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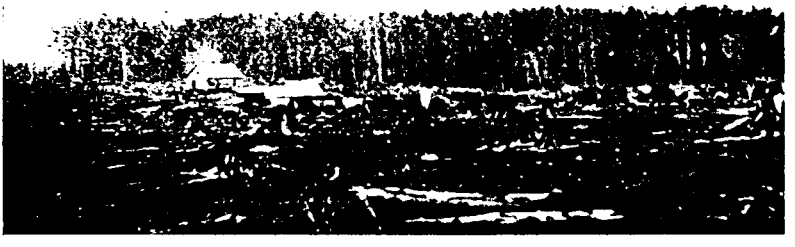
HORTICULTURAL DIVISION.



Stump lands needed for farming should be so used but there is a large amount of such land in Minnesota that will not be wanted for this purpose for a long time and much other land that is not fit for farming. These should be kept growing timber.

DECEMBER, 1896.

RATE OF INCREASE ON THE CUT-OVER TIMBER LANDS OF MINNESOTA.

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RATE OF INCREASE ON THE CUT-OVER TIMBER LANDS OF MINNESOTA.

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Assisted by H. B. Ayres.

INTRODUCTION.

During the several past years of agitation for the preservation of our forests, many have felt the need of some reliable figures that would show the possibilities of a new growth on our timber lands, and that the cause of forest preservation would be greatly advanced if the yearly value of a growing crop of timber could be generally known by the owners.

That our forests do improve the climate of Minnesota cannot be doubted; that it is important to have the area about the headwaters of our rivers in forests is without question, but these are general statements and the individual owners of timber lands cannot be expected to sacrifice their immediate interests for the good of the general public, but if it can be shown that the proper management of forest lands will be profitable to the individual owner, then we have got a long ways ahead in obtaining the desired settlement of the problem of the retention of forests for their effect on climate and on the flow of water in our rivers.

The object of this bulletin is to present the results of a study of the actual conditions of the cut over timber lands of this state and to estimate their probable natural increase in value. It is also designed to show what a great curse are forest fires in preventing the realization of the estimates herewith given so that the people of Minnesota may understand what an immense loss to the state is annually caused by fire. It is also hoped that this information may help bring about a better enforcement of the present law against forest fires.

As I see the situation most forest fires are permitted through ignorance of the loss they entail and our people have little idea of any property value in growing timber.

This bulletin has been prepared under my direction largely by Mr. H. B. Ayres, of Carlton, Minn., who has made all the calculations and to whose earnestness and care in this work its value is largely due.

It has been thought best to use only the common names of trees in the body of this bulletin as they are the names of well known trees in this section. Among the last pages will be found a list of the botanical names of the trees to which they apply.

METHOD OF CALCULATING USED IN THE FOLLOWING STATEMENTS.

In calculating the volume of annual accretions given in the following pages the prismoidal formula has been used where very accurate statements seemed desirable.

This formula is as follows: $V = \frac{A + 4m + a}{6} \times H$. In this formula V = volume; A = area of the large end of the log; a = area of small end of the log; H = the length of the log, and m = the mean average area of the log.

On account of the swell in the lower trunk forming a concave profile, the average of the end areas of the lower sections of the trunk is entirely too large a factor to be multiplied by the length. Even the prismoidal formula gives too large results on the lower trunk. On account of the convex profile of the upper stem the average of the end areas there would be a very accurate factor while the prismoidal formula would give slightly too small results for the upper stem.

Thus it is thought the prismoidal formula while giving too large results for the lower stem and too small results for the upper, does, when applied to the whole tree, give the closest approximation possible.

In making calculations of the volume on acres, and on some individual trees where great accuracy was thought unnecessary, form factors, or the ratios of volumes of the trees in question to the volumes of cylinders having equal bases and altitudes have been used.

Bark has not been included in any of the following measurements or calculations. All diameters have been measured inside of bark.

ANNUAL ACCRETIONS.

The volume of annual growth or accretion has been determined by measuring the thickness of the annual layers and calculating their contents. On this subject, Schlich, in his Manual of Forestry, says: "All trees increase annually in diameter. The diameter increment produces every year an additional concentric ring. Frequently false rings appear. These may be distinguished by finding that they do not run right round the tree." See false ring caused by drought of 1894 in photograph of section of tamarac (fig. 11).

In answer to a request for opinions as to the possibilities of renewing a crop of timber on the pine lands of Minnesota, some of the largest holders of timber lands in this section and others have replied and their views are given irrespective of whether they support the conclusions of this bulletin.

The appropriation for this bulletin was very small and consequently the work is not as thorough as was desired. But it is hoped that further appropriations may be made to extend the scope of this work. In this connection it would seem proper to state that it is earnestly hoped that one or two sections of school or university land now having good forest conditions may be turned over to the University Experiment Station for careful experiments in reproductive forest management that the people of this state may have an object lesson in the profits coming from proper management of forest property.

THE FOREST RESOURCES OF MINNESOTA.

The most reliable estimates of the forest area in Minnesota, and of the timber upon this area are probably those collected by the state forest fire-warden. These place the total area of natural forest, excluding brush land and open swamps, at 11,890,000 acres.

The marketable timber estimated upon this area is shown in Table IX.

TABLE IX.—Marketable Forest Timber in Minnesota, 1895.

KIND OF TIMBER.	Feet, Board Measure*	Cords
White Pine	14,424,000,000	
Norway Pine	3,412,475,000	
Jack Pine	640,000,000	
Spruce	1,050,000,000	
Cedar	1,010,500,000	
Tamarac	450,000,000	
Hardwood	3,803,600,000	
Fuel		106,930,000

The Importance of the Lumber Industry to the state is represented by the value of the finished product. The census of 1890, owing to incomplete returns, does not represent the entire industry, yet it presents the figures given in Table X.

TABLE X.—Minnesota Lumber and Woodworking Industries.

Value of product of mills and factories	$25,075,132
Capital invested	$39,837,000
Average number of employes	25,715
Wages paid	$6,166,266

This does not include wood used as fuel, or railway ties, piles, poles, posts, fencing, mine timber, house logs, charcoal, medicinal products or the products of distillation.

The Saw-mill Cut of Minnesota, as estimated from the annual statements of the Mississippi Valley Lumberman,

*As it is impossible to draw the line sharply between log timber and other wood material, it is thought the use of board measure is best (cubic feet not being popular as yet,) to express the volume of all that is large enough for log timber. The board feet may be reduced to cubic feet by dividing by 12 and adding the uncertain but large factor of waste. The cord may be reduced to cubic feet by multiplying by 100.

averaged, during the past five years 1,323,497,000 ft. B. M.* The log cut in the state during the past five years, probably averaged over 1,000,000,000 feet B. M. About 323,000,000 feet B. M. of the saw-mill cut came from other states.

The Normal Yield of Our Forest Area.—By reference to the yield tables of white pine of medium quality prepared by Pinchot and Graves, the normal yield of our forest area should be 2,199,650,000 feet B. M. per annum, on our 11,890,000 forest acres, or a mean annual increment of 185 feet B. M. per acre. This would leave a wide margin above our present annual cut without eating into or impairing our normal growing stock, but our forests are far from the condition necessary to produce a normal yield.

The Maintenance of the Lumber Industry is not hoped for by the men engaged in it. As it goes now there are no reproductive cuttings and no improvement cuttings. Young and growing stock is cut with that which is mature. Fires destroy what is left, whether young stock, seeding trees, seeds, seedlings or the fertile soil. Not only is the forest thus destroyed but non-productive land is made by the same disaster. Much of our once forested area is naturally agricultural land, but only a small percentage of it is now in demand for agriculture, and under the present wasteful process this land also becomes non-productive, while, if these lands were kept growing timber until they were needed for agriculture, the industries dependent upon our forests might be maintained a long time. As it is, our forest is being worked like a mine that cannot grow. The body of timber remaining being measureable, and the condition of our stump land and other forest areas being almost non-productive by reason of fire, we can divide our present amount of standing timber by the annual cut, then add an attenuation and approximately find the end.

Others Beside Lumbermen are Interested in this Question.—The lumberman's interest, as a rule, ceases when the original timber is cut off. The interest of the tax payer and the community continues, and the interest of the state is perpetual. The tax payers, in what were formerly timbered

*Board Measure.

counties, are seriously affected by the increasing areas of unproductive land, and their taxes are fast becoming a burden, since large areas once well timbered are now considered not worth the taxes levied upon them and consequently the amount of taxable property is much reduced.

Estimates of Forfeited and Unredeemed Lands have been kindly furnished by some of the county auditors and are given in Table XI.

TABLE XI.—Estimate of the Amount of Land now Unredeemed in Eleven Counties from the Tax Sales of the Last Five Years.

COUNTIES.	1891.	1892.	1893.	1894.	1895.	Estimated by Totals.
Becker						6,500
Benton	4,650	7,140	9,380	9,010		
Chisago						3,000
Crow Wing						210,000
Isanti	300	250	1,000	1,400	4,000	
Lake	18,000	20,000	22,000	23,000	25,000	
Morrison	22,200	28,500	30,000	34,800	36,000	
Pine	5,720	7,280	30,080	18,480	38,080	
St. Louis	190,324	253,724	278,926	360,648	427,089	
Stearns		8,400	10,000	13,500	17,000	
Todd	6,525	6,598	15,970	35,981	25,554	

This table only includes an estimate of the land unredeemed from the tax sales of eleven counties and probably nearly all of it was formerly timbered and is now waste land land or is land on which the standing timber will soon be cut and it will then become waste land. There are about twenty other counties formerly containing timber lands which probably have considerable waste land that has been forfeited to the state but we have not been able to obtain an estimate of the amount from the county officers. But making a rough estimate of the land remaining unredeemed in the twenty counties not reported and allowing for that which will be redeemed we are forced to the conclusion that there is in Minnesota a total of not far from 2,000,000 acres of cut over timber land remaining unredeemed and practi-

cally abandoned by the owners. The tax title under which these lands revert to the state are seldom perfect and consequently not satisfactory. This large amount of land is left then in the anomalous position of being too poor for the individual to bother with and yet the state can do nothing with it on account of its poor title and consequently no one cares what becomes of it.

The forfeiture and non-redemption of these lands proves their lack of value under the present let-alone policy, and the question arises whether timber could not be grown upon them profitably if they had a little care. Most of it is, however, in a very poor condition for this purpose, being deprived of growing stock and seeding trees, however, it is a question that invites investigation and experiment.

STATE LANDS.

Another class of lands in which the people should be greatly interested are those that belong to the state and the state institutions. If the practice of individuals in sweeping off all marketable timber to get immediate returns during their own life time, and then abandoning the land, seems unwise what may be said of the state and state institutions, whose lives do not cease, if they, with especial need of a permanent and increasing income, convert their growing endowment of forest stock imperfectly into money, and put that money in bonds that pay a low rate of interest, when by keeping a growing stock of timber they might get a much larger income.

From a paper read by Mr. Jewett before the Minnesota Forestry Association, we quote the areas of forest lands owned by the state and state institutions as shown in Table XII.

TABLE XII.—Lands of the State and State Institutions.

STATE LANDS.	Number of Acres.
School lands (unsold)	343,014
University lands (unsold)	46,014
Internal Improvement Lands (unsold)	22,208

STATE LANDS.—*Continued.*	Number of Acres.
Unappropriated swamp lands (unsold)	800,000
School lands expected to accrue upon completion of surveys (estimated.)	906,264
Swamp lands expected to accrue upon completion of surveys (estimated.)	950,000
School indemnity expected (estimated.)	60,000
Total	3,127,500

This land is all within the forest region and the state has now or will have direct supervision over it.

The tax payers of the state are directly and deeply concerned in these endowments, for it is important that the state realize as much as possible from them that as much direct taxation as possible may be avoided.

From the foregoing figures it will be seen that the State of Minnesota will own or control in the near future close to 5,000,000 acres of land within its forested area and a little needed legislation might result in making the title of the state perfect to the whole amount. The problem that naturally presents itself under these circumstances is as to whether this large area, in round numbers as large as the State of Massachusetts,* cannot be made to contribute more of value to the state than it now does. Many careful and conservative men believe it is now being wretchedly neglected.

CONDITION OF STUMP LANDS AFTER LOGGING.

The variety of conditions in which our pine land is left after logging is so great that few general statements can be applied to them. When every tree is marketable, every tree is cut. On the other hand, cutting scattered trees and small trees is not very profitable and some of such of marketable size are frequently left. The tops and other material cut or broken and left is a varying quantity that it is impossible to estimate closely.

*The land area of the State of Connecticut contains about 3,000,000 acres or about the same amount that Minnesota will eventually hold under various grants to public institutions.

The coarser material, where the timber has been dense, is left in heaps and ridges between the skidding trails, often so high that men at work cannot see each other over them. The finer material, especially the resinous leaves and the twigs broken and scattered by the fall of the brittle frozen trees, lie scattered over the surface, sometimes several inches deep. Under this material are more or less tree seeds dropped the previous autumn or during the winter, and the fertile accumulation of decaying vegetation. Standing between the skidding trails and among the debris are whatever trees it has been found unnecessary to cut, and, as an undergrowth, more or less seedlings. The trees that are thus left standing are the especial object of this study. Usually, fire burns the debris and kills the trees, seedlings and seeds, but there are exceptions.

There have been no intentional reproductive cuttings in Minnesota. Economy in getting the material to the mills has been the only consideration. In the earliest operations only the best and the most accessible timber was cut, and rarely any trees less than twelve inches in diameter were taken. Prior to 1880 few logs less than ten inches in diameter were taken. In 1885 and '86 stumpage contracts required the taking of every log eight inches in diameter at the small end, sixteen feet long, and scaling two-thirds of a full scale. At present, when lumbermen are cutting on their own land, nothing is left that would make a log five inches in diameter at the small end and twelve feet long. Cutting so clean leaves very few seeding trees, and these are the defective ones.

The saplings left are usually small and few on land that has been well stocked with log timber and cut by the owner, but more abundant when scattered among hardwood, or cut under contract without close supervision. The lumbermen have studied the question of saving young trees for future growth, but have found the risk of fire too great.

When fires are prevented more young stock will be left in logging. At present by far the greater portion of land once logged has merely a growth of brush among dead stubs and trees. Many well stocked acres may be found immediately

after cutting, but only a few of these escape ruin by fire. Some of these unburned acres which we have studied are herewith given.

WELL STOCKED LAND LEFT AFTER LOGGING.

White Pine Over-topped by Norway.—An acre of partially stocked stump land east of Grand Rapids was selected for study. The timber cut from it during the winter of 1893 and 1894 was scaled, stump and top, in the usual manner, and the amount of log timber removed in the customary method of logging was thus ascertained. The tops left on the ground were also measured, and their contents exclusive of branches and bark calculated and found to be as shown in Table XIII.

TABLE XIII.—Showing an Acre of White Pine Over-topped by Norway. The Trees Cut Were:

No. of Trees.	Species.	Age of Trees. Years.	Cubic Feet Contained.	Amount Removed. Ft. B. M. Scribner.
70	Norway	74 to 84	3,646	13,910
4	White Pine	72 to 75	96.78	300
1	Jack Pine	76	32.66	120
	Total Contents of Trees Cut		3,775.44	14,330

The trees suppressed before the cutting, or broken or uprooted since, are:

No. of Trees.	Species.	Inches in Diameter.	Feet in Height.
20	White Pine	4 to 9	50 to 84
5	Norway	5 to 9	50 to 80
2	White Spruce	5 to 10	35 to 60
3	Black Spruce	3 to 5	40 to 70
9	Fir	4 to 7	45 to 70
7	Tamarac	5 to 11	60 to 75
9	White Birch	6 to 10	60 to 75
4	Aspen	8 to 13	60 to 80

The uncut thrifty trees left were:

No. of Trees.	Species.	Inches in Diameter.	Feet in Height.	Cubic Feet.
88	White Pine	4 to 13	33 to 80	1,100.00
4	Norway	8 to 10	62 to 90	39.53
2	White Spruce	5 to 8	35 to 75	14.40
2	Black Spruce	4	30 to 45	2.61
8	Fir	5	47	39.53
8	Tamarac	5 to 9	75 to 92	85.12
14	White Birch	4 to 11	50 to 90	120.40
	Total			1,401.59

In addition to the above were: 18 white pine, 4 to 7 inches high; 82 fir, 1 to 8 feet high; 60 aspen, 4 to 10 feet high.

There was also a scant growth of hazel, bush honeysuckle, vine maple, cornel, strawberry, ground pine and pine grass. The soil is a light buff loam, much like moulding sand, and is common in that region.

The accretions formed during the past three years on two of the white pine saplings left standing were measured 28 feet above ground. On an average tree of those left uncut—one 8 inches in diameter and 70 feet high—the material formed before the cutting is about 11 cubic feet, that formed during the year 1896 is .53 cubic feet, therefore, on the 88 white pines left, a total increment of 47 cubic feet was formed during the season of 1896.

According to the yield tables prepared by Messrs. Pinchot and Graves for Pennsylvania, a fully stocked acre of best quality of white pine at this age should contain 228 trees, and should for the 90th year lay on 90 cubic feet.

The acre we are considering has but 88 white pines, they have laid on 47 cubic feet. We thus find that our acre with less than half the number of trees has laid on more than half the normal increment for a fully stocked acre of white pine in Pennsylvania. It should be noted that the tops of the trees cut had a volume, excluding bark and branches, of 2,255 cubic feet or 62 per cent of the whole

volume. This material being in the main straight stem formed a core around which later growth might be formed during the vigor of the tree, increasing in volume in proportion to the square of the years and reducing the percentage of waste as the trunk grows larger.

The accretion on the live trees may be expected during the next 20 years to make a total volume of 2,522 cubic feet, of which about 50 per cent or 12,610 feet B. M. would be marketable log timber, at $3 per M.,* this would be worth $37.83 per acre. The present value on this basis at 5 per cent should be about $14.46 per acre, and yet this land is regarded as valueless and it is not probable that any one knowing the circumstance would accept this land as a gift and keep the taxes paid up on it.

INCREASE ON SMALL TREES.

White Pine Over-topped by Aspen.—Frequently, between the groups of log timber in the natural forest, are areas well stocked with pine not yet large enough to cut. These are left uncut in logging. On one-tenth of an acre that is typical of such forest was found the stock shown in Table XIV.

TABLE XIV.—Showing the Stock on One-Tenth of an Acre of White Pine, Over-topped by Aspen.

No. of Trees.	Species.	Age of Trees, Years.	Diameter in Inches.	Height in Feet.	Equal to Cubic Feet on Acre
37	White Pine	81 to 84	6¼ to 7¾	52 to 66	2,738
27	Aspen	84 to 90	10	74	10,889
	Total				13,627

This plat is unusually heavily wooded. Lying immediately below a beaver dam, it has a good supply of water; the soil is fertile, porous, and over one-half clay. This acre is especially promising for a large yield of good timber. The pine trees will soon over-top and suppress the aspens and then will make a much more rapid growth than at present; the trunks are already long and free from branches. The number of white pine trees at present on this acre is 370,

*Thousand feet board measure.

and will be abundant stock after the aspen is gone; in fact, the yield tables show for stock of first quality, of this height and age that about 214 trees is the normal number. Although the cubic feet of pine alone is less than the normal amount as given in the yield table, the amount of aspen and pine together is more than double this amount.

The 10,889 cubic feet of aspen may be removed and the pine left in better growing condition than it is now.

Assuming that this acre would, if the aspen were now cut, speedily reach the normal accretion (it is really expected to exceed it) the future growth may thus be found in the yield tables. On this basis, in twenty years from now, this acre, at present not worth logging,may be expected to yield, if protected from fire, 34,000 feet B. M. If left 70 years, 50,400 feet, B. M.; 120 years, 70,000 feet with a possibility of its reaching 100,000 feet, the highest that may be hoped for in white pine.

There seems to be something incongrous in the fact, that while this stock is worth nothing today in the market, it would, in twenty years, yield 34,000 feet of lumber, Scribner's rule, worth say, $3.00 per 1000 feet on the stump, or $92.00 for the acre. This discrepancy in the supposed present value of this stock is attributed to the danger of fire.

The state is invited to consider this fact, for, this and many other similar tracts are on school and and other state lands, and the question should be determined whether efficient fire protection cannot be provided for less than this figure, which is $4.60 per acre. A photograph of this tract is shown in figure 1.

White Pine Among White Birch.—Another well stocked tract of timber trees, too small to cut, and surrounded by stump land is represented by the following one-tenth acre of white pine among white birch shown in Table XV.

TABLE XV.—Showing the Amount of Stock on One-Tenth of an Acre Well Covered with White Pine and Birch.

Species.	Age. Years.	Diam. Inches.	Height. Feet.	Cu. Ft. Av.	Trees. 1/10 Acre.	Cu. Ft. 1/10 Acre.	Trees Per Acre.	Cu. Ft. Acre.
White Birch	86 to 92	5 to 12	65	10.2	26	265.	260	2650
Aspen	86	8 to 10	66	13.	4	52.	40	520
Red Maple					3		30	
Fir		2 to 3	18 to 28	.20 .68	2	.9	20	9
White Pine	86 to 92	5 to 12	48	8.5	26	221.	260	2210
Total						538.9	610	5389

Under the above mentioned trees is a light growth of hazel and vine maple.

Comparing this with white pine in the yield tables, it is found there that an acre of white pine of second quality has a normal yield of 5,325 cubic feet at 85 years old, and an average height of 68 feet. As the white pine on this acre will probably over-top the birches within 25 years, it is thought that this one is in better condition than the normal one from the yield table, and while it would be unprofitable to cut this timber now it may be expected when 100 years old, or 15 years from now, to yield at least 18,500 feet B. M. This, at $3.00 per thousand, would then be worth $55.50 per acre. Its present worth, if safe from fire, should be $26.69, yet it is of little if any value; this yield would be increased if the birch and aspen were cut at once. The soil is a light colored sandy loam of about the consistency of moulding sand, with a subsoil of boulder clay. A photograph of this tract is shown in figure 2.

White Pine Over-topped by Tamarac.—On a piece of land where white pine was over-topped by tamarac and in other respects similar to the foregoing tracts was found the stock shown in Table XVI.

TABLE XVI.-Showing Stock on one Acre of White Pine overtopped by Tamarac.

Species	Age Years	Diam. Inches	Height. Feet	Average per tree Cu feet.	Cu. Ft. 1/10 Acre.	Trees 1/10 Acre.	Cu. Ft. Acre.	Trees per Acre.
Tamarac...	86	6 to 13	65 to 82	16.3	195.2	12	1952	120
White Pine	75	4 to 6	42 to 60	3.12	137.3	44	1373	440
Fir.....		6 to 8	30 to 50	4.8	14.4	3	144	30
Total					346.9	59	3469	590
Undergrowth	15 Fir 8 inches to 2 feet high. 11 Aspen 2 to 5 feet high.							

This stock as compared with normal yield tables, although showing too many trees for thrift, is, in point of yield, between second and third quality of normal stock for this age. If untouched this pine would eventually become valuable forest, but much waste timber would be formed in suppressed trees, and the final yield would have a large proportion of rotten timber. It needs thinning. A photograph of this tract is shown in figure 3.

INCREASE ON SCATTERED TREES LEFT AFTER LOGGING.

In addition to the foregoing well stocked land, the scattered saplings or underlings, much exposed after logging or after burning, or both should be considered, for many acres are left with scattered trees on them. Many of them being suppressed are defective and rotten and if very tall and slender and much exposed, these scattered trees are apt to be broken or blown down by the wind, but it is common to find some of them surviving and thrifty.

To find some data for estimating the prospective yield of such trees, a number of them were cut and their annual accrement was measured. In calculating their accretions the prismoidal formula was used as explained in introduction.

One isolated tree of white pine that was measured was standing in dead brush with stubs of medium sized aspen and white birch among old stumps. The soil is of medium fertility, but porous, with rocky sub-soil, at the southern front of a hill, and the roots could reach constant water.

The results of the calculations of the annual increment in this case are shown in Table XVII.

TABLE XVII.-Increase on Scattered White Pine Left After Logging, Alternately Free and Crowded.

Height of Section Above Stump. Feet.	No. of Rings.	Whole Diameter Inside of Bark. Inches.	Whole Diameter. Inside of Bark. Millimeters.	Increment Past 10 Years on radius. Millimeters.	Diameter Inside of Increment. Millimeters	Contents Cubic Feet by Prismoidal Formula. Increment of Last Ten Years.
00	99	13.9	350	102	146	3.33446
5	94	10.6	267	77	113	2.16868
10	87	9.8	248	58	132	1.86071
15	73	9.6	241	61	119	1.69512
20	67	9.0	229	51	127	1 53530
25	62	8.8	222	54	114	1.46050
30	56	8.4	212	51	110	1.14500
35	45	7.0	178	39	100	0.94529
40	35	6.6	165	49	67	0.71624
45	26	4.5	114	39	36	0.31550
50	23	2.6	64	25	14	0.08792
55	13	1.0	26	13	0	0.00952
55-top		0	0	0		
Volume of increment during past 10 years						15.23510
" " stem prior to " " "						4.72120
Volume of stem when cut						19 95630
Mean annual increment during past 10 years						1.5

The surroundings of this tree were such that in connection with the thickness of annual accretions its history could be determined:—

It started 102 years ago under birch and aspen, was nearly suppressed by them when between 20 and 25 years old. Overcoming them when about 30 years old it pushed upward rapidly until about its 50th year, when it was set free by fire and its height growth was thus checked again

until about its 75th year when rapid upward growth, due to crowding, began. At this time the lateral growth of branches was slight until about the 84th year, when a severe fire killed the surrounding trees and set this one entirely free.

Further study of the annual accretions of this tree shows:

1st. That while the rapid upward growth was being made the lateral accretions were slight.

2nd. That large accretions accompany full leafage.

3rd. That during the past 18 years, or since the surrounding growth was killed by fire, the tree has been strengthening that portion of the trunk that receives the greatest strain by wind—that is the butt.

4th. That in working toward the top of the tree the accretions are found to diminish as each live branch is passed.

WHITE PINE, CROWDED AND THEN SET FREE BY FIRE.

Another white pine that was first crowded severely then both injured and set free by a fire that killed the surrounding growth, was studied by making sections at each 5 feet above the stump, and the result is shown in Table XVIII, on following page.

The crown (live branches) of this tree was 35 feet high and 20 feet wide; 110 of such trees would stand on one acre without crowding, and these would each be expected to lay on as much as this specimen, for this was a short and inferior tree. 110 trees laying on .89 cubic feet each would form 98. cubic feet per acre per year. Looking into the yield tables of the first quality, prepared by Messrs. Pinchot and Graves, we find the normal annual increment per acre, 120 years old, in Pennsylvania, to be 60 cubic feet or but little over 60% of what is theoretically possible here. Practically an acre in exactly such condition could not be found after logging, but it seems well that this tree be taken to show what may be expected of the sound saplings left scattered about on stump land after they recover from the hardship of the exposure in-

TABLE XVIII.—White Pine—First Crowded, then Set Free by Fire.

Height of Section Above Stump. Feet.	No. of Rings	Whole Diameter Inside of Bark. Inches	Whole Diameter Inside of Bark. Millimeters	Increment on Radius During Last 10 Years. Millimeters	Diameter Inside of Increment. Millimeters	Contents, Cubic Feet by Prismoidal Formula of Increment During Last 10 Years
00	125	15.9	400	40	320	1.83
5	120	11.9	300	28	244	1.12
10	115	11.2	281	22	237	.99
15	99	10.5	265	25	215	.89
20	95	10.0	250	20	210	.89
25	87	9.5	240	23	184	1.02
30	71	9.3	235	30	175	.90
35	.....	7.7	195	27	141	.65
40	.....	6.4	160	23	114	.39
45	.....	4.0	102	19	64	.17
50	.....	2.1	52	15	22	.06
55	.....	1.0	24	12	00	.01
57	.....	.....	0	0	.....	

Totol volume of increment on stem during past 10 years	8.94
Total volume of stem prior to last 10 years	6.15
Present volume of stem	15.09
Mean annual increment during past 10 years	.89

cident to logging. The lowest limb on this tree was 32 feet above the stump. There being no branches the wood formed on this portion of the trunk is free from knots, and would make clear lumber. These sound trees, first crowded and then set free are therefore of special value, for the lumber found on them is of the best and they form but little waste material. A section of this tree is shown in figure 4.

WHITE PINE OPEN GROWN.

One white pine tree entirely open grown was selected and measured in the same manner as the foregoing. It grew on a sandy knoll 100 feet above a lake.

This tree, 56 years old, was 18 inches on the stump, 8 inches at 25 feet above, with a total height of 48 feet. The contents are shown in Table XIX.

TABLE XIX.—Open Grown White Pine.

Volume of stem prior to last 10 years	16.33 cubic feet.
Accretion of stem during past 10 years	12.52 " "
Volume of stem when cut	28.85 " "
Scale by Scribner's rule	70 feet B. M.
Mean annual increment during past 10 years	1.25 cubic feet.

As the live branches of this tree, or the crown, occupied the whole tree, the timber is very knotty. A proper crowding would have kept this tree from forming large branches on the lower trunk, would have stimulated its growth and less wood would have been formed during the early life of the tree. But, if, as in the case of the two former trees, it was first crowded and then set free, the best timber in the least time would be secured.

The growth of these scattered trees form some basis for calculating the effect of leaving the smaller trees in logging and protecting them against fire.

NATURAL RESTOCKING ON UNBURNED LAND.

(*a.*) Occasionally, and undesignedly, the cutting by loggers approaches reproductive cutting. An example of such work was found on or near Sec. 36, T. 50, R. 17.* The surface of the land is nearly covered with tops and culled logs left in logging, but on $\frac{1}{10}$ of an acre were found the stock shown in Table XX.

TABLE XX.—Stock left on One-Tenth of an Acre after Logging.

Five (5) White Pine stumps 20 to 30 inches in diameter, cut during the winter of 1890-1.

Six (6) Yellow Birch 6 to 11 inches in diameter and 50 to 70 feet high were left standing. The following seedlings were also found.

Ten (10) Red Maple 5 to 10 feet high.

Seven (7) Tamarac 18 inches to 5 feet high, and 5 years old.

Six (6) Fir 10 to 24 inches high, and 3 to 5 years old.

Three (3) Black Spruce 3 to 5 years old.

One Hundred and Seventeen (117) White Pine 6 inches to 3 feet high, and 2 to 5 years old.

* NOTE.—Sec. section. T. township. R. range.

Some blue berry bushes are growing with cornel, gold thread and moss on the ground. The soil is loam of medium quality with well moistened sub-soil and eastern exposure. A large body of white pine log timber stands about ⅛ mile southward.

As the count in the table is on ⅒ of an acre only, a whole acre would have 1170 white pine which is an ample stock for timber. In fact, 100 trees of white pine well distributed among hardwood is ample stock for one acre.

(*b.*) Another tract where reproductive cutting of white pine has accidentally been approximated, is found on the S. E. ¼ of N. W. ¼ of Sec. 16, T. 56, R. 23.

This plat of one acre from which 12,000 feet B. M. were cut during the winter of 1892-3 had 32 white pine saplings 8 to 11 inches in diameter and 30 to 80 feet high left after logging. These with 1,267 white pine seedlings grown since the cutting, were found on this acre in the autumn of 1894. When re-examined in October, 1896, the condition of the seedlings was of much interest. Where there were 1,267 in the fall of 1894, but 108 remained. The missing ones have probably been smothered by the dense growth of raspberry vines, coarse grasses, weeds and brush that have grown rapidly under the very slight shade of the trees left after logging. These 108 trees would be an ample number of mature white pine per acre, but they are not evenly distributed. In this case, not enough shade was left and so much light was let in on the ground that the shrubs and grasses grew and smothered the small pines. If several dry seasons had followed the cutting, the seedlings might have done well, however. The surviving seedlings were on hummocks and other dry places.

(*c.*) On the road from Grand Rapids to the Diamond Mine, on or near Sec. 36, T. 56, R. 25, is a tract where accidental reproductive cutting promises complete restocking.

On one-tenth of an acre of this land, from which during the winter of 1890-1, three white pines about three feet each in diameter were cut, and through which a logging road was made the same winter, were found the trees and seedlings shown in Table XXI.

TABLE XXI.—Result of Accidental Reproductive Cutting.

Species.	Inches Diameter.	Feet High.
1 White Birch	10	45
1 "	5	50
1 "	14	15
1 "	6	45
1 Double White Birch, each	6	60
1 Yellow Birch	4	45
1 Fir	3	30
1 Fir	1	5
1 Sugar Maple	6	40
1 "	5	28
1 "	3	26
1 "	3	24
1 "	4	30
1 "	5	35

These trees about half shade the ground. Under them are 341 white pine seedlings 3 to 5 years old and 10 to 40 inches high. The seedlings are most abundant in the log road where they average about 2½ feet apart. Shrubs and sprouts of red maple, sugar maple, vine maple, basswood and hazel, some 3 to 5 feet high, form a light undergrowth.

As 341 white pine are here on $\frac{1}{10}$ of an acre, or 3410 per acre, many of these could be spared to fill in spaces where ample stock was not secured.

NATURAL RESTOCKING ON BURNED LAND.

(*a*) About 13 years ago from $\frac{1}{10}$ acre on S. E. ¼ Sec. 23, T. 50, R. 17, 6 white pine trees 20 to 30 inches in diameter were cut. The land was afterwards severely burned. There are now 665 seedlings 6 to 12 years old, as shown in Table XXII.

TABLE XXII.—Showing Stock on Severely Burned Land Thirteen Years after Logging.

No.	Species	Inches Diameter.	Height.
115	Aspen	1 to 2½	15 to 30 feet.
3	White Birch	1 to 1½	15 to 20 "
60	Inferior Aspen		About 10 "
100	Red Cherry	½	5 "
6	Tamarac	¼ to ½	3 to 5½ "
2	Spruce	.22	1 " 6 in.
2	Fir	18	2 " 2 in.

71 white pine, 5 inches to 5½ feet high and 1 to 8 years old, or 710 white pine per acre.

There was a light growth of hazel with ground pine and wintergreen on the ground. The pine seeds had evidently been shed from scattered trees left in logging. The soil is light, sandy and well drained, with southeast slope.

(*b.*) Another tract of severely burned stump land now well stocked with white pine seedlings was found on the S. E. ¼ of Sec. 2, T. 48, R. 17.

This tract was logged about 25 years ago and the logging has been followed by repeated fires which have consumed all the debris except the stumps, and a few of the larger sticks left among the tops.

On one-quarter of an acre were found 1,076 seedlings, ranging from 1 to 20 years old and from 6 inches to 23 feet high, which is equal to about 4,304 seedlings per acre, as shown in table XXIII, on following page.

The average distance between these seedlings is about 3 feet, but the trees are grouped somewhat and there are some vacant spaces. Although not crowded enough to prevent branch growth at present, the crowding would soon begin and the white pine may be expected to eventually overtop and suppress all others (though it would be slow in overtopping the tamarac), thus forming a dense forest of all white pine.

The soil varies from sand to gravel, and is on the border of a post-glacial river bed, now thoroughly drained. A

TABLE XXIII. Showing Stock on One-quarter of an Acre of Repeatedly Burned Land Twenty-five Years After Logging.

SPECIES.	No. of Trees.	Per cent.
White Pine	384	35
Aspen	359	33
White Birch	120	12
Red Cherry	97	9
Willow	32	3
Tamarac	32	3
Black Spruce	10	1
Red Maple	10	1
Other Species	32	3

sand hill 100 feet high lies to the westward. At present there are few living white pines in sight, but dead trees are standing scattered over the stump land. These were probably living 10 or 15 years ago, when most of these seedlings started.

In this case the severe fire had destroyed all humus and the conditions were unfavorable to grass and low shrubs; even the aspen found itself unable to make a vigorous growth. Nearly all the aspen are injured by fungus growth or borers, and their feeble growth has not retarded the growth of the pines.

(*c*.) Upon one acre of an abandoned field near Twin Lakes, Minn., were found seedlings 22 to 28 years old as shown in Table XXIV.

TABLE XXIV.—Stock on an Abandoned Field near Twin Lakes.

Number of Trees.	Species.	Inches in Diameter.	Feet in Height.
1270	White Pine	2½ to 8	30 to 36
90	White Birch	1½ to 5	30 to 39
30	Aspen		39 to 45
20	Red Oak		
20	Groups of Alder		15 to 20
40	Willow		15
20	Red Cherry	4 to 6	30 to 39

The soil is red loam and nearly one-half sand.

NORWAY PINE.

The usual condition of Norway forest before logging may be learned from an acre on Sec. 9, T. 59, R. 24. On it are 93 Norway and 8 white pine, 120 to 125 years old, averaging 102 feet high and 200 feet B. M. per tree, or 20 thousand feet B. M. per acre. The smallest tree 30 feet B. M., the largest tree contains 400 feet B. M. The crowns of the Norway were from 15 to 30 feet long and 8 to 24 feet wide. One crown was found to have lateral dimensions of 5x10 feet. All the crowns were damaged by whipping against each other even when a space of three feet was left between them. Under the timber trees were 390 white pine, 25 Norway and 25 spruce 3 to 15 feet high.

This timber was not sufficiently crowded when young and is therefore very knotty. The Norway knots, less than 30 feet above the ground, are covered by the later accretions, while the white pine are bristling with stubs of limbs.

NORWAY STUMP LAND.

The Norway pine left after cutting varies less than the white pine and being straighter and more sound, smaller sizes are cut, and fewer trees are left. Norway lands, too, being drier than white pine lands are more frequently and more severely burned and a well stocked acre one year after logging can hardly be found. Some isolated and some partly crowded trees were studied, however, with the following result:

(*a.*) On Sec. 3 in T. 49, R. 23, from which, during the winter of 1883-4 six trees were cut within a radius of 33 feet, was found an increase of accretion on the Norway pine trees left, one-tenth of an inch per annum on diameter before the logging, to nearly one-half inch accretion on the diameter after the logging. The soil is sandy and dry.

(*b.*) Another Norway pine on Sec. 13, T. 48, R. 23, eighty years old, 8 inches in diameter, and 94 feet high, with 25-foot crown, from which the surrounding growth had been cut five years before, had doubled the thickness of its accretions; that is, the accretions of 1895 and 1896 were twice as thick as those of 1890 and prior years.

(*c.*) A Norway pine near Wakefield Brook south of McGregor, never entirely free, was crowded severely in its 26th year when the diameter was 4½ inches. It was partly set free again by fire in its 42d year with a diameter of 8 6¾ inches. In its 60th year it was cut with a diameter of 10½ inches and a height of 69 feet, with 54 lineal feet of log timber and a height of 44 feet to first live limb. The volume of stem was approximately 17 cubic feet.

(*d.*) The effect of crowding is shown again by a Norway on Sec. 11, T. 49 of R. 23. There were 65 rings on this stump, which was 13 inches in diameter. At 24 feet above the stump there were 38 rings and a diameter of 9 inches. The total height was 51 feet. This tree has been crowded only recently. The whole accretion of the last seven years is but one-half inch thick. This is a reduction in annual accretions from 5 rings per inch to 14 per inch. This was a "pig iron Norway," being of rapid growth, soft and sappy. In 68 years it formed 21.16 cubic feet of which 15.84 cubic feet was marketable log timber scaling 60 feet B. M.

(*e.*) That the scattered survivors of logging and fire recover and form good timber quite rapidly is further shown by the following tree near Sawyer, that had been nearly suppressed by crowding and was finally set free by cutting and fire. It was twice severely injured, yet thoroughly recovered. See figure 8. This tree had 128 rings and a diameter of 17⅓ inches on the stump with a diameter accretion of 2⅖ inches during the last ten years. The following volumes were carefully calculated by the prismoidal formula, and are shown in Table XXV.

TABLE XXV.—Increase on Norway Pine Left after Logging.

The volume of stem prior to last 10 years was	15.08 cubic feet.
The volume of accretion during last 10 years was	7.87 "
The volume of stem when cut was	22.95 "
The mean annual increment during past 10 years	.79 "

The effect of crowding during the early life of this tree, the effect of fire, and the effect of having the crowding trees removed may be seen in the illustration. The soil was

gravelly loam with boulder clay sub-soil. This tree grew near, and about 10 feet above, a small slough sometimes dry.

(*f*.) An open grown Norway pine ("Pig Iron Norway") was also cut in sections and measured as shown in Table XXVI.

TABLE XXVI.—Increase on an Open Grown Norway Pine ("Pig Iron Norway.")

Volume of tree prior to last 10 years	16.05	cubic feet
Volume of accretion during last 10 years	9.56	"
Total inside of bark when cut	25.61	"
Mean annual accretion during 10 years	.96	"
Log timber, Scribner's rule	54	feet, B. M.

(*g*.) In marked contrast with this tree is one that has been severely crowded, reaching a total height of 97 feet in 90 years, the diameter on the stump was 9 inches, and 48 feet above the stump, 6½ inches, making 45 feet B. M. of marketable log timber out of a total volume of 19.45 cubic feet. This tree is of the growth called "timber Norway."

Young growths of Norway pine are occasionally found on the dryer portions of white pine land, often as pure Norway on sandy lands, but most frequently among jack pine. Norway pine seedlings seem to endure more sun than the white pine seedlings and bear less shade.

Under crowded tall jack pine with some seeding Norway among them, is the place to find Norway seedlings. The following plat studied near Grand Rapids may serve as an illustration:

On $\frac{1}{10}$ acre were 36 living jack pine, 5 to 10 inches in diameter, 65 to 73 feet high and 63 to 65 years old. The greatest vacant space between the trees is 18x24 feet. There are also 11 dead jack pine, injured by fire and suppressed. Under the jack pine are 42 living Norway pine 2 to 6 inches in diameter, 15 to 20 feet high, and 51 to 59 years old.

In this case the Norway pine had not been able to overtop the jack pine, probably owing to repeated slight fires injuring the Norways. Besides, the soil and exposure were very favorable to jack pine. Northeast of this plat, and 40

feet from its nearest edge, begins a group of large Norway pine 12 to 20 inches in diameter and 70 feet high. The young Norway on the plat studied were probably seeded by the old trees. The seedlings continue 40 rods southeast of the large trees. The young Norway about which the jack pine were especially injured by fire have trebled the thickness of their accretions during the past five years since they have had room to grow. There is no undergrowth but wintergreen and moss. The soil is very sandy. Permanent water is 10 to 20 feet below the surface. The exposure is eastward.

On jack pine land near seed-bearing Norway trees, a good stock of Norway seedlings may be expected if the ground be harrowed under the jack pine about the first of September of a good seed year.

JACK PINE.

This species is not much sought for log timber and but little is cut in logging, except as good trees are found mixed with Norway or white pine. Most of the jack pine cut has been for railroad ties and fuel. At present very few if any ties are being made of this timber, and the fuel cut is principally for local use. It is, however, brought from the north and retailed in St. Paul and Minneapolis at $3.50 per cord. Tie cutting has taken but few trees here and there. What logging of this species is possible does not usually destroy the forest cover. Cutting for fuel, however, sweeps the land nearly clean, and as in the region about Mahtowah and Sturgeon Lake, where charcoal was made for the Duluth iron furnaces, this cutting is followed by fire and a reseeding to the same species, if seeding trees remain, with perhaps here and there a Norway among them.

Jack pine abounds on Norway stump land, both as stock left in logging and as a new crop following cutting. Crowding seems almost necessary in growing jack pine for value, as it is much inclined to branch if started alone, and, if set free after crowding is very liable to be broken by wind and snow. Crowded by hardwood on fertile, porous, well watered soil, it has been measured two feet in diameter on the stump and 125 feet high.

(*a.*) Some of the jack pine trees cut for lumber have been measured. By the use of form factors and the diameter of the stumps they may be compared with the form of white pine. See Table XXVII.

TABLE XXVII.—Some Figures on Jack Pine Cut for Lumber.

Diameter inches on stump,	17	14	15	13	16	14	14	15
Scale (board feet)	210	170	200	90	220	160	190	50

(*b.*) The large area of jack pine often left on Norway stump land do not differ essentially in condition from areas of natural forest, except that they are somewhat more exposed to the wind and are more liable to fire. The rate of growth of such stock may be seen from the following $\frac{1}{10}$ acre near Grand Rapids. On it are:—54 trees 5 to 9 inches in diameter, 60 to 81 feet high and 50 to 65 years old, with crowns 4 to 11 feet wide and 30 to 36 feet long. In the stems of these trees are 504.3 cubic feet, or 5043 cubic feet per acre, or about 40 cords of fuel per acre, which at 25 cents per cord stumpage would make this acre worth $10.00. The land is worthless for farm use, being very sandy.

The best use of jack pine in forest management will be found in uniform mixture with Norway. Where Norway is about 25 feet apart and jack pine between, the Norway will be kept free from branches without retarding its accretions greatly, and whereon will form a long shaft or trunk of clear timber, and when this has been formed, the jack pine may be cut if of any marketable value. If left it would be suppressed and killed by the Norway. It is believed that in the above relations of jack pine and Norway will be found the clue to the problem of managing our waste sandy and gravelly lands.

RESTOCKING WITH JACK PINE.

This species is especially adapted for the covering of very sandy lands that are especially liable to fire. It might aptly be called "the fire pine" owing to its peculiar habit of holding its seed in the cone until unusual heat sets them free. The cones are sometimes opened by the sun, but when shaded, they remain closed and adhere to the branch until over-

grown by moss, and even nearly buried by accretions of wood. The vitality of the seeds in these very old cones has been tested and over 50% of them grew vigorously. When a fire sweeps through the jack pine the heat of it opens the cones, usually without injuring many of the seeds, which are shaken out upon the ashes of the quickly subsiding fire, where they find conditions favorable for germination.

To aid nature in this seeding may prove a difficult task, yet an experiment might be tried in harrowing the ground, then building fires under the branches of cone bearing trees that are to be cut. When timber trees are wanted Norway seed should be sown at the same time.

Young jack pine is found on all the sandy land in the northern part of the state, and has more economic value than is usually credited to it.

TAMARAC.

Tamarac is seldom cut for lumber but is mostly used for ties, poles, posts, fencing, mine props and fuel. It is especially adapted to cultivation around sloughs in farm regions. The mingling of various species is usually slight on tamarac lands.

As a rule tamarac is confined to swamps, not excessively wet and with a decomposed muck or humus that is dry at times. On such land nothing can compete with this species and it holds the ground. But on wetter land the cedar and black spruce rival it, and on dryer land, the white birch, and even the aspen and white pine, crowd, yet do not overtop it except as the white pine, by its thrift in old age holds on after the tamarac loses its vigor. The growth of tamarac and white pine together has been noted under white pine. It is a common opinion that tamarac in which some cutting has been done, does not thrive so well as before. There is certainly some truth in this, because the cutting out of part of the trees lets in too much sun and wind, both of which tend to make the uncertain supply of moisture on the usual tamarac land give out altogether. The wind too, very often topples over the exposed trees which are shallow rooted in consequence of the hard pan commonly underlying the basins

in which this tree is usually found. That tamarac often recovers from such exposure is true.

Some measurements of moderately crowded tamarac trees cut for ties, are as follows:

(*a.*) On S. E. ¼ of Sec. 31, T. 48, R. 22, one tree had 64 rings on stump, was 14 inches in diameter, and had accretions varying irregularly from .04 to .20 inches. At 33 feet above the stump it had 42 rings and a diameter of $8\frac{1}{2}$ inches. It was 87 feet high and made four ties. This tree grew on the border of a swamp where moisture was not constant. The varying thickness of accretions was probably due to the variations of water supply.

(*b.*) A tamarac in the same vicinity as the above had 76 rings and a diameter of 16 inches on stump, with accretions varying from .04 to .30 inches. This tree had 51 rings at 43 feet above the stump where the diameter was 8 inches; was 58 feet high and made five ties.

(*c.*) A tamarac grown on fertile upland near a swamp was 19 inches in diameter and had 79 rings. The accretions were from one-eighth to one-fifth inches in thickness during the first forty years. At 59 feet above the stump the diameter was $9\frac{3}{4}$ inches with 45 rings. This tree made seven ties and was ninety feet high.

NATURAL REPRODUCTION OF TAMARAC.

Natural reproduction of tamarac unconsciously aided by man has been noticed frequently along railroad lines where the right of way has been cleared through a tamarac swamp. Such young growth is found about a half mile east of Sawyer on the Northern Pacific railway.

(*a.*) A piece of tamarac about three-quarters of a mile north of Carlton on the St. Paul & Duluth railway was measured and 11,560 trees were found on one acre 18 years old, $\frac{3}{8}$ to $3\frac{1}{4}$ inches in diameter and 9 to $19\frac{1}{2}$ feet high with uniform accretions. The largest of these trees produced seed when 14 years old.

(*b.*) Concerning the rate of growth of tamarac Mr. F. B. Clark, an experienced cruiser and logger says: "When I came here 17 years ago there was a young growth of tam-

arac 3 to 5 inches through on the S. ½ of Sec. 19, T. 48, R. 22. This grew in 15 years so that two years ago I cut 11,000 ties from it. After this cutting an ample stock of thrifty trees were left but the fire of 1894 burned it all down.

(*c.*) Through the kindly interest of Mr. Wyman Elliot, of Minneapolis, attention was called to a second growth of tamarac on his land a few miles west of Minneapolis. A tree in this place was cut into blocks four feet long. The section at each cut was measured and the contents of the tree including bark and branches were carefully calculated by the prismoidal formula. The measurements are shown in table XXVIII.

TABLE XXVIII.—Second Growth Tamarac.

Height of section above stump. Inches	0	4	8	12	16	20	24	28	32	36	40	44	44½
Number of rings at section	38	33	28	25	23	20	15	13	11	10	6	2	0
Diameter inside of bark (inches)	11.1	8.6	7.7	6.9	6.5	6.0	5.2	4.2	3.6	2.6	1.0	0.2	0
Diameter inside of bark (millimeters)	280	217	193	173	163	150	130	105	90	65	25	4	00
Diameter prior to accretions of last 10 years (millimeters)	220	161	143	119	115	94	50	5	0	....	....	....	....

A section of this tree is shown in figure 11.

Volume before the accretion of the last 10 years...3.67 cu. ft.
Volume of the accretion of the last 10 years.....4.56 " "
Total volume of tree inside of bark.....8.23 " "
Mean annual accretion during last ten years..... .46 " "

The live trees surrounding the one cut were:

Tamarac	North	5	feet	7	inches	diameter,	45	feet high.
"	S. 40° E.	10	"	8	"	"	50	" "
"	East	18	"	9	"	"	47	" "
"	S. 50° E.	12	"	6	"	"	40	" "
"	S. 42° E.	14	"	6	"	"	42	" "
"	S. 40° E.	18	"	6	"	"	35	" "
"	S. 20° W.	12	"	8	"	"	40	" "
"	S. 30° W.	12	"	7	"	"	40	" "
"	N. 80° W.	15	"	5	"	"	40	" "
"	N. 30° W.	16	"	7	"	"	40	" "

Stumps were found surrounding this tree as follows:

N. 45° E.	14	feet.	Rotten tamarac	10	inches	diameter.
East	6	"	" "	9	"	"
S. 50° E.	21	"	" "	11	"	"
S. 75° W.	9	"	" "	10	"	"
West	13	"	" "	8	"	"
N. 40° W.	15	"	" "	8	"	"
N. 10° E.	21	"	" "	11	"	"

Mr. Elliot says this land was cut clean during the winter of 1855-6. Part had been cut before, but the last was taken then. At that time there was a dense growth of young tamarac about 18 inches high. In this instance reproduction cutting was unconsciously applied and successfully. The cutting from year to year let in light. When the right conditions were reached the seeds from the remaining trees grew.

WHITE SPRUCE.

This timber tree does not abound in the southern portion of our Minnesota forest, but toward the northwest it is more frequent. In northwestern Manitoba it becomes the principal timber tree and occupies the ground with white birch and aspen as an undergrowth or frequently covers all the ground itself. In Minnesota, however, the trees are so scattered among pine that when cut the stump lands are classed as pine rather than spruce. Unless severely crowded to keep the branches from growing (and there seems to be no tree but spruce to crowd it enough) the timber grows knotty and the knots are often dead or "black."

White spruce is usually found in fertile and well watered soil and frequently makes large and tall trees. Some white spruce trees found during stump and top scaling and cut for lumber are shown in table XXIX.

TABLE XXIX. Showing the Size of White Spruce Cut in Minnesota.

Diameter on stump (inches)	13	13	12	14	13	14	13	11	15	10	11	14	14	12
Scale (feet B. M. Scribner)	110	80	70	120	140	120	100	60	200	40	80	80	130	90
Diameter on stump (inches)			17	14	12	13	14	17	14	16	22	17	13	14
Scale (feet B. M. Scribner)			**180**	**160**	**70**	**110**	**10**	**340**	**140**	**240**	**500**	**240**	**120**	**160**

A tree grown under very favorable circumstances was on the S. E. ¼ of Sec. 10, T. 55, R. 25, in dark and fertile loam with eastern exposure and in a hollow (once a small water course) where water in the subsoil seems constant and at a moderate depth. Here was a group of white spruce from which one was selected as a type of the best growth that may be expected of this species in this state. It was 55 years old, 11¾ inches in diameter on the stump (2 feet above ground) and 79½ feet high. The height growth of the leader was 24 inches. The width of crown was 14 feet and its length 37½ feet. The diameter of stem at base of crown was 9 inches. This tree contained 109 feet B. M. of marketable log timber. The cubic contents of stem, exclusive of branches were approximately 27.06 cubic feet. The accretions on trunk were of nearly uniform thickness. The surrounding trees are:

Fir	N. 33° E.	13½	feet,	8	inches	in	diameter	and	40	ft.	high.
Aspen	N. 43° E.		"		"	"	"	"	80	"	"
White Spruce	N. 57° E.	9	"	5	"	"	"	"	35	"	"
" "	N. 57° E.	13	"	6½	"	"	"	"	40	"	"
" "	East	14	"	7	"	"	"	"	45	"	"
" "	S. 89° E.	15	"	2½	"	"	"	"	25	"	"(45 yrs.)
" "	S. 80° E.	15	"	2	"	"	"	"	20	"	"
" "	S. 60° E.	14	"	6½	"	"	"	"	40	"	"
" "	S. 40° E.	9	"	7	"	"	"	"	50	"	"
Tamarac	South	5	"	5	"	"	"	"	60	"	"(45 yrs.)
White Spruce	S. 25° W.	14½	"	7	"	"	"	"	35	"	"
" "	S. 65° W.	12	"	9	"	"	"	"	70	"	"
" "	S. 88° W.	13	"	5	"	"	"	"	30	"	"
" "	N. 86° W.	18	"	4	"	"	"	"	30	"	"
" "	N. 79° W.	22	"	4½	"	"	"	"	40	"	"
" "	N. 63° W.	26	"	5	"	"	"	"	40	"	"
Aspen	N. 53° W.	27	"	8	"	"	"	"	70	"	"(55 yrs.)
White Spruce	N. 52° W.	28	"	5	"	"	"	"	38	"	"
Aspen	N. 43° W.	24	"	11	"	"	"	"	75	"	"
White Spruce	N. 40° W.	30	"	4	"	"	"	"	30	"	"
Aspen	N. 22° W.	23	"	4	"	"	"	"	40	"	"
"	N. 13° W.	22	"	4	"	"	"	"	40	"	"
White Spruce	N. 5° W.	24	"	6	"	"	"	"	65	"	"(52 yrs.)
" "	N. 30° E.	20	"	8	"	"	"	"	66	"	"

There was no undergrowth. The ground was covered with spruce needles. It is inferred from the habit of this tree

in coming in under white birch and aspen that it might be successfully seeded broad cast on such land.

SOME PRINCIPLES OF FORESTRY FOR MINNESOTA.

The Principles of Forestry first to be applied to the original timber lands in Minnesota, should be:

1st. Protection from fire.

2nd. While cutting mature timber, helping nature to produce a new crop by leaving the young stock of timber trees in a favorable condition for growing, and the proper number of trees of desirable kinds, and the proper amount of light and shade for the seeds of the best kinds to germinate and grow into timber.

Some Further Principles of Forestry that are essential to the best yields are:

1st. Accretions of wood are proportional to leaf surface, therefore each acre should be as nearly as possible covered with leaves, and these leaves should be on trees valuable for their timber.

2nd. Leaves need light; partly shaded branches form little and imperfect wood, and those heavily shaded, die; therefore, by crowding and shading, the trunks of valuable timber trees can be kept free from branches and a large proportion of valuable, clear log timber formed on them.

WASTE MATERIAL IN FORESTS.

Waste material in forests is formed in at least three ways:—

1st. In Branch Wood, crooked trunks, and rotten trunks, the amount of the waste in branch wood varies according to the exposure, being very great in trees entirely open grown and very light in trees severely crowded. Crowding prevents this waste.

The amount of waste in rots and crooks is not measurable, but is thoroughly appreciated by experienced lumbermen. The principal cause of rot is over-crowding. This can be prevented by early thinning. The principal cause of crooks is crowding on one side. This can be prevented by cutting the crowding tree or branch.

2nd. In growing the kinds of trees that are not marketable. The kinds of wood that are marketable depend upon demand. In stocking a forest or in deciding which trees to save, the demand to be met is a future one. Conservative policy should rule. As crowding is best done by smaller trees between the timber trees, these crowding trees should be of kinds that are marketable when small, or at the time the timber trees begin to join their branches above them.

3rd. By Cutting Timber Trees when Small. The amount of waste in the stem of straight trees, excluding branches and bark varies from 81% in a tree 8 inches in diameter on the stump and 90 feet high, to 6% in a tree 40 inches on the stump and 150 feet high.

INJURIES BY FIRE.

Fires stand eminently as first among the causes of injuries to the forest.

Fires in our state have destroyed large areas of pine log timber before it could be made accessible to market. In the western and in the north-eastern portion of the pine region are large tracts of either aspen or white birch with uncut pine stumps and stubs standing thick among the brush and saplings, and in the wide belt of sandy land sweeping from Red Lake through Becker, Hubbard and Crow Wing counties to Mille Lacs, much Norway pine has been destroyed. Where accessible to market and where there is demand for lumber, the loss by the killing of mature trees is comparatively slight as such timber can be cut the winter following the burning without much loss.

When half grown stock is killed by fire the loss amounts to the present worth of this stock; the value of seeding and shading trees, and the value of the forest soil, from this may be deducted whatever marketable stumpage there may be left. In the case of such acres as are shown in tables XVIII, XIX, XX and XXI, although there is now no marketable timber upon them, yet, they have a stock that would with usual growth and at present price of stumpage be worth from $50 to $92 per acre in 20 years. If there were no danger of fire the present value of this stock would be found by simply

calculating the capital that would in 20 years amount to the average, or $71.00 per acre at a reasonable interest at 5% the present value, in this case would be $26.76. But the danger of fire has discouraged lumbermen from holding their land for a second growth.

It is impossible for fire to run over any forest land without doing great damage. This damage is difficult to estimate, but it is plain that whatever land is kept non-productive, is at least being kept from yielding the average 50 cubic feet or 500 board feet for each acre each year.

The greatest aggregate damage is probably done by light fires that repeatedly run over the ground and prevent a new growth.

Spring Fires are very damaging, for the trees being then full of sap, endure little heat and the seeds which are on the ground and possibly just sprouted are destroyed.

Autumn Fires, owing to the ground being very dry at that season, usually run deep, burning off the roots of the trees and consuming all the vegetable material which constitutes that valuable mulch and fertilizer called the forest floor.

The Tangible Causes of Forest Fires have been discussed so much that they must now be well known. The real cause is more remote and in the minds of the people. It might be called the lack of appreciation of the damage done by fires. Two essential steps toward the prevention of fires are, an appreciation of this damage, and a thorough co-operation among the people injured. As every tax payer in the state is injured by our forest fires all should co-operate cordially in the very important work of preventing them:

SUCCESSION OF TREE GROWTH.

A so-called succession of hardwood after pine is sometimes found upon unburned land that is left stocked with young hardwood after the pine is cut.

Oak lands, on the other hand often have a growth of young pine on them which takes possession when the oaks are cut. This applies to only small areas in the pine region of Minnesota, for oaks in the northern part of our state sel-

dom grow vigorous enough to seriously compete with the pine.

A few general statements can be made on this subject.

(*a.*) Trees grow wherever their seeds can sprout and overcome the competing vegetation.

Aspen finds such conditions on the fertile burned lands; jack pine finds it on the sandy lands.

(*b.*) Seedlings that start vigorously often kill other species that are tender which start at the same time, as, the aspen and white birch may kill the white pine under some conditions.

(*c.*) The most essential condition for a succession of pine seems to be, that seeding trees of pine be present to repeatedly scatter their seeds. The pines are long lived, and conditions in the forest below them change while they survive, and they continue dropping their seeds until the condition is right for the seeds to grow.

(*d.*) It is common to see white pine growing under aspen and white birch, and to see Norway growing under jack pine and under aspen.

Restocking.—Where land is well stocked with mature timber trees and a new stock of the same species is desired, it should be remembered that seeds will be born by the original stock, and that nature needs only the little aid that may be given by providing the conditions under which these seeds may grow.

The tiny seedlings of white and Norway pine are very tender until several years old, but just the conditions they need can be provided by merely cutting such a portion of the original stock as would let in the proper amount of light and air, while the portion left uncut would provide the proper shade. The simplicity and inexpensiveness of restocking in this way make this one of the most important details of forest management.

Planting.—Where there are no seeding trees of valuable timber kinds, as in large areas of small aspen or of small jack pine it may sometimes be advisable to cut a few of the present growth here and there, and to plant white pine among the aspen, and Norway among the jack pine. Plant-

ing is expensive, but in this case seedlings could be obtained from the forest where they have grown under similar conditions, and if the lopping be done properly no after care would be necessary. No outlay seems warranted, however, until the stock would be made safer from fire than at present.

MISCELLANEOUS NOTES.

H. B. AYRES.

The Oldest White Pine, noticed by the writer in Minnesota, was on Sec. 32, T. 59, R. 24. It had 348 annual rings on the stump, with a diameter of 30 inches. Sixty-eight (68) lineal feet of log timber were taken from it, scaling 1400 feet B. M. The top of this tree was broken off at 114 feet above the stump.

The Oldest and Largest Norway Pine seen by the writer in Minnesota, had 330 annual rings on the stump where the diameter was 32 inches; seventy-two (72) lineal feet of log timber, scaling 1,830 feet B. M. were taken from it. This tree was 103 feet high.

The Largest White Pine seen by the writer was on Sec. 16, T. 55, R. 23, and was 48 inches on the stump; 4,050 feet B. M. of log timber were taken from this tree; 1,079 white pine cut from this section at the same time made 3,077 logs, scaling 1,117,567 feet B. M. (1036 feet per tree.) From ten of the largest of these trees, 43 logs scaling 35,390 feet B. M. were cut. These large trees grew on fertile soil among hardwood. They were about 253 years old when cut. When 50 years old they were only 8 inches in diameter, but at 150 years old were adding about ½ inch to their diameter each year. These were cut about 1886.

In 1892-3 ten trees were cut on the same section, that altogether scaled but 310 feet B. M. or 31 feet per tree.

Logs four inches in diameter at small end are sometimes taken in logging. 176 logs have been counted on one load being hauled to the landing.

The Most Rapidly Grown Trees noticed were:

Norway Pine 100 years old, 30 inches on stump yielding 1,050 feet B. M.
White Pine 106 " " 27 " " " " 1,050 " "
White Pine 108 " " 32 " " " " 1,450 " "

The Heaviest Acre Yield of white pine scaled by the writer in Minnesota was on the N. E. ¼ of Sec. 29, T. 48, R. 16. The full scale on this acre was 111,050 feet B. M. After deducting for rot and crooks 94,264 feet B. M. of sound timber remained.

The Smallest Annual Accretion measured was on Muskeeg spruce, where 31 layers made a thickness of ⅛ inch, and 73 years were occupied in growing a tree 1⅛ inches, or 28 millimeters in diameter.

A tamarac under similar circumstances formed a diameter of $1\frac{1}{10}$ inches or 30 millimeters in 48 years.

BOTANICAL NAMES.*

Botanical names of the most common trees and shrubs of Northern Minnesota:

ASPEN.....*Populus tremuloides*, Michx.
ALDER.....*Alnus incana*, Willd.
BLACK ASH.....*Fraxinus sambucifolia*, Lam.
BLACK CHERRY.....*Prunus serotina*, Ehr.
BLACK SPRUCE.....*Picea nigra*, Link.
BOX ELDER.....*Negundo aceroides*, Moench.
BALM OF GILEAD.....*Populus balsamifera*, L.
BUSH HONEYSUCKLE.....*Diervilla trifida*, Moench.
BASSWOOD.....*Tilia Americana*, L.
BITTER NUT.....*Carya amara*, Nutt.
BUTTERNUT.....*Juglans cinerea*, L.
BURR OAK.....*Quercus macrocarpa*, Michx.
CORK ELM.....*Ulmus racemosa*, Thomas.
CORNEL.....*Cornus Canadensis*, L.
COTTONWOOD.....*Populus monilifera*, Ait.
CHOKE CHERRY.....*Prunus Virginiana*, L.
DWARF BIRCH.....*Betula pumila*, L.

*As the new botanical nomenclature is not popular as yet, it is thought that used in Gray's Manual would be most readily understood.

DIAMOND WILLOW. *Salix cordata, Muhl., var. vestita*, Anders.
FIR..... *Abies balsamea*, L.
GREEN ASH..... *Fraxinus viridis*, Michx.
HEMLOCK..... *Tsuga Canadensis*, Carriere.
HACKBERRY..... *Celtis occidentalis*, L.
HAZEL..... *Corylus Americana*, Walt.
HAZEL..... *Corylus rostrata*, Ait.
IRONWOOD..... *Ostrya Virginica*, Willd.
JACK PINE..... *Pinus Banksiana*, Lambert.
LEATHERWOOD..... *Dirca palustris*, L.
NORWAY PINE..... *Pinus resinosa*, Ait.
PRICKLY ASH..... *Xanthoxylum Americanum*, Mill.
RED CEDAR..... *Juniperus Virginiana*, L.
RED OAK..... *Quercus rubra*, L.
RED MAPLE..... *Acer rubrum*, L.
RED ELM..... *Ulmus fulva*, Michx.
RED OR BIRD CHERRY..... *Prunus Pennsylvanica*, L.
ROCK ELM..... *Ulmus racemosa*, Thomas.
SCARLET OAK..... *Quercus coccinea*, Wang.
SUGAR MAPLE..... *Acer saccharinum*, Wang.
TAMARAC..... *Larix Americana*, Michx.
VINE MAPLE..... *Acer spicatum*, Lam.
WHITE PINE..... *Pinus Strobus*, Linnæus.
WHITE SPRUCE..... *Picea alba*, Link.
WHITE CEDAR..... *Thuya occidentalis*, L.
WHITE OAK..... *Quercus alba*, L.
WHITE MAPLE..... *Acer dasycarpum*, Ehrh.
WHITE ELM..... *Ulmus Americana*, L.
WHITE ASH..... *Fraxinus Americana*, L.
WHITE POPLAR..... *Populus grandidentata*, Michx.
WHITE BIRCH..... *Betula papyrifera*, Marshall.
WINTERGREEN..... *Gaultheria procumbens*, L.
YELLOW BIRCH..... *Betula lutea*, Michx.

LETTERS.

A large number of lumbermen and others interested in the growth of pine timber in this state, have been asked for their opinion as to the feasibility of securing a new growth of white pine in Minnesota, and their replies are as follows:

From Weyerhaeuser & Co., St. Paul, Minn.

PER. F. WEYERHAEUSER.

In my opinion the only way to preserve the young pine timber in Minnesota is to make such laws as will be reasonably sure to keep all fires from destroying the young and growing timber, then reduce the taxes on all cut-over lands. What would be safer still, would be to have all cut-over lands deeded back to the state at a small consideration.

No one can hold cut-over lands and pay the present taxes. Holders are compelled to sell as best they can to escape the heavy taxes, which are largely levied at the request of settlers and hardly ever used to best advantage of the county in which such lands are located.

From Cloquet Lumber Co., Cloquet, Minn.

PER GEO. S. SHAW, PRESIDENT.

It is very difficult to form or give an opinion. Small sapling pine on good land will increase so that at sixty years it would be large enough to cut 12 to 14 inches. On poor sandy soil it would take much longer. Large timber will not increase much; doubtless if wind and rot in trees it does not decrease.

From C. A. Smith Lumber Co., Minneapolis, Minn.

PER C. A. SMITH, PRESIDENT.

We believe it perfectly feasible to secure a continued growth of pine timber in the northern part of our state. In order to do so, however, we believe that it would be necessary to adopt the same policy as is being done in Northern Europe, that is, to plant the seed and protect the young plants and the growth for a great many years from being destroyed by cattle. As a rule, after the pine has been cut off fires will be started and burn the tops and limbs left in

the woods. In doing this it burns all vegetation, and subsequently a growth of poplar and birch is being secured instead of pine. As stated, this, we believe, is the rule. Still more or less young pine comes up. Especially is this the case where fires have not passed over the ground after the pine timber has been cut.

From Cranberry Lumber Co. Duluth, Minn.
PER L. L. HOTCHKISS, LOCAL MANAGER.

In answer to your questions we have to say. First.—We do not think the growth of pine possible on lands which have been once cut over. Second.—Our experience is that often the pine has been cut off and where the fire passes through, as is very nearly always the case, that the following growth is from seed timber more hardy than pine, and which has not been destroyed such as oak, poplar, balsam elm, etc.

From Mr. Warren Upham, St. Paul, Minn.
SECRETARY OF MINNESOTA HISTORICAL SOCIETY.

Yes, I think that the valuable white and red pine growth in Northern Minnesota may be renewed through natural means after it has been cut off by lumbermen. In New Hampshire where I have had most opportunity for observation, many extensive areas of pasture land have become well covered with white pine during the past thirty or forty years. Seed-bearing pines shed their seeds chiefly in windy days, and the seeds are borne by strong winds often a half-mile from the parent tree. To secure reforesting in the much desired pine growth, a few old pines, often such as have no value for timber, ought to be left here and there, one or better, several near together, on each tract of forty acres.

From Mr. Asa Paine, Carlton, Minn.

I do consider a growth of young timber possible. There does not seem to be any doubt in my mind on that score.

As to the second step, that of the securing of such a growth, in the first place, precaution to guard against fire must be very carefully attended to and rigidly enforced. It occurs to me that the only way to secure valuable results would be

to offer bounty, the conditions to be fixed by the Forestry Commission.

From Hon. John H. Stevens, Minneapolis, Minn.

I would say that beyond all doubt or possibility of a doubt, pine timber in the northern part of the state will grow on denuded lands as a second crop in a most satisfactory manner. Of course it is necessary that fires should be prevented when second growth would be a spontoneous product; nature has wisely provided for this great and beneficial help to mankind.

From Mr. John McCarthy, Stillwater, Minn.

On a near section 34-4-24 from 1878 to 1880 all the largest pine was cut out. About 10 years afterwards some 500,000 feet were taken from two of these forties. A few years ago this same tract was sold for $15,000.

From Mr. Geo. Seley, Little Falls, Minn.

Sections 25 and 26-50-23 from which Norway pine was cut in 1885 or prior and partially cut since is now well stocked with Norway and jack pine. Sections 1-49-23 cut in 1887-8 and 1888-9 has now young Norway on the N. ½ S.½ sections 11,16 and 19 also cut 1887-8 have some young Norway. Sections 10-49-23 the N.E. and N.E. and N.E.,S.E. cut in 1886-7-8 and were again cut in 1895-6.

From Mr. F. J. Kline, Minneapolis, Minn.

In township 145-36 white pine and Norway estimated in 1882 at 16 logs per M. has recently been reestimated at 9 to 10 logs per M. In townships 143-26 white pine cut in 1873 not since burned, there is now a mixed stock that has made a noticeable growth.

From Mr. Leonard Day, Minneapolis, Minn.

On a tract we cut in 1873 and abandoned for taxes, we recently were offered a settlement of the taxes and $1.50 per M. for the second growth.

From Mr. A. E. Horr, Minneapolis, Minn.

There is no second growth cut because the fires will not let it grow. Second growth would be alright except for fire. The burning of tops left in logging is impractical.

From Mr. Geo. McCrea, Minneapolis, Minn.

There is no second cutting on land once cut clean because of fire. Pine would grow if fire were kept out, especially on light lands. In clay the hardwood crowds out pine leaving at best only scattered trees. These do well, however.

From Mr. G. A. R. Simpson, Minneapolis, Minn.

I know of no land once cut clean to yield a second crop. The growth is too slow. It does not pay the individual. It would pay the state to hold it if fire could be kept out.

From Captain J. N. Cross, Minneapolis, Minn.

Oct. 26th 1896, I was at the residence of Amos Beach in Lien Top, Grant Co., Minn., on east shore of Cormorant Lake. There were four box maple trees set out 18 years before. We measured the two largest; 5 feet from the ground, one measured 53 inches, the other 63 inches in circumference. On Sept. 18, 1896, I was on Murdock mountains, Townshead, Vt., and there where my grandfather's barn stood in June 1873 were six trees. I measured three of them. One, a black birch, was 57 inches, one, a white birch, was 56 inches and one a butternut was 55 inches in circumference.

From Mr. W. L. Bassett, Minneapolis, Minn.

I think the law against setting fire is not strong enough. I heartily favor all good work.

From Mr. Caleb Dorr, Minneapolis, Minn.

Visiting Moosehead Lake, Maine, last winter I expected to find all burned about the lake, but all was green and they were cutting out the largest trees separately. I never noticed so much young pine in Minnesota but have seen some. I think the climate here is different.

From Mr. Ray M. Jones, Minneapolis, Minn.

That fire law is a good thing. I don't know of any second cutting. There might be except for fire.

From P. and J. Meehan, Thief River Falls, Minn.

PER JAS. MEEHAN, JR.

We think the young growth of pine timber can be preserved and an immense forest grown therefrom. The most feasible plan would be for the state to purchase the stump lands which have timber thereon and withdraw them from the market for a period of ten or fifteen years.

In 1872, 160 acres 12 miles north of Grand Rapids, Minn, were cut. Three forties of this was large timber the fourth was sapling, white and Norway. 835 M. was cut during the winter of 1896-7. This was on the S.E.¼ of 14-57-25.

A lot of young white pine on the east side of S. 20, T. 48, R. 16 was when logging began in that vicinity considered too small to cut. It has recently been cut yielding some 25,000 feet per acre.

From Mitchell & McClure, Duluth, Minn.

PER MR. M'CLURE.

During our experience of over 25 years in the lumber business we have seen very few clumps of what we call second growth pine. In a few instances we have cut some of these clumps, and they show for themselves to be of recent growth, as generally they are quite soft, thin sap, red knotted and make very nice strips. They have usually been quite small, taking from 15 to 20 logs to the thousand. This was in Michigan, where we were located for about 20 years. In our experience we have never known any pine timber to grow where pine has been cut off. As a rule it grows up to popple and wild cherry. Our observation is that the white pine growth is exceedingly slow, and how it could be cultivated is something we have never taken into consideration. The small pines that grow sometimes on the plains where the timber has been burned over, after sometimes 50 years, we have noticed, but not to any ex-

tent. These possibly might be transplanted, but our judgment is that it would not be practicable to ever again produce the white pine forest by artificial means. The cost would be great, and the process would be so slow, that as a business proposition we would not consider it feasible.

From Hon. W. S. Dodon, Taylors Falls, Minn.

If forest fires can be avoided pine timber will come in again in old cuttings, if there is any matured trees left to reseed the ground. If the ground has been burnt over a young growth of aspen and birch should first be started to make a vegetable mould on the surface to protect the young pine, and if there is no old trees near to furnish the seed it must be sown, as a pine seed hardly ever falls over 40 rods from the tree on which it grows. Pine will grow up again on the same ground where a forest of the same timber has been once cut off, if it is properly seeded and has protection while young.

Figure 1.—White Pine Overtopped by Aspen. At present this stock is of no value, but in twenty years if protected from fire it will probably cut 34,000 feet B. M. per acre, worth $92.00 on the stump. See page 271.

Figure 2.—White Pine Among White Birch. At present this stock is of no value, but in twenty years if protected from fire it will probably cut 18,500 feet B. M. per acre, worth $55.50 on the stump. See page 272.

Figure 3.—White Pine Overtopped by Tamarac. See page 273.

Figure 4.—Section of White Pine Trunk; alternately crowded and set free in its growth. This is plainly shown by the size of the yearly rings. See page 275. Scale indicates inches.

Figure 5.—Heavy stand of jack pine on land that is worthless for farming purposes, being very sandy and dry. Will cut forty cords per acre. See page 285.

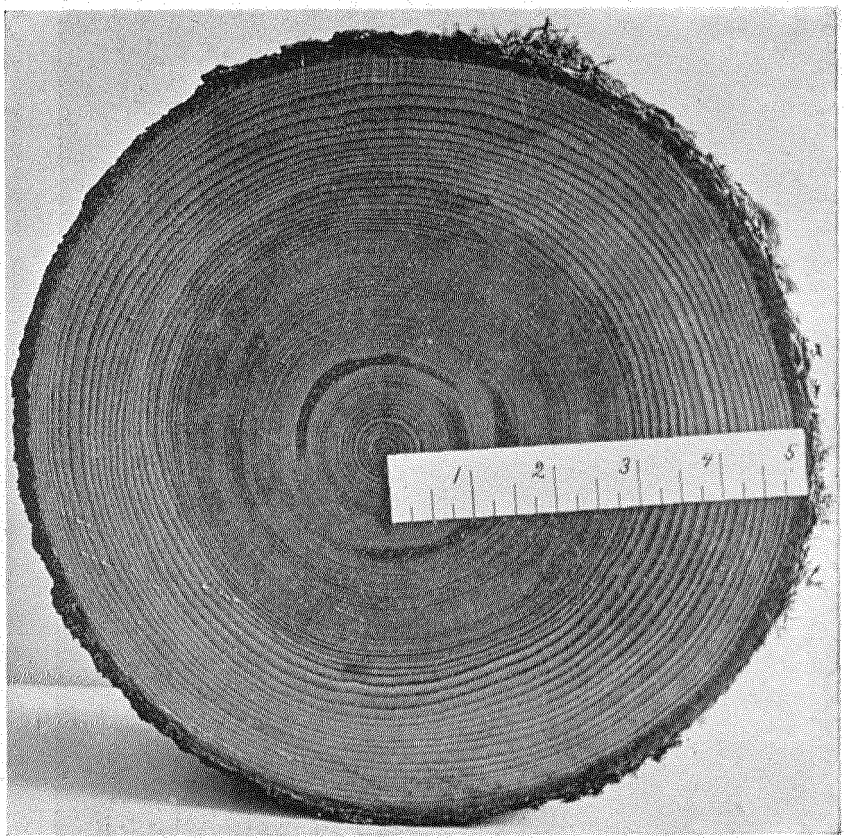

Figure 6.—Section of White Pine. Crowded and then both injured and set free by fire. Note annual rings are very narrow while tree was crowded and large since tree was set free. Mean annual increment during past ten years was .80 cubic feet. See Table IX. Scale indicates inches.

Figure 7.—Section of White Pine Open Grown. Note large size of yearly rings and that they are very wide and uniform in size. Diameter on stump, 18 inches; diameter at 25 feet above, 8 inches; total height, 48 feet. Mean annual increment during past ten years, 1.25 cubic feet. Scale indicates inches. See page 276.

Figure 8.—Section of Norway Pine. Severely crowded and then both injured and set free by fire. Note increase in size of yearly rings since it was set free. Mean annual accretions during past ten years, .78 cubic feet. Scale indicates inches. See page 283.

Figure 9.—Section of Norway Pine. Open grown. "Pig Iron Norway." Mean annual accretions during past ten years, .95 cubic feet. Scale indicates inches. See page 284.

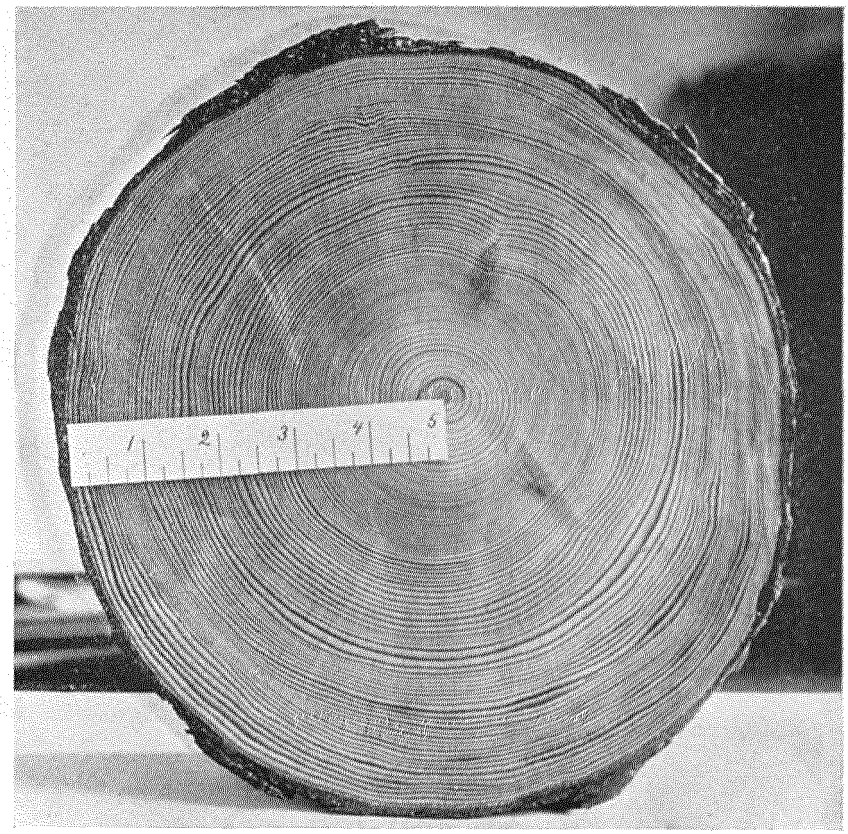

Figure 10.—Section of Norway Pine. Alternately open and crowded. Scale indicates inches.

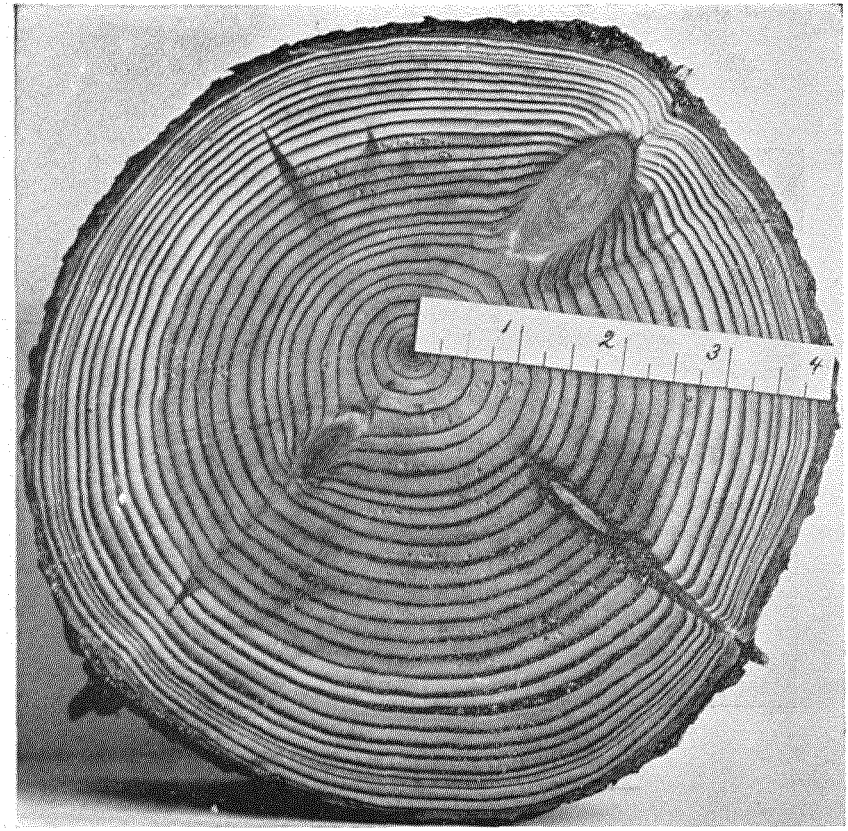

Figure 11.—Section of Second Growth Tamarac. Grown on land in Hennepin county, Minnesota. The history of this tree is known from the time it was 18 inches high. Age 88 years. Mean annual increase during past ten years, .46 cubic feet. Scale indicates inches. See page 289.

Figure 12.—Typical Norway Stump Land in Minnesota. Showing few seeding Norway left and a heavy young growth of jack pine that has come in since logging. Photo by H. B. Ayres.

Figure 13.—Large White Pine Near Carlton, Minn. Somewhat injured by fire but still alive.