FOREST SUCCESSION ON THE
WELL-DRAINED SOIL IN THE HIGGINS
LAKE AREA OF MICHIGAN

Thesis for the Degree of Ph. D.
MICHIGAN STATE COLLEGE
Kim Kwong Ching
1954

This is to certify that the

thesis entitled

Forest Succession on the Well-Drained Soil in the Higgins Lake Area of Michigan

presented by

Kim K. Ching

has been accepted towards fulfillment
of the requirements for

Ph. D degree in Forestry

T. W. Stevens

Major professor

Date November 30, 1954

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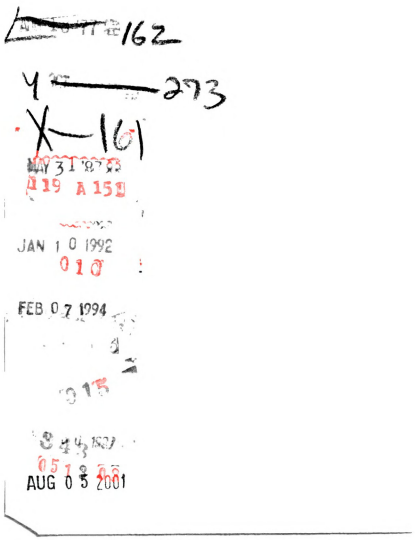
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FOREST SUCCESSION ON THE WELL-DRAINED SOIL IN THE HIGGINS LAKE AREA OF MICHIGAN

By

Kim Kwong Ching

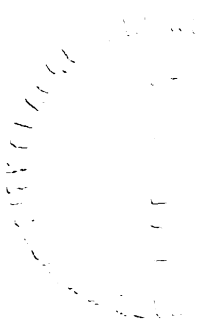
A THESIS

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

Department of Forestry

1954



ACKNOWLEDGMENT

The writer is grateful to Dr. T. D. Stevens for his advice pertaining to the study and for his assistance in the preparation of the manuscript. The writer wishes, further, to express his appreciation to Dr. C. L. Gilly of the Botany Department of Michigan State College for information, concerning the identification of plant specimens collected from the field study. Thanks are also due to Drs. Robert Dils, Ivan Sneider, A. E. Erickson, for helpful suggestions.

Acknowledgment is also due to Dr. T. T. Ku for his valuable assistance and discussion in the field as well as in the laboratory.

For his invaluable aid in obtaining information about the studied area, especial acknowledgment is due to the Regional Forester, H. V. Borgerson of the Conservation Department of the State of Michigan.

A deep appreciation is owed Dr. Victor J. Rudolph and Dr. W. B. Drew for helpful criticisms during the preparation of this manuscript.

Lastly, the writer is indebted to his wife, Te-May, who has shared generously in the organization of data and preparation of the manuscript.

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FOREST SUCCESSION ON THE WELL-DRAINED SOIL IN THE HIGGINS LAKE AREA OF MICHIGAN

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AN ABSTRACT

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DOCTOR OF PHILOSOPHY

Department of Forestry

Year 1954

Approved _____

Kim K. Ching

ABSTRACT

The upland forest of Higgins Lake area were studied in an attempt to set the pattern of secondary succession on this vast cut over land. Quantitative data were collected from five different vegetational covers - grassland, oak, aspen, jack pine, and conifer-hardwood types, by the quadrat method of sampling. Stands for studying were carefully selected so that (1) they represented natural forests of adequate size; (2) they were free from disturbances in the forms of fire, grazing or excessive cutting; and (3) they were on upland land forms on which run-off water never accumulated.

In the introduction, the place of forest ecology is briefly outlined. The basic information of original and present forest cover were also discussed. Sections following were devoted to analysis of the environmental factors listed as climatic, edaphic, and biotic. Comparisons between the composition of different soil types and profiles were subjected to analysis. Further work dealt with the development of plant communities and their interrelationship with various soil types and the influence of environmental factors on these different vegetational covers.

Through statistical studies, the following facts have been established: (1) evaporation increased rather uniformly with increased temperature and presents a more definite expression on different forest cover types. (2) the forest soils of most of the studied stands are strongly acid in the upper portions of the profile, especially the A layer. (3) in the presence of a sufficient supply of available nutrients, pH of soils is of minor

importance to growth of plants in the studied stands. (4) the moisture content of soil in the field varies according to vegetation types on different dates, but not at the six and eighteen inch depths. (5) the covering vegetation do not influence the soil organic matter content in the six sample plots. (6) soil temperatures are significantly different under various plant communities with the grassland type having a definite higher reading. (7) among all the factors which fall in the biotic group, destructive logging and fires are largely responsible for the present distribution of plant growth.

It was the opinion of the writer that the forest successional trend on this cutover land will progress in the following manners: the closed canopy of an aspen or oak stand will give place to a higher genetic type, the most frequent ones are pines on the sandy upland, whereas on the better soils, the invading species would be the beech, sugar maple and yellow birch predominantly. Under the present prevailing climatic condition, on the more xeric habitat with decreasing soil moisture, a red or white pine stage may be reached before the arrival of the formation of the northeastern coniferous climax. On more hydric sites, the conifer-hardwood type is often succeeded by the northeastern deciduous forest climax.

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I. INTRODUCTION

With the national forests, Michigan has over 6,000,000 acres of publicly owned forest land, nearly one-third of the total forest area of the state. These public lands are a source of current and future supplies of timber and at the same time serve a great and increasing public demand for hunting, fishing and other forms of recreation.

After a century and a half of settlement, land clearing, lumbering and forest fires, the area adjacent to Higgins Lake is essentially a cut-over region. The non-timbered character of much of the surrounding territory--the Great Plains to the west, and intensively farmed and industrial areas to the south--created demands for timber from Michigan and was a factor in causing early liquidation of the original pine forests. Likewise it is a feature deserving some attention in connection with future timber growth goals.

Today the region faces the problem of supplying as much as possible of its own timber needs without paying excessive cross-country freight, of supporting a very valuable pulp and paper industry and other wood-using plants, of giving employment to settlers in the poorer agricultural districts, and of stimulating an active tourist and recreation industry, all on a foundation of young second-growth timber. Only a very small remnant of the original virgin forests remains, and relatively small areas of second growth have reached saw-timber size. Nearly nine-tenths of the land which supports second growth from seedling to pole-size trees is in very poorly stocked stands.

In order to control the destructive agents that threaten to curtail and impair the usefulness of the forests, and promote and maintain conditions favorable to multiple use with a minimum of detriment to the forest, one must rely on the application of sound silviculture, which in turn is based upon biological facts and principles. Intelligent management of our forests cannot be achieved without thorough knowledge of the behavior of tree species and stands. Nature, unguided by man, produces a forest which is in complete harmony with the soil and the plant and animal life it supports. Such a forest is the climax forest toward which vegetation is always tending. Stable tree associations, characteristic of climax types, are best adjusted to meet the impact of counteracting forces. Such forests are inherently healthy; under good management they are easily maintained in a high state of vigor, thus increasing the growth-rate, their capacity to resist damage from insects, disease, and other destructive agents. However, this is not meant to imply that the climax forest type necessarily represents the ideal toward which management should invariably be directed, for other disturbances such as fire and repeated cutting, may alter the soil conditions to such a degree that the early establishment of species natural to the site may find difficulties to survive; or certain subclimax species possessing a higher value as far as their lumber is concerned, may justify efforts to maintain them as dominants in the stand. Nevertheless, compositions characteristic of climax associations should be used as guides for setting up silvicultural objectives.

The present paper deals with the general trend of succession in the

major forest types on the well-drained soil in the Higgins Lake area and their interrelations with each other and with certain physical factors of the environment. The plan of the investigation used in this work is an adaptation of the mass collection method used by taxonomists. (1) It is a well known fact that variation in floristic composition is one of the most important characteristics that may be determined in the study of any vegetation, and this may be understood only after a great many examples of the type have been analyzed.

It is important that the initial ideas of the type limits be sufficiently broad to preclude the dangers of subjective selection of only those stands which fit a preconceived notion as to what a particular community should be. The criteria used for the selection of stands for this study were: (1) that they be natural forests of adequate size, not artificially planted; (2) that they be free from disturbances caused by fire, grazing or excessive cutting; (3) that they be on upland land forms on which run-off waters never accumulate.

II. REVIEW OF LITERATURES

1. On the Studied Area

The northern part of the Lower Peninsula of Michigan lies in the edge of the deciduous forest province, and is also occupied by the southern border of the northeastern conifer province. These facts are responsible for the great variety of associations present, and the successional relationship are often much involved in consequence (75).

Current opinions and activities toward revegetating exploited and submarginal land in the Lake States (84, 53, 54) justify the expenditure of considerable time in improving our knowledge of the behavior of native species and the successional trends under the stress of prevailing conditions.

Numerous papers (43,31,67) have appeared during the past few decades dealing with the general ecology and distribution of types of vegetation in Michigan. Dice (31) placed this region in the Alleghenion biotic province. The thorough investigation of Michigan flora have been well done by Beal (68), Farwell and others (35,67). Vegetation of the sand plains were given special attention in these preliminary studies. It has also been shown that there is great competition between the various associations of the above-mentioned two complexes wherever they come in contact, and that in general the associations of the southern complex tend to displace those of the northern. This was early demonstrated by Whitford(102), Gleason (42) and Quick (75) who discussed the general

distribution of the associations throughout the lower Peninsula of Michigan.

The early days of lumbering and destructive forest fires which had alarmed the country caused many investigations and suggestions as how to utilize this vast area of cut over land (2) (47) (84) (46).

Other investigators such as Veatch (91) reconstructed the forest cover of Michigan from soil maps and determined the correlations between soil types and forest growth.

Terminology used in this study is essentially as defined by Braun-Blanquet (14), and names of forest cover types were adapted from the publication of Society of American Foresters (81). Reference is also made to Cain (23) who has discussed the forest climax and its complexities in his work concerning some phytosociological concepts.

2. Concept of Succession

In forest areas, the perennial herbs are soon superseded by woody plants, which become dominant; when a cultivated field is permitted to lie fallow, it produces a crop of annul weeds the first year, numerous perennials the second year, and a community of perennials thereafter. If any disturbance of natural vegetation occurs--such as cultivation, lumbering or fire, a similar sequence of communities appear with several changes in the dominant vegetation through the years. This is the general trend of plant succession. However, it was not until the seventeenth century that any systematic study of such changes was made, and those studies dealt primarily with the development of peat bogs. Bog

studies were continued in the eighteenth century and in addition some attempt was made to apply principles of Ecology to burned and disturbed upland areas. It was then that the term "succession" was first applied to the vegetational changes involved. It was during the years of 1860 (26) that a regional study of vegetation in Central Europe was made in which succession was recognized as fundamental to all community development.

Between 1890 and 1905, the modern concepts of succession were clarified through the efforts of several workers such as Cowles, Clements. The idea about succession is that plant communities are never completely stable. They are characterized by constant changes, sometimes radical and abrupt, sometimes so slow as to be scarcely discernable over a period of years. These changes are not haphazard, for within a climatic area, they are predictable for a given community in a particular habitat. This means, of course, that similar habitats within a climatic area support a sequence of dominants that tend to succeed each other in the same order. Contrasting habitats do not support the same sequence of communities. As a result, any region with several types of habitats will have an equal number of possible successional trends.

In the course of studying plant succession, a specific, immediate cause of a particular change of species may not always be obvious because of the interrelationship of controlling factors. However, two general types of habitat change may cause differences in the community, namely, development of the community causes parallel developmental changes of the environment, and physiographic changes can likewise modify the envi-

ronment materially. Developmental changes of the environment may result from reactions upon the habitat by the organisms living there, such as the case in accumulation of litter on the forest floor affecting run-off, soil temperature, and the formation of humus. Accumulation of litter, in turn, contributes to soil development, modifies water relations, available nutrients, pH value, aeration, and affects soil organisms; whereas the habitat may also be modified by forces quite apart from the effects of organisms. A flood plain or swamp may become better drained as a stream cuts more deeply into its channel; and silting in off a lake raises the level of mineral soil. Such modifications of the habitat also produce vegetational changes. These two types of habitat changes caused by the development of the community or physiographic origin are commonly in operation at the same time and their effects cannot always be readily separated.

Ecologists of various parts of the world have agreed that the type of plant succession on a bare area where no vegetation has grown before is designated as primary succession. It may be observed on glacial moraine exposed by recession of ice, or a new island or any similar habitat newly exposed to colonization. A migratory advance postulates the development of individuals in territory not previously occupied and requires an environmental change of sufficient extent in order to permit the growth of the migrants. Each successive group of species to colonize a new area meets with increased competition. Succession results when migration is so complete and is shared by individuals of so many species that the nature of the vegetation is fundamentally changed. Moisture

relationships usually control the ability of the pioneering plants which invade the new area. If the habitat is extremely dry it is described as xeric; if wet, hydric; and if intermediate, mesic. The successional trends are similarly referred to as being xerarch, hydrarch or mesarch succession. Whatever the condition of the initial habitat, reaction of vegetation tends to make it more favorable to plants and always results in improved moisture conditions. Thus xeric habitats become more moist and hydric ones become drier as succession progresses.

On the other hand, secondary succession results when a normal succession is disrupted by fire, cultivation, lumbering, wind throw, or any similar disturbance that destroys the principal species of an established community. Although the first communities that develop again on this area may not be typical of primary succession, the later stages again are similar. The rate of this vegetational change depends, of course, on the severity of the disturbance.

All successional trends lead toward relative mesophytism within a climatic area and eventually lead to a single community, which is composed of the most mesophytic vegetation that the climate can support and whose moisture relations are average or intermediate, for the region as a whole. This community, determined by the climate, terminates succession and is called the climax community or climax for that climatic area. It is capable of reproducing itself, and since it represents the last stage of succession, it cannot be replaced by other communities so long as the climate remains the same. It is, therefore, a stable community in which the individuals that become overmature and die are replaced by their own progeny, leaving the character of the community unchanged.

Just as portions of a single species may be isolated during its migrations, so areas of one type of vegetation may be completely surrounded by an advancing flora and left isolated from the main body. These are known as relic colonies. An important cause of such isolation is the failure, up to the present time, of sufficient environmental change to cause their extinction, or, in ecological terms, it is the relative slowness of the succession in certain habitats unfavorable to most of the advancing species.

III. DESCRIPTION OF THE STUDIED AREA

1. Climate

All areas of the Higgins Lake area have a similar climate with essentially the same distribution of precipitation and temperature during the year.

The main features of the climate are a mean annual temperature of 41-43.1° F., a normal precipitation (including melting snow) of about 27-30 inches, probable annual snowfall of about 60-73.6 inches, low wind movement, low evaporation, low percentage of sunshine and moderately high humidity.

The precipitation (rainfall and melted snow) is quite evenly distributed throughout the year, except that the six months from April 1st to October 1st, get a little more than the six months from October 1st to April 1st. There is, of course, some noticeable variation during different years. As much as 11 inches below normal distribution has been reported, and as much as 17 inches above normal.

The rainfall generally occurs as low gentle rains or showers; but cloud-bursts, hail storms and tornadoes are rare. In the forest, however, the evidence of past wind and hail storms is shown by the old windfalls and the hail marks on the trunks of the pines. The prevailing winds are westerly.

The summers are characterized by moderate temperature, with a seasonal average from June to August, inclusive, of 63-65.9° F., and a

high percentage of sunshine. The pleasant summer compensates for the length and rigor of winter. Snow forms a permanent ground cover ordinarily from November to early in April, freezing to sub-zero temperatures are common. However, the winter has many pleasant days when the temperature rises well above freezing.

Real spring weather usually starts during the latter part of April or early in May. The growing season, that is the season ordinarily free from killing frost, will average about 114-122 days. The season extending from the latter part of May to the middle of September is the average frost free season, but frosts of sufficient severity to kill tender vegetation have been known to occur during every month of the year (25).

2. Geology

Geologically the lower Peninsula is known as the Michigan Basin, because the rocks are all sedimentary, and the strata lie one upon another like a pile of saucers with smaller ones towards the top.

The Mississippian, which is known as a part of the Carboniferous time was one of abundant vegetation and brackish and shallow waters in the Michigan Basin. Rocks of Mississippian age outcrop in a broad somewhat circular band occupying most of the Lower Peninsula, except about a dozen of the central counties. Mississippian rocks consists of sandstones, limestones, shales, salt and gypsum, and are perhaps the most important sedimentary rocks in Michigan (62) (50).

At the time of the glacial period some 15,000 to 50,000 years ago, the great ice-sheet covered Michigan and extended as far south as the

valley of the Ohio River. After several retreats and re-advances, the final retreat of the ice left the State with its former rock masses planed down, its former valleys filled, and its surface covered with a general mantle of rock-debris and drift with variation in thickness. The soils thus derived are various in character, as well as in origin (61) (Figure 3).

The significance of this fact was pointed out by Beal (5,6,7,8) in his publications on Michigan Flora that probably three-fourths of our plant species are common to all sections, though by no means equally distributed, some being very abundant in one district and rare in another at no great distance. In most cases such change is due to soil rather than to differences in elevation, temperature or atmospheric moisture.

3. Original Vegetation

The entire land area of Northern lower Michigan at the time of its first occupation by white men, was covered by a dense forest except for a small inconsequential acreage of bog or marsh and some open land on the drier sand plains. Most of this virgin forest was white and red pine, with smaller areas of hardwoods and swamp forests (43).

In its virgin condition, the forest was made up of several types of forest-growth or tree associations that were distributed with close regard to the natural differences in soil character and drainage. The following types of forest were represented: (1) The pine forest in which white, red pine or red and jack pine predominated; (2) The hard-

wood forests in which hard maple, beech, yellow birch and hemlock were the principal species and elm, basswood, ash and white pine were subordinate species; (3) The mixed deciduous and coniferous forest, in which such species as oak, elm, ash, red maple, aspen, and yellow birch were intimately associated with white pine, red pine or red and jack pine predominated; (4) The lowland Hardwood Forest in which elm, black ash, yellow birch, red maple, white birch and balm of Gilead were the principal species, but seldom without a subordinate amount of white cedar, balsam fir, and tamarack; (5) The coniferous swamp forest consisting of a mixture of white cedar, balsam fir, black spruce and tamarack, but including also limited areas of more nearly pure cedar, spruce, and tamarack (91).

There were, of course, innumerable situations where two or more of these associations merged to occupy soil and drainage conditions of intermediate or transitional character and developed a forest of more diverse composition than outlined above.

The following diagram (Figure 1) prepared by Wilde (97) fully illustrates the general distribution of the original forest types on different geologic formations in the Lake States.

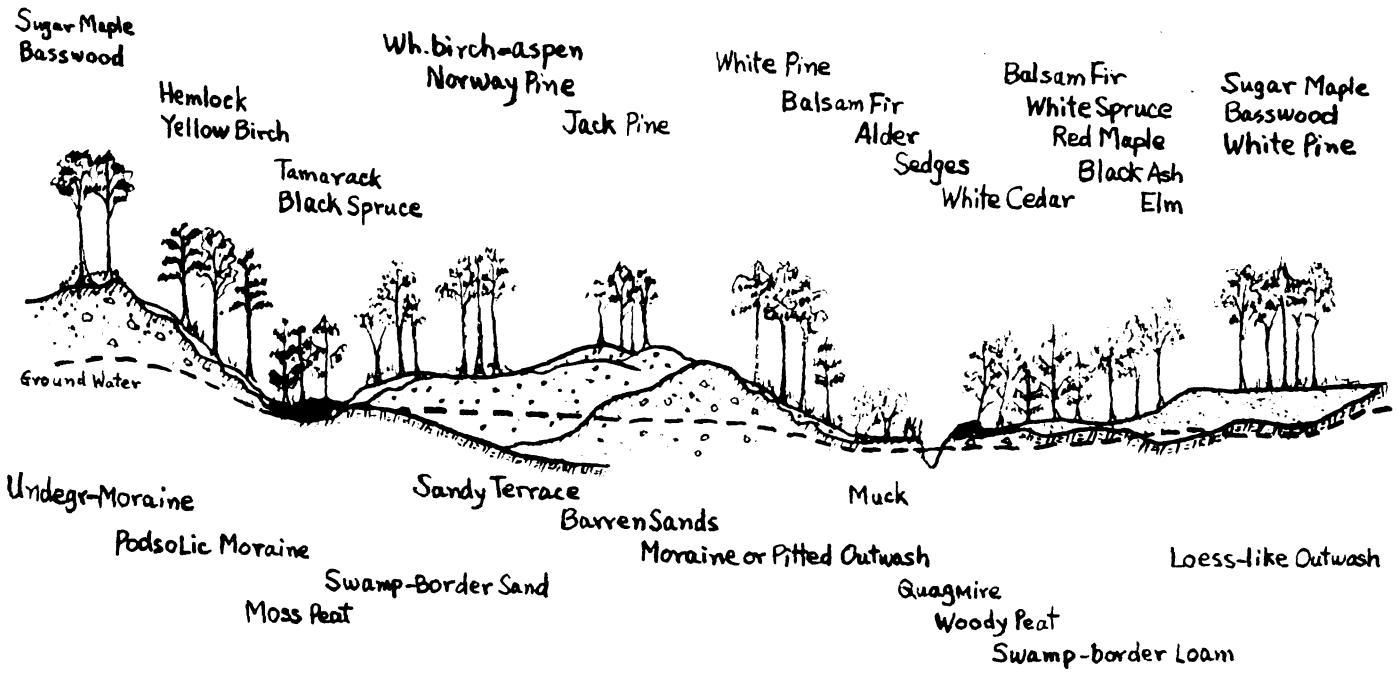


Figure 1. General Scheme of The Original Distribution of Forest Species In Relation to The Water Table, Texture of The Soil and Podsolization in The Glaciated Area of The Podzol Region of The Lake States (After Wilde, 1935)

4. Present Vegetation

Much of the rolling to hilly part of the former pine forest land has been converted to desolate stump land, covered with a dense growth of brush, briers and grass, or has grown up to aspen, scrub oak and red maple with very little natural reproduction of the original dominant species. The level pine plains now support a patchy stand of jack pine with sweet fern, low blueberry, bracken fern and grasses in the openings. The hardwood forest lands where not cleared for farmland, are now partly occupied by stands of second growth hardwood of varying age, density, and quality, and partly by the growth of briars, grasses and tangled reproduction that has covered the burned over slashings. The open bogs have a low shrubby growth of leather leaf, Labrador tea, and blueberry with sphagnum moss and cotton grass. The marsh growth consists of a variety of sedges with reeds, cattails and blue-joint. The swamps have suffered less change in the character of their forest growth than the uplands. Poplar, alder and willow have encroached on the severely burned cut-over swamps but elsewhere the present growth contains a generous reproduction of the original species.

5. Description of Various Types of Forest on the Well-Drained Soil

The white pine. This type of forest is of little importance in this study because the natural growth total acreage is small. The original pine stands of this type have nearly disappeared due to destructive logging practices and subsequent fires. Today only one area of virgin white pine remains near the region, the Hartwick Pines, located near

Grayling in sections 15, T. 27 N.R. 3W. The white pine, according to other reports, very seldom is found in pure stands, but often mixed with a small percentage of red pine (58). Mixture with other species is also quite common so that on the sandy sites the white pine stands usually contain more or less red pine, oak and aspen as the principal associated species, while on the more loamy sites the associated species may consist of hemlock, maple, beech and yellow birch. So far the white pine has not been able to reproduce itself to any general extent on the area formerly occupied by the virgin white pine stands.

The red pine type. This type, like the white pine, was one of the most valuable produced in the virgin forests and likewise was exploited at an early date. Today, its importance in the region is small because of its limited acreage. The red pine, like the white pine, has also been unable to reproduce itself extensively because of repeated fires that followed the destructive logging methods (102). The red pine type is generally limited to the so-called "poor site", i.e. the drier and sandier types of soil. This is largely due to the fact that red pine cannot compete with the hardwoods for continuance as a type on the better classes of land which favor hardwood reproduction.

Jack pine type. It occurs both in pure stands and in association with other species. It is found mixed with white and red pine on their preferred sites and is commonly found growing with oak and aspen on the drier white and red pine sites. Repeated burning on red pine and sandy white pine lands usually results in a stand of pure jack pine or jack pine and poplar. The type is rather wide spread and has persisted in

spite of the abuse from cutting and fires. Jack pine is considered by many as a "weed tree", since it so commonly takes possession of old abandoned fields and heavily burned lands in this part of the state. It is the principal forest type on the admittedly poor, loose, dry, strongly acid, deep sandy soils. This species starts to seed early in life and usually reproduces itself well under ordinary conditions since dense stands commonly come in on the pine areas that have been recently burned over. The chief defect of this type as it exists today is the fact that the stands occur in densely stocked clumps with open spaces and poorly stocked areas in between. The present utilization for jack pine is principally for box boards, lath and some rough lumber, though in other localities it is also being used for pulp.

Northern pin oak type. This is the most widely spread species of the region. Formerly, because of the prevailing poor site condition, the oak stands were generally considered of little future value for commercial production. They were commonly understocked, short-boled as a rule, and frequently showed much fungus and fire damage. At present, under the protection from fire, in general the diameter growth of these stands has been fair and the height growth has been satisfactory. To-day a large proportion of this type consists of open ragged stands of straight bole trees and clumps of sprouts of other species.

Red oak, white oak, Hill's oak are commonly represented in the oak stands. The common associated species are aspen, red maple and frequently jack pine. This mixture produces open stands where all individuals have plenty of room to grow. Occasionally scattered red pine- a remnant of

the previous pine types-- is also included. The oak type reproduces easily from seed and sprout and has gained ascendancy over land where previously only individuals existed in the virgin stand. In fact, there is little indication that a pure oak type existed alone in the virgin forest. The type owes its existence largely to the fact that the oak was able to replace white and red pine after the pine was cut. It is the most common type on the rolling to hilly sandy and sandy loam soils. This type is apparently there to stay for a long time since it occupies areas on which red pine, together with some white pine formerly grew, and there are only a few scattered pine seed trees left. To all appearances, the red pine is not restocking these areas. Oak will likely remain the dominant type in these areas unless some other species are artificially planted. It has a rather wide and general distribution over the region as an associate in combination with jack pine, poplar and red maple. With fire protection, tie material can be produced but where fires are allowed to reburn the area at frequent intervals, the oak is reduced to a clump growth.

Northern hardwood hemlock type. The principal associated species of this upland hardwood type are sugar maple, beech, elm, basswood, and yellow birch with an occasional hemlock, white pine and black cherry. The basswood and elm are usually absent on the lighter, sandier hardwood soil. . According to the record of Land Economic Survey of Michigan, there is a considerable difference in the composition of the virgin and second growth stands. The virgin stands usually contain all of the species mentioned above while the second growth stands are predominantly

maple (58). This condition no doubt is traceable to the maple's ability to reproduce freely from seed.

Not too large an area is now occupied by the hardwood type and nearly all of it has been cut over. At the present time, the bulk of the hardwoods is limited to the loamy sand soils because the heavier loam soils that it once covered are now mostly cleared for farms.

The condition of the present day hardwood type varies considerably. The virgin stands which remain are generally well stocked, but the second growth ranges from excellently stocked to very poor. The variable condition in the stocking of the second growth stands is due very largely to the occurrence or non-occurrence of fire following the logging operation. The capacity of hardwoods to reproduce more prolifically than pine types has enabled them to withstand to better advantage the destructive effect of logging and fires.

The most profitable use of most of the timber produced in this type is for saw logs. Chemical wood is in demand in some sections for the small inferior material and the sound portion of large "cull" trees.

Aspen type. On the basis of the area occupied, the aspen type is third in importance to the oak and jack pine types. The type is composed of trembling aspen, large-toothed aspen and Balm of Gilead. Trembling aspen is the major species and is found to some degree on all sites occupied by the type. Large toothed aspen is found to make up a significant portion of the stand on the dry sandy hills and on areas where the type is in association with the oaks. Balm of Gilead is the least important species of the aspen type. It is found associated with the trembl-

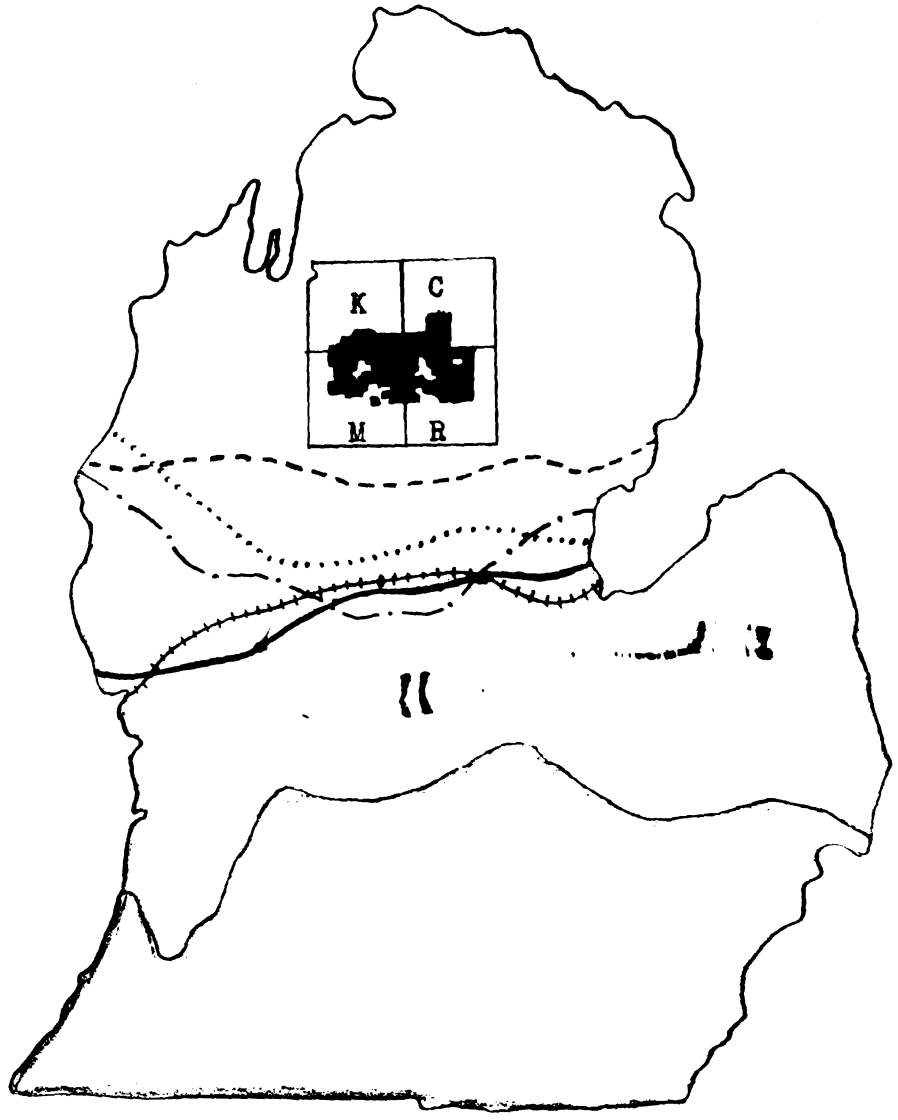
ing aspen only on the more moist upland sites and the better drained swamp sites. Variations from the pure aspen stands, however, are common. These variations include mixtures of the two aspens and the oaks, red maple, white birch and conifers.

The condition of the type from a commercial standpoint is not very promising. Like the oak type it reproduces easily from seed and sprouts, and is chiefly a replacement type after fires. The stocking is generally fair to good, but on the poorer sites the trees often remain small and die at early age. Fungus and insect damage is rather common (102).

The type on the more favorable sites does have some value, however, for pulpwood, excelsior and box boards. Probably its chief value at present is in providing game cover, in erosion prevention, and as a nurse crop for more valuable species.

The aspen type occurs on nearly every class of soil and site from denuded hardwood and pine uplands to swamp lands. On most of the soils, it exists as a temporary cover, and is quite easily replaced by other species in time (51). Usually on the hardwood sites, the area will eventually revert to the original growth if fires are kept out(35). Repeatedly, hardwood burned over areas generally restock with the aspen type because of its ability to reproduce from sprouts. However, the best stands of aspen are produced along stream bottoms and on lowlands which are less frequently invaded by fire .

Aspen and paper birch type. It occurs in small areas scattered throughout the region. This type is usually found on the moist sand, sandy loams and loams, although it may occur on practically all soils



Legend:

- Spruce
- Jack Pine
- Oak-Hickery
- Podzol
- Brown Forest Soil
- Red Pine
- White Pine
- N.Boundary of Beech-Maple
- Transition Soil
- Higgins Lake State Forest

K.....Kalkaska County
C.....Crawford County
M.....Missaukee County
R.....Roscommon County

Figure 2. Map of Lower Michigan Showing Boundary Between the Beech-Maple and Hemlock-White Pine-Northern Hardwoods Regions, and its Relation to tree ranges and Soil. (After Braun, 1950 and Veatch, 1928)

from the drier sands to mucks. It reaches its best development on the heavier soils. It occurs on nearly the same range of sites as the aspen type, with the exception that white birch drops out of the association on the drier, sandier soils. The poplar and white birch type makes a good cover or nurse crop for planted red or white pine if constant attention is given to the removal of competing vegetation (75). The majority of the natural seeded young red and white pine is found growing under an over story of this type. Given fire protection, poplar and white birch reach mechantable size in a comparatively short period. It has further value for game cover. The present utilization of poplar is chiefly for excelsior bolts and to a great extent for pulp. The large size of white birch has an extensive use in novelty manufacturing.

6. History of Economic and Social Changes

In 1840 the northern part of the southern peninsula of Michigan was divided into counties. At that time the area now known as Crawford County was called "Shawona", the name of a famous Chippewa chief. Later in 1843, the name was changed to Crawford. In 1871 and 1875, Kalkaska and Roscommon counties were organized respectively. Settlement began in 1872. In the early days of this area's development, the lumber industry unquestionably brought the largest number of people into the counties. At the same time agriculture was also gaining a foothold so that the population on farms was being increased. Due to the fact that new lumber camps and the continued inflow of mill workers and woodsmen created a good market for farm produce, the agricultural population also increased rapidly.

After the lumbering operations started, the farmers did not depend entirely on agriculture for a livelihood. These pioneer families usually made their homes on the farm for the entire year but the older boys and men worked in the logging camps during the winter and customarily spent only the summer months at home clearing land and working on the farm. Hunting and trapping, cutting ties and hemlock bark, and working in the wood-using industries were other sources of income for the pioneer farm settlers.

The logging operations of the former decade had left great areas of cut-over pine and some hardwood land. Much of this had been burned over by forest fire. Farm settlement was not then being attracted to these cutover land. For large area of this former timber land, no promisingly profitable use seemed evident and tax payments were being defaulted on such land by their owners.

Around 1900, when most of the virgin timber had been cut, and the value of the lakes for resort and recreation purposes had not yet been generally realized, the county fund of all the counties which comprises the Michigan "pinery" were in a bad condition. Of course, the hard-pressed financial conditions were being felt more keenly by those counties which had the largest area of cutover pine lands.

Beginning in 1902, various intensive real estate selling operations were carried on, various holdings were disposed of to land seekers and settlers from southern Michigan and neighboring states for poultry farms and general farms and ranches. Most of these settlers have since left their farms and their lands have reverted to the state for delinquent taxes.

During all these years, federal and state land laws encouraged settlement, and numerous grants were made to open up the country and get land on the tax roll. However in northern Michigan, the tax base was shrinking and tax delinquency mounted. Here farms have not replaced forests to the extent as expected; in fact, by 1920 that part of the state had fewer farms than in 1910. There were large and increasing areas of cutover, burned-over, idle lands. The following table shows major changes in land use from 1924-1939 in Roscommon county (2).

Table 1. Major changes in land use from 1924-1939 in Roscommon County, Michigan.

Type of land use	1924	1939	net change in area +	net change in area -
Forest	319,167	320,692	1525	-
Farm	15,529	11,939	--	3,590
Abandoned	3,865	5,305	1440	--
Other	35,443	36,068	625	--

7. Present Land Use

The most recent development in this area has centered on resort and recreational property. During the years when travel was still mainly confined to the railroad and horse-drawn vehicles, access to lakes of the area was considered difficult so that their development lanquished. With the advent of improved roads and motor transportation, however, various lakes and surrounding areas began to attract more summer visitors each year as hunting, fishing and outing grounds.

The data which were obtained by Andrews and Bromley (2) in studying trends in land use in northern Michigan, show that shift from one land

use to another are constantly taking place; nevertheless, many settlers, particularly since the depression, are still trying to make a living on soils too poor for profitable agriculture. Their report reveals that the recent measures of fire protection have so greatly improved forest conditions that it is possible to expect the region to be able to produce considerable quantities of merchantable forest products in the near future. The data also indicate that recreation has increased so enormously as to constitute one of the major forms of land use in the region. Consequently, little or no tax delinquency occurs in most of the area today.

As far as timber resources are concerned, this region is by no means a worthless area as it is still generally regarded, but contains extensive areas of conifers and hardwood lands, and the latter, especially is valuable for farming purposes. Whether or not this conversion of forest land into farm may be less profitable to the state at large than the continued production of timber will not affect the case. For when there are lands of such value for farming, they will be purchased and held for this purpose and the interest of the state will in the end have to be adapted to those of the individual, provided the land is being utilized properly.

The public agencies, both through actual land ownership and through cooperation with private owners, have an important part to play in the future development. Adjustment in land use and improved resource management are still needed.

IV. THE STUDY OF VEGETATIONAL COVERS

1. Terminology

A. Frequency. It has to do with homogeneity, the uniformity of distribution of species throughout a community. It is the ratio of number of quadrats containing a given species to number of quadrats surveyed, expressed as a percentage. The relative homogeneity of stands and communities may be compared graphically by frequency diagrams, provided quadrats of the same size be employed. These diagrams show percentage of species belonging to each frequency class. The five frequency classes here used are as follows:

Class A -- species in 0-20 percent of quadrats.

Class B -- species in 20-40 percent of quadrats.

Class C -- species in 40-60 percent of quadrats.

Class D -- species in 60-80 percent of quadrats.

Class E -- species in 80-100 percent of quadrats.

Quadrat frequency (F_q) is expressed as the percentage of quadrats in which

(1) a given size class of a given species occur i.e. frequency per size class per species

$$F_{qn} \text{ of species A} = \frac{\text{No. of quadrats in which size class n of A occur}}{\text{Total number of quadrats examined}} \times 100$$

(2) a given species occurs i.e. frequency per species.

$$F_{qs} \text{ of species A} = \frac{\text{No. of quadrats in which species A occur}}{\text{Total number of quadrats examined}} \times 100$$

(3) relative frequency (F_r) -- a relative expression (as a percentage) of the frequency for a given species as obtained by F_q and based on the total of the frequency values for all species

$$F_r \text{ of species A} = \frac{\text{Frequency of species A} \times 100}{\text{Sum of frequency values for all species}}$$

B. Density. It is the number of individuals on a unit area basis. The number of individuals recorded from the actual area surveyed were reduced to an acre or quadrat basis.

(1) D of species A = $\frac{\text{Total no. of individuals of species A counted}}{\text{Total no. of quadrats examined.}}$

(2) Relative density (D_r) -- a relative index of plentifulness expressed as the percentage representation of:

(a) Each species, based on the total number of individuals counted i.e. relative density per species.

$$D_r \text{ of species A} = \frac{\text{Total no. of individuals of species A counted} \times 100}{\text{Total no. of individuals of all species}}$$

(b) Each size class of a species, based on the total no. of individuals in that size class i.e. relative density per size class per species.

$$D_{rn} \text{ of species A} = \frac{\text{Total no. of size class n stems of species} \times 100}{\text{Total no. of size class n stems of all species}}$$

(c) Each size class, based on the total number of individuals counted in all quadrats.

$$D_{rc} \text{ of size 2} = \frac{\text{Total no. of individuals of size class 2 counted} \times 100}{\text{Total no. of individuals of all size class}}$$

C. Abundance. This term is an appreciation of the relative number of individuals of each species entering into the constitution of the plant population of the territory under study. A scale of five degree of abundance is suggested by Braun-Blanquet (14).

A1. -- species very rare in the community.

A2. -- species rare in the community.

A3. -- species not very abundant in the community.

A4. -- species abundant in the community, and

A5. -- species very abundant in the community.

The value of abundance estimates depends on the extent of area, richness and variability of the flora, and the ability and experience of the estimator.

Abundance is also expressed in a more concrete way in this study in the following manner for the tree species.

Abundance (A) -- the average number of individuals of a tree species per quadrat considering only the quadrats in which the tree species is represented

$$A \text{ of species } B = \frac{\text{Total no. of individuals of species B counted}}{\text{No. of quadrats in which species B occurs}}$$

$$\text{But } D = \frac{\text{Total individuals}}{\text{Total quadrats}}$$

$$\text{and } F_q = \frac{\text{Quadrats of occurrence x 100}}{\text{Total quadrats}}$$

$$\text{so } A = \frac{100D}{F_q}$$

D. Cover. It deals with the surface covered by individuals of the herb and ground layer vegetation. The five-point scale of Braun-Blanquet was further subdivided. Class 1 was divided into two classes: class o representing species with less than 1 percent coverage, and class 1, representing species covering 1 to 5 percent of the surface. This proved very satisfactory since such a large number of species occurred in each

community with coverage less than 1 percent. The six point scale as used in this study follows:

Class 0— species covering less than 1 percent of the ground surface.

Class 1— species covering 1 to 5 percent of the ground surface.

Class 2— species covering 5 to 25 percent of the ground surface.

Class 3— species covering 25 to 50 percent of the ground surface.

Class 4— species covering 50 to 75 percent of the ground surface.

Class 5— species covering 75 to 100 percent of the ground surface.

E. Basal area. It is a concept of foresters and is the total cross-sectional area in square feet of the stems of a tree species based on diameters at breast height. This is a convenient way to show physiological dominance of tree species, since there is probably a close correlation between basal area and the surface or volume of tree crowns.

Relative basal area (B_r)— a relative index of dominance expressed as the percentage of basal area occupied by a given species.

$$B_r \text{ of species A} = \frac{\text{Total B.A. occupied by individuals of species A}}{\text{Total B.A. occupied by all species}} \times 100$$

2. Method of Sampling

Quantitative studies of plant communities yield valuable data relative to the number, size and dispersion of community elements. The value of such data accrues in large part from the statistically valid means they provide for comparison of plant communities in either space or time, or in the concrete or abstract sense. Also, as a permanent record, they are subject to reconsideration by other investigators, who may reinterpret them in the light of additional experience or information.

Usually the numbers of an entire plant community cannot be counted or measured, and even if this were done, the information would be no more useful or significant than an adequate set of data acquired by proper sampling.

However, prior to sampling, observation and reconnaissance of the community are of extreme importance in determining where, how, and what to sample. The community should have been observed repeatedly in different parts of its range and more particularly under the varying local conditions where it exists. Finally, the specific stand should be observed thoroughly to determine its obvious variations, its extent, this together with the size of individual plants, the strata present, and the purposes for which the sampling is to be done, one may plan his procedure in terms of the desired results, the necessary degree of accuracy, and the time available for doing the work. This is the exact procedure this writer has carried out in this study.

In this ecological study, the list-count quadrat method has been used. This method was subjected to some modification depending upon circumstances. For trees, the individual diameters were also recorded and segregated into different size classes according to Weaver and Clements (94) as the following:

Medium reproduction size class 2; more than 6.0 ft. high and up to 0.9 inch D.B.H.

Large reproduction size class 3; 1.0 in. to 3.5 in. D.B.H.

Small trees size class 4; 3.6 in. to 9.5 in. D.B.H.

Large trees size class 5; 9.6 in. or more D.B.H.

The basal areas (indicative of dominance) for tree species were also computed. Increment borings also were taken from representative trees of various species to determine their approximate ages.

The cover of ground vegetation were recorded by height class designated as:

Class 1. Plants up to 0.9 foot tall.

Class 2. Plants from 1 to 3 feet tall.

Class 3. Plants over 3 feet and up to 6 feet tall.

In this type of study, as one soon learns, the major concern is to get adequate data with a minimum of effort. With this object in mind, 16 milacre quadrats were used on grassland type sampling while 16 one-fifth acre square plots, with 93 feet on each side for sampling tree species were employed for the four different forest cover types. The location of such quadrats were randomly placed within the realm of the stands where the border effect of streams or ponds or highway would be minimized. And smaller quadrats (one-tenth of an acre and one thousandth of an acre) for sampling subordinate strata were to be "nested" in the largest quadrat.

All field data were recorded on "Field-data Quadrat" sheets, one such sheet being required for each quadrat.

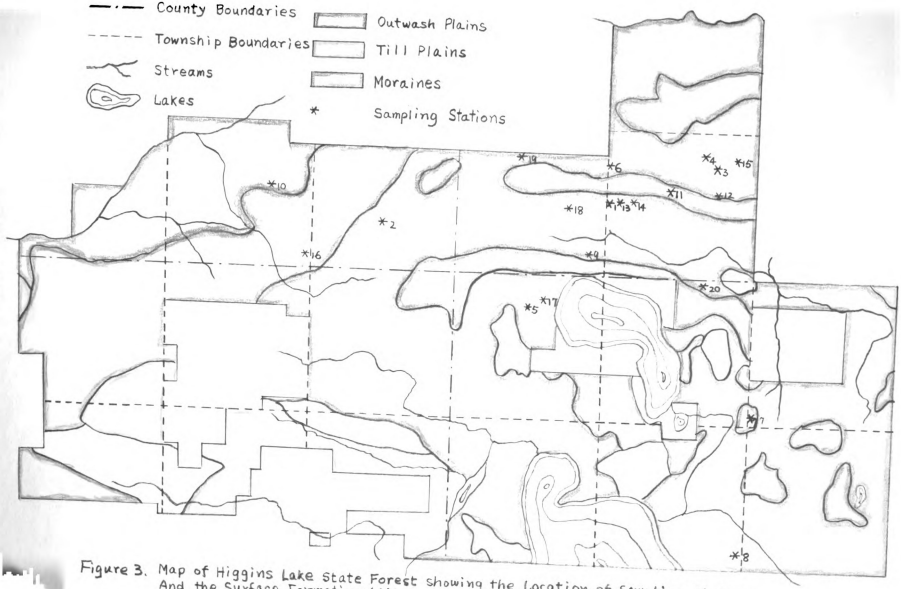


Figure 3. Map of Higgins Lake State Forest showing the Location of Sampling Stations And the Surface Formations (After Leverett 1924)

3. Observation

Grassland type. The type of upland grass occupies those open burned wild lands on which the established cover includes the genera Andropogon, Poa, Danthonia, Agrostis, Schizachne, Bromus and Koeleria. One of the characteristic plants of this area is the sweet fern (Comptonia peregrina) located chiefly on the drier sandy pine plain where no type of forest cover has been established. The only true fern species that is really abundant and becomes a component of the ground cover is the common brake, which forms large patches in the light soil of the plains. W. J. Beal (8) made statistical studies showing that 95 percent of the plants common in the "Jack pine" plains are perennials with deep roots or rootstocks adapted to severe conditions of drought or of surface-burning. Nearly half of them are included in the four plant groups, namely, the Compositae, the Gramineae, the Rosaceae and the Ericaceae.

In the spring, wild flowers such as one of the bluets (Houstonia longifolia), sand violet (Viola adunca), pink milkwort (Polygala polygama) are certain to attract the attention of the visitor to this region, and during the summer or early fall other species lend their color to the landscape, such as blazing star (Liatris Nieuwlandii), wild sunflower (Helianthus occidentalis), a golden rod (Solidago spp.). In August especially, cudweed(Gnaphalium Macounii) may be seen whitening here and there.

Table 2. Data of the vegetation in the milacre quadrats of the grassland type as recorded in percentage of coverage or number of plants by height classes.

Station 1 Location: SW¼, Sec.18, T26N, R4w.	Distribution of Coverage Classes for the Type Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Agrostis scabra	3	-	-	2	-	-	2	-	-	3	-	-
Arabis glabra	-	-	-	-	-	-	-	-	-	0	-	-
Arctostaphylos Uva-ursi	-	-	-	-	-	-	2	-	-	-	-	-
Artemisia caudata	1	-	-	-	-	-	-	-	-	1	-	-
Aster laevis	0	-	-	1	-	-	1	-	-	1	-	-
Bromus Kalmii	1	-	-	1	-	-	-	-	-	1	-	-
Campanula rotundifolia	-	-	-	0	-	-	-	-	-	-	-	-
Carex tonsa	3	-	-	2	-	-	2	-	-	3	-	-
Cirsium Hillii	-	-	-	0	-	-	-	-	-	-	-	-
Comptonia peregrina	1	-	-	3	1	-	2	1	-	2	1	-
Convolvulus spithamaeus	1	-	-	1	-	-	0	-	-	1	-	-
Danthonia spicata	0	-	-	1	-	-	1	-	-	0	-	-
Erigeron annuus	1	-	-	1	-	-	0	-	-	-	-	-
Erigeron racemosa	0	-	-	-	-	-	-	-	-	-	-	-
Fragaria virginiana	1	-	-	1	-	-	0	-	-	1	-	-
Gnaphalium Macounii	-	-	-	-	-	-	-	-	-	1	-	-
Hieracium aurantiacum	2	-	-	-	-	-	0	-	-	-	-	-
Hieracium venosum	0	-	-	-	-	-	-	-	-	0	-	-
Houstonia longifolia	1	-	-	1	-	-	0	-	-	1	-	-
Lactuca canadensis	0	-	-	0	-	-	-	-	-	0	-	-
Liatris Nieuwlandii	0	-	-	-	-	-	-	-	-	1	-	-
Lithospermum arvense	0	-	-	-	-	-	-	-	-	-	-	-
Physalis subglabrata	0	-	-	-	-	-	-	-	-	-	-	-
Polygala polygama	-	-	-	0	-	-	-	-	-	-	-	-
Poa compressa	1	-	-	1	-	-	-	-	-	-	-	-
Prunus pumila	1	-	-	-	-	-	0	-	-	-	-	-
Prunus virginiana	-	-	-	-	-	-	-	1	-	-	-	-
Pteridium aquilinum	1	1	-	1	1	-	-	-	-	-	1	-
Rubus idaeus	2	-	-	1	-	-	2	-	-	3	-	-
Rumex Acetosella	1	-	-	1	-	-	0	-	-	1	-	-
Salix humilis	1	-	-	-	-	-	-	-	-	1	-	-
Schizachne purpurascens	0	-	-	-	-	-	-	-	-	-	-	-
Senecio Balsamitae	-	-	-	0	-	-	-	-	-	-	-	-
Solidago canadensis	0	-	-	1	-	-	1	-	-	0	-	-
Solidago juncea	0	-	-	0	-	-	1	-	-	0	-	-
Solidago racemosa	0	-	-	1	-	-	1	-	-	0	-	-
Viola adunca	0	-	-	1	-	-	0	-	-	0	-	-

* number of plants.

Table 3. Data of the vegetation in the milacre quadrats of the grassland type as recorded in percentage of coverage or number of plants by height classes.

Station 2 Location: SE¼, Sec. 24, T25N, R6W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Agrostis scabra	1	-	-	0	-	-	-	-	-	-	-	-
Andropogon scoparius	-	-	-	1	-	-	-	1	-	1	-	-
Arabis glabra	0	-	-	-	-	-	-	-	-	-	-	-
Artemisia caudata	-	-	-	-	-	-	1	-	-	-	-	-
Aster laevis	1	-	-	1	-	-	0	-	-	-	-	-
Cirsuum Hillii	1	-	-	-	-	-	-	-	-	-	-	-
Comptonia peregrina	2	3	-	2	2	-	2	1	-	2	-	-
Convolvulus spithamaeus	1	-	-	1	-	-	-	-	-	1	-	-
Danthonia spicata	2	-	-	-	-	-	1	-	-	1	-	-
Erigeron annuus	-	-	-	-	-	-	-	-	-	0	-	-
Erigeron ramosus	-	-	-	-	-	-	-	-	-	1	-	-
Fragaria virginiana	-	-	-	-	-	-	1	-	-	1	-	-
Gnaphalium Macounii	-	-	-	-	-	-	0	-	-	-	-	-
Hieracium aurantiacum	0	-	-	1	-	-	0	-	-	-	-	-
Hieracium venosum	-	-	-	0	-	-	-	-	-	-	-	-
Koeleria cristata	1	-	-	-	-	-	-	-	-	-	-	-
Lactuca canadensis	0	-	-	0	-	-	-	-	-	-	-	-
Liatris Nieuwlandii	-	-	-	-	-	-	1	-	-	-	-	-
Physalis subglabrata	-	-	-	-	-	-	0	-	-	-	-	-
Poa angustifolia	0	-	-	0	-	-	-	-	-	0	-	-
Polygala polygama	-	-	-	-	-	-	0	-	-	0	-	-
Prunus pensylvanica	-	-	-	-	1*	-	-	1*	-	2*	-	-
Prunus pumila	-	-	-	-	-	-	-	-	-	-	2	-
Solidago canadensis	0	-	-	0	-	-	-	1	-	-	-	-
Solidago juncea	0	-	-	1	-	-	1	-	-	0	-	-
Solidago racemosa	0	-	-	0	-	-	0	-	-	0	-	-
Viola adunca	-	-	-	-	-	-	0	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	-	-	-	1	2	-
Rubus idaeus	1	-	-	3	-	-	1	-	-	1	-	-
Rumex Acetosella	1	-	-	1	-	-	0	-	-	-	-	-
Salix humilis	-	-	-	-	-	-	-	-	-	-	1	-

* number of Plants.

Table 4. Data of the vegetation in the milacre quadrats of the grassland type as recorded in percentage of coverage or number of plants by height classes

Station 3 Location NW¼, Sec.14, T26N, R3W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Agrostis scabra	2	-	-	0	-	-	-	-	-	-	-	-
Andropogon Gerardi	2	-	-	3	-	-	4	-	-	3	-	-
Anemone cylindrica	-	-	-	-	-	-	-	-	-	0	-	-
Antennaria neglecta	-	-	-	-	-	-	1	-	-	1	-	-
Arctostaphylos Uva-ursi	-	-	-	-	-	-	1	-	-	0	-	-
Artemisia caudata	0	-	-	1	-	-	-	-	-	-	-	-
Asclepias syriaca	1*	-	-	4*	-	-	-	-	-	-	-	-
Aster laevis	-	-	-	0	-	-	-	-	-	-	-	-
Campanula rotundifolia	-	-	-	0	-	-	-	-	-	0	-	-
Comptonia peregrina	2	3	-	3	-	-	2	1	-	3	-	-
Erigeron annuus	-	-	-	-	-	-	-	-	-	0	-	-
Erigeron strigosus	0	-	-	-	-	-	0	-	-	-	-	-
Gnaphalium Macounii	-	-	-	-	-	-	-	-	-	0	-	-
Helianthus occidentalis	-	-	-	-	-	-	-	-	-	1	1	-
Hieracium aurantiacum	-	-	-	1	-	-	0	-	-	-	-	-
Liatris Nieuwlandii	-	-	-	-	-	-	-	-	-	0	-	-
Lysimachia quadriflora	-	-	-	-	-	-	0	-	-	0	-	-
Oenothera biennis	-	-	-	-	-	-	-	-	-	0	-	-
Oenothera parviflora	-	-	-	-	-	-	-	-	-	0	-	-
Poa angustifolia	0	-	-	1	-	-	-	-	-	1	-	-
Polygala polygama	-	-	-	-	-	-	-	-	-	0	-	-
Prunus pumila	-	-	-	-	-	-	1	1	0	2	-	-
Rubus idaeus	2	-	-	-	-	-	-	-	-	-	-	-
Rumex Acetosella	1	-	-	1	-	-	-	-	-	-	-	-
Solidago juncea	-	-	-	-	-	-	1	0	-	-	-	-

* number of plants

Table 5. Data of the vegetation in the milacre quadrats of the grassland type as recorded in percentage of coverage or number of plants by height classes

Station 4 Location NW¼, Sec.10, T26N, R3W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Agrostis scabra												
Andropogon Gerardi												
Andropogon scoparius	3	-	-	3	-	-	3	-	-	4	-	-
Danthonia spicata												
Schizachne purpurascens												
Antennaria neglecta	0	-	-	1	-	-	-	-	-	-	-	-
Artemisia caudata	1	0	-	-	-	-	-	-	-	-	-	-
Aster laevis	1	-	-	-	-	-	0	-	-	0	-	-
Campanula rotundifolia	-	-	-	0	-	-	-	-	-	-	-	-
Comptonia peregrina	2	-	-	3	-	-	2	-	-	1	1	-
Erigeron annuus	0	-	-	-	-	-	-	-	-	-	-	-
Erigeron strigosus	1	-	-	-	-	-	-	-	-	-	-	-
Fragaria virginiana	-	-	-	-	-	-	0	-	-	1	-	-
Gnaphalium Macounii	-	-	-	-	-	-	1	-	-	-	-	-
Hieracium venosum	-	-	-	1	-	-	1	-	-	-	-	-
Houstonia longifolia	-	-	-	1	-	-	0	-	-	-	-	-
Liatris Nieuwlandii	0	-	-	0	-	-	-	-	-	1	-	-
Rubus idaeus	1	-	-	0	-	-	2	-	-	-	-	-
Solidago juncea	1	0	-	-	-	-	-	-	-	1	-	-
Solidago nemoralis	-	-	-	0	-	-	-	-	-	1	-	-
Solidago racemosa	0	-	-	0	-	-	1	-	-	-	-	-

Aspen type. In the thick pine country, where the lumberman's ax has let in the sunlight, different plants sprang up freely. The most frequent ones are pin-cherry and blackberry with two dominant species of aspen, namely, Populus tremuloides and P. grandidentata, and they are also often supplied with red maple and red oak. Of the latter two species mentioned, red maple is most widely distributed in the ground cover, agreeing with its importance in the large-stem classes of the mature stand. The most abundant and common ground cover is Vaccinium angustifolium with Rubus spp. a close competitor.

The bracken fern, Pteridium aquilinum which is abundant and characteristic of the aspen and jack pine forest, should be considered as a subdominant, since it may act as dominant both in invading new areas and in remaining as relics if the aspens is replaced, which is true in the case of station 17 in the conifer hardwood type forest. This particular species occurs in great abundance, often composing 50 percent of covering of the ground vegetation. It also has rhizomes about 8 to 10 inches below the surface of the ground, out of reach of fire. Their leaves spread out at a height of 10-20 inches in the sun, or in a shaded area as high as 4 feet. They cover the ground with a moderate shade, which, however, does not preclude the development of various secondary plants such as blueberries. Although the shading effects of the wide fronds has been pointed out, yet the dominance of this plant shown in Table 8 cannot be taken as an average figure for all times, for at different periods during the year, this plant varies widely in its spread or coverage in the ordinary sense.

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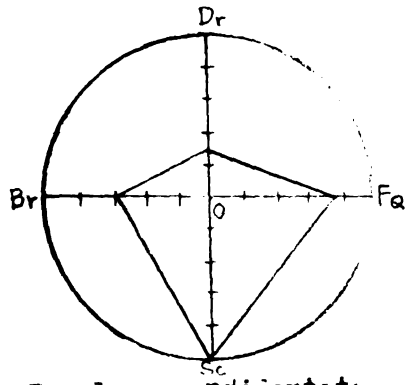
Table 6. Summarized Field Data of the Four 1/5 Acre Quadrats of the Aspen Type by Size Classes

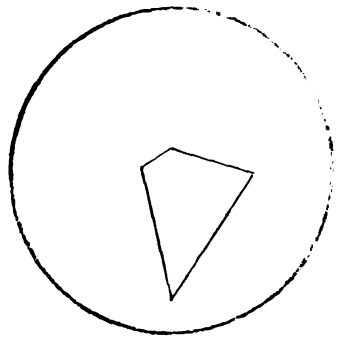
Species	SIZE CLASSES 2 Freq. No.	%	Dens. No.	%	3 Freq. No.	%	Dens. No.	%	4 Freq. No.	%	Dens. No.	%	5 Freq. No.	%	Dens. No.	%	TQ	TOTALS Freq. FQ	FR	Dens. Ts	D	Dr	Abundance	Basal Area Ft^2	Rel.	/Acre
Populus grandidentata	-	-	-	-	2	50	38	11.87	3	75	169	46.55	2	50	38	86.36	3	75	14.28	245	61.25	28.16	81.66	59.606	56.01	74.505
Populus tremuloides	1	25	5	3.54	2	50	22	6.87	2	50	88	24.24	1	25	2	4.54	2	50	9.53	117	29.25	13.44	58.50	19.978	18.77	24.975
Acer rubrum	2	50	37	26.24	2	50	162	50.62	3	75	21	5.78	-	-	-	-	3	75	14.28	220	55.00	25.51	73.33	6.600	6.20	8.250
Quercus rubra	1	25	30	21.27	2	50	34	10.62	2	50	23	6.33	-	-	-	-	3	75	4.76	87	21.75	10.00	29.00	4.333	4.08	5.415
Betula papyrifera	1	25	1	.70	1	25	23	7.18	1	25	29	7.98	-	-	-	-	1	25	4.76	53	13.25	6.09	53.00	6.040	5.68	7.550
Pinus banksiana	1	25	1	.70	1	25	8	2.50	1	25	24	6.61	1	25	3	6.84	1	25	4.76	36	9.00	4.13	36.00	7.581	7.12	9.475
Pinus resinosa	-	-	-	-	1	25	1	.31	-	-	-	-	-	-	-	-	1	25	4.76	1	.25	.11	1	.016	.01	.020
Quercus alba	1	25	7	4.96	2	50	10	3.12	2	50	8	2.20	1	25	1	2.27	2	50	9.53	26	6.50	2.98	13	1.942	1.82	2.425
Prunus serotina	2	50	48	34.04	1	25	3	.93	1	25	1	0.28	-	-	-	-	2	50	9.53	52	.13	5.97	.26	.161	.15	.200
Amelanchier canadensis	2	50	11	7.80	2	50	16	5.00	-	-	-	-	-	-	-	-	2	50	9.53	27	6.75	3.10	13.50	.144	.13	.180
Ulmus americana	1	25	1	.70	1	25	3	.93	-	-	-	-	-	-	-	-	1	25	4.76	4	1.00	.46	.04	.046	.04	.058
TOTALS			141	16.24			320	36.86			363	41.82			44	5.07		525	100		100	100		106.447		132.053

5 Dens. No.	%	TQ	Freq. FQ	FR	TOTALS Dens. Ts	D	Dr	Abundance	Basal Area Ft^2	Rel.	/Acre
38	86.36	3	75	14.28	245	61.25	28.16	81.66	59.606	56.01	74.505
2	4.54	2	50	9.53	117	29.25	13.44	58.50	19.978	18.77	24.975
-	-	3	75	14.28	220	55.00	25.51	73.33	6.600	6.20	8.250
-	-	3	75	4.76	87	21.75	10.00	29.00	4.333	4.08	5.415
-	-	1	25	4.76	53	13.25	6.09	53.00	6.040	5.68	7.550
3	6.81	1	25	4.76	36	9.00	4.13	36.00	7.581	7.12	9.475
-	-	1	25	4.76	1	.25	.11	1	.016	.01	.020
1	2.27	2	50	9.53	26	6.50	2.98	13	1.942	1.82	2.425
-	-	2	50	9.53	52	.13	5.97	.26	.161	.15	.200
-	-	2	50	9.53	27	6.75	3.10	13.50	.144	.13	.180
-	-	1	25	4.76	4	1.00	.46	.04	.046	.04	.058
44	5.07		525	100		100	100		106.447		132.053

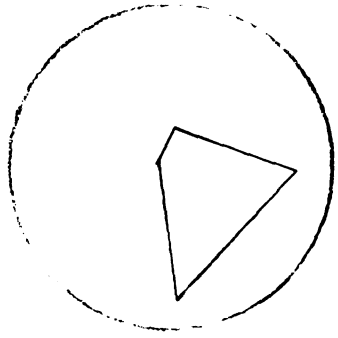
Figure 4. Phytographs of Important Species in Aspen Type



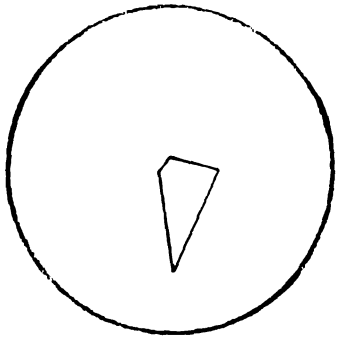
Populus grandidentata



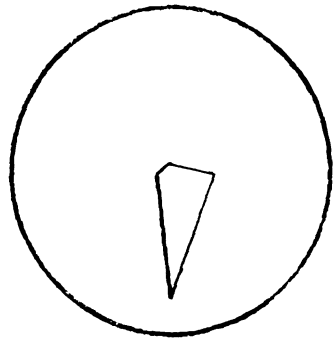
Populus tremuloides



Acer rubrum



Betula papyrifera



Pinus banksiana

Legend: ODr--Relative density in percent
OFq--Quadrat frequency in percent
OSc--Size Classes in percent
OBr--Relative basal area in percent

Table 7 and 8. Data of the vegetation in the milacre quadrats of the aspen type as recorded in percentage of coverage or number of plants by height classes

Station 5 Location SE¼, Sec.9, T25N, R5W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	4*	-	-	12*	-	-	1*	-	-	3*	-	-
Apocynum androsaemifolium	-	-	-	1	-	-	-	-	-	-	-	-
Carex spp.	1	-	-	0	-	-	1	-	-	1	-	-
Danthonia spicata	1	-	-	0	-	-	-	-	-	-	-	-
Gaultheria procumbens	-	-	-	0	-	-	1	-	-	0	-	-
Populus grandidentata	8*	-	-	17*	-	-	13*	-	-	5*	-	-
Prunus pensylvanica	11*	-	-	14*	-	-	-	-	-	1*	-	-
Pteridium aquilinum	2	-	-	2	-	-	2	-	-	2	-	-
Quercus alba	2*	-	-	-	-	-	-	-	-	-	-	-
Quercus rubra	8*	-	-	-	-	-	1*	-	-	1*	-	-
Rubus spp.	0	-	-	1	-	-	1	-	-	0	-	-
Smilacina stellata	-	-	-	0	-	-	1	-	-	1	-	-
Vaccinium angustifolium	-	-	-	2	-	-	-	-	-	2	-	-

* number of plants

Station 6 Location SW¼, Sec.7, T26N, R4W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Amelanchier canadensis	-	-	-	-	-	-	1*	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	1	-	-	-	-	-
Aster laevis	1	-	-	1	-	-	0	-	-	-	-	-
Carex spp.	3	-	-	3	-	-	2	-	-	-	-	-
Cirsium Hillii	-	-	-	0	-	-	0	-	-	-	-	-
Comptonia peregrina	2	-	-	2	-	-	2	-	-	-	-	-
Danthonia spicata	1	-	-	-	-	-	1	-	-	-	-	-
Erigeron annuus	-	-	-	1	-	-	0	-	-	-	-	-
Gaultheria procumbens	-	-	-	-	-	-	1	-	-	-	-	-
Hieracium venosum	0	-	-	-	-	-	0	-	-	-	-	-
Panicum Scribnerianum	-	-	-	1	-	-	-	-	-	-	-	-
Prunus pensylvanica	1*	-	-	-	-	-	-	-	-	-	-	-
Prunus serotina	6*	-	-	1*	-	-	1*	-	-	-	-	-
Pteridium aquilinum	-	-	-	-	-	-	2	-	-	-	-	-
Quercus rubra	5*	-	-	1*	-	-	-	-	-	-	-	-
Rubus spp.	2	-	-	2	-	-	1	-	-	-	-	-
Vaccinium angustifolium	1	-	-	2	-	-	3	-	-	-	-	-

* number of plants

Table 9. Data of the vegetation in the milacre quadrats of the aspen type as recorded in percentage of coverage or number of plants by height classes

Station 7 Location SW¼, Sec.31, T24N, R3W.	Distribution of Coverage Classes for the Type Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	1*	-	-	5*	-	-	6*	-	-	2*	-	-
Amelanchier canadensis	-	-	-	3*	-	-	2*	-	-	2*	-	-
Aster cordifolius	1	-	-	0	-	-	0	-	-	0	-	-
Danthonia spicata	-	-	-	0	-	-	0	-	-	1	-	-
Gaultheria procumbens	-	-	-	1	-	-	1	-	-	-	-	-
Lonicera canadensis	-	-	-	-	-	-	0	-	-	-	-	-
Monotropa Hypopithys	-	-	-	1	-	-	1	-	-	1	-	-
Prunus pensylvanica	1*	-	-	2*	-	-	1*	-	-	2*	-	-
Pteridium aquilinum	1	3	-	2	2	-	1	3	1	1	2	-
Quercus alba	-	-	-	2*	-	-	-	-	-	-	-	-
Quercus rubra	2*	-	-	1*	-	-	2*	-	-	2*	-	-
Rubus spp.	1	-	-	-	-	-	1	-	-	1	-	-
Smilacina stellata	-	-	-	1	-	-	-	-	-	-	-	-
Solidago nemoralis	-	-	-	1	-	-	0	-	-	-	-	-
Vaccinium myrtilloides	1	-	-	1	-	-	1	-	-	-	-	-
Viburnum acerifolium	-	-	-	-	-	-	-	-	-	1	-	-

* number of plants

In station 8 of this type, which was situated in a transitional zone of well- and poorly-drained land, birch has become such a dominant species that is quite striking. Also in this particular sampling plot, the number of herbaceous species has greatly increased due to the more favorable moisture conditions. Species like Galium, Equisetum which never appeared in other stands showed up in the tally.

Table 10. Data of the vegetation in the milacre quadrats of the aspen type as recorded in percentage of coverage or number of plants by height classes

Station 8 Location NE¼, Sec.36, T23N, R3W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	137*	-	-	138*	-	-	56*	-	-	93*	2*	-
Achillea Millefolium	-	-	-	1	-	-	-	-	-	-	-	-
Amelachier canadensis	8*	-	-	-	-	-	1*	-	-	1*	-	-
Antennaria neglecta	0	-	-	-	-	-	-	-	-	-	-	-
Aster sagittifolius	1	-	-	1	-	-	-	-	-	-	-	-
Athyrium Filix-femina	-	-	-	-	-	-	1	-	-	-	-	-
Botrychium dissectum	-	3	-	1	3	-	1	4	-	1	-	-
Carex spp.	1	-	-	1	-	-	0	-	-	2	-	-
Coptis groenlandica	-	-	-	-	-	-	0	-	-	-	-	-
Cornus spp.	-	-	-	-	-	-	1	-	-	-	-	-
Diervilla Lonicera	1	-	-	0	-	-	-	-	-	-	-	-
Fragaria virginiana	0	-	-	-	-	-	-	-	-	0	-	-
Galium triflorum	0	-	-	0	-	-	1	-	-	0	-	-
Hieracium venosum	0	-	-	-	-	-	0	-	-	0	-	-
Lactuca spp.	-	-	-	-	-	-	0	-	-	0	-	-
Lonicera canadensis	-	-	-	-	-	-	1	1	-	-	-	-
Lycopodium obscurum	-	-	-	0	-	-	-	-	-	-	-	-
Onoclea sensibilis	-	-	-	-	-	-	-	-	-	0	-	-
Populus grandidentata	-	-	-	-	-	-	-	-	-	-	1*	-
Prenanthes alba	-	-	-	-	-	-	0	-	-	-	-	-
Pyrola rotundifolia	-	-	-	-	-	-	1	-	-	0	-	-
Rubus spp.	1	-	-	1	-	-	1	-	-	1	-	-
Smilacina stellata	1	-	-	0	-	-	1	-	-	0	-	-
Solidago canadensis	0	-	-	0	0	-	-	-	-	-	-	-
Solidago Curtisii	0	-	-	0	0	-	0	-	-	0	-	-
Trifolium dubium	0	-	-	-	-	-	-	-	-	-	-	-
Ulmus americana	-	-	-	-	-	-	1*	-	-	-	-	-
Viburnum acerifolium	1	-	-	-	-	-	-	-	-	-	-	-
Vaccinium angustifolium	-	-	-	-	-	-	1	-	-	-	-	-
Viola blanda	1	-	-	1	-	-	1	-	-	1	-	-

* number of plants

Northern pin oak type. Five distinct tree species occupying considerable area in this type of plant community. Three of these species belong to the Fagaceae; namely, Quercus alba, Quercus rubra and Q. ellipsoidalis. The other two are Populus grandidentata and Acer rubrum. Cutting, fire, and grazing of the past are responsible for the generally depreciated stand composition, understocking, and large amount of defect in most of the oak stands. This type generally occupies certain red pine and white pine sites that have deteriorated severely as a result of at least two or three fires. Many investigators (62,95,31) have compared this type to the aspen type in that it is a temporary type into which the original occupants of the site gradually encroach. However, this reversion to the original type of tree growth seems to have to wait for a longwhile before it becomes a reality, as judged from the quantitative data obtained from the area. First of all, there are not enough reproduction or parent seed trees to provide a satisfactory nucleus for a pine forest. Secondly, the fact that twenty-seven percent of the tree species are in size class two; thirty-four percent in size class three; thirty-six percent in size class four; and only 2.6 percent in size class five, definitely suggests the young character of this so called temporary oak type forest.

Six tree species make up the understory with Amelanchier canadensis appearing more frequently.

Advance reproduction of oaks in unmanaged stands is often sparse. Such is the case in the quadrats studied in this region, since oak seed trees must be reasonably close together and uniformly distributed because the seed is disseminated only a short distance.

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Table 11. Summarized Field Data of the Four 1/5 Acre Quadrats of the Northern Pin Oak Type by Size Classes.

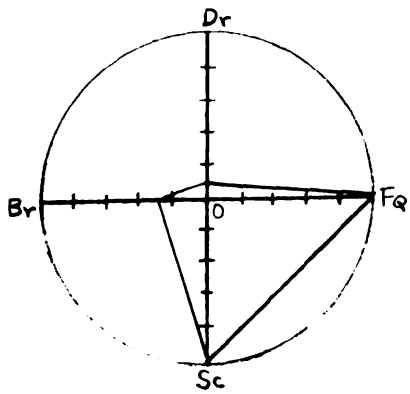
Species	SIZE CLASSES 2 Freq. No.	2 Freq. %	2 Dens. No.	2 Dens. %	3 Freq. No.	3 Freq. %	3 Dens. No.	3 Dens. %	4 Freq. No.	4 Freq. %	4 Dens. No.	4 Dens. %
Quercus ellipsoidalis	1	25	2	.98	3	75	13	5.06	4	100	51	18.90
Quercus rubra	1	25	1	.49	2	50	20	7.78	2	50	35	13.01
Quercus alba	2	50	3	1.47	3	75	31	12.06	4	100	42	15.61
Populus grandidentata	2	50	8	3.94	2	50	53	20.63	3	75	123	45.72
Acer rubrum	3	75	21	10.34	3	75	84	32.69	3	75	16	5.94
Betula papyrifera	-	-	-	-	1	25	11	.38	1	25	1	.37
Amelanchier canadensis	3	75	34	16.75	3	75	37	14.40	-	-	-	-
Prunus serotina	1	25	1	.49	-	-	-	-	-	-	-	-
Hamamelis virginiana	4	100	65	32.02	1	25	25	7.00	-	-	-	-
Prunus pensylvanica	1	25	6	2.95	-	-	-	-	-	-	-	-
Crataegus gravis	1	25	6	2.95	-	-	-	-	-	-	-	-
Cornus spp.	1	25	56	27.58	-	-	-	-	-	-	-	-
Pinus banksiana	-	-	-	-	-	-	-	-	1	25	1	.37
			203	27.10			257	34.31			269	35.91

Species	TOTALS 5 Freq. No.	5 Freq. %	5 Dens No.	5 Dens %	Freq. Tq	Freq. Fq	Freq. FR	Dens. Ts	Dens. D	Dens. Dr	Abundance	Basal Area Ft²	Basal Area Rel.	Basal Area /Acre
Quercus ellipsoidalis	3	75	6	30.00	4	100	13.80	72	18	9.61	18	20.459	29.89	25.575
Quercus rubra	1	25	8	40.00	2	50	6.89	64	16	8.55	32	11.781	17.20	14.725
Quercus alba	3	75	6	30.00	4	100	13.80	82	20.50	10.94	20.52	11.954	17.47	14.945
Populus grandidentata	-	-	-	-	3	75	10.34	184	46	24.57	61.33	19.735	28.80	24.670
Acer rubrum	-	-	-	-	3	75	10.34	121	30.25	16.16	40.33	3.847	5.62	4.810
Betula papyrifera	-	-	-	-	1	25	2.45	2	0.50	.26	2	.116	.17	.145
Amelanchier canadensis	-	-	-	-	3	75	10.34	71	17.75	9.48	23.66	.297	.43	.370
Prunus serotina	-	-	-	-	1	25	3.45	1	0.25	.13	1	-	-	-
Hamamelis virginiana	-	-	-	-	4	100	13.79	83	20.99	11.07	20.99	.110	.16	.138
Prunus pensylvanica	-	-	-	-	1	25	3.45	6	1.50	.80	6	-	-	-
Crataegus gravis	-	-	-	-	1	25	3.45	6	1.50	.80	6	-	-	-
Cornus spp.	-	-	-	-	1	25	3.45	56	14	7.48	56	-	-	-
Pinus banksiana	-	-	-	-	1	25	3.45	1	0.25	.13	1	.165	.24	.205
			20	2.67		726	100	749		100		68.464	100	85.583

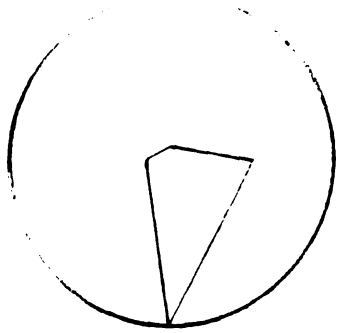
TOTALS

Dens No.	%	Freq. Tx	Fx	FR	Dens. Ts	D	Dr	Abundance		Basal Area Ft²	Rel.	/Acre
6	30.00	4	100	13.80	72	18	9.61	18		20.459	29.8	
8	40.00	2	50	6.89	64	16	8.55	32		11.78[illegible]		[illegible]25
6	30.00	4	[illegible]					20.52				14.945
-	-									.80		24.670
-	-									[illegible]	5.62	4.810
-	-									.116	.17	.115
-	-									.297	.43	.370
-	-									-		-
-	-											
										-	-	-
								56		-	-	-
							.13	1		.165	.24	.205
							100			68.464	100	85.563

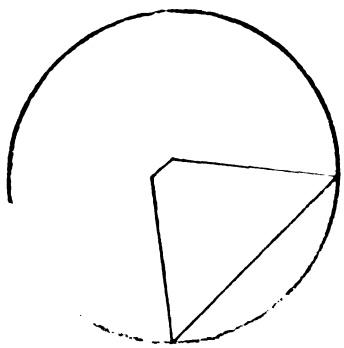
Figure 5. Phytographs of Important Species in Northern Pin Oak Type



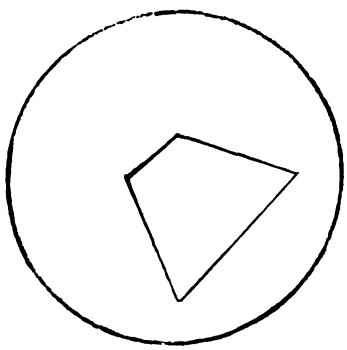
Quercus ellipsoidalis



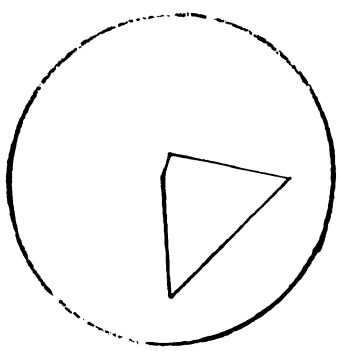
Quercus rubra



Quercus alba



Populus grandidentata



Acer rubrum

Legend: ODr--Relative density in percent
OFq--Quadrat frequency in percent
OSc--Size classes in percent
OBr--Relative basal area in percent

Table 12 and 13. Data of the vegetation in the milacre quadrats of northern pin oak type as recorded in percentages of coverage or number of plants by height classes

Station 9 Location SW¼, Sec.25, T25N, R4W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	1*	-	-	1*	-	-	-	-	-	-	-	-
Amelanchier canadensis	1*	-	-	-	-	-	11*	-	-	-	-	-
Apocynum androsaemifolium	1	-	-	1	-	-	-	-	-	-	-	-
Aster laevis	1	-	-	1	-	-	1	-	-	-	-	-
Aster sagittifolius	-	-	-	-	-	-	0	-	-	-	-	-
Carex spp.	2	-	-	2	-	-	1	-	-	-	-	-
Danthonia spicata	-	-	-	1	-	-	-	-	-	-	-	-
Hamamelis virginiana	8*	3*	2*	6*	4*	3*	5*	4*	1*	-	-	-
Lonicera oblongifolia	1	-	-	-	-	-	-	-	-	-	-	-
Pteridium aquilinum	3	-	-	2	-	-	3	-	-	-	-	-
Quercus rubra	1*	-	-	1*	-	-	-	-	-	-	-	-
Rubus allegheniensis	-	-	-	-	-	-	1	-	-	-	-	-
Solidago nemoralis	-	-	-	0	-	-	-	-	-	-	-	-
Vaccinium angustifolium	2	-	-	2	-	-	2	-	-	-	-	-

* number of plants

Station 10 Location NW¼, Sec.14, T26N, R4W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	4*	-	-	8*	-	-	3*	-	-	5*	-	-
Carex spp.	1	-	-	1	-	-	1	-	-	1	-	-
Comptonia peregrina	-	-	-	-	-	-	1	-	-	1	-	-
Corylus americana	1*	1*	1*	-	-	-	1*	-	-	3*	-	-
Hamamelis virginiana	-	-	-	1*	-	1*	1*	-	-	-	-	-
Hieracium venosum	-	-	-	-	-	-	-	-	-	0	-	-
Gaultheria procumbens	1	-	-	1	-	-	1	-	-	1	-	-
Prunus pensylvanica	-	-	-	-	-	-	-	-	-	2*	-	-
Pteridium aquilinum	1	2	-	2	2	-	1	2	-	1	1	-
Quercus alba	3*	2*	-	2*	-	-	-	-	-	-	-	-
Quercus rubra	-	-	-	1*	-	-	3*	-	-	2*	-	-
Smilacina stellata	-	-	-	0	-	-	-	-	-	-	-	-
Solidago nemoralis	-	-	-	-	-	-	-	-	-	0	-	-
Vaccinium angustifolium	-	-	-	0	-	-	1	-	-	1	-	-

* number of plants

Table 14. Data of the vegetation in the milacre quadrats of northern pin oak type as recorded in percentages of coverage or number of plants by height classes

Station 11 Location SE¼, Sec.16, T26N, R4W.	Distribution of Coverage Classes for the Type Quadrat											
	1			2			3			4		
	Height Class in feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	11*	-	-	21*	4*	-	55*	2*	-	18*	2*	-
Agropyron trachycaulum	-	-	-	-	-	-	-	-	-	1	-	-
Amelanchier laevis	63*	-	-	1*	-	-	17*	-	-	22*	-	-
Aster ciliolatus	1	-	-	1	-	-	-	-	-	-	-	-
Aster laevis	-	-	-	0	-	-	1	-	-	0	-	-
Carex spp.	1	-	-	1	-	-	1	-	-	2	-	-
Convolvulus spithamaeus	-	-	-	0	-	-	-	-	-	-	-	-
Crataegus spp.	1*	1*	-	-	-	-	-	-	-	1*	-	-
Epigaea repens	-	-	-	1	-	-	-	-	-	-	-	-
Fragaria virginiana	1	-	-	0	-	-	-	-	-	0	-	-
Gaultheria procumbens	2	-	-	2	-	-	2	-	-	1	-	-
Linnaea borealis	0	-	-	-	-	-	1	-	-	-	-	-
Lonicera oblongifolia	1	-	-	2	-	-	2	-	-	1	-	-
Melampyrum lineare	-	-	-	0	-	-	-	-	-	-	-	-
Monarda fistulosa	-	-	-	-	-	-	-	-	-	-	1	1
Populus grandidentata	-	-	-	-	1*	1*	-	-	-	-	-	-
Prenanthes alba	2*	-	-	-	-	-	-	-	-	-	-	-
Prunus pensylvanica	1*	-	-	-	-	-	1*	-	-	-	-	-
Pteridium aquilinum	-	3	-	-	3	-	0	3	-	0	4	-
Pyrola minor	-	-	-	1	-	-	-	-	-	-	-	-
Pyrola rotundifolia	-	-	-	1	-	-	0	-	-	-	-	-
Quercus alba	2*	-	-	-	-	-	-	-	-	-	-	-
Quercus ellipsoidalis	-	-	-	1*	-	-	1*	-	-	1*	-	-
Rubus allegheniensis	2	-	-	2	1	-	1	1	-	-	-	-
Smilacina stellata	1	-	-	0	-	-	0	-	-	1	-	-
Thalictrum dioicum	1	-	-	-	-	-	-	-	-	-	-	-
Vaccinium angustifolium	1	-	-	1	-	-	2	-	-	2	-	-

* number of plants

Again on the ground cover layer, bracken fern maintains its dominance over other herbaceous plants. Although big tree relics can hardly be found, yet numerous ground plants which remain as relics are still plentiful, such as Vaccinium angustifolium, Gaultheria procumbens, Aster spp. and Carex spp..

Table 15. Data of the vegetation in the milacre quadrats of the northern pin oak type as recorded in percentages of coverage or number of plants by height classes

Station 12 Location SE¼, Sec.14, T26N, R3W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	-	-	-	2*	-	-	-	-	-	1*	-	-
Amelanchier canadensis	-	-	-	1*	-	-	1*	-	-	-	-	-
Antennaria neglecta	1	-	-	-	-	-	-	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	-	-	-	0	-	-
Arctostaphylos Uva-ursi	-	-	-	-	-	-	-	-	-	1	-	-
Aster cordifolius	-	-	-	-	-	-	-	-	-	0	-	-
Aster laevis	0	-	-	-	-	-	-	-	-	0	-	-
Carex spp.	2	-	-	-	-	-	-	-	-	1	-	-
Comptonia peregrina	1	2	-	-	2	-	1	2	-	1	2	-
Crataegus gravis	-	2*	-	-	-	-	-	-	-	-	-	-
Euonymus spp.	0	-	-	-	-	-	-	-	-	-	-	-
Fragaria virginiana	1	-	-	-	-	-	-	-	-	0	-	-
Gaylussacia baccata	-	-	-	-	-	-	-	-	-	1	2	-
Gaultheria procumbens	-	-	-	0	-	-	0	-	-	-	-	-
Hamamelis virginiana	-	-	-	-	-	-	2*	-	1*	1*	-	-
Hieracium venosum	0	-	-	-	-	-	0	-	-	-	-	-
Oryzopsis asperifolia	2	-	-	2	-	-	2	-	-	2	-	-
Phlox pilosa	-	-	-	0	-	-	-	-	-	-	-	-
Prunus serotina	-	-	-	-	-	-	-	-	-	1*	-	-
Pteridium aquilinum	1	3	-	-	1	-	0	-	-	1	2	-
Quercus alba	4*	2*	2*	4*	1*	-	10*	-	-	1*	-	-
Quercus ellipsoidalis	2*	-	-	6*	-	-	-	-	-	5*	-	-
Rubus canadensis	-	-	-	-	-	-	0	-	-	-	-	-
Solidago nemoralis	0	-	-	-	-	-	-	-	-	-	-	-
Vaccinium angustifolium	1	-	-	1	-	-	3	-	-	2	-	-
Viburnum acerifolium	-	-	-	-	-	-	-	-	-	1	-	-
Viola adunca	0	-	-	-	-	-	-	-	-	-	-	-

* number of plants

Jack pine type. By the time the field has been abandoned for some years, the forest has encroached considerably on the area occupied by various herbaceous growth. Jack pine is the dominant member of the flora and poplar and oak are also present. In places, a thick growth of jack pine appears and there are but a few young oaks growing among them. This is the general picture of invasion of different plant community which is well depicted by the data on station 11 on the pine type study. Phytographs and summary of field data show definitely the dominance of the jack pine, as indicated by the basal area and other qualities are concerned.

The open crown of the pine is reflected in a rather rich ground cover of herbs and the scarcity of seedlings of trees (Table 16,17,18,19). In quadrat 14 and 15 of all the species present in the herbaceous layer, seedlings of the dominants in the arboreal layer were poorly represented, accentuating a decided intolerance of these conifers. It is, therefore, very evident that tolerant broadleaved species could easily crowd out the pines if climate were favorable to their invasion. This is so graphically expressed in the pollen profiles of some Michigan bogs.(73).

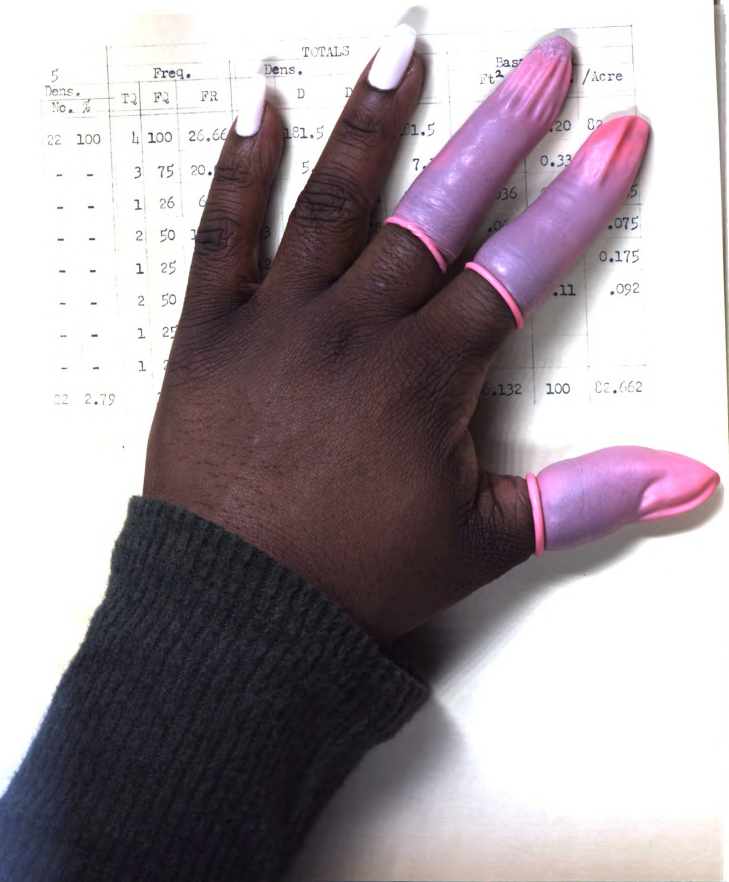
Though the numbers of species appearing in the ground cover is large, frequency is low for most of them. This is, however, what one would expect according to Raunkiaer's law of frequency (71).

One of the most significant fact observed in station 13 is the apparent ability of the conifers to reproduce and develop well under the parent group, evidently acquiring more light than many of the herbs and a a few of the broadleaved tree species received. This agrees with the finding of Shirley (80) who reports the same competition for pine seedlings by aspen and bracken fern.

Table 16. Summarized Field Data of the Four 1/5 Acre Quadrats of the Jack Pine Type by Size Classes.

Species	SIZE CLASSES 2 Freq. No.	2 Freq. %	2 Dens. No.	2 Dens. %	3 Freq. No.	3 Freq. %	3 Dens. No.	3 Dens. %	4 Freq. No.	4 Freq. %	4 Dens. No.	4 Dens. %
Pinus banksiana	2	50	208	84.55	4	100	244	91.38	4	100	252	99.60
Quercus rubra	2	50	18	7.31	1	25	3	1.12	1	25	1	0.39
Populus tremuloides	1	25	10	4.06	1	25	3	1.12	-	-	-	-
Quercus ellipsoidalis	-	-	-	-	2	50	3	1.12	-	-	-	-
Pinus resinosa	1	25	2	0.81	1	25	10	3.74	-	-	-	-
Prunus serotina	2	50	4	1.62	1	25	4	1.49	-	-	-	-
Amelanchier canadensis	1	25	3	1.21	-	-	-	-	-	-	-	-
Quercus alba	1	25	1	.40	-	-	-	-	-	-	-	-
TOTALS			246	31.21			267	33.88			253	32.10

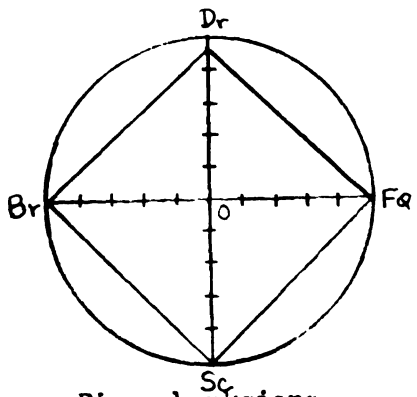
Species	5 Freq. No.	5 Freq. %	5 Dens. No.	5 Dens. %	TOTALS Freq. TF	Freq. FF	Freq. FR	Dens. Ts	Dens. D	Dens. Dr	Abundance	Basal Area Ft^2	Basal Area Rel.	Basal Area /Acre
Pinus banksiana	2	50	22	100	4	100	26.66	726	181.5	92.13	181.5	65.605	99.20	82.005
Quercus rubra	-	-	-	-	3	75	20.00	22	5.5	2.91	7.33	.216	0.33	0.270
Populus tremuloides	-	-	-	-	1	26	6.67	13	3.25	1.64	13	.036	0.06	0.045
Quercus ellipsoidalis	-	-	-	-	2	50	13.33	3	.75	.38	1.5	.060	0.09	0.075
Pinus resinosa	-	-	-	-	1	25	6.67	12	.3	1.52	12	.141	0.21	0.175
Prunus serotina	-	-	-	-	2	50	13.33	8	2	1.01	4	.074	0.11	.092
Amelanchier canadensis	-	-	-	-	1	25	6.67	3	.75	.39	3			
Quercus alba	-	-	-	-	1	25	6.67	1	.25	.12	1			
TOTALS			22	2.79		375	100	788		100		66.132	100	82.662



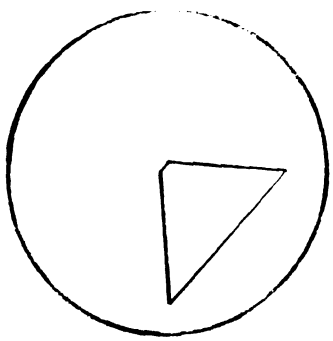
TOTALS

5 Dens.		Freq.			Dens.		Bas Ft²	/Acre	
No.	%	TQ	FQ	FR		D			
22	100	4	100	26.66		181.5	1.5	.20	82
-	-	3	75	20.		5	7.	0.33	
-	-	1	26	6			036		5
-	-	2	50	1					.075
-	-	1	25						0.175
-	-	2	50					.11	.092
-	-	1	25						
-	-	1							
22	2.79						.132	100	82.662

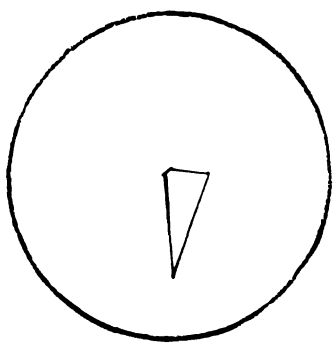
Figure 6. Phytographs of Important Species in Jack Pine Type



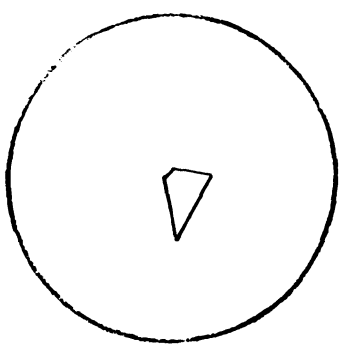
Pinus banksiana



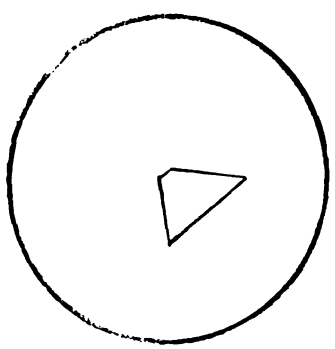
Quercus rubra



Populus tremuloides



Pinus resinosa



Prunus serotina

Legend: ODr--Relative density in percent
OFq--Quadrat frequency in percent
OSc--Size classses in percent
OBr--Relative basal area in percent

Table 17. Data of the vegetation in the milacre quadrats of the jack pine type as recorded in percentage of coverage or number of plants by height classes

Station 13 Location SE¼, Sec.18, T26N, R4W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Andropogon Gerardi	1	-	-	2	-	-	1	-	-	-	-	-
Andropogon scoparius	2	-	-	3	-	-	2	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	1	-	-	-	-	-
Artemisia caudata	0	-	-	0	-	-	-	-	-	-	-	-
Aster laevis	2*	-	-	2*	-	-	5*	-	-	-	-	-
Aster sagittifolius	-	-	-	15*	-	-	2*	-	-	-	-	-
Campanula rotundifolia	-	-	-	2	-	-	-	-	-	-	-	-
Carex pensylvanica	0	-	-	0	-	-	1	-	-	-	-	-
Cirsium Hillii	-	-	-	4*	-	-	-	-	-	-	-	-
Comptonia peregrina	3	-	-	2	-	-	1	-	-	-	-	-
Danthonia spicata	1	-	-	1	-	-	3	-	-	-	-	-
Rubus hispidus	1	-	-	1	-	-	-	-	-	-	-	-
Vaccinium angustifolium	-	-	-	-	-	-	3*	-	-	-	-	-
Viola adunca	-	-	-	4*	-	-	8*	-	-	-	-	-

* number of plants

The data show that Pinus banksiana is by far the most dominant species with a frequency of 100, a density percentage of 92, and making up 99 percent of the total basal area. The tree species with second rank is Quercus rubra: frequency 75, but with a rather low density percentage of 2.9, and the total basal area per acre is negligible. On the basis of size-class representation for all tree species recorded on this forest type, those of size class 2,3 and 4 are evenly distributed. Furthermore, advanced young growth of red pine has appeared in some plots, adds the necessary elements to suggest that the coniferous species have gradually returned to their sites after lumbering and subsequent fires.

Table 18. Data of the vegetation in the milacre quadrats of the jack pine type as recorded in percentage of coverage or number of plants by height classes

Station 14 Location SE¼, Sec.17, T26N, R4W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Amelanchier humilis	6*	-	-	-	-	-	-	-	-	-	-	-
Andropogon scoparius	1	-	-	1	-	-	0	-	-	-	-	-
Antennaria neglecta	-	-	-	1*	-	-	-	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	-	-	-	1	-	-
Arctostaphylos Uva-ursi	-	-	-	-	-	-	3*	-	-	-	-	-
Aster laevis	11*	-	-	43*	-	-	23*	-	-	10*	-	-
Cirsium Hillii	2*	-	-	-	-	-	-	-	-	-	-	-
Comptonia peregrina	3*	-	-	7*	-	-	2*	-	-	2*	-	-
Convolvulus spithamaeus	-	-	-	0	-	-	-	-	-	0	-	-
Crataegus Dodgei	1*	-	-	-	-	-	-	-	-	2*	-	-
Danthonia spicata	4	-	-	3	-	-	3	-	-	-	-	-
Epigaea repens	3*	-	-	-	-	-	-	-	-	15*	-	-
Fragaria virginiana	-	-	-	-	-	-	1	-	-	-	-	-
Gaultheria procumbens	20*	-	-	61*	-	-	34*	-	-	30*	-	-
Helianthus occidentalis	-	-	-	-	-	-	-	-	-	1*	-	-
Hieracium venosum	-	-	-	2*	-	-	-	-	-	-	-	-
Maianthemum canadense	-	-	-	-	-	-	1*	-	-	-	-	-
Melampyrum lineare	1*	-	-	-	-	-	-	-	-	-	-	-
Nemopanthus mucronata	-	-	-	-	-	-	-	-	-	1*	-	-
Prunus pensylvanica	-	-	-	1*	-	-	-	-	-	-	-	-
Prunus pumila	-	-	-	-	-	-	-	-	-	1*	-	-
Pteridium aquilinum	1	-	-	3	-	-	3	-	-	-	-	-
Rubus allegheniensis	-	-	-	13*	-	-	-	-	-	-	-	-
Rubus canadensis	-	-	-	-	-	-	4*	-	-	-	-	-
Smilacina stellata	-	-	-	-	-	-	-	-	-	0	-	-
Solidago juncea	-	-	-	-	-	-	-	-	-	3*	-	-
Vaccinium angustifolium	2	-	-	1	-	-	2	-	-	2	-	-
Vaccinium vacillans	-	-	-	-	-	-	-	-	-	2*	-	-

* number of plants

The principal species forming the ground cover are Pteridium aquilinum, Comptonia peregrina, Rubus spp., Epigaea repens and Gaultheria procumbens. The higher shrub layer is well developed and is composed of Crataegus Dodgei, Amelanchier spp. and two species of the genus Vaccinium.

Table 19. Data of vegetation in the milacre quadrats of the jack pine type as recorded in percentages of coverage or number of plants by height classes

Station 15 Location NW¼, Sec.12, T26N, R3W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Agropyron trachycaulum	1	-	-	1	-	-	1	-	-	0	-	-
Andropogon scoparius	1	-	-	1	-	-	0	-	-	0	-	-
Antennaria neglecta	-	-	-	-	-	-	1	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	1	-	-	-	-	-
Arctostaphylos Uva-ursi	1	-	-	0	-	-	-	-	-	0	-	-
Aster laevis	1	-	-	0	-	-	1	-	-	0	-	-
Cirsium Hillii	-	-	-	-	-	-	0	-	-	-	-	-
Danthonia spicata	0	-	-	0	-	-	1	-	-	0	-	-
Diervilla lonicera Epigaea repens Erigeron annuus	-	-	-	-	-	-	0	-	-	1	-	-
Frageria virginiana	1	-	-	0	-	-	0	-	-	0	-	-
Lonicera oblongifolia	-	-	-	0	-	-	0	-	-	-	-	-
Melampyrum lineare	0	-	-	0	-	-	1	-	-	1	-	-
Pteridium aquilinum	1	2	-	1	3	-	1	2	-	-	2	-
Prunus pensylvanica	-	-	-	-	-	-	-	-	-	2*	-	-
Salix humilis	-	-	-	-	-	-	4*	-	-	-	-	-
Solidago nemoralis	0	-	-	0	-	-	0	-	-	0	-	-
Smilacina stellata	0	-	-	-	-	-	-	-	-	0	-	-
Solidago juncea	-	-	-	-	-	-	0	-	-	0	-	-
Vaccinium vacillans	2	-	-	2	-	-	1	-	-	2	-	-
Viola adunca	-	-	-	-	-	-	1	-	-	-	-	-

* number of plants

Table 20. Data of the vegetation in the milacre quadrats of the jack pine type as recorded in percentages of coverage or number of plants by height classes

Station 16	Distribution of Coverage Classes for the Type											
Location NE¼, Sec.36, T25N, R6W.	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Amelanchier laevis	-	-	-	-	-	-	-	1*	-	-	-	-
Andropogon scoparius, Danthonia spicata, Poa compressa	4	-	-	3	-	-	3	-	-	4	-	-
Antennaria neglecta	0	-	-	-	-	-	-	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	-	1*	-	-	-	-
Artemisia caudata	0	-	-	-	-	-	1	-	-	-	-	-
Arctostaphylos Uva-ursi	-	-	-	1	-	-	2	-	-	-	-	-
Asclepias syriaca	-	-	-	-	-	-	0	-	-	-	-	-
Aster laevis	1	-	-	0	-	-	1	-	-	1	-	-
Cirsium Hillii	1	-	-	1	-	-	1	-	-	-	-	-
Comptonia peregrina	0	-	-	-	-	-	1	-	-	0	-	-
Hieracium aurantiacum	0	-	-	-	-	-	1	-	-	0	-	-
Hieracium venosum	0	-	-	0	-	-	1	-	-	0	-	-
Pteridium aquilinum	1	3	-	-	2	-	1	2	-	-	3	-
Pterospora andromedea	-	-	-	-	-	-	0	-	-	1	-	-
Rubus canadensis	-	-	-	-	-	-	-	-	-	1	-	-
Salix humilis	3*	-	-	-	-	-	-	-	-	3*	-	-
Solidago nemoralis	0	-	-	1	-	-	1	-	-	0	-	-
Vaccinium angustifolium	1	-	-	2	-	-	1	-	-	0	-	-
Viola adunca	0	-	-	0	-	-	0	-	-	0	-	-

* number of plants

Northern-hardwood-hemlock type. Conifer-hardwood group, generally includes the northern hardwood type, characteristically composed of sugar maple, yellow birch, basswood, beech, and hemlock, occurs principally on loamy upland soils. The oldgrowth stands, contain trees ranging in age from 160 to 300 years or more, in diameter from 18 to 30 inches and second-growth sawtimber forests, in height from 80 to 100 feet. Commonly residual stands from heavy partial logging, often include a disproportionate share of inferior species and cull trees. The pole stands and sapling areas, likewise, contain scattered saw-timber trees left at the time of logging, but are made up mainly of young trees of more or less even age.

The four stands included in the study of conifer-hardwood type were located where no recent-burning evidence could be found, and were distributed over a wider area than the pine forests; they also involved more stages of development than other type of forests, making possible observations from early youth to decadent maturity.

Representative of the typical mature stand was Station 20, a decadent stand which is situated on M 18 to Roscommon. Incidentally, the stand is also a representative of a forest after some disturbance by cutting; and the one at Station 17 pictures secondary succession from complete denudation of a former hardwood stand. The youthful character of the stand of maple-beech forest in the station number 19, is expressed by the small diameter of the stems and also by the large number of stems per unit area. These features are shown in Table 20.

Though the complex of species playing a part in the crown cover

is not so simple as in the pine forests, it is still very simple when compared with the southern mixed hardwood community, such as found in southern Michigan and Indiana, where up to 40 species play a part.

In the hardwood type, three layers can be recognized: (1) tree layer, usually consisting of superior and inferior strata; (2) shrub layer, consisting of shrubs and tree saplings; (3) herb layer, composed of herbs, pteridophytes, seedlings of trees and shrubs. On the whole, there is some clear cut separation of layers but sometimes it is rather overlapping.

In general, the canopy is quite irregular, since it represents an uneven-aged mixed stand of trees. A few of the larger trees, occasionally reaching a great height, stand above the superior layer as "dominants".

The tree species that are most common, and present in most of the stands are Fagus grandifolia, Acer saccharum, and Acer rubrum. Other species of tall trees at times become codominant in the crown cover are Populus grandidentata, Tsuga canadensis, but their distribution is scattered and erratic.

Under the open crown cover of the mature stands, there are some shrubs and small tree strata developed. The tree species present at all regularly is Acer rubrum and it outnumbers all other species in reproduction. This could be an indication that the original composition of the stand had been disturbed and recession of the climax species thus resulted. In Station 19 where young trees over 9 feet in height, but under one inch in diameter, size class two, and also in 1-3.5 inch class, size class three, were tabulated, Acer saccharum had a greater represen-

tation than all other species combined. Tilia americana and Prunus serotina shared this abundance in stems of 1-3.5 inch and 3.6-9.5 inch D.B.H. in class 3 and 4. It is striking how abundance of stems per unit decreases with maturity, such is shown in station 20. Even though hemlock and beech were low in number of stems per acre, their basal area showed doubtlessly that they were the dominant species before the destructive logging operation hit this stand. One thing worth notice in this particular instance, is that there were quite a number of large decayed and dead trees in the sampling area. Although they were not tallied, this may show that some of mature or overmatured stands in the area should be operated under a better management.

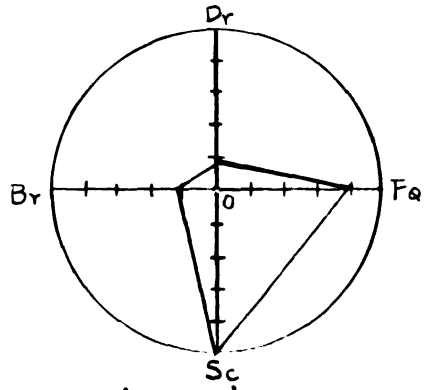
The flora of the deep hardwood forest is interesting. Some undergrowth of inferior tree species were found here, and the gloomy recess of this type of forest nourish plants that thrive in the shade. Here the Lycopodiums find a congenial home and flourish luxuriantly, while Trientalis covers the ground. The great Clintonia with its broadoval leaves close to the earth, is also frequent and striking. We shall also meet Rubus, Smilacina, Maianthemum and a few ferns particularly Dryopteris spinulosa. Other species occur, of course, but not so abundantly.

Table 21. Summarized Field Data of the Four 1/5 Acre Quadrats of the Northern Hardwood-Hemlock Type by Size Classes

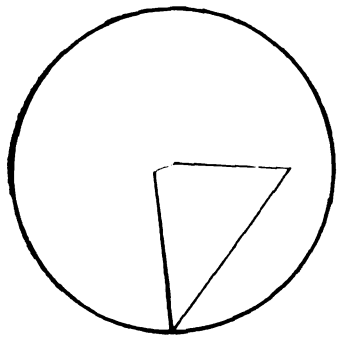
Species	SIZE CLASSES 2 Freq. No.	2 Freq. %	2 Dens. No.	2 Dens. %	3 Freq. No.	3 Freq. %	3 Dens. No.	3 Dens. %	4 Freq. No.	4 Freq. %	4 Dens. No.	4 Dens. %	5 Freq. No.	5 Freq. %	5 Dens. No.	5 Dens. %	TOTALS Freq. TQ	Freq. FQ	Freq. FR	Dens. Ts	Dens. D	Dens. Dr	Abundance	Basal Area Ft²	Basal Area Rel.	Basal Area /Acre
Acer rubrum	1	25	45	16.30	3	75	69	12.36	3	75	57	22.53	1	25	12	26.66	3	75	9.69	183	45.75	16.18	61	20.869	21.26	26.335
Quercus rubra	1	25	4	1.44	2	50	3	.53	3	75	28	11.06	2	50	3	6.66	3	75	9.69	38	9.50	3.36	12.66	11.033	11.24	13.789
Quercus alba	1	25	30	10.86	1	25	12	2.15	1	25	8	3.12	1	25	1	2.22	1	25	3.22	51	12.75	4.51	51	1.938	1.96	2.423
Populus grandidentata	1	25	2	.72	2	50	4	.71	2	50	16	6.32	1	25	0	20.0	2	50	6.46	31	7.75	2.73	15.50	11.470	11.68	14.340
Fagus grandifolia	2	50	9	3.26	2	50	50	8.96	1	25	11	4.34	2	50	3	6.66	3	75	9.69	73	18.25	6.46	24.33	6.487	6.61	8.110
Tsuga canadensis	1	25	1	.36	2	50	8	1.43	1	25	15	5.92	1	25	7	15.55	2	50	6.46	31	7.75	2.73	15.50	8.757	8.92	10.935
Betula lutea	-	-	-	-	1	25	3	.53	2	50	5	1.97	1	25	2	4.44	2	50	6.45	10	2.50	.89	5.00	3.798	3.87	4.748
Abies balsamea	1	25	1	.36	1	25	1	.17	-	-	-	-	-	-	-	-	1	25	3.22	2	.50	.18	2.00	.046	0.04	0.058
Acer saccharum	2	50	165	59.78	2	50	300	53.76	3	75	22	8.69	1	25	2	4.44	3	75	9.69	489	122.25	43.19	163.00	10.948	11.15	13.685
Ostrya virginiana	-	-	-	-	1	25	12	2.15	1	25	7	2.76	-	-	-	-	1	25	3.22	19	4.75	1.67	19.00	.176	0.17	.220
Tilia americana	-	-	-	-	1	25	36	6.45	1	25	54	21.34	-	-	-	-	1	25	3.22	90	22.50	7.95	90.00	8.774	8.93	10.968
Prunus serotina	-	-	-	-	2	50	39	6.98	2	50	22	8.69	-	-	-	-	2	50	6.45	61	15.25	5.39	30.50	4.551	4.63	5.688
Quercus ellipsoidalis	-	-	-	-	-	-	-	-	1	25	1	.39	-	-	-	-	1	25	3.22	1	.25	.09	1.00	.383	0.39	0.405
Prunus pensylvanica	-	-	-	-	1	25	2	.35	-	-	-	-	-	-	-	-	1	25	3.22	2	.50	.17	2.00	.096	.09	0.120
Quercus velutina	-	-	-	-	1	25	3	.53	-	-	-	-	-	-	-	-	1	25	3.22	3	.75	.26	3.00	.129	0.14	0.160
Carpinus caroliniana	1	25	4	1.44	1	25	15	2.68	-	-	-	-	-	-	-	-	1	25	3.22	19	4.75	1.67	19.00	.551	0.58	0.690
Pinus strobus	-	-	-	-	1	25	1	.17	1	25	4	1.58	1	25	3	6.66	1	25	3.22	8	2.00	.70	8.00	4.633	4.72	5.790
Pinus resinosa	-	-	-	-	-	-	-	-	1	25	3	1.18	1	25	3	6.66	1	25	3.22	6	1.50	.53	6.00	3.560	3.62	4.450
Amelanchier canadensis	1	25	15	5.43	-	-	-	-	-	-	-	-	-	-	-	-	1	25	3.22	15	3.75	1.32	15	-	-	-
TOTAL			276	24.38			558	49.29			253	22.35			45	3.97		775	100.00	1132		100		98.139	100	122.913

5 Dens.		TOTALS Freq.			Dens.			Abun-	Basal Area		
No.	%	Tq	Fq	FR	Ts	D	Dr	dance	Ft2	Rel.	/Acre
12	26.66	3	75	9.69	183	45.75	16.18	61	20.869	21.26	26.335
3	6.66	3	75	9.69	38	9.50	3.36	12.66	11.033	11.24	13.789
1	2.22	1	25	3.22	51	12.75	4.51	51	1.938	1.96	2.423
0	20.0	2	50	6.46	31	7.75	2.73	15.50	11.470	11.68	14.340
3	6.66	3	75	9.69	73	18.25	6.46	24.33	6.487	6.61	8.110
7	15.55	2	50	6.46	31	7.75	2.73	15.50	8.757	8.92	10.935
2	4.44	2	50	6.45	10	2.50	.89	5.00	3.798		4.748
-	-	1	25	3.22	2	.50	.1	00	.04		0.058
2	4.44	3	75	9.69	489	122.25	43.	00	10.		13.685
-	-	1	25	3	19	4.75	1	00		.17	.220
-	-	1	25	3	90	22.50		0.00		8.93	10.
-	-	2	50	6		15.25		0.5		4.63	
-	-	1	25	3		.2		1	3	0.	
-	-	1	25	3.		.					3
-	-	1	25	3.							.160
-	-	1	25	3.2							0.690
3	6.66	1	25	3.22						72	5.790
3	6.66	1	25	3.22						.82	4.450
-	-	1	25	3.22						-	-
45	3.97		775	100.0						00	

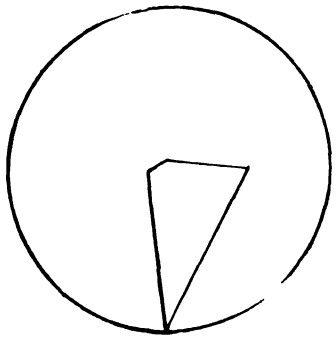
Figure 7. Phytographs of Important Species in Northern Hardwood-Hemlock Type



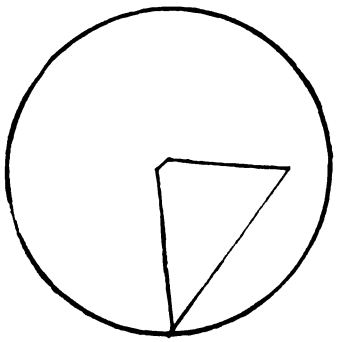
Acer rubrum



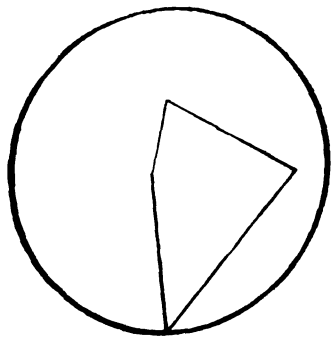
Quercus rubra



Populus grandidentata



Fagus grandifolia



Acer saccharum

Legend: ODr--Relative density in percent
OFq--Quadrat frequency in percent
OSc--Size classes in percent
OBr--Relative basal area in percent

Table 22 and 23. Data of the vegetation in the milacre quadrats of the northern hardwood-hemlock type as recorded in percentages of coverage or number of plants by height classes

Station 17 Location NW¼, Sec.10, T25N, R4W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Classes in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	28*	-	-	26*	-	-	25*	-	-	10*	-	-
Amelanchier canadensis	7*	-	-	-	-	-	-	-	-	-	-	-
Carex spp.	-	-	-	1	-	-	0	-	-	-	-	-
Danthonia spicata	2	-	-	2	-	-	2	-	-	2	-	-
Gaultheria procumbens	0	-	-	0	-	-	1	-	-	-	-	-
Koeleria cristata	0	-	-	-	-	-	-	-	-	-	-	-
Lonicera canadensis	0	-	-	-	-	-	0	-	-	-	-	-
Populus grandidentata	1*	-	-	-	-	-	-	-	-	1*	-	-
Prunus serotina	4*	-	-	4*	-	-	11*	-	-	3*	-	-
Quercus alba	1*	-	-	2*	-	-	1*	-	-	-	-	-
Quercus rubra	1*	-	-	4*	-	-	2*	-	-	12*	-	-
Vaccinium angustifolium	-	-	-	-	-	-	1	-	-	1	-	-

* number of plants

Station 18 Location SE¼, Sec.14, T26N, R4W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer saccharum	-	-	-	4*	-	-	2*	-	-	3*	-	-
Aster lucidulus	-	-	-	-	-	-	-	-	-	0	-	-
Carex blanda	1	-	-	1	-	-	-	-	-	-	-	-
Carex spp.	1	-	-	-	-	-	1	-	-	1	-	-
Corylus cornuta	1*	-	-	-	-	-	-	-	-	3*	-	-
Fagus grandifolia	-	-	-	2*	-	-	1*	-	-	1*	-	-
Mitchella repens	1	-	-	-	-	-	-	-	-	-	-	-
Ostrya virginiana	5*	-	-	5*	-	-	5*	-	-	6*	-	-
Prunus pensylvanica	5*	-	-	15*	-	-	4*	-	-	1*	-	-
Smilacina stellata	0	-	-	-	-	-	-	-	-	-	-	-
Tilia americana	-	-	-	-	-	-	-	-	-	-	1*	-

* number of plants

Table 24. Data of the vegetation in the milacre quadrats of the northern hardwood-hemlock type as recorded in percentages of coverage or number of plants by height classes

Station 19 Location SW¼, SEC.9, T26N,R5W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	27*	-	-	21*	-	-	13*	-	-	10*	-	-
Acer saccharum	-	-	-	-	-	-	5*	-	-	10*	-	-
Amelanchier canadensis	2*	-	-	1*	-	-	-	-	-	-	-	-
Amelanchier spp.	9*	-	-	2*	1*	-	20*	-	-	7*	-	-
Antennaria neglecta	-	-	-	-	-	-	0	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	0	-	-	-	-	-
Aster lucidulus	1	-	-	1	-	-	0	-	-	1	-	-
Carex spp.	1	-	-	1	-	-	1	-	-	1	-	-
Chimaphila umbellata	0	-	-	-	-	-	0	-	-	-	-	-
Clintonia borealis	-	-	-	-	-	-	0	-	-	-	-	-
Corylus americana	3*	-	-	4*	-	-	1*	2*	3*	4*	-	-
Fagus grandifolia	1*	-	-	-	-	-	-	-	-	-	-	-
Fragaria virginiana	-	-	-	0	-	-	-	-	-	-	-	-
Hieracium venosum	-	-	-	0	-	-	-	-	-	-	-	-
Lactuca spp.	0	-	-	-	-	-	-	-	-	-	-	-
Lycopodium obscurum	-	-	-	-	-	-	0	-	-	-	-	-
Mitchella repens	-	-	-	-	-	-	0	-	-	0	-	-
Mitella diphylla	0	-	-	-	-	-	-	-	-	-	-	-
Ostrya virginiana	1*	-	-	7*	-	-	-	-	-	-	-	-
Pinus strobus	-	-	-	-	-	-	2	-	-	-	-	-
Pedicularis canadensis	1	-	-	1	-	-	-	-	-	1	-	-
Prenanthes alba	2*	-	-	-	-	-	-	-	-	-	-	-
Prunus penslyvanica	-	-	-	-	-	-	1*	-	-	1*	-	-
Pteridium aquilinum	-	2	-	-	2	-	-	1	-	-	-	-
Pyrola secunda	0	-	-	0	-	-	-	-	-	-	-	-
Quercus alba	2*	-	-	-	-	-	-	-	-	-	-	-
Quercus ellipsoidalis	-	-	-	1*	-	-	-	-	-	2*	-	-
Quercus rubra	-	-	-	4*	-	-	-	-	-	3*	1*	-
Salix discolor	-	-	-	0	-	-	-	-	-	-	-	-
Smilacina stellata	0	-	-	-	-	-	0	-	-	0	-	-
Solidago nemoralis	-	-	-	-	-	-	0	-	-	0	-	-
Trientalis borealis	-	-	-	-	-	-	1	-	-	-	-	-
Viburnum acerifolium	1	-	-	-	-	-	-	-	-	-	-	-
Viola blanda	1	-	-	0	-	-	0	-	-	0	-	-

* number of plants

Table 25. Data of the vegetation in the milacre quadrats of the northern hardwood-hemlock type as recorded in percentages of coverage or number of plants by height classes

Station 20 Location NW¼, Sec.2, T25N, R3W.	Distribution of Coverage Classes for the Type											
	Quadrat											
	1			2			3			4		
	Height Class in Feet											
Floristic List	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6	0-1	1-3	3-6
Acer rubrum	3	-	-	2	-	-	2	-	-	2	-	-
Agrostis alba	0	-	-	-	-	-	-	-	-	-	-	-
Agrostis scabra	-	-	-	1	-	-	1	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	-	-	-	-	-	-	1	-	-
Aralia nudicaulis	-	-	-	0	-	-	-	-	-	-	-	-
Carex intumescens	0	-	-	2	-	-	-	-	-	1	-	-
Carpinus caroliniana	1*	-	-	-	-	-	-	-	-	-	-	-
Centaurea maculosa	0	-	-	-	-	-	-	-	-	-	-	-
Clintonia borealis	-	-	-	-	-	-	1	-	-	1	-	-
Coptis trifolia	-	-	-	-	-	-	-	-	-	1	-	-
Cornus canadensis	-	-	-	-	1*	-	-	-	-	-	-	-
Cornus stolonifera	-	-	1*	-	-	-	-	-	-	-	-	-
Dryopteris spinulosa	-	-	-	-	-	-	-	-	-	2	-	-
Fagus grandifolia	5*	-	-	8*	-	-	4*	-	-	7*	-	-
Galium triflorum	0	-	-	-	-	-	0	-	-	-	-	-
Lycopodium obscurum	1	-	-	-	-	-	1	-	-	2	-	-
Maianthemum canadense	0	-	-	-	-	-	-	-	-	-	-	-
Mitchella repens	-	-	-	0	-	-	-	-	-	-	-	-
Polygonum cilinode	0	-	-	1	-	-	0	-	-	1	-	-
Polygonum Convolvulus	-	-	-	-	-	-	1	-	-	-	-	-
Prunus pensylvanica	-	-	-	5*	-	-	1*	-	-	-	-	-
Pteridium aquilinium	1	-	-	1	-	-	2	-	-	2	-	-
Quercus rubra	-	-	-	1*	-	-	-	-	-	-	-	-
Rubus hispidus	-	-	-	0	-	-	-	-	-	-	-	-
Rubus parviflorus	1	-	-	-	-	-	-	-	-	-	-	-
Rubus strigosus	1	-	-	1	-	-	-	-	-	1	-	-
Smilacina stellata	0	-	-	1	-	-	0	-	-	0	-	-
Trientalis borealis	1	-	-	1	-	-	-	-	-	1	-	-
Tsuga canadensis	-	-	-	3*	-	-	10*	-	-	-	-	-
Viburnum cassinoides	-	-	-	-	-	-	-	-	1*	-	-	-
Viola blanda	-	-	-	2	-	-	-	-	-	-	-	-
Viola scabra	-	-	-	1	-	-	1	-	-	-	-	-

* number of plants

V. THE STUDY OF EDAPHIC FACTORS

1. Physiographic Features and Description of Soils Under Different Vegetation Types

The glacial action which this region has been subjected has erased most of the sharp features of the topography. A large proportion of the region is relatively level to gently rolling, with slopes less than 25 percent. In some sections the land surface is practically level for miles. These areas, situated above the general level of the surrounding country, have excessive drainage and become dry in midsummer. Dotted through the region are swamp areas.

A great variety of soils, all podzolic, are represented by many soil types. Sand and sandy loams predominate. Locally peats and mucks or heavy clays occupy extensive areas. Generally speaking, the soils are deep as the result of extensive deposition during the glacial period. Stones and boulders are abundant in some soils, but almost entirely lacking on the sand plains.

Roselawn sand. Roselawn sand comprises the loose, yellowish-gray sand, which is dry to a depth ranging from 3 to more than 4 feet, on the pine and oak hills. The deeper underlying material consists mainly of sand but contains scattered gravel and boulders and in places pockets of clay. The soil is fairly uniform in that it consists dominantly of a mixture of medium and fine sand, with only a small proportion of silt

and clay. The land is for the most part free from stones but in places boulders and gravel pocket occur (Table 26).

The gravelly phase of Roselawn sand is distinguished by the presence of an appreciable quantity of rounded gravel and small stones on the surface and throughout the soil. The gravel consists of waterworn fragments of granitic rocks, chert, and some sandstone, with very little or no limestone.

This type of soil is one of the more extensive soils in the region. It occurs as low swells, smooth rounded ridges, and hills with broad dry swales or valleys intervening. The land is dry or well drained, owing to the perviousness of the soil and free downward percolation of water.

The original forest consisted dominantly of red pine, with perhaps a few scattered white pine, oaks and jack pine. The pine had been entirely cut by lumbermen, and the old cut-over land has grown up to a poor or fair growth of small oaks, red maple, aspen and white birch. A few scattered old red pines and most of the pine stumps left by the lumbermen remain. Roots of the tree extend visibly down to about 20 inches on average, and the fine roots continue to penetrate the soil to a depth of 30 to 44 inches. Bracken fern, sweet fern, and low blueberry are common, and in places there is a dense thicket of briers. Some hardwoods, maple, beech, and hemlock grew on the sandy loam areas which have been included with mapped areas of Roselawn sand (58).

The gravelly phase of Roselawn soil under the Northern pin oak type consists of the following layers; (1) A surface layer, A1 and A_o (The latter being a thin layer), varying from 1 to 2 inches in thickness,

of mold or a loose mixture of gray sand, charred organic matter, and plant roots; (2) The A_2 horixon, consists of grayish leached incoherently sand from 2 to 4 inches thick; (3) The horizon of B_1 with dull-yellowish slight loamy sand, tinted by organic colloidal matter; about 16 inches in thickness; with scattering gravels here and there; (4) B_2 horizon is a gradation from the loamy sand, with clay pockets fragments of granite rocks, stones, and gravels in places down to a depth of about 50 inches where tree roots usually end their extension, and (5) the weathered parent glacial drift material, the C horizon, consisting mainly of sand with some scattered gravels and boulders and here and there a pocket of clay (Figure 8).

The content of organic matter is uniformly low and not durable. Where the soil is grass covered, as in spots on old cut-over land, the dark-gray color from organic matter extends to a greater depth than under trees. The moisture-holding capacity and the average quantity of water held is low, but it is probable that a high proportion of that present is available. The total quantity of essential plant nutrients, such as calcium, magnesium phosphorous, and potassium is lower than in the heavier soils and those containing a greater proportion of limestone, but there is no evidence of an abnormal deficiency of essential plant-food elements. The low fertility is compensated to some extent by the penetrability of the soil and greater freedom of root development. The reaction is strongly acid to a depth ranging from 3 to 5 feet. The gravelly areas, spots in which some clay is present between depths of 3 and 5 feet, and the dry valleys or swales between hills may be slightly more productive than typical.

Grayling sand. This soil type comprises the deep, yellowish-gray sand soil of the drier pine plains. The forest soil of this type found under an aspen stand consists of the following layers: (1) A very thin layer of A_0. (2) The A_1 layer of mold and humous soil ranging from one-half to 1½ inches in thickness; (3) Underlaying the A_1 is the A_2 horizon in which gray sand changes to light gray sand from 2½ to 3 inches in thickness; (4) The horizon of B_1 has a dull-yellow loamy sand which becomes lighter in color with an average thickness of 16 inches and grades into (5) the B_2 substratum of light yellow, wet coarse sand, sand, and fine gravel at a depth ranging from 20 inches downward. The distinguishing characteristics of this soil are its loose consistence, incoherent, or single-grained structure, sandy texture throughout, and its perviousness and nonretentiveness of moisture. The average moisture content is very low to a depth ranging from 3 to 4 or more feet, and the fertility is correspondingly low. The reaction is medium or strongly acid to a depth ranging from 3 to 4 or more feet. Penetration of some tree roots extend to a depth of about 30 inches (Figure 8)(Table 26).

In the open grass-covered areas such as the sample plot on grassland type, station 4, the soil layer colored by organic matter is appreciably thicker and the tint is darker than in the same layer under jack pine or aspen.

This soil is fairly uniform throughout the region, but the texture of the sand varies somewhat, from medium to coarse, and the amount of gravel varies from place to place. These variations may have some slight significance, in relation to cultivated farm crops and in relation

to average moisture content and amount of plant nutrients affecting plant growth. There is a suggestion of a little higher natural fertility in areas of the gravelly phase, indicated by a somewhat more thrifty tree growth, and owing, perhaps, to a high proportion of minerals other than quartz in the parent materials or to a somewhat higher moisture-holding capacity.

Areas of this soil are level, plainlike or very slightly uneven, owing to shallow dry depressions and hummocks of wind-blown sand. The land is excessively drained and dry, due to the perviousness of the soil and the underlying geologic formation. The water table or permanently wet sand probably lies at a depth of more than 15 feet.

The original tree growth probably consisted mainly of jack pine and red pine; there were probably a few white pine and oaks. The present growth consists of mainly of jack pine, either in thickest or scattered in association with small groups of oaks, and aspen, and also some good aspen stands. In the more open areas, the characteristic and more common shrubs and herbs are blueberries, low willow, sweetfern, bracken fern, species of bluegrass, oatgrass and bunch grass.

Kalkaska loamy sand. Kalkaska loamy sand includes the lighter and deeper sand soil of the dry sandy plains and valleys, which supports a hardwood forest. Its chief visible differences from the sands of the pine plains is in the dark-brown or amber-colored layer which underlies the pale lavender gray A_2 leached layer at a depth of a few inches and in the characteristic slight cementation. Beneath this layer, beginning at a depth ranging from 15 to 20 inches, is the B_2 horizon which

consists of pale-yellow or gray loose penetrable comparatively dry sand mixed with stones and gravels which extends to a depth ranging from 8 to more than 10 feet. The soil is not highly fertile, and is moderately or strongly acid to a depth of 30 some inches, but apparently has a higher average moisture content and hence is a little more productive than the sand of the pine plains. The land is nearly level but is pitted here and there with shallow dry depressions and lake basins and is featured by low terrace escarpments (Table 26) (Figure 8).

The forest cover consisted principally of hard maple, beech, yellow birch, elm, and ironwood, together with a few scattered white pine. A few tracts of virgin forest still remain in the Kalkaska county, but the greater part has been cut over and has grown up to a second growth of maple, elm, and other species of the original forest, or, where more severely burned over, the growth is more largely aspen or the land is covered with grass. A considerable acreage has been cleared for farming. The soil is easily plowed, is nearly free from cobbles and large stones, and large bodies are comparatively uniform. Its chief deficiency is probably low moisture content. The sand also has some tendency to blow in clearly cultivated fields and, as on most of the sandy soils the fields are likely to be infested with quack grass.

Ogemaw sandy loam. From the surface downward it consists of (1) a thin surface layer of about ½ inch of forest mold and a one to two inches layer of dark gray loamy sand. (2) A leached, grayish or whitish, loose sand layer, varying from 4 to 6 inches in thickness. (3) Dark-yellow or coffee-brown sandy loam, in places gravelly or cobby and

slightly cemented sand, about 20 inches in thickness. (4) Leached grayish wet sand; and (5) comparatively impervious pale reddish-brown clay. The dark color at the surface, the dark-yellow or brown color of the third layer, and the presence of clay at a depth varying from 2½ to 4 feet below the surface are distinguishing characteristics. The basal part of the sandy soil is more or less permanently wet, and the average moisture content is higher than in other sandy soils such as Grayling sand, Roselawn sand, and Rubicon sand, and the fertility is slightly higher. In most areas, the surface is acid, although in a few places it may be nearly neutral or slightly alkaline; the underlying sandy layers are strongly acid; and owing to the presence of calcium carbonate the clay substratum is alkaline (Table 26).

This soil occurs in small patches on nearly level plains in association with the heavier soils. In places the land is very uneven on account of the small mounds and pits caused by the uprooting of trees. Under natural condition some of the land is wet and imperfectly drained. The higher average moisture content is shown by the darker color and greater accumulation of organic matter, as compared with some other soils, the aspect of the present vegetative cover, and the composition and nature of the original cover.

The original tree growth consisted mainly of white pine, with a variable mixture of hemlock and hardwoods, such as elm, ash, basswood, and beech and more or less spruce, fir and arbor vitae. The present cover of the uncultivated land consists of a dense brushy growth of poplar, aspen, maples, alder, willow, and briers, and scattered clumps or individuals of hardwoods and other original species (Figure8).

Rubicon sand. Rubicon sand consists of deep-yellow comparatively dry sand on pine plains and sandy valleys. The typical profiles of this soil type consists of (1) A_o, a thin layer of organic matter; (2) A_1, a horizon composes of forest humus mixed with dark gray sand with a thickness of from 1 to 3 inches; (3) the grayish leached sand which is designated as A_2 layer; (4) B_1 horizon which is a dark-brown layer of loamy sand occurs at a depth ranging from 6 to 24 inches below the surface, and beneath this is (5) the B_2 layer of pale-yellowish, incoherent pervious sand (Table 26).

Areas of this soil are level, and the soil has a thicker gray and brown subsurface layers unlike those in the Grayling sands. This soil is free from stone, moderately acid and the fertility is low, but supports a little greater amount of vegetation because of slightly higher average moisture content. At present, there is a poor to fair second growth of oaks, aspens, white pine and white birch, together with a few widely distributed individual relics species such as white and red pine (Figure8).

Figure 8. Schematic Presentation of Typical Profiles of Varicus Soil Types

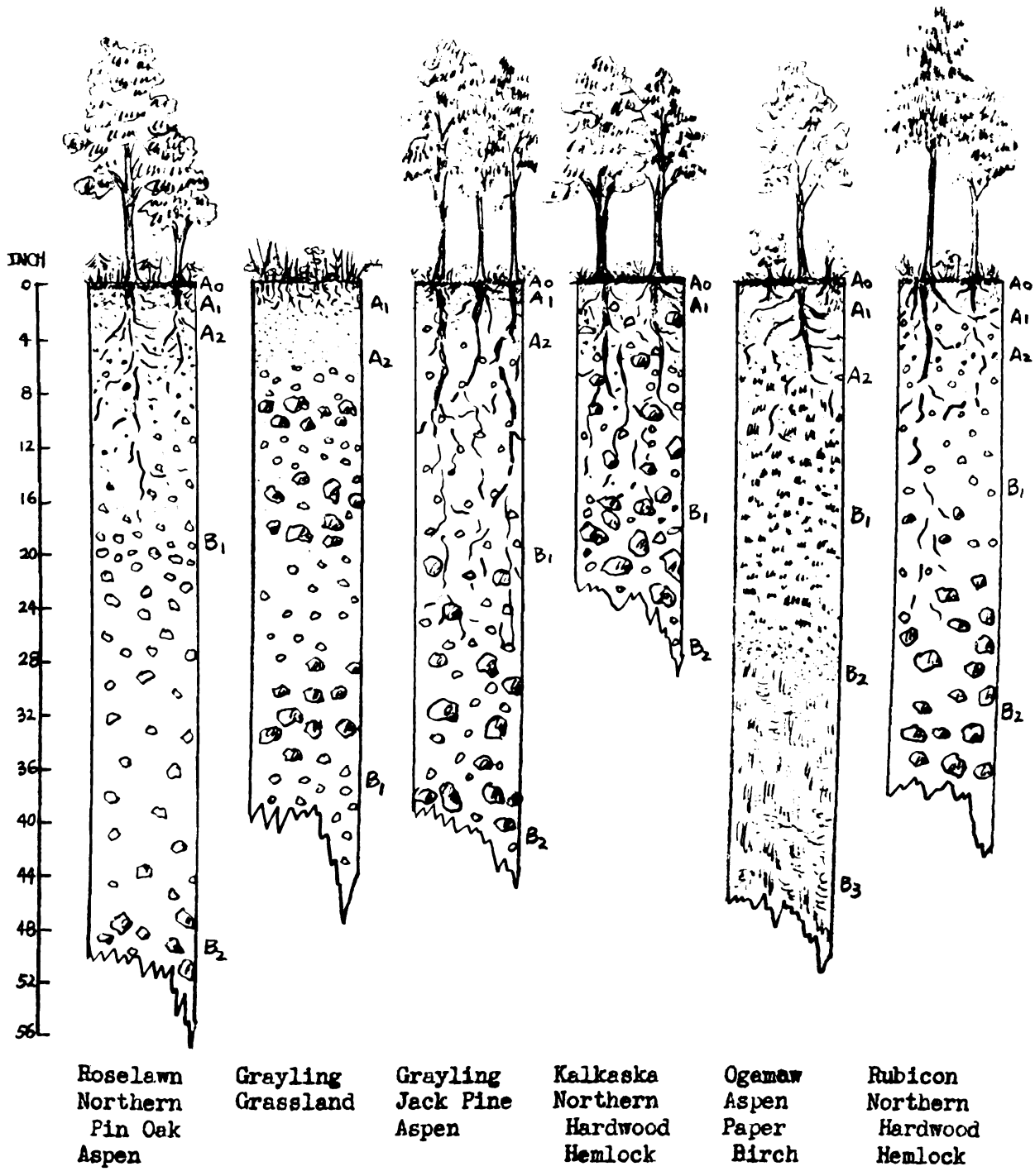


Table 26. The Depth, pH value, Content of Organic Matter and Mechanical Analysis in Various Horizons. The Soil Type and Cover Type in Six Sampling Stations.

Location	Soil Type	Cover Type and Important spp.	Horizon	Depth (in.)	pH	Org. Mat. %	Mechanical analysis (%) >2mm. sand	<2mm. sand	<50μ	5-2μ	<2μ
Station 4	Grayling Sand (Gravelly phase)	Grassland Type Andropogon spp. Danthonia spicata	A_1 A_2 B_1 B_2	0-2 2-6 6-38 38-	5.1 5.7 5.3 5.4	1.24 1.02 0.30 0.13	3.12 12.74 1.24 6.25	88.27 83.60 96.95 92.30	3.97 1.59 0.39 0.28	1.26 0.24 0.04 0.00	3.38 1.83 1.38 1.17
Station 5	Grayling sand (Gravelly phase)	Aspen Type Populus grandidentata Quercus alba	A B_1 B_2	0-5 5-20 20-36	4.4 5.3 5.0	1.63 0.85 0.27	0.46 2.32 1.32	87.43 86.20 90.38	8.15 6.09 4.77	0.91 0.06 0.30	3.14 5.03 2.93
Station 12	Roselawn sand (Gravelly phase)	Northern pin oak Type Quercus rubra Quercus ellipsoidalis Populus grandidentata	A_1 A_2 B_1 B_2	0-2 2-4 4-19 19-50	4.6 4.8 5.0 5.8	6.66 1.72 0.62 0.26	16.18 6.43 10.51 4.65	74.89 84.89 81.09 88.64	5.35 4.82 3.40 2.68	1.02 1.40 1.34 1.54	2.56 2.46 3.56 2.49
Station 8	Ogemaw Loamy Sand	Aspen Type Populus tremuloides Populus grandidentata Betula papyrifera Acer rubrum	A B_1 B_1 B_2	0-7 7-18 18-27 27-30	5.4 5.7 5.4 5.9	0.72 1.18 0.71 0.31	1.58 0.36 2.61 0.06	87.70 91.50 90.00 97.04	7.33 5.49 5.37 1.30	0.93 0.20 0.68 0.00	2.46 2.45 1.34 1.60
Station 18	Kalkaska Loamy Sand	Northern-Hardwood-Hemlock Type Acer saccharum Fagus grandifolia Tilia americana	A B_1 B_2	0-6 6-20 20-	5.4 5.4 5.7	1.33 1.06 0.46	3.73 7.39 10.04	83.34 75.63 83.10	10.16 10.03 3.69	0.79 1.28 0.90	1.98 5.17 2.27
Station 19	Rubicon Sand	Northern-Hardwood-hemlock Type Pinus strobus Acer saccharum	A_1 A_2 B_1 B_2	0-3 3-6 6-24 24.36	5.3 5.5 6.3 6.1	3.40 0.51 0.37 0.44	0.62 1.44 4.58 11.70	85.60 88.05 85.62 85.80	9.22 6.95 5.90 0.62	0.55 1.37 1.95 0.00	4.01 2.19 1.95 1.88

2. Topography

Although topography affects vegetation indirectly by modifying other factors of the environment, it has nevertheless a significant influence upon all plant communities. Uniform vegetation may be expected in area that is level provided other factors being equal. Usually irregularities in topography such as depressions or different slopes or exposures will produce entirely unsimilar light, temperature and moisture conditions, and the resultant of this interaction is the various types of plant growth. Furthermore, slopes affect surface runoff and consequently will determine the degree of erosion and soil moisture condition. Geologically speaking, if the topography is immature, drainage is relatively poor and depressions contain ponds or lakes which in turn will support different species of plants. In a region where moisture is rarely a critical factor, slope and exposure produce scarcely noticeable differences in vegetation. Whereas, local topographic effects will become apparent and result in vegetational zonation.

Two transition tendencies of plant growth are obvious in the study of this area: one, which occurs where there is increasing soil moisture, is toward the northern hardwoods; the other, which occurs where there is decreasing soil moisture, is toward the pine community. The hardwoods, too, consist of two variants in which one or the other of the two dominants, plays a more important role. On upland sites, with decreasing soil moisture, Acer saccharum predominates; such is the case in station 19; whereas in the more moist level land habitat, Hemlock (Tsuga canadensis) and beech (Fagus grandifolia) predominate as in station 20 of the Conifer-northern Hardwood type.

3. Soil Reaction

There are various designations for soil acidity. Generally it is expressed in terms of pH values. Thus, in a glossary of special terms in the United States Department of Agriculture yearbook of 1938 an acid soil is defined as:

> "A soil giving an acid reaction (Precisely, below pH 7.0; practically, below pH 6.6) throughout most or all of the portion occupied by roots. More technically, a soil having a preponderance of hydrogen ions over hydroxyl ions in the solution."

Likewise, an alkaline soil is defined as: "any soil that is alkaline in reaction (Precisely, above pH 7.0; practically, above pH 7.3)".

In the development of acid soils the soluble bases are removed by conditions of high rainfall and the resulting leaching processes, while alkaline conditions are accounted for by precisely the lack of leaching during the weathering of parent material. Contributing factors in the development of acid soils are the organic acids produced by plants, the low base content of residue materials added to the soil, and the character of their decomposition.

The pH of a forest soil is not constant but shows variations during the course of a year. Seasonal variations in the pH of soils are probably related to climatic conditions and to the nature of the vegetation. The degree of drying and the kind of soil also have a marked differences in soil reaction. It seems that drying of soils is generally in the direction of increased acidity. Furthermore, altitude, aspect and drainage influence this reaction of soil. In general, pH values decrease with increase elevation, the soils of north slopes tend to be

more acid than those of south and west slopes. Under conditions of poor drainage highly acid conditions are apt to develop.

There is very little evidence that low pH per se is responsible for poor growth of forest trees, for in northern Europe, soils having pH values of 4.0 or less are known to be highly productive, even for hardwoods, such as beech. It seems, however, that seedlings are more sensitive to soil reaction than old trees, and they develop best in soils having reaction values between pH 4.5 and 6.0. It has been known that sometimes it is necessary to acidify nursery soils in order to produce satisfactory coniferous stock.

The forest soils of most of the upland stands are strongly acid in the upper portions of the profile, especially the A layer, with a slight but gradual increase in pH with depth. The pH of the horizons from the B_1 upward was definitely lower in the poplar and oak stands than in the open grassland soil. These soil reaction tests conform with the findings of Wilde that the pH values range from 5 to 6.5 (98). The pH values of the several forest soils are given in Table 26.

Table 27. Analysis of Variance of pH Value in Different Soil Horizons and under different cover types.

Source	Degree of Freedom	Sum Squares	Mean Squares	F
Total	17	3.6700		
Between Horizon means	2	0.6132	0.3066	2.39
Between Type means	5	1.7652	0.3530	2.78
Error	10	1.2916	0.1292	

There were no significant differences in different soil horizons and under various vegetation covers as far as pH value is concerned.

4. Soil Temperature

Soil temperature is a highly important factor, since it influences to greater or lesser degree, the physical, chemical, and biological processes in the soil. The principal source of heat is solar radiation, and its intensity in turn will vary according to seasonal changes, atmospheric conditions, latitude, exposure and slope and also the living and non-living cover of the soil. Thusly, radiant energy reaching a given spot on the soil is not constant.

Beside all these external factors that can influence the soil temperature, certain characteristics of the soil itself should not be overlooked. For properties of soil such as color, content of water, specific heat and conductivity of heat etc. also may exert an important influence.

From the ecological view point, one may find that soil temperature influences the germination of seeds and the survival and development of seedlings. Many instances show that even if moisture and aeration conditions are favorable, seeds will not germinate or the period of germination will be prolonged, if the temperature is too low. This phenomenon may explain some dense forest stands are frequently without enough reproduction. On the other hand, in situations exposed to intense solar radiation, surface soil temperatures may rise high enough to be fatal to young seedlings.

Data obtained during this study show that the highest soil temperature at six inch under a 30-year-old jack pine stand were from 4° to 7°F lower than in the open grassland during August and September; and in October the differences were 6°F. There seem to be no significant differences in soil temperatures among different types of forest stands, except the mature hardwood stand of station 20 showed a slightly lower temperatures. The soil temperature data previously described are given in Table 28 and Figure 9.

Table 28. Soil temperature (°F) at six inches below surface in six different cover types on different dates.

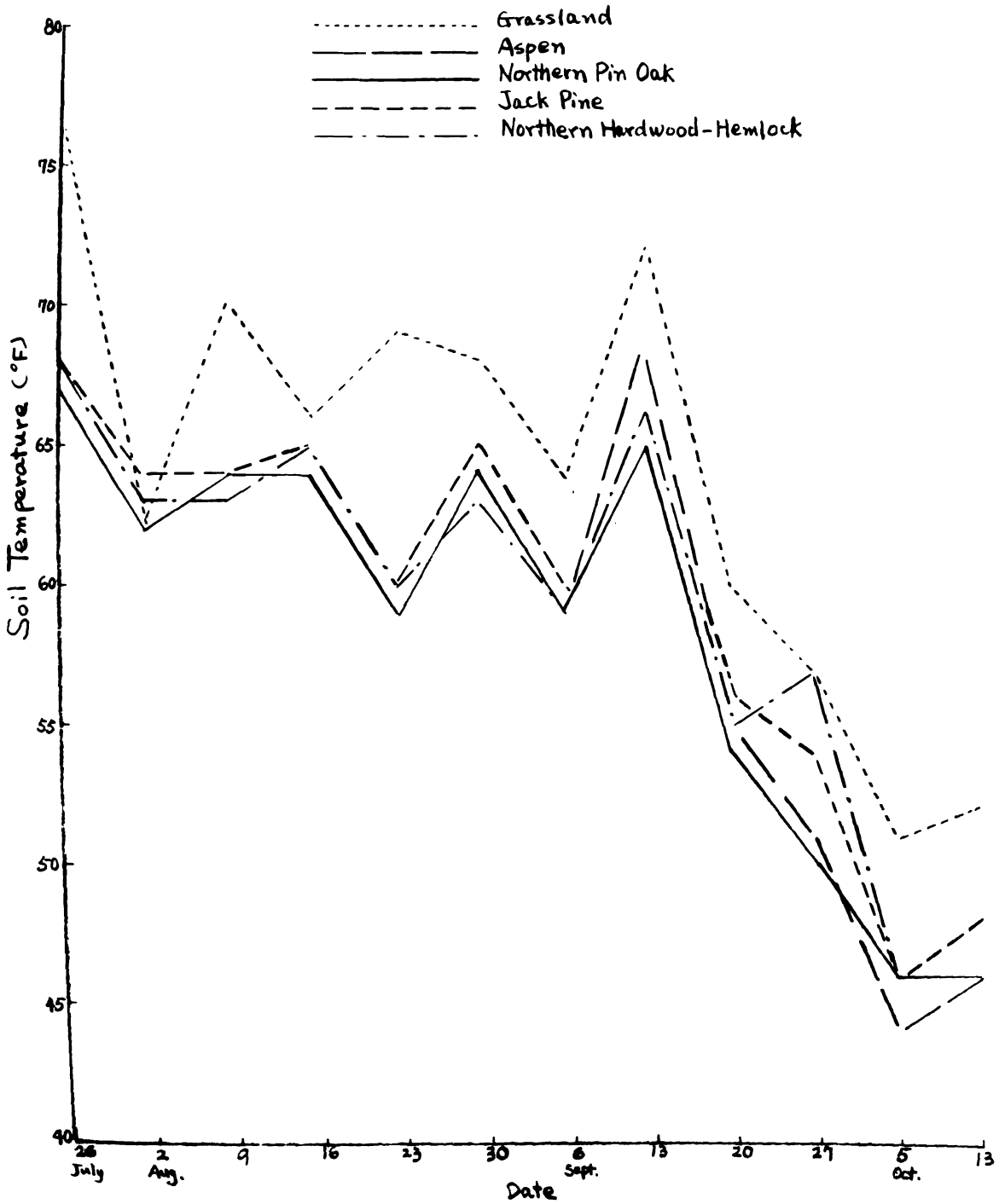
Type	Grass-land	Jack pine	Northern pin oak	Aspen	Aspen	Northern Hard-wood Hemlock
Station No.	4	15	9	6	5	18
July 26	77	70	67	68	68	68
Aug. 2	62	64	62	64	64	63
Aug. 9	70	63	64	64	64	63
Aug. 16	66	66	64	65	65	65
Aug. 23	69	58	59	59	60	59
Aug. 30	68	64	64	64	65	63
Sept. 6	64	60	59	59	60	59
Sept. 13	72	65	66	68	65	66
Sept. 20	60	54	55	54	56	55
Sept. 27	57	50	53	51	52	51
Oct. 5	51	46	46	44	46	46
Oct. 13	52	48	48	46	46	46

Table 29. Analysis of variance of soil temperature.

Source	Degree of Freedom	Sum of Squares	Mean of Squares	F
Total	71	4186.44		
Between Type Means	5	259.25	51.85	23.89**
Between Date Means	11	3807.42	346.13	154.89**
Error	55	119.77	2.17	

** Significantly different at 1% level.

Figure 9. The Relation of Soil Temperature to Date in Various Cover Types



Analysis of variance of soil temperature in six sample plots indicated that both covering types and dates caused significant difference. The grassland soil had definite higher temperature than other covering types, which were not significantly different among themselves.

5. Soil Moisture

As a result of transpiration, large amounts of water in the form of water vapor pass into the atmosphere from the leaves of trees and other plants. This water loss must be balanced by uptake of water from the soil. In many regions, the occurrence of forest types is largely controlled by the supply of water. An excessive amount of water may be quite as unfavorable for tree growth as a deficiency. Usually site quality improves with increasing amounts of available soil moisture. In an evaluation of the moisture relation of soils, consideration should always be given to the nature of the deeper soil horizons and underlying strata. Layers of finer-textured material lying several feet below the soil surface may be highly important to support a good growth of certain type of vegetation. Stoeckeler and Jump (86) found that direct seeding of conifers was feasible on sand-plain areas in the Lake States, where a water-table was situated from 2-5 feet below the surface, that did not fluctuate greatly. In such situations they invariably found more available moisture in the surface 6 inch of soil than was found in areas where the water table was deeper than six feet.

Precipitation is the principal source of water in soils, and its infiltration into the ground is influenced by the nature of soil. This

effect is not only affected by the total volume of non-capillary pores of the soil, but also by their size and arrangements. Beside the soil itself, other things such as the incorporated organic matter in mineral soils usually increases their permeability to water as a result of increased porosity.

Losses of soil water by evaporation may be substantial if the relative humidity of the atmosphere decreases. The loss of water from the soil, on the other hand, generally increases with wind movement.

Methods for measurement of soil moisture may conveniently be considered in two groups: (1) those involving removal of a sample from the soil body, and (2) those in which the moisture of soil is measured in situ. In this study of natural vegetation type, the need of a technique whereby moisture changes in undisturbed soil can be followed throughout the growing season and during seccessive years is most desirable. Thus, electrical resistance method of Bouyoucos was used and readings were obtained by means of a modified Wheatstone bridge.

The electric resistance of soil at the depth of 6" and 18" in six sampling plots, i.e. station no. 4,5,6,9,15,18, were recorded weekly, then corrected to 70°F and 60°F in order to convert the data to percentage of moisture content by using Bouyoucos colona sand curve and Della-Bianca's Grayling sand curve respectively. The results are summarized in the following table 30 and 31.

Since Della-Bianca's study (3) was done in the vicinity of this location and the nature of climatic, edaphic and phytosociological factors were closely related with that of the present research, thus

an analysis of variance of percentage of soil moisture content can be carried out according to Table 31.

Table 30. Percentage of soil moisture content in different cover types

By Coloma Sand Curve

Type	Hemlock Northern Hardwood		Grassland		Jack pine		Aspen		Aspen		Northern pin Oak	
Station	18		4		15		6		5		9	
Depth	6"	18"	6"	18"	6"	18"	6"	18"	6"	18"	6"	18"
July 26	7.5	--	8.5	--	6.5	--	7.0	--	--	--	7.5	--
Aug. 2	2.5	--	5.5	--	2.5	--	4.5	--	2.5	--	7.0	--
Aug. 9	7.5	--	7.0	--	5.0	--	7.5	--	6.5	--	7.5	--
Aug. 16	6.0	3.0	6.5	7.5	3.5	3.0	3.0	5.0	6.0	8.0	7.5	7.0
Aug. 23	3.0	7.5	6.5	8.0	4.5	7.0	4.5	7.0	4.5	7.0	7.0	7.0
Aug. 30	2.0	2.5	2.0	4.5	2.0	2.5	2.5	2.5	2.5	3.0	5.5	6.5
Sept. 6	3.0	2.5	4.0	3.5	2.5	2.5	2.5	3.0	4.5	5.0	4.0	6.5
Sept.13	2.5	2.0	1.5	2.5	1.5	1.5	2.5	2.0	3.0	4.5	5.0	6.5
Sept.20	2.5	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	2.5	5.5	5.5
Sept.27	2.5	4.5	2.5	2.5	2.0	5.0	2.5	2.5	3.0	5.5	6.5	5.5
Oct. 5	2.0	2.5	2.5	2.5	2.0	2.0	2.0	2.5	2.0	6.5	4.5	5.5
Oct. 13	2.0	2.5	2.0	2.5	1.5	1.0	5.0	2.5	2.5	6.0	4.0	5.5

Table 31. Percentage of soil moisture content in different cover types.

By Dalla-Bianca's Curve

Type	Hemlock Northern Hardwood		Grassland		Jack pine		Aspen		Aspen		Northern pin Oak	
Station	18		4		15		6		5		9	
Depth	6"	18"	6"	18"	6"	18"	6"	18"	6"	18"	6"	18"
July 26	11.0	--	11.0	--	11.0	--	11.0	--	--	--	11.0	--
Aug. 2	3.9	--	9.0	--	4.7	--	6.7	--	4.9	--	11.0	--
Aug. 9	11.0	--	11.0	--	8.0	--	11.0	--	10.3	--	11.0	--
Aug. 16	9.5	7.2	10.7	8.0	6.1	4.2	5.0	6.0	9.7	8.0	11.0	7.7
Aug. 23	9.6	8.0	10.3	8.0	7.9	8.0	7.5	7.7	7.1	7.8	11.5	7.6
Aug. 30	3.2	4.0	3.2	5.3	2.0	3.8	4.2	3.9	4.2	4.5	8.9	7.5
Sept. 6	5.2	3.9	7.0	4.9	3.8	3.9	4.6	4.4	6.8	6.1	6.8	7.5
Sept.13	4.6	3.2	2.0	3.5	2.0	3.0	4.8	3.5	5.4	5.4	8.2	7.3
Sept.20	3.7	2.5	2.8	2.9	2.0	3.5	3.5	2.4	2.8	4.1	9.1	6.2
Sept.27	4.6	5.3	3.9	4.4	3.2	6.0	3.9	3.9	5.3	6.6	10.5	6.6
Oct. 5	2.8	3.7	3.5	3.8	3.1	3.2	3.2	3.7	3.0	7.5	7.9	6.4

Figure 1C. Soil Moisture of Various Cover Type by Using Colome Sand Curve Determined by Bouyoucos

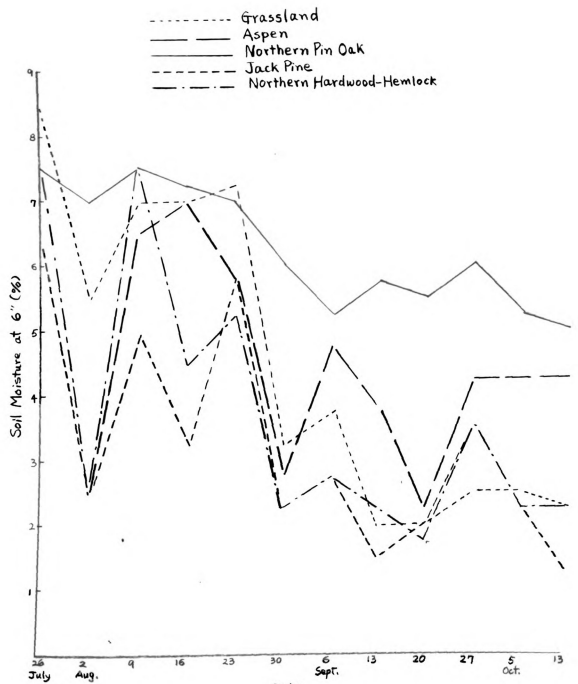


Table 32. Analysis of variance of soil moisture in different cover types, depths and dates.

Source	Degree of Freedom	Sum Squares	Mean Squares	F
Total	107	586.12		
Between Type Means	5	175.95	35.19	22.46**
Between Date Means	8	261.08	32.64	20.83**
Between Depth Means	1	3.25	3.25	2.07
Error	93	145.84	1.57	

** significantly different at 1% level.

The result indicates that the moisture contents of soil were different under various vegetation types and on different dates, but not at different depths. Further "t" test shows that the moisture content of soil in oak forest was highest and that of jack pine forest lowest, and followed the order as:

northern pin oak type > aspen type > grassland and noethern hardwood-hemlock type > jack pine-aspen type > jack pine type.

The fact that the jack pine type has the lowest moisture content among the various types of vegetation may be due to its possession of a rather open canopy and sparsely spaced trees, consequently the evaporation rate of soil moisture would be higher during a windy and hot period.

6. Organic matter

The organic matter of the soil represents an equilibrium or balance between the agencies supplying fresh organic debris and those leading to its decomposition. The balance is of course dynamic; the adjustment is probably closest in climax plant communities. In forests, the principal

sources are the leaves, stems, branches, roots, bark, fruits and seeds of trees. The contribution made by shrubby and herbaceous vegetation is smaller, but not without significance. In grasslands, by way of contrast, a large amount of organic matter is deposited annually in the soil body by the roots which die.

Humus is highly important from the standpoint of forest production. It functions in soil fertility, serving as a storehouse of nutrients necessary for plant growth. The physical, chemical and biological properties of soil are improved by humus with the result that conditions for the growth of higher plants and microorganisms are made more favorable. Organic matter tends to make fine-textured soils more porous and binds together the particles in coarse-textured soils. Internal drainage and aeration of soils are facilited by organic matter, and the field capacity is increased.

The dry combustion method was used to determine the content of organic matter in the soil of six sample plots. The procedure of the method is as follows: To 2 grams of finely ground air-dry soil (0.5 or 1 gram for some of the soil whose organic matter is very high) were added 0.25 gram manganese dioxide and 5 grams 60 mesh carbon free alundum. They were mixed well and placed in an alundum combustion boat and the boat was inserted directly into the hot silica tube of furnace, previously heated to operating temperature of about 950°C. The flow of oxygen was adjusted to about 100-200 c.c. per minute. Carbon dioxide evolved in combustion passed through the purifying section of the train, and was absorbed in a previously weighed tube filled with ascarite. Grams of carbon dioxide evolved was calculated and than

converted to percent of organic matter by using the converting factor 0.471.

Analyses show an average organic matter of the A horizon of 0.72% to 4.19%, with the A_1 layer practically always higher than A_2. In well developed Podzol profiles the A_2 is frequently the poorest as far as the content of organic matter is concerned as the result of leaching. Table 26 shows the distribution of organic matter of different horizons as found in six different locations under various vegetation covers.

Analysis of variance of organic matter in different horizons under various covers shows that (1) the covering vegetation did not cause any difference to the content of organic matter in soil in the six sampling plots. (2) the percentages of organic matter in various horizons were significantly different. Further "t"-test verifies that the organic matter in horizon A was significantly higher than that of B_1 and B_2, but there was no difference between that of B_1 and B_2.

Table 33. Analysis of variance of organic matter (%) in different cover types & horizons.

Source	Degree of Freedom	Sum squares	Mean squares	F
Total	17	16.5840		
Between type means	5	2.1903	0.4845	0.69
Between horizon means	2	7.4235	3.7118	5.36*
Error	10	6.9702	0.6970	

* significantly different at 5% level.

VI. THE STUDY OF CLIMATIC FACTOR

1. Temperature

Temperature is like water in its action upon plants in that it has more or less to do with nearly every function, but as a working condition and not as a material. All the chemical processes of metabolism and also many physical processes such as diffusion, precipitation, and coagulation as in cell-wall formation etc., are dependent upon temperature and accelerated by its increase up to an optimum. With a decrease of temperature to a certain minimum, growth of the plant may be retarded, and at a further decrease, death of the plant may even ensue.

Plants that migrate northward, such as the case here in Higgins Lake region, in addition to a corresponding adjustment to lower temperatures and a lower sum, run an increasing risk of encountering a fatal minimum. Prolonged periods during the summer with deficient precipitation and high temperature cause more damage to trees which are establishing themselves in their new environment, especially those of the size of seedling class. However, it has been noted that even under very severe conditions on this sand plain region, trees with a diameter of more than one-half inch at the root collar are seldom killed outright by heat, although larger trees up to 4 inches in diameter at the root collar often are injured (78).

In the course of studying, the highest temperature occurred in June 16 with a reading of 95°F although the average maximum temperature

of that month was only 79°F. The average temperature of the month reached the peak in July with a figure of 70.2°F. Table 34 gives a good indication of the distribution of daily temperature by months.

2. Precipitation

A light rain usually does not affect soil moisture, for most of it will be intercepted by vegetation and will evaporate quickly. It may raise the humidity temporarily and reduce transpiration for a short time. If rain falls heavily for short periods, much of it will be lost by run-off, the amount depending upon the steepness of slope, nature of soil and amount and kind of cover. But if rainfall is uniformly distributed throughout the growing season, moisture conditions may be far more favorable. Therefore, the total annual precipitation of an area is only a rough indication of moisture conditions for plant growth, but the seasonal distribution of rainfall is of much more importance than the total amount. Different types of vegetation usually are controlled partially by the kind of precipitation the area enjoys, for if precipitation is regularly seasonal, there certainly is followed by a limited type of plant growth. For instance, grasslands characterize those areas where rainfall is rather light and concetrated in the spring and early summer. Winter rains with dry summers, characteristic of several coastal regions, support shrubby vegetation.

During the time of studying, the month of July was very wet when compared with months like September and October which had a total rainfall of 1.26 and 0.75 inches respectively, while July enjoyed a total

rainfall of 6.24 inch which exceeded the normal rainfall by 3.37 inch. In one day, July 8, the area received 1.70 inch of rain. The following table 34 summarized the precipitation data.

Table 34. Climatological data recorded at Higgins Lake state forest weather bureau for the months of June, July, August, September, and October, 1952.

Temperature (°F)

Month	Average Maximum	Average Minimum	Average Reading	Departure from normal	Highest Reading	Date	Lowest Reading	Date
June	79.0	51.9	65.5	3.2	95.0	16	35.0	1
July	82.3	58.0	70.2	3.4	92.0	7	38.0	31
Aug.	77.7	51.7	64.7	0.1	89.0	28	36.0	23
Sept.	71.7	46.0	58.9	1.2	90.0	11	33.0	27
Oct.	53.9	30.6	42.3	-4.6	75.0	1	17.0	18

Precipitation (in.)

Month	Total	Departure from normal	Greatest Reading	Date	Snow, Sleet, Hail Total	Max. Depth on ground	Date
June	2.35	-0.78	0.64	17	0	0	-
July	6.24	3.37	1.70	8	0	0	-
Aug.	3.29	0.35	1.22	4	0	0	-
Sept.	1.26	-1.99	0.41	1	0	0	-
Oct.	0.75	-1.83	0.26	19	T	T	19

3. Relative Humidity

The moisture of the air which is in the form of vapor is termed humidity. It is one of the most important factors since it directly affects the rate of transpiration of plants. The amount of water that a plant losses frequently determines whether it can or cannot grow in a given habitat. The general humidity of a habitat depends upon climate and location with respect to bodies of water. Humidity is affected by temperature, wind, altitude, exposure, cover, and water content of soil. High temperatures increase the capacity of the air for moisture and consequently lower the relative humidity. Wind has a powerful effect upon humidity in that dry winds lower the amount of air moisture by removing the moist air about plants and mixing it with dry air. These two elements account for the decreased relative humidity in the air of the Higgins Lake area, especially during the months of summer when the temperatures and wind velocity were high during the day, (Table 35).

4. Evaporation

Within certain limits the combined effect of atmospheric humidity, atmospheric pressure, temperature, solar radiation, and wind is indicated by evaporation. It is impossible to determine the transpirational water loss of trees directly from evaporation, although in some trees the transpiration and evaporation trends are comparable. Different trees, owing to differences in stomatal movement, cell-sap density, colloidal content of cells, and incipient drying, respond differently

to the environmental factors controlling evaporation. The evaporation rate has a marked influence not only on transpirational water loss from trees but also on reduction of water content of the soil, especially in dry regions. Evaporation markedly determines the effeciency of rainfall, especially where the annual precipitation is less than 30 inches.

Evaporation is measured by the United States Weather Bureau by means of large open tanks of uniform size and depth, but this method is not quite satisfactory for most ecological purposes. The writer used the well-known Livingston atmometer which consists of a porous clay sphere or bulb connected to a reservoir by means of a tube. Water evaporates from the clay surface and is constantly replaced from within. The sphere and tube then are filled with distilled water so that no air bubbles are present, the water will be drawn from the reservoir through the tube. An additional small-bored tube is placed through the stopper of the reservoir will permit equalizing of pressure by negligible loss of water by evaporation. The reservoir is marked near the top and filled to the mark by lifting a stopper. Subsequent fillings of distilled water made at regular intervals indicates water lost to the air by evaporation over the period of time involved.

The weekly evaporation rate was measured continuously at four stations of different plant communities in this area during the period from July 16 to October 5, 1952. Atmometers were set up with bulbs placed 19 inches above the ground. Evaporation data in different types of vegetation are summarized in Table 35 and shown graphically in Figures 11 to 14.

The data show that evaporation increases rather uniformly with increased temperature and decreases with increased amount of precipitation. For instance, during the week of Sept. 6 to Sept. 13, there was hardly any rainfall, and the evaporation rate before correction was 85 c.c. per week in the aspen stand while the rate increased to 233 c.c. in the open grassland. The highest mean daily atmometer loss in the grassland community was 25.63 c.c. after correction, but only 10.92 c.c. in the jack pine forest community. Although evaporation rates were less in forest than in grassland, the evaporation rate in the pine forest is higher than the mixed hardwood and almost one and one half times as great as those in the densely canopied 40-year old poplar stand. The writer finds the trend of evaporation rate in this region, namely, highest rate in the open grassland, intermediate in pine forest and lowest in a more or less densely stocked hardwood forest.

During the growing season in this region, the evaporation rate is generally high. This is caused by rather high temperatures, low relative humidity, and generally constant wind during the daylight period. However, when comparing these data with the ones which were collected by other investigators, they seem to be low in their values. For instance, Whitfield reported an average weekly atmometer loss of 326 c.c. from white porcelain atmometer during the summer of 1928 on the plains near Colorado Springs (96). Whereas Williams and Holch recorded an average daily evaporation rate of 35.2 c.c. in a pine forest, 33.3 c.c. in grassland and 29.3 c.c. in Chaparral near the Black Forest, Colorado (100).

The fact that the rate of evaporation from the chamaephytic layer

is decreased in the development of mesophytism has long been demonstrated by many workers in this field. Fuller (37) says the decreased rate of evaporation caused by the heavier vegetation is the direct cause of succession between different associations. Therefore, with the development of the invading species the evaporation conditions of the ground layer are changed which is usually also accompanied by a change in the ground flora such as the ones we have witnessed in this study.

Table 35. Weekly total of evaporation (c.c.) in four different vegetation types, relative humidity, air temperature and total precipitation in Higgins Lake area (25).

Date	Evaporation				Ave. Relet. Humid.	Ave. Temp.	Total Precip.
	Northern Hardwood	Grass-land	Jack pine	Aspen			
	Station						
	13	3	15	5	%	°F	in.
July 16-July 26	65.4	136.3	97.0	47.7	51.4	61.3	2.02
July 27-Aug. 2	101.0	164.0	119.0	69.3	59.1	51.5	0.19
Aug. 3- Aug. 9	23.8	40.0	40.7	*19.6	65.3	51.1	2.24
Aug. 10-Aug. 16	49.2	109.0	76.1	38.5	58.7	53.1	0.12
Aug. 17-Aug. 23	71.5	104.0	84.7	52.3	51.4	48.8	0.42
Aug. 24-Aug. 30	69.2	142.0	114.0	64.6	62.1	51.9	0.00
Aug. 31-Sept. 6	*44.9	*87.1	56.2	35.4	65.7	53.1	0.98
Sept. 7-Sept.13	*66.5	179.0	131.0	65.4	54.7	51.1	0.00
Sept.14-Sept.20	50.8	100.0	74.5	49.6	68.1	46.1	0.21
Sept.21-Sept.27	30.8	73.0	43.8	30.9	65.0	38.5	0.56
Sept.28-Oct. 5	91.0	172.0	125.0	70.9	57.0	39.6	0.26

* Estimated missing data (Snedecor P. 268)

Table 36. Analysis of variance of evaporation in different cover types and on different dates.

Source	Degree of freedom	Sum of Squares	Mean Squares	F
Total	43	69679.57		
Between Type means	3	30202.02	10067.34	76.27**
Between Date means	10	35503.82	3550.38	26.79**
Error	30	3973.72	132.46	

** Significantly different at 1% level.

The evaporation rate among various covering types and dates were significantly different. As for covering types, the evaporation of grassland was highest and conifer-hardwood type lowest, and there was no difference between that of jack pine type and poplar type.

Fig

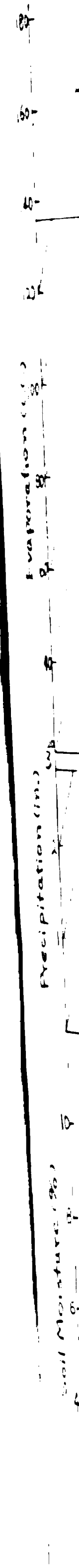
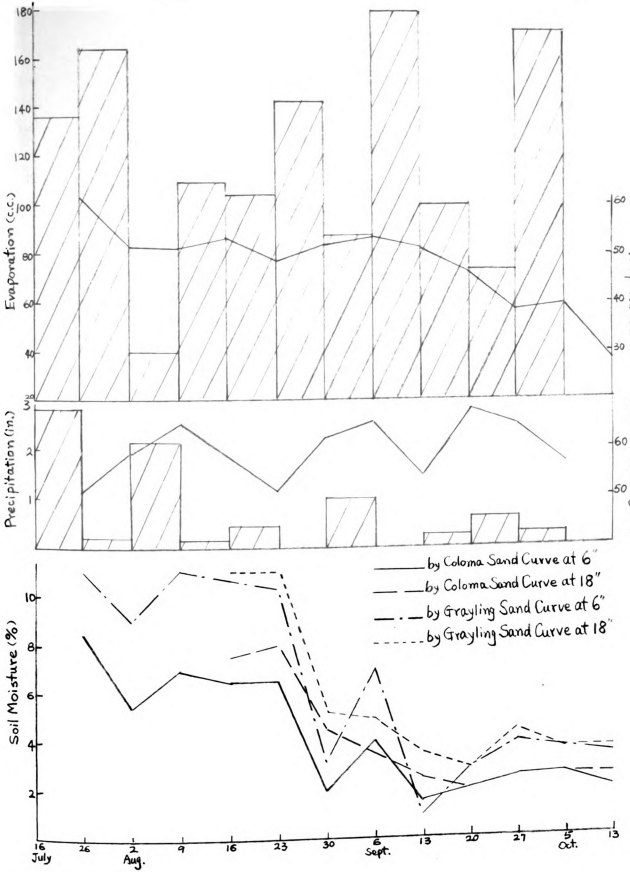
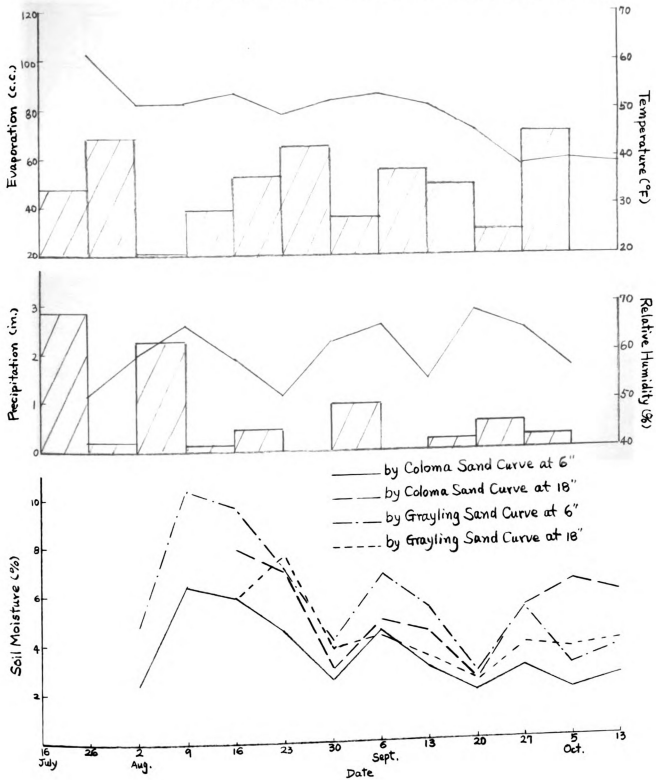


Figure 11. Graphs Showing Interrelationship Among Various Recorded Data on Soil Moisture, Precipitation, Air Temperature, Relative Humidity and Evaporation on the Grassland Type Cover



Precipitation (cm.)
Evaporation (c.c.)

Figure 12. Graphs Showing Interrelationship Among Various Recorded Data on Soil Moisture, Precipitation, Air Temperature, Relative Humidity, and Evaporation on the Aspen Type Cover



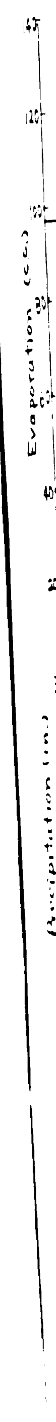
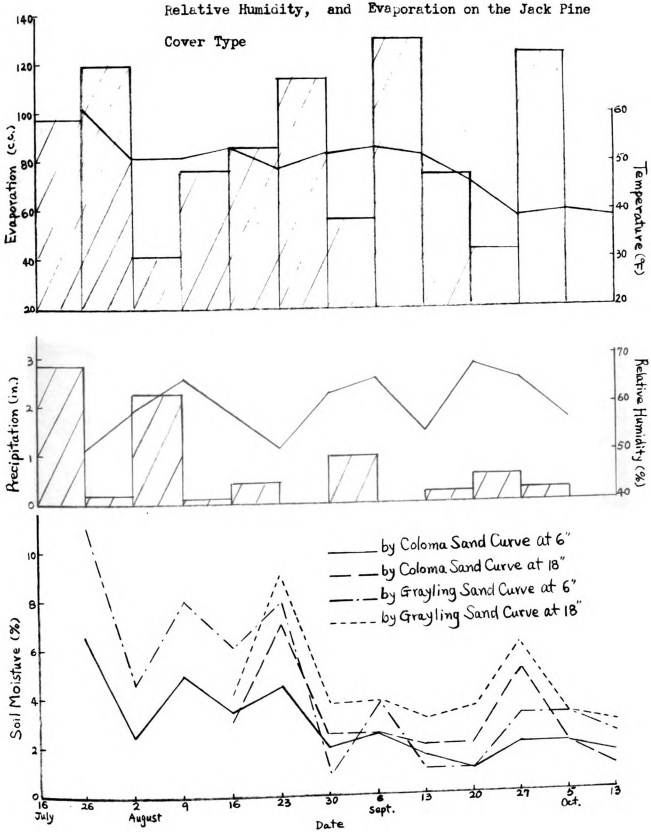

Evaporation

Figure 13. Graphs Showing Interrelationship Among Various Recorded Data on Soil Moisture, Precipitation, Air Temperature, Relative Humidity, and Evaporation on the Jack Pine Cover Type



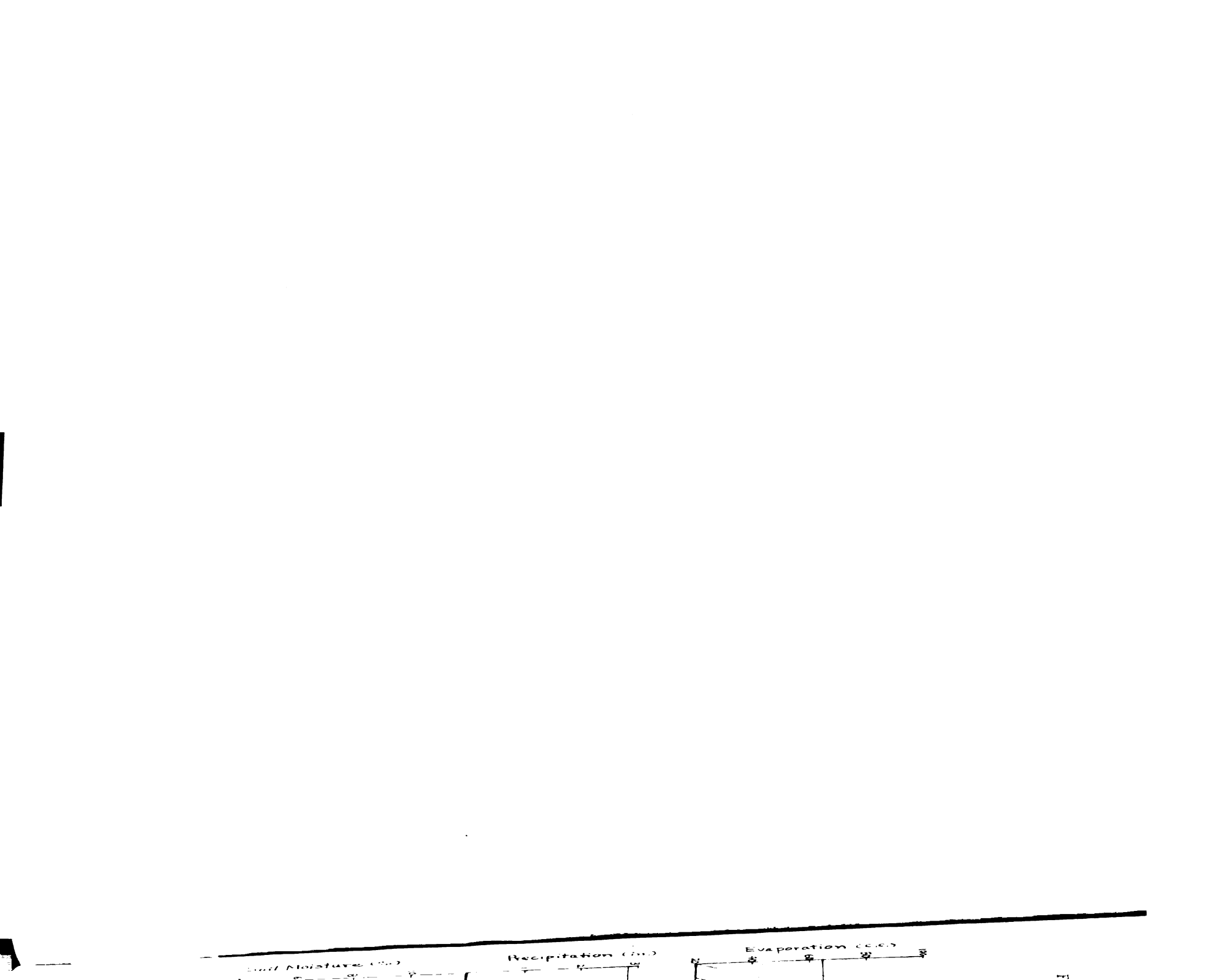
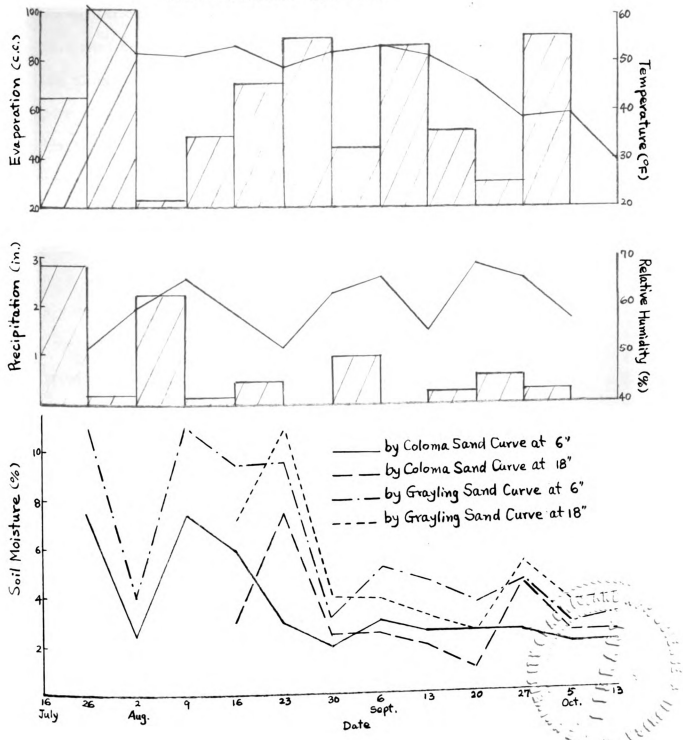

Soil Moisture (in.)
Precipitation (in.)
Evaporation (c.c.)

Figure 14. Graphs Showing Interrelationship Among Various Recorded Data on Soil Moisture, Precipitation, Air Temperature, Relative Humidity, and Evaporation on the Northern Hardwood-Hemlock Type Cover



VII. THE STUDY OF BIOTIC FACTORS

We may say that the initial cause is biotic when the series of succession starts because an area has been made bare by living agencies. Thus when an animal or plant pest produces a bare area by killing all the plants of the community as sometimes occur in forests growing in pure stands, the initial cause of the series is biotic. Sometimes the initial cause is destruction of vegetation by man. Lumbering does not usually initiate a serious succession except when followed by fire or a long period of over-grazing. Complete denudation by animal is of infrequent occurrence. Beavers may initiate a series by daming the outlet of a lake, causing denudation by overflow and drowning of vegetation. A very destructive barkbettle (Dendroctonus frontalis), common in the Southern Appalachian region, has killed shortleaf and pitch pines in groups and often over relatively large areas, hastening the normal succession from pine to hardwoods. The human interference of a certain stage in a forest succession is of great importance in forestry, the typical example of this is represented in the coastal plain, where subclimax pine forests are maintained indefinitely by the constantly recurring fires to which the pines are resistant and thus keep down the growth of hardwoods.

In the Higgins Lake region, the associated organisms having important influence upon each other and to their environment are described as follows:

1. Man

Man, to be sure, will modify some kind of catastrophe which visited the virgin forest. Fire, for example, and not so surely epidemics of insects and disease, will be less extensive under the present condition, and the chances are that windthrow and glaze storms, the frequency and devastation of which in virgin forests are only beginning to be reduced, will not ravage the shorter and more compact short-rotation forests of the future to as great a degree. On the other hand, with axe, saw, and fire in the slash, man can produce a forest catastrophe which surpasses in its thorough destruction of the past. Much more subtle, but no less profound, changes in the forests are bound to result from man's upsetting the natural balance between forest-dwelling squirrels, rabbits, mice, and deer, and their predators.

The natural forest landscape was subjected to a marked change by the complete cutting down of large areas of forest. Not only does such cutting considerably change the lighting conditions, but wind and precipitation are given freer rein, and the soil structure itself is changed markedly. While the power for nitrification increases, air capacity and permeability of the soil are decreased.

The degree to which the original forest was logged is also a very important influence on second-growth species composition. Light cutting of the virgin forest is followed by greater abundance of beech, sugar maple, and hemlock; whereas after both heavy and clear cutting the percentage of black cherry increases. Clear cutting, frequently associated with fire, is followed by increases in the abundance of red maple, sweet

birch, black cherry, and, to a less extent, of yellow birch.

Here is an excerpt from Herbert's study on a logged tract of hardwood forest near Johannesburg, Michigan (47);

> "This was what remained of the original timber two years after logging in a typical section of the hardwood region of the northern part of the Low Michigan. The ground was densely covered with reproduction weeds and underbrush that had come in after the logging or just prior to it. In that particular place, there was an adequate number of forest trees of seedling size to assure a future crop. The larger trees left by the woodcutters were either defective or too small to be merchantable. Most of the larger defective trees (three per acre) will die or be wind thrown before the second crop is merchantable. Those that do remain will be worthless, and will be occupying space upon which valuable timber trees could be grown. Many of the trees in the smaller diameter classes have been injured in logging or are suffering from the changes in the physical and biotic factors brought about by logging."

Fire; As pointed out by Braun-Blanquet (14), the most remorseless associate of man in the destruction of native vegetation is fire. Fire is particularly destructive upon very thin, sterile soils and especially in the transitional region between forest and prairie, where both types of vegetation are struggling for control. Fires are always followed, whether the original vegetation is destroyed partially or entirely, by a secondary succession, which tends anew toward climax.

Studies made on the old Michigan literature show that fires ran through the heavy pine slashing almost everywhere within a few years after logging. Many of them were set intentionally to clear the land. Some of the fires, like that of October 8, 1871, which started by destroying the city of Manistee and swept east entirely across the state, are matters of historic record. Kittredge reported that (54) out of 77 plots chosen for the most part to represent areas as little burned

as could be found, 66 showed evidence of one or more fires with an average of three fires since the origin of the predominating stand. Fifty-three of the plots had been heavily burned two or more times, with an average period of nine years between fires. Further evidence of the prevalence of fires up to 1929 is found in the fact that over 60 percent of the area of oak stands in the five counties in the Lower Peninsula covered by the Land Economic Survey were in the 0-3 inch diameter class. These sizes correspond to ages of less than 15 years.

The fires which burned on the average every nine years were hot enough to scar or kill many of the oaks of moderate size in spite of the fact that owing to their thick bark they are the most fire resistant species with the possible exception of the larger pines which have their crowns above the reach of a ground fire. These fires killed all of the smaller pines and other species, leaving only an open stand of fire-scarred oaks. The new crops of oak sprouts after each fire have formed the prevailing present stands.

Repeated burning since logging has been the fate of large areas in the Higgins Lake section with the result that open degenerated stands of aspen-pin cherry have developed. Much of this land is occupied by an understory of shrubby and herbaceous growth of which bracken fern, blackberry, dwarf bush honeysuckle, goldenrod, sedges and grasses are prominent.

The occurrence and particularly the severity of forest fires following original logging also influence the species composition of second growth. A destructive slash fire soon after cutting greatly

reduces the percentage of sugar maple, beech and hemlock in the subsequent stand and is followed by an increase in the abundance of light-seeded hardwood species such as the birches and red maple.

If fire comes shortly after the aspens have germinated, it may be sufficiently severe to kill them outright and necessitate reseeding. In such cases the land may be with little or no vegetation for two or more years. In the better types of soil, if fires recur at short enough intervals, the aspen association will maintain itself indefinately. If the fires are at long intervals the stump sprouts of beech or maples compete for dominance and may attain it. If fires occur often, the aspens are favored, unless the fires are so frequent that even the aspens are killed, as is the case when fires occur annually. Under such condition a meadow of grasses usually develops and maintain itself as long as such conditions continue. In the case of sandy land, the seriousness of the situation lies in the fact that a light fire is rather certain to kill all small, pine seedling.

Fortunately, under the present rigid and scientific system of fire control, also with the cooperation from the public, there had not been a single big forest fire in this region for more than 20 some years.

2. Animal

Grazing by domestic livestock is of such minor importance that it does not need special attention.

Rabbits are a menace to jack pine seedlings, especially where there are abundance of shrubs. The leaving of a few scattered trees or snags

as roosts for hawks and owls may provide adequate control in the less critical areas. Elsewhere this may have to be supplemented by controlled hunting, trapping, or as a last resort, poisoning. Postponement of planting until the rabbit population is low is also advisable where artificial reforestation is necessary in heavily populated areas.

Reports from various sources show that it is very likely that more nipping damage is done by deer than hares or rabbits, especially in open areas where the latter are never common and during years of low population. This is especially true in the case of plantations(77).

Although deer probably cause much more damage to plantations than they are credited with, they cause relatively little mortality other than in local areas. Many surviving trees, however, lost part of their growth and deformation resulted. Sometimes, nipping in such cases sets the trees back enough to nullify the effects of the relatively expensive release operation.

As far as the deer population is concerned, emphasis should be placed on the prevention of overpopulation to check the damage. But the planting and the maintenance of occasional groups of plants that make acceptable browse for deer are often advisable (78).

3. Insects

Spittlebugs: Much more serious damage is caused by the Saratoga spittlebug (Aphrophora saratogensis Fitch) to young jack and red pines. Only the adults of the Saratoga spittlebug feed on the pines, usually from July to October. They puncture the bark and suck out the plant

juices. Damage is more severe in open-grown stands with considerable ground cover. The eggs of the spittlebug are laid in dead and living bud scales of the host pines and other trees, such as oaks and maples. The nymphs descend to the ground and develop on the stems of sweet fern, or other low plants, in masses of spittle. Closed canopy stand or those with an admixture of hardwoods sufficient to shade out the ground cover, are not attacked seriously. This provides the key to prevention of Saratoga spittlebug damage. Some natural control is provided by late spring frost since temperature of 18° F. or below are known to kill the nymphs. Recently, aerial spraying with DDT before the adults lay their eggs has proved effective.

Pine tip-moths. The larvae of pine tip moths (Rhyacionia frustrana Schiff.) work on the soft tissue of the new shoots, tunneling through them and later emerging from the buds or shoots, and the trees growth consequently reduced. Evidence of tip moth work appears in the summer as a small pitch mass or a dead needle at the base of the bud. Later the tips turn brown and will break off easily because they are hollow. Sometimes red pine is attacked quite severely, even in the case of mature trees. It is known that in a red pine plantation in this region, nearly 60 percent of all the living trees were affected by tip moths in 1937. Spraying with a Penetrol-nicotine combination or with DDT have given good control against these tip moths.

Sawflies. The jack pine sawfly (Neodiprion baksianae Roh) is a defoliator confining its efforts to jack pine. More common in lower Michigan is the red-headed pine sawfly (Neodiprion lecontei Fitch).

The former's larvae begin eating the leaves of the previous season's growth late in the spring, but the latter consumes both old and new foliage. Damage often is most severe in trees growing under or adjacent to hardwoods. Complete defoliation, of course, means death for the tree, as does repeated partial defoliation. A lead-arsenate spray is effective if the infestation is small, but is too expensive if wide spread attacks occur. Airplane spraying with DDT in oil solution has provided fairly effective and cheap control of these sawflies.

Spruce bud worm. The spruce budworm, (Archips fumiferana Clem.) for quite a number of years, has been a serious pest on open-grown jack pine because such trees produce a large quantity of staminate flowers, the food most favorable to high survival of budworm larvae. Partial or complete defoliation may cause death or stagheadedness of, and occassionally reduced seed production by, the infested tree. The attack is most likely to be fatal when the budworm works in conjunction with the jack pine sawfly-the budworm consuming the new foliage while the latter attack the old leaves. This pest may be controlled most effectively by maintaining closed stands and by removing any wolf trees that bear large quantities of staminate flowers. As a rule, red, white pine or young jack pine are attacked severely only when they are growing under or very near infested older jack pine.

4. Diseases

Rot-producing fungi are the worst enemy of the hardwoods. The shoe-string fungus frequently invades trees that are injured in logging,

playing a secondary role in their decadence. Much of the windbreakage in mature trees is traceable to trunk rots. Beech, yellow birch, basswood are more susceptible to decay than their associates, and their wood rots more rapidly, once they are infected. The following are the most troublesome diseases that are common in this area:

Red ring rot(red heart, or pecky rot). This rot is caused by the ring scale fungus, Fomes pini. This fungus is world wide in its distribution in the North Temperate Zone; in the Higgins Lake region, losses resulting from this pecky rot far exceed those from any other types of decay. This fungus infects many jack pines, particularly damaged trees, the decay progresses rather rapidly. The incipient stage appears as a pink to reddish discoloration of the heartwood, which is usually retain its firmness and toughness. The advanced stage appears as few to many elongated, some what spindle-shaped pockets parallel to the grain and separated by apparently sound wood. In the pockets the wood is reduced to a white soft fibrous mass of cellulose. Prevention of injury to the trees and adjustment of the rotation are practical control measures.

Hypoxylon canker of poplar. Hypoxylon pruinatum causes this disease. Aspen and largetooth aspen are most commonly attacked, infected trees are finally girdled and killed, or the trunk may break off at the canker before girdling is completed. Trees less than 30 years old and trees on poor sites suffer most. Infection occurs through wounds, particularly insect punctures, but also through ax cuts, breakages caused by wind and ice, and through dead branches. In order to control this disease from killing the poplar and aspen stands, infected trees should be removed

in thinning. Trunk cankers often occur high enough so that they are difficult to see when the trees are in leaf. Consequently, thinning should be done, or at least the trees marked for removal, after the leaves have fallen. The first thinning should be moderate enough so that the area can be thinned again in about 5 years and a satisfactory stocked stand maintained. The second thinning is necessary to eliminate trees with incipient cankers missed by the first thinning and those with new infections. Since the fungus may live as a saprophyte on cankered trees cut and left, such material should be destroyed.

Recent investigation (44) have established a striking important fact on hypoxylon canker of aspen. In more than 95 percent of all cases observed in the Lower Peninsula of Michigan, where the cause of this type of infection could be positively determined, insects were responsible for the initial injury. By using proper silvicultural practices the abundance of these poplar borers may be materially reduced so as to minimize the infection of hypoxylon.

VIII. DISCUSSION OF FOREST SUCCESSION IN THE STUDIED AREA

The different stages of a certain plant succession, generally speaking, can not be observed directly, but numerous other considerations offer convincing evidence of the nature of the process. A number of criteria have been used rather generally by ecologists in recognizing climax associations, and one or two others have been proposed. Among these, the presence in the understory of the same species as in the overstory is obviously valid. A wide-age-distribution, or the presence among the dominant species of young as well as old trees, is another way of describing the characteristics of the dominant species. Species which seed regularly and abundantly without being narrowly limited as to seed bed, which endure shade, and which reach optimum heights, are most likely to characterize the climax, although longevity may offset the absence of one or more of these characteristics. Another criterion is the number of species in the dominant stand; only those best adapted to a given site will be likely to survive indefinitely for the climax. A criterion of dubious value is the maximum volume of wood produced at a given age or on a given site.

A study of the literature reveals that the virgin forest of the northern Michigan is now reduced to a very limited area, chiefly in public ownership and intended for permanent preservation. It is the second- or third-growth forests which from now on concern silviculturists, and to which they will apply the sivical information

gained by study of the undisturbed forests.

The studied area is classified by Dice (31) within the Alleghanian biotic province. The chief ecologic characteristic of this province is the extensive development of the pines (Pinus strobus, P. resinosa and P. banksiana), which form very important successional stages, sometimes long maintained and which perhaps in some situations may never be followed by hardwood forest.

Other investigators, such as Gleason (41), point out that the pine forests are a part of a great series of associations, which have been closely related to one another since pre-glacial time, which are connected by certain definite successional trends, and which occupy the same general range, extending in a broad belt across the continent from Alaska to Newfoundland. Whereas, the hardwood forest is similarly, a part of another gr at vegetation complex, occupying most of the land between the Missouri Valley and the Atlantic Ocean and between the Great Lakes and the southern end of the Appalachian Mountain System. There is great competition between the various associations of these two complexes wherever they come in contact, and that in general the associations of the southern complex tend to displace those of the northern. For if a species is not able to hold its own in competition, and if the associations of which it is not a part, a retreating migration is indicated. This is illustrated in the Northern Michigan by the regular replacement of coniferous communities by deciduous forests, indicating the retreat of the conifers and the advance of the hardwood trees. However, numerous relic colonies were left behind occupying

for the most part in extreme habitats, either xerophytic rock hills and sand dunes, clothed with pines such as Pinus banksiana; or a bog, characterized by species such as Larix laricina and Thuja occidentalis.

In his more specific work done in the northern Michigan sand plain, McAtee (67) classified the important upland forest types into four groups. The first one are areas where the dominant tree growth are oaks and maples. In this type, pin and choke cherry, witch-hazel and willow are most abundant; all of these plants are scattered also in the other types. The second type is the one which are dominated by two species of aspen, Populus tremuloides and P. grandidentata and is better supplied with sand cherry, service berry and choke cherry than the other groups. The most characteristic type of barren is that dominated by the jack pine; it appears to have more bearberry, New Jersey tea and bush honey suckle. The Northern hardwoods make up the remaining category with a little more complex species composition.

The associations of the second and third-growth forests, which have followed cutting by lumberman and, in most cases, forest fires, are without doubt staging in secondary succession.

Evidences all over the region indicate the profound changes which the white man has brought about. In the main, these changes are affected by: (1) the highly selective character of early logging, which removed only those species which were currently valuable; (2) the severity and extent of later logging, which removed seed-bearing trees over entire region; (3) more severe and more frequent fires; and (4) great increases in the population of certain animals such as deer.

The various stages of plant succession of this region can be postulated in the following manner:

The introduction of the blue grass (Poa compressa) was doubtless contemporaneous with the logging, and the association now marks the site of feeding grounds and logging area. The ultimate fate of the blue grass association depends entirely upon its relation to continuous human activity. According to Thomson (88), plant succession on such abandoned fields of hardwood lands can be summarized in these approximate steps: i.e., there is an abundance of ragweed (Ambrosia artemisiifolia) and sandbur (Cenchrus pauciflorus) during the first three years following abandonment; then, they practically disappear, persisting in the fields only as a result of grazing or some other disturbances. This fact suggests that most of the abandoned lands in this region have lain idle for quite a number of years, hence they are in the advanced stage of succession. After some more years of abandonment, Canada fleabane (Erigeron canadensis) becomes more dominant, other species such as Oenothera biennis, Carex pennsylvanica, Asclepias tuberosa have risen in frequency. Species such as Hieracium, Euphorbia, Helianthus occidentalis, Aristida spp. can be found with the bluestem (Andropogon scoparius). At this time, a young forest develops rapidly at the margin of this blue-grass association, and gradually encroaches upon it. In the meantime, scattered individuals of original species succeed in establishing themselves within the main body of the grass association, and by their shade contribute to the destruction of the bluegrass and the eventual reappearance of the forest. Among these pioneers,

Rubus idaeus var. and Acer rubrum are conspicuous in the succession by the beech-maple forest, while Rhus glabra and Prunus pennslyvanica in the succession by aspens, leading ultimately to a pine forest.

By the time the fields have been abandoned for fifteen years, the distribution of each species has been fairly even throughout the area, but after that period, the various species begin to appear in patches, rather than evenly distributed. This tendency becomes more accentuated in the old fields. Probably this tendency is due in part to the severe competition in the field and the micro-conditions within the field limit the distribution of each species. The growth forms of these grassland vegetation agree with the findings of Evens who studied the vegetation of an old field community in southeastern Michigan (33A).

In the pine region, when the field has been abandoned for thirty some years, the forest has encroached considerably on prairie flora. Jack pine is the dominating member of the flora, and Populus grandidentata is also present, shrubby plants including sweetfern, young Hills' oak, and Rubus spp., Corylus americana occupy considerable territory. Carex pensylvanica is common in the slight depression in the field, forming an almost continuous truf.

In places, a thick growth of jack pine appears and there are but a few young oaks present among them. Since the oaks are more tolerant of shading than the pine, they would survive until some accidents happen to the pines would open up a space for growth of the oaks when they would begin growing rapidly and shade out the younger pines which might start. In this way an interspersion of oaks and jack pine would result.

The northern hardwood type, as pointed out by Braun (13) is not made up of a number of distinct association, but it appears to be a formation with only one association. It is usually dominated by two species which have most of the characteristics of climax species, namely beech and maple. The latter not only the most ubiquitous species of this region, but appears most invariably in the underwood of all the stands. This is the inevitable consequence of its abundant seed production, ability to germinate and survive on varied seedbeds, and its tolerance of overstory competition. In this area, the beech maple communities of the hardwood forests may best be described as a local variant of the climax, or a stage just below the true climax-- hemlock and beech -- and seem likely to be invaded by hemlock at sometime in the future, and there can be no doubt that together they constitute a climax association. Although hemlock is less able to become established on all kinds of seedbeds, but it over-comes this handicap by extreme longevity. Usually, stunted individuals of beech and hemlock species in the understory grow wee when the larger trees are removed.

Beech-maple stands, are in some cases being invaded by hemlock as indicated by the presence of seedlings, and in other cases contain relics of a very old age class of that species. Because seedlings of hemlock is destroyed more readily by fire than the sprouting hardwoods, its absence from sampled areas today may be a result of past fire. Under the present condition, the beech-maple or maple-hemlock-beech forests are truly stable association that have great resistance to logging, fire and other destructive agencies. It is only where repeated

fires burn over the same area, or where poor air drainage results in frost pockets that the climax disappears completely and an entirely new association composed of pioneer species gains possession of the soil.

There are few principal combinations or forest types in which the species of oaks occur on the sandy soils of northern Michigan. However, the Hill's oak-white-red oak type with small proportions of red pine, jack pine, red maple and black cherry, aspens are mostly found on the slopes and dry, morainal ridges in this studied area. Sherrard's (80A) work in the Roscommon County in 1902, distinguished oak flats, oak ridge and jack pine plain as the main classification for the study of forest distribution. In these early publication in 1929 (52), this oak type forest was described as characterized by scrubby-looking clumps of oak sprouts three to fifteen feet high, scattered in the low brush. Today, one may still find the old charred pine stumps in this area, which indicates that the "scrub oak" lands were originally timbered with pure red pine or a mixture of white and red pine.

The present old growth forest in the Interlocken State Park offers an example of the original forest which has been preserved adjacent to a typical area of "scrub oak". This stand consists of a few large trees of white and red pine with an understory of varying sizes of oaks and other species. This evidence indicates that the original forest in general probably contained a large proportion of red pine and jack pine and less white pine, red oak, red maple and beech.

Study (67) made on a pine forest 60 to 80 year old in the heart

of the oak hills region in Ogemaw County can also be used to supplement the theory that the present prevalence of oaks, particularly of small sizes, in the stands which formerly were pine. In some of the pine forest, more than 7,000 red oak seedlings to the acre were found in the sampling plots, and that illustrated the ability of the comparatively few oaks which were present in the old pine stand to seed in abundatly under the pine.

A large part of the area of the aspen community in the region was occupied before human interference by a sub-climax forest which was dominated by white or red pine. Populus tremuloides probably occurred as a dominant in limited areas and as an inconspicuous subordinate species in the climax forests wherever accidents or the death of large trees left opening. Logging and fires destroyed or eliminated most or all of the conifers, maple and other hardwoods. In the growing season following the fire, the bare habitat was densely occupied by a group of pioneer species composed chiefly of those which came from light and wind-borne seed and from the under ground parts of the preceeding generation. The commonest of this group are, Aster spp., Betula, Corylus, Diervilla, Fragaria virginiana, Populus tremuloides and Solidago spp.. A large number of other species, relics which escaped the fires or those less efficient in their means of propagation are more or less frequent associates. Among them all the aspen suckers lead in height growth from the first season. If the aspens are not sufficiently abundant to dominate the community after one fire, they are almost certain to do so after the second, third, or fourth fire. This aspen

type is by far the most important secondary plant community in northern Michigan, revegetating nearly every type of location following the removal of virgin growth, thus standing between the devastated land and developement of the most desirable trees, whether for lumber or for recreational purposes. In general a wide range of habitats may be occupied by the aspen type, from the very driest in the region to very wet although not persistently submerged soil, and from almost pure sand to a somewhat clayly soil. The species of Populus grandidentata is most abundant in the drier sandy areas on which the aspen group occurs. The root system is widespread rather than deeply penetrating, which is somewhat favorable to windfall. Growth is rapid at first but within a few years decreases remarkably. Flowering and the maturing of seeds occurs early in the growing season. Trees from seeds or stump sprouts are soon thinned out on account of their intolerance, resulting in an open woodland. The other species, P. tremuloides prefers wetter sites, although it does grow in just as sandy land.

After ten to fifteen years or more under the closed canopy of an aspen stand developing on an area following one or two fires, usually gives place to a higher genetic type in a comparatively short time. Numerous invading species are present in the aspen community. The most frequent are pines on the sandy upland and usually it takes longer (at least thirty to fourty years) for the pine to displace the aspens. Whereas on the better soils, this invading species would be the beech and maple which will take over within twenty to twenty five years. Such invaders must be able to grow in the shade of the aspens. As this is

usually less than in the virgin forest, the growth of invaders is more rapid in the aspen stand unless the soil is too poor or too dry, or some other retarding feature prevents. Important invading species on better upland soils are sugar maple, beech, yellow birch, and on poorer upland soils the species would be red pine, white pine and red oak. Further fires favor continuance of the aspen association indefinitely. Fires as often as once in twelve years favor the aspen at the expense of the pines.

After the more mesic and shade-enduring species gradually invade, and become successfully established, and maintain themselves or increase in abundance and stature, the next stage of succession is thusly formed. The succession may take any one of several different directions depending primarily upon the environmental conditions. Most commonly it proceeds directly to the northeastern deciduous forest climax or to the northeastern conifer climax. As on more xeric habitate or on upland sites such as the case in this region, with decreasing soil moisture it may pass first to the white pine stage or even to a red pine stage; whereas in the hardwood association, Acer saccharum would predominate. On the hydric side, the succession of hardwoods is often developed to the ash-elm-maple stage or to cedar or sometimes to a mixture of these two.

IX. SILVICULTURAL SUGGESTION

Knowledge of what constituted the original forests of a given locality, and of the trends which may be expected in the development of the second growth, can be put to very practical use by forest land managers or silviculturists, to avoid costly mistakes in practice. They can also adapt timber stand improvement and harvest cutting methods as either to speed up natural forest succession or to hold it back, as seems required by the particular products or services desired from the land.

It is a well-known fact that repeated heavy cuttings of all merchantable timber deplete the growing stock and cause retrogression in species composition. Clear cutting of cord wood from young second-growth stands on short-rotation favors a great increase in the short-lived "weeds" or least desirable species, such as pin cherry, aspen, hornbeam. Furthermore shrubby and herbaceous vegetation and poorly formed stump sprouts also cover the ground to the detriment of desirable seedlings of the better tree species. In addition to these, forest fires, like heavy cuttings deplete the forest growing stock and cause a severe retrogression in both species composition and site quality. Fire is much more common and more difficult to control on heavily cut forest land, both because of the increased fuel and the more severe and unfavorable land condition.

Significant fact which has been established in this region now is that forests are not filling local requirements. Lake States forests

currently supply less than half of the saw timber products consumed in the region, and only about two-thirds of the total cubic volume of wood used. Shortages are most critical in softwood saw-timber products where the local forest lands supply less than one-fourth of the quantity used. Significant shortages appear also in coniferous pulpwood, and high-grade veneer timber. Timber requirements fifty years hence have been estimated one-third greater than at present. The previous heavy cutting has created a poorly balanced growing stock. The present extent of pine and hardwood forest under all kinds of protection does not indicate fully the area available for producing valuable timber in the future. However, under more aggressive management and probably with more available funds, many areas now occupied by grass, brush and poor aspen stands can be restored to better types of tree species. Of course this reforestation program has to have the wholehearted cooperation of other agencies in the field of conservation in order to achieve an allround result for the multiple use of natural resources.

If protected from forest fires long enough, much of this land would restock with trees naturally, although chiefly with less valuable kinds. Such a process of natural restocking, however, would be so slow that it would be against public interest in many cases to allow these lands to lie unproductive for so many years. Hence a large part of this land must be restored to valuable forest growth by planting. Although increased production of wood is the chief reason for reforesting the land, there are other important reasons. In some areas the planted trees would protect the watershed and prevent loss of the best

soil through erosion. Along streams, lakes, roads, or other areas reforestation would enhance recreational values; and trees and shrubs should be planted in some places to provide shelter and food for wild life.

The need for reforestation in the region had long been recognized however, even under the greatly expanded program between 1933 and 1942, when Civilian Conservation Corps and other state helps contributed to the work, the rate of reforestation was not great enough to replant the required area.

Looking ahead to large scale planting operations, the planting situation should be given careful thought and study by comparision to determine the least expensive class of stock which could be used to secure a well distributed stand. The experiment carried out in the "sand plain" test ground of the Huron National Forest showed that the transplants of 1-1 and 2-1 has a higher survival than the seedlings. However, the 2-0 stock on the basis of survival distribution, and height growth and the low final cost appears to be the most economical class of stock to plant. The 1-0 stock, is considerably below the 2-0 stock in survival and higher in final cost, especially under severe weather conditions.

Direct seeding is not a satisfactory substitute for planting except under especially favorable conditions, although jack pine, red oak have been successfully seeded on sites free from aggressive, competing vegetation and seed-eating rodents. Due to the facts that an excessive quantity of seed was used, the necessity of ground preparation, attack

on seeds by rodents, birds, fungi and insects, high temperature at the soil surface, and the cost of the operation. This method was found at least as great as planting would have been.

The present merchantable stand of aspen cannot be marketed advantageously because the consumption of aspen is comparatively small. Although the market for aspen -- chiefly as pulpwood, crating -- has already expanded substantially because of increasing paper mills that are equipped to utilize aspen and the impetus of the research work done on hybridizing aspen, there is still little likelihood that more than a small proportion of available aspen will ever be utilized. In view of the fact that there is little chance of growing aspen to saw-log size, except on the best site such as station 5 of the aspen type in this study, decay usually sets in by the time it reaches saw-log size and thereafter the rot progresses so rapidly that the trees soon become unmerchantable. It is obvious from the manner in which untreated aspen stands develop that even where advance growth is present, this species will not develop into merchantable size in sufficient quantity to yield a profitable return.

This is true also in the case of northern pin oak and jack pine type, which are being considered by some investigators as the so-called temporary types. They, like the aspens, occupy certain red pine and northern white pine sites that have deteriorated severely as a result of at least two or three fires.

In general, many of the stands support some red or white pine reproduction, but less than 10 percent of the area occupied by these temporary types provide enough reproduction to form a satisfactory

nucleus for a pine forest. Due to the facts that most of the tree species are of poor quality, frow slowly and will yield little merchantable material at the time growth culminates, profitable use of the land depends on conversion to another forest type. From the view point of wildlife management, conversion of an inferior forest type to a better suitable one can even change the type of animal and bird population quite favorably.

Ecologically speaking, these temporary types may look flourish enough to be classified as a distinct type for the time being, nevertheless, the force of succession has already set in as is shown by the fact that the original occupants of the site are actually encroaching back.

During the studying of the Roscommon and Crawford Counties, Livingston (63) found that scattering seedlings of white pine were then evident on practically all areas originally covered by that species, which have not been recently subjected to the action of fires. Seedlings of the red pine, however, were more numerous on these areas than were those of the white pine itself. They were plentiful throughout the region on light soils excepting the very lightest. There were some evidence that the red pine was gradually advancing its seedlings into the areas held by the jack pine.

The three species of pine native to the region, red, jack and white pine, grow naturally on the sandy oak lands and are the logical species to be first considered in connection with the natural conversion of oak to pine. In the original forest, red and white pine were the predominating species and the oaks were subordinate. The soil and climate are, therefore, suited to the restoration of the pines provided other factors

which have resulted from the cutting and burning of the areas are not prohibitive. Methods are protection from fire, proper methods of cutting and planting.

In this region, the evidence indicates that jack pine should be favored only on the sites less suitable to hardwoods, such as abandoned fields, or pastures, or aspen-pin cherry burns. Artificial planting of pioneer coniferous species will often be necessary on such sites.

Conversion of aspen to conifers should also be encouraged. Aspen does not thrive on dry sandy soils; thus, reconversion to pine is highly desirable. Unfortunately, the rate of natural conversion is slow. With present relatively good fire protection, the rate of reseeding to pine should accelerate, but not enough to insure complete conversion, without considerable planting. Much of the aspen has an understory of maple, basswood, elm, and some other species, eventually most of it will revert to other hardwoods unless cutting, burning, pasturing, or other activities interfere. Limited areas may require planting.

The conversion of good hardwood sites to white pine is not recommended, though silviculturally possible if cost is no object. Heavy harvest cuttings, in addition of leaving ample seed-bearing trees, and subsequent removal of hardwood sprouts and seedlings, are necessary measures for the perpetuation of pine forests on heavy soil.

Whereas, on comparatively heavy soils such as the one studied by Fisher (36) in central New England, forests of pure white pine develop on abandoned fields as an intermediate stage in succession. They show, however, strong tendencies to revert to hardwood, rendering reproduction of pine difficult. In this instance, the conversion of these forests

to stands of more valuable hardwoods, or mixture of hardwoods and pine, can be accomplished by removing the pine in one or several cuttings, followed about four years later by cleanings or weedings to favor individuals of the desirable species.

In the natural establishment of seedlings of the hardwood species, decaying of forest litter seem to be of extreme importance. Fire not only consumed these natural "seedling beds" but also deprived the shallow "A" horizon of much of its humus content. Sugar maple, as shown by Gates (39) has a potentiality for a wide range in habitat suitable to invasion. Its prolific reproduction sometimes establish competition too great for species such as yellow birch and hemlock. Partial cutting, not followed by fire, permits both species of Tsuga and Betula to reproduce in sufficient abundance to insure representation in the development and produce stands comparable to that in the primeval forest of the region.

As far as the silvicultural treatment on second-growth Northern hardwood-hemlock stands is concerned, partial cuttings are favorable to sugar maple, beech and hemlock. A silviculture based on light and frequent harvestings of either cordwood or sawlogs will maintain a species composition similar to the virgin forest climax. Such a forest probably is best able to meet the multiple demands for cellulose, control of water supply, wildlife, and recreation. Under this form of management, trees dying before maturity will be salvaged by light and frequent cuttings, growing stock will be maintained and high rates of growth in merchantable volume obtained.

X. SUMMARY

The successional trend of the major forest types on the well-drained soil in the Higgins Lake area is considered in relation to structural characteristics of the various concrete communities and also with certain physical factors of the environment. Quantitative data collected from 16 one-fifth acre quadrats, representing four different forest cover types and 16 milacre quadrats of grassland type on six different soil types were analyzed and postulated to formulate the successional sequence of the existing vegetational communities.

The major forest types were classified as (1) aspen type, (2) northern pin oak type, (3) jack pine type and (4) northern-hardwood-hemlock type. The other type of plant community included in this study beside these forest types was grassland which occupies open burned wild land.

The associations of all these second and third-growth forests, which have followed cutting by lumberman and, in most cases, forest fire, are staging in secondary succession. The blue grass association has invaded the abandoned field of hardwood lands with pioneer species such as Ambrosia artemisiifolia and Cenchrus pauciflorus. But within 15 years, scattered individuals of original species will succeed in establishing themselves within the main body of the grass association. In the pine region, when the field has been abandoned for about thirty some years, jack pine, the dominating member of the flora, will encroached considerably on those prairie flora. The northern pin oak and aspen

type have been considered temporary forest cover types, however, this reversion to the original type of tree growth on these land seems to have to wait for a long while before it becomes a reality by judging and studying the quantitative data obtained from the area.

Some climatic, edaphic and biotic factors were also studied in order to determine the interaction of these site factors. It was found that evaporation increases rather uniformly with increased temperature and decreases with increased amount of precipitation. During the growing season in this region, the evaporation rate is generally higher and was less in forested area than in grassland. This factor exerts a more definite expression on different types of vegetational cover among other site qualities.

Soil profiles of all six types were photographed and described. Soil samples were taken for analysis. The forest soils of most of the upland stands are strongly acid in the upper portions of the profile, especially the A layer, with a slight but gradual increase in pH with depth. There is very little evidence that low pH per se is responsible for poor growth of forest trees. The result obtained in field moisture study indicates the moisture contents of soil were unsimilar under various vegetation types and on different dates, but not at different depth of six and eighteen inches below the surface. The densely stocked oak-poplar forest has the highest figure while the open jack pine stand the lowest. Analysis of variance of organic matter in different horizons under various vegetational covers shows that the covering vegetation did not cause any difference to the content of organic matter in soil

in the six sampling plots, and the percentages of organic matter in various horizons were significantly different. Further "t"-test verifies that the organic matter in horizon A was significantly higher than that of B_1 and B_2, but there was no difference between that of B_1 and B_2. Analysis of variance of soil temperature indicates that both date and cover type caused significant difference in various plots, the soil of grassland type having a definite higher reading. It was found that evaporation rates were less in forested area than in grassland with the lowest reading in a densely stocked hardwood stand.

Among all the factors which fall in the biotic group, the destructive logging and fires were the main ones that were responsible for the present distribution of plant communities. The influence of animals, insects and diseases are comparatively of minor importance. Although disease such as hypoxylon canker could easily determine the future acreage of aspen stand due to the highly susceptibility of that particular species.

From all the evidences obtained through this field study, it was the opinion of the writer that usually after ten to fifteen years or more under the closed canopy of an aspen or oak stand developing on an area following one or two fires, if the condition permits, usually gives place to a higher genetic type, the most frequent ones are pines on the sandy upland. Whereas on the better soils, the invading species would be the beech, sugar maple and yellow birch which will take over in about twenty to twenty-five years. However, further fires favor continuance of the aspen association indefinitely.

Under the prevailing present climate in this region, on the more xeric habitat with decreasing soil moisture, a red or white pine stage may be reached before the arrival of the northeastern conifer climax. On the more hydric side, the succession of conifer-hardwood type is often developed into the northeastern deciduous forest climax.

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Plate 1. An open second-growth pure jack pine stand. A fairly open site is a requisite to the establishment of pine seedlings.

Plate 2. The stands of oak type occurring on ridges are often of poor quality. Note the thick growth of blueberries on the ground.

Plate 3. A typical stand of the aspen type. Some white oak, red oak and red maple are in mixture.

Plate 4. A representative stand of northern hardwood-hemlock forest. A well-stocked understory of saplings and poles of various species has developed under protection from fire.

Plate 5. A typical soil profile of Kalkaska loamy sand under a hardwood stand consists principally of hard maple, beech and elm.

Plate 6. A dense stand of young jack pine has successfully encroached and developed on this grassland area on a sandy soil.

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