A PLAN FOR THE SILVICULTURAL MANAGEMENT OF STAR ISLAND IN THE MINNESOTA NATIONAL FOREST.

THESIS FOR DEGREE OF M. FOR.

GEORGE CHESTER MORBECK

1915

SUPPLEMENTARY
MATERIAL
IN BACK OF BOOK

A PLAN FOR THE SILVICULTURAL MANAGEMENT OF STAR ISLAND IN THE MINNESOTA NATIONAL FOREST.

- - -

A THESIS

PRESENTED FOR THE DEGREE OF

MASTER OF FORESTRY

by

Geo. C. Morbeck

M. A. C., 1904

1915.

THESIS

TABLE OF CONTENTS.

1. PRELIMINARY MATTERS. Page.

A. STAR ISLAND - Location and Size ---------- 1

B. HISTORICAL CONSIDERATIONS ---------- 2

1. The Creation of the Minnesota National Forest -- 2
The "Morris Act" of June 27,1902 ---------- 2
The amendment to the "Morris Act" ---------- 4
May 23, 1908.
The above laws and their effects ---------- 5
briefly summarized.
2. Alienations ---------- 6
3. Early surveys ---------- 7
Land office survey lines ---------- 7
List of lands by township and sections ------ 8
Other surveys ---------- 8
4. Early Uses of the Forest ---------- 8
5. Present and Future Uses of the Forest ---------- 9
6. The Revenues Derived ---------- 10

C. GENERAL PHYSIOGRAPHIC FEATURES ---------- 10

1. Topography ---------- 10
Highland or bluff ---------- 11
Swamp and marsh ---------- 11
Types (4)
2. Surface ---------- 12
3. Drainage ---------- 13
4. Soil Conditions ---------- 13
5. Climate ---------- 14
Temperature and seasons ---------- 15
Precipitation ---------- 15
Winds ---------- 16

D. SOCIAL AND INDUSTRIAL CONSIDERATIONS ---------- 16

1. Population ---------- 16
Density - distribution ---------- 16
Nativity ---------- 16
Thrift, etc. ---------- 17
Occupations ---------- 17
Lumbering and milling ---------- 17
Agricultural pursuits ---------- 17
Manufacturing, etc. ---------- 18
2. Dependence of Inhabitants on Forest Industries-- 18
3. The Lumber Industry ---------- 18
a. Logging ---------- 18
Methods ---------- 18
Cost of each operation ---------- 19
Labor, and wages paid ---------- 20
b. The value of stumpage and prices paid for logs 21
c. Markets for forest products ---------- 22

d. Milling ---------- 23
Present milling operations ---------- 23
Methods ---------- 23
Costs ---------- 24
e. The box factory ---------- 25
Material used and dimensions ---------- 25
The manufacture of box shooks ---------- 25
Labor employed ---------- 25
f. The present prices of lumber at Cass Lake ---- 26
Red pine (listed by grades ---------- 26
g. Markets for the manufactured product --------- 27
Lumber ---------- 27
Local ---------- 27
Distant ---------- 27
Box shooks ---------- 28
4. Transportation Facilities and Freight Rates ----- 28

E. A DIGEST OF RECONNAISSANCE FIELD AND OFFICE WORK ---- 29

1. Time ---------- 29
2. Parties ---------- 29
3. Primary Control ---------- 29
4. Method of Reconnaissance ---------- 30
5. Recording Data (with sheets, etc.) ---------- 31

II. THE FOREST.

A. THE STAND: BY TYPES ---------- 33

1. General Conditions ---------- 33
2. The Pure Norway Pine Type ---------- 34
3. The Pure White Pine Type ---------- 37
4. The Mixed Pine Types ---------- 39
5. The Mixed Hardwood Type ---------- 40
6. Pure Hardwood Types ---------- 41
Birch ---------- 41
Aspen ---------- 42

B. THE GROWING STOCK. ---------- 42

C. THE AGE CLASSES ---------- 43
The age class map ---------- 44
Limits of the age classes ---------- 44
Present distribution of age classes ---------- 45

D. INCREMENT ---------- 46

Quality increment ---------- 46
Price increment ---------- 46

III. TREATMENT OF THE FOREST TO SECURE SUSTAINED YIELD.

A. THE OBJECTS TO BE ATTAINED IN MANAGEMENT ---------- 47

1. The General Policy of the Forest Service -------- 47
The production of saw logs ---------- 47
To put the land to its best use ---------- 47
To preserve the present attractiveness ------- 47

B. THE SPECIES TO BE USED IN MANAGEMENT ---------- 48

1. The White Pine ---------- 48
2. The Norway Pine ---------- 48
3. Other Species ---------- 48

C. THE SILVICULTURAL METHODS RECOMMENDED ---------- 48

1. A Discussion of Various Possible Methods -------- 48
   The seed tree method ----------, 49
   The shelterwood system ---------- 50
   Clear cutting and planting ---------- 51
2. The Silvicultural Systems Recommended ---------- 53
3. The Rotation ---------- 54
   Factors affecting the choice of a rotation -- 54
   Technical vs. financial rotation ---------- 55
   The rotation age ---------- 56
4. Marking Rules ---------- 56
5. Brush Disposal ---------- 57

IV. THE REGULATION OF THE YIELD.

A. THE NORMAL GROWING STOCK ---------- 58

1. The Determination of the Normal Growing Stock in a Mature Forest ---------- 58
2. Discussion of Methods of Determining the Normal Growing Stock ---------- 59
3. The Normal Growing Stock ---------- 60

B. THE YIELD ---------- 63

1. Difficulties in the Determination of the Yield -- 63
2. Determination of the Annual Yield.---------- 64
3. Distribution of the Surplus Growing Stock ------- 65

C. DISTRIBUTION OF THE YIELD ---------- 66

1. The Division of the Island into Compartments and Sub-Compartments ---------- 66
2. The General Stand Table ---------- 67
3. Cutting Plan for Working Period ---------- 68
   a. Table showing areas and amounts to cut yearly.

V. ADMINISTRATIVE PLAN.

General Recommendations for the Proper Administration on Star Island When Placed under Management as above Outlined ---------- 69

APPENDIX.

SECTION 1.

PRELIMINARY MATTERS.

(A) LOCATION AND SIZE.

Star Island lies in the midst of Cass Lake in the Minnesota National Forest. It is located in the western portion of the lake, and is some distance from the mainland at all points except in the northwest part where only a narrow stretch of shallow water separates the two. The Island is situated about 2 miles due north of the town of Cass Lake, the headquarters of the Forest, with which it is connected by a submerged telephone. During the summer months numerous launches ply between various points on the Island and the docks at Cass Lake, and in the winter communication is maintained on the ice.

Originally the tract was known as Cooper's Island and on many government maps it is still so designated; to the people living in the vicinity it is generally known as Star Island, so called from its shape which is roughly that of a star, having five main prongs extending more or less prominently into the lake.

Star Island comprises approximately 1175.5 acres, of which 185 acres are included within the boundaries of Lake Helen, a body of clear, shallow water lying in the northeastern part. Swamps and marshes occupy an area of about 186.2 acres. The portion of the Island above high water and upon which merchantable timber is found, comprises 804.3 acres or about 66.5% of the total area within its boundaries.

The shore line is remarkably regular and very extensive, the latter due to the numerous long projecting points. To one unfamiliar with the Island, it appears much larger than it really is. From the end of one point to the tips of others on the opposite side, is a journey of several miles.

(B) HISTORICAL CONSIDERATIONS.

Star Island is a very important part of the Minnesota National Forest, for it is one of the tracts upon which the timber shall remain uncut when the lands now within the Forest boundaries are formally turned over by the Interior Department to the Forest Service.

The history of the Island, in so far as it is of importance in forest management, is coincident with that of the larger unit. The early happenings are of no special interest from a forestry standpoint and will not be considered in this treatise.

(1) The Creation of the Minnesota National Forest.

The Minnesota National Forest was created by an act of Congress, approved, June 27, 1902, and enjoys the distinction of being the only National Forest originating in that manner. All other Forests were created by presidential proclamations under the Act of March 3, 1891. The law first above named is known as the "Morris Act", and was a law amending Section 5 of an act approved January 14, 1889, relating to the affairs of the Chippewa Indians. The "Morris Act" has been superceded by later legislation but

it is of sufficient historical interest to deserve mention, and its principal provisions are set forth below. After having made provision for the cutting of the pine timber standing upon the Indian reservations involved there follows:

"Provided further, That in cutting the timber on two hundred thousand acres of the pine lands, to be selected as soon as practicable by the Forester of the Department of Agriculture, with the approval of the Secretary of the Interior, on the following reservations, to wit, Chippewas of the Mississippi, Leech Lake, Cass Lake, and Winnebigoshish, which said lands so selected shall be known and hereinafter described as 'forestry lands,' the purchases shall be required to leave standing five per centum of the pine timber thereon for the purpose of reforestation, as hereinafter provided, said five per centum to be selected and reserved in such manner and under such rules and regulations as may be prescribed by the Forester of the Department of Agriculture and approved by the Secretary of the Interior: Provided further, That there shall be reserved from sale or settlement the timber and land on the islands in Cass Lake and in Leech Lake, and not less than one hundred and sixty acres at the extremity of Sugar Point, on Leech Lake, and the peninsula known as Pine Point, on which the new Leech Lake Agency is now located, which peninsula approximates seven thousand acres, and in addition thereto ten sections in area on said reservation last aforesaid, to be selected by the Forester of the Department of Agriculture, with the approval of the Secretary of the Interior, in lots not less than three hundred and twenty acres each in contiguous areas, and nothing herein contained shall interfere with the allotments to the Indians heretofore and hereafter made. The islands in Cass and Leech lakes and the land reserved at Sugar Point and Pine Point Peninsula shall remain as Indian land under the control of the Department of the Interior."

"Each purchaser (of Indian timber) ..... shall cut clean and remove all the merchantable pine timber, whether green or dead, standing or fallen ..... and to cut no timber other than pine ..... except such as may be absolutely necessary in the economical conduct of the logging operations."

The following is the section creating the Forest:

"After the merchantable pine timber on any tract, subdivision, or lot shall have been removed, such tract, subdivision, or lot shall, except on the forestry lands aforesaid, for the purposes of this Act, be classed and treated as agricultural lands, and shall be open to homestead entry in accordance with the provisions of this Act: Provided,

That on the forestry lands aforesaid, as soon as the merchantable pine timber now thereon shall have been removed from any tract, subdivision, or lot, as herein provided, such tract, subdivision, or lot shall, without further Act, resolution, or proclamation, forthwith become and be part of a forest reserve, the same as though set apart by proclamation of the President in accordance with the Act of Congress approved March third, eighteen hundred and ninety-one, and subsequent laws amending and supplementing the same, and shall be managed and protected in accordance with their provisions and the rules and regulations made and to be made in furtherance thereof: And provided further, That on said forestry lands aforesaid said pine timber shall be cut clean, except as to the five per centum as hereinbefore provided, and removed under the supervision and direction of the Forester of the Department of Agriculture, in accordance with rules and regulations to be prescribed by him and approved by the Secretary of the Interior, and the said Forester shall have power at all times to patrol and protect said lands and forests, and to enforce all rules and regulations made by him as aforesaid."

Provision is made for the blocking up of the Forest by allowing the selection of agricultural lands within the National Forest boundaries to the extent of 25,000 acres, which land shall not subsequently be opened to settlement or entry.

The law of January 14, 1889, relating to the affairs of the Chippewa Indians was again amended by the act approved, May 23, 1908. This legislation accurately defines the boundaries of the Minnesota National Forest, and is the one under which the affairs of the Forest are now being conducted.

The first section of the act sets forth clearly the Forest boundaries which are as shown on Map A, accompanying this treatise. The 10 sections mentioned in the earlier law upon which the timber is to be reserved from sale are expressly confirmed as part of the Forest. The islands and points in Cass and Leech Lakes, reserved in the original

act creating the Forest and placed under the jurisdiction of the Interior Department, are specifically included within the National Forest boundaries.

The cutting of the timber within the Forest is provided for in the following:

"The Secretary of the Interior is hereby authorized to proceed with the sale of the merchantable pine upon the above described lands outside of the 10 sections, said islands and points ..... and reserving 10 per centum of such timber from sale, said 10 per centum to be designated by the Forester of the United States Department of Agriculture; and as to the timber on said 10 sections and said islands and points the said Forester is authorized, under such rules and regulations as he may prescribe from time to time, to sell and dispose of so much of the standing timber thereon as he may deem wise and advisable in the conduct of a National Forest."

A commission is provided for, which shall appraise the pine timber left standing on the Forest after lumbering operations shall have been completed - the 5% and the 10% left standing for seeding purposes, and the reserved timber on the 10 sections, islands and points - and the amount finally determined upon, together with a sum to be paid for the land at $1.25 per acre shall be paid by the Secretary of the Treasury into the fund held in trust for the Chippewa Indians. Provision is made in the law for the purchase of Indian allotments located within the Forest, out of moneys derived from the sale of forest products which may properly be disposed of by the Forest Service.

A careful study of the above legislation reveals the following:

The Minnesota National Forest includes within its boundaries 294,000 acres of land, from all of which, with

with the exception of the 5% provided in the first act and the 10% provided in the act of May 23, 1908, reserved for seeding purposes, and the 10 sections and the islands and points in Cass and Leech Lakes, the merchantable pine timber has been or is now being removed. The hardwoods on the entire tract were reserved from sale and this timber goes with the land at a total price of $1.25 per acre. Upon the completion of the cutting of the pine timber within the boundaries of the Forest, the Indians will be paid for the pine remaining and the land out of funds in the treasury of the United States. The cutting of the timber will be completed in the year 1918, and until that time the work on the Forest will be largely protective, together with some nursery and planting work. Larger operations cannot be undertaken since the area is not yet fully under the control of the Forest Service. The Forest has been organized since its creation in 1902.

(2) Alienations.

Star Island is not all government land. Prior to the creation of the Forest, two allotments had been made to Indians on the tract. Fortunately, however, the allotments are small ones, and they will not seriously interfere with the proper management of the area. In this working plan they have been included as part of the tract to be placed under silvicultural management. Provision was made in the act creating the Forest for the purchase of allotments, and it is quite likely that the Government will subsequently come into possession of these alienated areas. The allot-

ments embrace about 50 acres in the south portion of the Island. One is owned by an Indian woman, and the other, occupying a beautiful hardwood point overlooking the lake, is the property of the "Soo" railroad. The Company had planned to erect a summer hotel on the land but have abandoned the project. The alienated tracts are shown in color on the topography and improvement map accompanying this working plan.

Several small areas on the high point extending northeastward were cleared for farming purposes by the Indiams, but have long since been abandoned. The land is now covered with an open stand of sumac and other shrubs, and small trees, but the evidences of cultivation are still plainly visible. These areas are not allotted but remain a part of the Forest.

(3) Early Surveys.

The townships within which Star Island lies were surveyed years ago, and the original survey lines are difficult to trace. The corner common to sections 1, 2, 35 and 36 on the township line was located almost exactly, since three of the original bearing trees are yet standing and the markings upon them may be easily discerned. The quarter corner one-half mile west was also approximately located. The township line across the entire island was retraced and tagged and made to serve as a base line for the reconnaissance work which followed. No corners other than the two mentioned above were located.

The Island, although comprising less land than is contained in 2 full sections, is so located that there are

within its boundaries parts of eight different sections, lying in two townships. The bulk of the area lies within Section 34, Township 146 North, Range 31 East, 4th P.M., as may be observed from the table below:

The Land Included within the Boundaries of Star Island Listed by Legal Subdivisions.

Township 145 North, Range 31 East, 4th P. M.

Section 1	19.6 acres.
Section 2	120.0 "
Total in township	139.6 acres.

Township 146 North, Range 31 East, 4th P. M.

Section 25	61.5 acres.
Section 26	29.6 "
Section 27	121.5 "
Section 34	92.0 "
Section 35	551.0 "
Section 36	180.3 "
Total in township	1035.9 acres
Total acreage of Island	1175.5 "

Surveys have been made of Cass and other lakes at the headwaters of the Mississippi, to determine their value as reservoirs for storage purposes. Evidences of these surveys are not often encountered, and they have no particular value in forest management.

(4) Early Uses of the Forest.

The forest on Star Island is a virgin tract of pine and hardwood timber. Previous to 1902 when it was taken over by the Forest Service the Island was a part of the Cass Lake

Indian Reservation, under the jurisdiction of the Department of the Interior. It was simply a tract of wild land owned by the Indians, and sufficiently out of the path of beaten travel that it was only rarely visited. The Indians along about the middle of the last century cultivated small patches of land in the north east corner. The hard maples on the south side of the Island are badly injured through the yearly crude tapping of the trees to obtain the sap for syrup and sugar making. The wooded areas are annually visited by Indians and others during the berry season and great quantities of blueberries and raspberries are gathered for home consumption and the market.

(5) Present and Future Uses of the Forest.

Within recent years the Island has become quite a popular summer resort. Along the south beach and on the bluffs of the east and west sides, many summer cottages have been built by people living in Cass Lake and other near-by towns. A large hotel affords accommodations to transient summer visitors. The value of the tract as a resort is largely due to the primaeval forest which it bears, and it is the policy of the Forest Service to maintain this condition perpetually. The plan for the silvicultural management of the Island as outlined in succeeding pages does not take into account the value of the forest from an aesthetic or recreative standpoint, but treats the area purely as a tract upon which timber is to be perpetuated for its principal value, that of producing wood supplies. All other

uses of the forest will be subordinate to silvicultural management.

(6) The Revenues Derived.

The revenues derived from the sale of timber consists in the money received from one sale of dead, down and diseased timber, approximately 1,000,000 feet b.m. made in 1907. Except for one or two small areas cut clean on account of insect infestation and which are not now regenerating, there are no evidences of this early sale. The money derived from the sale was paid into the treasury of the United States for the benefit of the Indians.

The Forest Service receives an annual rental of $5.00 for each lot upon which summer residences have been erected. No other revenues are derived from the Island. The expenditures to date have not been large. A ranger station costing about $500.00, a very serviceable dock extending 60 feet into the lake, a submarine telephone line, and a few trails, constitute the principal improvements constructed by the Forest Service in recent years.

(C) GENERAL PHYSIOGRAPHIC FEATURES.

(1) Topography.

Star Island may be divided topographically into three general types: highland, lowland or plain, and marsh land or swamp. Although the greatest elevation found is less than fifty feet above the level of the lake, the types are generally sharply defined.

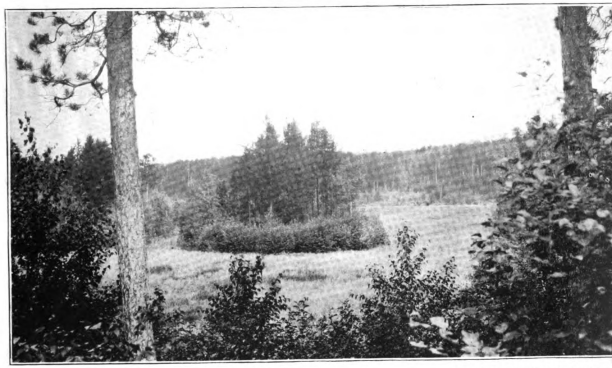
The highlands comprise the higher parts of the Island, of which there are three main bodies: the long and nar-

row point which stretches northeastward into the lake; a well defined area in the southeastern portion; and a wide strip extending across the central part of the Island, occupying roughly one-third of the whole area. Besides these main bodies there are a few small isolated tracts having lower elevations. The highlands are usually flat-topped, or at least only gently sloping and show but little variation in elevation. Their slopes are uniformly very abrupt along the lake shore - much more abrupt than the lines on the contour map indicate - but landward they are often gentle and there is no sharp line of demarcation between the highlands and the flats.

The highland type in the west half of the island is badly broken by numerous small swamps, marshes and "pot-holes", and consequently the general topography is very irregular.

The lowland or plains type occupies a much smaller area than the highlands. They comprise all the low flat areas which do not normally overflow, and, therefore, support a typical dry-land flora. The majority of the flat lands range in elevation from 15 to 5 feet above the normal lake level. They are characteristically horizontal or at least only gently sloping, and lie between the higher areas, or at one side along the lakes.

The swamps of the Island may be either artificial or natural. Dams placed across the Mississippi lower down in its course have caused the lake to rise several feet and remain at this stage for long periods. Many areas along



Photographed by Prof. G. B. MacDonald

A peat bog with Tamarack and Black Spruce forming an island on Star Island.

COURTESY, FOREST CLUB ANNUAL. I.S.C.

the shores of the lakes which formerly supported typical dry land vegetation are inundated, and are rapidly taking on the appearance of true swamps. The majority of the low areas, however, are natural and support typical swamp vegetation.

There are four distinct types of swamps on the Island: (1) the true marsh with its dense growth of sedges which constitues the bulk of the low areas; (2) the heath bog, of which there are only one or two; (3) the willow swamp; and (4) the low areas once tree clad, but now semi-swamp due to the rise of the water level. The three types first names are entirely unproductive from a forestry standpoint. The overflowed areas can be reclaimed by lowering the general level of the lake.

The swamps are the only areas on the Island incapable of producing valuable tree growth. They are found in all parts of the area, and range in size from the merest patch of green at the bottom of a pothole, to tracts several acres in extent, along the lake shores, especially in the northwestern part. The total amount of swamp land within the boundaries of the Island is approximately 186.2 acres.

(2) The Surface.

The surface of the Island is everywhere smooth. There are no exposed rocks, cliffs or outcrops, and no loose surface rocks of any description. At the foot of the high banks along the lake shore, particularly of the long point extending northeast, large boulders are numerous but are only noticeable during low stages of water.

The merchantable down timber from windfalls and fire was sold a few years ago, and the ground is now comparatively clean except on certain exposed areas which were badly hit by a severe storm that blew down large numbers of trees in June, 1914.

(3) Drainage.

The generally low or gently sloping central portion of the Island, which comprises the bulk of the area, is very poorly drained. There are no evident watercourses on the tract. The total precipitation, unless very heavy, is absorbed immediately by the loose, sandy soil. Erosion is nowhere serious enough to be noticeable, even on the steepest slopes. A large part of the rainfall drains into Lake Helen and the numerous marshes and swamps, and eventually into Cass Lake. On account of the very porous condition of the soil, areas but a few feet above lake level are sufficiently well drained to permit the full development of forest vegetation.

(4) Soil Conditions.

The soil is fairly uniform in composition on each of the various sites. It is of glacial origin, and the coarse sand drift is evident on all parts of the Island. Sand of various degrees of fineness composes the bulk of the soil. Gravel is not commonly found on the surface, although the coarser sands are plentiful especially on the lower areas.

On white pine sites, which include all the higher elevations of better soil, the sand has a large percentage

of clay in mixture and might be termed a light, sandy loam. The surface 2 or 3 inches of soil contains much humus in varying degrees of decomposition, the result of the heavy leaf fall and litter of the generally dense stand of underbrush and inferior hardwood species - birch and poplar. Uprooted trees expose a subsoil of a darker color, compact and firm, and containing large quantities of clay. The subsoil lies from a foot to 2 feet below the surface, and is often very hard and almost impervious to moisture.

Generally speaking, the best soil on the Island is found on the high areas covered with hardwoods and white pine. The hardwood soil is the richer, due to the greater quantities of humus and its superior physical condition.

On the lowland type the soil is almost pure sand. Where Norway pine predominates it contains practically no humus, due in part to the numerous early ground fires. On areas largely covered with braodleaf species, humus is much more plentiful and the soil is richer and in good physical condition.

The swamps and marshes have typical bog soils, underlain with gravel or sand. The raising of the lake level by damming the outlet, keeps the areas continuously boggy and the surface is so soft in many places that it will not sustain the weight of a man in walking.

(5) Climate.

The climate of northern Minnesota is similar to that of other northern regions. The seasons are definite; the winters are long and severe, the summers generally short

and hot. Spring and Fall are delightful seasons; the weather is fine and the surroundings beautiful.

The winter temperature often reaches very low marks - 30 and 40 degrees below zero are not uncommon. Snow falls in November and covers the ground until March or April, often becoming several feet deep. Excluding periods of extreme cold weather, the winters are ideal for carrying on logging operations.

Summer temperatures are extremely variable. Periods of exceedingly hot weather are common, the thermometer during these times frequently recording 100 to 110 degrees Fahrenheit. Cold spells are just as frequent, and for days at a time during the height of the season the weather is uncomfortably cool.

The precipitation is not as great as it is farther south in the state. The normal amount is 25 inches for the region about Cass Lake. The distribution of the precipitation throughout the year varies greatly. A large amount of rain fell during the summer of 1914, but during the fall and winter of 1914-15 the precipitation was rather light. Summer rains are usually thunder showers following hot periods, but occasionally seasons of foggy weather set in during which rain is almost continuous for several days. Such periods are very uncomfortable, as with the rain the temperatures drop, and the wind usually blows. There is sufficient precipitation for ordinary tree development during the growing season; during the early Spring and the entire Fall dry seasons are common, however, and the Forest must be closely guarded to

prevent the starting of fires.

Winds are almost continuous during the summer season. The general direction of the winds is westerly. Southwest and south winds are common and often blow for days at a time. Strong winds are frequent and occasionally do considerable damage. Such a storm the last week in June, 1914, uprooted a large number of partially protected Norway pines and broke off many others. North winds frequently blow, but are not strong enough to do any damage. In forest management, consideration must be given to the west and southwest winds, and cutting series arranged accordingly to prevent windfall.

(D) SOCIAL AND INDUSTRIAL CONSIDERATIONS.

(1) Population.

The Minnesota National Forest lies in a rather sparsely settled portion of the state. The dearth of population in the region is due to two principal causes: the generally sterile soil making agriculture of minor importance, and the large areas of land within Indian reservations which have not yet been opened to settlement. Star Island, however, is located near the town of Cass Lake which has a population of 2,000 inhabitants, and near three lines of railroad, making it easy of access from outside points and providing a means of transportation of forest products.

The people living in the region tributary to Cass Lake are mostly white or Indian or of mixed blood. Negroes and other races are very seldom encountered. The local white population with the exception of the woodsmen is permanent,

living in the towns or on small farms. The woodsmen are largely of the newer type, foreigners from the south of Europe, and are not stable but move about from camp to camp as circumstances warrant or inclination dictates. Indians and local whites fill the positions requiring skill, the foreigners doing a large part of the common labor.

Indians and mixed bloods are very common, particularly on and near the reservations. As a whole, they are shiftless and unreliable and the appearance of their farms and homes indicates woeful lack of thrift.

The town population is generally engaged in business pursuits, or at the mills. The people residing away from the settlements are either small farmers or woodsmen. The lumber industry is by far the most important of all the industries in and about Cass Lake. A large part of the population is dependent upon woods and mill operations for a livlihood.

Agriculture is not highly developed on the Forest or anywhere in its immediate vicinity. The soil is typically sandy and unfit for the growing of farm crops. The few farms encountered, outside of those on especially favored areas of hardwood land, or other selected locations, produce very light yields. The entire region is typically forest land and it should be largely used for forest purposes.

Grazing is limited to the ranging of a few head of Indian ponies, cattle and other live stock, and is of no special importance. There are no minerals on the Forest, therefore, no mining or related industries.

Manufacturing is confined to the production of lumber and other wood products. This phase of forestry is taken up fully elsewhere in this treatise.

(2) Dependence of Inhabitants on National Forest Industries.

The local population is not dependent on the National Forest for work, fuel or timber, at the present time. The adjacent forests, although but remnants of the original stands, contain large quantities of timber chiefly, however, of inferior species, hardwoods and jack pine. These will supply for a long time the needs of the local residents, except for the better grades of material which must be obtained elsewhere. The state forests recently authorized will soon be placed under administration and management and will, no doubt, supply a large part of the local demands in future years.

(3) The Lumber Industry.

The lumber industry is highly developed in all its branches on the Minnesota National Forest and in the adjacent region. The Forest is now being logged of all its merchantable pine timber except the 10 percent reserved for seeding purposes. The work will be completed in about four years.

(a) Lumbering.

Logging begins in the late Summer or early Fall and continues until the warm weather of Spring destroys the ice roads over which the logs are transported from the woods to the landing. The necessary work preliminary to logging, such as camp construction, road and bridge building, etc. is done in the early Fall when conditions are most favorable. Later on the trees are felled, bucked and skidded to the main

roads and spurs and decked. When the roads have been properly prepared, and the foundation of ice sufficiently solid to support the heavy sleighs, hauling to the landing begins. The topography of the region is usually gentle, and logging sleighs on ice roads are a cheap as well as effective means of delivering logs to the landing. Timber is generally hauled to a lake or river and driven to its destination in the spring. On the larger bodies of water it is often rafted.

Logging on Star Island is a very simple problem. No portion of the timbered area is farther than 40 chains from the shore of Cass Lake. Practically all of the logs may be skidded directly to the water. It may be advisable, however, to haul a large part of the timber to the landings because of deep snow in the winter season, or to decrease the damage to reproduction.

The cost of logging will depend largely on two factors: the size of the area logged and the method of cutting. If clear cutting is practiced (and this is the principal method to be employed during the first period) and the amount to be logged is considerable, the timber may be removed at a profit for $3.00 per M. A few years ago (1907) about a million feet of scattering dead, down and insect infested timber was removed from the Island at a contract price of $5.00 per M delivered in the lake, and a fair profit was realized by the logger.

The items and approximate cost of each in logging Star Island are as follows:

Felling and bucking ----------	$ .50
Swamping ----------	.25
Brush disposal ----------	.25
Skidding ----------	.60
Loading ----------	.25
Hauling ----------	.25
Overhead (Depreciation, etc.)-	.40
Profit ----------	.50
Total ----------	$3.00

The building of the necessary roads is included under swamping and hauling. If no hauling is done the cost of skidding will be proportionally increased. Logging roads on the Island will be short and of very simple construction - no icing being necessary.

The labor employed in the woods will be entirely local, and will probably be largely Indian. Indian labor is plentiful but not efficient or reliable. In the cutting of timber from the reservations in the vicinity of Cass Lake, contractors are required to employ Indian labor wherever practicable. It is likely that Indians will have to be employed in greater numbers as the timber becomes scarcer, because of the tendency of white woodsmen to emigrate to other regions where forests are more extensive. It is probable that local labor will always be sufficient to carry on the logging and other operations incident to future forest management on the Minnesota National Forest.

The wages paid woodsmen at present are very reasonable. During the winter of 1914-15, labor was especially

plentiful, and good woodsmen were hired at wages as low as $15.00 per month and board. Ordinary woodsmen receive from $20.00 to $30.00 per month; teamsters, $32.00; loaders, $35.00; cooks, $65.00; and camp labor, $15.00 to $25.00, all with board and quarters included.

(b) The Value of Stumpage, and Prices Paid for Logs.

Standing pine timber has risen steadily in price since the beginning of lumbering in Minnesota. The early prices received for pine stumpage were much lower than those received in neighboring states during the same periods, due to the fact that lumbering operations began much later in Minnesota than in the states farther east. The prices received for white pine stumpage by the state during the past thirty-five years, shows well the upward tendency of values of standing timber:

Year								
1880 -	Average	price	received	per	M.	feet	-----	$1.47
1885 -	"	"	"	"	"	"	-----	1.73
1890 -	"	"	"	"	"	"	-----	2.25
1895 -	"	"	"	"	"	"	-----	2.18
1900 -	"	"	"	"	"	"	-----	5.17
1905 -	"	"	"	"	"	"	-----	7.18
1909 -	"	"	"	"	"	"	-----	7.53

The minimum price for pine stumpage, largely Norway, considered by the Interior Department for the timber on the Chippewa Indian Reservation was $4.00 per thousand feet. The bidding was very lively and the timber sold at a price much above this figure.

The pine timber on Star Island is very favorably located and for this reason will command a higher price than timber less accessible. White pine, because of its large size and good quality, will bring at least $12.00 per thousand, standing; Norway pine, $10.00; and jack pine, $4.00. The prices received for choice logs in the pond at Cass Lake are, for white pine, $16.50; Norway, $15.00; and jack pine, $9.00 per thousand feet. Considering the cost of delivering the logs cut from Star Island from the stump to the storage boom at the mill as $2.75 (exclusive of profit) per thousand feet, the profit of the contractor as 15%, and the prices received for the logs as stated above, the true value of the stumpage at the present time is $12.03 for white pine; $10.28 for Norway; and $5.08 for jack pine. Owing to the decreasing supply of pine timber in the region, logs are selling at a price nearly equal to their true value. As timber becomes scarcer, the price of stumpage is sure to rise until it reaches a figure equal at least to the cost of growing the trees artificially plus a fair percentage on the money invested, and possibly a small profit. The future prices will surely equal those received in European countries for timber similarly produced.

(c) Markets for Forest Products.

Markets for rough forest products will never be lacking. The large saw mill at Cass Lake will be dismantled in a few years, probably before 1920, but smaller mills will spring up to saw the timber remaining. The mills at Bemidji, 16 miles distant, are always in the market for pine logs,

and good prices will be obtained. Jack pine, poplar and birch are extensively used at the box factory in Cass Lake. Other hardwood species can also be utilized in the manufacture of box shooks. Tops and defective logs of pine make good box boards.

The hardwood timber of merchantable size will have to be sawn at portable mills, since the large mills now operating do not saw broadleaf species. The maples and basswoods of the larger sizes will cut out lumber of a good quality. There is no material growing upon the Island that cannot be utilized to a top diameter limit of four inches. By installing a chemical plant in or near Cass Lake, practically complete utilization may be effected.

(d) Milling.

The milling operations in the immediate vicinity of the Forest, with lumber as the principal product, is confined to one plant located at Cass Lake, that of the J. Neils Lumber Company. This mill is thoroughly modern and up-to-date in every respect, and has a 2-shift capacity of about 230,000 feet of logs daily. The plant is operated only during the period when the log pond is free from ice, usually from April or May to November. The planing mill usually runs the year through, closing down only occasionally for overhauling and repairs.

Practically the entire log is utilized in the manufacturing operations. The principal product, lumber, is sawn by a single cutting band and a gang. The slabs are resawn to obtain the short boards which they yield. The

larger slabs are picked out of the conveyor and converted into lath. Slabs which will yield box shooks are also removed from the chute. The long edgings are tied into bundles and sold to the Great Northern Railway for kindling. Small slabs are sold as fuel. The sawdust is largely used under the boilers, generally mixed with small solid pieces of wood cut up in the hog. The refuse which finally reaches the burner consists principally of bark and thin edgings. No other mill in northern Minnesota utilizes so large a percentage of the raw materials as does this plant. Incidentally the plant pays the largest dividends of all the mills in the state. The company is now cutting the last of its timber and will probably dismantle its mill within the next five years.

The cost of manufacture is reduced to the minimum, since the handling of material, which at many mills is considered as refuse and sent to the burner, yields a profit or at least pays for the labor necessary in disposing of the same. The cost of converting the logs into lumber, the transporting of the sawn material to the yard and the piling of the boards, is approximately $3.00 per thousand feet b. m. Other items including transportation of lumber from yard to planer, grading, putting lumber through the machines, loading on cars, selling, depreciation, taxes, insurance, supervision, etc., will bring the total milling cost from the pond to the car to from $6.00 to $8.00 per thousand. The total cost of production, from the stump to the car, is, therefore, approximately $10.00 per thousand feet b. m.

(e) The Box Factory.

The box factory is the only other timber using industry in Cass Lake. The plant is equipped with saws for the manufacture of lumber, but the boards produced are short and generally narrow and are used entirely in the manufacture of box shooks. The factory is unique in that each machine in the box making department is electrically driven by means of a small motor, and each may be operated independently of the others. The degree of utilization at this plant is very high, since boards of all widths, lengths and thicknesses may be used in box making. The principal species used are white, Norway and jack pines, spruce, poplar and other hardwoods, and a slight amount of birch.

The first two species mentioned are obtained as slabs from the saw mill. The other timber is bought "in the round" by the cord. A cord of bolts is 8 feet long, 8 feet wide and 4 feet high, and contains 2 standard cords. Often, however, the bolts are cut 5 feet long, and a cord of such bolts contains about 1¼ standard cords. Jack pine and poplar cut this length sells at $4.50 per cord. Jack pine is the principal species used in making box shooks.

The factory operates one shift only and employs a large number of men. Common labor is very largely performed by foreigners from southern Europe. Cold weather is no bar to the operation of the factory, since practically the entire supply of box material is now delivered independently of water transportation.

(f) The Present Prices of Lumber at Cass Lake.

The principal species sawn at the Cass Lake mill is Norway pine. White pine and jack pine are cut in smaller amounts. The jack pine is mixed with the Norway and no discrimination is made in selling. Most of the jack pine, however, is found in the lower grades.

The selling prices of the various grades of Norway pine (including jack pine) during August,1914, are listed below. Accurate prices of white pine lumber at Cass Lake could not be obtained.

Prices of Norway Pine Lumber F. O. B., Yard, Cass Lake.

#1 Dimension SISIE 10'-16' - $23 - 26 per M.

#2 " $2.00 per M. less than #1. Rough $.50 more S4S $.50 more. Timbers and 3" rough 12'-14'-16'.

3x6 & 3x8	$24.00 per M.	4x6 - 8x8	$24.00 per M.
3x10	$24.50 " "	4x10 - 10x10	$26.00 " "
3x12	$25.00 " "	4x12 - 12x12	$28.00 " "
3x14	$27.00 " "	$.50 more SISIE	
4x4	$24.00 " "	$1.00 " S4S	

Boards Rough.

8" No. 1	$31.00 per M.	10" No. 1	$32.00 per M.
8" No. 2	$24.50 " "	10" No. 2	$24.50 " "
8" No. 3	$22.00 " "	10" No. 3	$22.00 " "
8" No. 4	$19.50 " "	10" No. 4	$20.00 " "
1' No. 1	$35.50 " "	4" & under 10-20x3	$21.50 per M.
1' No. 2	$31.00 " "	" " x4	$19.00 " "
1' No. 3	$23.50 " "	" " x5	$15.00 " "
1' No. 4	$20.00 " "		

Rough

4" No. 1	10-14	$29.00 per M.	6" No. 1	-	$32.00 per M.
4" No. 2	"	$22.00 " "	6" No. 2	-	$25.00 " "
4" No. 3	"	$18.50 " "	6" No. 3	-	$21.00 " "

Select.

B & better 12" - $71.00 per M.

B " better 8-10" - $66.00 per M.

C " better 12" - $58.00 per M.

C select 4"-6x8 - $46.00 per M.

D select " - $44.00 per M.

(g) Markets for the Manufactured Products.

The markets for the finished products of the forest are of two classes, local and distant. The local market is limited in extent and at most can only take care of a small percentage of the cut at the present time. With the increase in population, which will no doubt come with the opening of the Indian lands to settlement, much more lumber will be used, chiefly of the lower grades.

The upper grades of pine lumber are sold in more distant markets. White pine "uppers" are used for special purposes, and can compete with other species successfully in almost any part of the country. Cass Lake is a comparatively short distance from markets which absorb large quantities of building material, and only under exceptional circumstances is it difficult to dispose of the common grades of lumber at fair prices. Southern Minnesota, Iowa, Nebraska, the Dakotas and other near-by states are the principal fields in which Minnesota pine is marketed.

Box shooks are sold in distant markets in direct competition with those manufactured much nearer the place of consumption. This condition is due to the low cost of raw material, and the comparatively low freight rates. Chicago, Saint Paul, Minneapolis, Duluth and other large manufacturing centers receive the bulk of the output.

(4) Transportation Facilities and Freight Rates.

Transportation facilities from Cass Lake to distant points are excellent. Two trunk lines of railroad - the main line of the Great Northern from Duluth to Grand Forks, and the "Soo" line from Duluth north and northwestward to Winnipeg - pass through the town. An important branch line of the Great Northern coming from the south terminates in Cass Lake. The excellent means of transportation makes it possible to ship lumber and other wood products with despatch to all points in Minnesota and neighboring states.

Freight rates from Cass Lake to the principal points of consumption are comparatively low. This fact, along with the light weight of the lumber, makes it possible for pine to compete with other woods long distances from the point of manufacture. The rates per hundred pounds from Cass Lake to the principal cities where pine is extensively used are as follows:

Saint Paul ----------	9¢	per 100 lbs.
Duluth ----------	8.1¢	per 100 lbs.
Grand Forks ---------	"	" "
Omaha ----------	25¢	" " "

Des Moines ---------- 20½¢ per 100 lbs.

Milwaukee ---------- 16¢ " " "

(E) A DIGEST OF RECONNAISSANCE FIELD AND OFFICE WORK.

The data used in the preparation of this working plan was largely secured by making an intensive reconnaissance survey of the tract. The work was done principally by forestry students of the Iowa State College during the summer of 1914, under the immediate supervision and control of the writer. The class was divided into five field parties each containing six men. The parties were uniform in size, equipment and division of labor, and the data collected is as accurate and reliable as can be obtained on any reconnaissance similarly conducted.

The method employed was the Forest Service standard strip system of reconnaissance, covering 20% of the area. Each crew consisted of the following units: A compassman who directed the line, carried the front end of the chain and made the type map; a rear chainman who also sketched in the topography; two caliper men, one on each side of the line, who calipered the trees to a distance of 33 feet on each side of the chain; the tallyman who recorded the trees by diameters and species, and also made note of the ground cover and reproduction; the extra man directed the work of the crew and helped with other things when the necessity arose.

A base line was accurately laid out along the township line east and west across the entire Island. This line was well tagged with small pieces of white cloth fasten-

PHOTO, FORESTRY DEPT. I.S.C.

A RECONNAISSANCE CREW AT WORK.

A SMALL SWAMP IN FOREGROUND

ed to the trees by means of common carpet tacks. Beginning at the section corner on this line, a stake was set 2½ chains on each side, and beyond these points stakes were placed every 5 chains along the whole base line. On account of the irregular shape of the area it was necessary to run a line due north 60 chains from a point near the western end of the base line, and then run a secondary line due west to the lake, from which to cover the northern and western portions of the Island.

The unit of area for purposes of the reconnaissance was 10 acres. By placing the stakes on the base line 5 chains apart, two strips could be run north and south through each tier of 10 acre plots, above or below the line. The tiers of plots north of the base line are designated by large letters (capitals). Beginning at the section corner and proceeding westward the letters A, B, C, etc. are employed; eastward along the line the plots are lettered Z, Y, X, etc. The tiers of plots south of the base line are similarly designated, using small letters. The 10 acre tracts north and south of the primary central are numbered similar to townships in the United States surveys. Any full or fractional plot on the Island may be accurately located by reference to its letter and number. Plot E-3 is the third tract north of the base line in tier E. A small letter (e) indicates that the plot lies south of the base line.

The reconnaissance was carried on in a very intensive manner. A crew started either due north or due south from a stake on the base line and continued along this course

until completed, then offset 5 chains and returned to the base line through the opposite side of the tier of plots. In this manner 20% of the area was actually covered. The Forest Service standard compass was used in running all lines. Beginning at a stake the chain was pulled out along the course its full length, and a complete record of all the desired data along that chain was made before proceeding to the next. Since all the data recorded on the reconnaissance were obtained by tallying the trees and observing the conditions on a strip one chain wide, every chain length along the course represents one square chain in the tally. On every square chain all trees above 4 inches D.B.H. were calipered, and the tallies were made by placing the diameter directly in the proper square on the tally sheet. The sheets were provided with a series of 10 squares, each series representing a square chain along the cruise line. The number of squares in the series depends upon the number of species encountered on the strip. Space was always provided for white pine, Norway pine, jack pine, basswood, maple, birch, poplar and oak. Blank spaces were provided for additional species. The last space was reserved exclusively for notes on the reproduction. A partially filled tally sheet better illustrates the form used and the method of recording the data:

SAMPLE TALLY SHEET.

CHAIN	N.P.	W.P.	J.P.		BASS.	MAP.	OAK	BIRCH	POPLAR	REP.
1	6 18 7 21 5 17 9 24	5 21 8 9	6 12 6 7 8							.2 N.P.-60 W.P. 40 1'-3'
2	18 17 14 23				7 9 8			5 6 5 6 7 9 8 13	8 7 6 7	.7 N.P.80
3					9 4 15 8 13 6	5 9 6 12 7	4 13 9 7 6			.6 MAP 75 BASS 20
4	18 24 16 14							5 7 6 6 5 7 7 4 8 8 9 9	5 8 7 9 6 4 9 8 7 4 6 5	NO REP. BIR. POP.
5										
6										
7										
8										
9										
10										

Each tally sheet represents one-half of a 10 acre plot and the half covered is indicated at the top of the sheet. Plot E-5-W indicates that the tally sheet is for the west half of plot E 5. The direction of the line is always noted on the tally sheet. This enables one to locate every square chain in the tally with precision.

The tally man recorded the trees and made a note of the density, height and composition of the reproduction for every chain. The density was graded by tenths and hundredths, 1.0 being perfect. The composition was noted in percents, and the height in feet and inches. When possible, age was substituted for height. The rear chainman took elevations at every chain length, recording them on his map sheet and sketching in contours at 5 foot intervals. The compassman noted on his map sheet the changes in forest types along the line. The resulting data was compiled in the form of maps and estimates by the writer, copies of which accompany this thesis. All estimates were compiled by using volume tables best suited to the timber on the tract. These were wholly or partly constructed by measuring fallen trees on the Island and rounding off the results by curves. The volume tables used may be found in the appendix.

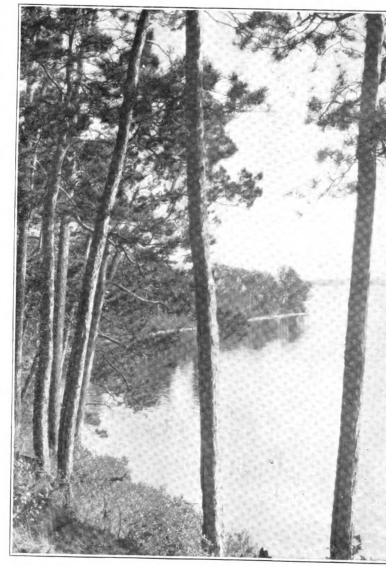
SECTION 11.

THE FOREST.

(A) THE STAND: BY TYPES.

(1) General Conditions.

Star Island is entirely forested save for small areas of swamp scattered here and there and a small cut-over



Photographed by Prof. G. B. MacDonald
Norway Pine, shore of Lake Helen, on Star Island.

COURTESY, FOREST CLUB ANNUAL.
I.S.C.

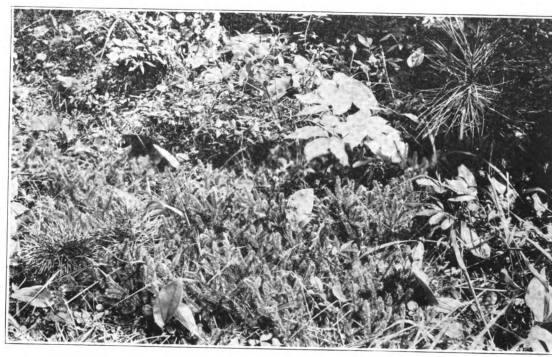
tract which has not yet restocked. The principal species found, white pine, Norway pine and jack pine, occupy more than 60% of the forested area. Hardwoods,- sugar maple, basswood, red and burr oaks, elm, ash, birch and aspen - comprise the remainder of the stand. Birch, aspen and basswood are often found in pure stands but are much more common in mixture with other hardwoods and pine.

In the reconnaissance detailed information was secured which made it possible to clearly define the forest types to show every change in the composition of the stand. The types indicated on the General Type Map give one a good idea of the present status of the forest. Many of the types are temporary only and will be replaced by more permanent ones, so that at the end of the first working period the inferior stand will have largely disappeared.

The principal types shown are the pure Norway pine type; the pure white pine type; the mixed pine type; the mixed hardwood type; and the pure hardwood types. Each of the foregoing will be taken up and analyzed to determine its present condition.

(2) <u>The Pure Norway Pine Type</u>.

Norway pine in pure stands occupies a large part of the forested area of the Island. There are two general sites upon which the species is found: the high bluff land and the rolling areas adjacent in the western half of the tract, and the low flat areas lying between Lake Helen and Cass Lake. Scattering trees of large size are found along the borders of the white pine type and in mixture with hard-



Vegetation in Norway Pine woods- Club Moss (Lycopodium) and False Solomon Seal on Star Island.

COURTESY, FOREST CLUB ANNUAL. I.S.C.

TYPICAL GROUND COVER,

woods on the better sites. These are not growing on typical Norway soil, hence a detailed description of the site is unnecessary.

The surface of the ground in the pure Norway stands is very smooth. There are no rocks, and fallen trees are not common. Repeated fires have burned over the ground in the past and most of the litter and smaller windfalls were entirely consumed. The merchantable dead and down timber was removed a few years ago.

The soil is typically sandy. For the first ½ inch or inch in depth, it is dark in color, due to the partly decayed leaves and humus in mixture. Below this is almost pure sand, varying in texture from fine to very coarse. On the better sites the sand is mixed with a small amount of clay. Where the timber forms a complete or nearly complete canopy, the ground cover consists of shade enduring plants, chief of which are the following: Blueberry, wintergreen, brake, ground pine, aralia, etc. In the more open stands dogwood and hazel brush form the principal ground cover. The brush and litter is everywhere so dense that reproduction is impossible.

The timber is largely mature to over-mature on the whole type. A few areas in the northwest part of the Island are under 80 years of age and are in a very thrifty condition. Repeated surface fires have scarred the bases of the trees, but the damage does not extend beyond stump height.

The average size of the trees ranges between 12

PHOTO BY FORESTRY DEPT. I.S.C.

A GOOD STAND OF YOUNG NORWAY

STAR ISLAND.

and 20 inches. The average height is about 90 feet. Analyses of several trees of merchantable size disclosed the fact that the bulk of the timber is over 200 years old. The condition of the stand is generally decadent. The yield is actually falling off each year due to rot and occasional windfall. The yearly increment is not equal to the natural loss incident to old age.

The quality of the timber has reached its highest point and is probably actually deteriorating. The trunks are usually rough, knotty and show other imperfections which affect the quality of the lumber produced. On the typical Norway areas the quality of the timber is about an average for the species. The large trees growing on the better sites are tall, straight, full-boled, and free from visible defects. The crowns are short, and the timber will cut a high percentage of the upper grades. In estimating Norway pine, 5% is allowed for defects which cannot be seen by a superficial examination.

Norway pine reproduction is sufficient to reproduce the stand only on a few favored areas. The young trees are uniformly thrifty and in good condition. Under dense stands there is very little reproduction. The possibility of natural regeneration on these sites under exisiting conditions is very slight. The trees are too old to produce seed in abundance, and the few seeds which fall cannot germinate because of the heavy ground cover and insufficient light. With one or two exceptions the whole type will probably have to be regenerated artificially when the stand is cut. The reproduction map accompanying this working plan shows in detail the extent, location, composition and size of the reproduction found on the

Island.

(3) The Pure White Pine Type.

White Pine forms only a small part, both in area and amount, of the timber on the tract. The one large area of this species is located along the east shore of the Island, occupying the highest, richest ground on that side. Smaller areas are to be found on the better soils in other localities.

The surface in the white pine type is usually exceptionally smooth. There are no rocks and only few windfalls.

The soil is of fair quality. The amount of humus in mixture is quite large, owing to the heavy stand of aspen, birch and hazel brush growing underneath the pines. Below the humus clay is found in admixture with the sand, forming a soil best described as a light sandy loam. The presence of the humus and litter in the soil puts it in excellent physical condition. A subsoil of a darker color underlies the loam at a depth varying from one to 2 feet below the surface.

The brush is so thick in the white pine type that grass, herbs and weeds are prevented from growing on these sites. Hazel brush forms the principal ground cover. This brush completely covers the ground and reaches a height of from 6 to 10 feet. Under denser cover hazel gives way to smaller shrubs, in more open condition.

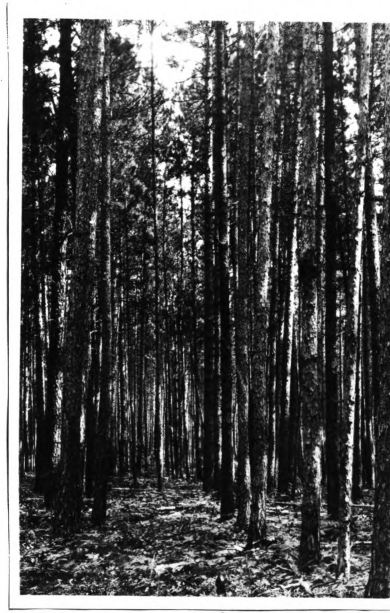
The white pine timber is uniformly overmature and decadent. It has long passed its prime and should be removed.

Large fallen trees are badly affected by rot. The yearly increment is not equal to the decay, and the value of the timber is actually decreasing each year it is left standing. The largest trees calipered measured 46" in diameter. Trees above 30 inches D. B. H. are very common. The average height of the trees is from 110-130 feet. The merchantable timber will scale upwards of 500 feet per tree, and the logs will run about 4 to 8 per thousand feet, b. m.

The stand is very open, due to the advanced age of the timber and is becoming more open every year. An understory of birch and poplar quickly fills in the openings caused by windfall, and the forest is gradually changing in composition.

The quality of the timber, judging from outside appearances, is very good. The large trees will probably produce a high percentage of "uppers", even though the heart be defective. The crowns begin high in the tops and are short, making high utilization possible.

There is practically no white pine reproduction on the type areas. Young hardwoods form the bulk of the new growth. The great problem confronting the forester is how to get white pine areas restocked with the species. The only solution seems to be to plant up the cut-over lands as soon as practicable after logging, handling the details as they arise. White pine apparently grows well under the open stands of Norway and where the soil is adapted to its growth, it is well to foster such reproduction. A notable example of this condition may be seen along the trail from the hotel



PHOTO, FORESTRY DEPT. I.S.C.

A MIXED STAND OF NORWAY AND JACK PINES. THE DENSITY IS INDICATED BY THE ABSENCE OF GROUND COVER.

to Lake Helen, where one small white pine has seeded up about 5 acres of fairly dense Norway. The seedlings are about 8 to 10 years old and are very thrifty.

(4) The Mixed Pine Types.

White and Norway pines often grade into each other along the borders of the types. These stands have, in general, the characteristics of the type which has the greatest number of its trees represented on the area.

The mixed Norway-jack pine type, which is quite extensive in the north and northwestern parts of the Island, has, however, characteristics peculiar to itself, which must be considered.

In general, the surface of the type is smooth. Windfalls are not numerous, owing to the density of the stand. There are no rocks or outcrops or other disturbing elements on the surface.

The soil is the most sterile to be found on the Island. It consists largely of sand with very little humus in mixture. There is no brush on the ground, and the stand has an open park-like appearance. The principal species in the ground cover are ground pine, wintergreen and brake. Needles and small debris form thick mats in places.

The timber is about evenly divided between Norway and jack pine, each battling desperately for supremacy in the stand. The trees are young, ranging in age from 40 to 80 years, and in size from 4 inches to 13 inches D. B. H.

The density is almost 1.0, and already many trees are dying from overcrowding and lack of light. The dominant

PHOTO, FORESTRY DEPT. I.S.C.

AN EXCELLENT STAND OF NORWAY AND JACK PINES ABOUT 80 YEARS OLD.

trees are in a thrifty condition and are carrying their crowns well up above their less fortunate neighbors. the timber is not of very good quality, owing to its youth and the many persisting dead branches. There is very little material in these stands suitable for saw timber, and none of it should be cut for that purpose at present. A little later the majority of the jack pine should be removed to enable the remaining Norway to develop properly.

There is practically no reproduction in this type. None is needed or desirable until near the end of the rotation, since the timber on each area is practically even aged.

(5) The Mixed Hardwood Type.

Mixed hardwoods comprise about 31% of the total productive area of the Island. The principal species are basswood, maple, elm, ash and oak. The three latter woods are not abundant and form but a small portion of the stand. The hardwood type is a typical selection forest with all ages represented. The long point extending northeastward into the lake is covered with a very thrifty young stand of basswood, of even age from sprouts. This timber should be allowed to grow at least through one rotation.

The surface and soil conditions in the mixed hardwood areas are similar to those found in the white pine types. The soil is of a somewhat better quality, due to the larger amounts of humus and clay in admixture with the sand.

The ground cover is light in the dense stands and consists mostly of weeds and low herbs. In the more open

areas, hazel, dogwood, snowberry and other low shrubs often form dense thickets.

The timber is generally young, thrifty and in good condition. The merchantable trees average about 14" D.B.H. and will yield two logs. The hard maple is the most important of the broadleaf species. It is found almost pure on certain areas in the southeastern part of the Island. Many of the trees have been badly damaged by the repeated crude tapping by Indians to obtain the sap, otherwise the timber is in good condition.

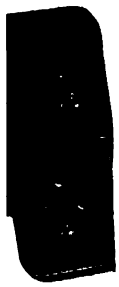
Basswood is the hardwood second in importance and abundance on the Island. The majority of the trees of this species are just under merchantable size. The timber is usually tall, straight, thrifty and in good condition.

Oak, elm, hackberry, white ash and cottonwood occur locally or scattered throughout the hardwood types and are of little importance in the management of the forest.

(6) Pure Hardwood Types.

Areas of pure hardwoods are confined principally to inferior species, paper birch and poplar.

Pure stands of birch occupy areas several acres in extent and are found mostly in the central and eastern portions of the Island. The trees range from 4 inches to 9 inches D. B. H. and are often found growing in very dense stands. The type is temporary only and occupies land which will eventually produce white or Norway pine through artificial or natural regeneration. It is quite likely that



most areas of birch will require stocking with pine artificially, since the neighboring trees are mostly too old to bear seed in abundance. Birch above 4" D. B. H. will eventually be used in making box shooks, novelties, for fuel and for other purposes where it is adapted.

Poplar covers large areas of low-lying lands, and many small areas of moist uplands. There are two species of poplar commonly found: the large toothed aspen and the quaking aspen. Cottonwood occurs at points along the shore. The balsam poplar is occasionally encountered.

Poplar ranges from 4 inches to 10 inches D. B. H. and from 25 to 50 feet tall. The type occupies sites which in many cases might be used more profitably for growing trees of better species. Poplar bolts above 4" at the small end are extensively used at the box factory in the manufacture of shooks. In time, most of the areas now occupied by poplar will be utilized for growing the more valuable crops of pine timber.

(B) THE GROWING STOCK.

All timber 4" D. B. H. and over on 20% of the area was actually calipered and the diameters recorded in even inch classes. Trees 10 inches and over D. B. H., except the poplars and birches, were considered merchantable for saw timber. The smaller trees between 4 inches and 10 inches D. B. H. and all birch and aspen timber were computed in cubic feet which were afterward converted into cords, using 80 cubic ft. as the converting factor. Estimates of the total growing stock were then computed by species in board feet and cubic feet for every whole and fractional 10 acre plot

on the Island. The volume tables used in computing the estimates are tabulated in the appendix.

A very important part of this working plan is the maps and tables of the growing stock on the Island. The following have been accurately prepared and accompany the text:

1. An Estimate Map, showing the estimates in board feet and cubic feet for every 10 acre tract or fractional area on the Island.

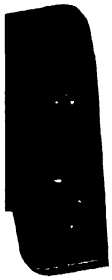
2. A Compilation of the estimates by species for the entire tract, showing the total volume of each species in board feet and cubic feet.

3. A General Stand Table, showing the amount of timber in board feet and cords for every compartment and subcompartment on the Island.

(C) THE AGE CLASSES.

The pine timber on the tract is approximately even aged in each separate stand. For the purposes of management six age classes have been made, each differing by 20 years, as follows:

Age Class 1, 1-20 years, (up to 4" D.B.H.)
Age Class 11, 21-40 " (4" - 8" D.B.H.)
Age Class 111, 41-60 " (5" - 10" D.B.H.)
Age Class 1V, 61-80 " (7" - 14" D.B.H.)
Age Class V, 81-100 " (9" - 16" D.B.H.)
Age Class V1, 101 + " (12"-24" D.B.H.)

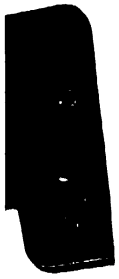


After careful consideration the average diameter B.H. for each age class has been fixed as follows: ll - 5.5"; lll - 7.5"; IV - 10.3"; V - 12.5"; Vl - 15.5".

The first four age classes have been very accurately determined, and the stands designated on the age class map are approximately correct.

The Age Class Map accompanying this treatise was very carefully prepared and shows as nearly as possible the extent and location of the various even aged stands. A few areas are densely covered with aspen or birch and have no trees of valuable species of any age growing on them. These have been termed blanks. The first age class is not represented on the map. This class includes trees up to 4" D. B. H. and is treated entirely as reproduction. A detailed Reproduction Map, a part of this working plan, shows the kind of young growth, its density, size and location for the entire area. It will be noted that there are but few areas of dense reproduction, growing in the open, which might properly be designated as age Class 1 on the age class map. The larger part of the young growth is under the light cover or in small openings in the oldest age class (Vl). The cutting of a tract in the oldest age class would result in converting it into age Class 1, by planting to supplement the natural reproduction, and the age class map would then have to be changed to conform to the new conditions.

The age classes ll, lll, and lV truly fall within the age limits prescribed, and the timber up to 80 years of age is properly classified. Age classes V and Vl are not



properly designated as to age, but rather as to size. Trees in these classes are mature to over-mature and range in age from 80 to 250 years. The smaller of the mature trees were placed in age class V, the larger in age class Vl. Class V includes only diameters which may be produced under good management in 80 to 100 years; class Vl includes all trees which normally require upwards of 100 years to attain the sizes of the remainder of the mature trees.

The total productive area of the Island is 804.3 acres. The mixed hardwoods occupy 264.2 acres, and the pine types 540.1 acres. The hardwood types are pure selection forests, containing all age classes from 1 to upwards of 150 years. The pine forests consist of approximately even aged stands, and the various age classes are present in the types as follows:

	Present Area.	Normal Area.
Blanks	16 acres	0 acres
Age Class 1	0 "	90.1 "
Age Class 11	30 "	90 "
Age Class 111	32.9 "	90 "
Age Class 1V	37.8 "	90 "
Age Class V	49.6 "	90 "
Age Class Vl	333.8 "	90 "
Total -	540.1 "	540.1 "

The above table clearly shows the condition of the pine stands. They are preponderately mature to over-mature.

The younger age classes are woefully deficient. To approximate normal conditions in a reasonable length of time is a difficult problem. By carefully selecting the mature stands to be removed, reproduction may be advanced in a short time to age class ll, and classes l and ll may be made fairly normal. The middle classes will remain deficient until after the first cutting period, when class ll has been advanced to classes lll and lV.

(D) INCREMENT.

No detailed volume and growth studies were made for the various age classes. However, a large number of mature trees were carefully analyzed and the rate of growth determined at different periods. A table showing the average rate of growth in volume appears in the appendix.

It is sufficient to say that the trees in age classes l to lV inclusive, are thrifty, in good condition and are increasing rapidly in volume. The mature and over-mature timber comprising age classes V and Vl is not only not increasing in volume but is actually decreasing, due to rot, especially in the white pine, and to windfalls. Taking the forest as a whole, including the hardwoods, it is probably increasing slightly in volume each year.

With an actual decrease in volume increment of the mature timber, there is a corresponding lowering of the quality increment, or even a negative quality increment may result. The quality will never be better than now, particularly in the white pine stands.

Price increment is likely to continue for years to come, but with the lowering of the volume, and the quality of the timber, a lower stumpage value per acre is the logical result.

SECTION 111.

TREATMENT OF THE FOREST TO SECURE SUSTAINED YIELD.

(A) OBJECTS TO BE ATTAINED IN MANAGEMENT.

(1) The General Policy of the Forest Service.

National Forests are managed with several main objects in view. Every parcel of land is to be put to its highest and best use. The land is classified and those areas principally valuable for agricultural purposes will be excluded from the forest. Timber will finally be produced on non-agricultural soil only.

The first and foremost function of the forest is the production of wood supplies. Watershed protection and the regulation of stream flow are important functions. The aesthetic value of forests is recognized in many regions, as the Yellowstone and Yosemite National Parks.

The land on Star Island is not suited to agriculture, and every productive acre should be utilized in growing timber. National Forests are often so managed silviculturally that the natural beauty of the woods is not impaired. This is done, in many instances, at a distinct sacrifice from an economic standpoint, since many of the mature trees which should be cut must be left standing for aesthetic reasons. This working plan does not consider, except incidentally, the aesthetic side of the forest and is designed to produce the greatest amounts of timber which the Island is capable of yielding.

(B) THE SPECIES TO BE USED IN MANAGEMENT.

The ultimate object of management is to have the entire productive area, save a few protective belts of hardwoods, covered with a normal forest of white and Norway pine. There are no tracts above high water which are not capable of producing timber of one of these species. The area each is to finally occupy may be accurately determined by studying the type map accompanying this thesis. Nearly all areas now covered with merchantable hardwoods, birch and poplar, will grow white pine, and these tracts should be converted into white pine stands as soon as practicable. Areas now bearing Norway pine or jack pine will be reforested with the former species. There are several border areas on which Norway pine is now growing which should be regenerated with white pine. As a rule white pine is not found in any quantity in mixture with Norway.

No hardwood species should be used in management. The areas now covered with young trees of merchantable broadleaf species should not be disturbed until the trees are mature, as in the case of excellent young stands of basswood growing in the northeastern part of the Island. White pine thrives excellently on hardwood soils, and as it is a much more valuable wood than the hardwood timber it should be extended over the deciduous areas as soon as the hardwoods have been removed.

(C) THE SILVICULTURAL METHODS RECOMMENDED.

(1) A Discussion of Possible Silvicultural Systems.

The problem in determining the proper method or

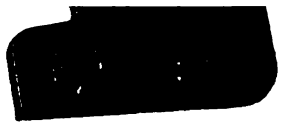
A good Norway pine seed tree surrounded by a dense ground cover. Reproduction is very scarce in such areas.

COURTESY, FOREST CLUB ANNUAL
I.S.C.

methods of silvicultural management of the principal species employed is a real one. There are numerous considerations which must be taken into account and must be fully analyzed and carefully weighed before final judgment is passed.

There are three principal silvicultural systems worthy of consideration for the species in question. The system now employed by the Forest Service on the Minnesota, as required under the act of May, 1908, is clear cutting leaving seed trees. The first law directed that 5% of the stand be reserved for reseeding the cut-over area. The trees to be retained to be healthy individuals well scattered over the tract. Later the law was amended and the amount of timber to be left for seeding purposes was increased to 10% of the stand.

The seed tree method has not been a success; the system has been in operation several years and results have been very unsatisfactory. If it were possible to cut the timber just after a heavy seed year, results would be much more encouraging. As it is, the cutting of timber at such periods is just a chance. Before a heavy yield of seed is again produced the ground cover becomes so dense that germination is impossible. Another objection to the method is that the seed trees, deprived of the mutual protection of their neighbors, fall before the first severe wind, thus becoming a total loss both for seeding and for lumber. The average stand of Norway pine on Star Island is probably close to 15,000 feet b. m. per acre. Ten percent left for seeding purposes is 1,500 feet. At $10.00 per thousand feet



standing, the timber remaining after lumbering under the 10% seed tree method is worth $15.00 per acre. Such an investment for regeneration purposes is not justified under the conditions which prevail, since the area may be replanted after clear cutting at a cost equal to but one-third of the value of the seed trees.

The shelterwood system may properly be employed with white pine and Norway pine under certain conditions. The method should not be used in the management of the white pine now growing on the Island. The timber is greatly overmature, and the type is largely shelterwood from natural causes. There is absolutely no coniferous reproduction under the white pine stands and none can come in on account of the dense undergrowth. It is possible to clear away the brush just previous to a good seed year, to promote natural regeneration, but the method is too costly and too uncertain to deserve serious consideration. White pine bears seed in abundance at regular intervals until the timber reaches an advanced age. This condition is a point in favor of the shelterwood system for the species in the normal forest.

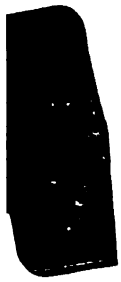
The shelterwood method for Norway pine on the Island would be an experiment, since conditions favorable to the system are all apparently lacking. Seedlings of Norway come up abundantly in open areas in the stand and in fewer numbers under the more open mature timber.

There is at least one well defined area of Norway pine in natural shelterwood. Whether this condition can be

produced artificially under conditions which prevail now, can only be determined by trying out the method. To succeed well under the shelterwood system the remaining trees should bear abundant seed. Norway pine bears seed most freely between the ages of 80 and 140 years. Mature and overmature timber constitute more than 60% of the pine stands. This timber is upwards of 200 years of age. There has been no seed produced in the mature stands during an observed period of 10 years. That the trees are probably too old to bear seed in abundance must be inferred from the evidence at hand.

The removal of 50% of the stand in a cutting for seed is advisable. A large part of the timber has reached such an advanced age that it has already begun to thin out naturally, and the remaining trees receive the maximum amount of light. It is quite likely that a cutting for seed in the shelterwood method would not produce the desired results, since the remaining trees have already adapted themselves to the changed conditions, due to the opening of the stand. Since seed years in the older stands have not occured in a decade, it is unsafe to predict them. If the seedlings did not come in immediately after logging, the cut-over area would quickly be covered with brush which would effectually preclude natural regeneration at a later date, and eventually the area would have to be restocked artificially.

Clear cutting and planting is a silvicultural system which seems best suited to the management of the timber on Star Island. It has become an established prac-



tice in forestry that timber which, because of its high quality or easy accessibility, brings a high stumpage price should be regenerated artificially. White and Norway pine on Star Island fall, without question, into this group of valuable species. In the methods previously described, clear cutting with scattered seed trees and the shelterwood system, several years elapse after the stand is cut before a good natural regeneration is secured. There are no delays in the clear cutting method followed by planting. The saving in time over the other methods often reduces the rotation period by several years. The clear cutting system also makes possible the removal of the entire stand at one operation, thus affecting a considerable saving in the cost of lumbering operations.

There are many areas on the Island now covered with aspen and white birch which must be regenerated artificially, either by seeding or planting. The cost of planting is comparatively low. It is the policy of the Forest officers on the Minnesota National Forest to use in planting operations, thrifty 3 to 4-year old transplants, setting out about 700 to the acre. An examination of a tract planted in this manner last year revealed 99% of live trees. The planting motto is "Plant large, thrifty, transplanted stock, carefully, in their permanent locations, with the idea that all will live, rather than plant twice the number of smaller stock with the idea that one-half will die." The planting operations carried on last year in the vicinity of Cass Lake, on brushy land, cost $5.00 per acre. This cost includes every item from the time the seed beds were prepared in the

nursery until the transplants were set in their final place in the forest.

(2) Silvicultural Systems Recommended.

After careful study of every phase and condition bearing upon the silvicultural methods of management of the Island, the following recommendations are made:

(a) All areas of non-timber species (birch and poplar), except those on very low sites, be clear cut, and the land replanted to white pine or Norway pine, depending on soil and site.

(b) All mature and overmature white pine be removed by clear cutting, and the cut-over areas be immediately regenerated by planting large, thrifty transplants of the same species.

(c) Mature and decandent Norway pine shall be removed by clear cutting and the areas cut over be immediately regenerated by planting good, thrifty, transplanted stock. Small areas may be managed under the shelterwood system as an experiment.

(d) Jack pine in mixture with Norway shall be removed by successive heavy thinnings, leaving the latter species to form the final stand.

(e) Hardwood areas are to be gradually converted into pine stands, at such times when the timber can be most profitably removed. Young stands of hardwoods should be allowed to reach saw timber size before removal. Borders of hardwoods should usually be left on the bluffs along the lake shore to break the force of the wind.

(3) The Rotation.

The pines are essentially producers of lumber. White and Norway pines are particularly adapted for the production of sawn material. The most valuable products of the species are the wide, clear boards and planks from which finish and factory material are obtained. The lower grades are used extensively in house construction. The short lengths are made into box shooks. Norway pine piling and crossties are common in the northern Lake States. Even the young trees of the species mentioned are better suited for lumber than for other purposes. White pine lumber is particularly adapted for purposes where a light, soft, even-grained wood, easy to work is desired. For these uses it brings a very high price. There are no coniferous species in the country which command the prices that are received for the upper grades of white pine.

The amount of stumpage in the country is decreasing each year. It is estimated that three times as much timber is cut as grows, and unless steps are taken to decrease the per capita consumption, or to increase the supply, a timber famine in the near future is inevitable. It is the policy of the Forest Service to produce saw timber on the National Forests wherever practicable, in order that the anticipated shortage of timber of log size may in a measure be met. The Government is perpetual; it pays no taxes, enjoys a low interest rate, and can carry a project successfully through a long term of years, hence it is peculiarly adapted to conduct a growing forest through a long rotation, where all

yields or income are deferred until the timber is cut.

The production of saw logs is conducted on a technical rotation; i.e., a rotation of sufficient length to produce trees of a size suitable for saw timber. The technical rotation for log production usually falls beyond the age at which the greatest money returns may be expected, and for this reason it is not adapted for individuals or short-lived corporations.

The financial rotation is the proper one to be adopted by all agencies growing timber exclusively for profit. Under this rotation the timber is cut at the time when the soil produces the highest returns at a specified rate of interest; i.e. when the soil rental is greatest. There are so many uncertain elements to be considered in computing the financial rotation that it is seldom undertaken except for approximations only. Using the yields for Norway as listed on page 60 and estimating the value of the timber to be that set opposite the respective ages; the cost of formation, $5.00; and the rate of interest, 4%, the net soil rentals for the various rotations are as shown in the table below.

Age, years	Yield, Feet b.m.	Value per M., b.m.	Net Soil rental per Annum.
40	3,200	$12.00	15¢
60	12,600	$14.00	52¢
80	23,600	$16.00	48¢
100	34,700	$18.00	30¢
120	44,000	$20.00	12¢

From the above it is seen that the greatest net soil rental per acre is realized when the stand is about 60 years old, and beyond this age it gradually drops off until 80 years is reached. At higher rotations the drop is much more pronounced. The financial rotation for Norway pine then lies somewhere near 60 years.

The rotation age is fixed at 120 years for both white and Norway pine. The hardwoods are to be cut when they can be profitably handled. Under good forest management Norway pine attains a diameter, breast high, of 15.5 inches and a volume of approximately 300 board feet, per tree. Placing the stumpage price of Norway at the end of the rotation period at $20.00 per thousand feet, the yield at 44,000 feet b.m. per acre, and the cost of planting, $5.00 per acre, the investment will pay 2% compound interest on a land value of $82.50 per acre. A 4% rate of interest will reduce the land value to $2.77 per acre. The price to be paid the Indians for the land on Star Island is $1.25 per acre. This sum will pay an interest rate of approximately 4¼% during the entire period of the rotation. From every standpoint the investment is a good one for the Government, since it yields a larger interest rate than is usually obtained for the Government's own securities.

(4) Marking Rules.

The timber on the Island is to be clear cut, and hence only simple marking rules are necessary. Mature pine and other age classes, except age class 1, are seldom found on the same area. In logging it is only necessary to use

care in preserving the reproduction as all the large timber is cut clear. It is seldom advisable to allow timber above 4" D.B.H. to remain standing on the tract lumbered, since the smaller trees are for the most part suppressed and are not capable of fully recovering. Trees under 10" D.B.H. have a good market as box factory material.

On areas where the shelterwood system may be employed, the trees to be removed in the first cutting are the largest, oldest, most defective and decadent individuals to be found on the tracts. The younger and thriftier individuals should remain to reseed the area.

Where Norway and jack pines are in mixture, cut out the jack pine gradually, removing the poorer individuals first. Jack pine bolts command a ready market for box material, and the thinning operations in this type may be conducted at a fair profit. Only such Norway should be removed on these areas as is badly suppressed or defective, as this species will form the future stand.

Hardwood types need no marking rules, since these areas will be clear cut and the land regenerated with pine.

(5) Brush Disposal.

All brush incident to logging operations shall be piled in neat, compact piles about 6 feet by 6 feet in size, away from all reproduction. Where reproduction is wanting the brush may be piled in rows instead of piles. All material, limbs, young trees, etc., 4 inches in diameter and under must be piled. Larger material may be cut into such lengths as will permit the pieces to lie flat on the ground, thus

facilitating decay.

The burning of the brush shall be done during damp weather or just after a rain in the summer season; during the winter months it may be conducted with safety at any time after snow has fallen. The details in the disposal of the brush must be worked out on the ground for each different type area, and changes made in the rules to conform with the experience gained.

SECTION IV.

THE REGULATION OF THE YIELD.

(A) THE NORMAL GROWING STOCK.

(1) The Determination of the Normal Growing Stock in a Mature Forest.

It is the aim of every forester in charge of a forest under management to bring the area as rapidly as possible into a normal condition. Virgin coniferous forests are seldom found in a state even approximating normality. The majority of such forests are overstocked with one or two age classes and are deficient in the others. Over 60% of the pine timber on Star Island is mature and overmature and falls into age class VI, leaving less than 40% of the area stocked with the other age classes, exlcuding age class 1. The mature timber is also upwards of 200 years old. The rotation period is 120 years, hence the great difficulty in determining the normal growing stock from the timber at hand. Trees 215 years old have an average volume of 47.2 cubic feet, exclusive of bark. The mean annual in-

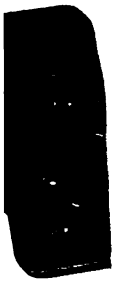
crement during the life of the stand is .465%. It is estimated that trees of the rotation age (120 years) under good management will yield an equal amount of timber and the mean annual increment will be much greater - approximately 1%.

(2) Discussion of Methods of Determining the Normal Growing Stock.

There are three principal ways of arriving at the amount of normal growing stock in the forest. The first is by determining the yield for each year in the rotation and adding them together. This method is undoubtedly the most accurate, but it is not adapted to long rotations.

Another method of determining the amount of normal growing stock is by means of yield tables which give accurately the yields at regular intervals. The third and least accurate way is by employing the mean annual increment in the formula $\frac{RI}{2}$, where R = rotation age, and I the total increment of all the age gradations in one year or the yield of the oldest age gradation. In rough preliminary work this method is often employed, but in more accurate plans the yield table method is used.

The method of determining the normal growing stock which employs normal yields figured at regular intervals is the proper one to use for the pine area on Star Island. It is generally considered that the yield of a properly thinned stand under good forest management is equal to the yield of a similar area fully stocked with dominant trees in an unthinned stand of the same age. Yields of unthinned dominant stands of all ages have been computed for Norway pine in and



near the Minnesota National Forest. These yields will apply very well to the area under consideration.

The average site quality of the pine lands on Star Island is I/II. The yields of the unthinned dominant stands mentioned above are for site quality I, hence it was necessary to reduce them somewhat to correspond with the changed conditions. The normal yields of Norway pine on the area at various ages is approximately the following:

Age, Years.	Yield, Feet b. m.
20	0
40	3,200
60	12,600
80	23,600
100	34,700
120	44,000

(3) The Normal Growing Stock.

The stand of timber of log size (10" D.B.H. and over) on the Island is 10,373,750 feet b.m. The material between 4" and 10" D.B.H. exclusive of non-timber species (birch, poplar and ironwood) amounts to 217,322 cubic feet. The latter when converted into board feet by using 5 feet b.m. for each cubic foot, amounts to 1,086,610 feet, b.m. This amount added to the volume of the stand 10" D.B.H. and over gives a total volume of all trees on the Island 4" and over D.B.H. of 11,460,360 feet b.m.

The coniferous species on the tract total 9,723,915 feet b.m., 10" D.B.H. and over, and 118,167 cubic feet, or a total of 10,314,750 feet b.m. of timber 4" and over D.B.H.

There are 194,645 feet b.m. of pine growing in mixture with the hardwoods. Deducting this amount from the total volume of pine timber leaves a net volume of conifers on strictly pine types of 10,120,105 feet. This timber is growing on 540 acres and constitutes approximately 90% of the total stand.

Considering .5% as a fair rate of growth per year for the whole Island, the mean annual increment amounts to 57,302 feet b.m. Applying the formula $Gn = \frac{RI}{2}$, the normal growing stock is 3,438,120 feet b.m. by this method. Since the timber now standing on the area is excessively mature and overmature, .5% does not represent the producing power of the land, and hence the estimated growing stock is much too low.

For the purposes of this working plan the three principal coniferous species will be considered together. The small amount of balsam fir found has been added to the jack pine. Norway pine constitutes 81.2% of the total pine stand; white pine, 13.5%; and jack pine, 5.3%. Norway and jack pines have similar habits and since they grow in mixture in almost exactly equal proportions, are the same size, and have approximately the same increment and yield, they may be considered together in determining the normal growing stock. These two species comprise 86.5% of the total coniferous stand. The white pine grows more rapidly than Norway, and will produce greater yields at the rotation age. The small amount of this timber, however, does not justify separate treatment at this time. Moreover, with every cut-

ting the composition of the forest changes, since the hardwood types are to be converted into pine stands, so that the normal growing stock is never constant.

The normal growing stock of the pine lands alone, considering that jack pine and white pine yield similarly to the Norway, may be computed by the formula: $Gn = N(a + b + c + \frac{d}{2})$, where a, b, c, d, etc. represent the normal yields at the ends of stated periods, and N = the number of years in the period. By employing this formula, and using the normal yields listed above, the normal growing stock of the pine types amounts to 8,649,000 feet b.m. The hardwood types on the Island have a total volume of all timber 4 inches D.B.H. and over of 1,142,650 feet b.m. Estimating the annual increment on these types to be 1%, the normal growing stock of the broadleaf species is 685,590, making a total normal growing stock on the tract of 9,334,590 feet.

The mature and overmature pine timber on the Island should be removed largely during the first working period, especial care being taken to cut the oldest timber first leaving the younger, thriftier trees until the last. The stand is in such condition that the majority of the timber should be removed in 20 years. During this period the forest should be brought, by judicious cutting, into a fairly normal condition, particularly as to area and distribution of the age classes. The normal growing stock at the end of the period will be deficient because of the necessity of removing large amounts of timber in the present decadent stand.

It will probably be necessary to defer cutting for some time at the completion of the first period, or cut less than the normal yield to allow the growing stock to accumulate.

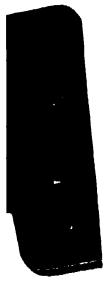
During the rotation - probably largely during the first two cutting periods - the hardwoods will be all removed, except for small patches and narrow strips along the lake shore for protection purposes, and the areas they occupied will be planted to pine. The forest should be so managed that at the end of the first rotation the whole productive area (except for the small amounts of hardwood noted above) shall be covered with a normal stand of white and Norway pines.

(B) THE YIELD.

(1) Difficulties in the Determination of the Yield.

The bulk of the timber on Star Island is largely decadent. Upwards of 60% of the total area of the pine types is included within age class V1, and more than 80% of the volume stands on these tracts. Age class V is principally mature so that at least 85% of the total volume on the pine sites is now ready for cutting. The timber in age classes V and V1 is not increasing in volume but is actually slightly decreasing, due to the loss through windfalls, decay and other agencies incident to old age. The remaining 15% of the stand is in a thrifty condition and is increasing rapidly in volume. The hardwoods are also thrifty and lay on each year a fairly normal increment.

The time allotted for the rejuvenation of the forest on the Island is 20 years, at the end of which period it



is contemplated that this working plan be completely revised. The main purpose of the working plan is to bring the forest as rapidly as possible into the best silvicultural condition. The cutting then must necessarily be heavy to reduce the amount of decadent timber and to avoid further loss from natural causes which accompany old age.

The annual yield of the whole area, estimating the mean annual growth at .5%, is but 57,302 feet b.m. at the present time. The annual yield under normal conditions should be 213,083 feet b.m., of which 198,000 feet are pine. Calculations from normal yield tables show that the normal growing stock on the pine types is 9,336,360 feet b.m.; the area of the types is 540 acres, and each of the six age classes should comprise 90 acres. The age class table on page 45 shows how abnormal this distribution of the age classes actually is, and the problem of bringing them to normality is difficult to solve. At least 85% of the total stand is not yielding an increment and should be removed to make way for new growth.

(2) The Determination of the Annual Yield.

The actual yield and the normal yield habe been stated above. Neither of these is the proper amount to be removed annually during the rejuvenation period. The annual yield to be cut during the first 20 years will be arbitrarily fixed and largely independent of growth. It will far exceed either the actual or the normal yields. The total stand on the Island is 11,460,360 feet b.m. The growing stock required to produce a sustained normal annual yield

is 9,334,590 feet b.m. The surplus to be removed, were all age classes normally present, is 2,125,770 feet. Since 85% of the stand, or 9,741,306 board feet, is mature and should be removed, it is obvious that a much larger amount than the surplus indicated above should be cut during the rejuvenation period. The amount of timber in age class V1 which should be present on the area under normal conditions is 3,541,500 feet b.m. of pine and 323,500 feet of hardwoods, a total of 3,865,000 board feet. This amount should be left standing on the tract at the end of the cutting period to form the new age class (V1). Most of this amount will be advanced from age class V, but some of the younger, thriftier stands in the present mature forest will have to be carried over to supply the deficiency. The entire immature stands in age classes 11, 111, 1V and V, amounting to 1,086,610 feet b.m. plus their increment for 20 years, 217,320 board feet should remain unmolested except for needed thinnings. The latter item need not be considered since it is not now a part of the growing stock.

(3) Distribution of the Surplus Growing Stock.

The amount of timber to be cut during the rejuvenation period is 6,508,750 feet b.m. This is determined by adding the normal amount in age class V1 and the immature stands in all the other age classes together, and subtracting this sum from the total stand. The stands to be left (3,865,000 feet b.m. plus 1,086,610 b.m.) taken from the total amount (11,460,360 feet b.m.) leaves the surplus as stated above (6,508,750 feet b.m.). Since there is no in-

crement in class VI stands, and the increment in the other classes should be allowed to accumulate to partly supply the deficiency caused by the removal of the mature timber, it is not necessary to consider the increase in volume of the stand during the first cutting period.

The rejuvenation period is 20 years. If the timber were cut annually during this time, 325,437 feet would be removed each year. This amount is hardly sufficient to make yearly operations economical, or at least the small cut will make lumbering much more costly. A biennial cut of 650,874 feet is much more desirable. It also fulfills in a measure a requirement of good management - that of producing frequent revenue. The spring following lumbering operations is to be devoted to brush burning and planting operations on the cut-over lands.

(C) THE DISTRIBUTION OF THE YIELD.

The total amount to be removed during the first cutting period is 6,508,750 feet b.m. in 10 equal or nearly equal installments. Especial care must be taken to cut the oldest areas first. The location of the stands is excellent for cutting. The prevailing winds are from the west and southwest, and danger from windfall is reduced to a minimum. The first stands to be cut are in the east and southeast portions of the Island. Cutting will proceed from east to west, in such manner that the remaining timber is well protected.

(1) The Division of the Island into Compartments and Sub-Compartments.

To facilitate management, a compartment map has been prepared on which the different stands have been designated. The Island is divided into six compartments. The boundaries of the compartments follow as nearly as possible U. S. survey lines and quarter section lines. They are marked in red upon the map. The lines should be well cleared out on the ground, so that they may be easily located. The compartments have no regular size or shape and are of value principally as means of locating the various parts of the area and as guides in all management operations.

The compartments are carefully divided into their component sub-compartments or stands. The compartments are numbered from 1 to 6. The stands are lettered. Each sub-compartment is an area upon which is growing a stand of timber of a definite character, requiring special treatment. An exception to this rule is made where large tracts are of similar character. These areas are divided into two or more sub-compartments, to facilitate forestry operations. The sub-compartment boundaries are not indicated on the ground. The stands on the Island are based almost entirely on the age and species of timber. The Roman figures indicate the age class. Where no figures occur the stand is all aged.

(2) The General Stand Table.

A very carefully prepared stand table accompanies the compartment map. This table contains the following data:

a. The compartments (numbered).

175.5 ACRES

REPRODUCTION

b. The sub-compartments (lettered).
c. The area of each of the above.
d. The character of the stand in each sub-compartment, whether young or old, (age class) and area.
e. Area by compartments of unproductive land, and reason for unproductiveness.
f. Stand of timber in each sub-compartment and compartment in feet, b.m., and in cords (4" - 10" D.B.H.) by species.
g. Reproduction by species - size and extent.
h. Grand totlas of the above information.

(3) The Cutting Plan for the Working Period.

The entire cutting during the first twenty years will be confined to compartments 2, 3, and 4. Compartment 1 is covered with a heavy young stand of basswood. Compartments 5 and 6 contain large quantities of young pine. The mature timber in these compartments will be removed in part during the second cutting period. Compartment 2 will be the first one cut over. When lumbering is completed here the V1 stands in 3 and 4 will be attacked. The inserted table shows the progress of the cutting during the period.

The total area to be cut over is 296.7 acres. On part of this area the mature and overmature trees only are removed, leaving a good stand of young timber on the ground. By carefully observing the reproduction map it will be seen that much of the young growth on the areas to be logged is now large, and by the time the tract is lumbered, will have advanced into age class 11. The areas cut over in 1933 are hardwood, and it will take some time to get good reproduction started after logging. These tracts will be included in age class 1 in the second period. By careful treatment of the exisiting reproduction, it is possible to have a fairly nor-

L
o
w
Ch
th
per

Sta
qua
the
atic
enti
bc s
medi
ant
vis

mal distribution of the age classes 1 and 11, and small patches of 11, 111 and 1V scattered throughout the mature stands which have advanced a period during the logging operations. The last column of the cutting plan shows in a general way the distribution of the age classes of the end of the working period.

SECTION V.

THE ADMINISTRATION PLAN.

It is planned to have the forestry operations on Star Island handled by the local ranger who has his headquarters there. A technical assistant will attend to all the technical details of the work and will inspect the operations as necessity requires. The rough work will be handled entirely by the ranger. The necessary planting stock will be supplied by the nursery at Cass Lake. Planting will immediately follow logging in all cases. The technical assistant and the ranger will be directly under the Forest Supervisor at Cass Lake.

APPENDIX.

TABLE 1.

Volume Table for Norway Pine.

D. B. H. Inches		Cubic Feet.
4	-	1.0
5	-	2.2
6	-	4.2
7	-	6.2
8	-	9.2
9	-	12.7
		Board Feet.
10	-	77
11	-	104
12	-	137
13	-	179
14	-	222
15	-	275
16	-	324
17	-	372
18	-	428
19	-	486
20	-	556
21	-	652
22	-	760
23	-	830
24	-	905
25	-	986
26	-	1075
27	-	1166

Table based on 73 trees measured on Star Island, supplemented by table prepared for the Minnesota National Forest. Used also for jack pine.

TABLE 11.

Volume Table for White Pine.

D. B. H. Inches.		Cubic Feet.
4	-	1.0
5	-	2.2
6	-	4.2
7	-	6.2
8	-	9.2
9	-	12.7
		Board Feet.
10	-	75
11	-	100
12	-	125
13	-	145
14	-	165
15	-	210
16	-	260
17	-	300
18	-	335
19	-	380
20	-	440
21	-	500
22	-	590
23	-	680
24	-	750
25	-	840
26	-	925
27	-	1000
28	-	1075
29	-	1150
30	-	1280
31	-	1370
32	-	1450
33	-	1575
34	-	1700
35	-	1830
36	-	1910
37	-	2000
38	-	2080
39	-	2170
40	-	2260

Adopted from Table prepared for the Minnesota National Forest.

TABLE 111.

Volume Table for Mixed Hardwoods.

D. B. H. Inches.		Cubic Feet.
4	-	1.2
5	-	2
6	-	3
7	-	5
8	-	6.3
9	-	9.6
		Board Feet.
10	-	55
11	-	74
12	-	89
13	-	120
14	-	143
15	-	170
16	-	225
17	-	262
18	-	308
19	-	392
20	-	440

TABLE IV.

Volume Table for Birch.

D. B. H. Inches.		Cubic Feet.
4	-	1.2
5	-	3
6	-	4.6
7	-	6.
8	-	8.3
9	-	11.2
10	-	13.7
11	-	17.9
12	-	21
13	-	25
14	-	28.9
15	-	33.5
16	-	39
17	-	45

TABLE V.

Volume Table for Poplar.

D. B. H. Inches.		Cubic Feet.
4	-	1.2
5	-	2
6	-	3.1
7	-	5.3
8	-	7.3
9	-	9.6
10	-	12.8
11	-	18.3
12	-	22.3
13	-	26.8
14	-	31.2

TABLE VI.

Norway Pine

Heights on Diameters

Based on 130 Average Trees.

(Read from a Curve)

D. B. H. Inches.		Height, Feet.
8	-	65
9	-	66
10	-	67
11	-	71
12	-	74
13	-	77
14	-	81
15	-	83
16	-	85
17	-	86
18	-	87
19	-	88
20	-	90

TABLE V11.

White Pine

Heights on Diameters

Based on 100 Average Tress.

Read from Curve.

D. B. H. Inches.		Height, Feet.
8	-	65
9	-	67
10	-	68
11	-	69
12	-	70
13	-	72
14	-	74
15	-	76
16	-	78
17	-	82
18	-	85
19	-	88
20	-	92
21	-	96
22	-	100
23	-	104
24	-	107
25	-	111
26	-	115
27	-	117
28	-	121
29	-	124
30	-	126
31	-	128
32	-	130

TABLE V111.

Analysis of Average Mature Norway Pine

Star Island.

D. B. H. - 17.0" Age - 215 yrs.

Age Years	D. B. H. Inches.	Height Feet.	Volume Cubic Ft.	Yearly Increase during period, %.
30	2.4	15.0	.25	
50	3.4	26.0	.98	5.9
70	8.2	35.0	5.67	7.0
90	11.05	42.0	12.00	3.58
110	12.5	48.0	18.55	2.14
130	13.3	55.0	23.97	1.27
150	14.5	61.0	32.16	1.46
170	15.15	66.0	37.07	.709
190	15.70	71.0	42.46	.677
209	16.1	76.0	47.20	.55

Mean annual increment is .2195 cubic feet or .467%.

A LIST OF THE ARBORESCENT SPECIES

OCCURRING ON STAR ISLAND.

Botanical Names.	Common Names.
Pinus strobus, L.	White pine.
Pinus resinosa, Ait.	Norway pine.
Pinus divaricata, DuM.	Jack pine.
Larix Americana, Michx.	Tamarack.
Picea Mariana, B.	Black spruce.
Picea canadensis, B.	White spruce.
Abies balsamea, Mill.	Balsam fir.
Thuya occidentalis, L.	Arbor-vitae.
Juniperus virginiana, L.	Red cedar.
Populus tremuloides, Michx.	Quaking aspen.
Populus grandidentata, Michx.	Poplar.
Populus balsamifera, L.	Balsam - Balm of Gilead.
Populus deltoides, Marsh.	Cottonwood.
Salix amygdaloides, Anders.	Almond willow.
Salix fluviatilis Var. Wheelerii, Nutt.	Sand bar willow.
Salix discolor, Muelh.	Glaucous willow.
Salix petiolaris	
Salix myrtloides	Myrtle leaved willow.
Salix humilis	Prairie
Salix glauca	
Ostrya virginiana, K.	Ironwood.
Betula lutea, Michx.	Yellow birch.
Betula papyrifera, Marsh.	Canoe birch.
Betula pumila	Swamp birch.
Alnus incana	Spotted alder.
Quercus rubra, L.	Red oak.
Quercus ellipsoidalis, Hill.	Black oak.
Quercus coccinea, Moench.	Scarlet oak.
Quercus macrocarpa, Michx.	Bur oak.
Quercus borealis (?)	
Ulmus americana, L.	White elm.
Ulmus fulva, Michx.	Slippery elm.
Celtis occidentalis, L.	Hackberry.
Amalanchier spicata	Service berry.
Prunus pennsylvanica, L.	Bird cherry.
Prunus pumila	Sand cherry.
Prunus virginiana	Choke cherry.
Rhus hirta, Sudw.	Staghorn sumac.
Acer spicatum, Sam.	Mountain maple.
Acer saccharum, Marsh.	Sugar maple.
Acer rubrum, L.	Red maple.
Acer Negundo, L.	Boxelder.
Tilia americana, L.	Basswood.
Fraxinus americana, L.	White ash.
Fraxinus nigra, Marsh.	Black ash.
Fraxinus pennsylvanica, Var. lanceolata, Sarg.	Green ash.
Viburnum lentago, L.	Sheepberry.

SHRUBS ON STAR ISLAND.

Botanical Names.	Common Names.
Corylus rostrata	Beaked hazel.
Cornus circinata	Dogwood.
Cornus stolonifera	Kin-i-kin-ick.
Lonicera glauca	Honey suckle
Lonicera canadensis var. americana	American fly honey suckle.
Diurvilla lonicera	Bush honey suckle.
Vaccinium pennsylvanicum	Dwarf blueberry.
Viburnum pubescens	Black haw.
Viburnum opulus	High bush cranberry.
Linnae borealis	Twin-flower.
Rosa blanda	Wild rose.
Rosa (Sp.)?	Wild rose.
Spiraea salicifolia	Willow-leaved meadow sweet.
Juniperus communis	Creeping juniper.
Rubus strigosis	Red raspberry.
Cassandra calyculata	Heath.
Andromeda polyfolia	Andromeda.
Sambucus racemosa	Elderberry.
Symphoracarpus occidentalis	Snow berry
Celastrus scandens	Bittersweet.
Rhus toxicodendron	Poison oak.
Rhus glabra	Smooth sumac.
Ribes floridum	Black currant.
Ribes gracila	Prickly gooseberry.
Ribes (Sp.) ?	Smooth gooseberry.
Vitis vulpina	Wild grape.
Ampelopsis quincafolia	Virginia creeper.

HERBS, GRASSES AND OTHER PLANTS CONSIDERED AS GROUND COVER.

Botanical Names.	Common Names.
Phragmites communis	Reed grass.
Poa serotina	Meadow grass.
Gnathalium (Sp.) ?	
Arisaema try phyllum	Jack-in-the-Pulpit.
Circaea (Sp.) ?	Enchanter's night shade.
Iris (Sp.) ?	Blue flag.
Phryma eliptastokia	Verbena.
Acquilegia canadensis	Large columbine.
Actaea spicata	Boneberry.
Impatiens fulva	Jewelweed.
Viola canadensis	Violet.
Apocynum cannabinum	Indian hemp.
Apocynum androsemaefolium	Indian hemp.

Comandra umbellata	Bastard toad flax.
Equisetum sylvaticum	Horsetail.
Palygonum emursum	Water smartweed.
Elymus canadensis	Wild rye grass.
Agropyram (Sp.) ?	Wheat grass.
Bromus kalmii	Soft brome grass.
Cynosuroides (Spartina) (Sp.)?	Slough grass.
Carex (Sp)?	Sedge.
Aster mocrophyllus	Aster.
Cornus canadensis	Dwarf cornel.
Aralia nuticaulis	Sarsaparilla.
Melanpyrum canadensis	Figwort.
Arctostaphylos uvi-ursi	Bearberry.
Pteris aquilina	Brake.
Lycopodium conplanatum	Club moss.
Clumophila umbrellata	Princess pine.
Gaultheria procumbens	Wintergreen.
Epilobium spicatum	Fireweed.
Equisetum robustum	Horsetail.
Equisetum arvence	Horsetail.
Carex stricta	Sedge.
Colomgrostis canadensis	Blue joint.
Hierocium canadense	Rattlesnake weed.
Aralia hispida	Spikenard.
Circium arvense	Canada thistle.
Unifolium (Sp)?	One leaf lily.
Fragaria virginiana	Strawberry.
Galium boreale	Northern bed straw.
Smilacena stellata	Smilax.
Artemesia canadensis.	

A LIST OF THE ENCLOSURES IN POCKET AT BACK.

Map A. Showing location of the Minnesota National Forest.

Map B. Topography and Improvement Map.

Map C. Estimate Map.

Map D. Compilation of Estimates.

Map E. Type Map.

Map F. Reproduction Map.

Map G. Age Class Map.

Map H. Compartment Map.

Map I. Cutting Map.

[redacted]

Pocket has: 9 Maps

[redacted]