A QUALITATIVE AND QUANTITATIVE STUDY OF THE SEED PRODUCTION AND REPRODUCTION OF NORWAY PINE (PINUS RESINOSA)

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PREFACE

The thesis which follows is based on the data obtained in a study carried on from August 1st, 1912 to April 15th, 1913. The field study was made in Wadena, Hubbard and Cass Counties during August, September and October; and the seed extracting and germinating was done during the winter at the University Farm. Many facts about the Norway pine were brought out, many of which are parallel with results of investigations of other pines. Although many new facts appear, the important value of this study is that it shows how much can be done and how much there is to do to complete a study of the tree.

Grover M. Conzet.

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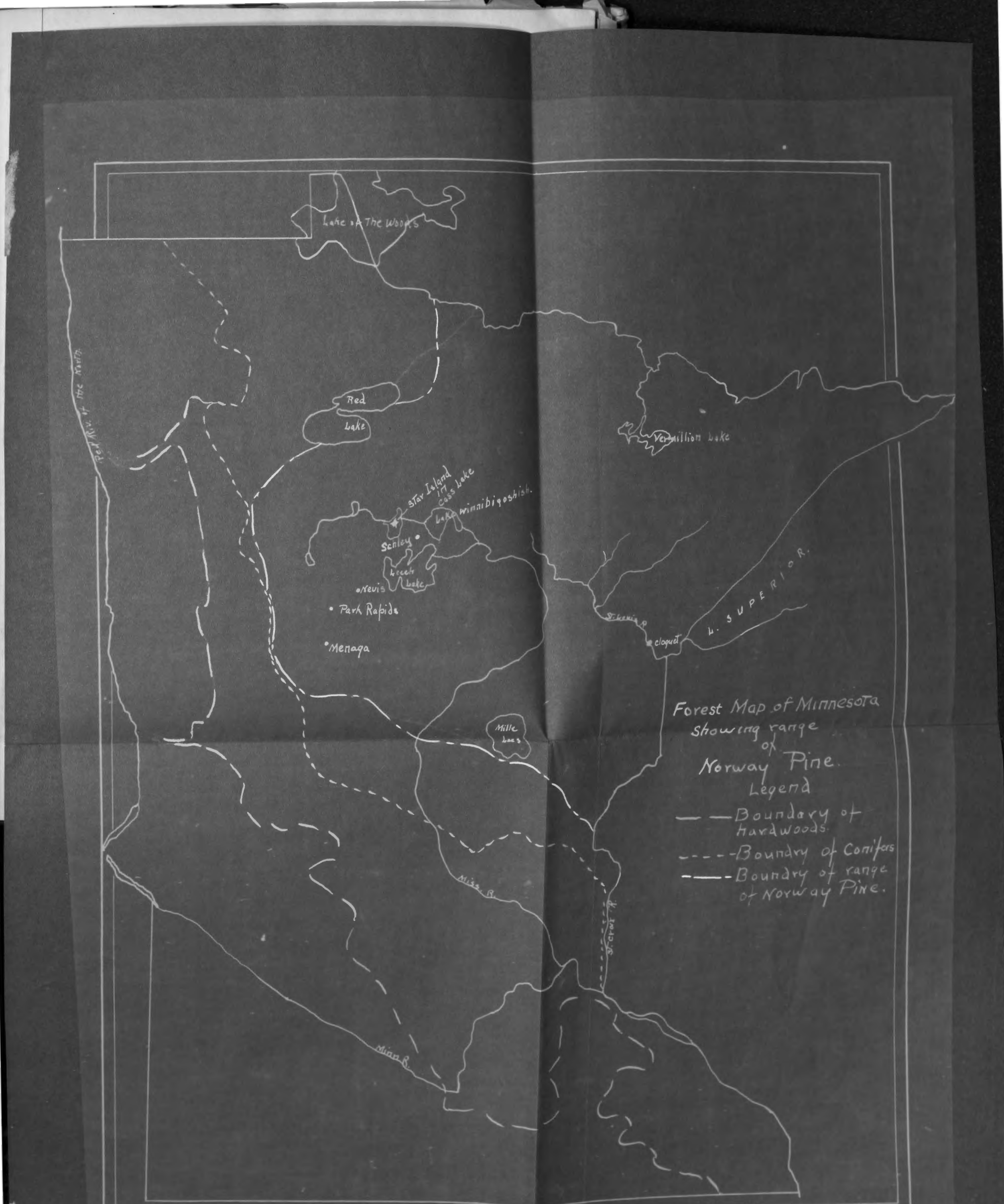
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Mian R.

Norway or Red Pine - Pinus resinosa

RANGE. Although this pine is called Norway pine, the tree is not a native of Norway. It is also known as Red pine, which seems to be a more appropriate name. In its natural range it is confined to the northeastern United States and southern Canada. It is found from the mouth of the St Lawrence river westward to Lake Winnipeg and as far south as northeastern Minnesota, Wisconsin, central Michigan, and eastward to Massachusetts. It reaches its best development and is most abundant in Minnesota, Wisconsin and Michigan. Lumbering and fire have greatly decreased its former abundance in these states. Throughout its range it is, for the most part, confined to the poorer situations, chiefly sandy areas.

Of the 28,000,000 acres of forested land in Minnesota, according to the estimate of the State

Forester, 13,000,000 acres will eventually be cleared for farming. The remaining 15,000,000 acres, because of the character of the land, will probably remain in forest. The total annual cut of lumber in Minnesota is now about 1,411,000,000 feet, a large part of which is Norway pine. This pine is now one of the best woods growing in Minnesota. It is being used as much as white pine for finish lumber and is far better for construction timber.

CLIMATE. "The average annual precipitation within the range of red pine is from twenty-five to forty-five inches. Snow is deep in winter, while rain is rather evenly distributed during the remainder of the year". The Norway pine seems best adapted to the drier western portion of its range. The annual range of temperature is especially wide in Minnesota, where extremes of 110 degrees above and 59 degrees below zero have been recorded. The mean annual temperature is 40 degrees F., the average winter minimum is 3 degrees F. and the summer average maximum is 78 degrees F. In portions of the range of Norway pine frosts occur in every month of the year. The interval of killing frosts is about four

months on an average, May 15th to September 15th.

SOIL AND MOISTURE. Norway pine is usually found on deep, loose, loamy sands or gravels, which retain a small amount of moisture. It requires better soil than jack pine, but thrives on soil too loose and dry for white pine. In mixture with white pine on sandy soils, Norway pine predominates on the drier ridges and plains, while the white pine is more abundant on moist lower slopes and depressions. Norway pine does not make heavy demands either on soil quality or soil moisture, but it can not endure poor drainage and is never found in swamps. Northern Minnesota has vast stretches of soil, which is exactly the kind on which Norway pine will win out. It has also much rocky, clayey soil, too rough for agriculture but excellent for tree growth. The Norway pine can, therefore, be considered a very promising and useful tree in the future afforestation and reforestation of Minnesota, both on account of its larger size and high quality of its wood, and because of its rapid growth and ability to thrive in northern Minnesota soils and climate.

ASSOCIATED SPECIES. In many of the sandy soils

Norway pine forms pure stands in large tracts, often growing very dense. In other soils it may be mixed with jack pine in more or less open stands, especially in younger ages. In better sites, where there is a large amount of clay and loam, white and Norway pine are mixed in all percentages. On the very best soils, the Norway pine is crowded out entirely by the white pine and hardwoods. Where the soil is a clay loam with a moderate amount of moisture, hardwoods such as aspen, birch, red maple, ash and oaks, are found in mixture with the Norway pine. On the open and sandy ridges considerable scrub oak is found.

HABIT. In the forest Norway pine is normally a tall, slender tree with a smooth, straight, clear bole and little taper. The tree does not ordinarily exceed 2 or 3 feet in diameter and 80 to 100 feet in height. Young trees have long, pyramidal crowns of stout, horizontal branches in regular whorls. The needles are four to six inches long in clusters of two, forming dense tufts at the ends of the branches. Old trees have short, broad, flattened crowns with heavy branches and needles at the ends. The bark is rather thin, reddish brown and in old

trees divided into roughly diamond-shaped plates. The root system of the Norway pine is well developed in old trees. It has a number of stout, lateral roots, which descending at acute angles gives the tree a strong support, and makes it very wind firm.

Norway pine lumber is harder and stronger than white pine lumber and its grain resembles that of the southern hard pines. The wood has a large amount of sapwood and is not very durable unless treated with a preservative. As a wood for paving blocks, as far as tests have been carried out, it is second only to the southern hard pines. It is chiefly useful for general construction, bridge timbers, ship building, car construction, and flooring and is fast becoming useful as interior finish lumber. With the decrease in the supply of Norway pine, its place is being taken by Douglas fir and southern yellow pine, both of which have to be shipped long distances.

TOLERANCE. "Throughout its life the Norway pine is intolerant. It can endure more shade than jack pine, but is decidedly less tolerant than white pine or any other of its common associates, except jack pine. Norway

pine clears itself of branches earlier and more perfectly than any other northern conifer, a habit which adds much to its value as a timber producer".

SUSCEPTIBILITY TO INJURY. "After the pole stage, Norway pine is somewhat more resistant to light surface fires than either white or jack pine. Because of its deeper root system it is seldom wind thrown. Slender trees are often broken off in severe winds".

No serious insect pests or fungous diseases are generally found on Norway pine. In areas where cutting has been carried on for several years and scattered mature trees are left, especially seed trees, they are often severely attacked by the red turpentine beetle, Dendroctonous valens. This is especially true around Cass Lake and on Cass Lake National Forest. Many trees, from which seed was collected, had a large number of gall-like swellings on the limbs in which were from one to six beetle larva of some species; but as the adults were not obtained, the exact name is unknown. These, however, do not appear to injure the vitality of the tree.

The Norway pine is quite generally free from fun-

gous attacks, especially Trametes pini, a heart rot which is found extensively onwhite pine, larch and jack pine. Less than three per cent of the Norway pine trees examined for heart rot (Trametes pini) were affected and these only in small, low spots. A witches'broom of some kind, possibly Aecidium sp., was found on a few trees. It did not appear to injure the tree, but it did affect the seed production, as branches badly affected had none or very few cones.

REPRODUCTION. The Norway pine is a rather poor seed producer. It begins bearing seed at about twenty-five years, the youngest tree found with cones being twenty-three years old. The seed years are three, four and five years apart and the crops are light. If periodicity of seed years could be shown by the number of trees of different ages in a locality, then charts Nos. 1, 2 and 3 would show such. It will be noticed that chart No. 1 runs from one to twenty years, and that chart No. 2 runs from twenty to thirty-five years. The heavier seed years - preferably germination years - run in three to five-year periods, the curve running higher each time un-

til a climax is reached,and then runs down. During the past thirty-five years, good germination years have been in three to five-year periods, while the very heaviest years come at ten to twelve-year periods. Chart No. 3, which was taken from stump analyses of old trees,also shows the same three to five-year period with the higher intervals of ten to twelve-year period. The accuracy with which these high points of the curve coincide with actual seed years is thrown in doubt by the ages of many reproduction trees found in the quadrats.

A study of the curve charts, charts Nos. 4, 5, and 6, made from a study of reproduction trees of Norway pine at Menaga, Nevis and Schley, Minnesota, shows that all seedlings of any considerable number have started on years when the average rainfall for May, June and July was over four inches, or if it were slightly less than four inches there had been an abundance the latter part of the season before. The dotted line of the curve represents the rainfall and the continuous line represents the number (or percentage) of seedlings that started on that season. The high points of the reproduction curve, it will be noticed,

rise simultaneously with the high points of the precipitation curve. There are points where the rainfall is high with very few trees from that year, but that is not against the theory because there may have been no seed present to germinate. Germination years are of course represented by those high points, but the question raised is, do germination years follow exactly the seed years. At first sight one might think that the reproduction shows that, (1) meteorological conditions effect seed years in such a way that light and heavy seed years coincide with years of light and heavy rainfall, or (2) that a certain amount of seed germinates each year, but only on moist years do the seedlings succeed, or (3) that seed can and does lie dormant on the ground until the proper moisture for success avails itself. The last is really the only one that is probable enough to deserve consideration. All the studies made of reproduction, especially those at Nevis and Schley, would tend to show that seed can lie dormant for one to three years and then germinate and produce good reproduction. Quadrats Nos. 2, 6, 9, and 11 (Nevis) and parts of the Schley transects, bear this out the strongest.

The timber at Nevis was cut twelve years ago (1899-1900). The following spring was very dry and only a small amount of reproduction started. The spring succeeding (1901) had a moderate amount of rainfall with a consequence that many seedlings started. The following seasons had considerable rainfall withthe result that a noticeable number of seedlings started on those years. These started one to three years after a clear cutting; so the conclusion must be that they started from dormant seed produced by the original forest. This would go to show that the germination years do not conform to the seed years. There is, however, no way of determining the periodicity of seed years by means of a reproduction study. With trees that hold their cones for any length of time, as jack pine, seed years could be figured back by old cones, but as Norway pine does not retain its old cones over two or three years, this method can not be used. The trees themselves would have to be watched. The Norway pine is not a prolific seed producer, and the cones release the seed the same year that the seed ma-

tures. It is, therefore, often at a disadvantage with the jack pine, which is a heavy seeder and always has cones ready to release seeds. This advantage of the jack pine is especially true after fires. The vitality of Norway pine seeds is generally high and germination will take place very readily on mineral soil, even in moderately dry situations. It will not germinate and grow beneath dense brush or on heavy litter or sod.

The quadrats taken at different directions and distances from fourteen different seed trees show that seedlings were established only in the partially shaded places and where grass or humus and litter were not thick, or where mineral soil was exposed. The trees used for this study were trees numbered 3, 25, 56, 83 and 96 on the map of seed collection, and also the seed trees in the Schley transects. These trees were selected with two ideas in view; (1) to get trees with different conditions under which the seed must start, and (2) to get trees with enough old cones on them to make certain that abundance of seed had been produced during the past two to four years. With the exception of tree No.

56, eight one-meter quadrats were made around each tree in eight directions. Four of them were ten meters from the tree and the other four were twenty meters distant.

No seedlings were found around tree No. 83. There was no underbrush present, but there was a very dense mat of pine needles. It was a dry south exposure, with medium dense leaf canopy.

Tree No. 96 was in very dense brush and small poplar. No seedlings could be found under this, but two seedlings were found in a partially open spot southeast of the tree.

Tree No. 25 was also in a very dense brush. Two seedlings were found, one under medium dense brush and pea-vines, and the other growing in a crack in an old rotten log.

Tree No. 3 was on a northeast slope with mineral soil exposed in many places. The brush was open with no grass, but some pea-vines. Several one-year seedlings were found around this tree, especially under the pea-vines which formed only partial shade.

Tree No. 56 had a very large crown and had a

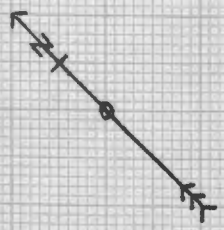
very large number of old empty cones from 1909 and 1910; so evidently much seed had been produced. The brush was not dense, especially on the south side of the tree. There was very little litter or grass on the ground. In places there was a small amount of moss. The chart shows that there were several seedlings around the tree, in fact more than around any other tree.

There is no reproduction whatever under the dense brush, while in the more open places, where there is only a small amount of shade and no dense grass, there is good reproduction. This holds true both of seedlings that were established before cutting and for those that have started since from seed trees. It will also be noticed that where grass is very dense - especially the bunch grass of this section - there is no reproduction whatever. This is probably due more to the dense sod formed by the grass roots than to any shading.

A study of the transect charts from Schley reveals the same feature as the foregoing. A more detailed explanation of these transects will be found later.

Charts 7 to 11

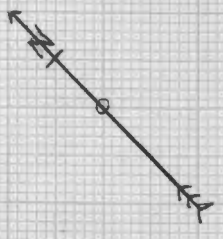
Charts Nos. 7 to 11 show the results of the study around certain trees in the locality where seed was collected. It shows the number of seedlings found under different conditions, as described on pages 11 to 13 of this thesis.



Scale ¼ inch = One Meter

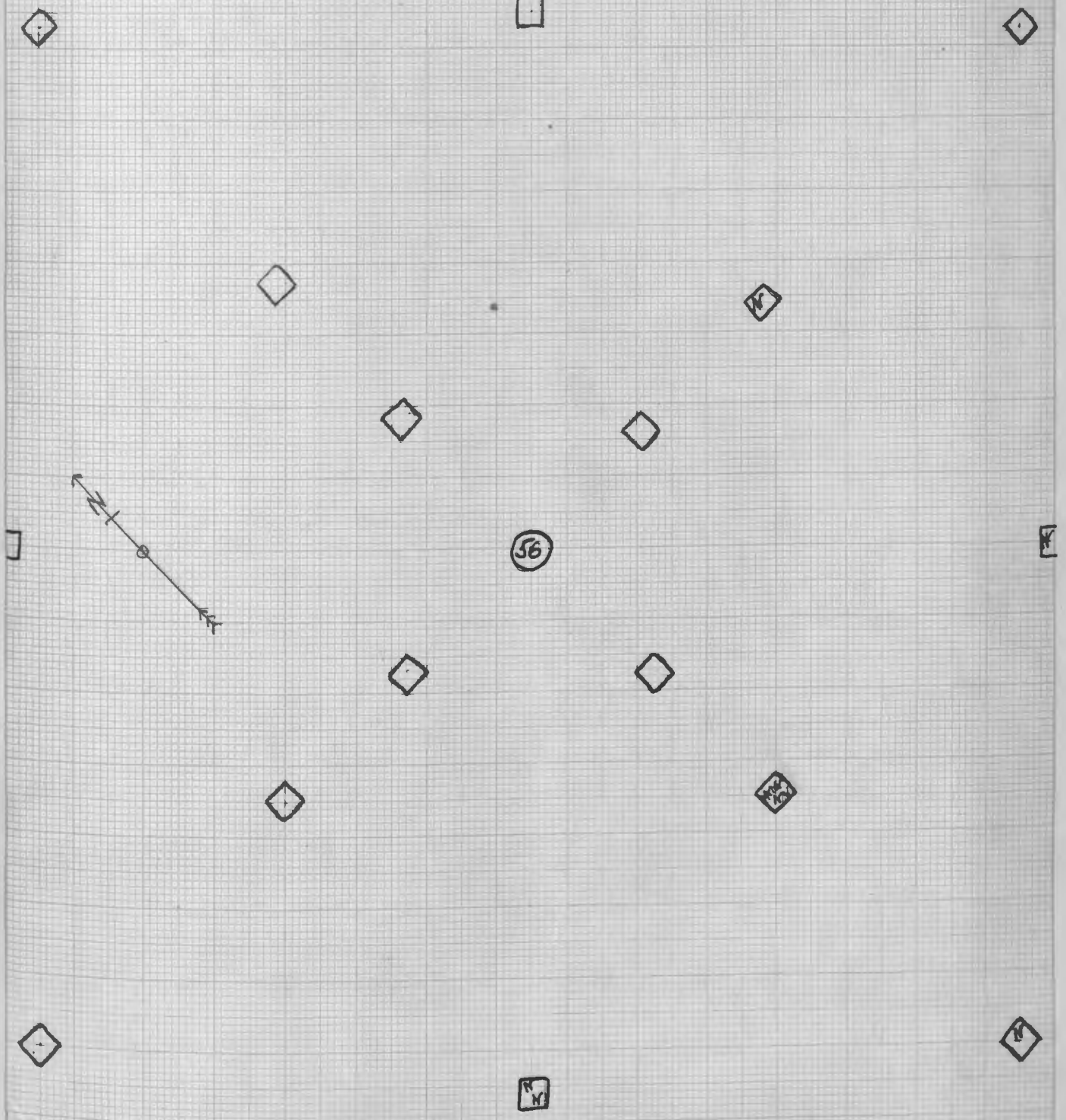
Chart No. 8.

Decayed log



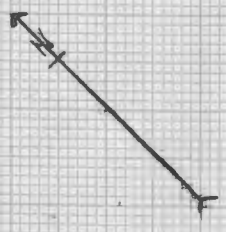
Scale: ¼ inch = One METER

Chart No. 9.



Scale ¼ inch = 1 meter

Chart No. 10.



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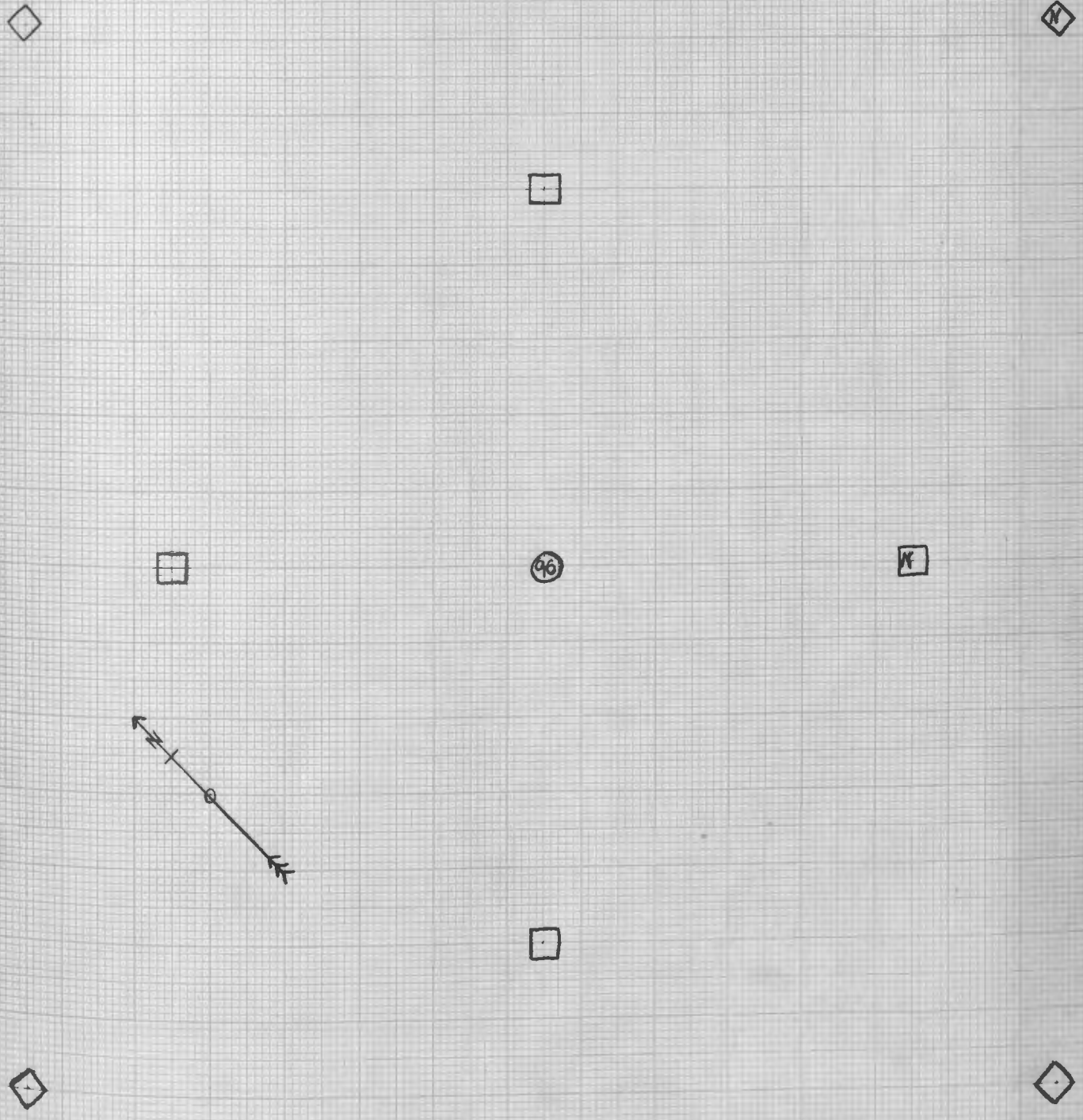
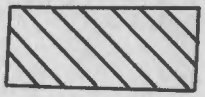


Scale 1/4 inch = 1 Meter

REPRODUCTION STUDY AT MENAHGA. The study of the Norway pine reproduction at Menahga covered very nearly all of four sections of land; viz., Secs.28, 30, 31, 32 and parts of Secs. 28 and 33, all in Twp. 138, R. 35. W. Different parts of this tract have been clear cut at different times for the last twenty to twenty-five years. Mr. A. C. De Puy, of Park Rapids, is an old timber cruiser of this section and was able to furnish the description of the lands, the time of cutting, etc. The accompanying map with legends sums up and puts in condensed form the present conditions of this reproduction tract.

The first thing that was done in the study was to run out the lines of the lands cut at different times. The whole tract was carefully cruised and a large number of quadrats ten feet square were made at places, as indicated on the map by the small numbered squares. These quadrats were to give a detailed idea of the quantity and quality of the reproduction. The quadrat numbers on the map correspond to the numbers on the charts.

No. 1  All the area marked thus on the map was cut eleven years ago. It was cut by the Mississippi Lumber Company and the land is still owned by them. It includes the greater part of Sections 30, 31, and 32, Twp. 138, R 35. W. The original stand was largely Norway pine more or less mixed with white pine. The stand was comparatively dense in most places, especially Sections 31 and 32. The slash was left on the ground unpiled and unburned, and in many places the decaying slash and old needles is very abundant. There has been no fire through here since the cutting, or only a very light spring fire over certain portions. Calculating from the fire scarred stumps, the fires of 1895 swept through portions of these lands.

The ground is generally quite level, sloping slightly eastward and northward to a lake and swamp. The soil ranges from clay loam free from rocks to a very rocky or gravelly soil. The soil for the most part would probably be considered agricultural. Grasses and clovers are growing well in the old roads and skidways which are still open and free from brush.

There is very little underbrush, especially on Sec. 31 on S.½ of Sec. 30 and W. ½ of Sec. 32. The original stand likely had dense enough crown to keep out any grass and underbrush, since the soil is good enough to support a good growth of underbrush if it could get enough light. There are, however, many places in this tract that have a dense growth of underbrush, both where the pine is crowded out and where it is predominating. A study of the quadrat charts reveals that there is very little brush in most places.

The reproduction of Norway pine over this area is very dense and in most places would be far too dense if the soil were poor. The good soil and the dense stand should produce tall, clean timber. Considerable white pine and some jack pine is mixed with the Norway, but computations from the quadrat charts show Norway to be over seventy-five per cent of the stand. The average of the Norway trees per quadrat for this area give 9121 trees per acre besides the white pine. The jack pine is rapidly being suppressed, except in more open places. The white pine is very thrifty with few suppressed trees.

The Norway trees were classified into three classes: viz., (1) dominant, those very thrifty and apparently able to compete with any of its associates, (2) co-dominant, those at present thrifty but not as tall as the dominant class, and are in such a position that they have a poorer chance than the dominant class, (3) the suppressed class, those that are very small and unthrifty or dying. The different percentages are as follows:

(1) Dominant	41%
(2) Co-dominant	29%
(3) Suppressed	30%

Even if the second and third classes are entirely eliminated, the forty-one per cent of dominant trees will make 7648 trees per acre, which is still too dense for growth. If this same classification is made ten years hence, the dominant class will be much smaller than now.

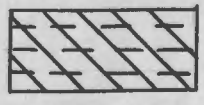
Although this tract was cut eleven years ago, the ages of the reproduction range from nine to sixteen years. All the seed from which this reproduction started must have been produced from the original forest, since it was clear cut and no trees old enough to pro-

duce seed were left. All trees in each quadrat were cut and the ages determined with the following percentage of classes as a result.

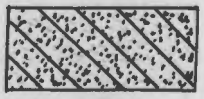
Age in Years	Per cent in Numbers
9	10
10	6½
11	3½
12	4
13	61
14	3
15	2½
16	9

This same result is shown in curve form on chart No. 6. This shows that at least ten per cent of the seed was dormant for at least one year. The height of the trees for this area varies almost directly as their ages. Six inches is about the minimum height of any living trees and fourteen feet the maximum. The nine and ten-year old trees are generally much suppressed. The thirteen-year old trees are all of good average height, ranging from six to ten feet.

The history of this tract may be summed up briefly as follows. The crown canopy was dense enough to keep out any large amount of grass and brush, and possibly the fires of 1895 killed out part of the brush, leaving a good seed bed. The year 1898 was evidently a good seed year followed by a year with plenty of moisture at the proper time of the season. This gave the seed a good chance to start. Following this was a dry year - 1900 - which was undoubtedly favorable in that the preceding year furnished enough water to the soil under the tree canopy, and the dry year - 1900 - was unfavorable to fungous diseases. Also this dry year would cause the seedlings to develop good root systems. In 1900-1901 the timber was cut and removed without fire in the slashing. During both the summers of 1901 and 1902, a moderate amount of rain fell and, with sufficient light and moisture, the conditions were ideal for the establishment of the seedlings as the results indicate.

No. 2  The conditions of this tract are the same as No. 1, it being owned by the same company and cut at the same

time. The soil is more rocky than that of tract No. 1 and is a better loam. Except for the rocks, it would be excellent agricultural soil. The Norway pine reproduction here is the same age as on No.1, but is much taller, reaching a height of sixteen feet. There are about 1500 trees per acre in most places mixed with dense birch and poplar of about the same height. This is forcing the pine in height, which will soon overtop and kill out part of the birch and poplar.

No. 3.  This is an area in No. 1 which is very open, sandy soil. There is no underbrush, but considerable grass (Danthonia spicata). There are a few scattering jack pine and Norway pine eleven to sixteen years old and four to six feet tall.

No. 4.  The area marked thus was cut the same year as No. 1 and has had the same general conditions. The original timber was in dense stand, but small. The soil is very sandy and the surface very level. It is typical jack pine soil and now has a good growth of jack pine eight to

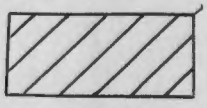
sixteen feet tall and thirteen to nineteen years old. There are five to six hundred trees per acre and the undergrowth is well shaded. The ground cover is mostly Bearberry.(Arctostaphylos uva-ursi) and wintergreen (Gaultheria procumbens). The Norway reproduction through out this tract is very dense and quite uniform. The density in places runs as high as fifteen trees per square foot. Quadrats Nos. 42 and 43 will show this, there being over one hundred trees per quadrat. The ages range about the same as for the previous tract - eight to thirteen years - but the heights are much less, ranging from six inches to three feet.

The history of this tract is similar to that of No. 1. The young trees are on much poorer and drier soil. Also they are under deeper shade conditions, due to their density and to the jack pine canopy. The age at which they will make merchantable timber will be much greater than for No. 1. At present they have a greater struggle among themselves than they have against the jack pine. If they can eliminate the struggle with each other and compete with the jack pine only, they will

overtop it, although they are too dense to produce good growth. See page 54 of this thesis.

No. 5.  The conditions of this tract are very similar to No. 4. The ground is level and soil sandy. The jack pine predominates, being about five hundred trees per acre three to ten feet tall. The Norway reproduction is one to four feet in height and fifteen to nineteen years old. It is somewhat scattered, but in places there is very good reproduction. The tract as a whole has not enough reproduction to produce a good stand of timber. The original stand was good timber, not as dense as No. 4, but somewhat larger timber. It was cut fourteen years ago. In comparing this area with No. 1, it would seem that the timber was cut the season preceding the good seed year that started No. 1, since the reproduction resulting from No. 1 is only thirteen years old and this tract has been cut fourteen years. The reproduction is fifteen to nineteen years old, but chiefly sixteen years. The year 1895 was apparently not as good a seed year as 1898, but conditions for the establish-

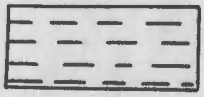
ing of reproduction following 1895 were very similar to those following 1898, the good seed year. The curve for reproduction ages and rainfall - chart No. 6 - show that areas No. 1 and No. 5 have both had about the same conditions, although on different years. For tract No. 5 there was an abundance of rainfall following a fair seed year, this year being considered 1895, since the ages of the trees would indicate that they started in 1896. They then grew during 1896 and 1897 under the canopy of the mother trees, with a gradual decreasing amount of moisture, but not wanting. In 1898 the timber was cut and removed. The season following was one of abundance of rainfall, and with their two-year old start and shade removed, they had good chance for success.

No. 6.  This land was cut the same year as No. 5 - fourteen years ago. The timber was fully as good or better. The soil is sandy, but of better quality than No. 5, but it is not as level. There are patches of dense jack pine twelve to thirty years old and about twelve to fourteen feet tall. Underneath this is Norway pine reproduction

fourteen to sixteen years old and six inches to four feet tall. It is often scattered, but it is generally dense and uniform in size. In places, there are very often open spots with scattered Norway pine and jack pine reproduction. In still other places, there are patches of nothing but dense brush. The reproduction is not as uniform in distribution as tract No. 5, but if it all succeeded, it would produce a good,average natural forest. The history of this reproduction must be exactly as for No. 5.

No. 7.  This land was cut between 1888 and 1890. It was a medium good stand of timber, somewhat open but large. The soil is good loam, but very rocky and gently rolling. The present tree growth is dense patches of jack pine twenty-five to thirty years old. Other places are rather open birch and poplar with considerable underbrush. The Norway pine is twenty to twenty-five years old, sixteen to twenty feet tall, and three to four inches in diameter D.B.H. It is rather scattering, ranging from 0 to 100 trees per acre. Judging from the

ages of these trees, they must have started the year following the removal of the timber. Seed beds and seed years were undoubtedly not favorable at any time shortly previous to cutting, so that only a slight reproduction was established.

No. 8.  This is state land and the date of cutting is not known. The soil and original timber conditions are very similar to No. 1. There is considerable white pine and Norway pine sixteen years old and also considerable jack pine, often in dense patches.

The area enclosed by dotted lines has been severely burned in the last five to six years and all small pine has been destroyed. It is now springing up to birch, poplar and more or less balsam fir.

In a general summary of the study of this tract, it would seem that the success of this reproduction should be attributed to four main reasons.

(1) The fires went through this region about two years before a seed crop, and removed litter, thus making a good seed bed for Norway pine seed, as well as destroying many of the rodents.

(2) There was a good seed year two years after the fire and two years before the cutting of the timber. Also favorable moisture conditions followed the seed year.

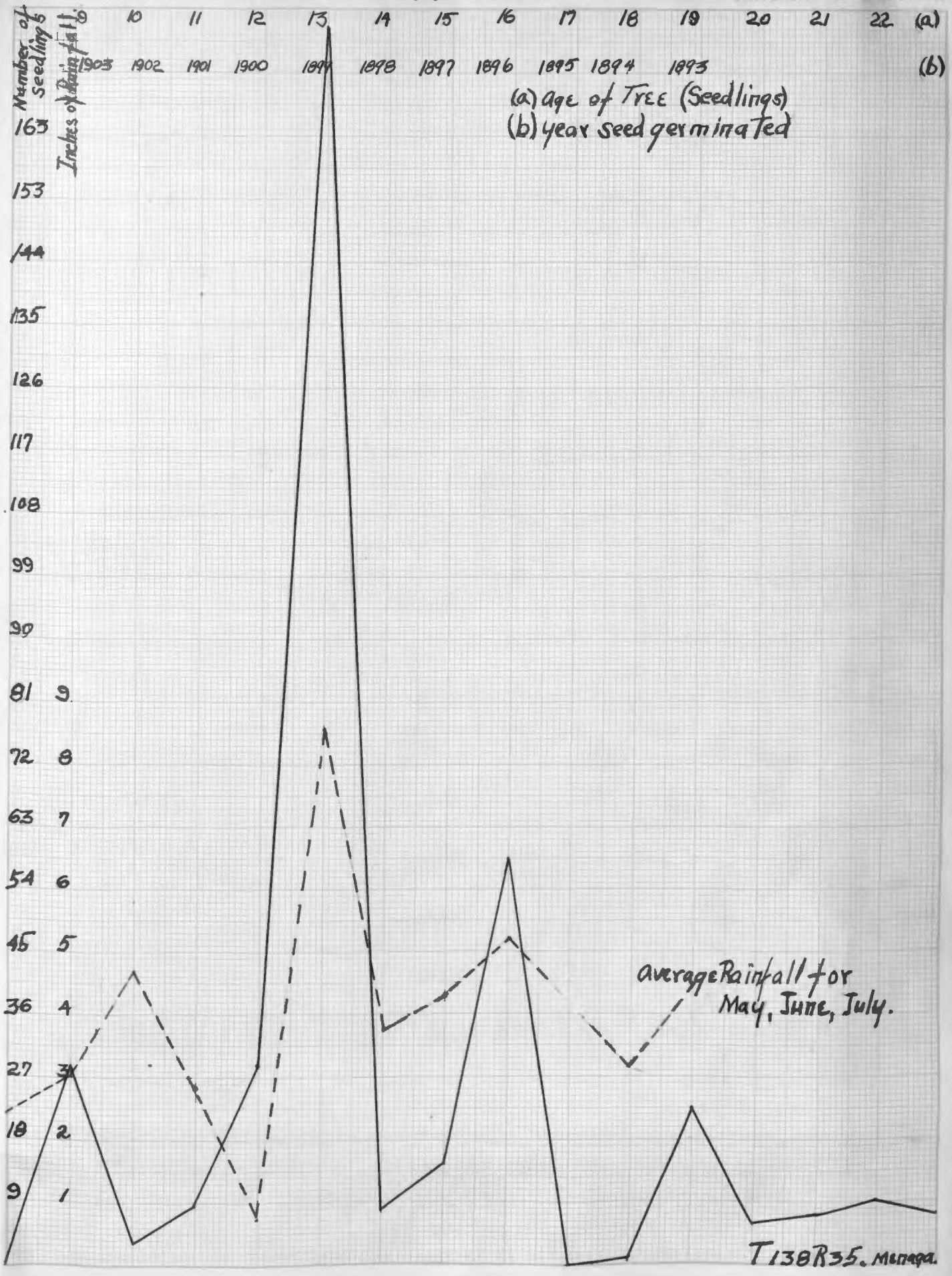
(3) The timber was removed when the seedlings were two years old and well established. The brush was left scattered and served as shelter for seedlings.

(4) Fires have been absent since the reproduction started.

The combination of these factors has brought about a very successful reproduction of Norway pine. In places it is far too dense to produce good timber unless artificially thinned. At present forty-one per cent of the trees are the predominating ones, thirty per cent are suppressed to a hopeless condition, and the other twenty-nine per cent is doubtful. If we calculate that during the next ten to twenty years the suppressed and co-dominant classes of trees will be eliminated, there will still be 3648 trees per acre. With artificial thinning, which should pay for itself at that age, a very good forest could be developed.

Chart No. 6

Chart No. 6 was made from data obtained in the study at Menahga. The solid line represents the reproduction, which ranges from nine to twenty-three years in age, Besides the age, the chart shows in what year the trees started. The broken line represents the average rainfall for the months of May, June and July of the various years. Rainfall data taken from Park Rapids records.


Number of seedlings
Inches of Rainfall
0 10 11 12 13 14 15 16 17 18 19 20 21 22 (a)
1903 1902 1901 1900 1899 1898 1897 1896 1895 1894 1893 (b)
(a) Age of Tree (Seedlings)
(b) Year seed germinated
163
153
144
135
126
117
108
99
90
81 9
72 8
63 7
54 6
45 5
36 4
27 3
18 2
9 1
Average Rainfall for May, June, July.
T138R35. Mahnomen.

The following map was made from data secured at Menahga. It shows where the quadrats were taken and the extent of each kind of reproduction described.


42
43
Very Dense Norway
6'-3ft Tall. 3yrs old
Under dense jack Pine
37
34
35
36
Level Sandy Soil. Norway 15-19 yrs.
1-4ft Tall- under dense jack Pine.
22
23
CUT 1888-1890
Very scattering Norway
20-25 yrs old.
28
Norway Pine
14-16 yrs old
6'-14ft tall
Under Jack Pine
29
30
19
20
28
38
41
40
24
25
26
27
Scattering
White and
Norway
Jack Pine
Dense Jack Pine
39
33
32
Burn, 5yrs. old
28
29
30
31
Dense Norway Pine Mostly 13yrs old.
3 to 6ft tall
Timber cut, 1900-1901
31
32
33
Menaga- T138R35.

Quadrats 19 to 43

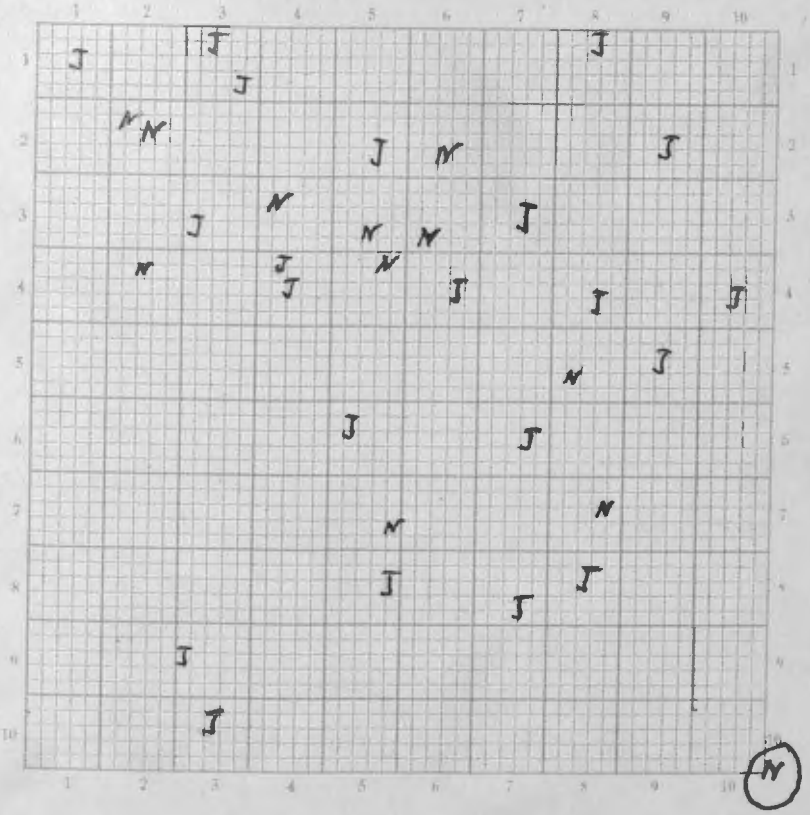
The following quadrats are all 10 by 10 feet in dimensions. In all of them the top of the page is north. Each one was made in locality as indicated on the map.

QUADRAT 19 LOCATION T138 R35 Sec. 28 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND: scale: 1 CM = 1 FT

N = Pinus resinosa - 15 to 19 yrs - 6" to 3' tall.

J = Pinus divaricata - 18 yrs - 12" to 6 FT tall.

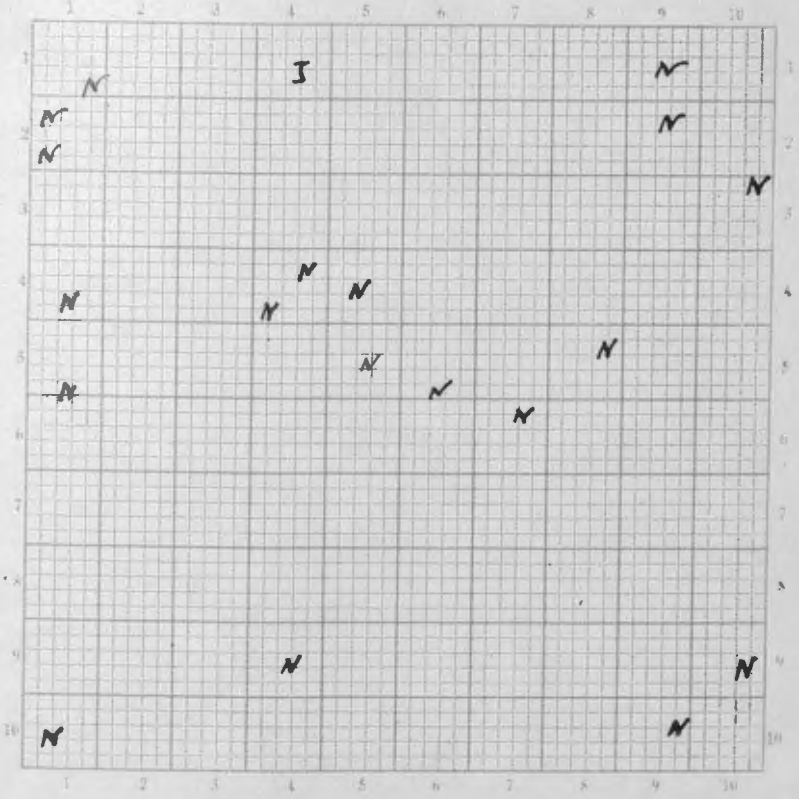
(N) = Norway Pine stump.

QUADRAT 20 LOCATION T138 R35 S29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

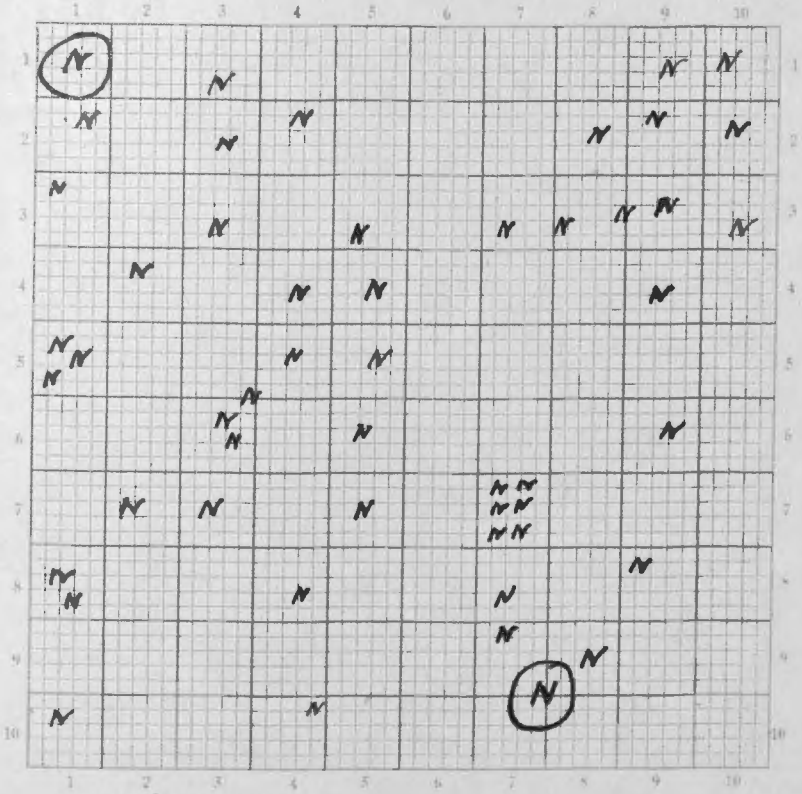
N = Pinus resinosa - 14 to 16 yrs old
I = Pinus divaricata - 25 yrs.

QUADRAT 21 LOCATION T138 R35 S29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

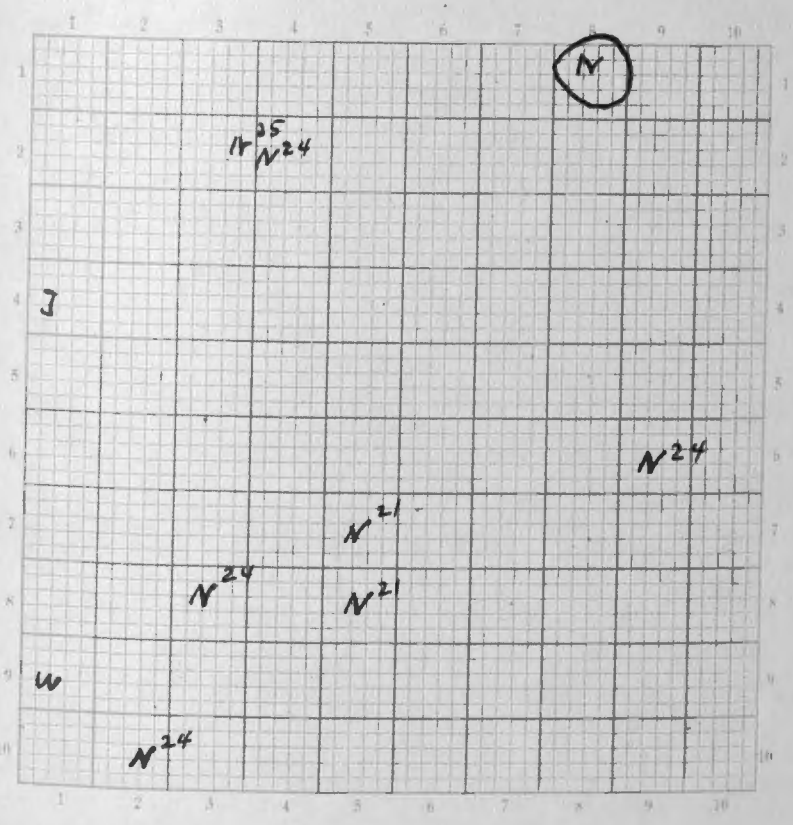
N = Norway Pine - 9 To 16 yrs.
(N) = Old Norway Pine Stump

QUADRAT 22 LOCATION T 138 R 35 S 29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

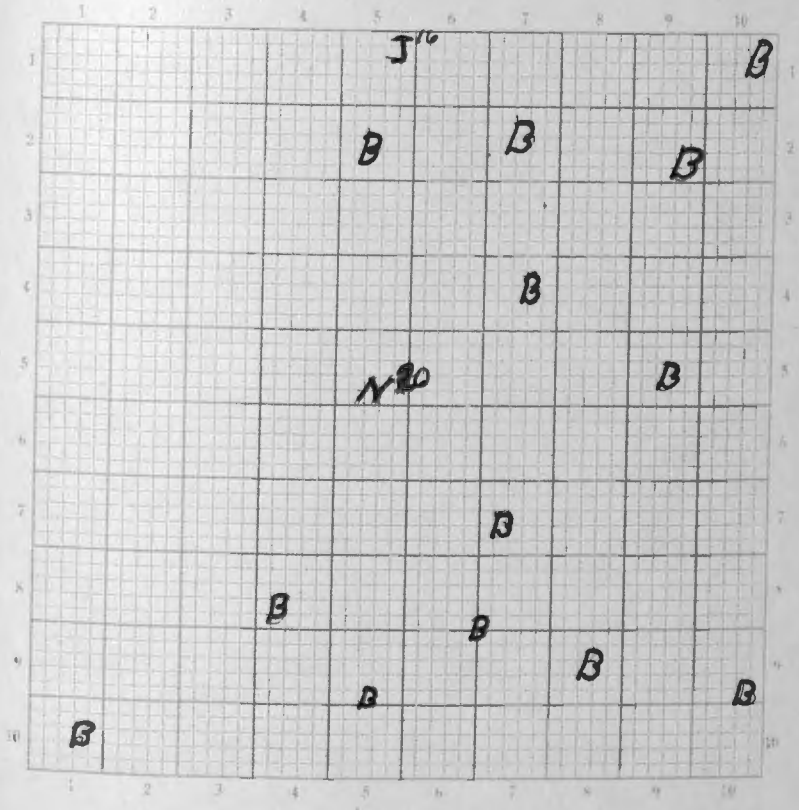
N = Pinus resinosa – 12 To 20 ft. Tall
W = Pinus STrobus
Ⓝ = Norway Pine stump
J = Jack Pine – 16 To 25 yrs.

QUADRAT 23 LOCATION T13S R35 Sec 29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

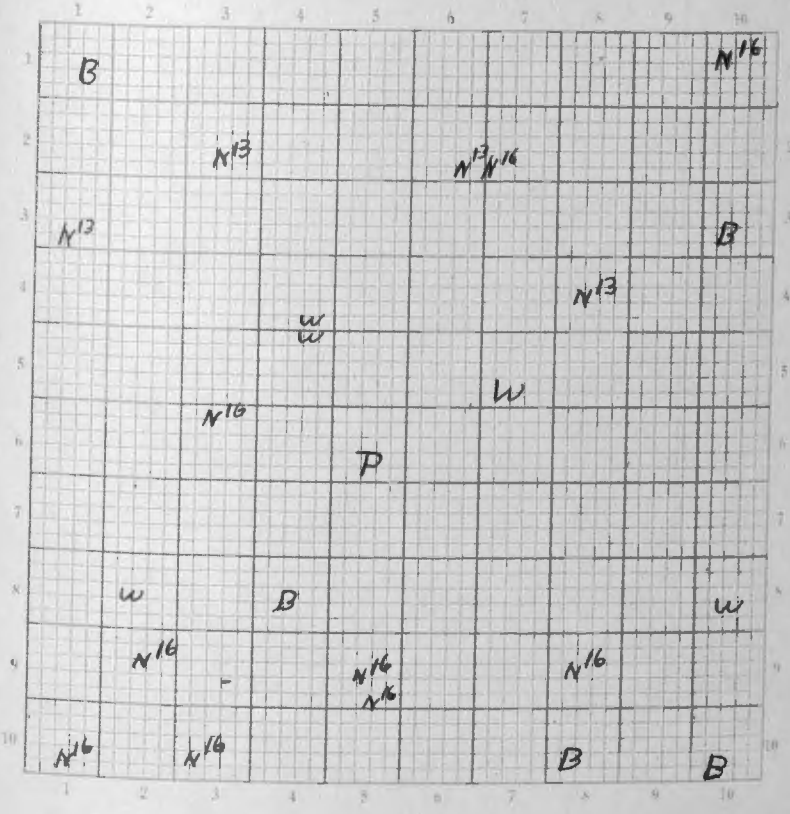
Scale: 1 cm = 1 ft.
N = Pinus resinosa - 14 ft. tall.
B = Birch (B. Papyrifera) 18 ft tall.
J = Pinus divaricata.

QUADRAT 24 LOCATION T138 R33 S29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

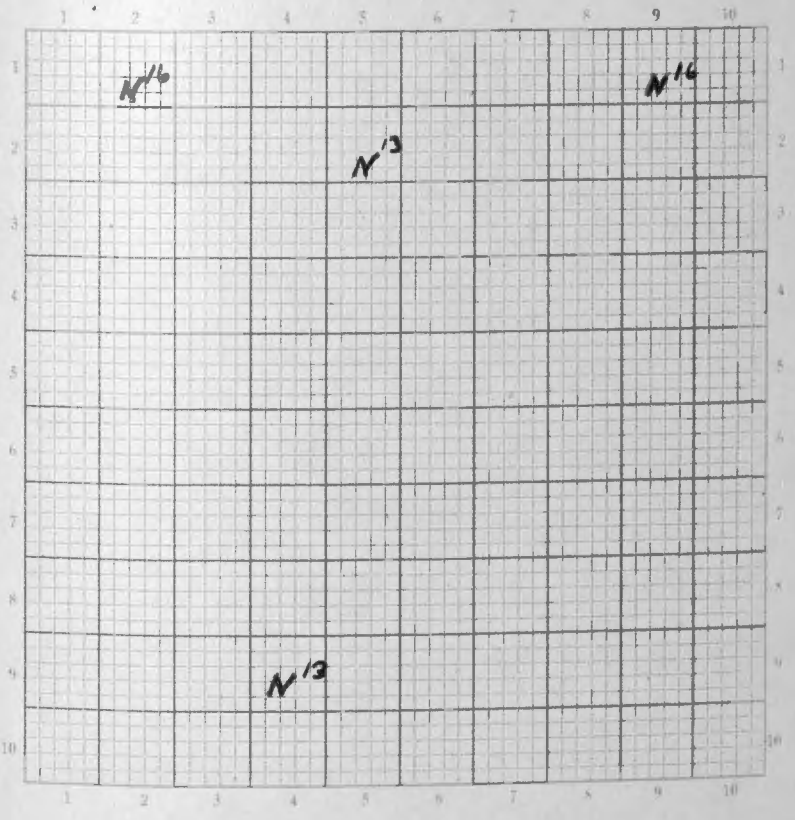
N = Norway Pine - 10ft tall - (exponent = age)
W - White Pine - 13 to 16 yrs
P = Populus deltoides
B = Betula papyrifera

QUADRAT 25 LOCATION T130 R35 S 29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale: 1CM = 1 ft.

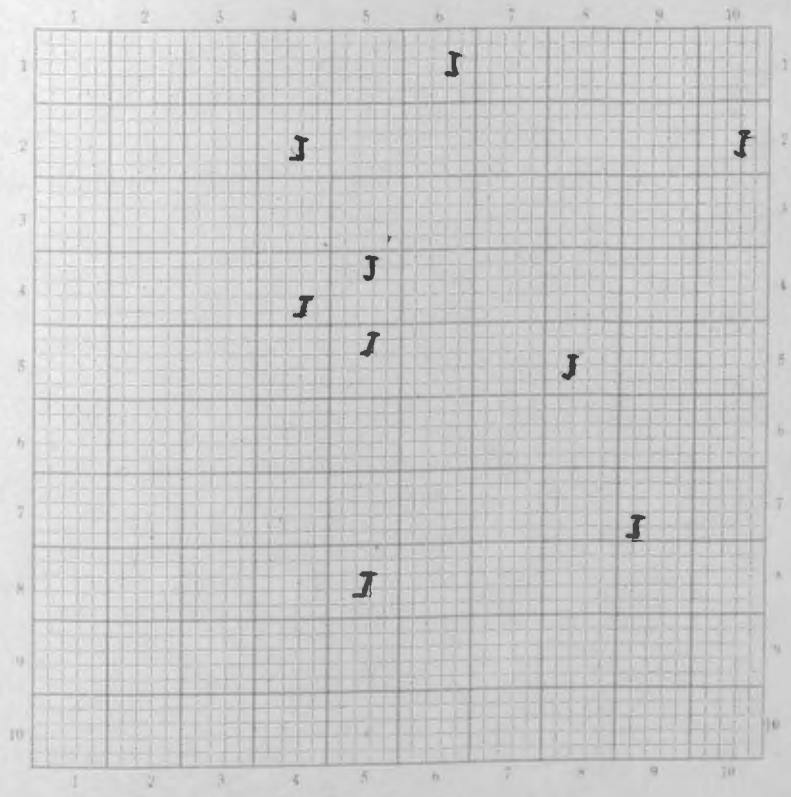
N = Pinus resinosa - 9 To 16 ft. tall.

QUADRAT 26 LOCATION T138 R35 Sec 29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale: 1CM = 1FT.

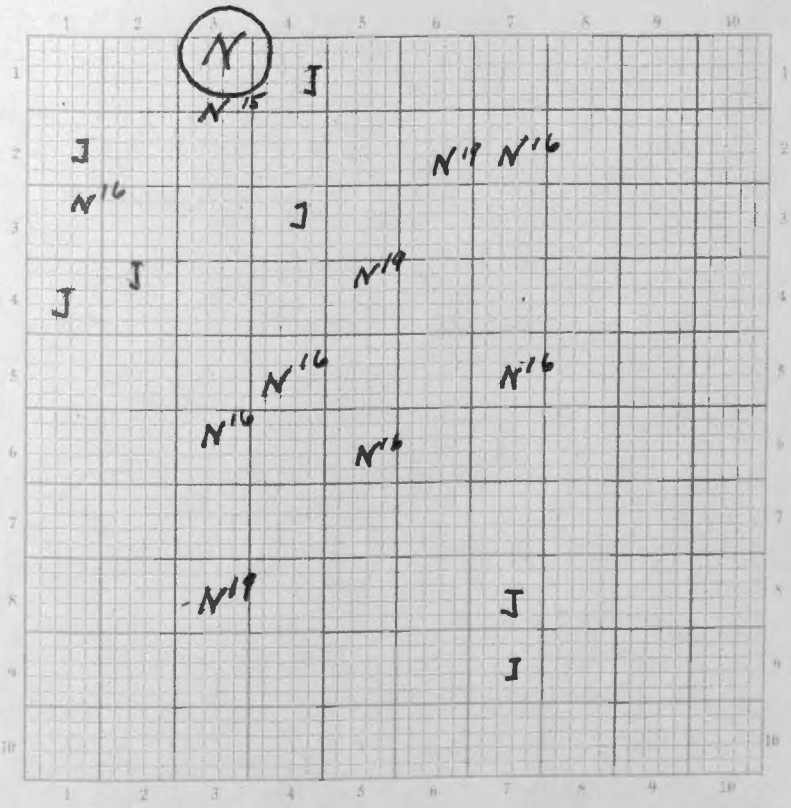
J = Pinus divaricata
12FT. Tall 16yrs.

QUADRAT 27 LOCATION T138 R35 Sec 29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale 1CM = 1 FT.

N = Pinus resinosa - 6" to 3 ft Tall.

J = Pinus divaricata

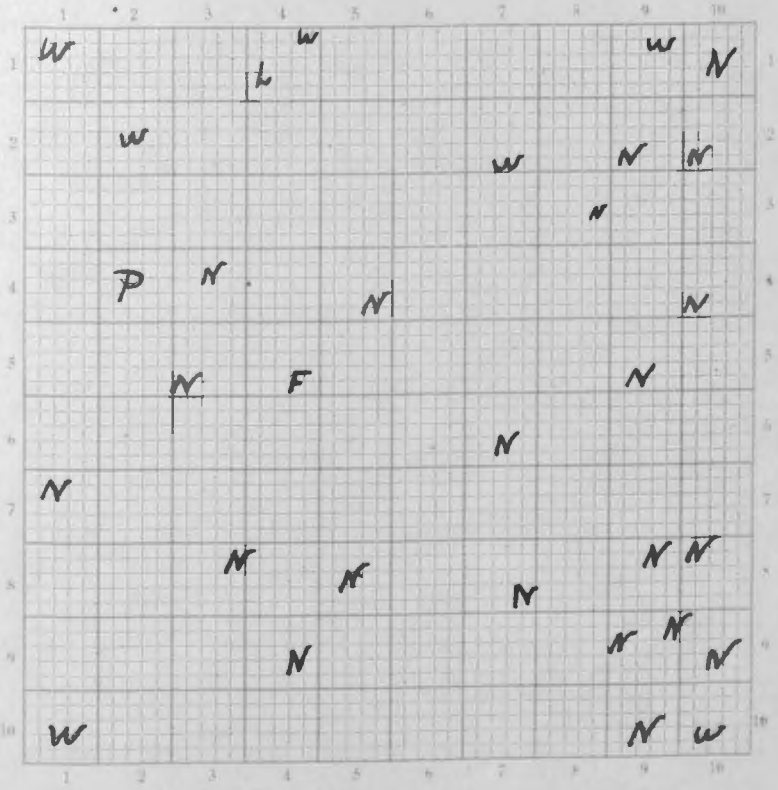
(N) = Norway Pine Stump.

QUADRAT 28 LOCATION T138 R35 Sec31 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale: 1CM=1 ft

W = Pinus Strobus

N = Pinus resinosa; 14 to 16 yrs.

L = Larix americana

F = Abies balsamea

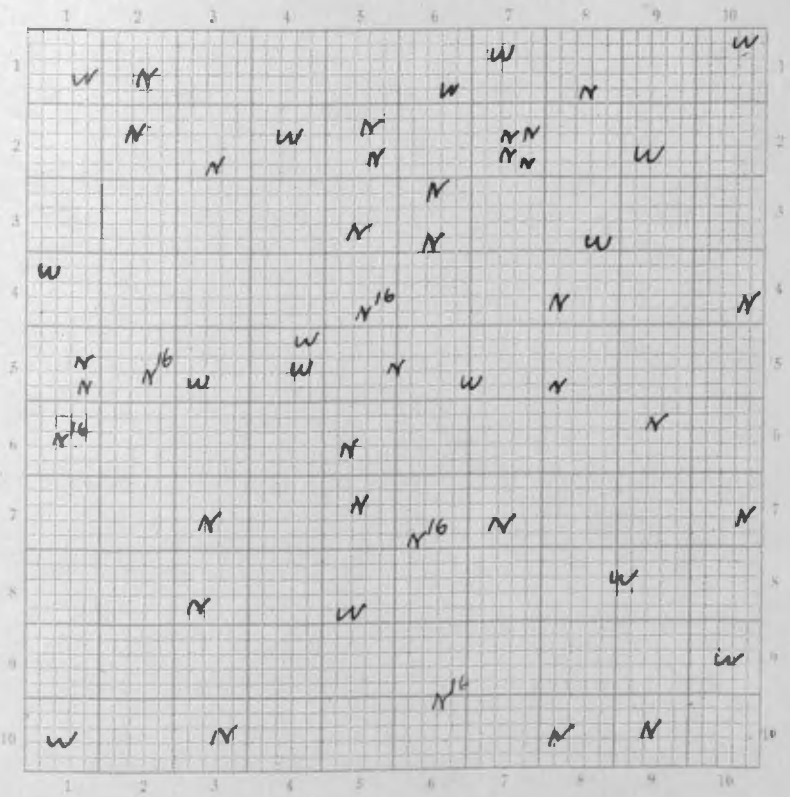
P = Populus deltoides

QUADRAT 29 LOCATION T138R35 Sec 31. DATE

FORMATION

CONSOCIES

SOCIETY



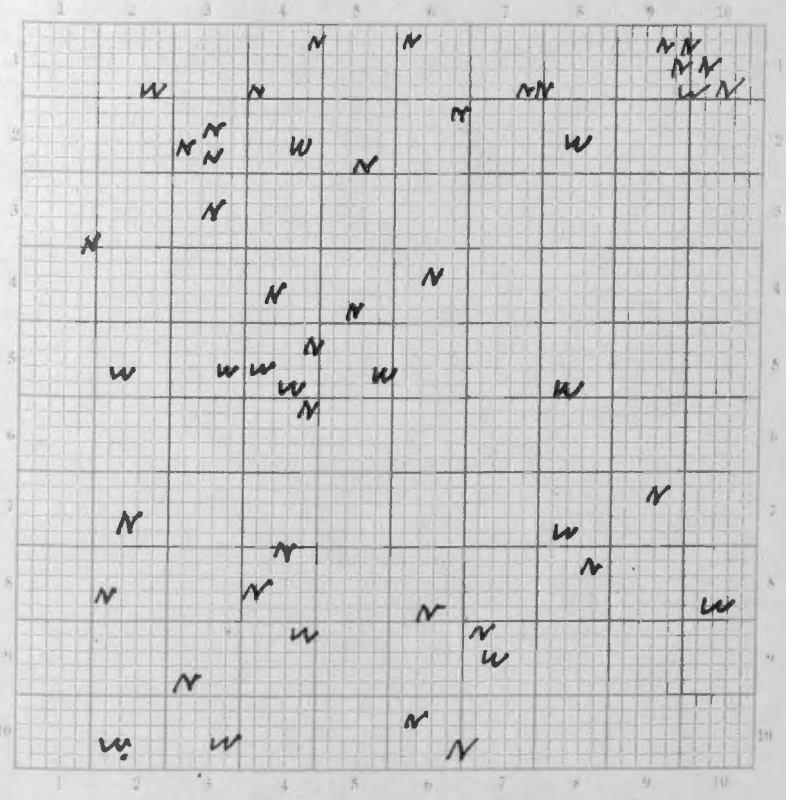
LEGEND: Scale : 1cm. = 1M.
W = Pinus Strobus
N = Pinus Resinosa 9-13yrs
N^{16} = Pinus Resinosa 16yrs

QUADRAT 30 LOCATION T138 R33 S31 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

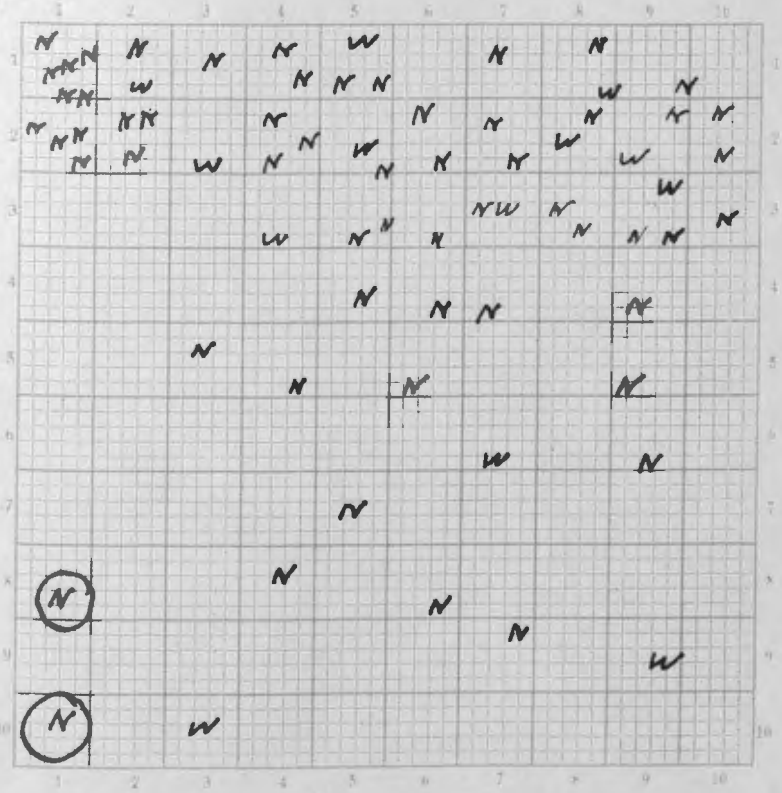
N = Pinus resinosa: 9 To 16 yrs - 3 to 7 ft tall.
W = Pinus strobus - 9 To 13 yrs.

QUADRAT 31 LOCATION T138 R33 S31 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

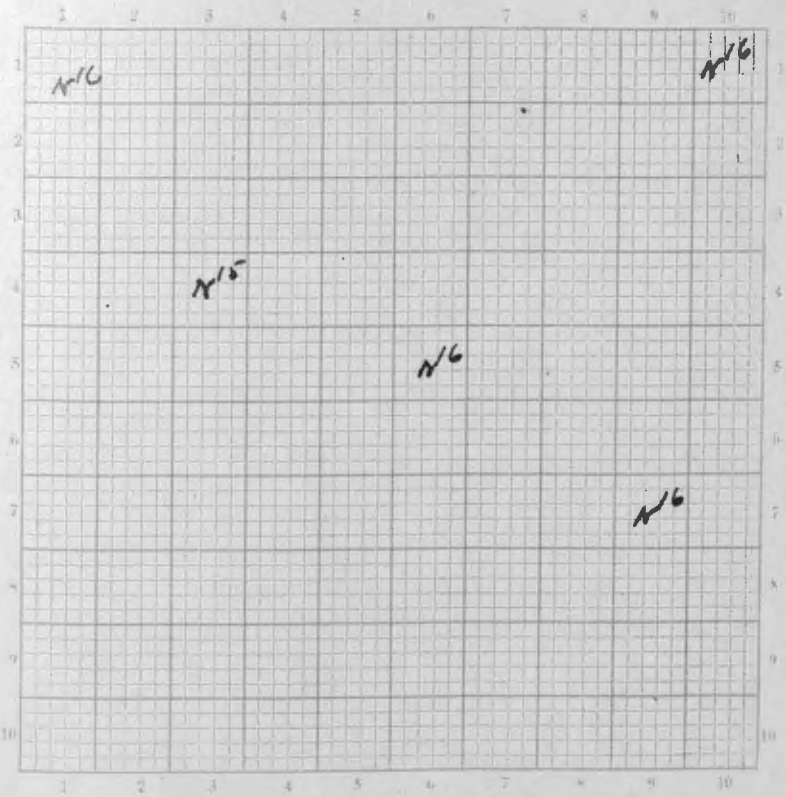
N = Pinus resinosa - 9 to 16 yrs - 6" to 5 ft tall.
W = Pinus strobus
(N) = Norway Pine Stump

QUADRAT 32 LOCATION T138R35-S 29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

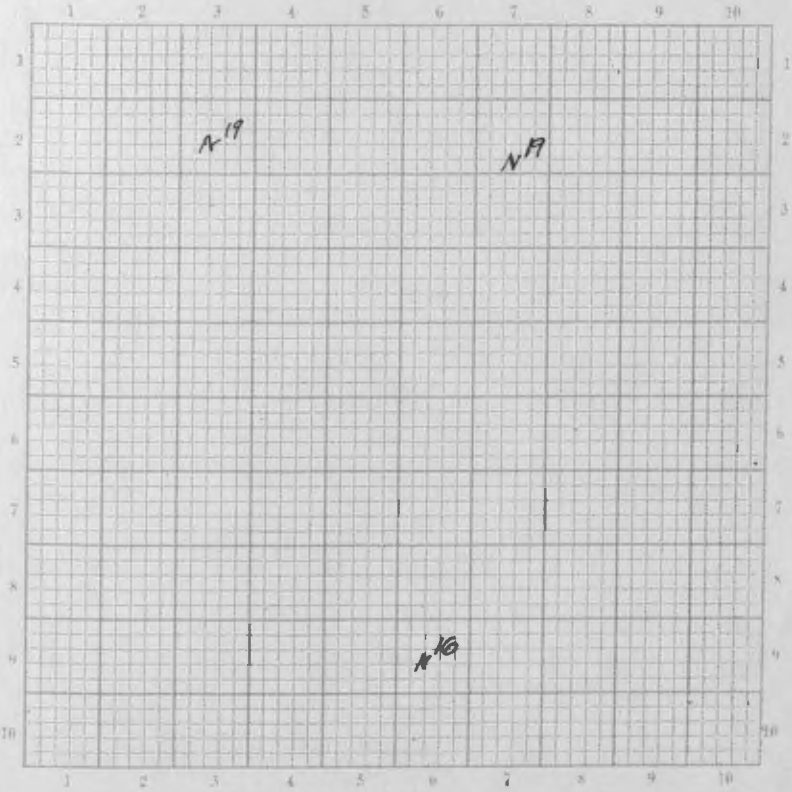
N = Pinus resinosa (Exponent = age)
all over 13 ft. in height.

QUADRAT 33 LOCATION T13S R33 S 30 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

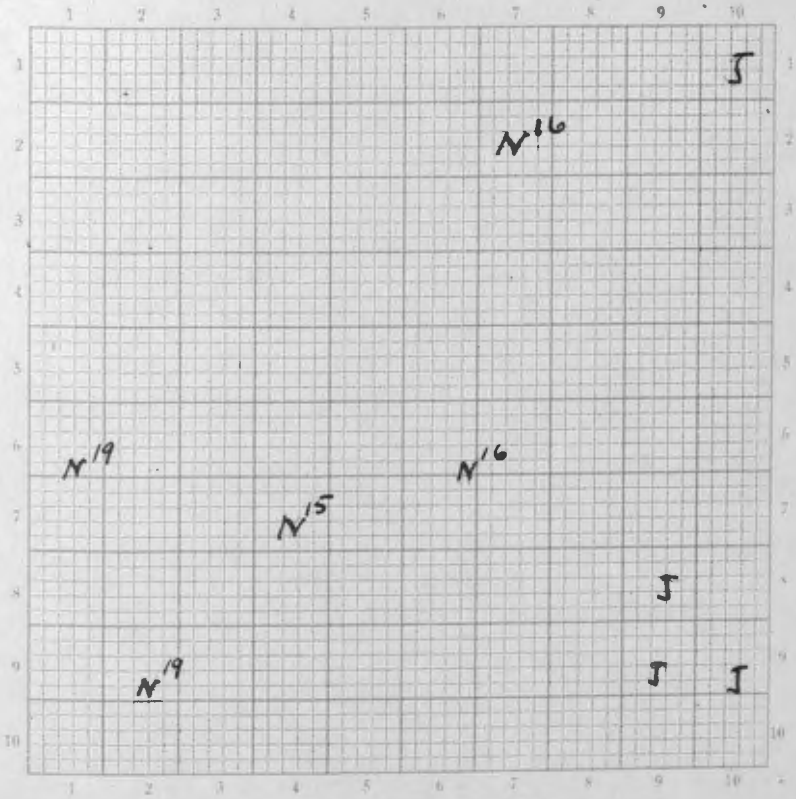
N = Pinus resinosa
Exponent = age.

QUADRAT 34 LOCATION T138 R35 Sec 29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

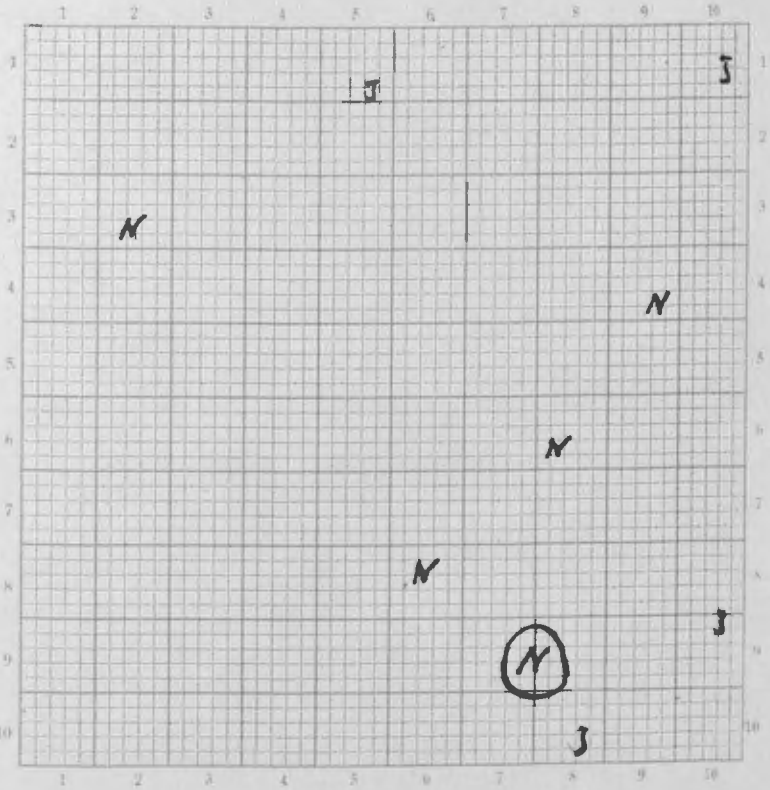
Scale - 1CM = 1 FT.
N = Pinus resinosa
J = Pinus divaricata, - 16-20 yrs

QUADRAT 35 LOCATION T138. R35S 28 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale: 1cm = 1ft.

N = Pinus resinosa, 15-19 yrs

J = Pinus divaricata, 16-20 yrs.

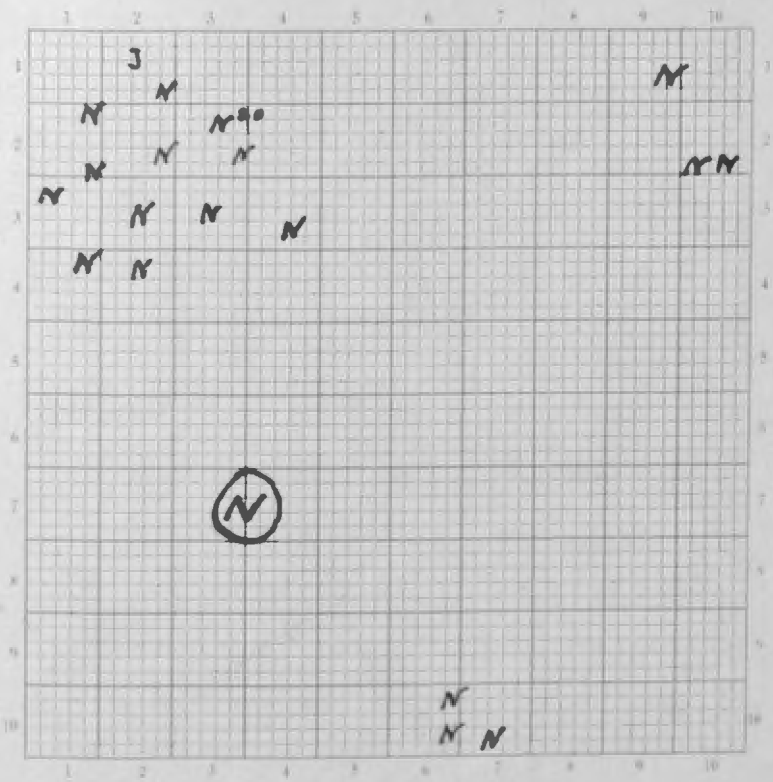
(N) - Norway Pine Stump.

QUADRAT 36 LOCATION T138 R35 Sec 28 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

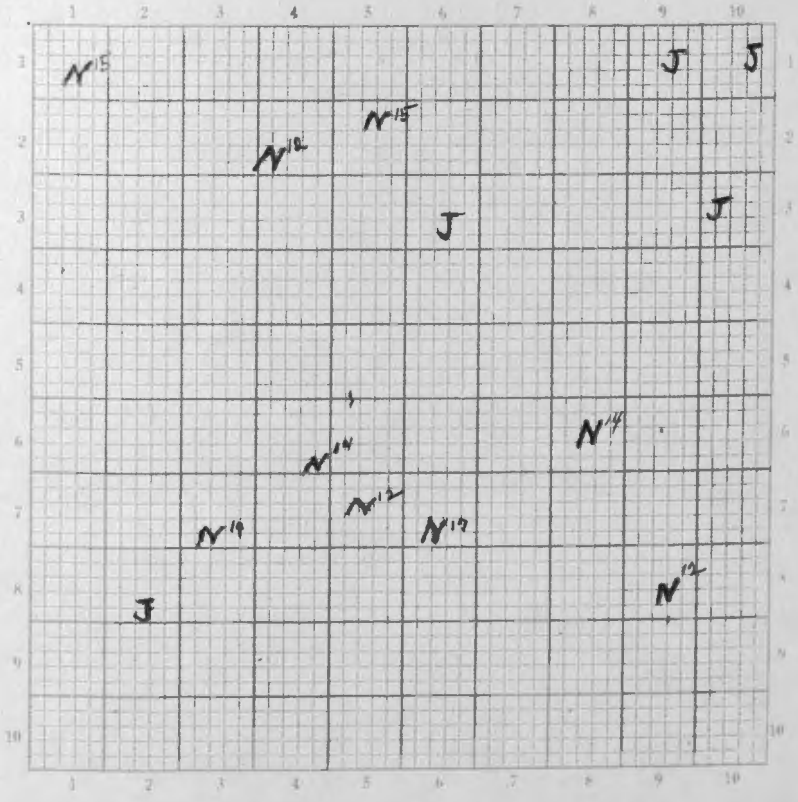
Scale: 1cm=1ft.
N=Pinus resinosa: 15-19 yrs.
J=Pinus divaricata: 16 yrs.
(N)=Norway Pine Stump

QUADRAT 37 LOCATION T13BR35. Sec29 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

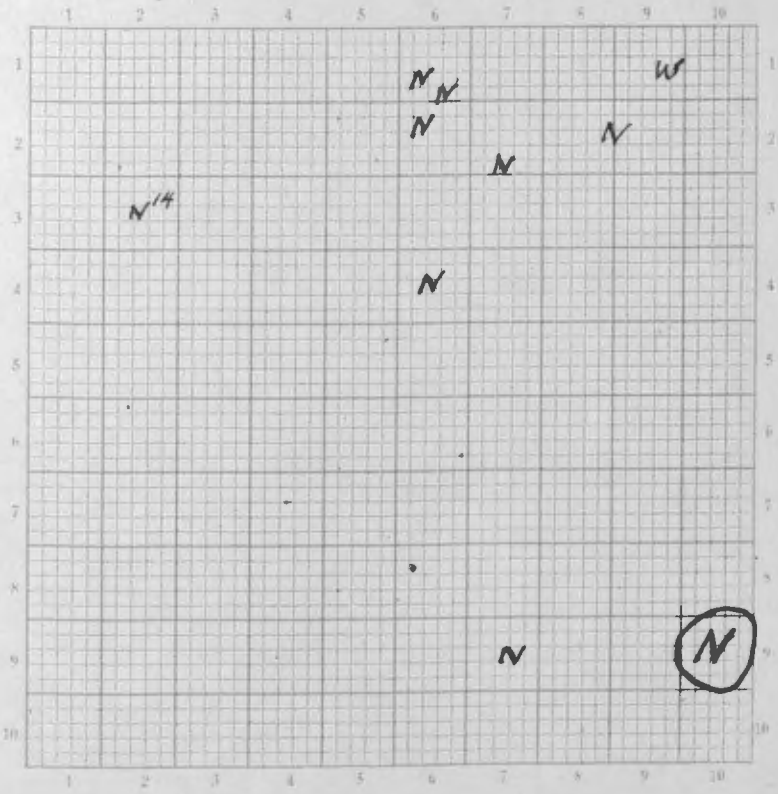
Scale: 1cm=1 ft.
N = Pinus resinosa
J = Pinus divaricata - 16 to 20 yrs.

QUADRAT 38 LOCATION T138R35 Sec 30 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale: 1CM = 1 FT.

N = Pinus resinosa, 13yrs., 2-3ft. Tall.

(N) = Norway Pine Stump.

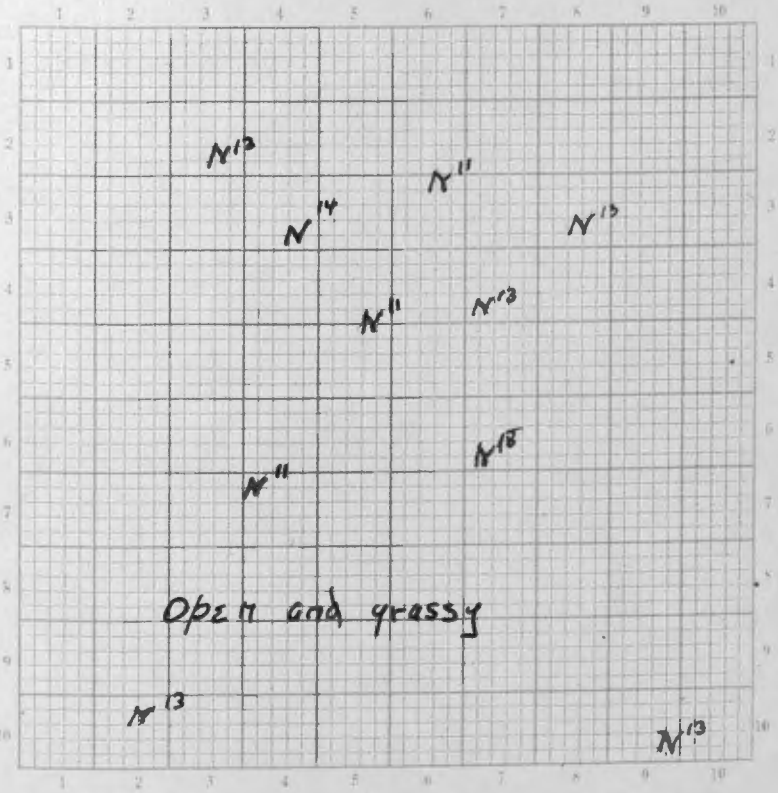
w = white Pine; 13yrs.

QUADRAT 39 LOCATION T138 R35 Sec. 30 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

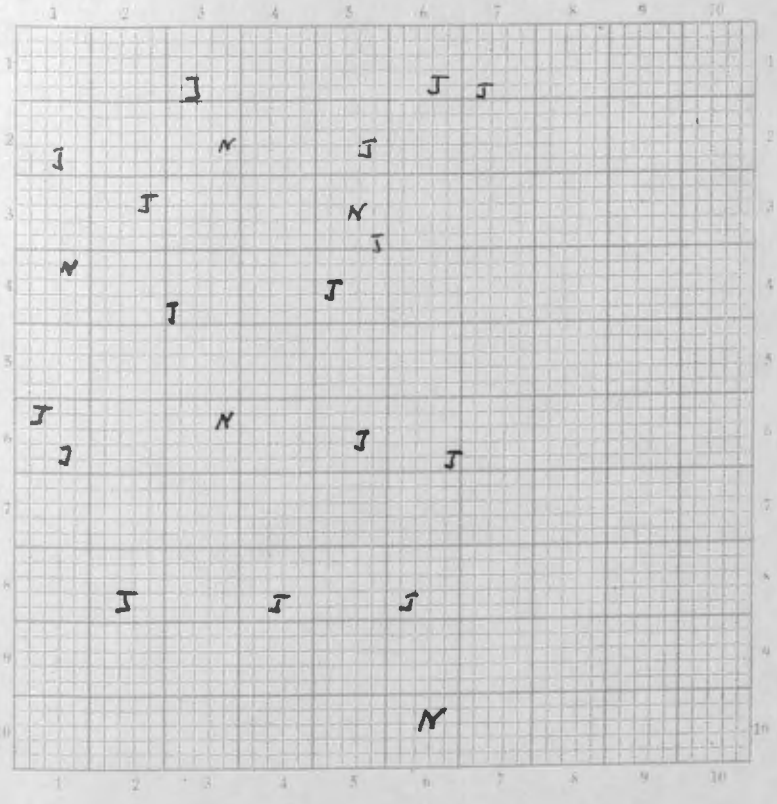
Scale: 1CM = 1 FT.
N = Pinus resinosa, 4-6 FT.
Exponent = age

QUADRAT 40 LOCATION T 130 R 35 S. 30 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

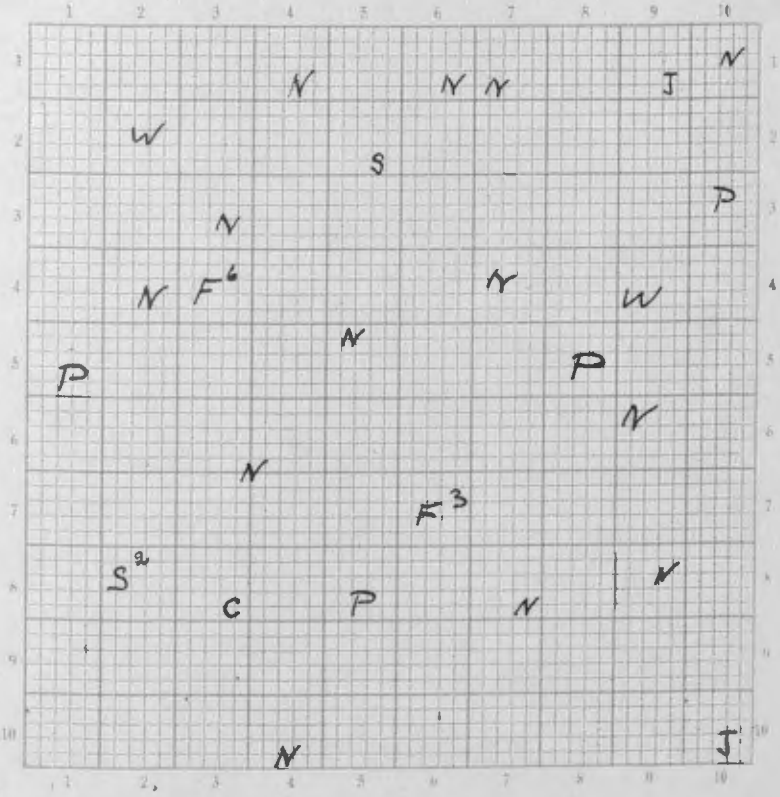
N = Pinus resinosa - 15-19 yrs
J = Pinus divaricata - 16 yrs.

QUADRAT 41 LOCATION T138 R35 Sec 30 DATE

FORMATION

CONSOCIES

SOCIETY



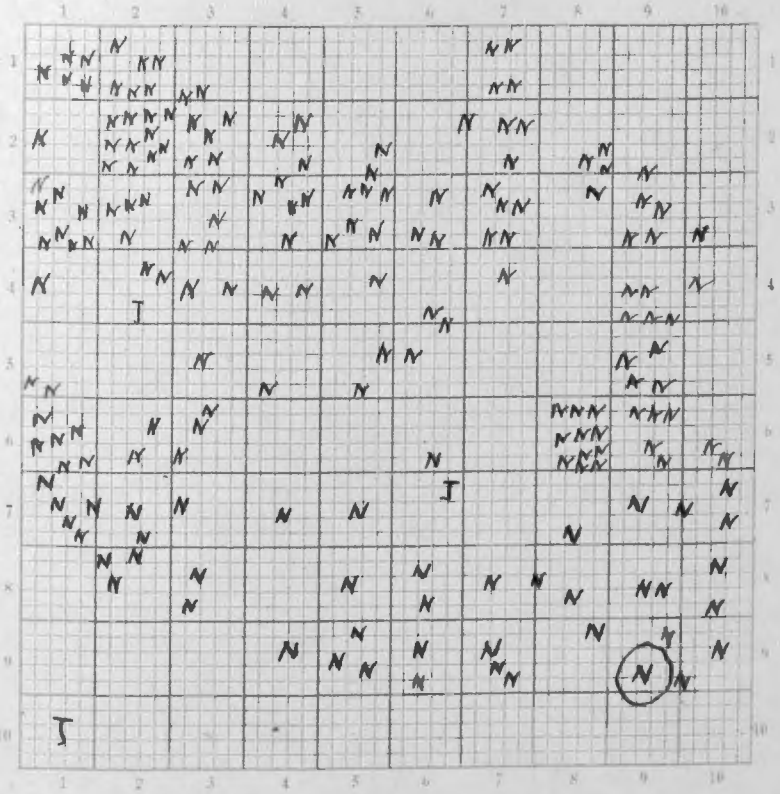
LEGEND: Scale: 1CM = 1FT.
N = Pinus resinosa: 11-13yrs
W = Pinus strobus
J = Pinus divaricata
F = Abies balsamea
C = Picea canadensis
P = Populus tremuloides
S = Salix sp.

QUADRAT 42 LOCATION N½ of NW¼ Sec. 29. T 21 R 33

FORMATION

CONSOCIES

SOCIETY



LEGEND: N = Norway Reproduction - 8 to 12 yrs. old. 6' to 4' in height.

Ⓝ = Norway Pine Stump

J = Jack Pine - 16 yrs. old. 10 ft. in height.

REPRODUCTION IN NEVIS TOWNSHIP

A study was also made in Twp. 140, R. 33 on exactly the same plan as that at Menahga and it will be given in the same form.

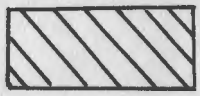
No. 1.  Quadrats Nos. 10, 11 and 12 were taken on this area. The timber was cut during the winter of 1899-1900. The original stand of timber was medium dense and considered good timber. It is now very open with no, or very little, underbrush and a sandy soil, somewhat rolling. There has never been a fire through any part here since the timber was cut and the slash is still lying decayed on the ground. Although there is some reproduction fifteen or sixteen years old, practically all of the Norway pine reproduction is eleven to thirteen years old and three to six feet in height.

Quadrat No. 11 was taken in a place where the reproduction was very dense. The same classification as to dominant, co-dominant and suppressed trees was made as at Menahga. The following is a list of the ages and

classes under those ages:

Age in Years	Dominant	Co-dominant	Sup-pressed
10	0	0	5
11	0	1	18
12	0	0	2
13	0	5	4
14	1	1	0
15	1	5	0
16	5	2	0

This table shows that the older trees which got the first start are the thriftier ones and the younger ones are the weaker. Quadrat No. 11 was very dense - much too dense to produce a stand of timber if left entirely to nature, but the reproduction for the Nevis tract as a whole is none too dense to produce a good stand. Quadrat No. 10 shows no trees and No. 12 shows only four. The average of the quadrats will show more than the general average of the whole tract, which is much less than two thousand trees per acre.

No. 2.  Quadrats Nos. 17 and 18. This tract was cut the same time as No. 1, but the stand of timber was not as dense. The soil is of better quality and the land more rolling. The better soil and more open stand of timber was encouraged a considerable stand of underbrush in which is mixed considerable jack pine sixteen years old. The Norway pine reproduction is smaller than No. 1 and quite scattering. Even if every Norway pine tree here would succeed, there would only be an open stand of timber. The jack pine is dense enough, however, to make the Norway grow tall and prune itself fairly well.

The past history of No. 1 and No. 2 is the same. They were cut down at the same time and there has been no fire in either. It would seem that the seedlings started in the spring of 1899, i.e., at least forty per cent. This was the spring following the cutting. There was abundant rainfall and many seedlings should have started. The year following this had plenty of rainfall and a large number of seedlings started, in fact fifty-

five per cent. This fifty-five per cent must have started from dormant seed produced, at the latest, in the season preceding the cutting, 1899-1900. It is possible, and very probable, that the seedlings that started during the spring of 1899 were very numerous, and that their lower percentage now is due to the dry season following the cutting of the timber, which naturally caused many to die. Had the timber been cut one year later, the percentage of thirteen year old trees would likely be very high. The Menahga charts would seem to bear this out.

No. 3.  Quadrats Nos. 13, 14, 15 and 16. The soil is good sandy loam and comparatively level. At the present time there is considerable growth of scrub Norway pine, perhaps two to four trees per acre, and jack pine, both ranging from forty to sixty years old. There never has been a general cutting, but it has been culled for the past ten years. There is considerable underbrush of poplar, willow and scrub red oak. In the open places there is dense blueberry (Vaccinium sp.) and bearberry

(Arctostopholus ura-ursi). The Norway pine reproduction is slightly scattering and is mixed in the brush. All ages from one to ten years are present, but the predominating ages are four to eight years. The stand of Norway is nearly dense enough now to insure a good stand of timber, but it has good chances of getting denser, as the brush is not too dense and the standing trees are now producing considerable seed each year, some of which ought to grow. This area should then be considered as very likely to be reclaimed by the Norway pine.

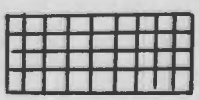
No. 4.  Quadrats Nos. 1 to 9 inclusive. The entire area is rather open and free from any considerable underbrush. The land is sandy loam and somewhat rolling with a general southwest slope. The original stand of timber was medium dense and large. It was cut twelve years ago. The present reproduction is Norway pine ten to thirteen years old and four to six feet high mixed with a more or less scattered jack pine eleven to thirteen years old and three to six feet high. There are still a few old jack pine trees living.

This tract of land has likely had the same history as No. 1 and probably the same future. There are two possible explanations why there should be trees nine to ten years old when the timber was removed twelve years ago.

(1) Some small scrub trees may have been left at the time of the general cutting and cut later.

(2) Dormant seed

The first is eliminated, for there are no evidences of later logging and the reports of the settlers are that it was clear cut. The theory that it started from dormant seeds would seem the better, because (1) the rainfall was quite favorable on those years, and (2) the nine and ten-year ages can be found scattered throughout the tract.

No. 5.  Quadrat No. 5. This is an area of about sixty acres in No. 1 where the original stand was open timber. The young trees are nine to thirteen years old and one to three feet high. In places it is very dense. It is growing under Norway pine trees twenty-five years old,

twenty-five to thirty feet high and three to six hundred trees per acre. The ultimate end is probably that the most of the younger reproduction (nine to thirteen years) will be suppressed to death, as the canopy of the twenty-five year trees is very dense. The twenty-five year trees are not so dense but that they can live up to fifty to seventy-five years old, but part of these will eventually be suppressed. This means that the smaller reproduction will always be in the shade.

In summarizing the whole Nevis tract the reproduction is not entirely successful, but is promising in places. Granting that the conclusions drawn from the study at Menahga are correct, this tract would have had a much better stand of reproduction, or in fact as good a stand as would be desirable, had the timber been cut one or two seasons later. As it was, cut in 1899-1900, it exposed the young seedlings to open sunlight and hot winds which dried out both the seed beds and the young seedlings. If the timber had been cut in 1901 or 1902, it would have preceded a moderately moist season and given the seedlings a chance to develop better roots and

get stronger under the mother canopy. There had been a fire through sometime shortly before 1899 - probably 1898, which may have added materially in making a favorable seed bed.

Chart No. 4

Chart No. 4 was made at Nevis and on the same plan as Chart No. 6 for Menahga.

CHART 1104.

	10	11	12	13	14	15	16	17	18	19	20	21	22	(a)
	1903	1902	1901	1900	1899	1898	1897	1896	1895	1894	1893			(b)

(a) age of Tree (seedlings)
(b) year seed germinated

Number of seedlings

Inches of Rainfall

162
153
144
135
126
117
108
99
90
81 9
72 8
63 7
54 6
45 5
36 4
27 3
18 2
9 1

average Rainfall for May, June and July

T140R33 Sec9-15 NEVIS, Minn.

The following map was made from data obtained in the study at Nevis, showing the extent of and the different types of reproduction found.


Shallow lake
Deer lake
5
4
3
2
1
Norway Pine 25yrs old
No underbrush. Rolling sandy land.
Norway Pine 10-13yrs. old
4-6ft. tall Some small jack
Timber cut 1899-1900.
8
6
9
10
7
8
11
Scattering Norway
Jack and dense brush
18
17
12
13
14
15
16
Timber cut 1899-1900
Mostly 11 to 13 yrs
3-8ft tall. No Brush
Timber cut 1899-1900
Norway Pine in all ages, 1-10yrs
Dense brush in patches
Timber cutted and
many boyes trees standing
17
16
Elbow lake
T140 R33 Yuma

Quadrats 1 to 18

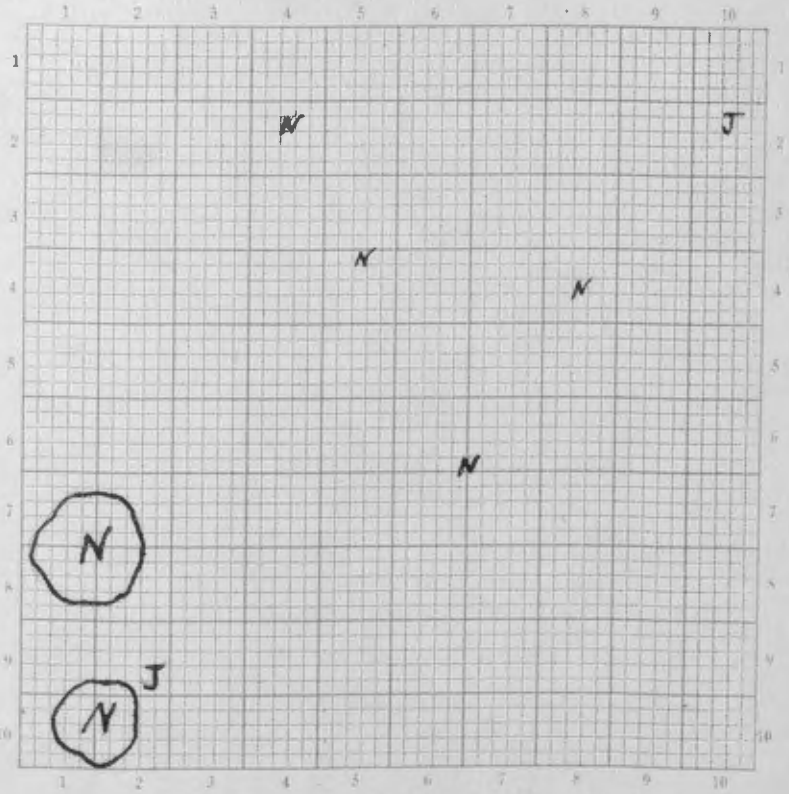
Quadrats Nos. 1 to 18 were made at Nevis. All are 10 x 10 feet in dimensions. The top of the page is north.

QUADRAT No1 LOCATION T140R33 Sec 9 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

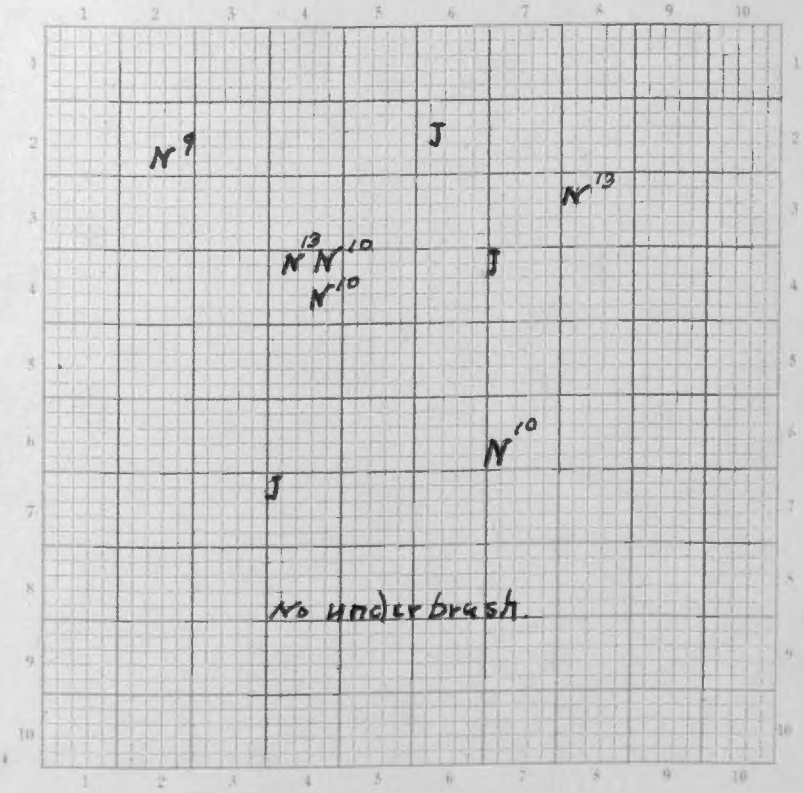
J = Jack Pine 13yrs
N = Norway Pine 13yrs
(N) Norway Pine Stump

QUADRAT No 2 LOCATION T140R33 Sec9 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

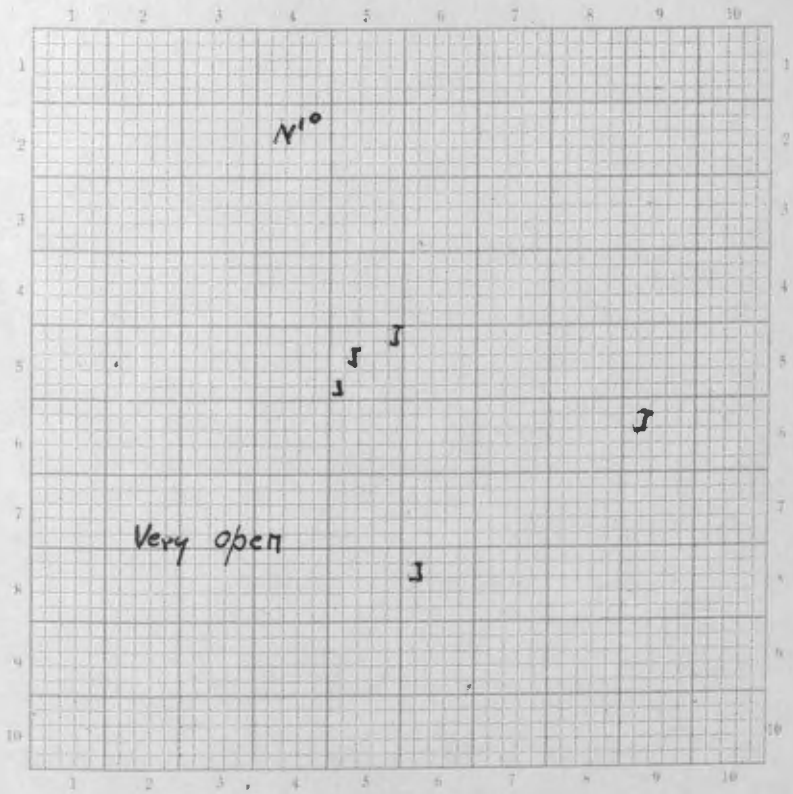
N = Norway Pine - Exponent = age
J = Jack Pine - 13yrs.

QUADRAT N03 LOCATION T140R33 S 9 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

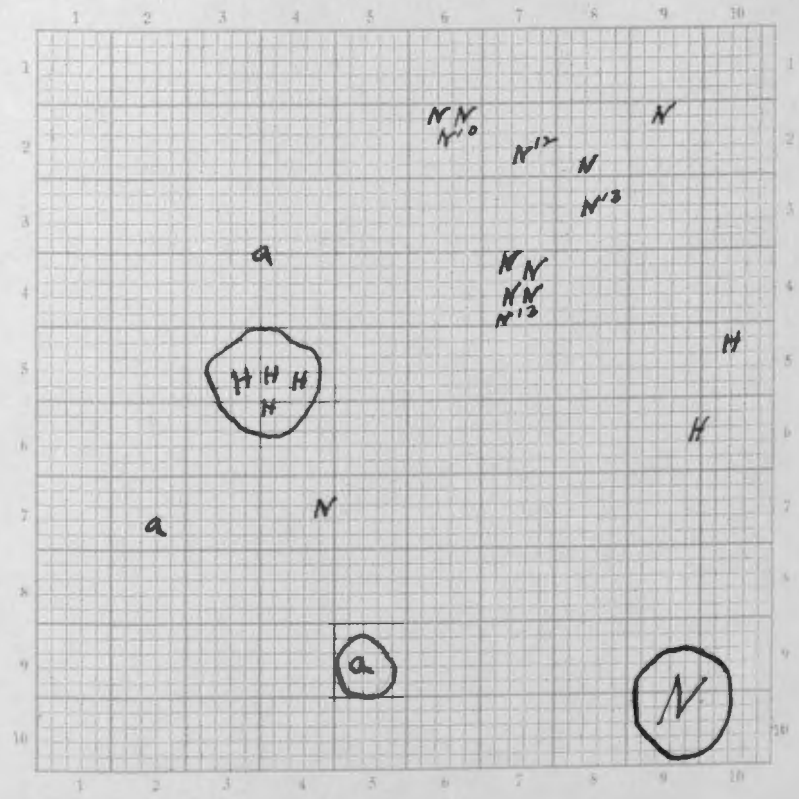
N1°-Norway Pine - 10yrs. - 3ft. Tall.
J = Jack Pine - 11yrs.

QUADRAT No 4 LOCATION T 140 R 33 Sec 9 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

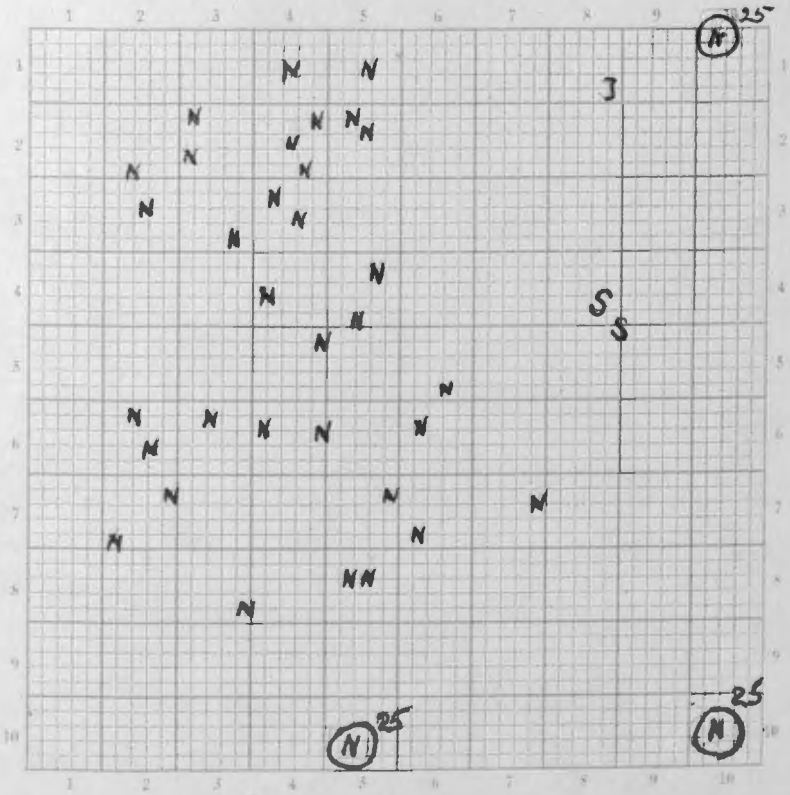
N = Norway Pine - 11yrs old.
Exponent = age of others
a = alder
H = Hazel
(N) Norway Pine Stump

QUADRAT 85 LOCATION T140R33 Sec.8 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

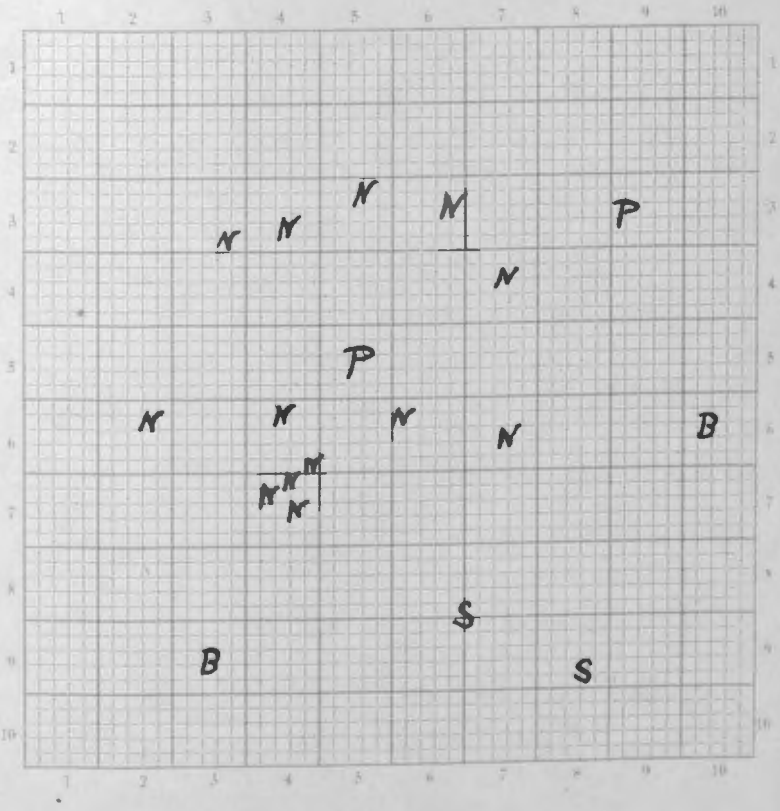
N = Norway Pine - 37 T.
J = Jack Pine - 20 YRS
(N) = Norway Pine Trees

QUADRAT No 6 LOCATION T140 R33 Sec 8 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

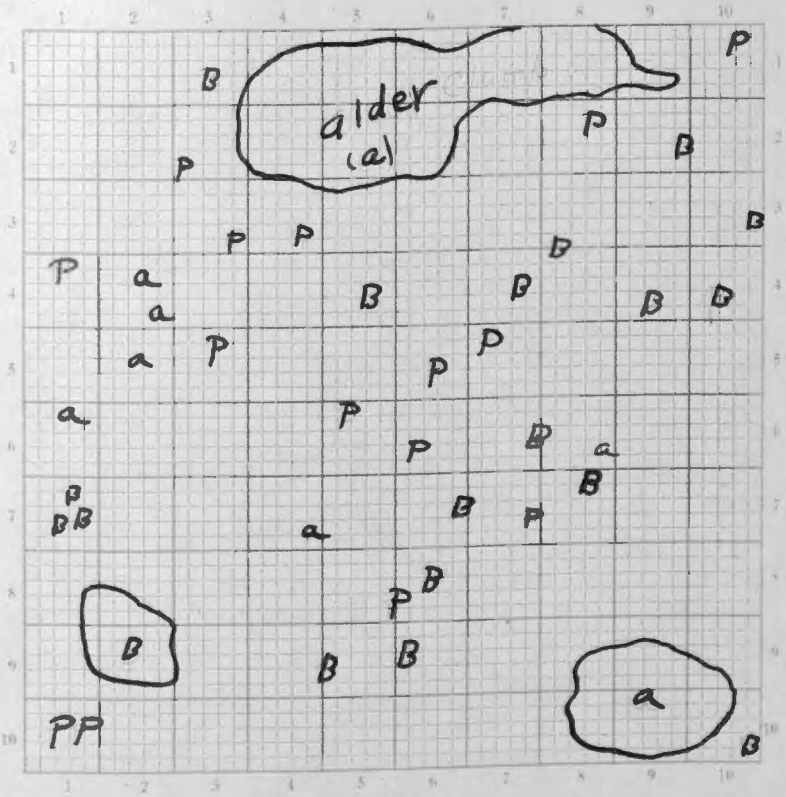
N = Norway Pine (10-13yrs)
P = Populus Tremuloides
B = Betula papyrifera
S = Salix sp.

QUADRAT No 7 LOCATION T140 R33 Sec 8 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

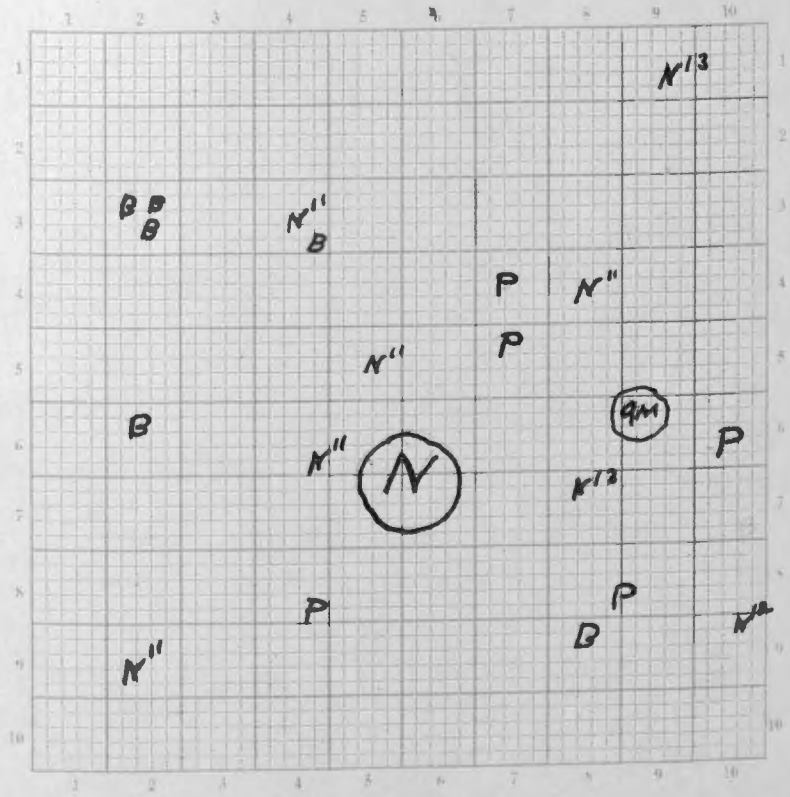
(a) = alder
P = Poplar
B = Birch

QUADRAT No 8 LOCATION T140R33 Sec 9 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

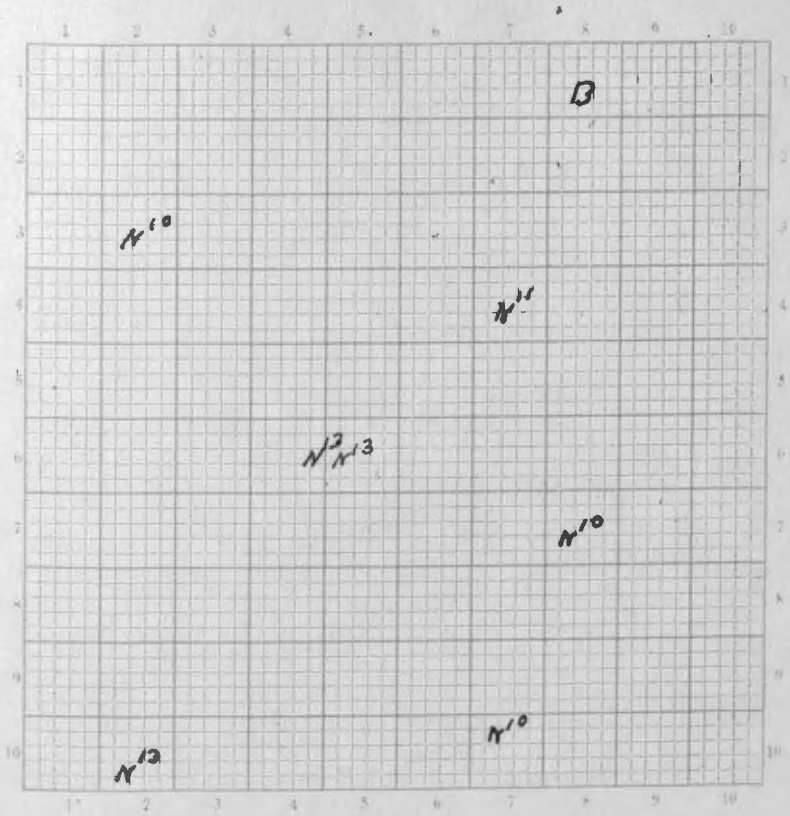
B = Birch (4-10ft)
P = Poplar (4-8ft)
9M = Bunch of Juneberry
N = Norway Pine (11-13yrs)
N = Norway Pine Stump.

QUADRAT No 9 LOCATION T140 R33 S 9 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

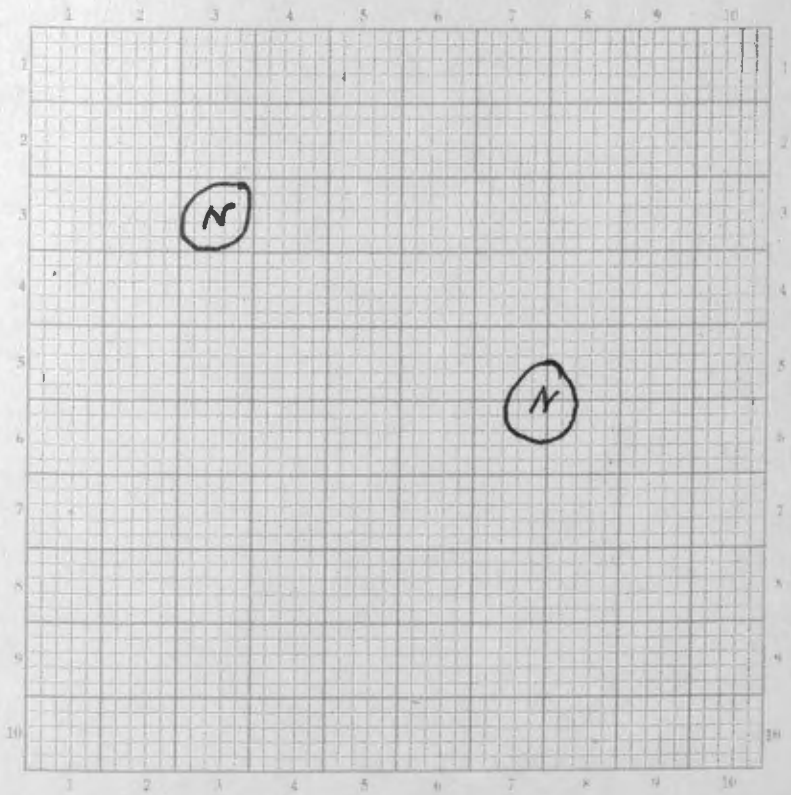
N = Norway Pine (10-13 yrs) (4-6 ft tall)
B = Birch

QUADRAT No 10 LOCATION T140 R33 Sec 15 B DATE

FORMATION

CONSOCIES

SOCIETY



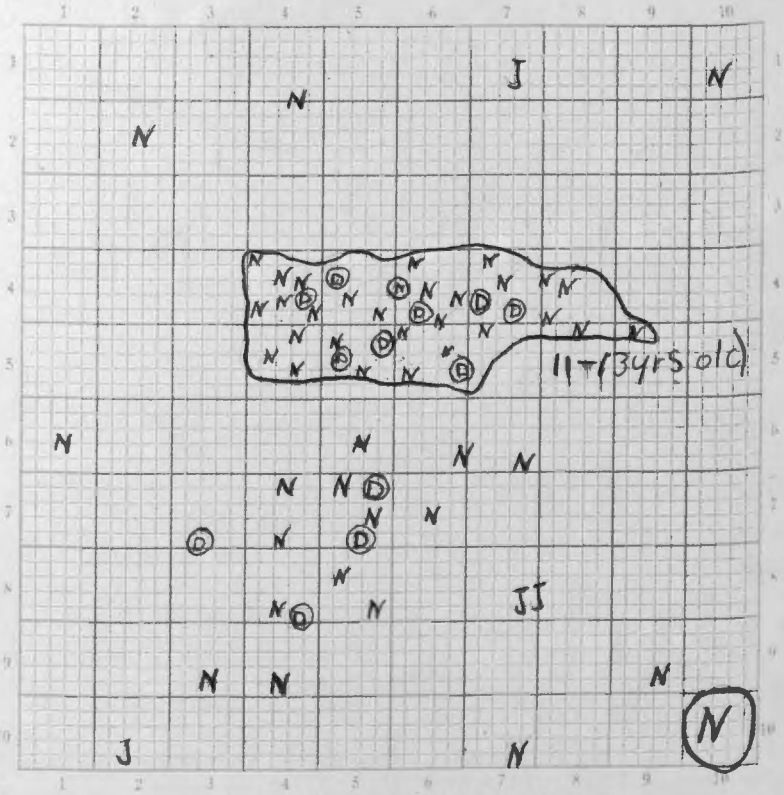
LEGEND: (N) = Norway Pine Stump

QUADRAT No 11 LOCATION T140 R33 Sec 18 DATE

FORMATION

CONSOCIES

SOCIETY



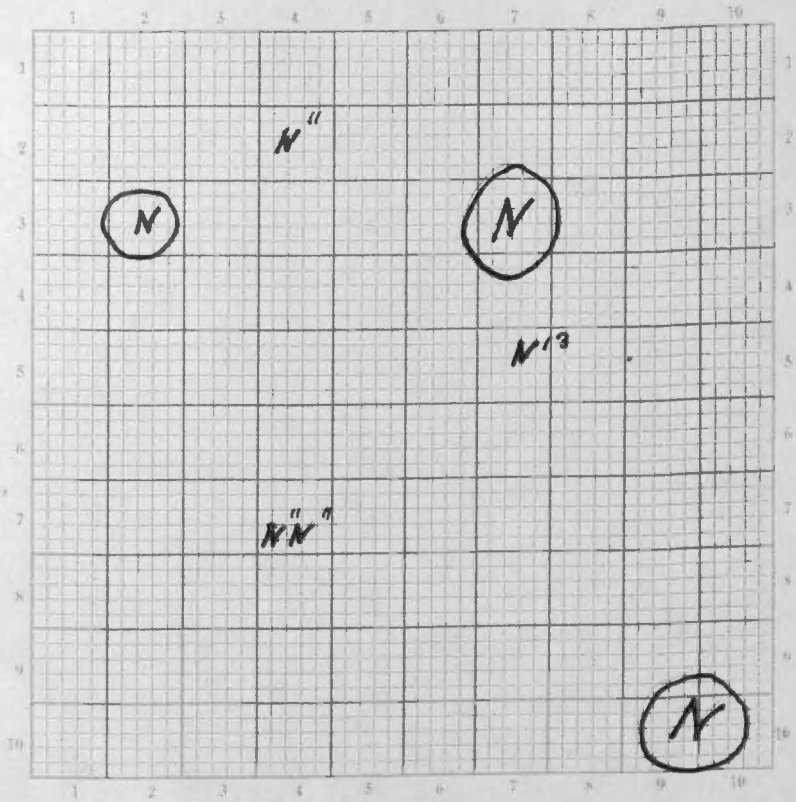
LEGEND: (D) = Dead Norway pine
N = Live " " " 10-16yrs
J = Jack Pine
(N) = Norway Pine Stump.

QUADRAT No 12 LOCATION T140 R33 Sec 15-17 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

N = Norway Pine (11-13yrs)

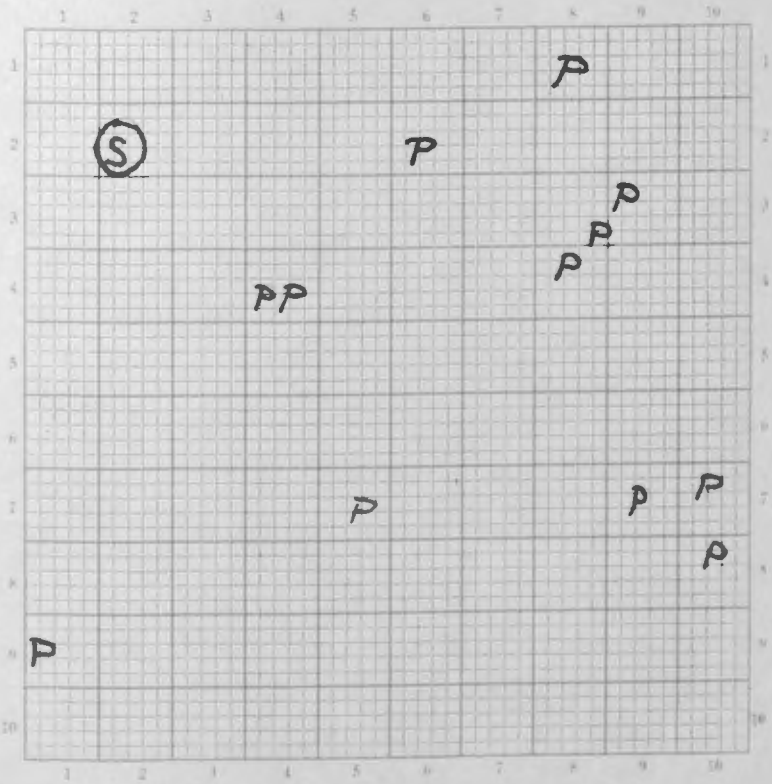
(N) = Norway Pine stump

QUADRAT No 13 LOCATION T140R33 Sec. 17 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

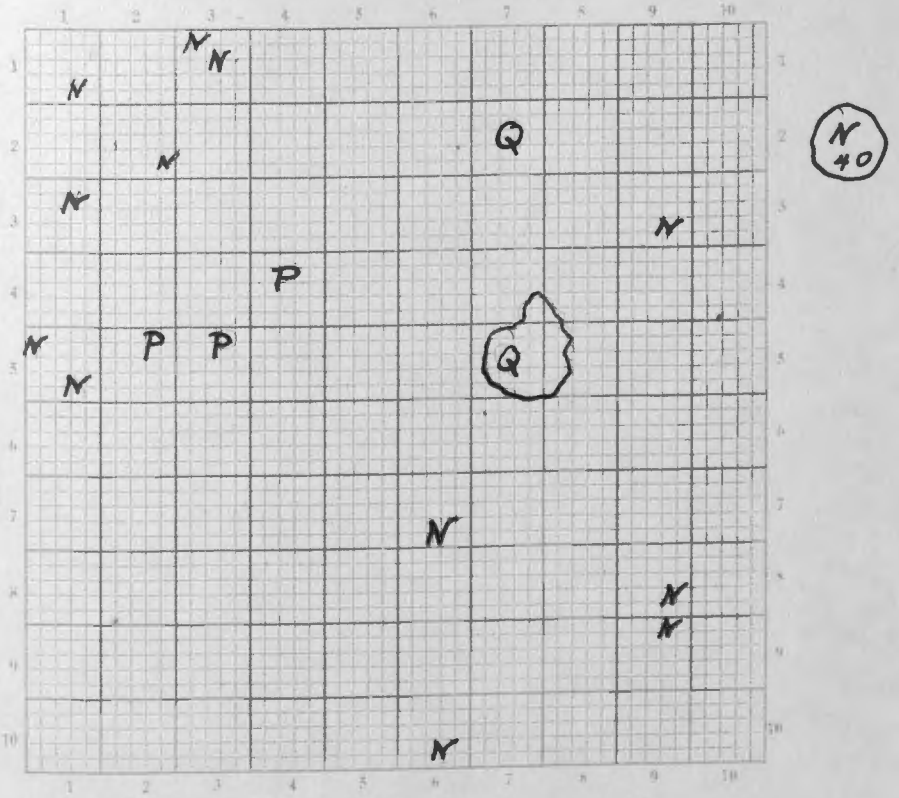
S - Clump of Salix sp.
P: Populus tremuloides

QUADRAT No. 14 LOCATION T140R33 S 16 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

N = Norway Pine 4 To 8 yrs old.

(N 40) = Norway Pine - 40 yrs

P = Populus ~~deltoides~~ Tremuloides

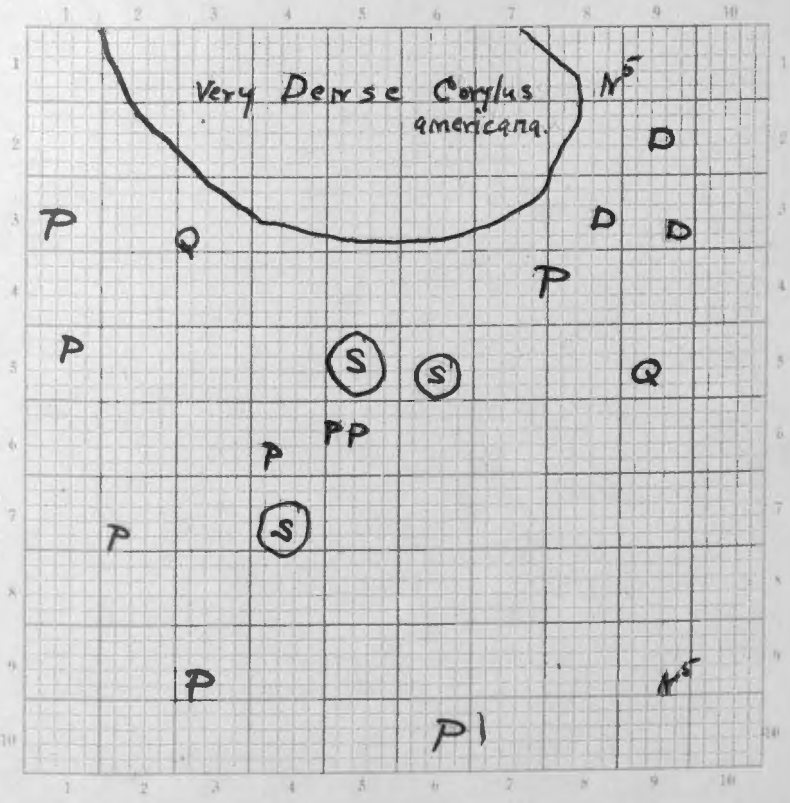
Quercus rubra, Q

QUADRAT Ko 15 LOCATION T140R33 S.16 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND: Scale: 1CM = 1 ft.

N = Pinus resinosa = 5yrs.

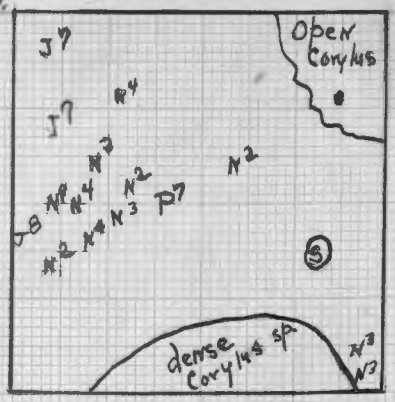
D = Pinus divaricata = 5-16yrs.

P = Populus ~~deltoides~~ Tremuloides = 6-10yrs

Q = Quercus rubra

(S) = Bunch of Salix sp.

Quadrat No 16.



N 40yrs

N 40yrs old

N 40yrs.

N 40yrs.

Quadrat No. 16.
T 140 R 33. Sec 16
N = Norway Pine
J = Jack Pine
S. Bunch of Salix
Scale 1 inch = 5 ft.

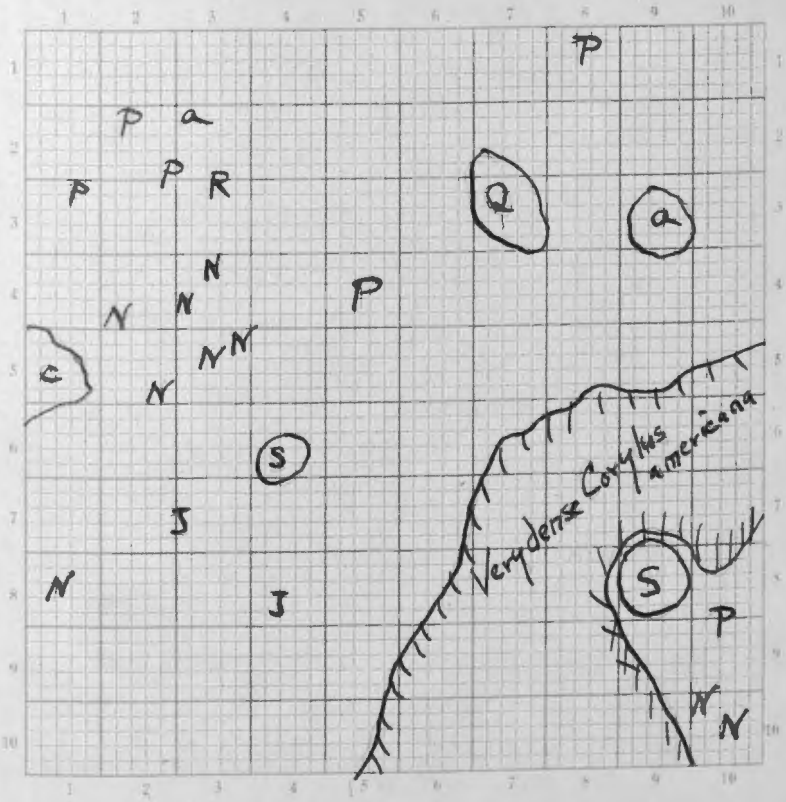
N 50yrs.

QUADRAT No. 17 LOCATION T140 R33 S ~~15~~ 17 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale: 1CM = 1 FT.

N = Pinus resinosa (11-13 yrs)

J = " divaricata (16 yrs)

(a) = Bunch of Alnus incana

a = Alnus incana

P = Populus Tremuloides

(S) = Bunch of Salix sp

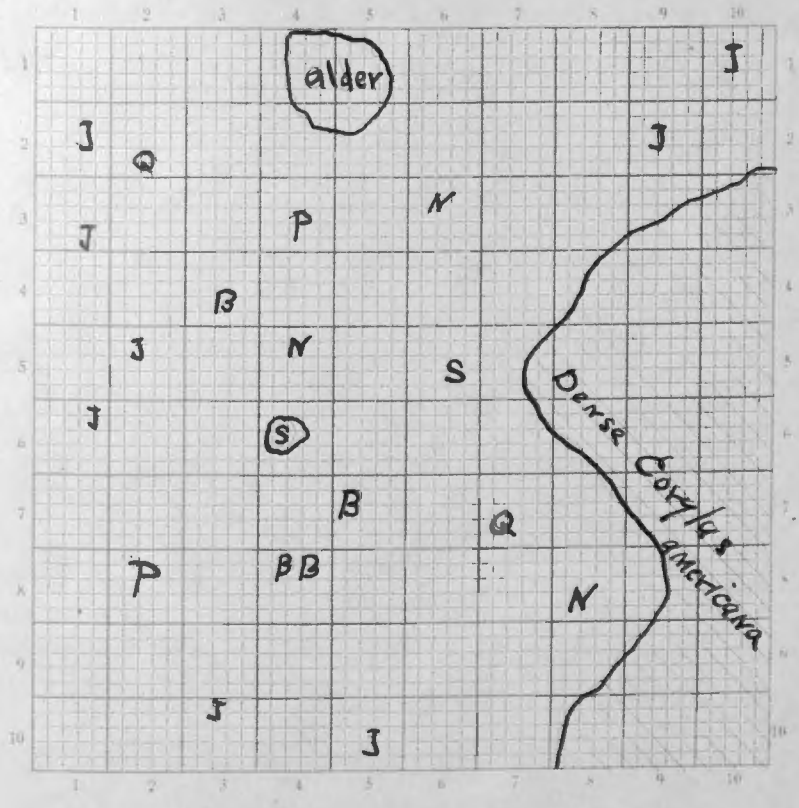
(Q) Bunch of Quercus rubra

QUADRAT No 18 LOCATION T 140 R 33 S ~~15~~ 19 DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

N = Pinus resinosa (11-13yrs)
J = Pinus divaricata (14yrs)
B = Betula papyrifera
S = Salix sp.
Q = Quercus rubra

Fig. 1

Nevis Reproduction near quadrat No. 11

Fig. 2

Nevis Reproduction. Quadrat 1 - 9

Near No. 2.

Fig. 3

Nevis Reproduction. Quadrats 1 - 9, near No. 4.

TRANSECT STUDY OF REPRODUCTION

In order to make a further study of the succession of Norway pine, a study was made on the Cass Lake National Forest near Schley, Minnesota. This was done by means of the transect method on two tracts from which the timber had been removed six years previous, and on which five per cent of the original stand of timber was left for seed trees. This made slightly more than one seed tree on three acres. In the first place, this is too few seed trees to entirely reseed the area; however the effect around each individual tree could be studied, as well as the reproduction throughout the area established by the original forest.

LOCATION. Transect No. 1 was made long the Great Northern Railroad about one-half mile east of the Schley Ranger Station, while transect No. 2 was made about a mile farther south near the Soo railroad tracks. Transect No. 3 was made near Bena, Minnesota.

NATURE OF STUDY. Transects Nos. 1 and 2 may be

called closed transects, i.e., the transect was run from one tree to another until it finally intersected the starting tree, thus enclosing a polygonal area. The transects were made one meter in width. The magnetic bearing of, and the distance between, all the trees was taken, this making it possible to plot the transects. Twenty quadrats one meter square were also made around each seed tree in the manner shown on the charts Nos. 12 to 20. The distance of these quadrats from the trees were 5, 10, 15, 20 and 30 meters respectively. Where seedlings were not numerous or uniform in size, they were cut off and their ages charted with them. Where they were very dense and uniform, several were cut and counted and the ages averaged for that spot.

The first fact noticeable in this study is the condition of health of the seed trees. Of the twelve seed trees in the two transects, the following conditions were noted:

Thrifty trees	4
Unthrifty appearing or dying	3
Dead from lightning	1
from insects	4

This shows that forty-one per cent of the seed trees have died in six years. These are all very large trees about one hundred feet high, with high medium open crowns, and all very wind firm. The ranger reports that there was a great deal of seed produced throughout that region by the Norway pine, both during 1910 and 1911, and deducting from this fact, these trees must have produced seed also. There should then be present many one-year seedlings, as well as seedlings from the spring of 1912. There was an abundance of rainfall during the season of 1911 and 1912, so moisture should not enter as a factor against the lack of seedlings. The ground cover is either very open or very shaded. When the timber was cut the brush was piled and burned, and all such spots are bare of vegetation. The best reproduction is five to seven years of age and without cover, or is under some open hazel brush or ferns.

I would not consider that much of the present reproduction has been established from the seed trees, since seventy-six per cent of the seedlings are of such age that their seed must have been produced by the origi-

nal forest. Also seedlings of ages varying from four to nine years can be found in equal numbers at distances from the seed trees, too great for probable wind carraige. There is some reproduction, which has, without a doubt, been established by the seed trees. This can be seen by noticing the ages indicated on the transect maps and on the quadrat charts.

TRANSECT NO. 1. In studying the map of Transect No. 1, starting at tree No.1 and going towards tree No. 2, no vegetation is found except a dense mass of short bunch grass or else barren areas where brush has been burned. Trees Nos. 1 and 2 are both dead, this leaving no chance for natural reproduction on this area.

From tree No. 2 to tree No. 3, a good substantial uniform reproduction is found, ranging from five to seven years of age. About tree No. 3 is shown an area of nearly one hundred feet radius, which has no reproduction and is claimed by bunch grass and ferns. Outside of this is good reproduction five to seven years old. Tree No. 3 is alive and thrifty, and may meet conditions favorable to reproduction.

From tree No. 3 to tree No. 4 is practically the same as from No. 2 to No. 3, but there is a considerable amount of reproduction five years old and younger. This young reproduction can be credited to the standing seed trees, since both are alive, and two hundred feet is the greatest distance that seed would have to travel from either No. 3 or No. 4.

Since fire has destroyed everything between tree No. 4 and No. 5, no results are obtained for this report.

The long span from tree No. 6 to tree No. 1 has varied vegetation. No reproduction is found where blueberry vines, bearberry vines or grass is dense. Considerable good reproduction exists where the brush is low and thin. The seedlings vary from two to eight years in age, but the five to seven-year class predominates.

TRANSECT NO. 2. In transect No. 2 a large percentage of the seed trees are thrifty appearing, but the ground cover is not generally favorable to the establishment of young seedlings. It is covered with a thick mat of leaves and has a dense growth of brush. Other places are very grassy or barren.

It will be noticed that there is no reproduction between tree No. 1 and tree No. 3. Tree No. 2 is thrifty. No. 1 is dying and No. 3 is dead. The chances of establishing Norway pine by any other than artificial means are poor.

Midway between tree No. 3 and No. 4 some good reproduction begins; in fact the whole east half of the enclosed area has good reproduction. Tree No. 4 is thrifty and there are numerous seedlings around it under five years of age which have probably started from this tree.

From tree No. 4 through No. 5 to No. 6 are found about the same conditions. Seedlings are well established where there is open hazelbrush or few ferns and pea-vines. Where the brush is very dense, there is no reproduction.

From tree No. 6 to No. 1, there is considerable brush and grass. About midway between them, where the brush and grass is thin, there is good reproduction. The reproduction on this transect is exactly as in No. 1. The predominating age class is five to seven years, and

around the good seed trees considerable can be found younger than that.

ESTABLISHMENT OF SEEDLINGS. Since at least seventy-six per cent of the present reproduction must have been started by the original stand of timber, it would be well to look into its history. The timber was cut during the fall of 1906. A considerable number of seedlings started (seven year old trees) during the spring of 1905 and lived for two summers under the canopy of the mother forest. Both of these years had plenty of rainfall and the seedlings thrived well. The six year seedlings started during the spring of 1906 and therefore lived only that one summer under the mother canopy. The timber was removed during the following winter, but there was an abundance of rain during both of the succeeding summers, this aiding the seedlings very materially in their establishment.

This seems to repeat the same story, that if the forest is cut one or two years after a good seed year, with at least moderate rainfall, the establishment of the seedlings will be most certain.

SEED DISTRIBUTION. The quadrat study around the seed trees of both transects does not reveal any striking features as to carriage or distribution of seed, since no large amount of seedlings were found. A large number of seedlings under six years of age were found within ten meters of the seed tree and sixty-one per cent were within fifteen meters. This would go to show that such seedlings were from the seed tree rather than from dormant seed from the original forest. It is natural that most seedlings should be found near the tree, because cones open best on still hot autumn days and the seeds simply fall to the ground. The percentage of seedlings found in different directions from the tree are as follows:

Directions	Per cent
N	7
NE	15
E	3
SE	20
S	10
SW	5
W	10
NW	30

No data can be found for this locality as to direction of winds for those months, but it would seem that they were

largely northwest or northeast.

The quadrats also reveal the same feature as did the transects, viz., where there is dense brush or dense grass, or very open places, there is no reproduction.

SUMMARY. In summing up and drawing conclusions from this amount of study, the seed tree method of reforestation or establishing a crop of young trees is not the best, for

(1) In six years 41% of the seed trees are dead

(2) In six years they have not established enough seedlings, even close to themselves, to produce a good stand. (There have been good seed years during the last six years)

(3) Where there is no ground cover of brush, ferns, or other favorable plant cover, the seed trees do not furnish enough shelter for seedlings.

(4) 5% of stand is not enough trees to seed the area.

61% of the seedlings are within fifteen meters of the seed trees. There should be at least two, and better four, seed trees per acre.

(5) Planting the area to transplants by hand would be cheaper.

(a)	Two seed trees per acre means 2000 B.F. of stumpage worth $12 per M. Compound interest on $24 for six years	$6.36
(b)	41% of trees are dead and only worth $7 per M. Loss in stumpage value	4.10
(c)	Increased cost of logging $1.50 per M	3.00
(d)	Interest on unstocked land 4% per year at $6 value of land	1.59
	Total cost of restocking one acre of land by seed tree method, providing a good stand is secured in six years	$15.05

With an allowance of $15.05 per acre, this kind of land could be well planted with transplants and a good crop assured. On this supposition the seed tree method is not a paying proposition for replanting.

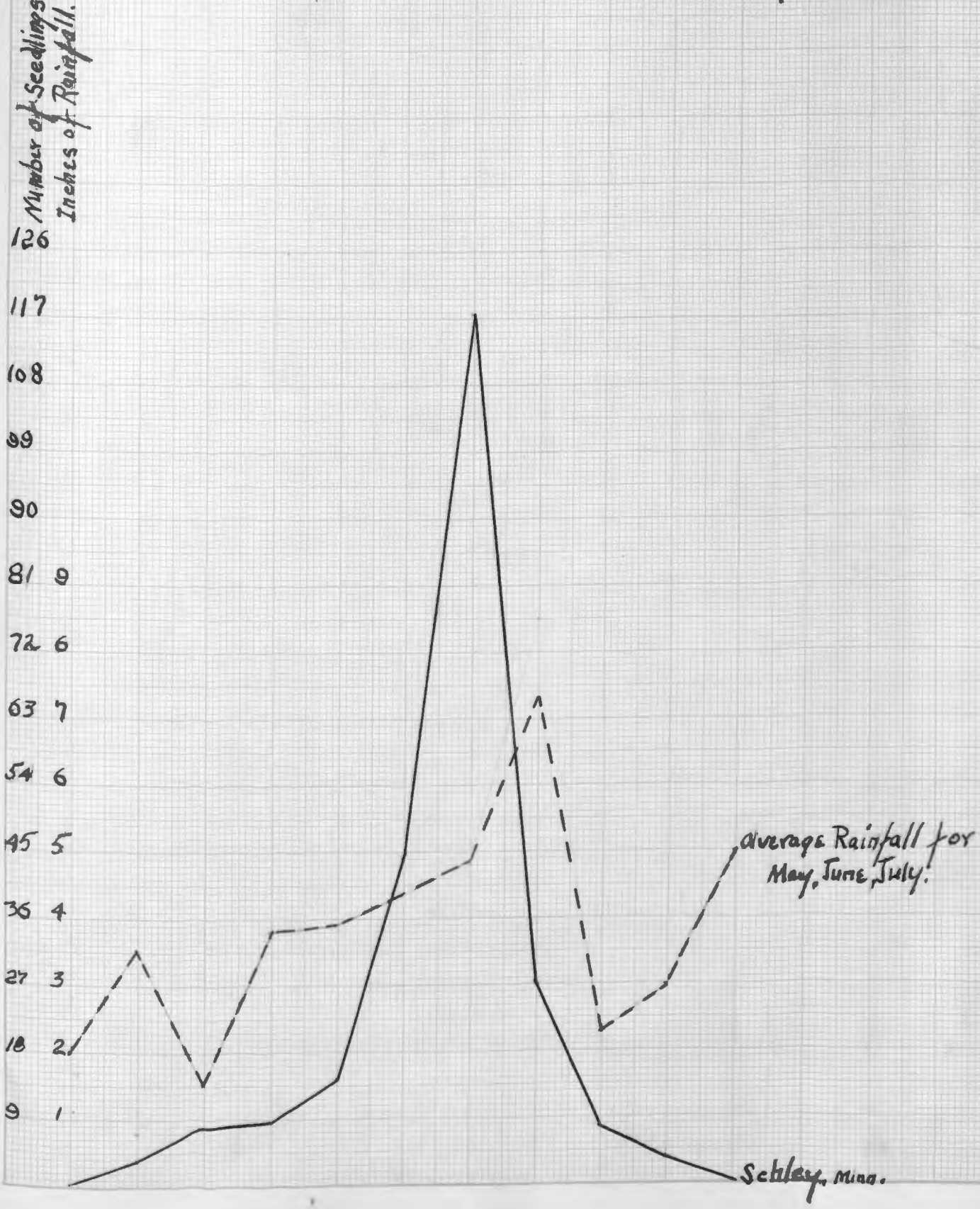
Chart No. 5

Chart No. 5 was made from studies at Schley and is made on the same plan as previous charts Nos. 4 and 6 from Menahga and Nevis. It is to bring out the same kind of results. The weather data was from Cass Lake records.

Chart No. 5.

1912	1911	1910	1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	(a)
	1	2	3	4	5	6	7	8	9	10			(b)

(a) Year Seed germinated.
(b) Age of Seedling.



Schley Transect No.1
1 inch = 50 ft.

2 - Lighting killed 1910.

Dense short Bunch grass
Nobrush - Few burnt spots.

1 - Dead.

6-7 yrs.

6 - Dying from insects.

Burned

grass and Blueberry

Road

grass - ferns
Bearberry

Oaks

5-8 yrs

Dense Blueberry

Bunch grass

3 Thrifty

Tag w berry and ferns

5-7 yrs.

grass (Danthonia spicata) and open soil.

4 - Live, but not Thrifty

all fire killed

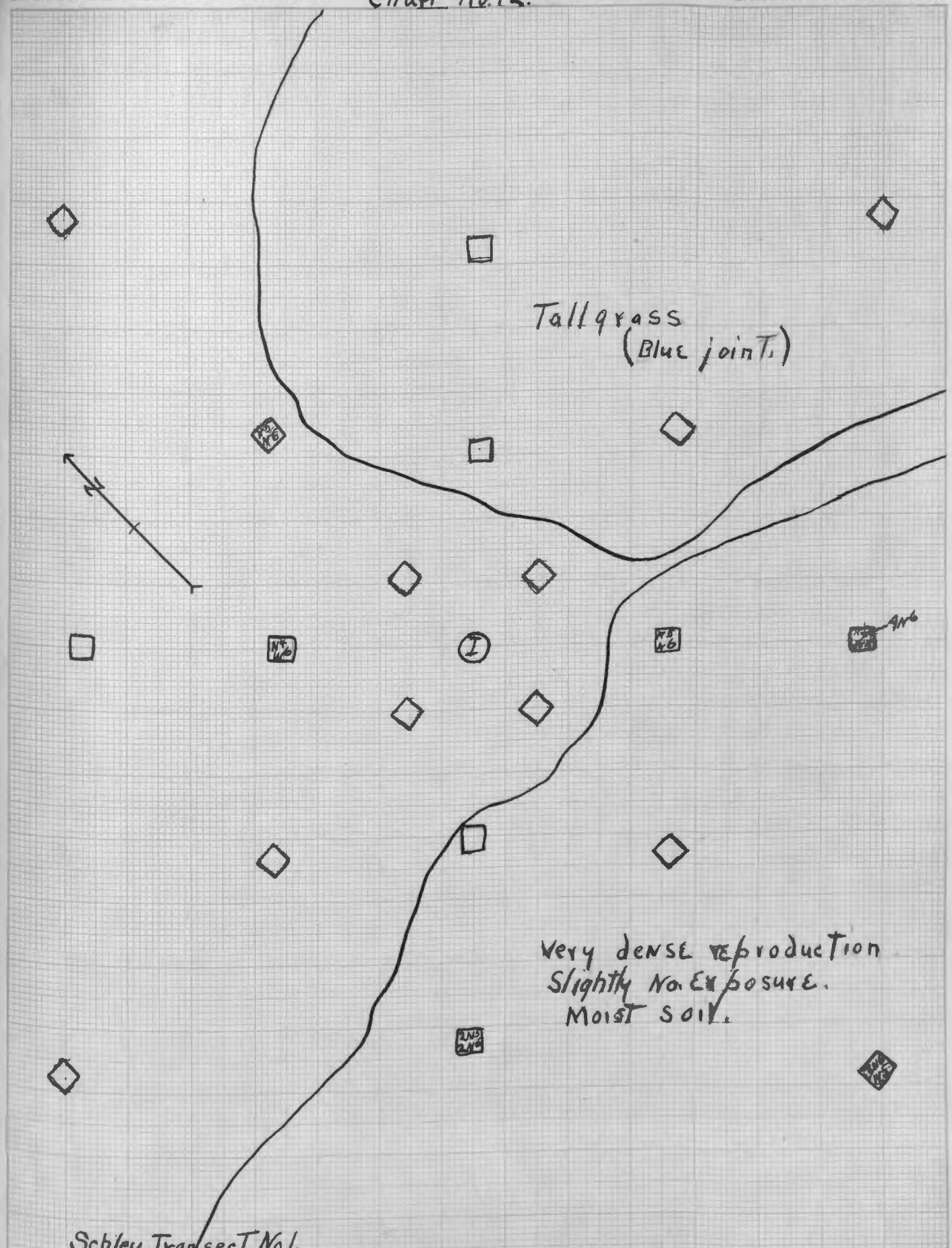
Open grass

5 - Dead.

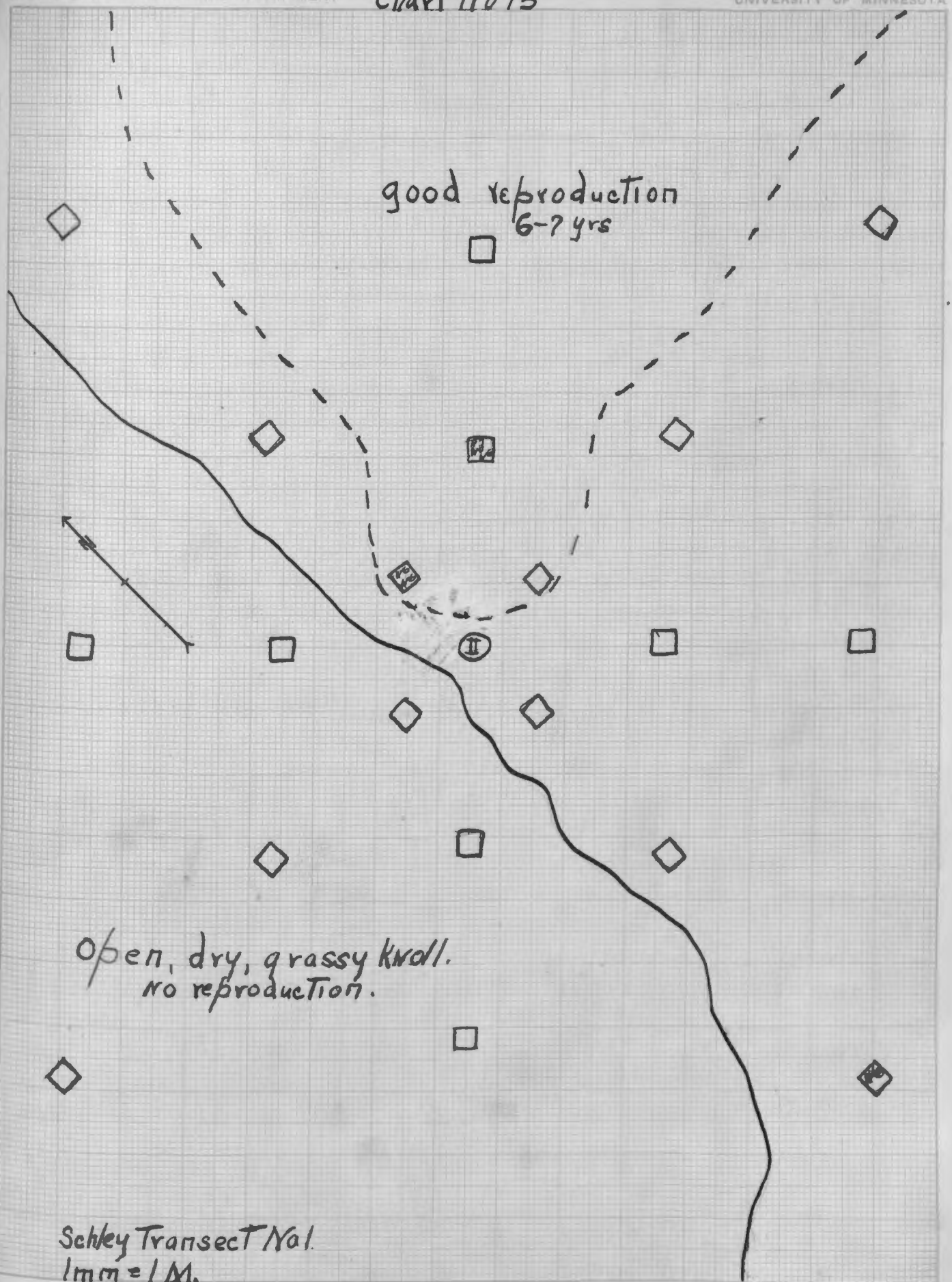
Charts Nos. 12 to 17

Charts Nos. 12 to 17 are from studies made around trees 1 to 6 in Schley transect No. 1.

Chart No. 12.

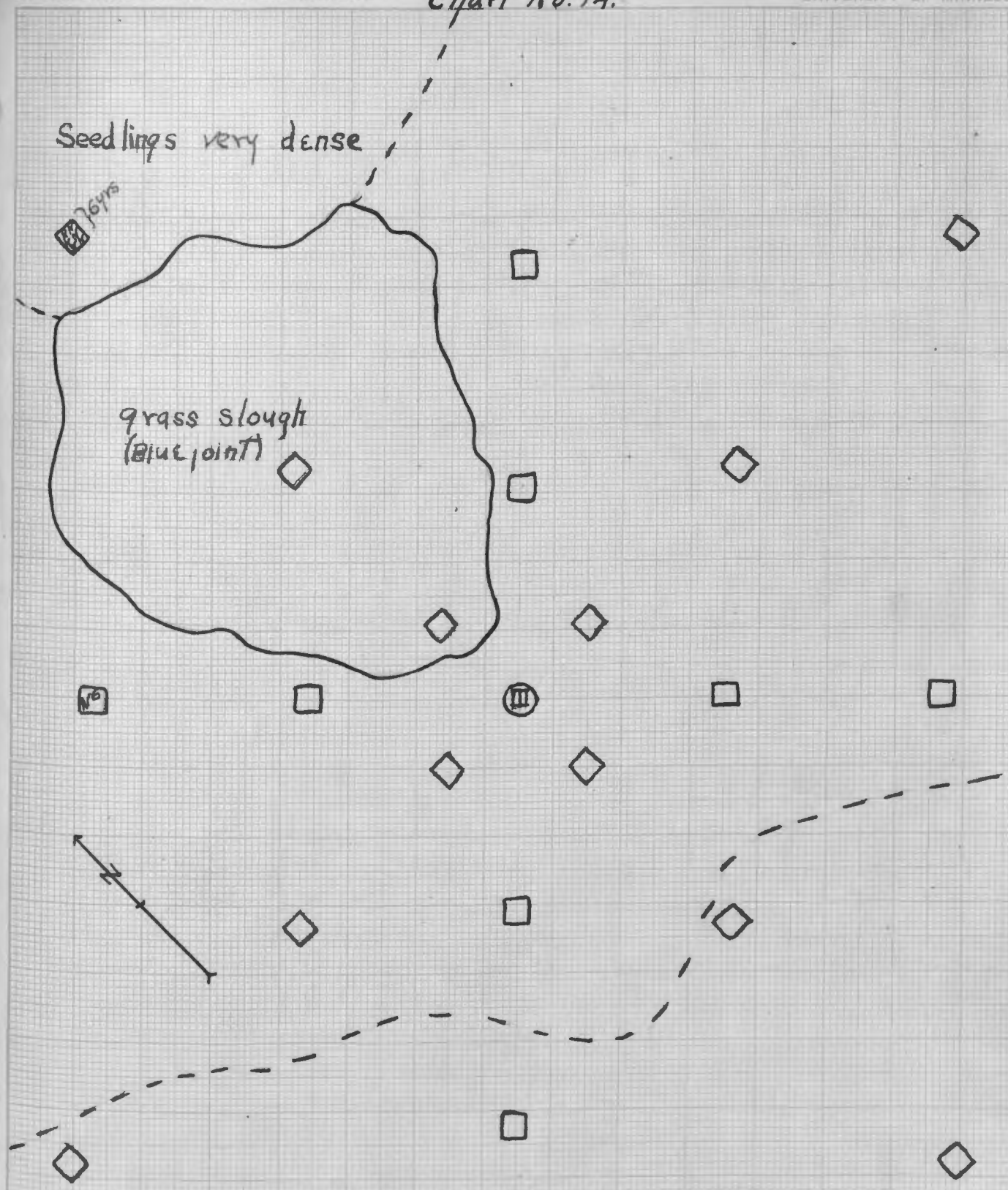


Schley Transect No 1.
Scale: 4mm = 1M.

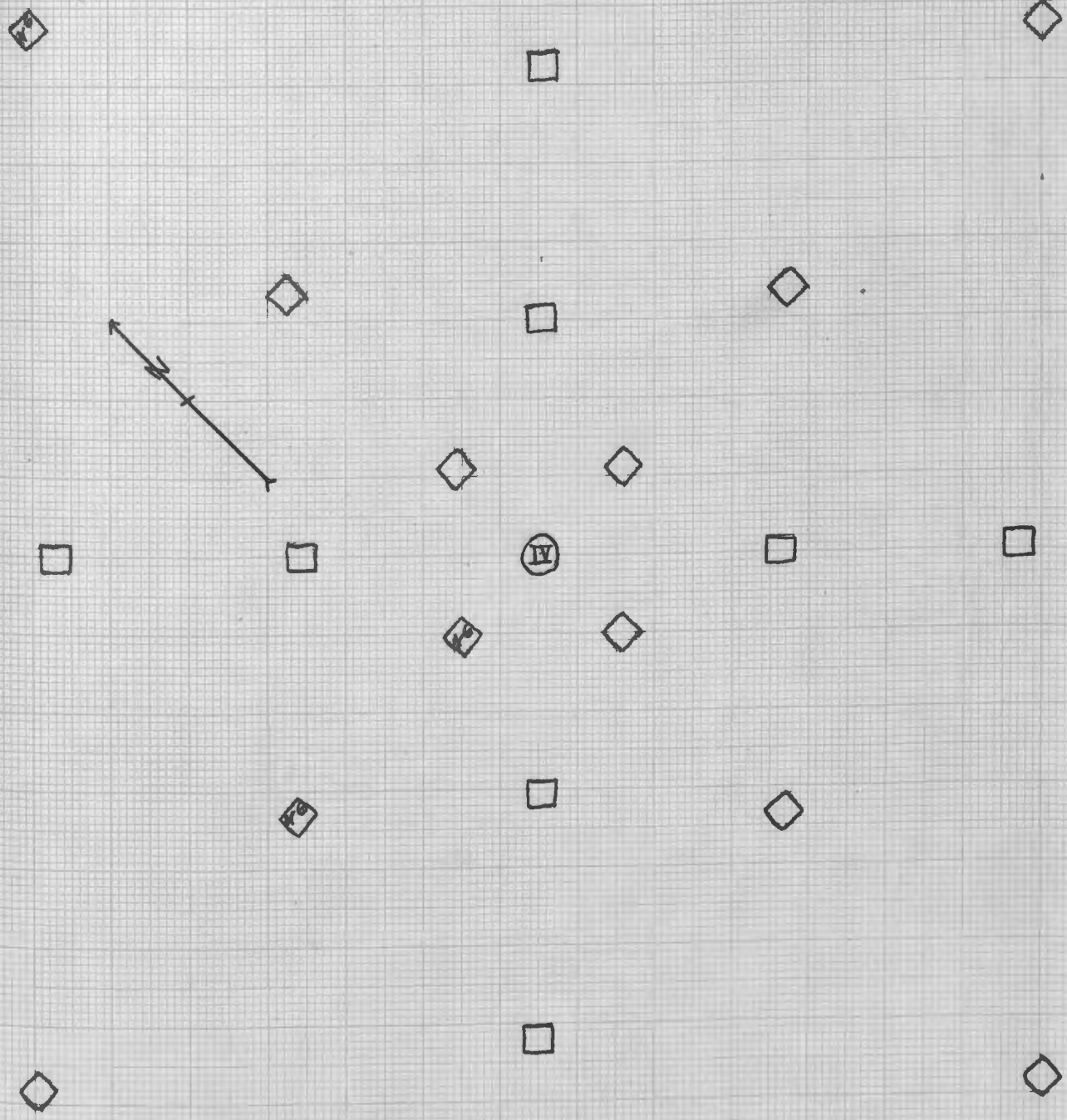


Schley Transect No 1
1mm = 1 M.

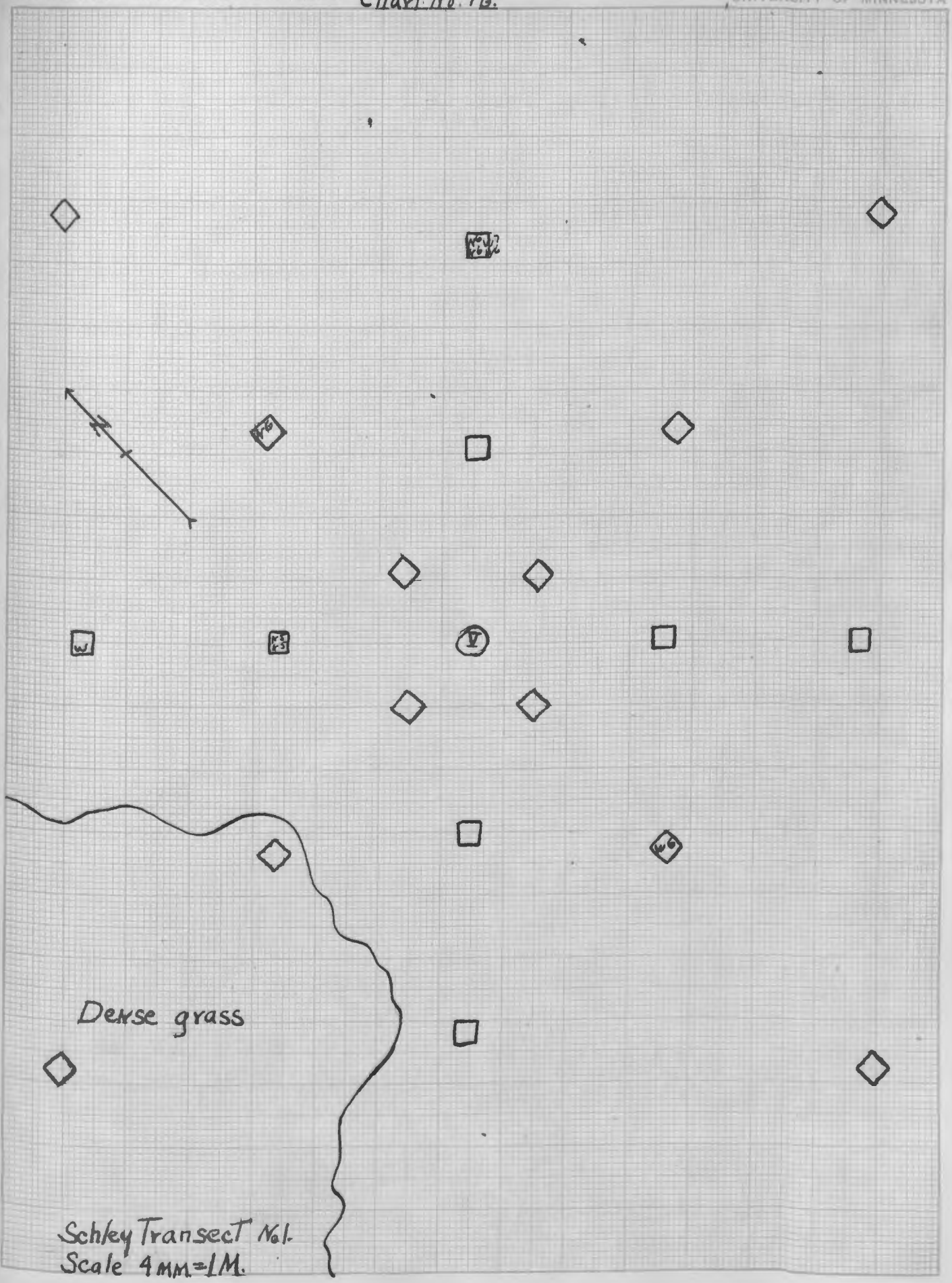
Chart No. 14.

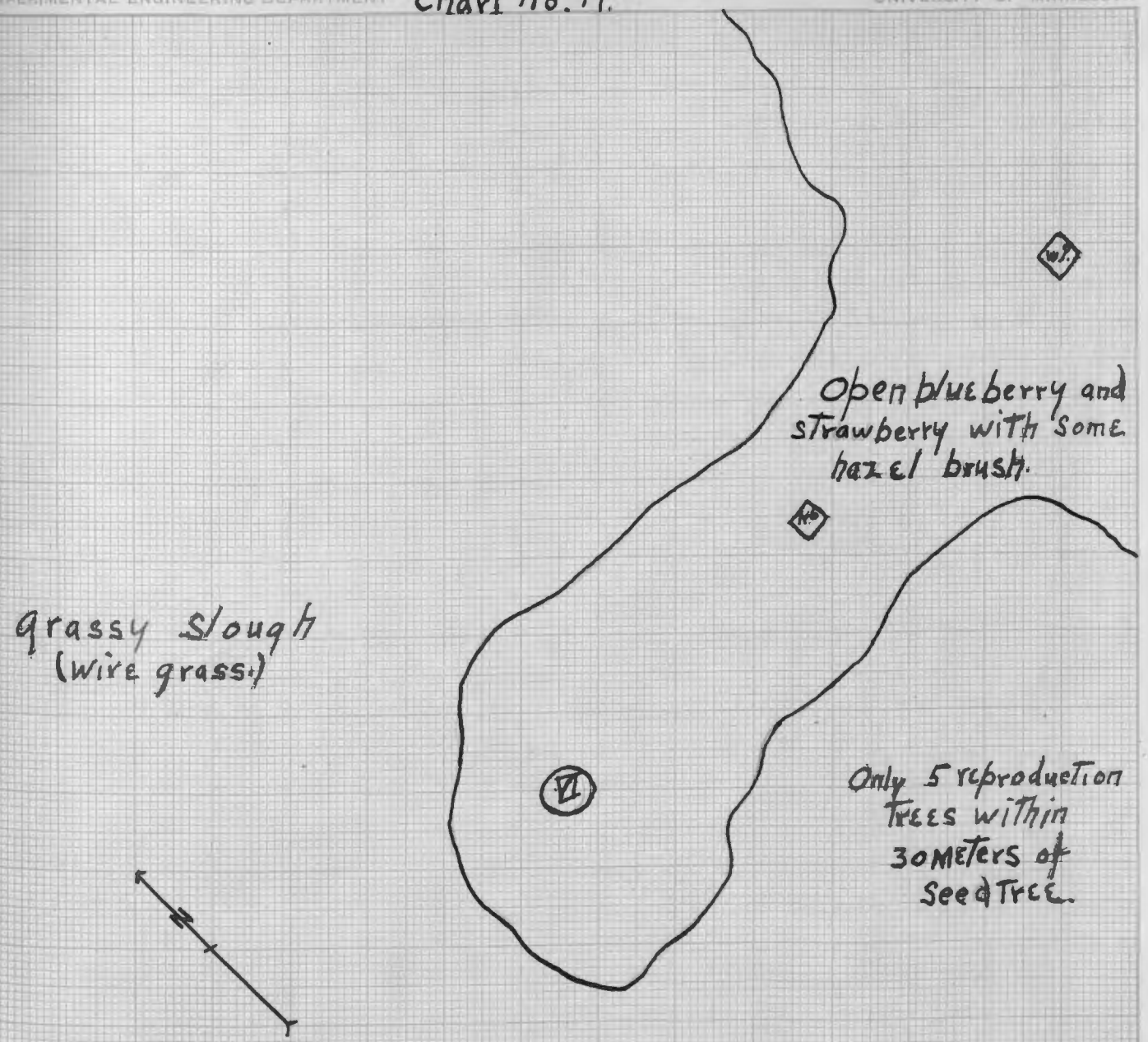


Schley Transect No 1
4mm = 1 M.



Schely Transect No 1.
Scale: 4mm = 1M.


Dense grass
Schley Transect No1.
Scale 4 MM=1M.



Schley Transect No. 1.
4 mm. = 1 M.

QUADRAT 44

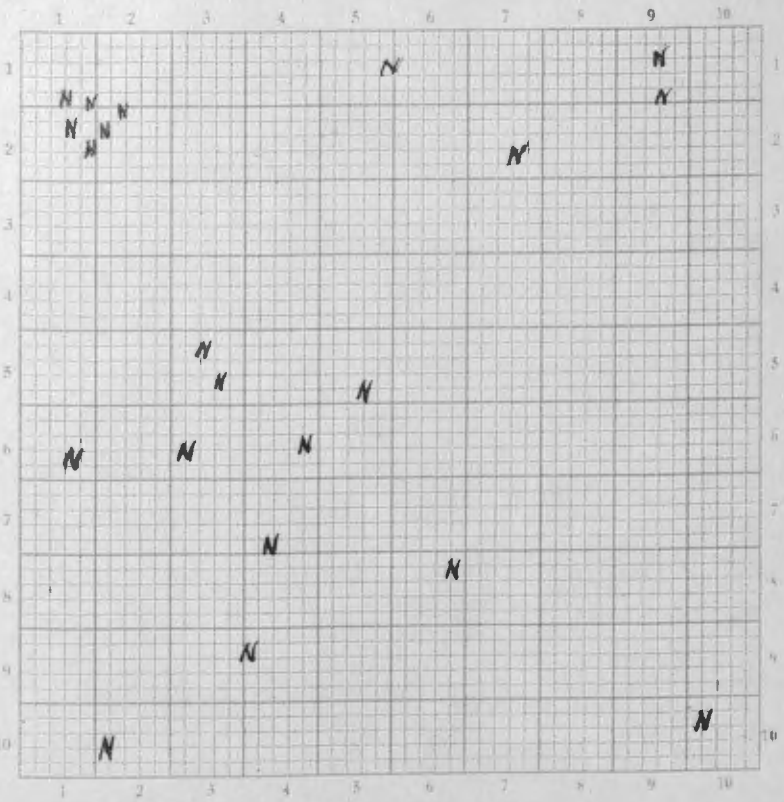
LOCATION 50 M. Due East of Tree No. 5. Schiley Transect No 1.

DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND: N = Norway Reproduction - 6 yrs. old.

QUADRAT 45

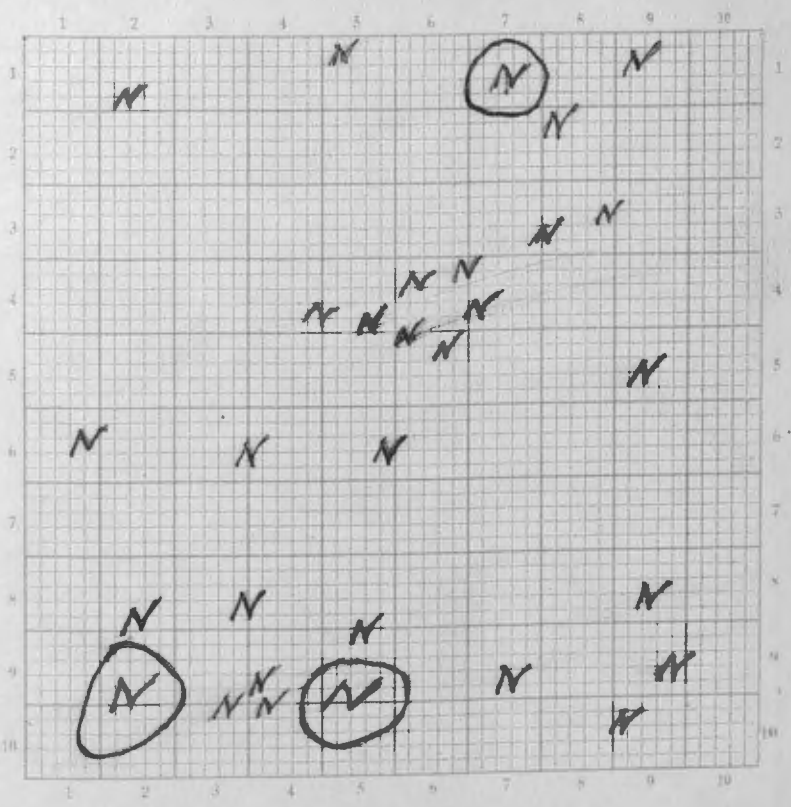
LOCATION 30 meters SE of Tree No 1. Schley transect. No I.

DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND: N = Norway Pine Reproduction, 5-7 yrs. old.

(N) Norway Pine Stump.

Schley Transect No. 2.
1 inch = 50 ft.

⊙1 - Top dying

Short hazel and Poplar - 3 ft. high

Open Hazel - grass

2 - live

grassy Slough

Dense Hazel

Bog

Short hazel, scattering birch and alder

⊙3 - dead

Dense hazel, alder, birch 3-8 ft. high.

Dense short hazel - Small arrow wood
Dense ferns and pea vines

Blue joint Slough
(Calamagrostis canadensis)

6 - Thrifty

open hazel birch

Open bare Soil.

5 - live

short hazel thin grass

Muskeg

Fair Reproduction.

Scattering hazel and poplar

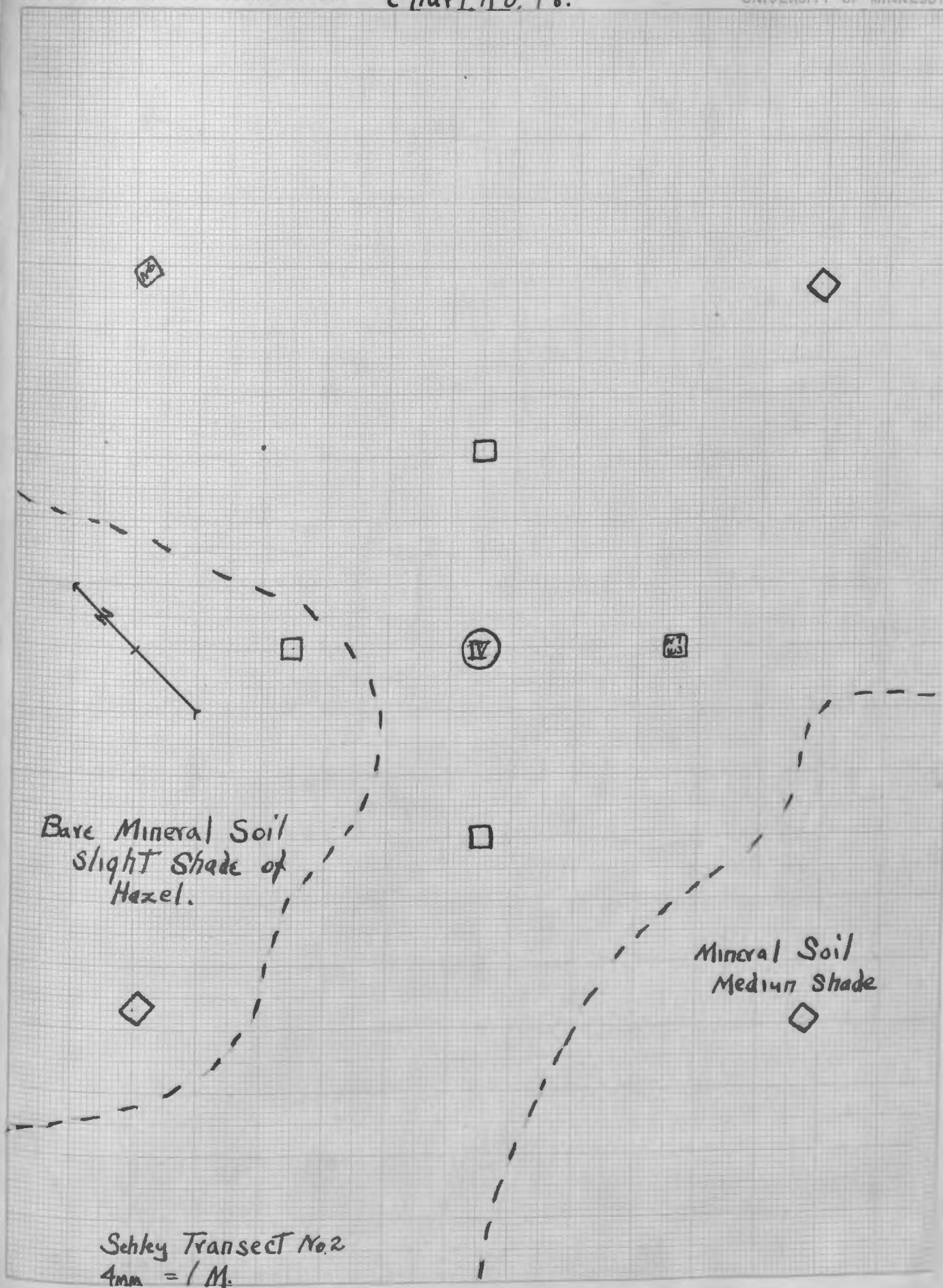
Thrifty - 4 ⊙

Antennaria and Danthonia

open hazel and grass

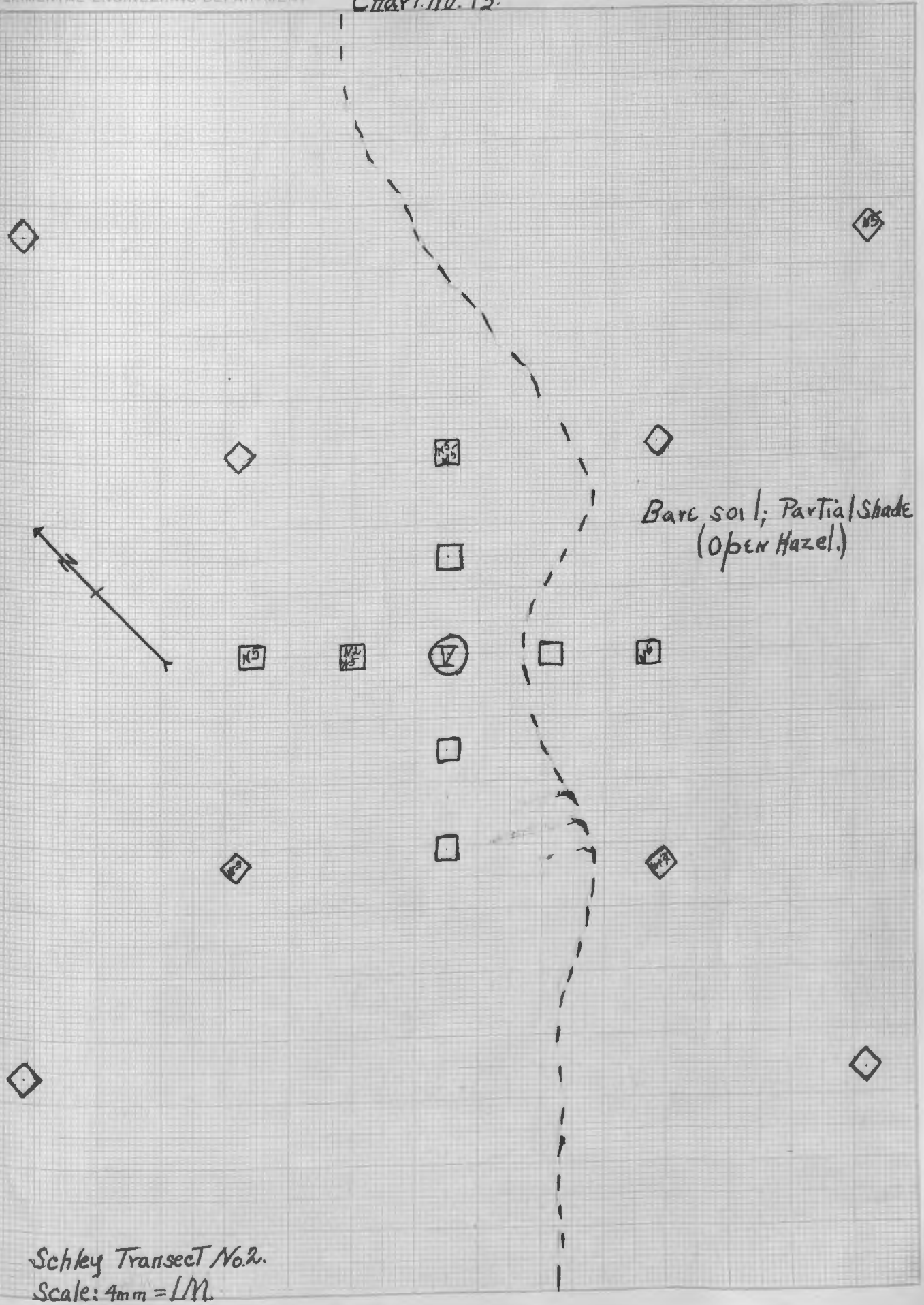
Charts Nos. 18 to 20

Charts Nos. 18 to 20 were made from studies around trees 4, 5 and 6 of Schley transect No. 2. Trees Nos. 1, 2 and 3 were dead, so no charts were made.



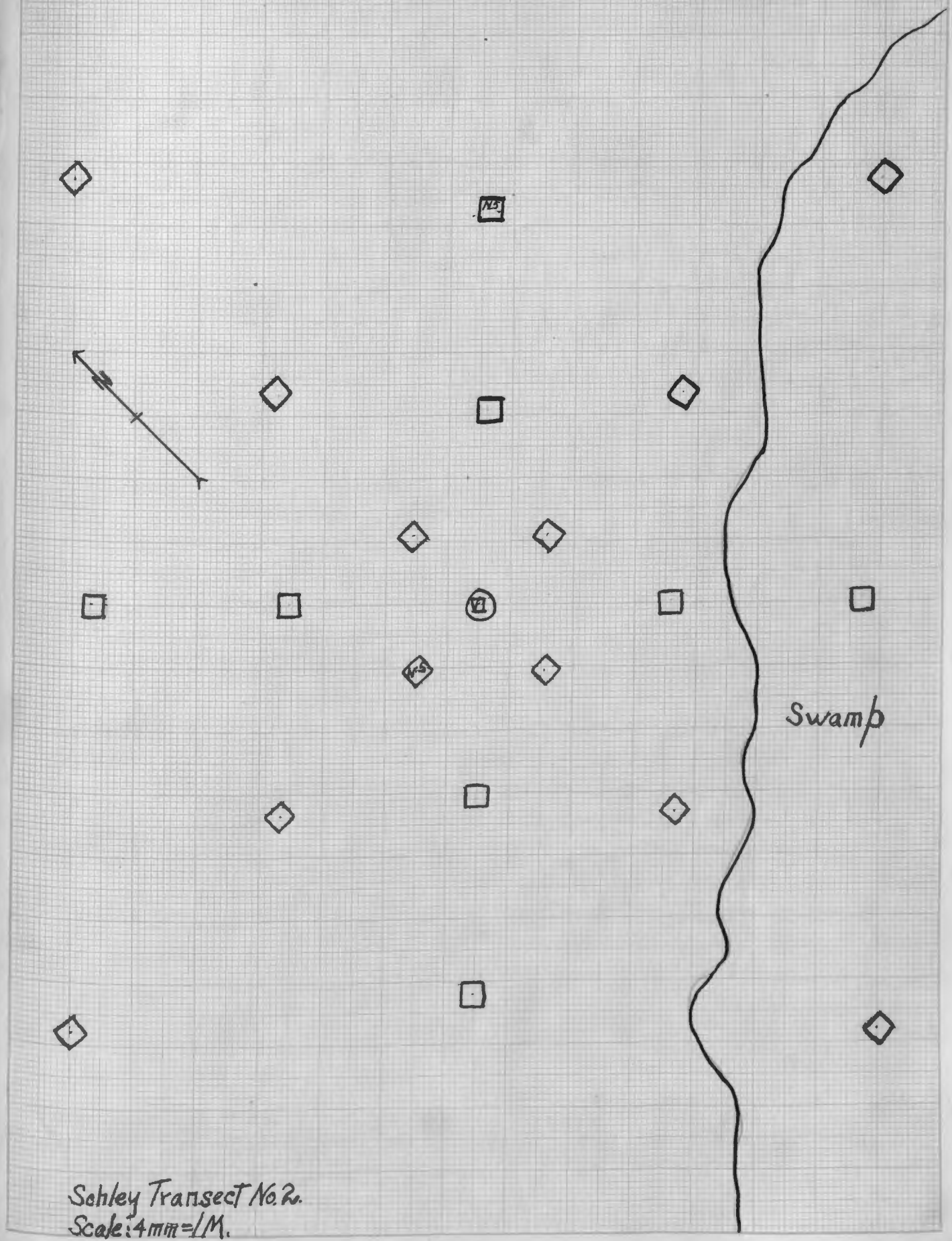
Schley Transect No. 2
4mm = 1 M.

Chart No. 12.



Schley Transect No. 2.
Scale: 4mm = 1M.

Chart No. 20.



Schley Transect No. 2.
Scale: 4mm = 1M.

STAR ISLAND REPRODUCTION

On Star Island, Cass Lake, a remarkable Norway pine reproduction was found under a very dense canopy of mother trees. The reproduction is remarkable for its tolerance, in that it is dense, dwarfed and of considerable age - twenty to thirty-five years.

With the exception of that around quadrats Nos. 46, 47 and 48, the land is very level and sandy soil. There is everywhere much litter or a deep bed of moss. The ground cover is mostly moss, ground pines (Lycopodium sp.) and a few scattering blueberry vines. It has been an exceedingly long time since any fire was through these woods. Where a cutting has been made of about three acres in one place, there is very little moss on the ground and there is some scattering underbrush of hazel, raspberry and blueberry.

Quadrats Nos. 46, 47 and 48 were taken on a twenty per cent south slope facing this opening. The ground cover is thin moss and ground pines with scatter-

ing wintergreens (Gaultheria sp.). The mother trees are one hundred eighty years old and sixteen to twenty-two inches in diameter D.B.H. and is a medium dense stand of timber. The reproduction growing under this is three to nine years old and three to eight inches in height. The quadrat charts Nos. 46, 47 and 48 show the density and ages of these.

The total ages and numbers of the three quadrats are:

Ages	No.
3	3
4	3
5	1
6	5
7	11
8	10
9	1

This was the only place in this vicinity where the reproduction was found under twenty years of age. The moss is not as dense as in other places and the shade not as dense. The moss is probably moist enough to form a good germinating bed for the seed and is not deep enough to prevent the roots from reaching mineral soil.

Quadrats Nos. 49, 50 and 51 were made under a very dense canopy with very few open spots. The ground was very level and covered with moss six inches deep. There is no vegetation other than young Norway pine, except a small amount of blueberry and raspberry. The Norway pine reproduction is very dense in these quadrats, No. 49 having sixty-five trees; No. 50 having forty-three and No. 51 having twenty-seven. They are very uniform in size and height, none of them being over three feet high, or over one-fourth to three-fourths inches in diameter at the ground, and ranging from twenty to thirty years in age. The shade is very heavy on account of the dense canopy of the old trees, and their foliage is very thin. The old trees are one hundred eighty years old, have a diameter of fourteen to eighteen inches D.B.H. and are up to four hundred trees per acre in density.

Quadrats Nos. 54 and 55 were taken under the same leaf canopy as Nos. 49, 50 and 51. All conditions are as near alike as could be detected. No. 54 has thirteen trees three feet high with a ground diameter of three-sixteenths to one inch. Quadrat No. 55 has thirty

trees ranging from six inches to two feet tall. All the trees in these two quadrats have very thin foliage and show suppression. Their ages are the same as the preceding, ranging from twenty to thirty-five years, chiefly twenty-four to twenty-five and thirty-one to thirty-three years.

Quadrats Nos. 52 and 53 are under the same light conditions and have about the same soil and ground cover as the last five preceding quadrats described. They were at lower level, in a slight draw near the lake, and had better moisture conditions. The trees were the same age as the preceding, ranging from twenty-four to thirty-three years. They were, however, much taller and sturdier, ranging from five to nine feet in height and one-half to one and one-half inches in diameter.

According to Mr. Zon, Bulletin No. 92 of the U. S. Forest Service, tolerance is not due to light and shade conditions as much as to available soil water. Reproduction under old trees is more likely to die from lack of available soil moisture than lack of light, the lack of light being due to the greater demand of the

larger trees. "The 'light increment', or the increase growth after logging or thinning, is not due to the greater excess of light to the remaining trees", but to the proportionate increase in water due to decreased competition.

If we could grant this theory as true, the fact that reproduction found in quadrats Nos. 52 and 53 is larger and better than other places of same shade conditions and surroundings would then be due to larger amount of moisture in the soil at these lower levels, thus increasing the tolerance. But, as Mr. Zon's theory is not accepted by many as proven, no certainty should be based on it without further evidence.

In contrast to quadrats Nos. 52 and 53 is quadrat No. 60, another quadrat taken only one hundred feet from No. 52, but on higher ground. The crown density of the mother trees and the ground cover seemed identical. The trees of this quadrat were thirty-nine in number, none of them over one foot in height and three-tenths to nine-sixteenths inches in diameter at ground. They were very slender with no lateral branches, the only

needles being in a thin cluster at the top. The ages were the same as the other quadrats, twenty-four to thirty years, the larger number being twenty-five years old. They were making exceedingly slow growth and would likely die were it not for the moss ground cover which apparently aids in retaining soil moisture.

What most of the previously described reproduction could develop into, even as suppressed as it is, is undoubtedly shown by the study made in quadrats Nos. 56, 57, 58 and 59. These were taken in the opening where the timber had been cut some five years previous. None of these are over three hundred feet from quadrats 49 and 50. The original conditions appear to have been as those now existing for quadrats Nos. 49, 50 and 51. The ground floor has very little moss, but has considerable litter and more or less underbrush of raspberry, blueberry and hazel. The young trees are exactly the same age, twenty to thirty-five years. These that have grown in the open for the last five years have a greener, healthier appearance and denser foliage. Their heights are two to six feet. An increase in the rate of growth was further

shown by increased thickness of annual rings for the last two or three years.

SUMMARY. In summing up the study of the reproduction on Star Island, the outstanding feature is the tolerance of the young Norway pine trees under these conditions. Quadrats Nos. 42 and 43 at Menahga and No. 5 at Nevis showed considerable tolerance, but nowhere as great as on Star Island. If the water content is a deciding factor in the tolerance, as would seem, then its tolerance may be explained in that the water table is not very low here, and also the deep moss everywhere present may help very materially in retaining soil moisture.

That this kind of reproduction long suppressed can succeed if opportunity prevails is shown by the reproduction in the opening where the timber had been removed.

Quadrats Nos. 46 to 60

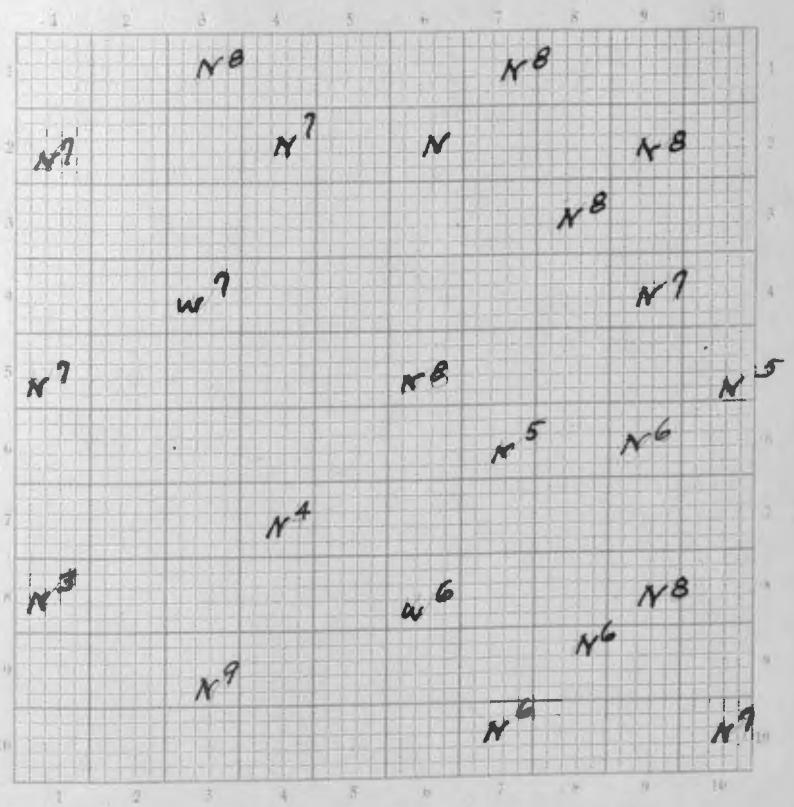
Quadrats Nos. 46 to 60 were made from studies on Star Island. The quadrats are 10 x 10 feet in size and the top of the page is north.

QUADRAT 46 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

Scale: 1cm = 1ft.

N = Norway Pine No = age

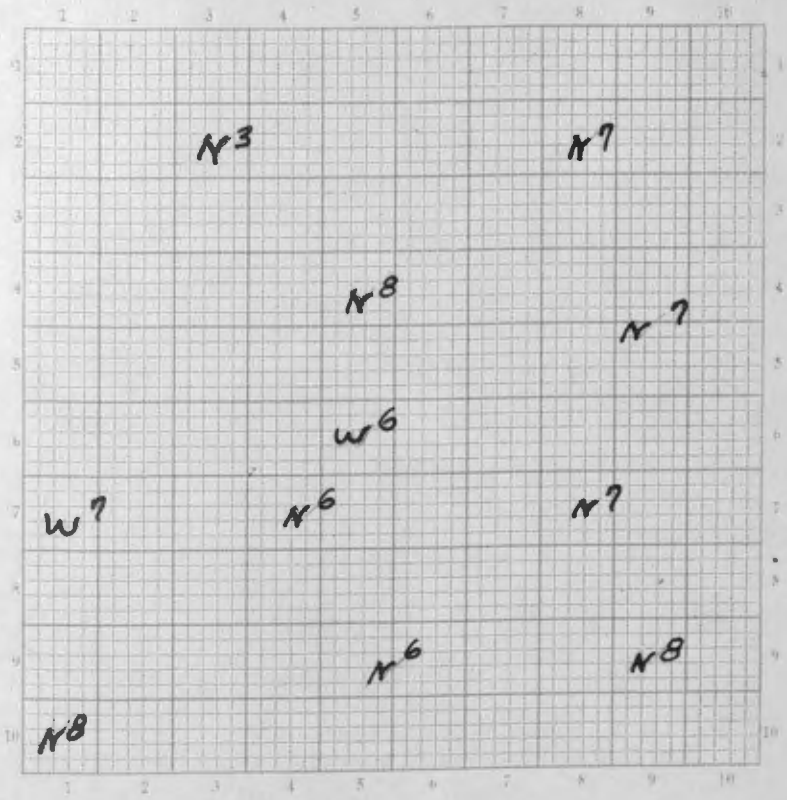
W = White Pine.

GUADRAT 47 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

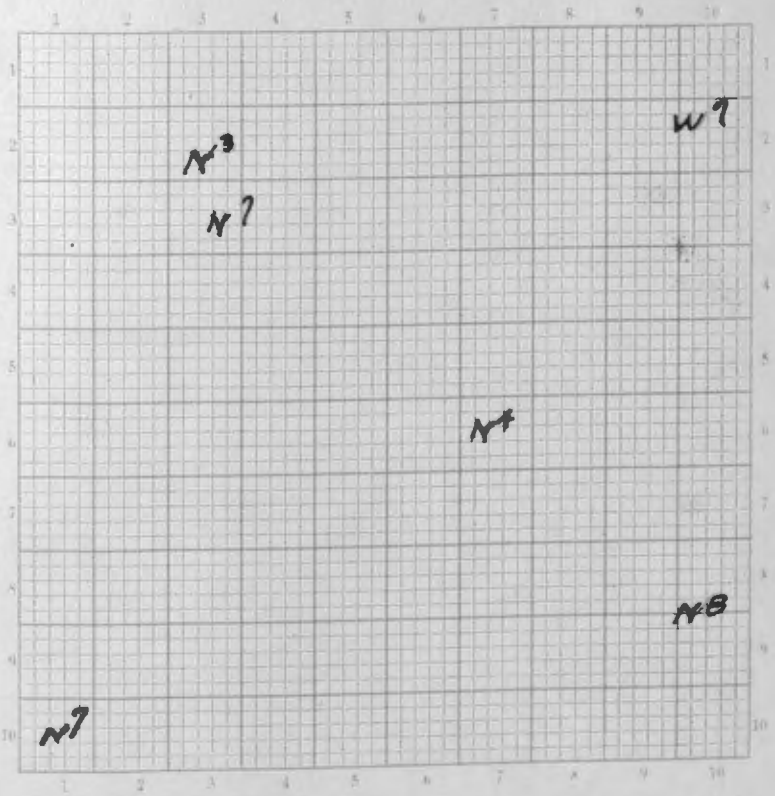
N=Norway Pine No=age
W=White Pine.

QUADRAT 48 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

N = Norway Pine. No. = age

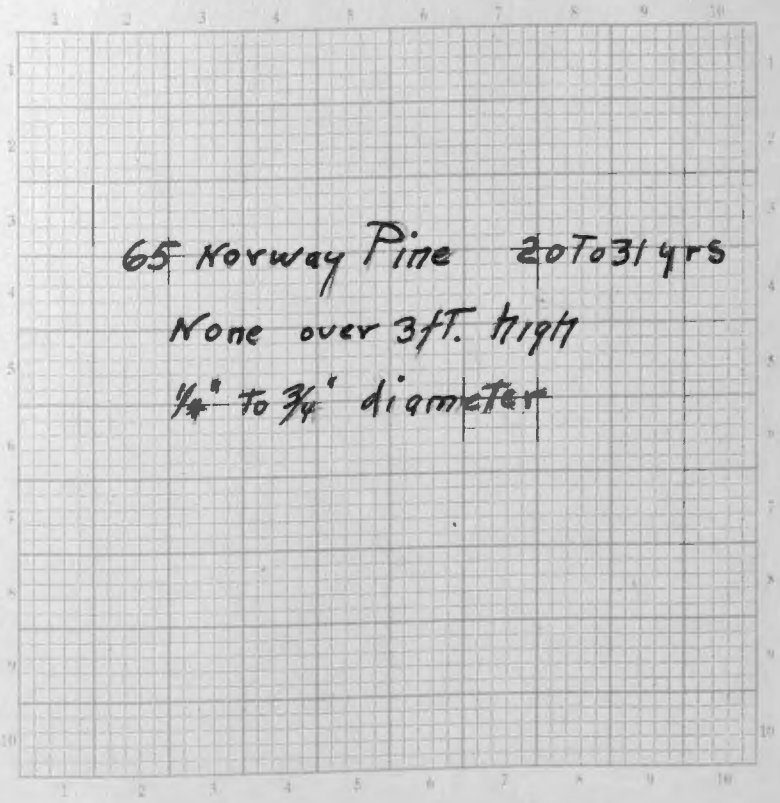
W = White Pine.

QUADRAT 49 LOCATION Star Island DATE

FORMATION 49

CONSOCIES

SOCIETY



65 Norway Pine 20 To 31 yrs

None over 3 ft. high

¼" to ¾" diameter

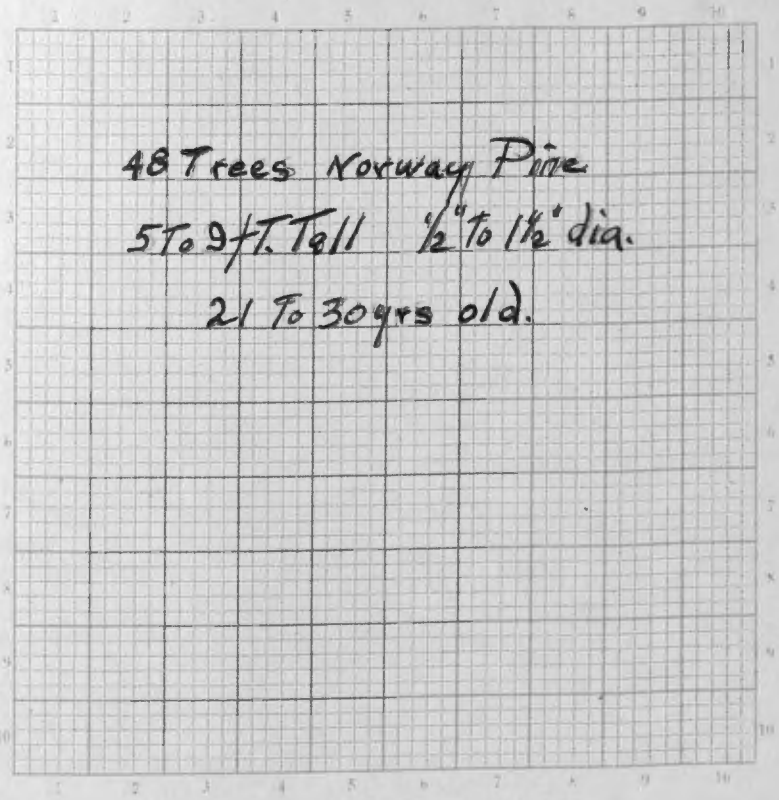
LEGEND:

QUADRAT 52 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



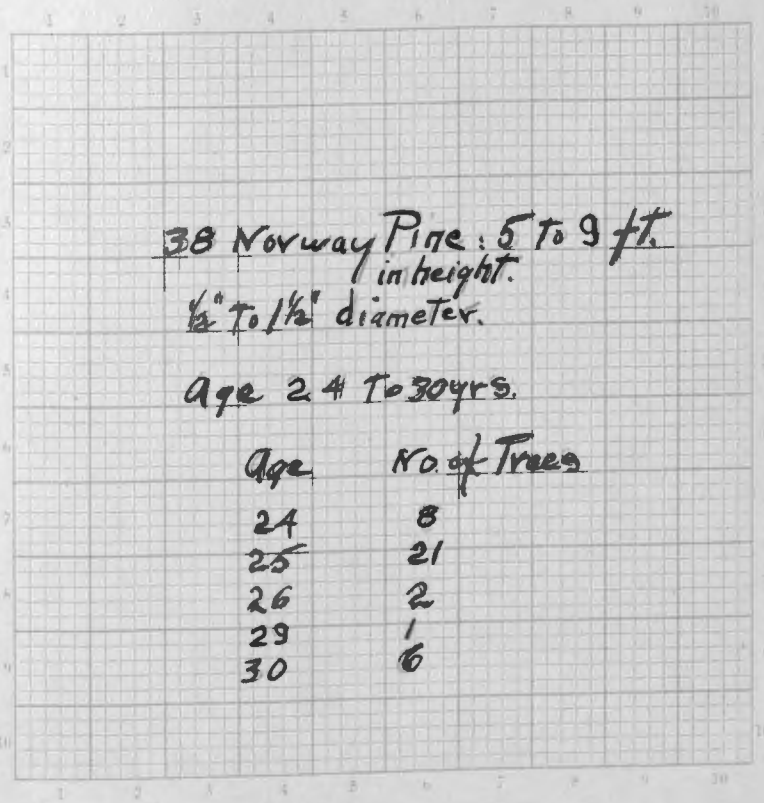
LEGEND:

QUADRAT 53 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



38 Norway Pine: 5 to 9 ft. in height.
½" to 1½" diameter.

Age 24 To 30 yrs.

Age	No. of Trees
24	8
25	21
26	2
29	1
30	6

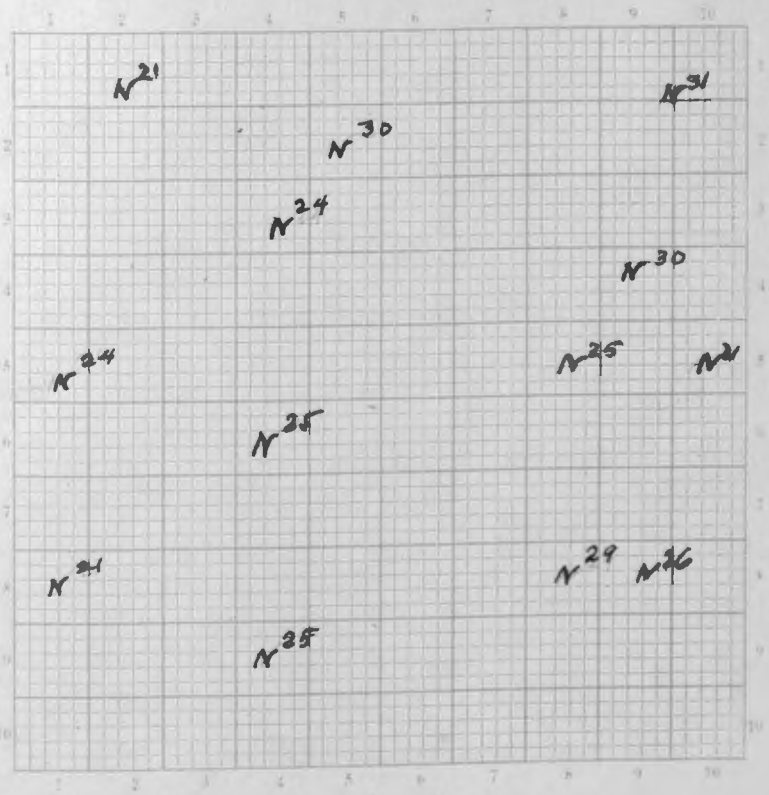
LEGEND:

QUADRAT 54 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



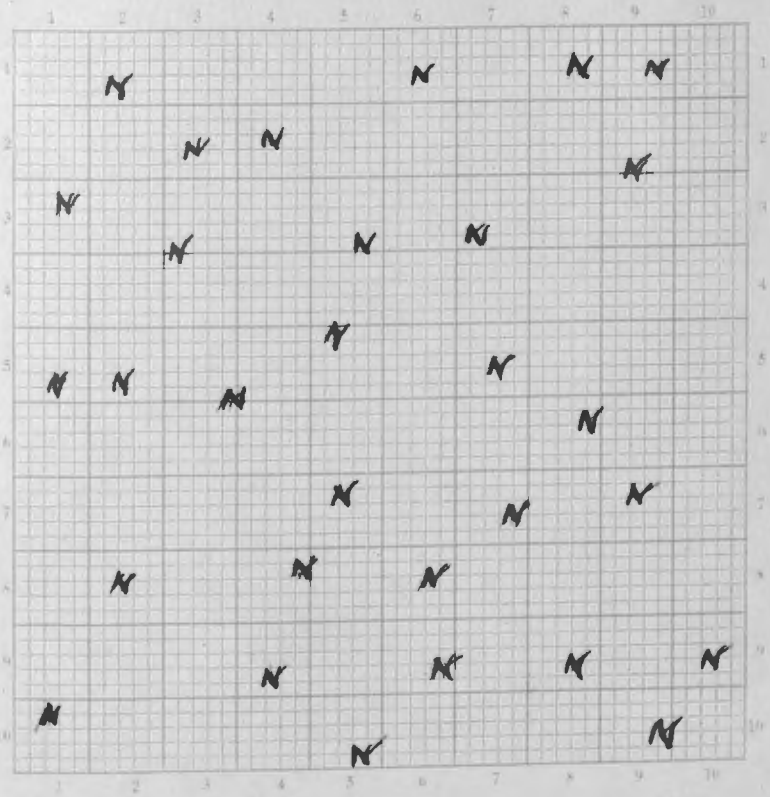
LEGEND: N = Norway Pine : 3 ft. Tall
No = age

QUADRAT 55 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND: N=Norway Pine - 6" To 2' Tall

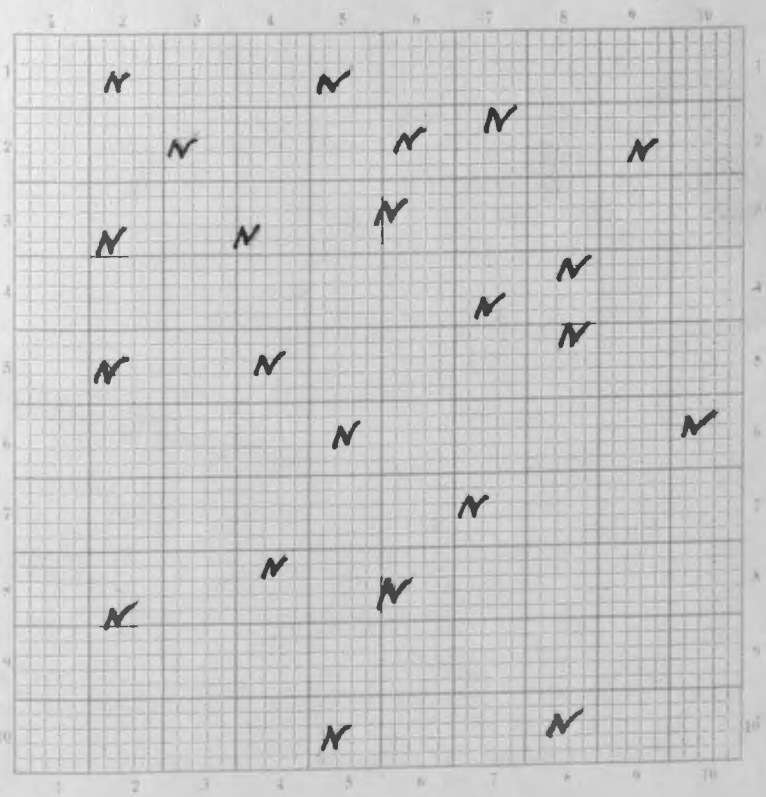
Age	No. of Trees
21	2
24	3
25	5
26	2
29	2
30	2
31	9
33	5
35	0
36	0

QUADRAT 56 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND: N = Norway Pine : 20 To 35 yrs.

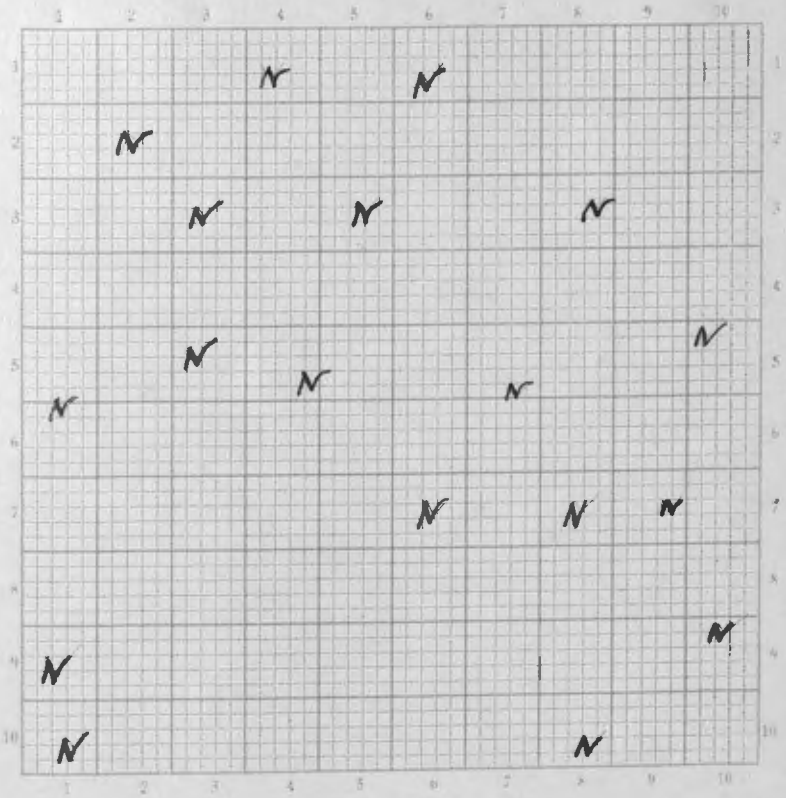
age	No of Trees
20	3
21	3
25	4
26	4
30	2
31	5
35	1

QUADRAT 57 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



LEGEND:

N = Norway Pine

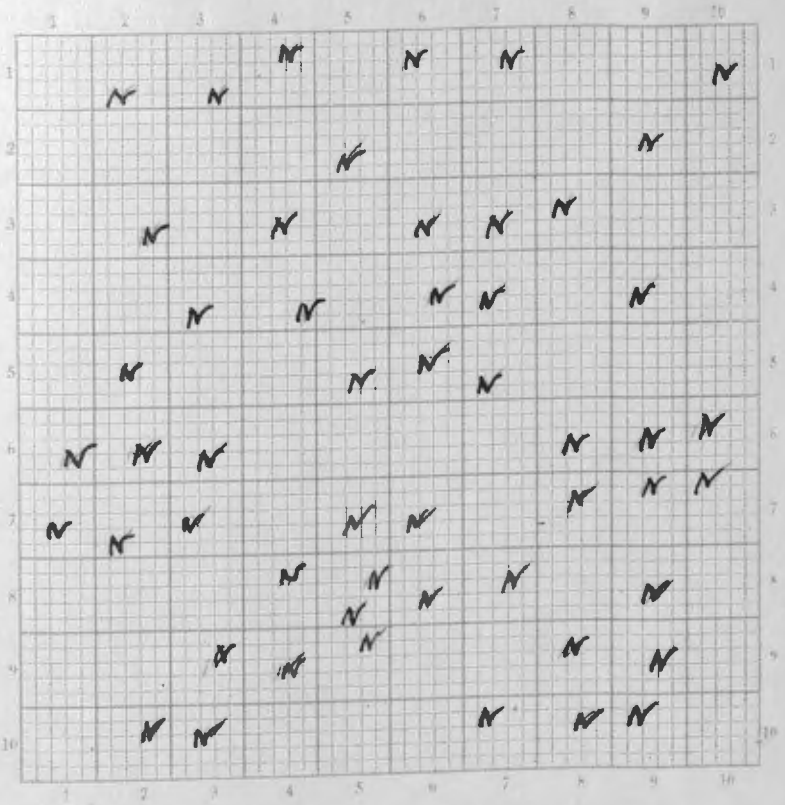
age	No. of Trees
20	1
21	1
25	4
26	4
30	6
31	1
35	1

QUADRAT 58 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



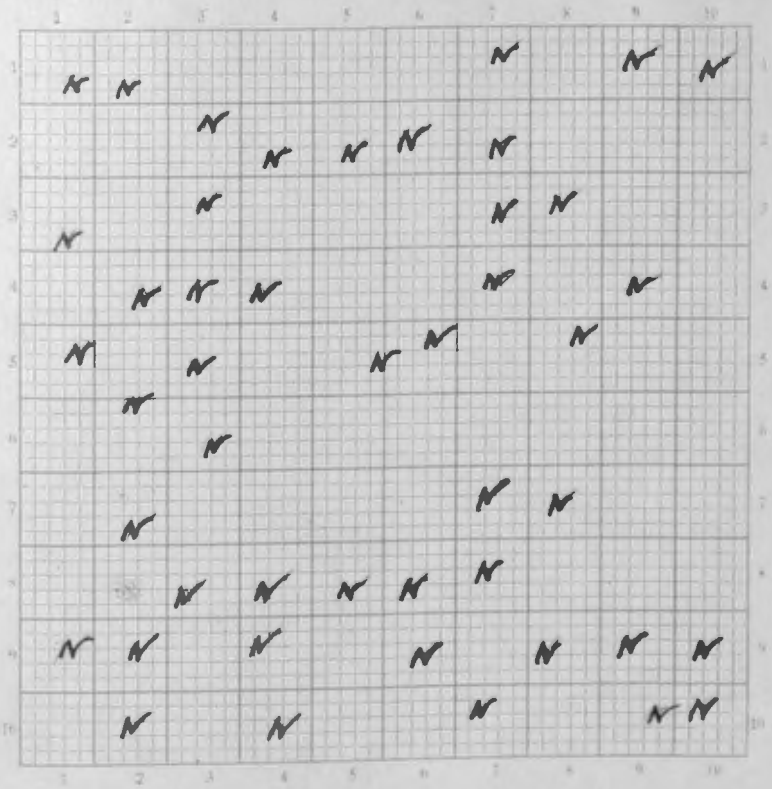
LEGEND: N = Norway Pine 2-4 ft. Tall
20 To 35 yrs.

QUADRAT 59 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



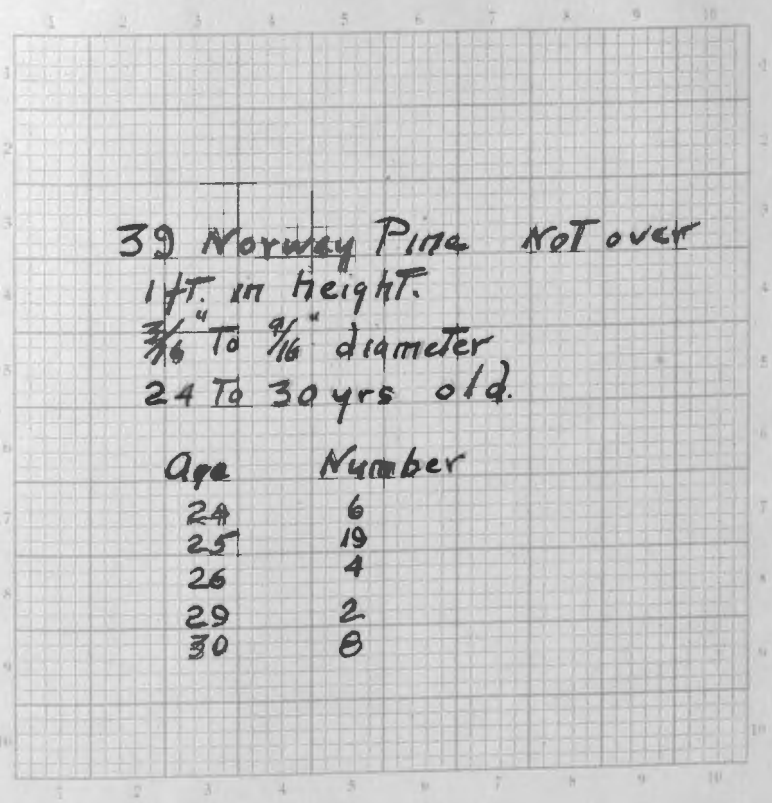
LEGEND: N = Norway Pine 2 To 6½ ft. in height
20 To 35 yrs.

QUADRAT 60 LOCATION Star Island DATE

FORMATION

CONSOCIES

SOCIETY



39 Norway Pine not over
1 ft. in Height.
3/16" To 9/16" diameter
24 To 30 yrs old.

Age	Number
24	6
25	19
26	4
29	2
30	8

LEGEND:

Photo by Wentling

Fig. 4

Showing density of stand - Star Island.

Photo by Wentling

Fig. 5

Crown canopy - Star Island

Photo by Watling

Fig. 6

Reproduction under dense forest canopy as quadrats 54 and 55 - Star Island.

Fig. 7

Looking from the timber into the opening. Reproduction as in quadrats No. 56 to 58 - Star Island.

BENA TRANSECT

At Bena, Minnesota, a transect was run three-fourths of a mile in length. It was run through land that had been loggedthe past winter with all slash burned and ten per cent of the stand left for seed trees. Fig. 9 shows the present condition and Fig. 8 shows appearance of adjoining timber. The timber is not large, but is dense and has a dense canopy. There is absolutely no underbrush, the land being very level except one end, which is slightly rolling, the soil a white sand and the water table only six to twelve feet deep. The soil, except in a few places, is nearly barren of vegetation.

This transect passed through two places of slightly lower levels, three to six feet lower than the average surface. The original timber was the same here as elsewhere. One of these was thirty feet wide, and in the one meter transect crossing this were eleven Norway trees five to seven years old and one to two feet in height. The other was eighty feet in width and in the

meter strip there were nineteen Norway pine trees five to seven years old and one to three feet high. The center of this was very moist and had no trees, but was covered with dense moss and few ferns.

Since the forest has been removed only one year, these treesmust have started under the canopy of the forest. The fact that reproduction was surviving in these moist places under the forest canopy and not on the high places may again lead back to Mr. Zon's theory that tolerance to shade is dependable on available soil moisture, as appeared on Star Island.

The fact presents itself, however, that the forest floor, or the soil in other parts of the forest than the low places is too dry to support seedlings in competition withthe roots of larger trees. Hence it would appear that the struggle of the seedling, or the young tree, is more for moisture than for light.

Fig. 8

Timber before cutting. Bena.

Fig. 9

After Timber was removed and 10% stand left. Bena.

STUDY OF YOUNG NORWAY PINE UNDER JACK PINE

TWP. 141, R. 33

As evidence to support the theory that the Norway pine trees ten to thirteen years old, under jack pine sixteen to twenty-five years old, will live and eventually outtop the jack pine and make a Norway pine type (Referring to quadrats Nos. 27, 42 and 43 at Menahga and Nos. 17 and 18 Nevis), data on this same kind of type fifteen years farther along will be given. The most promising is about three-fourths if a section of land in Twp. 141, R. 37. It is an average sandy jack pine land and somewhat level. There is a medium dense stand of jack pine thirty-five to forty-five years old and about four hundred trees per acre, four to eight inches in diameter D.B.H. and up to forty feet tall. Mixed in this is Norway pine twenty to thirty years old, two to six inches in diameter D.B.H. and twenty to thirty-five feet tall, ranging from twenty to ninety trees per acre.

The jack pine is still shading the Norway pine considerably, causing it to lose its lower branches, but forcing it in height at the rate of six inches to two feet per year. The shade is dense enough so that the ground vegetation is limited to moss, lichens, club moss, and in the more open places blueberry, bearberry and wintergreen.

All the Norway pine is thrifty and has all indications of becoming good, large, well-pruned trees, eventually suppressing and outliving the jack pine. To me this would seem good evidence, showing that jack pine can serve as a nurse crop for Norway pine.

Charts Showing Periodicity of Germination Years.

Chart No. 1 shows a curve of the germination years back for twenty years. It has been made from all reproduction found from one to twenty years old. It is a combination of Charts Nos. 4, 5 and 6.

Chart No. 2 shows curve for reproduction trees from Star Island, ages ranging from twenty-one to thirty-five years.

Chart No. 3 shows a curve made from trees one hundred nineteen to one hundred thirty-eight years old. The ages were taken from the stumps on the tract from which seed was collected.

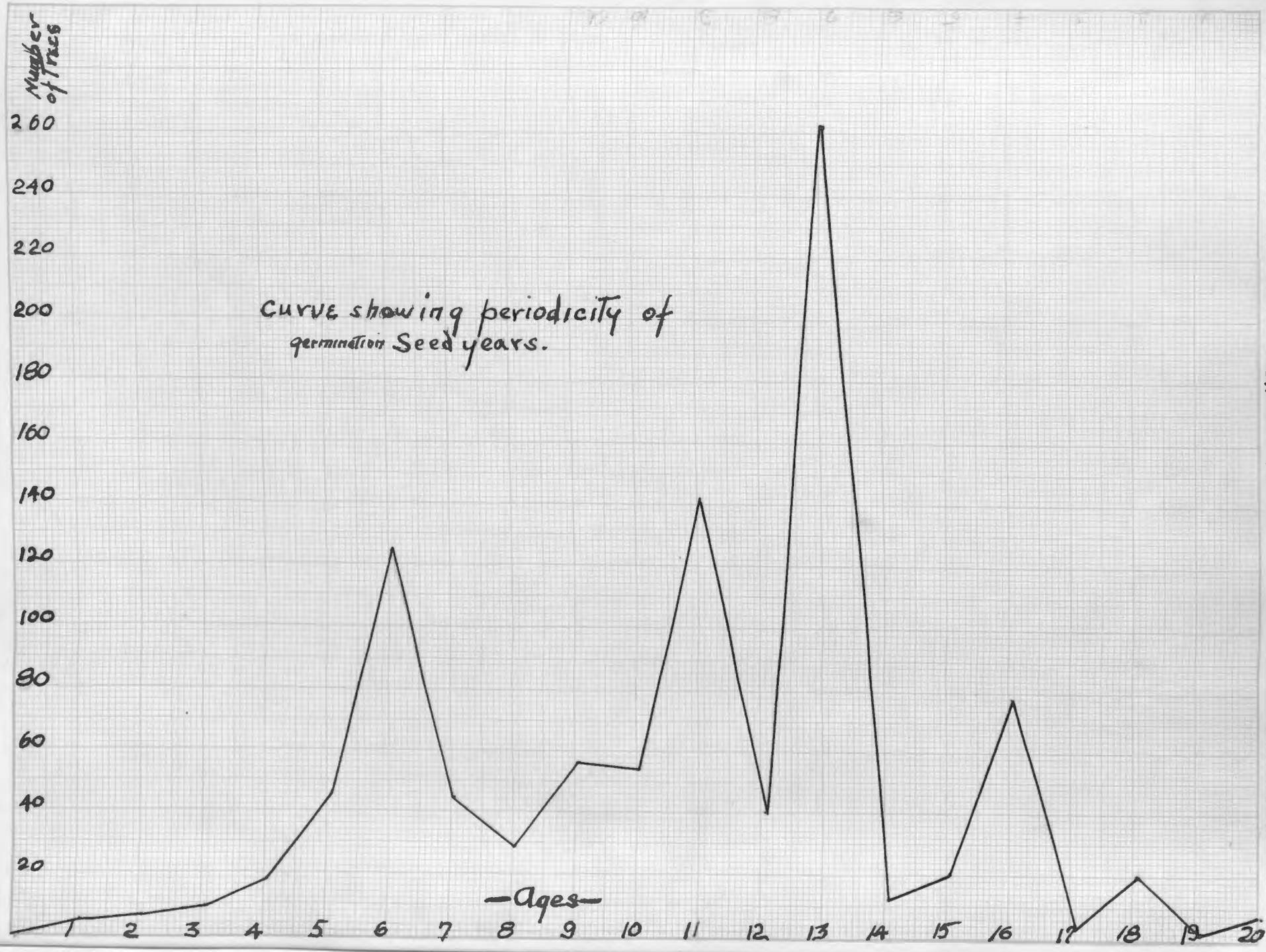
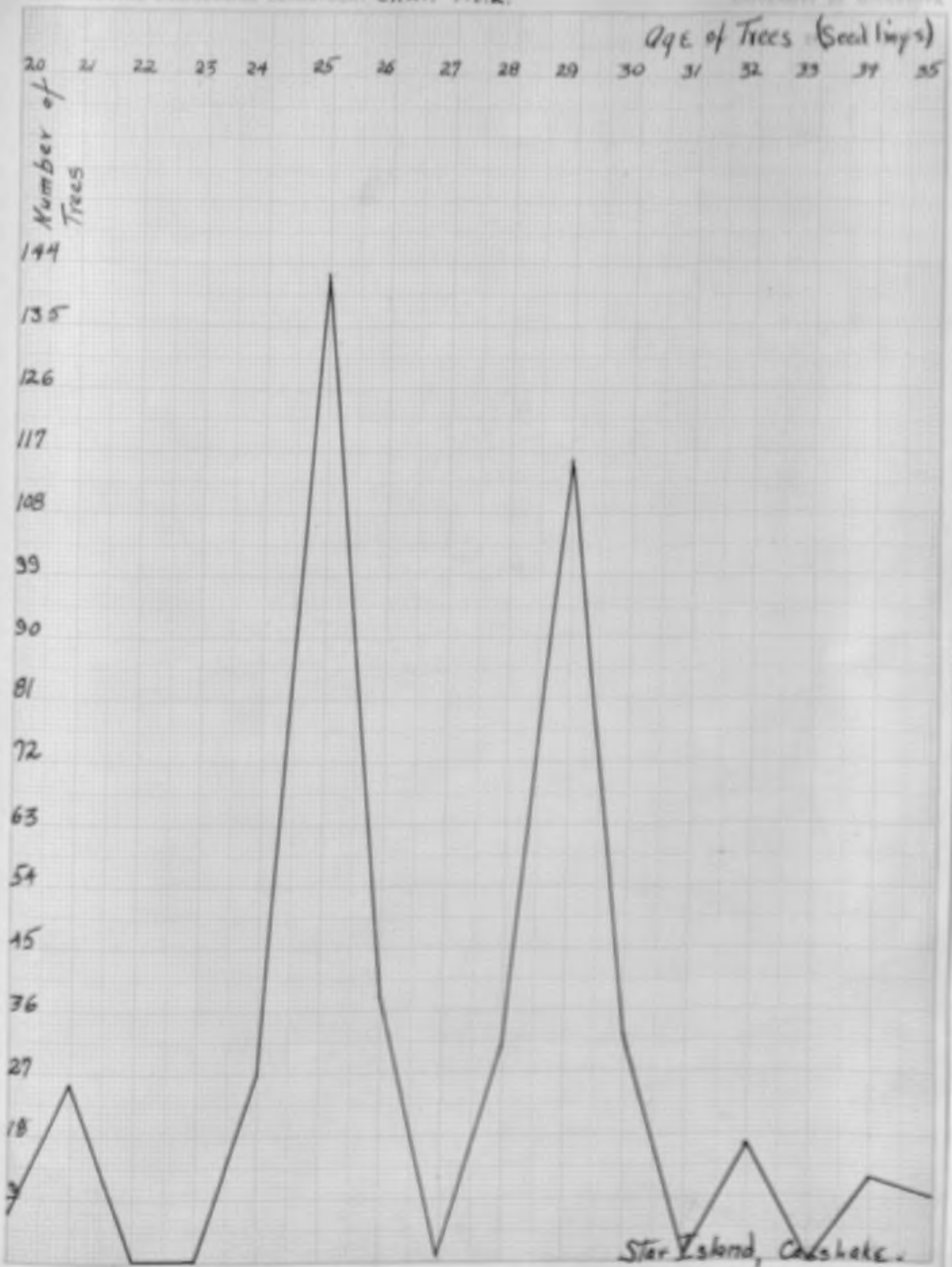


Chart No. 1.

Chart No. 2.


Age of Trees (Seedlings)
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Number of Trees
144
135
126
117
108
99
90
81
72
63
54
45
36
27
18
9
Star Island, Cass Lake.

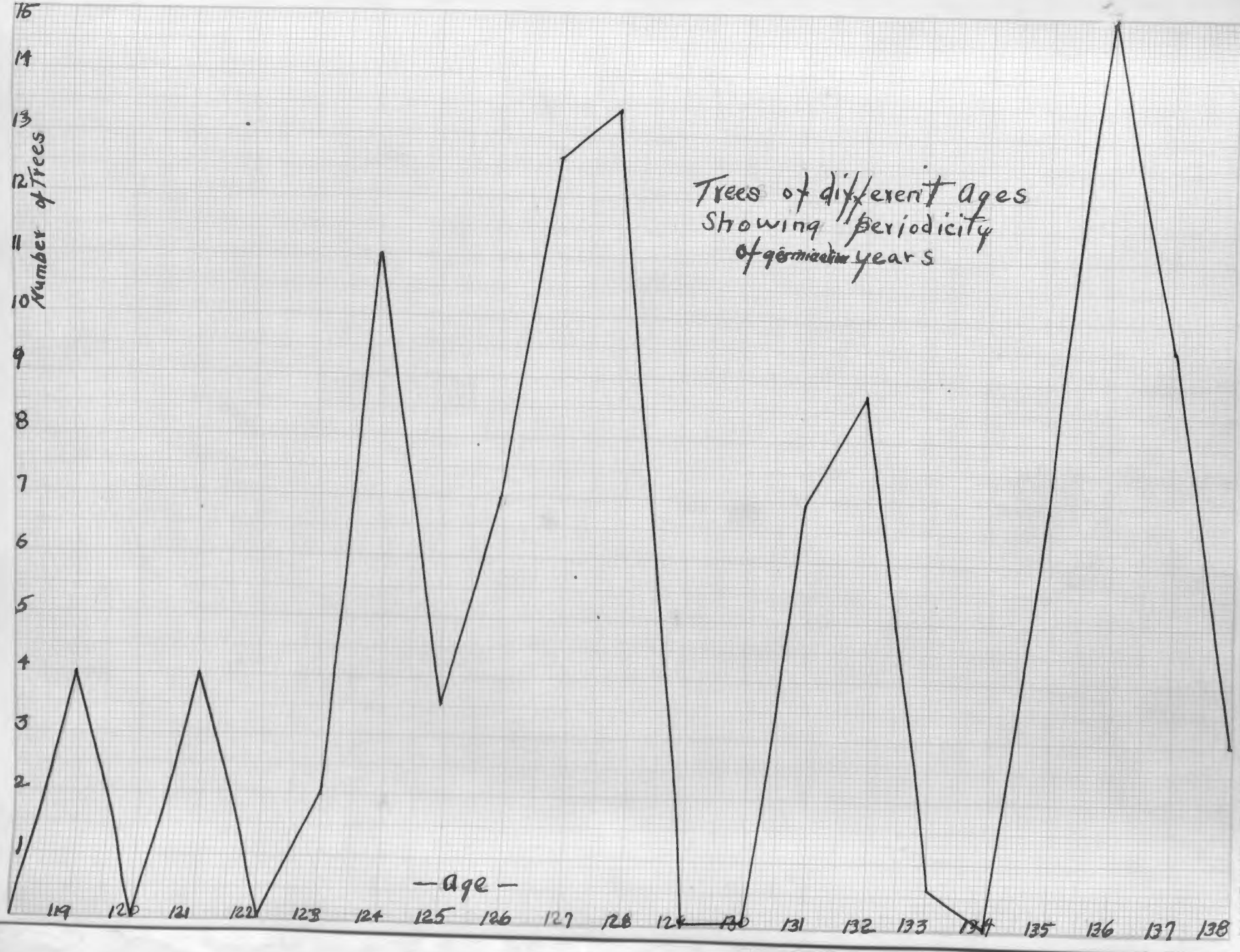


Chart No. 3.

MANAGEMENT OF NORWAY PINE.

"The sylvical characteristics of Norway pine make it suitable for management by the shelterwood system rather than by leaving scattered seed trees". Cutting should not be so extensive as to admit light and wind enough to dry out the mineral soil.

The study of the seed trees at Schley and Bena will go to show that the seed tree method is not the proper system. The shelterwood system should work out well. In one way it worked out very good in nature, as shown at Menahga, T. 138, R. 35. The fire cleaned the ground of litter and made a good seed bed for the seed crop that fell one or two years later, and at the same time destroyed many seed eating rodents. The timber was removed two years after the seed crop, thus opening up the canopy, and the slash was left on the ground, affording partial shelter to the seedlings. This same thing was found true at Nevis, T. 140, R. 33, although the cutting of the timber was only one year

following the seed year. The reproduction at Nevis was not as perfect as at Mennahga. However, a good stand exists.

There are no reasons why the same conditions could not be found at other places and at other times. Since the Norway pine may seed in one locality one year and in another locality another year, it would be possible to work a system somewhere each year exactly as it worked out at Mennahga; viz., (1) to burn litter preceding a seed year, (2) not to cut timber until two or three years after seed year, and (3) to leave slash scattered on the ground.

Even if it could be absolutely proved that slash scattered on the ground is very helpful to the establishment of the seedlings, it would probably have to be burned in most cases on account of the fire hazard.

At Schley somewhat the same results were found as at Mennahga and Nevis. The stand is not perfect, nor as good as at Nevis. The timber at Schley was cut the year following the seed year. The slash was piled and burned, thus leaving the seedlings in somewhat open

exposure, and also leaving many barren spots. Had the land at Schley been burned over the year preceding the seed year, and the slash left scattered, the reproduction would probably have been as good as desirable.

The Norway pine thrives best in open sunlight, but it can endure deep shade under certain conditions. This was especially brought out by the study on Star Island. Further, tolerance, but not as great, is shown in quadrats Nos. 23, 42 and 43 at Menahga, quadrat No. 5 at Nevis, and the older stand of Norway described for Twp. 141, R. 33. From the general study, and especially from the study of quadrats Nos. 23, 42 and 43 at Menahga, quadrat No. 5 at Nevis and Twp. 141, R. 33, it would seem that jack pine is as much of a nurse crop for Norway pine as poplar or birch is for white pine.

CONCLUSION

In conclusion to the study of Norway pine reproduction, the following factors may be gathered as to establishment of seedlings:

(1 They will not establish themselves under dense brush, dense grass or on sod.

(2) They will not start in open, exposed soil.

(3) They will not start in dense litter.

(4) They can start under open hazel, ferns or pea-vines.

(5) They will start and grow in moist moss ground cover, if not deep.

(6) They will start and survive for a long time under a dense canopy of mother trees, if there is abundance of available moisture.

(7) Canopy, if dense, is best removed after two or three years.

SEED PRODUCTION

"The influence of the character of the mother plant upon the quality and quantity of seed produced and upon the character of the offspring is a factor which is well recognized in plant breeding." (Pearson, U.S. F.S. Cir. 196) In forestry this factor should be considered, both in seed collecting for artificial establishment of forests and for the selection of seed trees for seeding cut-over areas. In selecting seed trees, one should ask himself which will produce the most seed and the best quality.

One type of a tree may produce twenty per cent more seed than another, but it may be of a much lower percentage of vitality. The object of the study would be then to ascertain what type of a tree will produce that largest quantity of seed and which will produce seed of the highest vitality. From this a mean may be struck which will produce the largest amount of viable seed.

LOCALITY OF STUDY. This study was made in Hubbard County, S. W. ¼ Sec. 11 in Twp.142, R. 35. The

Map of Tract
on which
S. was Collected.

Legend
Nos. 1, 2, etc. = Tree Nos. Seed Was
Collected from these. Pinus resinosa
= Pinus resinosa No Seed collected.
J = Pinus divaricata
W = Pinus strobus.
S = Picea mariana
Scale - 1 inch = 50 ft.

N

Scattering Norway Pine.

Dense Populus sp.

Dense Jack Pine

Pond

Alnus, Cornus, and Salix Sp.

Springy

Spring

Rock Outcrop

tract studies were not of large extent, so results are somewhat limited to one locality. It was, however, an area very typical of the entire pine belt of northern Minnesota. This was the only locality in that part of Minnesota where there was a good seed crop, and as the lumber company was logging there at the time the cones were mature, it made conditions very favorable for such a study.

FIELD WORK. The seed collecting was begun on the 22nd of August and continued to the 21st of September, when the cones began to open badly on the trees. The collecting was done as close behind the sawyers as possible. Every cone that could possibly be gotten from each tree was collected and the cones of each tree kept in separate muslin bags. Since it was impossible to get every tree felled, care was taken to get, as near as possible, the same number of various types of trees and not to entirely miss a certain type.

FIELD DATA -

1. Tree number
2. Feet up to first dead or dying branch

3. Feet up to first live branch
4. Feet up to first limb bearing cones
5. Length of main crown
6. Width of main crown
   Comparative density of crown and branches
7. Length of unmerchantable top
8. Total height of tree
9. D.B.H. (Diameter breast high)
10. Age and stump analysis
11. Fire scar
12. General health of tree
    (a) Fungous disease
    (b) Insect injuries
    (c) Fire injuries
    (d) General appearance
13. Approximate number of cones to mature
14. General remarks - 1913 photos

SITE. The study of site is recorded in the form of a topographical map, showing contours with elevations. Also each tree of the stand, whether or not seed were

saved from it, is marked on the map, thus showing the density of the stand at various places.

As soon as the cones were collected from a tree, they were sacked and stored in a hay mow and kept free from moisture and squirrels. After the collecting of the cones was finished, they were sorted into four grades and the cones counted. The following grades were used:

1. Good merchantable cones (Large and free from insect or fungous attacks)
2. Small nubby cones
3. Partially wormy or diseased
4. Wholly worthless on account of worms, etc.

The first three grades of cones were extracted separately, so that germination tests could be made of each grade, as well as for the whole tree, so that the amount of seed produced by each could be obtained. Only the results for the first grade of cones (merchantable) have been used in the comparative results for each tree.

THE EXTRACTION was done in a galvanized iron oven with gas heat. The temperature of extraction was compara-

tively uniform, ranging from 120 to 140 degrees F. and continued until the cones were well opened, it generally taking from five to seven hours. In order to get any seed that would not shake out over a sieve, the cones were run through a corn sheller, which got out five to twenty per cent more. The wings of the seed were rubbed, mostly by hand, and cleaned in a small cleaning mill. The wind was regulated so as not to blow out any small or hollow seeds. The seed of each tree was weighed separately and kept in separate paper bags for germination.

GERMINATION. Seed samples were germinated between regular seed germinating blotters, and were at a temperature of 66 to 76 degrees F. The blotters were kept moist, but not dripping. The number of germinated seeds were counted and thrown out every three days. When germination ceased, the hollow seeds were counted and also, if any, the number of ungerminated seeds that were not hollow. In most cases one hundred seeds were used, but in many cases one hundred fifty to two hundred were used. Very few seeds germinated within the first

six days, but nearly sixty per cent germinated within nine to ten days. The following are average figures.

100 Seeds Used

Number of Seed Germinated

Date Feb.	1	6	9	12	15	18	21	Hollow	Not hollow but ungerminated
	0	0	63	5	2	4	0	25	1
	0	0	60	8	0	3	2	27	0
	0	8	70	0	1	1	0	12	8
	0	28	26	18	2	3	0	20	3
	0	2	74	7	0	1	0	12	4

The molds caused some trouble, but by repeating the test of these, good results were obtained. Treating the seeds did not aid materially, although there was a difference.

The trees studied were divided into twelve classes, some of thich overlapped, i.e., the fire-scarred and unfire-scarred classes included trees that would be considered thrifty, medium healthy and unthrifty; also

open grown, medium dense, and close grown trees. Cones were collected from a number of trees that had been fire injured during 1911. No fire scars were made, but the heat was great enough to injure the cambium. These trees were classified as"sickly fire injured". Other classes are "witches' broomed", heart rot and suppressed trees.

Table No. 1.

A Table showing results of the study in a condensed form.

Tree class	Ounces seed per tree	Aver. germination per cent	Aver. no. of good cones per tree	No. of good cones per oz. Seed	Bases Trees
Poor unthrifty	.20	71	49	245	8
Suppressed	.22	83	80	363	7
Sickly - Fire Injured	.36	70	92	296	15
Heart Rot	.52	76	126	243	10
Bad Fire Scar	.78	83	200	260	34
Close Grown	.83	81	194	232	20
Medium Health	.90	75.5	195	217	36
Witches'Broom	1.20	70	381	317	6
No Fire Scar	1.26	77	322	255	57
Very Vigorous	1.61	77	409	249	72
Medium Open Grown	1.85	78	427	231	12
Open Grown	4.20	72	727	172	7

CLOSE GROWN TREES SHOW HIGHER PER CENT OF GERMINATION BUT PRODUCE LESS SEED PER TREE THAN OPEN GROWN TREES. The classification was made as follows: Where there were ten or less trees per acre they were called open grown; ten to fifty trees per acre medium grown and over fifty trees per acre close grown.

Table 11.

Trees Classified as to Density of Stand

Class of Trees	Aver. germination per cent	Aver. Amt of seed per tree (ounces)	Aver. no. of good cones per tree	No. cones to produce one oz. seed
Open Grown	72	4.20	727	172
Medium Grown	78	1.85	427	231
Close Grown	81	.83	194	232

This table shows that although the open grown trees produce seed of a lower germination per cent than the close grown, they produce a great deal more of it. The open grown trees also produce a much larger number

of cones. The close grown trees had the better germination per cent, 81%, but produced a small amount of seed, .83 ounce. The medium grown trees show a mean between the two preceding, both in germination per cent and amount of seed. Open grown trees have much larger cones, only 172 cones being required to produce one ounce of seed, as compared with 231 for normal.

SEED FROM CLOSE GROWN TREES (81%), SUPPRESSED TREES (83%), AND FIRE SCARRED TREES (83%) SHOW THE HIGHEST PER CENT OF VITALITY. The class called suppressed includes trees that are under sixty-six feet in height and under ten inches in diameter D.B.H. and of the same age as other trees, viz., 124 to 135 years. They are growing exceedingly slow and are under, or very close to, some large tree. This class would be somewhat similar to the close grown class. It has a germination per cent of 83, and has an average of only .22 ounces of seed per tree. The average number of cones per tree is only 80, and the cones are very small, requiring 363 for one ounce of seed as compared with about 225 for average trees.

The next class of trees with a high per cent of germination is the fire-scarred. This class shows a germination of 83% (6% above uninjured trees), but with an average of only.78 ounces of seed per tree. The fire scars are at the base of the tree and are old and generally from repeated fires. Some of them are four to twelve feet in height and in places heart deep. Others are low and may extend for two-thirds of the perimeter of the base of the tree. Invariably fire-scarred trees have grown exceedingly rapid at the point of injury, laying on as much as three-fourths inch of wood per year. The effect of the fire scar would naturally tend to reduce the water and food carrying surface of the tree, thus depriving the top of water and roots of food. The increase growth of sapwood around these injuries would tend to make this surface nearly normal.

As a matter of fact, the badly scarred trees come very close to the suppressed and close grown classes since very few trees were found fire-scarred and were not in dense stands, or where two or three trees were

close together. In the following table it will be noticed that the germination per cent and the amount of seed produced by the three classes are nearly the same.

Table III

Class of Tree	Av.Germination per cent	Aver.ozs seed per tree	Aver. no. cones per tree
Fire-scarred	83	.78	200
Close grown	81	.83	194
Suppressed	83	.22	80

The conclusions to be drawn fromthe foregoing would be that at least after the first effect of the fire, i.e., after the scar had started to heal, there is no difference between the fire-scarred trees and those in similar conditions but uninjured.

In the following table is a comparison of the medium open grown trees, medium healthy trees, unfire-scarred trees, and as a contrast the fire-scarred.

Table No. IV.

Class of Tree	Av. germination per cent	Aver.ozs. seed per tree	Aver. no. cones per tree
Medium Health	75.5	.90	195
Medium Open grown	78	1.85	427
Unfire-scarred	77	1.26	322
Fire-scarred	83	.78	200

The trees with no fire scars were mostly in medium open stand and would fall in the class with the medium open grown and medium health trees. They have nearly the same germination per cent and produce about the same amount of seed. The difference between the fire-scarred and unfire-scarred trees is almost identical with the difference between medium open grown trees and close grown trees. The results are then negative and the conclusion would seem to be that the fire scar scar does not affect the vitality of the seed or the amount produced.

Recently fire injured trees show different re-

sults. The class called"sickly fire-injured" was made up of trees that had been severely injured in a spring fire of 1911. These could not be considered in the fire-scarred class because the injury was so recent that they have had no time to recuperate or become normal again. The fire did not burn the bark, but it did injure the cambium inside. The lower limbs were killed or injured badly enough to make the foliage look yellow and sickly. The foliage at the top looked good and medium healthy. The cones were medium to small and had thin, light scales.

Germination	70%
Ounces of seed per tree	.36
Number of good cones per tree	92

These trees are in a medium dense stand, and from all indications they were good, average trees before the fire went through, so it would seem quite conclusive that the low vitality and the low amount of seed per tree could be attributed to the effect of the fire. On many trees the cambium was injured only on one side,while on others it was two-thirds of the perimeter of the base

and well up the trunk of the tree.

INFLUENCE OF HEALTH OF TREE ON THE QUANTITY AND QUALITY OF THE SEED PRODUCED. In classifying trees as to health, they were classified as "unthrifty","medium health"and "vigorous". The basis for this was largely general appearance of the tree, condition of foliage, i.e. whether or not the foliage was free from rust, etc., and was of a good thrifty color and growing well. The rate of growth of the twigs and leaders and increase in diameter was considered important in this classification. All fire injured trees, or trees appearing to be suppressed or handicapped,were excluded from these classes. Neither were there any of the open grown trees used. The trees that were growing rapidly at the twigs and leader, increasing rapidly in diameter, and had healthy appearing foliage were called"vigorous" Those that were increasing slowly in diameter, growing very slow at the twigs and branches and appeared to have sickly, thin foliage were called "unthrifty". The intermediate trees were classed as medium health. The following table shows the condensed results.

Table No. V.

Class of Tree	Aver. germination per cent	Aver.no. of ounces seed per tree	Average number cones per tree
Unthrifty	71	.20	49
Medium health	75.5	.90	195
Vigorous	77	1.61	409

This shows an upward rise in the germination per cent, amount of seed and number of cones per tree from unthrifty to vigorous trees. The difference in the germination per cent is not great, but the amount of cones and seed is very striking, the vigorous trees having the lead.

HEART ROT DID NOT APPEAR TO MATERIALLY EFFECT THE SEED PRODUCING QUALITY OF THE TREES. No tree was found with heart rot extending up the bole greater than six feet. Only three per cent of the trees examined had rot. Of nine trees found with rot, one was Pleorotus sp. and the other eight were undoubtedly Trametes pini. Most of those effected were trees growing in the richer soils

at the foot of the ridges. Five of them had bad scars as well as heart rot. They had all variations of crown density and appearance of foliage. Seven were in medium dense stands, two dense and one open. The average of the whole, except for the fire scars, would class them close to the medium healthy and medium grown classes. The following are their averages:

Germination	75%
Ounces of Seed	.52
Number of cones per tree	126

The germination percentage is very close to that of the classes with which it has been compared. The number of cones per tree and the amount of seed is much below the average. The conclusions formed fromthis would be very indefinite, since the number is not large inthe first place, and there seems to be one or two other complications entering in each case. The results are negative rather than otherwise, since the rot is not very prevalent, it is not very extensive in the tree and it works on the heart wood, which is dead as far as the tree is concerned.

WITCHES'BROOMED TREES SHOW A LOW PERCENTAGE OF GERMINATION. A very large number of trees had more or less of witches' broom on them, but only a few had it in any considerable amount. Nothing could be found in the limited study that would go to show what caused the "brooming". However it is a disease without a doubt. The only description that could be given is that it caused an extremely dense growth of needles on certain branches, oftentimes one-half of the tree affected. The needles have a very fresh green color. They are slightly shorter than normal needles and finer. Branches that have had the disease some time have a great many dead"stubs" of twigs. It would seem that the smaller twigs die off and new ones are stimulated to grow out. Most of the witches' broom was found on trees that were open grown, or at the edge of an opening in the woods. No cones whatever were found on badly "broomed" branches. Where partially broomed a few cones would be found. The witches' broomed trees show rather different results than other trees.

Germination per cent	70
Ounces of seed per tree	1.20
Average number of cones per tree	381
Number of good cones to produce one ounce of seed	317

The germination percentage is lower than the medium grown trees, the class in which the "broomed" would likely fall if unaffected. Both the number of cones and the number of ounces of seed per tree is less than for medium trees. Furthermore in witches' broomed trees, three hundred and seventeen cones are required to produce one ounce of seed, while only two hundred thirty-one cones of the other classes are necessary. Although the witches' broom disease stimulates an abnormal growth of needles, the additional amount of food made by the increased foliage does not seem to be enough for it,so there must still be a drain upon the tree. The increased foliage surface may cause a correspondingly increased transpiration, and thus a "broomed" branch may use an excess of water, depriving some nearby branch of its share. A probable cause of the small amount of seed

produced, and the lower vitality, may then be considered nutrition.

SUMMARY. The condition of the tree seems to affect the size and number of cones a great deal more than the vitality of the seed. The highest quality of the seed was produced in dense stands, although the smaller amount of seed was also produced there. At first thought one might expect better seed from open trees where light conditions are better, but generally there is sufficient light for the cones if the needles can thrive well. The chief reason, however, is the pollination which is evidently more complete in dense stands. The lack of vitality in seeds is due to the lack of pollination, or at least lack of fertilization. There is such an enormous amount of pollen produced by the Norway pine that, even if only a small per cent of it is good, there should be enough to sufficiently pollinate the pistillate cones if it is carried properly. Also the moderating effect of the close crown upon the temperature and evaporation would tend to favor the development of the seed, especially in early stages. The

greater amount of seed produced by the open grown trees is largely due to their longer and broader crowns. There is a great deal more surface and less crowding than in the close grown trees with shorter,flatter crowns.

The practical tree for seed production is the open grown. Although it has a lower germination percentage, it has an exceedingly large amount of seed. For seed trees and for the shelterwood system, they are also much more wind firm. In regard to cone production, there might appear to be an individuality among trees. Trees that have had a great many cones this year (1912) had a great many old cones of both 1911 and 1910, as well as many cones to mature in 1913. Trees with few cones this season had few or none for the preceding season and have few or none for the coming season. However a study over an extended period would be necessary to confirm any theory like the above; but,if it would prove true, it would certainly be a character to search for in the selection of seed trees, or for a shelterwood system.

AMOUNT OF SEED PRODUCED BY A FOREST.

On a tract of nine acres where this seed study was made were two hundred twenty-six trees of seed producing capacity. This means twenty-five trees per acre. producing approximately twenty-nine ounces, or 105,000 seeds. If five per cent of this would escape the rodents, germinate and grow, there would be over five thousand seedlings per acre. At Menahga and Nevis there are now over five thousand trees per acre, showing that either more seed was produced or that a larger per cent succeeded. A large per cent of the seed that reaches the ground must succeed according to this, because the toll of cones by the squirrels is large and the seed is again tolled by the chipmunks and mice after it reaches the ground. Growing conditions must, therefore, be very favorable if reproduction is to be established. One of the chief benefits of a fire preceding a seed year is the destruction dealt to the rodent population.

FURTHER EXAMINATION OF THE SEED.

Further germination tests were made of seed of

different cones of the same tree. Nine trees were used and the average taken of these. The cones used were average, normal cones, nubby or dwarfed cones and wormy cones. The following is the germination per cent of the seed from each kind of cones.

Average normal cones	79.5%
Nubby cones	73 %
Wormy cones	70.5%

In picking cones, it was found that invariably most of the small cones came from the lower branches. The first thought would be poor pollination, since pollen generally rises upward; but from a study made by putting all trees with germination data in height classes from fifty-four to one hundred three feet and plotting them with reference to germination and tree height, no constant difference was revealed in height classes. Therefore it is safe to grant that pollination was successful on lower branches. Nutrition is the more probable reason. The lower branches are always more or less suppressed for want of light and have a thin, scant foliage. The branches are lateral and growing very slowly. Most

of the water would pass to the faster growing and more rapid transpiring top, while most of the surplus food would pass down to the roots; hence the smaller cones and poorer seed on lower branches. Small cones not only had a low per cent of germination, but had small seed and only a small amount of seed per cone. It took approximately 2500 nubby cones to produce one ounce of seed as compared with only 225 cones of average trees and 172 of open grown trees. The average number of seed per pound is 86,560. Small cones as a rule opened quite readily when subjected to heat.

Wormy cones had seed with a germination per cent of only 70.5 . The chief reason for this low percentage is the fact that resin has been exuded by the injured scales and the seeds are so coated that they are impervious to water, or too hard for the radical to penetrate. Very few seeds are partially insect injured. They are either unaffected or totally destroyed. The insect did not appear to injure the axis of the cone, but attacked each individual scale and its seeds. Some

cones were totally destroyed, while others were only partially. The total wormy cones were simply counted and then thrown away. Wormy cones were very hard to open. One or two injured scales would prevent the opening of all other scales on that side of the cone. This was especially true when it occurred near the base of the cone, it being due to the overlapping or "shingled" arrangement of the scales. The injured scale exudes a great deal of resin, which also partly prevents opening. Dipping the cones in water before heating aided materially in opening. Wormy cones really contain a great deal more seed than can ordinarily be extracted. As these cones run, it took 2065 cones to produce one ounce of seed.

It is surprising to find what a large per cent of the cones produced by a forest are defective or poor cones. The following is an average of the different kinds of cones for one hundred ten trees of different classes.

Good merchantable cones	54%
Nubby, dwarfed cones	15%
Partly wormy cones	15%
Totally wormy cones	16%

With two exceptions, there appeared to be no great variation between the tree classes, as the range in the following is small

Good merchantable cones	52 to 58%
Nubby or dwarfed cones	10 to 23%
Partly wormy cones	14 to 19%
Totally wormy cones	12 to 18%

The exceptions to this are the sickly, fire-injured trees with forty per cent of good cones and twenty-three per cent of nubby cones, and the suppressed trees with forty-eight per cent of good cones and twenty-five per cent of nubby cones. It would seem from this that the insect attacks are the same on all of the classes throughout the forest, and that nubby cones occur alike on all trees.

In the following it has been attempted to show

a comparative cost of collecting seed from small, wormy and good cones. The conclusions are arrived at primarily from calculations from the number of seeds per pound. 86,500 is the number of small seeds and 65,200 the number of large seeds per pound. *

Good cones required two hundred twenty-five cones with seed 79½% of germination test to produce one ounce of seed. Small cones required approximately 2500 cones with 73% germination test to produce one ounce of seed. Wormy cones with a germination tests of 70½% required 2065 cones for one ounce of seed. Estimating that all grades of cones - good, small or wormy - can be picked at the same rate, and making calculations from the foregoing figures, it would cost 9.7 times as much to collect small cones and 10.1 times as much to collect wormy cones as good, normal cones. In hand-picking, in

* NOTE - 65,200 seeds per pound appear high for Norway pine, but the seed comes from the cones without any of the light or hollow seeds being blown out. If the 10% to 15% of hollow seeds were blown out, it would make it almost exactly the same number per pound as standard seed (55,000).

slash, etc., a person should not take time to pick any small, nubby cones, or any that show signs of being wormy. (Previously in this thesis, it was noted that nearly one-half of the cones on a tree are defective) In collecting from squirrel caches, very few small cones will be obtained, as squirrels work near the top and larger lateral branches of the tree. They do, however, cut a large number of wormy cones, but as a rule they are not badly injured. No estimate of the cost of estraction of wormy or small cones can be given except that it takes ten to thirty degrees F. more heat, especially for wormy cones, to open them in the same length of time as normal cones.

A very important point to be noticed in the collection of seed is the time of the season. It was found in this seed study that seed from trees cut before August 23rd were very inferior in germination quality.

The following table shows a comparative result from cones collected on various dates.

Date of Cutting	Per Cent Vital
Aug. 5	0 to 45%
Aug. 12 and 13	51 to 63%
Aug. 23 and later	68% and higher

It can be seen from this that two weeks' time makes a great deal of difference in the quality of the seed. When the cones were cut open - at the time of picking, the seed appeared as good as other seed, but upon drying the kernel inside shrunk badly.

An interesting fact was noticed here. The squirrels were eating the cones as early as August 5th, but they did not do any active cutting of cones until August 22nd. This would tend to show that when squirrels start cutting cones they are mature for seed collecting.

In a superficial study of the quality of the seed in the different parts of the cone, that at the base was found the poorer in quality. The larger number of the lower scales are sterile and most of the light seed produced comes from the lower part of the cone. In

opening, the lower scale of the cone always opens first. In the process of extraction, the seed that was released during the first two hours germinates only 70%, while that which came out at the end of the heating was 82% good. The last, which would not shake out, was removed by means of a corn sheller and had a germination per cent of 84. This last seed was in the scales at the tip of the cone, and the tip naturally has the best position for both nutrition and pollination.

Fig. 10

Open grown trees.

Fig. 11

Trees medium to open grown.

Fig. 12

Medium grown trees.

Fig. 13

Trees grown in open, but four trees are real close together. From right to left Nos. 46, 47, 48 and 54.

Fig. 14

Canopy of dense stand.

Fig. 15

Crowns of Trees over-topping other trees.

Fig. 16

Dense Stand near trees 84 to 87 on map.

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