botanist will tell you that in Michigan there are three and only three species of pine, while the lumberman says that there are eight or ten. He applies the term 'buckwheat pine' to a thrifty, usually young tree of white pine which has a large low top. It is of no value for lumber or timber. Occasionally some call a tree of Pinus Banksiana, 'buckwheat pine' if it is the shape above described.
>
> . . .'Sapling' or 'Bull sapling' is the name applied to a tall and thrifty white pine with a good top. The branches are rather numerous, the limbs extending downwards pretty well. Such a tree is making a good annual growth and has a thick sap with a relatively small amount of heart wood.
>
> . . .A sapling pine is improving, and in time would become a 'cork pine'. A 'cork pine' is a white pine which has seen its best day.
>
> . . .The red or Norway pine (lumbermen universally call it by the latter name) is called 'black Norway' when the trees are low and have large tops and a relatively large proportion of sap wood. A tree is 'yellow Norway' when it is tall with a small top, when it is making a slow growth and has but little sap wood.
>
> Where trees of Pinus Banksiana are short, with large, wide tops, and the proportion of sap wood large, they are called 'black jack pine'. Where they are crowded, tall, with small tops and a large proportion of heart wood, they are called 'yellow jack pine'.

The list of common names used by the surveyors to identify the witness and "line" trees follows:

1. Alder	12. Dogwood	23. S. Pine
2. Aspen	13. Elm	24. Spruce
3. Balm of Gilead	14. Fir	25. Sugar
4. Basswood	15. Hemlock	26. Tamarack
5. Beech	16. Ironwood	27. White Ash
6. Black Ash	17. Jack Pine	28. White Birch
7. Black Cherry	18. Maple	29. White Oak
8. Black Oak	19. Norway Pine	30. White Pine
9. Black Pine	20. Red Maple	31. Willow
10. Black Spruce	21. Red Oak	32. Yellow Birch
11. Cedar	22. Red Pine	33. Yellow Pine

In drawing the comparisons between the original forests of Missaukee County, as interpreted from the original field notes, and the present day composition of the second growth upland hardwood stands, as well as in computing the quantitative analysis for the original forests and making comparisons with regard to these differences, it was necessary to make some interpretations regarding the possible duplication of names of tree species between those of the surveyors and those of this study. As already indicated, there is evidence of duplication within the various common names applied by the surveyors to the species of Pinus. In this study, the number of individuals recorded by the surveyors as either red or Norway pine are considered together as being representative of a single species, *Pinus resinosa*. It is noted in the statement of Beal (1888, p. 79), quoted above, that the "yellow" pine of the surveyors might be either *Pinus Banksiana* or *P. resinosa*. Because of the habitat where this tree species was most frequently noted by the surveyor, it is presumed that "yellow" pine, as used by the surveyors in Missaukee County, referred to *P. resinosa*. However, as it was impossible to establish exact duplication in this instance, the trees recorded as "yellow" pine are not included in the tabulations for *P. resinosa*, but are rather carried within the tables as "yellow" pine. The list of common names, as used by the surveyors, contains three representatives of Acer: "maple", red maple, and "sugar". "Sugar" is a term used very frequently in identifying both witness and "line" trees in the field notes. It is here interpreted to mean _Acer saccharum_. "Maple", as used by the surveyors, is interpreted to mean any other species of Acer, excepting _A. saccharum_. In the computations made, the number of individuals recorded by the surveyors as either "maple" or "red maple" are grouped together as a single total under _Acer rubrum_ because this is the only other canopy species of this genus appearing in the quantitative data for the present study. There are three different oaks referred to by the surveyors: red, white, and "black". The three have been treated here as separate individuals but there is some question as to the identity of the "black" oak of the surveyors. In many instances, the present land owners, when speaking of their woodlots, were frequent in the use of the term "red-black" oak. This practice could possibly be interpreted to indicate that the "black" oak of the surveyor is the "red-black" oak of the present land owner, which is _Quercus rubra var. borealis_ of this study. Both _Populus grandidentata_ and _P. tremuloides_ appear in the quantitative data of the present study for Missaukee County. The surveyor's field notes contain only the common name "aspen". When drawing comparisons between the differences in vegetation of the two periods of time, the surveyor's "aspen" has been considered comparable to the _P. grandidentata_ of today as the habitat in which the "aspen" was mentioned by the surveyors was typical of _P. grandidentata_ rather than of _P. tremuloides_.

The kinds of quantitative expressions which might be used for indicating phytosociological aspects of the forest distribution as interpreted from the original land survey are of necessity limited to the restricted data of the field notes. Yet, as Blewett and Potzger (1950, p. 40-41) have said:

> It is very likely that a few representatives of a mass of vegetation taken at widely separated points within a large area give the same picture as does a concentrated tabulation of a small area. We find this to be true in other situations.

The operation of this "law" is assumed in this situation. Two phytosociological criteria have been used in making an interpretation of the forest composition from the data of the original land survey field notes. One, constance, is a synthetic character which treats of the community in the abstract; the other, density, is a quantitative character showing a structural characteristic of the concrete community.

Constance is usually obtained by listing the species present within a unit area of the association rather than in the entire extent of the stand. In this instance, the county has been considered the entire extent of the community, and specific sections have been chosen to represent the unit areas within the whole. Sections 8, 11, 26, and 29 within each of the sixteen townships were selected. This selection gave a wide and even distribution throughout each township, and hence the county, and avoided duplication of species by eliminating any joint section boundaries. This synthetic character, as expressed in a five degree scale of constance classes, reveals that the forest formation of Missaukee County, at the time of the original land survey, was a Hemlock-Hardwood Association. The results of these calculations are shown in Table LIII. A glance at the summary totals of the Table shows that Hemlock (Tsuga canadensis) was an important and constantly present member (Class Five) of the community, as were both beech (Fagus grandifolia) and white pine (Pinus Strobus). Both "sugar" (Acer saccharum) and "maple" (Acer rubrum) attained fourth class ranking (mostly constant), the former species being constant for 69 percent of the sections and the latter for 73 percent. None of the twenty-eight species could be given class three rank; however, seven different species could be considered as seldom present on the basis of the class two ranking. The remaining group all belong to class one (rare), being constant for less than 20 percent of the sections.

The phytosociological character of density for the concrete stand was obtained by counting all of the recorded trees in the same sections as used in obtaining the synthetic concept of constance. There were a total of 2,038 trees listed by the surveyors in sections 8, 11, 26, and 29 of all townships. Listing the total number on the basis of different species and dividing their total number by the sum total for all the trees recorded gave an expression of percent density for each of the species. A summary of these calculations is shown in Table LIV. The species having the highest percent density(23%) was hemlock (Tsuga canadensis); beech (Fagus grandifolia) was second highest with a percentage density of nineteen. "Sugar" (Acer saccharum), with a percent density of twelve, was third, closely followed by white pine (Pinus Strobus), with a percent density of eleven.

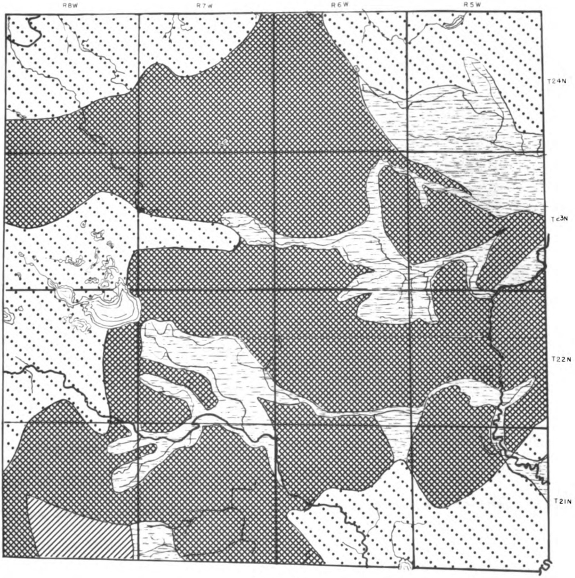
The limits of distribution for the four plant communities, as reconstructed from the field notes of the original land survey, are shown on the map in Fig. 30.

TABLE LIV

PERCENT DENSITY OF THE TREE SPECIES AS COMPILED FROM THE DATA OF THE FIELD NOTES OF THE ORIGINAL LAND SURVEY FOR SECTIONS 8, 11, 26 and 29 OF EACH TOWNSHIP

TREE SPECIES	No.	Percent
Hemlock	459	22.90
Beech	394	19.33
"Sugar"	236	11.56
White Pine	230	11.29
"Yellow" pine	120	5.85
Norway Pine*	90	4.40
"Maple"	89	4.35
Cedar	87	4.25
Tamarack	68	3.30
Black Ash	48	2.30
Yellow Birch	33	1.60
Elm	30	1.40
Fir	28	1.30
"S." Pine	26	1.24
Black Spruce	25	1.23
White Birch	12	.59
Red Oak	11	.54
Aspen	10	.49
"Black" Oak	9	.44
Ironwood	9	.44
Basswood	5	.25
Black Cherry	5	.25
White Ash	4	.20
White Oak	4	.20
Dogwood	2	.10
Spruce	2	.10
Jack Pine	1	.05
Alder	1	.05
Total	2038	

*Norway pine includes the surveyor's red pine.



Legend

Pine Plains | Mixed Conifer-Hardwoods | Hardwoods | Swamp communities

Fig. 30. Map of Missaukee County showing the primeval forest as **interpreted** from the original land survey field notes of 1854.

1. Swamp Community

The swamp communities were located along the numerous streams and were, for the most part, on till plains and outwash aprons. According to the field notes, many of these areas were characterized as "variety" swamps. The woody vegetation of such areas, as noted by the surveyors, included alder, cedar, hemlock, aspen, black spruce, tamarack, black ash, and willow. In other swampy areas the vegetation was apparently less varied as the surveyors distinguished them by such phrases as: "alder thicket; tamarack, cedar, hemlock swamp; cranberry swamp; black ash thicket; tamarack, cedar, spruce swamp; tamarack swamp." In summarizing the north boundary of T21N:R5W, John Brink (1837) said:

> . . .The first four miles is mostly swamp. The Muskegon (River) has low banks and overflows. This is the worst part of the county where the river runs through and there ought to be one more such a one in Michigan and then sunk.

The largest continuous area of swamp community occupied a large part of T23N:R5 and 6W and T24N:R5W. This area is now known as the Dead Stream Swamp. According to the general description for T23N:R6W, as written by Brink (1837) in the field notes:

> . . .The land marked as swamp bordering the west branch of the Muskegon River which meanders west to east through the whole township is made so artificially by the Beaver whose works we found in section 21 and 22 indicating great force and present activity. . .
>
> . . .the only real waste land seems to be embraced in sections 1-2-3-10-11-12. A large mass of swamp with but little apparent drainage. This however will be an exhaustless reservoir of fencing timber in cedar and black ash in which it abounds. . .

Curtis (1852) described the swamps in T23N:R5W as being of two kinds: 1) open; and 2) dense. He described the latter as being heavily timbered with tamarack, cedar, black ash, and black spruce and the open swamps as having a scattering of tamarack and spruce. The swamp com-

munity covering the southern portion of T24N:R5W was described by Camnose (1854) as being mostly grassy and wet with tamarack, cedar, alder, and spruce in groves. He found the swamps in T24N:R6W contained:

> . . . .cool, clear, wholesome water and are well distributed to accommodate families with stock water and what is still better bottoms contain an inexhaustible supply of fencing timber in which the upland is deficient.

2. Pine Community

A glance at the map in Fig. 30 will reveal that the pine community occupied four sites in Missaukee County at the time of the original land survey. The southeast, northeast, northwest corners and the lake area in the west central portion of the county were covered with "pine plains". Topographically, the limits of distribution for the pine communities do not correlate with any one physiographic feature but rather embrace all three forms. However, comparison of these limits of distribution for these pine communities with an unpublished land type map (Veatch 1942) indicates that they were situated in areas of sandy soil.

In order to obtain some expression of the degree of dominance for the various trees within one of the pine communities, the total number of the listed trees was computed and the percent density calculated for the individual species recorded. The results of these calculations for the pine community within the lake area are shown in Table LV. On the basis of these data, white pine (Pinus Strobus) would be considered the dominant species with "yellow" pine, hemlock (Tsuga canadensis) and Norway pine (Pinus resinosa) the principal secondary dominants.

TABLE LV

PERCENT DENSITY OF THE TREES COMPRISING A PINE COMMUNITY IN THE LAKE AREA AS COMPILED FROM THE FIELD NOTES OF THE ORIGINAL LAND SURVEY

TREE SPECIES	No.	Percent
White Pine	203	27.75
"Yellow" Pine	139	18.99
Hemlock	101	13.80
Norway Pine*	80	10.95
Beech	65	8.87
"Maple"	32	4.37
Cedar	20	2.73
Jack Pine	19	2.59
"Black" Oak	14	1.91
"Sugar"	13	1.77
Tamarack	13	1.77
Red Oak	8	1.09
White Birch	6	.82
Yellow Birch	6	.82
Fir	5	.68
White Oak	3	.41
Black Ash	2	.27
Elm	2	.27
Basswood	1	.14
Total	732	

*Norway Pine includes the surveyors' red pine also.

The quantitative studies for the 23 one hundred square meter quadrats occurring on the Roselawn Soil Series of the present study of the second growth upland hardwoods of Missaukee County, were all located within the limits of distribution of this particular pine community. The results of these quantitative studies (Tables VI and VII) indicate that the present composition of the area is a deciduous forest with _Quercus rubra var. borealis_ being dominant (DFD Index-1). The present representatives of the species which gave character to the former pine community are two in number: _Pinus resinosa_ and _P. Strobus_. The percentage density for _P. resinosa_, as computed for the pine community at the time of the original land survey, was eleven, there being eighty trees listed for this species in the sum total of 732 recorded trees. The percent density for the same species in the present quadrat studies was .62, there being six individuals of the species present in the sum total of 938 trees within the 23 one hundred square meter quadrats. The percent density of _Pinus Strobus_ was twenty-eight, on the basis of 203 recorded for the species in the total sum of 732 trees within the pine community of the original land survey. The percent density for this species on the Roselawn Soil Series was .96, there being nine white pines in the total of 938 trees.

The recorded diameter sizes for the trees, as entered in the field notes, indicate that the trees used as reference points were large ones, for the most part. The range of diameters varied from a low of eight inches to a high of fifty-two inches, the latter a white pine. The majority of recorded diameters appearing in the field notes were between twelve and twenty-six inches. The record for the diameters of the present

The quantitative studies for the 23 one hundred square meter quadrats occurring on the Roselawn Soil Series of the present study of the second growth upland hardwoods of Missaukee County, were all located within the limits of distribution of this particular pine community. The results of these quantitative studies (Tables VI and VII) indicate that the present composition of the area is a deciduous forest with Quercus rubra var. borealis being dominant (DFD index-1). The present representatives of the species which gave character to the former pine community are two in number: Pinus resinosa and P. Strobus. The percentage density for P. resinosa, as computed for the pine community at the time of the original land survey, was eleven, there being eighty trees listed for this species in the sum total of 732 recorded trees. The percent density for the same species in the present quadrat studies was .62, there being six individuals of the species present in the sum total of 938 trees within the 23 one hundred square meter quadrats. The percent density of Pinus Strobus was twenty-eight, on the basis of 203 recorded for the species in the total sum of 732 trees within the pine community of the original land survey. The percent density for this species on the Roselawn Soil Series was .96, there being nine white pines in the total of 938 trees.

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3. The Mixed Conifer-Northern Hardwood Community

The community most extensive at the time of the original land survey was the mixed conifer-northern hardwood. Wedged in between the less extensive pine, swamp, and hardwood communities, this expression of the forest community accounted for more than half of the area of the county. The data, as compiled from the field notes, indicate that at times the conifers and northern hardwoods formed extensive tracts of forest of a mixed character, while at other times, now one and then the other were more abundant in their occurrence, resulting in small islands of either hardwoods or conifers surrounded by the larger mixed forest community. Beech, "sugar", "maple", white pine, hemlock, Norway pine, basswood, black cherry, red oak, jack pine, white and "black" oak were frequent species used as witness trees by the surveyor within the limits of distribution for these communities.

In describing the nature of this community in T24N:R7W as it appeared in 1853, Comnose said:

> The township is broken in sharp ridges and narrow valleys where hard timber and best soil prevail . . .where white pine is mixed in with hard timber it is generally of a larger size and fine body for shingle and clear stuff.

That portion of T22N:R6W, which is representative of the mixed conifer-northern hardwood community is described by Coffenbury (1838) as follows:

> In the township this kind of land (except swamps) is covered generally with a fine heavy growth of hemlock and some large old white pine and very many old pine logs in all states of decay and rotting. . . .Through the center of the township east and west is a tract of excellent land affording fine sugar orcharding; of the very largest trees, with large pines enough for all lumbering purposes.

The following are some of the various kinds of trees that the surveyor recorded in his field notes while running north, south, east, and west boundary lines for the township: Beech, hemlock, "sugar", ash,"lin", elm, ironwood, pine, cedar, balsam, tamarack and alder.

So as to have some basis for quantitative comparison between the mixed conifer-northern hardwood community as expressed in Missaukee County at the time of the original survey, and the present composition of the same region, as indicated by this quantitative quadrat study, two areas located within the original survey were arbitrarily selected and the percent density for the recorded trees calculated in the same manner as for the pine community. The arbitrary selections were made from the map constructed from the original field notes, which showed, by symbols, the species used as a reference point for the section corners and "line" trees. The selections were made to give two varied expressions representative of the community: One area gave the appearance of having an abundance of hardwood species and the other area appeared on the map as

having a more even mixture of conifers and northern hardwoods. The first area comprised sections 31, 32, 33, 34, and 35 of T24N:R7W and section 1, 2, 3, 4, 5, and 6 of T23N:R7W. The sum total of the trees recorded in the field notes for this area was 222. Nine different species were used by the surveyors as witness trees and "line" trees. On the basis of percent density as a criterion for dominance, the area could be characterized as a beech-hemlock-maple association. Beech (108 trees) had a percent density of forty-nine, hemlock (53 trees) had a percent density of twenty-four and "sugar" (49 trees), 22%. The details for these calculations are given in Table LVI.

Except for a small area of swamp land in the southern part of T24N:R7W, section 34 and T23N:R7W, section 3, the area being considered is entirely within the Emmet Soil Series of this study. Reference to the data for the quadrat studies on this soil series (Tables IX and X) reveals that the present community is a maple-beech association. Hemlock is still a constituent of the forest, but it no longer plays as prominent a role, being ranked fourteenth on the DFD Index scale which included nineteen different species. The second area selected as a basis for comparison with the present quantitative quadrat study was composed of sections 32 - 36 of T23N:R7W and sections 1 - 5, 8 - 12, 13 - 17 of T22N:R7W. The calculations of percent density gave a list of fourteen different species, totaling 264 individuals, the details of which are shown in Table LVII. Four of the fourteen species were coniferous and the remaining ones deciduous. While the three species with the highest percent densities were identical with those of the first area, the relationship of the remaining species was of such having a more even mixture of conifers and northern hardwoods. The first area comprised sections 31, 32, 33, 34, and 35 of T24N:R7W and section 1, 2, 3, 4, 5, and 6 of T23N:R7W. The sum total of the trees recorded in the field notes for this area was 222. Nine different species were used by the surveyors as witness trees and "line" trees. On the basis of percent density as a criterion for dominance, this area could be characterized as a beech-hemlock-maple association. Beech (101 trees) had a percent density of forty-nine, hemlock (53 trees) had a percent density of twenty-four and "sugar" (49 trees), 22%. The details for these calculations are given in Table LVI.

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TABLE LVI

PERCENT DENSITY OF THE TREE SPECIES COMPRISING AREA ONE OF THE MIXED CONIFER-NORTHERN HARDWOOD COMMUNITY AS COMPILED FROM THE FIELD NOTES OF THE ORIGINAL LAND SURVEY

TREE SPECIES	No.	Percent
Beech	108	48.64
Hemlock	53	23.87
"Sugar"	49	22.07
"Yellow" Pine	3	1.35
"Maple"	3	1.35
White Pine	2	.91
Yellow Birch	2	.91
White Birch	1	.45
Black Ash	1	.45
Total	222	

TABLE LVII

PERCENT DENSITY OF THE TREE SPECIES COMPRISING AREA TWO OF THE MIXED CONIFER-NORTHERN HARDWOOD COMMUNITY AS COMPILED FROM THE FIELD NOTES OF THE ORIGINAL LAND SURVEY

TREE SPECIES	No.	Percent
Hemlock	62	23.48
Beech	61	23.11
"Sugar"	54	20.45
White Pine	43	16.29
"Yellow" Pine	14	5.30
"Maple"	10	3.79
Black Ash	5	1.89
Norway Pine	4	1.52
Yellow Birch	3	1.14
Ironwood	3	1.14
Elm	2	.75
Basswood	1	.38
Red Oak	1	.38
Black Cherry	1	.38
Total	264	

character as to indicate a greater mixture of conifers and northern hardwoods within the area at the time of the original land survey.

Quantitative quadrat studies of the present composition within the area include expressions on the Arenac, Emmet, and Selkirk Soil Series. The data for these studies (Tables IX - XII, IXX, XX) indicate that *Acer saccharum* is the dominant species at the present time with *Fagus grandifolia* codominant. Hemlock, white and Norway pine, while present within the forest, are never rated high on the DFDIndex scale.

4. Hardwood Community

A small portion in the southeastern part of T21N:R8W of the county supported a northern hardwood community according to the data compiled from the field notes. Brink's (1833) description of the area stated, in part:

> There is a great majority of the timber in the south part of the township of the finest and largest sugar trees that I have ever seen affording a great opportunity of making sugar. The trees have never been tapped or worked.

Topographically, the area is confined to the massive moraine of the Lake Michigan-Saginaw Interlobate Tract (Leverett 1917). Calculations from the field notes yielded a total of 267 trees for the area, numbering twelve different species. On the basis of percent density as a criterion for dominance, "sugar" was dominant with 56% and beech codominant with 22%. The details of these calculations are presented in Table LVIII. This hardwood community is represented in the quantitative quadrat study by the Emmet Soil Series (Tables IX-X). These data indicate that "sugar" (*Acer saccharum*) and beech (*Fagus grandifolia*) are the dominant species and that many of the other deciduous species are comparable, for example:

TABLE LVIII

PERCENT DENSITY OF THE TREE SPECIES COMPRISING THE HARDWOOD COMMUNITY AS COMPILED FROM THE FIELD NOTES OF THE ORIGINAL LAND SURVEY

TREE SPECIES	No.	Percent
"Sugar"	149	55.81
Beech	59	22.10
Hemlock	18	6.74
Elm	14	5.24
Basswood	10	3.75
Black Ash	7	2.62
Black Cherry	2	.75
White Pine	2	.75
Yellow Birch	2	.75
Cedar	2	.75
Tamarack	1	.37
Maple	1	.37
Total	267	

Basswood (Tilia americana); elm (Ulmus americana); black cherry (Prunus serotina). Hemlock, while still present today, is less plentiful and white pine, present in the community at the time of the land survey, does not appear in the present quadrat studies within the area. It was observed, however, within the area though not included in any quadrat.

5. Comparisons Between the Composition of the Ninety-Eight Stands of Upland Second Growth Hardwoods and That of the Same Sections at the Time of the Original Land Survey

The phytosociology of the second growth hardwoods of Missaukee County has been presented by establishing certain synthetic characters for considering the community in the abstract and several structural characteristics for depicting the concrete community. As a further means of comparison between the present upland second growth hardwood community and the forest representative of these locations at the time

of the original land survey, the synthetic character of presence has been chosen. The presence list (Table II) indicates the degree of regularity in which the numerous woody species occurred in the ninety-eight stands of second growth upland hardwoods in Missaukee County. Their degree of regularity is summarized by a five degree scale of presence classes on page 67 .

In order to contrast a comparable list for the community at the time of the original land survey, the sections in which the ninety-eight stands were located were used as a basis for comparison with the stands. Duplications of stands within the same section reduced the number of sections to seventy-nine. A presence list was then compiled on the basis of the witness and "line" trees recorded by the surveyors in their field notes. In view of the fact that the quantitative quadrat study was concerned with the nature of the second growth upland hardwoods, the members of the swamp community, when encountered on the map and in the field notes of the survey, were omitted from this latter presence list. The two presence lists were then compiled. They are presented in Table LIX. They offer a means of comparing the degree of regularity in which the species occurred in the stands at the time of the quadrat studies and the original land survey, either on the basis of the five degree scale of presence classes, or stand within section.

An analysis of these data reveals that only two species, Acer saccharum and Fagus grandifolia, were constantly present (class five) at both times. Hemlock was also constantly present at the time of the original land survey, according to these data, but was only seldom present (class two) at the time of this study. There were no species in presence class four (mostly present) at either period of time. Only of the original land survey, the synthetic character of presence has been chosen. The presence list (Table II) indicates the degree of regularity in which the numerous woody species occurred in the ninety-eight stands of second growth upland hardwoods in Milwaukee County. Their degree of regularity is summarized by a five degree scale of presence classes on page 67.

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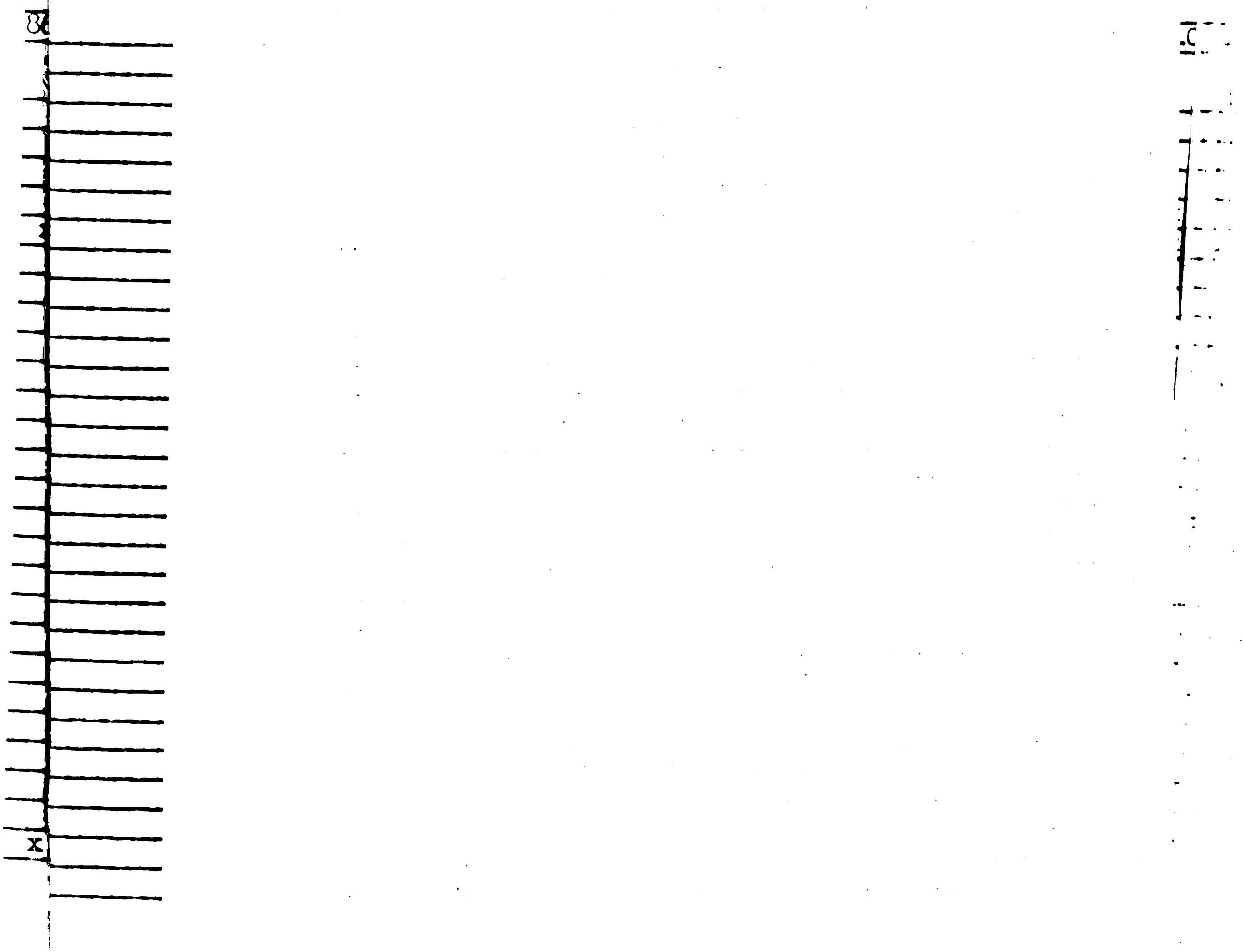
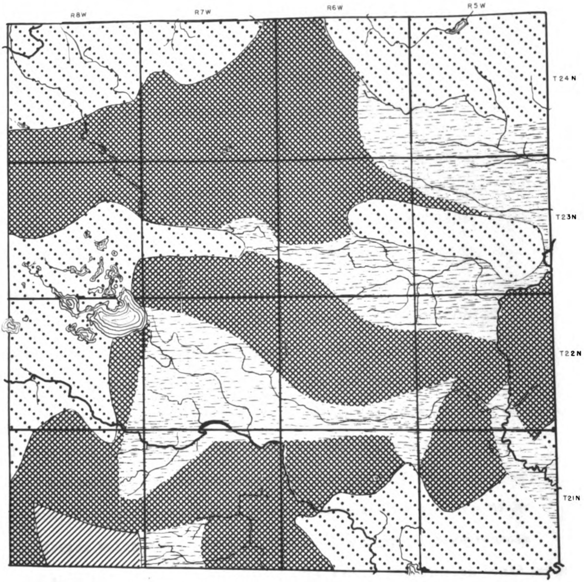


Pinus Strobus could be ranked in class three (often present) at the time of the original land survey, while Tilia americana, Ulmus americana, Fraxinus americana, Ostrya virginiana, and Prunus pensylvanica were all often present (class three) according to the presence list calculated from data in this investigation. "Maple" was found as seldom present (class two) in both instances. Duplications of class one (rare) were frequent in the comparisons: Black ash, white birch, cedar, red and white oak, and Norway pine. There were twenty-three species making up the presence list for the area at the time of the original land survey and twenty-two in that for the present study. The species appearing on the former list and absent from the latter were: spruce (class one); "yellow" pine (class two); jack pine (class one); "black" oak (class one); and fir (class one). Those species figuring in the presence list for this study and absent from the list of the original land survey were: quaking aspen (class one); rock and slippery elm, both in class two; fire cherry (class three).

This evidence, as indicated by the synthetic character of presence, further supports the fact already revealed by the other synthetic and structural characteristics considered, that the forest community at the time of the original land survey was a hemlock-beech-maple association of a mixed conifer-northern-hardwood community and that the present composition of the second growth upland hardwoods is a maple-beech association in a mixed conifer-northern hardwood community. In the mixed conifer-northern hardwood community of the earlier days, there was a greater preponderance of the conifers than there is today. The greater recorded diameters of the trees would indicate more maturity then than now. The present composition of these stands is not only lacking in the variety and abundance of the conifers, but also includes a greater

number of successional deciduous species: *Populus tremuloides*; *Populus grandidentata*; *Prunus pensylvanica*; and *Quercus rubra var. borealis*.

The original forests of Missaukee County, as indicated by Marschner (1946), are shown by the map in Fig. 31. This map is the result of enlarging Missaukee County from Marschner's map of the Original Forests of Michigan. Marschner, a research assistant in the Office of Agricultural Economics, Department of Agriculture, compiled his map from land office field notes. Comparisons between the map in Fig. 31 with that in Fig. 30, which was compiled for this study from the data of the field notes of the original land survey now on file in the Lands Division, State Conservation Department, Lansing, Michigan, reveal one major difference. The Marschner map indicates a fairly extensive "pine plain" running west to east in the central part of T23N:R6 and 5W. The data from the surveyor's field notes, when plotted on a county map (Fig. 30), would indicate rather that this area is cut by swamps, leaving isolated islands of high ground which supported, in some instances, mixed conifer-northern hardwood communities and, at other times, nearly pure hemlock groves. In all probability, the difference in the size of the scale of the two maps would account for this major discrepancy. The larger scale used in the preparation of the map for interpretation of the original forest at the time of the land survey would reveal more clearly these details. On the other hand, the smaller scale map, used for showing The Original Forests of Michigan, would lack much of the finer detail.



Legend

Pine Plains | Mixed Conifer-Hardwoods | Hardwoods | Swamp communities

Fig. 31. Map of Missaukee County showing the original forests as interpreted by Marschner and redrawn by Perejda, 1946.

DISCUSSION

A. Ecological Classification of Plants

Two possibilities as to the nature of the second growth upland hardwood forests of Missaukee County may be postulated. The first of these is that the forests represent an amorphous collection of plants in which no patterns or units are distinguishable. That is, they are only chance aggregates according to the viewpoint of Mason (1947, p. 210) and are dependent solely on a "coincidence of tolerance" between plants and the environment. The presence of a pattern definable in terms of tree composition and the fact that trees and other plants are not found together in chance mixture, but in a rather definite pattern, would indicate that this postulation is not tenable in this situation.

Secondly, it could be maintained that these forests represent several discrete communities, distinguishable from one another by boundaries which are reasonably distinct in terms of measurements available to the plant ecologists. The second postulation would appear to be applicable here. The evidence as brought forth by the synthetic characters used to establish the nature of the abstract community, as well as that of the structural characters used in ascertaining the nature of the concrete community for Missaukee County's upland second growth hardwoods, indicates that the present composition fits most nearly cover type 12 of the Society of American Foresters (1932, p. 463). Further, the quantitative data for the composition of the various stands located on the six different soil series indicate that there are lociations within the larger maple-beech-yellow birch community. Finally, the geographical location of Missaukee County is such that its forests would be a part of the Hemlock-White Pine -Northern Hardwoods Region of the deciduous forests of eastern North America (Braun, 1950, p. 337).

The dominant plants of any community are considered to be those which, by reason of their size, abundance and distribution, largely determine the conditions under which other organisms shall live in association with them. Primary dominants are those which, because of their wide and more or less even distribution and abundance, exert their influence over the greater part of the community. Secondary dominants are those which, because of their less frequent occurrence, do not exercise as great an influence over the community, but they occur rather regularly within the community. Incidental dominants are such trees as obtain large size and thus exert an influence over a limited area, but which do not occur in numbers, or with any degree of regularity within the community. All other plants are considered as subdominants. On this basis the plants of the stands of second growth upland hardwoods of Missaukee County may be classified as in Table LX.

On the basis of the criteria of dominance, as presented in Observations and Results, _Acer saccharum_ far surpasses any other single species. It must therefore be considered the primary dominant of the second growth upland hardwood stands of the county. Only in the synthetic character of presence is its position of dominance approached by another species, _Fagus grandifolia_. _Acer saccharum_ fulfills the requirements of every criterion for a climax dominant.

The percentage of frequency and density for the primary, secondary and incidental dominants within the five DBH size classes are shown by

TABLE IX

ECOLOGICAL CLASSIFICATION OF PLANTS IN THE SECOND GROWTH UPLAND HARDWOOD COMMUNITIES OF MISSAUKEE COUNTY, MICHIGAN

1. Primary Dominants
   a. Acer saccharum

2. Secondary Dominants
   a. Fagus grandifolia
   b. Ulmus Thomasi
   c. Ulmus americana
   d. Tilia americana

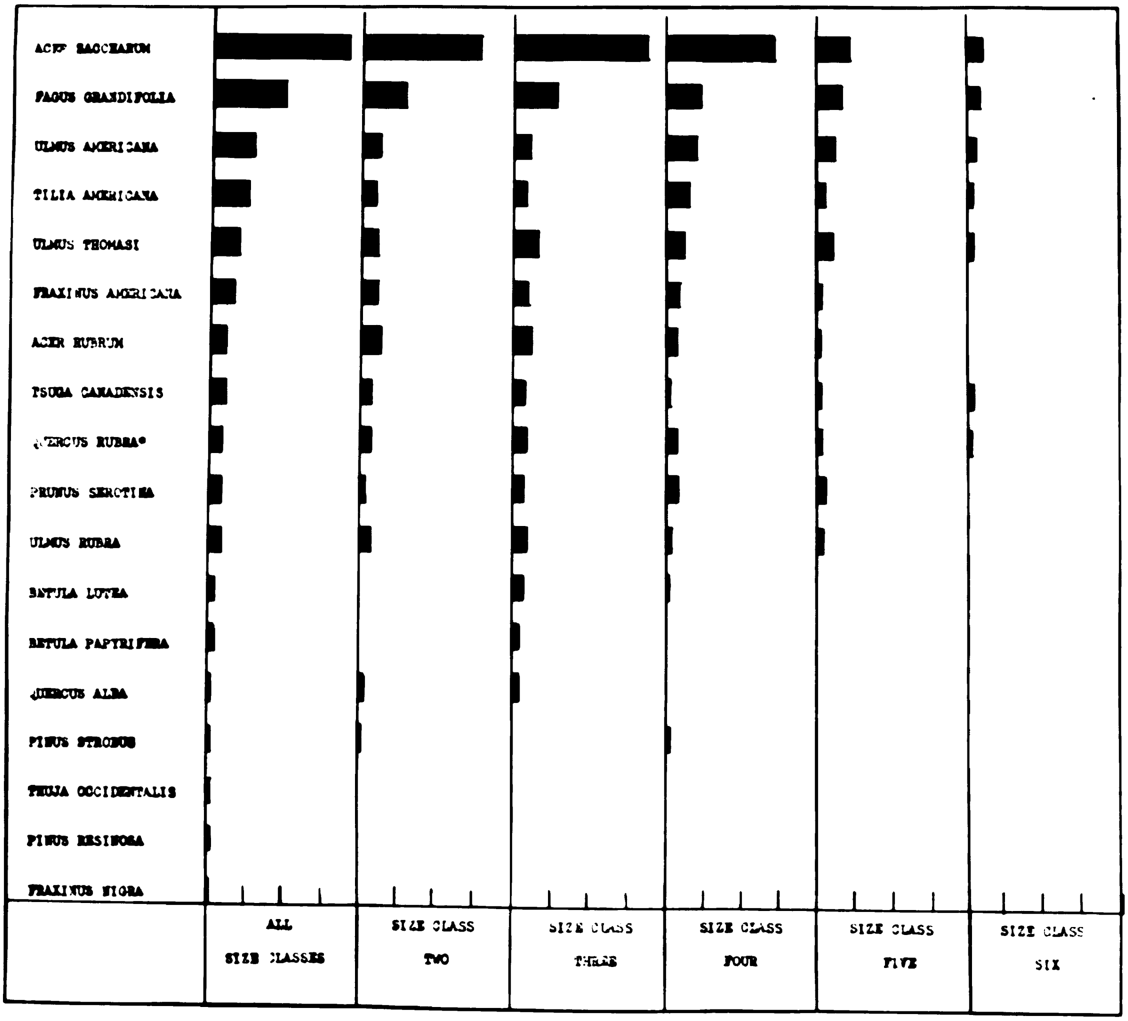
3. Incidental Dominants
   a. Fraxinus americana
   b. Acer rubrum
   c. Quercus rubra*
   d. Tsuga canadensis
   e. Prunus serotina
   f. Ulmus rubra
   g. Betula lutea
   h. Quercus alba
   i. Betula papyrifera
   j. Pinus Strobus
   k. Pinus resinosa
   l. Thuja occidentalis
   m. Fraxinus nigra

4. Subdominants
   a. Ostrya virginiana
   b. Prunus pensylvanica
   c. Amelanchier sp.
   d. Populus grandidentata
   e. Populus tremuloides
   f. Cornus alternifolia
   g. Corylus cornuta
   h. Rhus typhina
   i. Acer spicatum
   j. Ribes cynosbati
   k. Sambucus pubens
   l. Crataegus sp.
   m. Rosa sp.
   n. Spiraea sp.
   o. Viburnum acerifolium
   p. Vines, herbs, ferns, mosses and lichens not considered in the quantitative study

*Quercus rubra var. borealis

means of a bar graph in Figs. 32 and 33. These data, as shown by the graphs, are indicative of the dominant position maintained by the sugar maple. Not only does the species exceed considerably the other trees when all size classes are considered, but it also has the largest percentage of frequency and density within every size class. The graphs reveal that there is a smaller differential between Acer saccharum and the other species within the upper two size classes. The smaller differential results from a reduction in the total numbers of sugar maple rather than in an increase in numbers of other individuals.

According to Braun (1950, p. 352): "All statistical data for the hardwood forests of this part of the section (Northern lower Michigan) illustrate the overwhelming dominance of sugar maple and beech, not only in the forest canopy, but in the lower layers as well." While this study bears out the above statement regarding sugar maple, the data indicate that in Missaukee County beech is less dominant. It should be pointed out that, while the quantitative data represent Fagus grandifolia as being considerably less dominant than Acer saccharum for the area, certain disturbance factors have been responsible for some of these differences. Conversations with the land owners revealed that during World War II, there was considerable selective cutting of beech in the county in order to fulfill the increased demands of the aircraft industry. These conversations are supported by the evidences within the woodlots of the many beech stumps. However, the amount of beech taken out at that time, as indicated by the stumps, does not begin to account for the loss in dominance of Fagus in the community between the time of the original land survey and the present time (Tables II, LII, LIX). The cultural



*Quercus rubra var. borealis

Fig. 32. Bar graph showing the percent frequency of the canopy tree species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

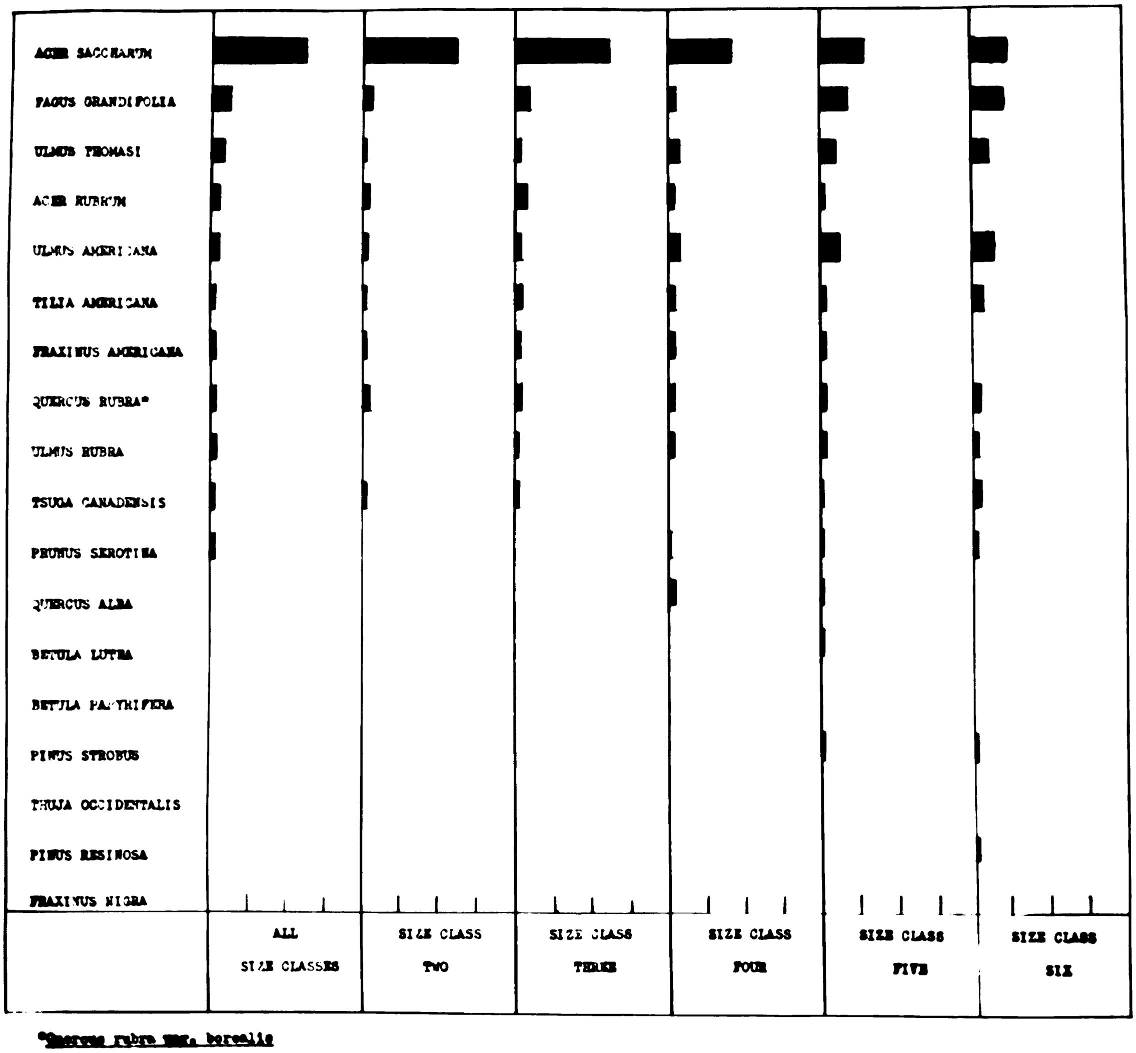


Fig. 33. Bar graph showing the percent density of the canopy tree species in the ninety-eight stands of second growth upland hardwoods of Missaukee County.

practice of using all woodlots for open pastures has also been responsible for some loss of beech. While sugar maple is the most aggressive reproducer, beech, which is probably more tolerant, does not usually bear as large an annual seed crop and much of that which is borne may be destroyed by animals. Thus, while Fagus grandifolia was found to be much more abundant at the time of the original land survey, the composition has changed today because of the selective cutting, pasturing and natural biological factors.

There are smaller differences and greater variations among the species with respect to the structural phytosociological characters of the secondary and incidental dominants. On the basis of the DFD Index (Curtis 1947), Ulmus americana is ranked third (Table III). Two other criteria used for expressing dominance, the phytographs (Fig. 9) and the presence classes (Table II), likewise indicate the same position for the species. However, the greater reproduction of Ulmus Thomasi than of U. americana in size class two, as borne out by the data (Fig. 32), suggests the close relationship of these two species within the community. Tilia americana was more frequent than Ulmus Thomasi, but the latter was in greater numbers (density) and the trees were larger (basal area), so that it ranked higher in dominance within the community, as revealed by the quantitative data (DFD Index value 3; Table III; phytograph, Fig. 9).

Alone or together, the three species of Ulmus are an important part of the composition of the stands of second growth upland hardwoods in Missaukee County. They were encountered in quadrats on outwash aprons, till plains, as well as on the crest and slopes of the moraines. Ulmus is a constant associate of the forest climax. The genus is considered by many as being "a subclimax flood plain dominant somewhat out of its optimum habitat requirements in a mixed-mesophytic forest cover" (Blewett and Potzger 1950, p. 42). However, the varied habitat sites in which the three species of the genus were found during the field work for this study would seem to indicate that, in Missaukee County, it had become successfully adapted to the mesophytic site. On the basis of the high frequency, density and basal area for the species of the genus, it would further appear that Ulmus plays a more important part in the composition here than is usually considered. Frothingham (1915) credits elm with comprising eight percent for the state as a whole. However, in speaking of the composition of the northern hardwood for Michigan and Wisconsin, he says (p. 27): "Basswood and elm sometimes form one third of the total stand." Potzger (1946, p. 248) has indicated that Ulmus has an abundance percentage of three in his graphic representation of the differences in abundance of climax forest associates for the eastern Wisconsin, upper and western lower Michigan section of an east-west transect of the Lake Forest. Braun's (1950, p. 353) consideration of the canopy and second layer of forest communities in two hardwood stands in northern lower Michigan indicated that _Ulmus americana_ made up 3.2% of the forests at Mud Lake on mucky soil of shallow ravines and only 0.3% of the canopy forest on the better drained soils of the swells. In the second layer, _Ulmus americana_ had a percentage of 7.7 in the first soil situation and 1.3% in the latter. Her figures for the hardwood stand at Carp Lake indicate a percentage of 0.4 in the canopy of the forest on an old beach ridge for _U. americana_ and no data for the second layer. The typical beech-maple forest at Carp

Lake (p. 352) included no species of either U. Thomasi or U. rubra in the canopy or second layer of the stands reported.

McIntire (1931, p. 241) has pointed out that it is the presence or absence of beech, elm or basswood which gives character to the association within the four distinct upland hardwood types recognized by the Land Economic Survey for upper Michigan. The quantitative data for the upland second growth hardwood stands of Missaukee County would indicate a type M classification (hardmaple, beech, elm, basswood, yellow birch) when such a scale is used for identification. (See page 31.)

A Frequency Index Community Coefficient was used in comparing the composition of the second growth upland hardwood stands of Missaukee County with the reported data for other stands in Michigan, Wisconsin and Minnesota. An examination of these data as shown in Tables XXIII - LI, indicates that the percent frequency for Ulmus is one of the principal differences between the stand composition of the area being considered. Other differences were indicated in an earlier section of this study and will not be considered again. However, these data are evidence of the importance of this genus in the present stands in Missaukee County and also indicate that, from a quantitative standpoint, the elms are a less important constituent within the other areas reported.

Dansereau (1946), Blewett and Potzger (1950) and Braun (1950) have indicated that Ulmus is a successional species for the climax northern hardwood community. Dansereau's (p. 240) "Quasi-climax" contains one element which he characterizes as the "Aceretum saccharophori Ulmosum". It just precedes the climax "Aceretum saccharophori laurentiantum". Preceding the "Quasi-climax", there is a segment identified as the

"Acereto-Ulmetum laurentianum", which is an earlier successional stage called by Dansereau "The Sous-Climax" (subclimax). The status of Ulmus in the climax, as considered by Blewett and Potzger (1950, p.42) is mentioned above. Braun (1950, p. 356) presents a successional diagram showing the various forest communities as related to one another in the sequence of decreasing water requirements. This diagram portrays sugar maple-beech at the top and indicates a complex of sugar maple, basswood, elm, beech next in order. According to the diagram, the successional pattern originated from a streamside of alder, willow, ash, and maple.

On the other hand, Frothingham (1915), Quick (1923), Gleason (1924) and Nichols (1935) consider Ulmus americana to be a codominant in the climax mixed conifer-northern hardwood forest. Quick (p. 224) has indicated that: "Ulmus americana, the white elm, is a member of the climax association through the Lower Peninsula, especially in the southern part. Its ratio of occurrence on sand and clay is 3:5. Next to the sugar maple it is the most common member of this association." Gleason (p. 293) has said that there are twenty-three species characteristic of the association which are distinguished not only by wide distribution, but also by high frequency indices within the area. The American elm is one of the five species which are a part of this larger list (Gleason 1924). In describing the Hemlock-White Pine-Northern Hardwood Region of Eastern North American, Nichols (1935, p. 408) stated that basswood and elm, though sparingly represented in the climax forest eastward, are much more extensively developed westward where, in the Lake States, Frothingham states that the two together comprise more than 20% of the hardwoods. It is this writer's opinion that the first view (Ulmus as a subclimax, successional species) leads naturally into the latter one. It would appear that the elms are in greater abundance and hence attain higher dominance in the late stages of the subclimax, but that they remain a component of the climax forest although reduced in abundance and hence in dominance. The species are less tolerant than either sugar maple or beech (Frothingham 1915, p. 16). Consequently, they could be presumed to attain better status under the more open conditions of the forest canopy during the subclimax stage than could be expected of them at the time that the sugar maple and beech produce a heavy shaded canopy in the climax community. This fact may be considered as partially accounting for the position of dominance attained by both *Ulmus americana* and *U. Thomasi* in the present stands of second growth upland hardwoods in Missaukee County. Another contributing factor is the nature of the five soil series on which these species are so abundant. Their character is such that good moisture relationships are provided throughout the growing season.

If it could be presumed that the normal successional patterns would remain in force within the hardwood stands of the county, then it could be expected that at some future date the elms would have dropped out of their present dominant place in the community. Normal succession should develop a maple-beech canopy sufficiently heavy to reduce considerably the less tolerant elms within the stands. However, the present cultural practices now operating as disturbance factors should retard the normal course of succession for some time to come.

Missaukee County is just north of the reported northern limits of distribution for *Ulmus Thomasi* (Harlow and Harrar 1950, p. 386; Dominion

Forest Service, 1942, p. 186; Hough 1947, p. 184). The nearness of the county to the northern limits of the range for the species should result in critical growth conditions for the tree (Cain 1942, p. 19). However, these data indicate that such is not the case. Not only is the rock elm a prominent member of the community in numbers, but it is found with considerable regularity throughout the numerous sites within the county. It would appear that this is evidence suggesting a northern extension of the range of Ulmus Thomasi. As such, it is here considered as previously overlooked as a member of the climax forest in this locality and it is suggested that in the future revisions of the distribution maps of the species, notice of this northern extension be taken.

Yellow birch (Betula lutea) is a characteristic species for the northern hardwood climax forest. In Missaukee County's upland hardwood second growth stands, it is today only rarely present (Table II). According to the DFD Index (Table III), it ranks fifteenth in importance among the total of twenty-three different species. The species is represented in all but the largest size class and is most frequent in size class four (Table IV).

Tilia americana is also a characteristic species of the northern hardwood climax forest. In this study within Missaukee County, the species ranked fifth on the DFD Index scale. Like the elms, its density is greatest in the higher size classes and the relative percent of frequency about the same throughout all of the five size classes.

Earlier literature relative to the nature of the Maple-Beech association and the mixed conifer-northern hardwood community as it occurred in Michigan (Gleason 1924; Gates 1912, 1926; Woollett and Sigler 1928) has indicated that Hemlock (Tsuga canadensis) occurring within the forest community should be interpreted as a relic species. Gleason (1924, p. 294) has said:

> Hemlock is present . . . .but hemlock seedlings were not observed. Almost all hemlock trees in the hardwood stands of the region are veterans. After their death, which may be expected in a comparatively short time, hemlock will practically disappear as a component of the association.

Yet, hemlock (Tsuga canadensis) was found to have a presence class of two (seldom present), instead of class one (rare) in this study. On the DFD Index scale it ranked twelfth (Table III), midway between Acer saccharum (DFD-one) and Fraxinus nigra (DFD-23). The species was present in every size class (Table IV) indicating that it was a successful member of the community. The other coniferous representatives, which gave character to the mixed conifer-northern hardwood community of the primeval forest, are now sadly depleted (Tables III, IV, and LVIX).

The phytographs in Fig. 9 are arranged to portray the dominance of the trees concerned as indicated by their DFD Index values (Table III). Careful scrutiny of these phytographs will reveal that the degree of dominance as expressed by (1) the DFD Index scale and (2) the phytographs is not always in agreement. For example, Quercus rubra var. borealis is in eighth position on the basis of the DFD Index scale (Table III) and Acer rubrum is in the seventh position. They are therefore arranged in this order in Fig. 9. However, on the basis of the degree of dominance, as indicated by the area of the trapezium within the phytograph, the two species are reversed in position. The trapezium of the phytograph for Quercus rubra var. borealis includes a greater area than does that for Acer rubrum and consequently, if the arrangement of the species in regard to their dominance were in consecutive order on this criterion, the phytograph for the former species should be placed ahead of that for the latter. The differences in the degree of dominance as shown by these two criteria are to be found in the different structural characteristics used. The DFD Index (Curtis 1947) is the sum of the percent density, frequency and dominance (basal area) of each species. It does not take into consideration the percentage of size classes represented for each one. The phytograph includes the latter factor as well as the other three. There are instances when the factor of percent of size classes, as shown within the phytograph, can result in misleading interpretations. The lower radius (o–c) is a critical indicator of the reproductive success of a species. When the tree is represented in all size classes, the lower angle of the trapezium extends to the edge of the circle. If a size class is lacking, the trapezium extends 80% of the total radius. A serious criticism of this method of showing size classes is that it does not indicate which of the size classes is absent (Daubenmire 1936, p. 242).

If, as in the case of Ostrya virginiana (Fig. 10), one interprets shortness of the o–c axis as indicating failure to reproduce and hence unsuccessful participation within the community, false conclusions may be reached. The life-form of the species may be such that it never attains the diameter represented in the higher size classes, and yet it may be an integral part of the community. Ironwood is the leading subdominant in these stands. It is ranked sixth on the DFD Index scale, which included all of the tree species for the stands. The percent frequency and density was the greatest in size class three and four, and there were no individuals recorded for size class six. Other subdominant species were Populus grandidentata, P. tremuloides, Prunus pensylvanica and Amelanchier sp. The phytographs for the subdominants are shown in Fig. 10. They are arranged in the order of dominance as indicated by the DFD Index scale.

On the basis of (1) the structural characters of the concrete community, as established by the quantitative quadrat studies, (2) the qualitative characters which have been indicated by these analyses, and (3) the synthetic characters of the abstract community here considered, it would appear that the second growth upland hardwood stands of Missaukee County are representative of a disclimax. The disturbing agent is man. Two cultural practices operating in the county appear to be pasturing in all of the woodlots, and unselected cutting of the trees for supplemental fuel supplies during the long cold winters. They have produced a disclimax in the area under study with the dominant trees of the climax mixed conifer-northern hardwood forest (Acer saccharum, Fagus grandifolia, Tilia americana, Fraxinus americana, Betula lutea, Tsuga canadensis, Ulmus americana, and U. Thomasi) intermingled with such subclimax species as Betula papyrifera, Quercus rubra var. borealis, Acer rubrum and Prunus pensylvanica. Outside of the upland hardwood areas, in some locations formerly occupied by the pine communities, there are today fine examples of the Aspen Association (Gates 1930). The former pine community in the northwestern corner of the county (Fig. 30) is now typical of that phase of the association dominated by Prunus pensylvanica. In the southeastern corner of the county, where the soils are sandy and the topography upland, the dominant species is Populus grandidentata.

The present ecological status of Acer saccharum in the community cannot be questioned. The ecological role of Fagus grandifolia, Ulmus americana, U. Thomasi, Tilia americana, Betula lutea and Tsuga canadensis has been considered in detail. These species are considered as representatives of the mature (climax) forest for the area. That the present composition of the second growth upland hardwood stands in Missaukee County is not a climax expression is attested to by the presence of such subclimax species as Betula papyrifera, Quercus rubra var. borealis, the aspens and fire cherry. Their ecological place within the community has been discussed. The quantitative data of these quadrat studies would indicate that the composition of these stands fits nearest Type 12 (Sugar Maple-Beech-Yellow Birch) of the forest cover types given by the Society of American Foresters for the eastern United States (1932, p. 463).

B. Composition Differences of the Second Growth Upland Hardwood Stands in Relation to the Six Soil Series

The ninety-eight stands of second growth upland hardwoods within Missaukee County were located on six different soil series which are a part of the great podzol soil group. An analysis of the different profiles which are characteristic of each series (p. 49) indicates that each one of them compares with the general description as given by Wolfanger (1950, p. 38) in Conservation of Natural Resources:

> The surface soil is especially lacking in the features generally associated with good soils. It is so low in organic matter that it is conspicuously whitish or gray in color. The colloidal clay is very low in absorbed nutrients and has only a limited absorptive capacity. The subsoil is also low in nutrients but is typically a striking coffee-brown and relatively heavier in texture owing to a marked transfer of organic colloids and other fine soil particles.

The varied composition of the communities composing the second growth upland hardwood stands growing on the six soil series is in part a result of the differences found in the horizons of the soil profiles. The quantitative data for the quadrat studies as they treat of the nature

of the composition of these stands as they grew on the different soil series are presented in Tables XIX, XX, LXI and the Appendix (Tables LXII through LXXVI). Dominance values for the canopy and understory species, as indicated by phytographs, are presented in Figs. 11-22. Observations relative to the relations and interrelations of the species on and between each of the soil series have been noted in Observations and Results, p. 84 through 136.

It may be seen from an examination of these data that the Roselawn Soil Series is the critical one when related to an expression of the climax northern hardwood forest community. An analysis of the summary of significance of differences in percentages of frequency, density and basal area (Table XXII) indicates that when the significant differences are greater than mathematical chance, they favor the Roselawn Soil Series for the more xerophytic species and are unfavorable (negative) for that soil series for the more mesophytic species. For example, the data show that in four instances, the larger percentage of frequency and basal area for <u>Quercus</u> <u>rubra</u> <u>var</u>. <u>borealis</u> were due to some factor other than mathematical chance. In each instance (Arenac, Emmet, Nester and Selkirk Series) the larger percentage resulted on the Roselawn Soil Series. The same is true also for white oak (<u>Quercus</u> <u>alba</u>) when it was present on one of the other soil series (Emmet and Selkirk). On the other hand, when some of the more mesophytic species are considered, it is seen that when percentage differences are greater than mathematical chance, the significant difference is away from the Roselawn Soil Series. Between this soil series and the Emmet, Kalkaska, Nester and Selkirk series, the three factors of percent frequency, density and basal area have a significance of difference greater than mathematical chance for <u>Acer</u>

TABLE LXI

PRESENCE OR ABSENCE OF THE CANOPY AND UNDERSTORY TREE SPECIES FROM THE SIX SOIL SERIES

CANOPY TREE SPECIES	A	E	K	N	S	R
Acer saccharum	x	x	x	x	x	x
Fagus grandifolia	x	x	x	x	x	x
Ulmus americana	x	x	x	x	x	x
Ulmus Thomasi	x	x	x	x	x	
Ulmus rubra		x	x	x	x	x
Tilia americana	x	x	x	x	x	x
Prunus serotina	x	x	x	x	x	x
Fraxinus americana	x	x	x	x	x	x
Fraxinus nigra				x		
Acer rubrum	x	x		x	x	x
Betula lutea		x		x	x	
Betula papyrifera		x		x	x	
Quercus rubra var. borealis	x	x		x	x	x
Quercus alba		x			x	x
Tsuga canadensis	x	x	x	x	x	
Pinus Strobus				x	x	x
Pinus resinosa					x	x
Thuja occidentalis				x	x	
UNDERSTORY TREE SPECIES						
Ostrya virginiana	x	x	x	x	x	x
Populus grandidentata		x	x	x	x	x
Populus tremuloides		x		x		
Prunus pensylvanica	x	x	x	x	x	x
Amelanchier sp.		x		x	x	x
Crataegus sp.		x		x		
Rhus typhina		x		x		

A - Arenac Soil Series
K - Kalkaska Soil Series
S - Selkirk Soil Series
E - Emmet Soil Series
N - Nester Soil Series
R - Roselawn Soil Series

saccharum, and compared with the Arenac Soil Series, differences in percentages between the first two factors are greater than mathematical chance. In three out of five possible combinations of comparisons between the soil series, the factors of percent frequency, density and basal area exhibited differences greater than mathematical chance in relation to Fagus grandifolia (Emmet, Kalkaska and Selkirk). Each time, the greater differences were in favor of the latter three soil series, rather than in favor of the Roselawn Soil Series. In two instances, Ulmus americana showed a percentage of frequency and basal area greater than mathematical chance away from the Roselawn Soil Series (Arenac and Emmet).

Dominance, as indicated by either the DFD Index scale (Table III) or phytographs (Fig. 9), indicates that such preclimatic species (Weaver and Clements 1938, p. 84) as Quercus rubra var. borealis and Q. alba are important members of the community as represented on the Roselawn Soil Series. The presence of Acer saccharum, Fagus grandifolia, Tilia americana and Ulmus americana is indicative of the extent that the course of succession has advanced from the subclimax xerosere toward the climax forest community. Pinus resinosa is considered by Whitford (1901, p. 299) to indicate a probable transitory stage from more xerophytic to less xerophytic between Pinus Banksiana and Pinus Strobus. The Roselawn Soil Series is the only one of the six considered for Missaukee County which contained the species (Pinus resinosa) within the quadrat studies.

At first sight, the high dominance attained by Acer rubrum on the Roselawn Soil Series might seem to invalidate the suggested subclimax xerosere status of the community. The species is commonly associated with the subclimax successional stages of the hydrosere and it is often a dom-

inant of flood plain, where it frequently replaces Acer saccharum in poorly drained stands (Secor 1949, p. 76). However, the species (Acer rubrum) has a very wide tolerance range and is almost as often found as a conspicuous member of the invading deciduous forest on former pine plains (Sherrard 1902, p. 406; Livingston 1905, p. 28:, Dansereau 1946, p. 247). In a very comprehensive study of The Relation of Certain Soil Characteristics to Forest Growth and Composition in the Northern Hardwood Forests of Northern Michigan, Westveld (1933, p. 37) concluded that "Red maple and white pine are possibly more characteristic of the drier coarser textured soils than that of the finer textured soils due to the lesser degree of competition on these sites." These factors, as defined by Westveld, are believed to account for the dominance of this species within the community of The Roselawn Soil Series in Missaukee County.

The general description for the soil profile (Description of the Area, Section E, Soils, p. 46) is indicative of the xeric nature of the soil series and yet it also reveals some factors which would be favorable to invading mesophytic trees. The largest portion of the profile (part of the A and most of the C horizon) is incoherent sand. There is little or no leaf litter in the A_{oo} horizon. The extremely shallow humus layer is characteristically a mor type, and the illuvial portion of the A horizon shows much leaching. It is probably the eight inches of light yellow loamy sand, forming the B_1 layer of the B horizon, which favors any expression of the deciduous tree species characteristic of a mature (climax) northern hardwood forest. The B_2 layer changed from a loamy sand to a loose sand. The C horizon, which is only one to one and a

half feet below the surface, was and excepting for occasional reddish clay pockets within the patches of gravel.

Acer saccharum is the primary dominant within the other five soil series on the basis of all criteria.

An examination of the phytographs (Figs. 13 through 21) and the DFD Index scales (Tables IX through XX) shows that there is some variation among the secondary dominants in regard to their relative position of dominance for the five different soil series. The results of the quantitative data, as well as the phytographic interpretations, indicate that Fagus grandifolia is the dominant secondary species on both the Emmet and Nester Soil Series. Its position is taken over by Ulmus Thomasi on the Arenac, Kalkaska and Selkirk Soil Series, a fact which can be partially accounted for on the basis of differences between the soil series involved. The data in Table XXII indicate that when the differences in percentage of frequency, density and basal area for the species are significant, they favor one of the preceding soil series rather than either Emmet or Nester. Between Emmet and Kalkaska, differences in both percent frequency and percent basal area are statistically significant in favor of the latter soil series. Comparisons of the soil profiles for these two soil series indicates that the Kalkaska soil is less acid in reaction and tends to have better drainage. The percent frequency and density were both significantly different for the species (U. Thomasi) between the Emmet and the Selkirk Soil Series, with the significant differences favoring the Selkirk Soil Series. The profile description again indicates that the pH reaction is less acid for the Selkirk than for the Emmet series. However, drainage conditions are imperfect within the Selkirk

Soil Series. Only the percent frequency for _U. Thomasi_ revealed a significantly important difference as concerned the Arenac Soil Series in relation to the Emmet Soil Series. Again the greatest difference in favor of better growth for the species, as revealed by a comparison of the soil profiles, was the less acid reaction of the former soil. It would appear that the lower acidity of these three soils as well as their coarser texture in relation to the Emmet and Nester Soil Series are factors which together offer better site conditions for _Ulmus Thomasi_.

The varied degrees of dominance which are indicated by either phytographs or the DFD Index for the other secondary dominants are not statistically significant (Table XXII). It would appear, on the basis of these quantitative structural characters here considered, that the composition of these lociations is in a closer balance than one might expect for the different soil series. The actual causes resulting in the variations of dominance, as indicated above, are real even though the differences are not statistically significant. This evidence is indicative of the controlling influence of the many microclimatic factors of the soil, topography and atmosphere. As already indicated, long range, controlled field experiments will be necessary to isolate the relations and interrelations which operate to produce these conditions. The difference in the dominance of one species over another within a particular soil series may suggest the position of such a lociation within the disclimax period of succession. When such species as _Ulmus Thomasi_, _U. americana_, and _Acer rubrum_ attain a higher degree of dominance than such species as _Fagus grandifolia_, _Tilia americana_, and _Fraxinus americana_, the lociation may be considered further removed from the climax forest stage than in the instances where the latter species have attained the greater dominance. Thus, the lociation expressed by the Emmet Soil Series (*Acer saccharum*, *Fagus grandifolia*, *Ulmus americana*, *Tilia americana*, *Fraxinus americana*, *Ulmus Thomasi*, *Prunus serotina* and *Ulmus rubra*) may be considered to be farther advanced toward the climax northern hardwood forest type than the lociation expressed by the Arenac Soil Series (*Acer saccharum*, *Ulmus Thomasi*, *U. americana*, *Fagus grandifolia*, *Fraxinus americana*, *Tilia americana*, *Acer rubrum* and *Tsuga canadensis*). Other examples may be drawn from reference to either the DFD Index scale or the phytographs for the six soil series.

C. The Composition of the Woody Vegetation in the Ninety-Eight Stands of Second Growth Upland Hardwoods of Missaukee County Compared with the Composition of the Woody Vegetation in other Areas of Michigan, Wisconsin, and Minnesota

The composition of the second growth upland hardwoods in Missaukee County as revealed by the quantitative studies was compared with numerous other vegetational studies in Michigan, Wisconsin and Minnesota. Two different criteria were used for establishing the comparisons, depending upon the manner in which the data of the other studies were reported. A Frequency Index Community Coefficient (Gleason, 1920; Gates, 1949) was established for comparative purposes between many of the communities, while in the comparisons with Stearns' (1951) report from Wisconsin, a DFD Index scale (Curtis 1947) was employed.

According to Gates (1949, p. 42): "The coefficients obtained by the Gleason method yield relatively high figures, usually in excess of eighty, if the two areas are in the same association in the same region. Still one may find areas close together, appearing similar to the eye, which do not yield coefficients in excess of sixty." Reference to the details of these comparisons (Tables XXIII through XXXIX) will show that high coefficients were never obtained; but rather, the tendency was to find coefficients lower than sixty. The comparisons, as drawn, can be considered only as indicators of what may occur if and when the vegetation in Missaukee County attains climax status. In the first place, the communities used in the comparisons were reported as mature (climax) undisturbed stands while the Missaukee County study is concerned with second growth, upland, disturbed stands. Secondly, the methods of sampling are not always identical. For example, the methods of both Cain (1935) and Stearns (1951) are comparable with those used in Missaukee County, while Gleason (1924, p. 287), determined the composition of the dominant forest layer by counting all the trees six inches or more in diameter on a strip about 50 feet wide extending across the area. On the other hand, Quick (1923, p. 221) determined the composition of the climax forest Beech-Maple association in Michigan by means of transect counts in strips 20 feet wide. Such varied methods of sampling must have provoked Cain (1935, p. 508) to state that:

> One finds an attempt to synthesize the various quantitative data largely thwarted because of the diverse sampling methods which prevent the resulting data from being directly comparable.

Such also is the case here. Consequently these comparisons must be considered, in this light, as only possible indications of possible future successional direction.

D. The Woody Vegetation of Missaukee County Yesterday and Today

The forest communities of Missaukee County, as interpreted from the original land survey field notes and maps, have been discussed in detail (p. 178, Observations and Results, Section D), and shown by maps (Figs. 30 and 31). It is evident from this presentation that there were four principal communities at that time: swamp, pine, mixed conifer-northern hardwood and northern hardwood.

Four major changes were observed while doing the reconnaisance work necessary for establishing the present day quadrat sites in the second growth upland hardwoods. All but one of these changes manifests itself in the quantitative and qualitative data and that one is precluded because of the nature of this study. In the first place, there has been a great reduction in the amount of land now in forests when compared with that at the time of the original land survey. This is a natural result in a count which at the turn of the century was in the grip of the early lumbering industry, as previously discussed (p. 55). The second major difference is the complete absence of the former pine communities. Here the ravages of lumbering and fire have taken their greatest toll. Much of the former pine lands are now in some stage of the Aspen Association (Gates 1930) or are still similar to the vegetation described by Livingston (1905, p. 28-29) for Roscommon and Crawford Counties (these two counties are the eastern neighbors of Missaukee County):

> . . .over vast stretches originally covered with pine there are no trees at all. There are regions of dwarfed _Quercus_ _alba_, _Q_. _rubra_, _Acer_ _rubrum_ and a number of shrubs.

> . . .Among the lower forms occurring here may be mentioned: *Rhus hirta*, *Monarda fistulosa*, *Pteris aquilina*, *Gaylussacia resinosa*, *Vaccinium canadensis*, *Comptonia peregrina*, *Solidago hispida*, *Hamamelis virginiana*, etc. The growth of sweet fern being so luxuriant that the numerous prostrate logs are often hidden from view.

It is very evident that the toll taken by the former lumbering operations and subsequent fires has been enormous and that the disturbance factors have done much to retard the normal course of plant succession. The factors which are responsible for this long delay in recovery of the vegetation in this area are yet mostly unstudied. The phytosociology of the former pine lands and the autecology of the plants within the area offer a wide field for future studies.

Another noticeable change between the past vegetational communities and their present appearance is the large reduction in the extent of the area once occupied by the swamp community. A large share of this reduction has come about through the modern tillage practices of the farmers and their desire to reclaim more land for agricultural uses. Efforts of the State Conservation Department to improve the wildlife habitat in the county have likewise resulted in changing the aspect of this community. In the fall of 1939, the GameDivision of the Conservation Department constructed the Reedsburg Dam across the Muskegon River (T23N:R5W, Section 25), so as to improve the wildlife habitat for wildfowl, fish and fur bearing animals. While the Division has no records concerning the effects of the dam in respect to increasing or decreasing the amount of swamp land, it may be presumed, on the basis of the general effect which such structures produce, that the swamp area along the river below the dam would be improved (decreased) and above the dam would be increased. The latter case could also be considered an improvement in the light of the purpose for

which the dam was constructed. The records of the Game Division indicate that the population of both wild fowl and fur bearing animals has increased by several hundred percent since the project was completed. It is now a very popular spot for early season wild fowl shooting and the amount of successful trapping, especially among commercial trappers, became so great that it was necessary to limit the take by shortening the season. According to the cover maps made before and after the dam was built, it would appear that _Thuja occidentalis_ is soon destroyed by flooding, as it was among the first to succumb within the area flooded by the back waters of the dam. Both _Fraxinus nigra_ and _Acer rubrum_ seem to show considerable tolerance to such conditions as their abundance has changed little within the course of time since the cover mapping.

Finally, it was observed that the coniferous element of a mixed conifer-northern hardwood forest was much reduced in representation. Other differences in the mixed conifer-northern hardwood and hardwood communities were more evident after analyzing the quantitative data of the area for both periods of time. At the time of the original land survey, this community was a Beech-Hemlock-Maple Association. Now the community is predominately sugar maple (_Acer saccharum_) with _Fagus grandifolia_, _Ulmus Thomasi_, _U. americana_, _Tilia americana_, and _Fraxinus americana_ as the principal secondary dominants. Hemlock and pine, while still present, are at best incidental dominants. There is also a shift in dominance of the important secondary species within the hardwood community of "then and now". In the past this community was dominated by sugar maple but the beech was much more abundant. Today, _Acer saccharum_ is even more predominant and the secondary dominants are more closely

grouped together in regard to their respective degree of dominance.

A careful checking of the distribution map constructed for the county from the land survey field notes indicates that there were a number of small isolated stands which could be considered as typical of the Lake Forest: ". . .a single association, in which Pinus Strobus, P. resinosa, and Tsuga canadensis were climax dominants" (Weaver and Clements 1938, p. 497). Needless to say, this aspect is found nowhere in the county today.

E. Natural Land Divisions; Land Management Programs; Recreational and Economic Implications

The natural land divisions for Missaukee County, as mapped by Veatch and Schneider (1948), are shown in Fig. 5. The manner in which these natural land divisions fit into the surface geology of the county may be seen by comparing this figure with the map in Fig. 3. Similarities and differences of the vegetation for these natural land divisions as given by Veatch and Schneider (1938, p. 25 and 27) may be seen by comparing the quantitative data for both quadrat studies and the interpretation from the original land survey field notes. Because the natural land divisions treat of larger areas any differences which do appear are the result of the larger treatment on the one hand and the smaller areas considered by the quantitative studies on the other. For example, the vegetation pattern correlated with the natural land divisions would account for three "pine plains" (Land Types C and D of the map in Fig. 5) while the interpretations from the original land survey field notes indicated four such areas (Fig. 30)

A land management program is beyond the scope of this study, yet it must be pointed out that soil types included in a natural land division occur in close association and thus must be considered together in any such program. Only as the present composition of the second growth upland hardwoods can be considered as an indicator of the interrelations of these closely associated soil types within a natural land division is this study related to a land management program. That these interrelations are close among Arenac, Emmet, Kalkaska, Nester and Selkirk soil series has already been indicated. Greater differences, as revealed by the nature of the woody vegetation, have been indicated between the Roselawn Soil Series and those mentioned above.

Wolfanger (1950, p. 39-40) has said:

> The chief future hopes of the podzol region are its forests and recreational resources. . . .The most valuable land in the podzol region is that which has a water frontage, since water has an irresistible appeal to man.

The nature of the present upland second growth hardwoods in the county has already been discussed at length. They, as scattered woodlots or patches in an area delimited as state forest, represent the highest development of forest resources for the county. The small area covered by each privately owned woodlot, and the wide separation of all of them, places some limitation upon their future value as a lumber resource. To these factors should be added the previously cited cultural practices which will prevent these stands from developing in their best possible manner. The use of the considerable lake frontage is yet another problem. At the present time much of this land is in the control of the Missaukee Lake Land Company. The company is a real estate development organization mostly interested in profit, but is far from "chamber of commerce" minded. This large area of some 500-600 acres, including several lakes, is strictly maintained as private. Under this particular arrangement a con-

siderable area of the county, rich in potential recreational resources, is withheld from the large summer resort trade which would otherwise avail themselves of the area.

This study may be considered to indicate some of the future forest resources which can be made available in Missaukee County. Certain implications are made regarding the potentials of its lumber resources. Much of the area, now in the hands of private hunt clubs, and free from unusual disturbances, will continue to improve as a game refuge. Other parts, under the supervision of the State Conservation Department, will also advance in value as suitable wildlife habitats. However, in order to develop a comprehensive plan for the overall improvement of the many natural resources of the county, as well as the proper land management of agricultural areas, a study in the manner of Schoenmann's (1931) Land Inventory for Rural Planning in Alger County, Michigan is needed. Some steps in this direction are seen in the recommendations of such broader studies as Trends in Land Use in Northern Michigan (Andrews and Bromely, 1941) and The Land Nobody Wanted (Titus, 1945).

The phytosociology of the second growth upland hardwoods of Missaukee County is another small part which contributes to the whole picture. It also adds another vital link to the chain of evidence concerning the nature of the vegetation in and near the transition zone of Michigan's lower peninsula.

SUMMARY AND CONCLUSIONS

The phytosociology of the upland second growth hardwood stands in Missaukee County is considered in relationship to the structural characters of the concrete community and the synthetic characteristics of the abstract community. Quantitative data from 546 one hundred square meter quadrats, representing ninety-eight stands on six different soil series, were analyzed and interpreted in order to establish the type of forest communities now representative of the area.

The interrelations between the six soil series and their effect upon composition differences has been discussed. The implications of the indicator value of these various lociations in regard to the close association of different soil types in natural land divisions and land management programs are pointed out.

Contrasts and comparisons are made between the present day composition of the second growth upland hardwood stands in Missaukee County and the distribution of the forest communities as interpreted from the original land survey field notes of 1837-1854. Comparisons were also drawn between the composition of these upland second growth hardwood stands and other vegetational studies from Michigan, Wisconsin and Minnesota.

On the basis of these data it may be concluded that:

1. The present day composition of the upland second growth hardwood stands in Missaukee County represent a disclimax stage of succession within an area which has a climax forest of mixed conifer-northern hardwood tree species.

2. This composition is maintained in the disclimatic stage by the continued operation of two wide spread cultural practices which are open pasturing in all of the woodlots, and unselected cutting for supplementing the fuel supply during the long, cold winters.

3. *Acer saccharum* is the primary dominant.

4. *Fagus grandifolia*, *Ulmus Thomasi*, *U. americana*, *Tilia americana*, and *Fraxinus americana* are the principal secondary dominants.

5. The predominance of *Ulmus Thomasi* in most situations within Missaukee County suggests a northward extension for its range and it is suggested that such be considered in future revisions of its distribution maps.

6. Various soil series interact to produce lociations of varied degree of dominance among the secondary dominant species.

7. There is considerably less area now in forest than there was at the time of the original land survey and that the composition now is considerably different than it was at that time.

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APPENDIX

TABLE LXII

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	A %F	E %F	SD	A %D	E %D		A %BA	E %BA	
Acer saccharum	100.00	98.70	-0.54	66.81	66.20	-0.05	29.87	39.00	0.93
Ulmus Thomasi	42.11	12.10	-2.60	11.63	2.00	-1.27	10.04	7.00	0.43
Fagus grandifolia	31.58	54.30	2.07	13.68	8.70	-0.61	9.58	14.00	0.58
Ulmus americana	36.84	38.80	0.17	6.13	4.00	0.38	38.05	16.00	1.94
Tilia americana	15.79	31.30	1.78	2.54	3.30	0.20	2.41	7.00	1.47
Fraxinus americana	21.05	20.10	0.10	.85	2.10	0.56	2.72	3.00	0.07
Prunus serotina	5.26	9.60	0.80	.21	.50	0.26	1.00	3.00	0.83
Ulmus rubra		9.90			.80			2.00	
Quercus rubra*	5.26	9.00	0.69	.20	.23	0.01	0.92	2.00	0.49
Acer rubrum	10.53	8.00	-0.37	1.90	1.50	-0.12	0.11	1.00	0.10
Tsuja canadensis	5.26	6.50	0.23	0.21	0.20	0.01	2.40	1.00	0.37
Betula lutea		3.70			0.20			0.50	
Quercus alba		0.90			0.03				
Betula papyrifera		0.60			0.03				

A - Arenac Soil Series
E - Emmet Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXIII

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	A %F	K %F	SD	A %D	K %D	SD	A %BA	K %BA	SD
Acer saccharum	100.00	100.00	0.00	66.81	75.44	0.63	29.87	45.60	1.12
Fagus grandifolia	31.58	51.32	1.90	13.68	6.07	0.89	9.58	12.20	0.35
Ulmus Thomasi	42.11	55.17	0.88	11.63	9.66	0.25	10.04	26.60	1.54
Ulmus americana	36.84	17.24	1.49	6.13	3.03	0.49	38.05	9.00	2.32
Tilia americana	15.79	10.34	0.53	2.54	0.69	0.48	2.41	3.00	0.12
Prunus serotina	5.26	24.14	2.00	0.21	1.10	0.40	1.00	1.90	0.26
Tsuga canadensis	5.26	3.44	0.29	0.21	0.14	0.04	2.40	0.30	0.58
Fraxinus americana	21.05	3.44	1.77	0.85	0.28	0.20	2.72	.00	
Ulmus rubra		3.44			0.14				
Acer rubrum	10.53		1.90				0.11		
Quercus rubra*	5.26		0.85				0.92		

A - Arenac Soil Series
K - Kalkaska Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXIV

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	A %F	N %F	SD	A %D	N %D	SD	A %BA	N %BA	SD
Acer saccharum	100.00	93.60	+1.77	66.81	43.93	+1.00	29.87	33.83	0.34
Fagus grandifolia	31.58	49.30	0.14	13.68	5.95	+0.92	9.58	7.90	+0.21
Ulmus americana	36.84	32.90	+0.32	6.13	3.60	+0.41	38.05	8.29	2.56
Ulmus Thomasi	42.11	25.10	1.30	11.63	3.91	1.00	10.04	11.37	0.17
Tilia americana	15.79	29.10	1.38	2.54	2.16	0.09	2.41	6.80	0.97
Tsuga canadensis	5.26	27.80	3.13	0.21	1.67	0.85	2.40	4.59	0.52
Fraxinus americana	21.05	20.20	0.08	0.85	2.35	0.57	2.72	5.26	0.56
Prunus serotina	5.26	18.90	2.00	0.21	1.33	0.65	1.00	3.00	0.67
Acer rubrum	10.53	12.60	0.25	1.90	4.46	0.67	0.11	4.43	1.75
Ulmus rubra		15.00			0.53			1.19	
Betula papyrifera		11.40			1.44			1.61	
Thuja occidentalis		4.90			.46			0.85	
Betula lutea		12.60			.57			.48	
Pinus Strobus		3.50			0.35			1.23	
Quercus rubra*	5.26	3.50	0.32	0.85	0.42	0.10	0.92	0.44	0.23
Fraxinus nigra		2.00			0.15			0.22	

A - Arenac Soil Series
N - Nester Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXV

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	A %F	R %F	SD	A %D	R %D	SD	A %BA	R %BA	SD
Acer saccharum	100.00	30.43	7.17	66.81	18.67	4.86	29.87	3.44	2.35
Fagus grandifolium	31.58	17.39	1.06	13.68	8.00	0.54	9.58	0.93	1.12
Ulmus americana	36.84	4.35	2.85	6.13	0.41	1.00	38.05	1.99	3.19
Ulmus Thomasi	42.11			11.63			10.04		
Ulmus rubra		4.35			0.31			0.44	
Tilia americana	15.79	13.04	1.84	2.54	1.31	0.23	2.41	6.38	0.64
Prunus serotina	5.26	4.35	0.13	0.21	0.31	0.07	1.00	0.91	0.03
Fraxinus americana	21.05	4.35	1.62	0.85	0.10	0.33	2.72	0.16	0.67
Acer rubrum	10.53	69.57	4.96	1.90	29.44	2.75	0.11	4.91	1.06
Quercus rubra*	5.26	95.65	13.69	0.85	18.15	2.08	0.92	55.80	5.16
Quercus alba		47.83			9.64			16.70	
Tsuga canadensis	5.26			0.21			2.40		
Pinus Strobus		13.04			0.92			4.44	
Pinus resinosa		8.70			0.62			0.32	

A - Arenac Soil Series
R - Roselawn Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXVI

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	A %F	S %F	SD	A %D	S %D	SD	A %BA	S %BA	SD
Acer saccharum	100.00	93.10	1.87	66.81	45.35	1.74	29.87	34.54	0.38
Ulmus Thomasi	42.11	55.56	1.05	11.62	12.41	0.09	10.04	16.63	0.79
Fagus grandifolia	31.58	52.50	1.73	13.68	6.55	0.84	12.97	9.58	0.44
Acer rubrum	10.53	25.00	1.66	1.90	6.60	1.11	0.11	5.06	1.90
Tsuga canadensis	5.26	26.39	2.85	0.20	3.39	1.35	2.40	3.79	0.33
Ulmus americana	36.84	20.83	1.33	6.13	2.79	0.47	38.05	7.05	2.67
Fraxinus americana	21.05	23.61	0.23	0.85	1.58	0.28	2.72	3.03	0.07
Ulmus rubra		16.67			3.26			3.09	
Tilia americana	15.79	11.12	0.51	2.54	2.09	0.11	2.41	5.64	0.71
Prunus serotina	5.26	13.89	1.32	0.21	0.70	0.35	1.00	1.85	0.30
Betula lutea		12.50			1.02			1.07	
Betula papyrifera		6.94			0.60			0.51	
Quercus rubra*	5.26	5.56	.05	0.85	0.84	.00	0.92	0.18	0.33
Thuja occidentalis		4.17			0.23			0.24	
Pinus resinosa		1.39			0.05			0.57	
Quercus alba		1.39			0.13			0.18	

A - Arenac Soil Series
S - Selkirk Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXVII

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	E %F	K %F	SD	E %D	K %D	SD	E %BA	K %BA	SD
Acer saccharum	98.70	100.00	0.68	66.20	75.44	1.10	39.00	45.60	0.69
Fagus grandifolia	54.30	51.52	0.64	8.70	6.07	0.84	14.00	12.20	0.75
Ulmus americana	38.80	17.24	2.83	4.00	3.02	0.29	16.00	9.00	1.22
Tilia americana	31.30	10.34	3.38	3.30	0.69	1.45	7.00	3.00	1.14
Fraxinus americana	20.10	3.44	4.15	2.10	0.28	1.51	3.00	.00	
Ulmus Thomasi	12.10	55.17	4.57	2.00	9.66	1.39	7.00	26.60	2.36
Prunus serotina	9.60	24.14	1.78	0.50	1.10	0.26	3.00	1.90	0.42
Ulmus rubra	9.90	3.44	1.04	0.80	0.14	0.09	2.00		
Quercus rubra	9.00			0.90			0.20		
Acer rubrum	8.00			1.50			1.00		
Tsuga canadensis	6.50	3.44	.85	0.20	0.14	0.20	0.30	.01	.58
Betula lutea	3.70			0.20			0.50		
Quercus alba	0.90			0.03					
Betula papyrifera	0.60			0.03					

E - Emmet Soil Series
K - Kalkaska Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXVIII

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	E %F	N %F	SD	E %D	N %D	SD	E %BA	N %BA	SD
Acer saccharum	98.70	93.60	1.10	66.20	43.93	3.71	39.00	33.82	0.87
Fagus grandifolia	54.30	49.30	0.80	8.70	5.95	0.88	14.00	7.90	1.69
Ulmus americana	38.80	32.90	1.00	4.00	3.60	0.17	16.00	8.29	2.08
Tilia americana	31.30	29.10	0.40	3.30	2.16	0.59	7.00	6.80	0.06
Fraxinus americana	20.10	20.20	0.02	2.10	2.35	0.13	3.00	5.26	0.86
Ulmus Thomasi	12.10	25.10	2.39	2.00	3.91	0.86	7.00	11.37	1.11
Prunus serotina	9.60	18.90	1.97	0.50	1.33	0.58	3.00	3.00	.00
Ulmus rubra	9.90	15.00	0.77	0.80	0.53	0.80	2.00	1.19	0.57
Quercus rubra*	9.00	3.50	2.11	0.90	0.42	0.59	2.00	0.44	1.35
Acer rubrum	8.00	12.60	1.15	1.50	4.47	1.29	1.00	4.33	1.44
Tsuga canadensis	6.50	27.80	4.07	0.20	1.67	1.05	1.00	4.59	1.49
Betula lutea	3.70	12.60	2.28	0.20	0.57	0.47	0.50	0.48	0.02
Quercus alba	0.90			0.03					
Betula papyrifera	0.60	11.40	3.00	0.03	1.44	1.17	.00	1.84	
Fraxinus nigra		2.00			.15			0.22	
Pinus Strobus		3.50			.35			1.23	
Thuja occidentalis		4.90			.46			0.85	

E - Emmet Soil Series
N - Nester Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXIX

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	E %F	R %F	SD	E %D	R %D	SD	E %BA	R %BA	SD
Acer saccharum	98.70	30.43	7.17	66.20	18.67	5.59	39.00	3.44	7.56
Fagus grandifolia	54.30	17.39	4.39	8.70	8.00	0.10	14.00	0.93	4.66
Ulmus americana	38.30	4.35	6.89	4.00	0.41	2.11	16.00	1.99	3.89
Tilia americana	31.30	13.04	5.21	3.30	1.31	0.79	7.00	6.38	0.11
Fraxinus americana	20.10	4.35	3.28	2.10	0.10	2.00	3.00	0.16	2.37
Ulmus Thomasi	12.10			2.00			7.00		
Prunus serotina	9.60	4.35	1.16	0.50	0.31	0.16	3.00	0.91	0.95
Ulmus rubra	9.90	4.35	0.79	0.80	0.31	0.40	2.00	0.44	0.91
Quercus rubra*	3.50	95.65	20.03	0.90	18.15	2.26	2.00	55.80	5.17
Acer rubrum	8.00	69.57	6.14	1.50	29.44	2.94	1.00	4.91	0.85
Tsuga canadensis	6.50			0.20			1.00		
Betula lutea	3.70			0.03					
Quercus alba	0.90	47.83	4.51	0.03	9.64	1.55	.00	16.70	
Betula papyrifera	0.60			0.03					
Pinus Strobus		13.40				0.92		4.44	
Pinus resinosa		8.70				0.62		0.32	

E - Emmet Soil Series
R - Roselawn Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXX

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	E %F	S %F	SD	E %D	S %D	SD	E %BA	S %BA	SD
Acer saccharum	98.70	93.10	1.86	66.20	45.35	3.25	39.00	34.50	0.73
Fagus grandifolia	54.30	52.80	0.23	8.70	6.55	0.65	14.00	12.97	2.34
Ulmus americana	38.80	20.83	1.44	4.00	2.79	0.52	16.00	7.05	2.48
Tilia americana	31.30	11.12	4.48	3.30	2.09	0.63	7.00	5.64	0.43
Fraxinus americana	20.10	23.61	0.63	2.10	1.58	0.31	3.00	3.03	0.01
Ulmus Thomasi	12.10	55.56	3.78	2.00	12.41	2.66	7.00	16.63	2.09
Prunus serotina	9.60	13.89	0.92	0.50	0.70	0.20	3.00	1.85	0.67
Ulmus rubra	9.90	16.67	0.96	0.80	3.26	1.11	2.00	3.09	0.49
Quercus rubra*	9.00	5.56	1.11	0.90	0.80	0.05	2.00	0.18	0.21
Acer rubrum	8.00	25.00	3.20	1.50	6.60	1.35	1.00	5.06	1.56
Tsuga canadensis	6.50	26.39	3.75	0.20	3.39	1.41	1.00	3.73	1.24
Betula lutea	3.70	12.50	2.23	0.20	1.02	0.66	0.50	1.07	0.44
Quercus alba	0.90	1.39	0.35	0.03	0.13	0.05	.00	0.18	
Betula papyrifera	0.60	6.94	2.11	0.03	0.60	0.07	.00	0.51	
Pinus Strobus		1.39			0.09				
Pinus resinosa		1.39			0.05			0.57	
Thuja occidentalis		4.17			0.23			0.24	

E - Emmet Soil Series
S - Selkirk Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXXI

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	K	N		K	N		K	N	
	%F	%F	SD	%D	%D	SD	%BA	%BA	SD
Acer saccharum	100.00	93.60	1.95	75.44	43.93	3.29	45.60	33.82	1.10
Fagus grandifolia	51.72	49.30	0.35	6.07	5.95	0.02	12.20	7.90	1.26
Ulmus americana	17.24	32.90	1.79	3.03	3.60	0.15	9.00	8.29	0.11
Tilia americana	10.34	29.10	2.54	0.69	2.16	0.66	3.00	6.80	0.90
Fraxinus americana	3.44	20.20	2.94	0.28	2.35	1.08	.00	5.26	
Ulmus Thomasi	55.17	25.10	2.88	9.66	3.91	0.92	26.60	11.37	1.71
Prunus serotina	24.14	18.90	0.58	1.10	1.33	0.10	1.90	3.00	0.33
Ulmus rubra	3.44	15.00	2.22	0.14	0.53	0.35	.00	1.19	
Quercus rubra*		3.50			0.42			0.44	
Acer rubrum		12.60			4.47			4.33	
Tsuga canadensis	3.44	27.80	4.06	0.14	1.67	0.95	0.30	4.59	1.70
Betula lutea		12.60			.57			0.48	
Betula papyrifera		11.40			1.44			1.61	
Fraxinus nigra		2.00			0.15			0.22	
Pinus Strobus		3.50			0.35			1.23	
Thuja occidentalis		4.90			0.46			0.85	

K - Kalkaska Soil Series
N - Nester Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

***Quercus rubra var. borealis**

TABLE LXXII

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	K %F	R %F	SD	K %D	R %D	SD	K %BA	R %BA	SD
Acer saccharum	100.00	30.43	8.20	75.44	18.67	4.98	45.60	33.44	4.10
Fagus grandifolia	51.72	17.39	4.08	6.07	8.00	0.26	12.20	0.93	4.48
Ulmus americana	17.24	4.35	1.57	3.03	0.41	0.75	9.00	1.99	1.14
Tilia americana	10.34	13.04	0.43	0.69	1.31	0.22	3.00	6.38	0.56
Fraxinus americana	3.44	4.35	0.16	0.28	0.10	0.15	.00	0.16	
Ulmus Thomasi	55.17			9.66			26.00		
Prunus serotina	24.14	4.35	2.09	1.10	0.31	0.21	1.90	0.91	0.30
Ulmus rubra	3.44	4.35	0.16	0.14	0.31	0.14	0.00	0.44	
Quercus rubra*		95.65			18.15			55.80	
Acer rubrum		69.57			29.44			4.91	
Tsuga canadensis	3.44		0.14				0.30		
Quercus alba	3.44	4.35	0.16	0.28	0.10	0.15	0.00	0.16	
Pinus Strobus		13.04			0.92			4.44	
Pinus resinosa		8.70			0.62			0.32	

K - Kalkaska Soil Series
R - Roselawn Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXXIII

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	K %F	S %F	SD	K %D	S %D	SD	K %BA	S %BA	SD
Acer saccharum	100.00	93.10	1.97	75.44	45.35	3.03	45.60	34.50	1.01
Fagus grandifolia	51.52	52.80	0.19	6.07	6.55	0.09	12.20	12.97	0.18
Ulmus americana	17.24	20.83	0.42	3.03	2.79	0.33	9.00	7.05	0.31
Tilia americana	10.34	11.12	0.11	0.69	2.09	0.69	3.00	5.64	0.62
Fraxinus americana	3.44	23.61	3.36	0.28	1.58	0.75	0.00	3.03	
Ulmus Thomasi	55.17	55.56	0.03	9.66	12.41	0.41	26.60	16.63	1.74
Prunus serotina	24.14	13.89	0.27	1.10	0.70	0.18	1.90	1.85	0.01
Ulmus rubra	3.44	16.67	2.36	0.14	3.26	1.42	0.00	3.09	
Tsuga canadensis	3.44	26.39	3.72	0.14	3.39	1.47	0.30	3.73	1.37
Acer rubrum		25.00			6.60			5.06	
Betula lutea		12.50			1.02			1.07	
Betula papyrifera		6.94			0.60			0.51	
Quercus rubra*		5.56			0.84			1.16	
Quercus alba		1.39			0.13			0.18	
Pinus Strobus		1.39			0.09				
Pinus resinosa		1.39			0.05			0.57	

K - Kalkaska Soil Series
S - Selkirk Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercuse rubra var. borealis

TABLE LXXIV

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY	N	R		N	R		N	R	
TREE SPECIES	%F	%F	SD	%D	%D	SD	%BA	%BA	SD
Acer saccharum	93.60	30.43	6.73	43.93	18.67	2.56	33.82	3.44	4.67
Fagus grandifolia	49.30	17.39	3.29	5.95	8.00	0.54	7.90	0.93	1.93
Ulmus americana	32.90	4.37	4.19	3.60	0.41	1.20	8.29	1.99	1.50
Tilia americana	29.10	13.04	2.97	2.16	1.31	0.30	6.80	6.36	0.07
Fraxinus americana	20.20	4.35	2.55	2.35	0.10	1.32	5.26	0.16	1.96
Ulmus Thomasi	25.10			3.91			11.37		
Prunus serotina	18.90	4.35	2.38	1.33	0.31	0.71	3.00	0.91	0.77
Ulmus rubra	15.00	4.35	1.45	0.53	0.31	0.15	1.19	0.44	0.44
Acer rubra	12.60	69.57	5.70	4.47	29.44	2.53	4.33	4.91	0.11
Quercus rubra*	3.50	95.65	19.60	0.42	18.15	2.48	0.44	55.80	5.32
Pinus Strobus	3.50	13.04	1.30	0.04	0.92	0.44	1.23	4.44	0.71
Quercus alba		47.83			9.64			16.70	
Pinus resinosa		8.70			0.62			0.32	
Fraxinus nigra	2.00			0.15			0.22		
Betula lutea	12.60			0.57			0.48		
Betula papyrifera	11.40			1.44			1.61		
Tsuga canadensis	27.80			1.67			4.59		
Thuja occidentalis	4.90			0.46			0.85		

N - Nester Soil Series
R - Roselawn Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXXV

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	N %F	S %F	SD	N %D	S %D	SD	N %BA	S %BA	SD
Acer saccharum	93.60	93.10	0.11	43.93	45.35	0.24	33.82	34.50	0.08
Fagus grandifolia	49.30	52.80	0.43	5.95	6.55	1.50	7.90	12.97	1.01
Ulmus americana	32.90	20.83	1.70	3.60	2.79	0.28	8.29	7.05	0.28
Ulmus Thomasi	25.10	55.56	4.00	3.91	12.41	1.80	11.37	16.63	0.92
Tilia americana	29.10	11.12	2.99	2.16	2.09	0.03	6.80	5.64	0.29
Tsuga canadensis	27.80	26.39	0.19	1.67	3.39	0.68	4.59	3.73	0.26
Fraxinus americana	20.20	23.61	0.50	2.35	1.58	0.35	5.26	3.03	0.77
Prunus serotina	18.90	13.89	0.83	1.33	0.70	0.39	3.00	1.85	0.46
Acer rubrum	12.60	25.00	1.96	4.47	6.60	0.57	4.33	5.06	0.20
Ulmus rubra	15.00	16.67	0.28	0.53	3.26	1.25	1.19	3.09	0.79
Betula papyrifera	11.40	6.94	0.94	1.44	0.60	0.56	1.84	0.51	0.77
Betula lutea	12.60	12.50	0.01	0.57	1.02	0.32	0.48	1.07	0.42
Pinus Strobus	3.50	1.39	0.87	0.04	0.09	0.29			
Quercus rubra*	3.50	5.56	0.60	0.42	0.84	0.35	0.44	0.18	0.34
Thuja occidentalis	4.90	4.17	0.22	0.46	0.23	0.19	0.85	0.24	0.61
Fraxinus nigra	2.00			0.15			0.22		
Quercus alba		1.39			0.13			0.18	
Pinus resinosa		1.39			0.05			0.57	

N - Nester Soil Series
S - Selkirk Soil Series
SD - Significance of difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis

TABLE LXXVI

SIGNIFICANCE OF DIFFERENCES BETWEEN PERCENTAGES

CANOPY TREE SPECIES	S %F	R %F	SD	S %D	R %D	SD	S %BA	R %BA	SD
Acer saccharum	93.10	30.43	6.27	43.35	18.67	2.66	34.50	3.44	4.63
Ulmus Thomasi	55.56			12.41			16.63		
Fagus grandifolia	52.80	17.39	3.57	6.55	8.00	0.19	12.97	0.93	2.73
Acer rubrum	25.00	69.57	4.08	6.60	29.44	2.28	5.06	4.91	0.02
Tsuga canadensis	26.39			3.39			3.73		
Ulmus americana	20.83	4.35	2.57	2.79	0.41	1.03	7.05	1.99	1.20
Fraxinus americana	23.61	4.35	2.91	1.58	0.10	0.97	3.03	0.16	1.30
Ulmus rubra	16.67	4.35	2.01	3.26	0.31	1.22	3.09	0.44	1.10
Tilia americana	11.12	13.04	0.43	2.09	1.31	0.27	5.64	6.38	0.12
Prunus serotina	13.86	4.35	1.63	0.70	0.31	0.28	1.85	0.91	0.37
Betula lutea	12.50			1.02			1.07		
Betula papyrifera	6.94			0.60			0.51		
Quercus rubra*	3.50	95.65	18.43	0.84	18.15	2.13	0.18	55.80	5.34
Thuja occidentalis	4.17	-	-	0.23	-	-	0.24	-	-
Pinus resinosa	1.39	8.70	1.21	0.05	0.62	0.33	0.57	0.32	0.17
Quercus alba	1.39	47.83	4.42	0.13	9.64	1.47	0.18	16.70	2.11
Pinus Strobus	1.36	13.04	1.63	0.09	0.92	0.41	0.24	4.44	0.97

S - Selkirk Soil Series
R - Roselawn Soil Series
SD - Significance of Difference

F - Frequency
D - Density
BA - Basal Area

*Quercus rubra var. borealis