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FOREST PLANTING EXPERIMENTS IN MINNESOTA

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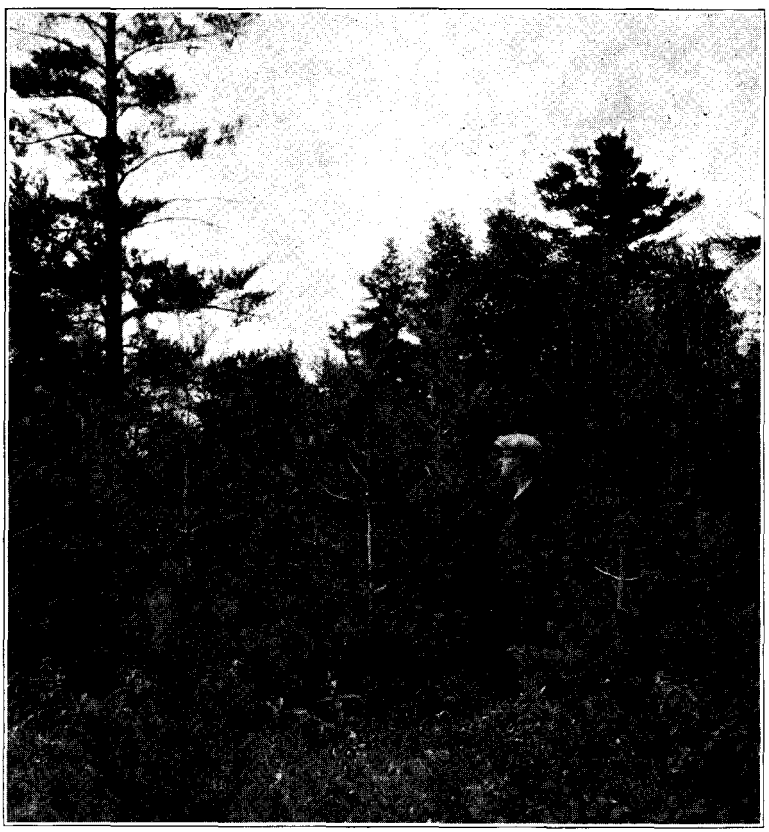


UNIVERSITY FARM, ST. PAUL

CONTENTS

SUMMARY

1. All planting was done with a 6x6 spacing or 1200 trees per acre. If it is assumed that 600 well established trees 5 years old are sufficient, then 80 per cent of all the plots established can be considered successful. Sixty-six per cent of the failures were found on the thick brush type. The planting of cut-over lands is a practical proposition for the Cloquet Forest Experiment Station, on everything except the thick brush type.

2. The character of weather during the actual planting is of less importance than the distribution of precipitation during the first growing season.

3. White pine survives better than the other species with a small amount of overhead shade. Norway, jack, and Scotch pine are to be preferred on more open sites.

4. White pine, Norway pine, and Scotch pine transplants are to be preferred to seedlings. This difference is not so marked in the jack pine.

5. Fall planting is almost always as successful as spring planting. White pine is the only species that had a slightly higher survival in the spring than in the fall.

6. In thick brush all plantings of this study have been a failure.

7. Rabbit injury runs up to 100 per cent in the thick brush and under dense jack pine, but is practically absent on the more open sites. Evidently rabbit injury is as important as the brush in determining the success of the planting.

8. From the results five years after planting, there seems to be very little choice as to species used. All four species have given good results. The real effect of the different species can be looked for when the plantings are old enough to show a volume increment.

9. Transplant stock is to be preferred to seedling stock.

FOREST PLANTING EXPERIMENTS IN MINNESOTA

T. S. HANSEN[1]

INTRODUCTION

When the Cloquet Forest Experiment Station was established in 1909, it consisted of about 160 acres of virgin Norway and white pine timber and 2500 acres of cut-over land, 1600 acres of which were considered to be in need of planting. Owing to this comparatively large area in need of planting and the general importance of the problem in Northern Minnesota, it was natural that experimental planting would receive considerable attention in the investigative program of the station.

General observations made on the cut-over lands of northern Minnesota indicated that natural reproduction could not be depended upon to stock the area fully—planting seemed to be the only solution. Jack pine was considered to be of little value. Foresters generally advocated the conversion of these stands by natural or artificial means into Norway pine stands, but very little work had been done to demonstrate how this might be accomplished.

Since then, through the operation of natural and economic causes, conditions have changed. The protection of this area from fire has given nature an opportunity to restock much of the area unaided. So well has this been done that some of the plantings have been almost completely overshadowed by the natural reproduction. Blank areas which at that time appeared in need of planting have disappeared. Jack pine has now become valuable enough to warrant its encouragement anywhere except on the better sites. Thus the 1600 acres, which appeared in need of planting, have dwindled to something less than 300 acres.

These facts might lead one to believe that the time spent in studies of forest planting is wasted. Such, however, is not the case. The conclusions drawn from these studies can be applied throughout the northern cut-over area where similar conditions prevail and planting is necessary. Nowhere else in this region is found such a detailed and fully controlled experiment, both extensive enough to be practical and intensive enough to answer the questions that arise in connection with

[1] This study was planned and inaugurated by W. H. Kenety and G. H. Wiggin. The writer's part has been the making of periodical observations and the drawing of conclusions from the results.

planting. These studies, then, can serve as a guide for planting work in this region.

Even tho nature has been generous with her natural seeding at the station, it has been found necessary to plant some of the blank spaces in order that the area may be kept 100 per cent productive. The results of the planting study have been of value in the selection of species, class of stock, and method of planting. The problem of reproducing brushy areas arose in connection with the managing and harvesting of the crop. While these studies did not solve this perplexing question, they served as a basis for further trials.

Fig. 1. An Experimental Planting Completely Taken Over by Norway and Jack Pine

EARLY PLANTINGS

The real planting work at the station was begun in the spring of 1913, when approximately twenty-five acres of cut-over lands was planted to white pine. The stock was a miscellaneous lot purchased from a commercial nursery. Good stands were secured with the stock planted on cut-over lands and with that planted under jack pine. About 90 per cent survived thirteen years after planting. In the open, the trees averaged about twelve feet in height ten years after planting; under jack pine they averaged about four feet. (See cut on cover.)

Fig. 2. White Pine Planted Under Jack Pine in 1913
Photographed in 1924

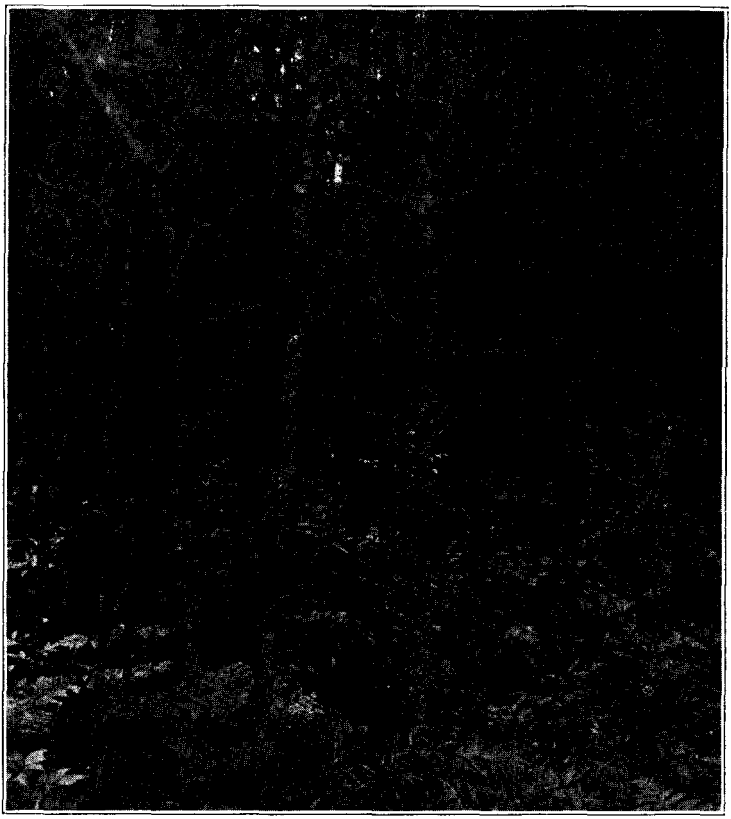


Fig. 3. Young Dense Jack Pine Site
Average age, 27 years

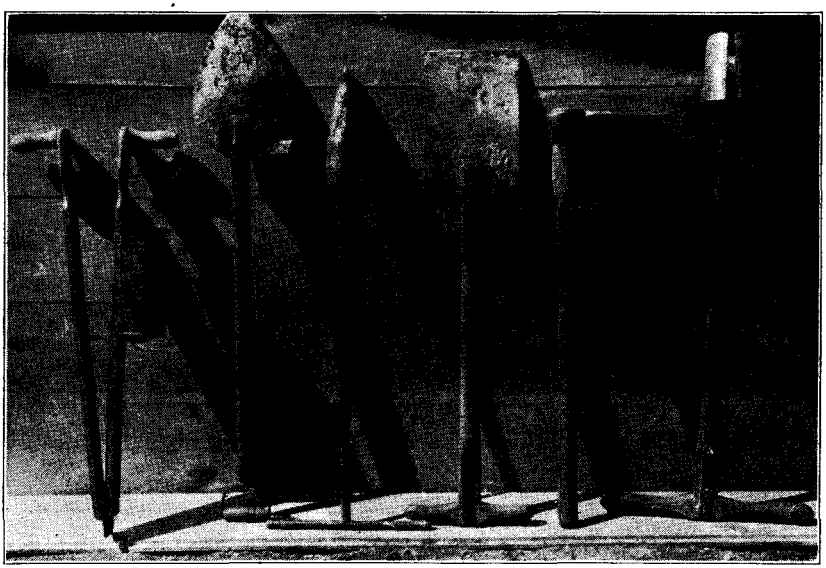
THE PLANTING PROBLEM

The questions which arose fell into two general classes, those dealing with the technic of planting and those dealing with the natural behavior of the stock after planting.

The questions of technic were comparatively easy of solution. They involved simply the most efficient methods of planting the stock and the best planting tool to use. A study of direct seeding was also included in this project. The results of these studies were published in Bulletin 169 of the Minnesota Agricultural Experiment Station, by W. H. Kenety. As this publication is now out of print, some of the results have been included in this bulletin.

PLANTING TECHNIC

No special planting tool had ever been developed for use in the Lake States. The mattock, or grub hoe, was still the standard. Based on experience elsewhere, plans were drawn for planting tools which were made by a local blacksmith (see Fig. 4). All these tools proved more efficient than the mattock. Table I gives the results of planting half-acre plots, using these tools. There was no furrowing or other soil preparation. The percentage of survival at the end of the second season is given as an indication of the efficiency of the method.



1 2 3 4 5 6

Fig. 4. Tools for Forest Planting
1. Corn planter used in one method of seed-spotting
2. Heart-shaped spade
3. Iron wedge (this was improperly made)
4. Wedge spade
5. Mattock or grub hoe used in planting and seed-spotting
6. Cylindrical spade used for planting and for digging forest-pulled stock

For the success of the above tools in the different situations, and for conclusions as to their practicability, see Table I.

The results of these experiments are of as much value now as they were ten years ago. There is a considerable variation in cost with the different tools. The most expensive method was the mattock center hole, while the cheapest was the heart spade, with the wedge spade a close second. Both these tools gave almost as good results as did the mattock center hole. In most of the subsequent planting work, the heart spade and wedge spade were used.

TABLE I

RESULTS OBTAINED BY EMPLOYING VARIOUS TYPES OF PLANTING TOOLS

	Situation	Wedge spade	Heart spade	Cylinder spade	Iron wedge	Mattock sidehole	Mattock center hole
Actual time required by 2 men to plant 500 trees, hrs. and min.	Open cut-over	3:30	2:00	3:30	3:45	3:15	5:45
	Gravel knolls	2:39	2:55	3:45	3:45	3:20	5:00
	Under 8 in. jack pine...	2:20	2:15	3:30	3:00	2:15	4:30
	Thick brush	4:10	2:20	5:50	6:05	5:00	7:55
Cost of planting one acre to 1000 trees by two men at 40 cents an hour	Open cut-over	$5.60	$3.20	$5.60	$6.00	$5.20	$9.20
	Gravel knolls	4.00	4.68	6.00	6.00	5.32	8.00
	Under 8 in. jack pine ..	3.92	3.60	5.60	4.80	3.60	7.20
	Thick brush	6.68	5.32	9.32	11.32	8.00	12.68
Av. cost per tool		$5.00	$4.20	$6.64	$7.04	$5.54	$9.28
Percentage alive at end of second season	Open cut-over	85	72	77	82	39	85
	Gravel knolls	70	87	86	74	42	64
	Under 8 in. jack pine ..	76	83	76	64	76	89
	Thick brush	48	15	22	4	7	26

SEED SPOTTING

Several methods of seed spotting were tried out. It was found necessary to remove the duff, break it up, sow the seed and tramp it in, finally mulching the spot with the duff. This operation required almost as much time per seed spot as planting a transplant or seedling. The only economy, then, would be the cost of the seedling as compared with the seed. But even so, the saving would be large enough to be worth while if a reasonable degree of success were possible with the seed.

Seed spotting was tried with white, Norway, and Scotch pine seed on three sites—under jack pine, on sweet fern, and on open cut-over areas. Scotch pine gave promise of best results. Only one plot, however, that on a cut-over open area, remains now. In this plot, 85 per cent of the spots still have seedlings; only remnants of most of the other plots remain.

Figure 5 shows the condition of one of the successful spots of Scotch pine fifteen years after sowing. The trees average six feet in height throughout the plot and where not too much crowded they reach twelve feet. The crowding might have been avoided by thinning after the seedlings became thoroly established. They were left unthinned in order that the behavior of the various spots might be studied.

The questions of technic have been well answered by these studies. The method of planting was standardized to the use of a wedge spade or a heart spade. The superiority of planting over direct seeding has also been demonstrated.

Fig. 5. Scotch Pine Seed Spot 15 Years After Establishing
Note the unequal development of seedlings

BEHAVIOR OF STOCK AFTER PLANTING

The behavior of the stock after planting is not so easily or so quickly determined. This involves a long time element and many factors not under human control. The questions of suitable stock, time of year to plant, and species to use, are all involved. It was necessary to establish almost five hundred plots varying in size from 1/10 to 1/2 acre to answer these questions.

CLIMATIC CONDITIONS AFFECTING PLANTING

In the early days of the station, as at present, neither labor, money, nor time was available to establish these plots in one season. If they could have been established in one day, the effect of variable weather would have been eliminated. These limitations caused the period of establishment to extend from 1914 to 1917 inclusive. This meant different planting conditions each year. Tables II to V give the average survival in the plots planted on the various dates in the different years,

and weather conditions on the day of planting. Temperature, relative humidity, wind velocity, and precipitation at time of planting, are factors which affect the condition of the stock.

TABLE II

AVERAGE SURVIVAL ON PLOTS ESTABLISHED IN 1914

Date planted	Average survival Nov. 1914	Maximum temperature	Relative humidity	Average wind velocity	Precipitation
	per cent	°F.	per cent	mi. per hr.	in.
May 14	76	60	43	5.7	..
15	66	67	31	2.8	..
16	81	75	36	2.8	..
17	..	77	41	5.1	..
18	76	78	39	6.5	..
19	71	82	51	7.6	..
20	..	75	90	3.9	0.26
21	75	74	47	4.7	.10
22	57	69	48	5.9	..
23	70	69	36	4.1	..
24	..	66	75	4.8	..
25	58	87	100	6.0	.41
26	62	86	38	5.2	..
27	70	85	39	3.9	..
28	45	73	100	5.6	.74
29	59	70	29	8.0	0.16

TABLE III

AVERAGE SURVIVAL ON PLOTS ESTABLISHED IN 1915

Date planted	Average survival Nov. 1915	Maximum temperature	Relative humidity	Average wind velocity	Precipitation
	per cent	°F.	per cent	mi. per hr.	in.
May 12	77	80	76	11.0	0.03
13	78	55	71	11.14	..
14	84	56	54	8.3	..
15	..	50	100	12.8	1.85
16	..	40	92	13.0	0.54
17	..	40	90	2.2	0.27
18	91	50	58	5.9	..
19	85	53	61	6.5	..
20	73	49	100	6.1	0.11
21	..	43	100	10.9	0.19
22	88	56	71	3.6	T

TABLE IV

AVERAGE SURVIVAL ON PLOTS ESTABLISHED IN 1916

Date planted	Average survival Nov. 1916	Maximum temperature	Relative humidity	Average wind velocity	Precipitation
	per cent	°F.	per cent	mi. per hr.	in.
May 31	92	73	67	8.8	T
June 1	85	70	100	4	0.10
2	82	69	30	9	0.01
3	94	69	100	3	0.26
4	..	64	46	7	..
5	87	62	71	5	T
6	92	63	68	5	..
7	86	59	100	4	0.01
8	90	63	72	11	0.36
9	..	65	100	2	0.01
10	92	72	55	3	..
11	..	79	50	2.5	..
12	..	79	47	3	..
13	..	75	89	4	1.47
14	..	68	61	2.5	0.46
15	88	67	88	2	0.78

TABLE V

AVERAGE SURVIVAL ON PLOTS ESTABLISHED IN 1917

Date planted	Average survival Nov. 1917	Maximum temperature	Relative humidity	Average wind velocity	Precipitation
	per cent	°F.	per cent	mi. per hr.	in.
May 22	87	47	..	9.7	..
23	71	57	..	2.1	..
24	58	66	..	5.9	..
25	69	79	..	5.4	..
26	68	55	..	7.0	..
27	..	56	..	6.9	..
28	84	71	..	0.7	..
29	64	65	..	4.4	0.02
30	..	52	..	4.5	.15
31	72	54	..	7.0	.14
June 1	75	65	..	2.6	..
2	68	74	..	2.4	..
3	..	66	..	3.4	.09
4	..	55	..	7.1	.40
5	86	61	..	10.0	..
6	90	57	..	13.6	.28
7	..	64	..	8.7	0.06
8	76	74	..	2.0	..

Relative Humidity

In these tables no constant relationship between survival and planting conditions is evident. In 1914 the plots having the highest survival at six months were planted on a day with low relative humidity, while those having the poorest survival were planted on a rainy day. The same thing was true in 1915, while in 1916 conditions were reversed. This does not mean that rainy weather is undesirable planting weather, but that weather conditions at the time of planting are not the most important factor.

Precipitation

Table VI gives the precipitation for three spring months in 1914, 1915, 1916 and 1917, and the average survival at the end of the first season for all the plots planted during that season.

TABLE VI

PRECIPITATION IN THREE SPRING MONTHS, 1914-17

Year	April	May	June	Total for 3 months	Average survival for all plots, first season
	in.	in.	in.	in.	per cent
1914	2.20	2.54	4.47	9.21	67
1915	0.97	3.72	5.15	9.84	84
1916	4.25	3.96	6.82	15.03	89
1917	1.11	0.41	2.54	4.06	74

The figures show no constant relationship between precipitation and percentage of survival. Obviously, other factors than the total amount of precipitation during the planting season are involved. Table VII gives the precipitation by months following the planting season.

TABLE VII

PRECIPITATION FOR FOUR MONTHS FOLLOWING PLANTING SEASON, 1914-17

Year	July	August	September	October	Total 4 months	Average survival for all plots, first season
	in.	in.	in.	in.	in.	per cent
1914	1.78	4.47	3.02	1.14	10.41	67
1915	1.32	1.72	1.75	3.17	7.96	84
1916	1.64	4.11	2.83	1.75	10.33	89
1917	5.23	2.47	2.59	2.81	13.10	74

An attempt was made to study the distribution of precipitation in relation to survival. The weather data during the growing season, June 1 to November 1, were analyzed. Any period of ten days or more with 0.01 inch or less rain was designated as a danger period.[2] Table VIII gives the number of danger periods and the average survival.

TABLE VIII

RELATION BETWEEN SURVIVAL AND NUMBER OF PERIODS OF DROUTH

Year	Average survival end of first season	No. of danger periods
	per cent	
1914	67	3
1915	84	1
1916	89	0
1917	74	0

[2] The writer is indebted to J. Kittredge, silviculturist, Lake States Forest Experiment Station, for this suggestion.

Distribution of Rainfall

Distribution of rainfall seems to be the most important factor influencing the survival of plantations. There is some variation, probably due to the relatively small number of years involved. If a longer period of years were covered in the study, this relationship might have been more constant.

To overcome this variable, most of the plots were duplicated. Those planted in 1914 and 1915 were repeated in 1916 or 1917 in as similar a location as possible. This tends to neutralize the effect of variable weather conditions during and following planting.

SOIL AS A FACTOR IN PLANTING

The soil of the Cloquet Forest Experiment Station is very uniform in character. Two types have been recognized by the Division of Soils of the University —Omega sand and Cloquet sandy loam. In 1905 the United States Bureau of Soils made a survey of this region and classified the Omega sand as Miami sand and the Cloquet sandy loam as Miami sandy loam. While the 1905 classification no longer holds good, the mechanical analyses made at that time give an indication of the physical make-up of the soil.

TABLE IX

PHYSICAL COMPOSITION OF OMEGA SAND (MIAMI SAND, 1905) AT THE CLOQUET FOREST EXPERIMENT STATION

	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Soil	0.9	11.7	19.1	56.3	7.0	2.0	2.8
Subsoil	3.7	23.5	20.4	44.7	5.4	1.7	2.4

Miami sand is described as a medium fine sand 6 to 10 inches deep, with a subsoil of medium or coarse sand sometimes grading into gravel beds at 2 to 3 feet. It is a combination of glacial flood plain and moraine material. This type comprises the largest part of the area.

TABLE X

PHYSICAL COMPOSITION OF CLOQUET SANDY LOAM* (MIAMI SANDY LOAM, 1905)

	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Soil	3.4	18.6	18.2	19.3	8.1	22.3	10.0
Subsoil	4.1	16.8	24.2	23.8	6.9	12.4	6.6

* Soil Survey Carlton area, U. S. Bureau of Soils, 1905.

Miami sandy loam is of medium texture 8 to 14 inches deep, some times mixed with gravel. The subsoil is medium coarse sandy loam grading into gravel beds at 2 to 3 feet.

The physical analysis reveals some difference in the two types of soil, principally in the amount of fine sand and silt and clay present. This makes some difference in the water-holding capacity of the soil, a factor which undoubtedly influences survival. Other factors, such as the ground water level and surface cover, enter in to such an extent that it has been impossible to notice any effect of soil upon survival. The differences in soil will undoubtedly show up much more markedly when the plantings are old enough to show yields.

Most of the planting work was confined to the native species—white pine, Norway pine and jack pine. A few exotic species were tried; Scotch pine and western yellow pine were used throughout; while red spruce, Norway spruce, and blue spruce were given a very limited trial. Scotch pine was the only one that proved at all successful, the others were considered as total failures.

It was necessary to use all the different classes of stock which might be practical in this region. Five classes were decided upon: 2-0, 3-0, 1-2, 2-1, and 2-2. (The first figure refers to the number of years the tree was held in the seedbed, the second to the number of years it was held in the transplant bed.) The various classes of stock represent different stages of development and have a considerable variation in cost, the cheaper classes being the 2-0 and 3-0 stock which have not been transplanted. The cost of the planting stock is an important factor in all forest planting. It often constitutes the largest single item in planting cost.

All the plots were planted with a spacing 6x6 feet, or 1200 trees per acre. The size of the individual plots varied from 1/10 to 1/2 acre.

TEST OF SITE

The cut-over area was divided into three classes, designated as "sites." The first site was called the "cut-over barren," and was apparently most in need of planting. It had been rather heavily burned during slash disposal, and had a very sparse growth of blueberry, grasses, and fireweed. In some cases alder and hazel had begun to come in. Figure 6 illustrates this site.

"Sweet fern" areas were the second type. Here the ground cover consisted almost exclusively of a mat of sweet fern with some aspen, willow, hazel, and blueberry scattered through the more open spots. This site is illustrated in Figure 7.

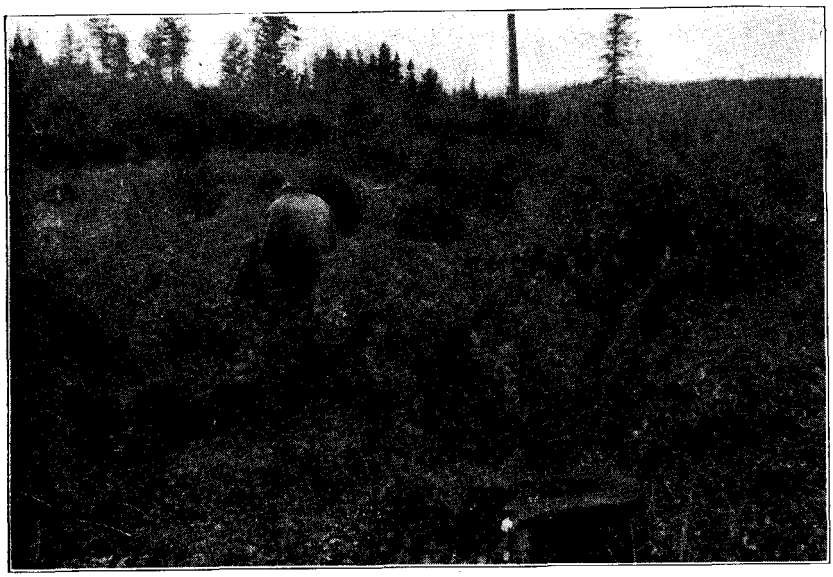


Fig. 6. Cut-Over Barren Planting Site

Fig. 7. Site 2, Cut-over Sweet Fern Area

Besides the dense cover of sweet fern, the following kinds of brush are found: Poplar 2 to 4 feet high, willow, hazel, and blueberry. All these are scattered.

The third site was the brushy areas. Here is found a herbaceous growth of bracken fern, wild sarsaparilla, and bunch grasses overtopped by popple, alder, willow, hazel, and cherry. The height of the brush varied from 2 to 20 feet and in nearly all cases gave more than three-quarter shade. Aspen predominated in the brush. Figure 8 illustrates this site.

Fig. 8. Site 3, of Planting Project

The purely herbaceous growth consists of bracken fern, wild sarsaparilla, and bunch grasses. The brush includes alder to 10 feet in height. Poplar to 20 feet in height is predominant, with a mixture of willow, hazel, and cherry. The permanent type was white and Norway pine on a sandy clay top soil and with a subsoil of gravel. This is typical of all situations used for Site 3.

In addition to these sites on the cut-over area, a series of plots was planted under mature open jack pine where the brush was negligible. These plots were not of the same nature as the underplanting, which will be discussed later.

It was necessary to determine which class of stock and which species should be planted on each of these sites. For this purpose 160 plots were established. Unfortunately the plots on which white pine, Norway pine, and part of the jack pine were planted under thick brush were destroyed by fire. Table XI gives the survival and average height five years after planting for all the species and classes of stock on the four sites.

TABLE XI

SURVIVAL OF ALL CLASSES OF STOCK. NORWAY, WHITE, JACK, AND SCOTCH PINE ON FOUR SITES AT FIVE YEARS AFTER PLANTING

Class of stock	White Pine		Norway Pine		Jack Pine		Scotch Pine	
	Alive 5 yr.	Average height	Alive 5 yr.	Average height	Alive 5 yr.	Average height	Alive 5 yr.	Average height
	per cent	in.	per cent	in.	per cent	in.	per cent	in.
Cut-Over Barren								
2-0	55	6	67	7	74	30	76	15
3-0	55	6	64	11	75	24	..	..
1-2	46	20	79	10	..	..	80	36
2-1	61	14	79	12	75	12	81	24
Sweet Fern								
2-0	66	12	61	8	71	24	66	11
3-0	58	11	44	8	39	20	50	16
1-2	58	7	69	10	..	..	73	12
2-1	75	16	56	12	62	26	77	20
2-2	69	15	72	17	74	36	77	30
Thick Brush								
2-0	Burned	Burned	Burned	Burned	..	..	..	..
3-0	"	"	"	"	71	16	81	16
1-2	"	"	"	"	..	..	94	36
2-1	"	"	"	"	86	4	83	30
2-2	"	"	"	"	1	..	22	6
Mature Open Jack Pine								
2-0	80	6	91	12	87	28	79	16
3-0	62	6	..	..	59	20	64	12
1-2	66	20	66	14	..	..	..	..
2-1	81	14	70	12	62	24	86	19
2-2	77	18	87	16	66	36	65	24

The survival of all classes of white pine stock is better under the mature open jack pine, indicating that a moderate amount of overhead shade is less injurious to white pine in the early stages. The "cut-over barren" is the most severe site for that species. When survival alone is considered, 2-1 stock has a slight advantage over the other classes.

Rabbit injury in these plots is very light, and where found was confined to the lower lateral branches, leaving the terminals intact.

The best survival for Norway pine, also, is found under the mature open jack pine. The advantage is not very marked, however, indicating that while Norway pine can endure shade there is little advantage to any class of stock. Sweet fern seems to be the most severe site for Norway pine. On all sites except under jack pine, 2-2 stock survives best. In all cases it made the best rate of growth. Rabbit injury was negligible throughout this series of plantings.

The best results with jack pine were on the cut-over barren areas. In only one instance, that of the 2-0 stock under mature open jack pine, was a higher survival found than on the cut-over barren. This is logical, as jack pine is a relatively intolerant tree. Sweet fern offers more competition for jack pine than a scattering stand of mature timber

overhead. The plots which were planted in thick brush are too few to warrant any conclusions. The high survival in two of the cases given is due to the uneven character of the brush, the survival occurring in the open spaces. All classes of stock give fairly uniform results, 2-2 stock having a more rapid rate of growth and better development than the other classes. In jack pine the transplants show less advantage over the seedling stock.

Rabbit injury was of minor importance except in thick brush, where it amounted to 100 per cent and was both terminal and lateral.

Considering all classes of stock as a unit, the best results were secured with Scotch pine on the cut-over barren site. The planting under mature open jack pine showed slightly better results than that under sweet fern. No single class of stock stands out uniformly above the rest, but all the transplant classes have a lead over the seedlings. The plots in thick brush do not indicate the true condition because of an unequal distribution of the brush in some of the plots, the 2-2 plots having a more uniform cover than the other three classes of stock.

There was almost no rabbit injury except under thick brush where 100 per cent of the trees were injured both laterally and terminally.

Figure 9 shows the survival and growth at five years of all the species and classes of stock planted under mature open jack pine.

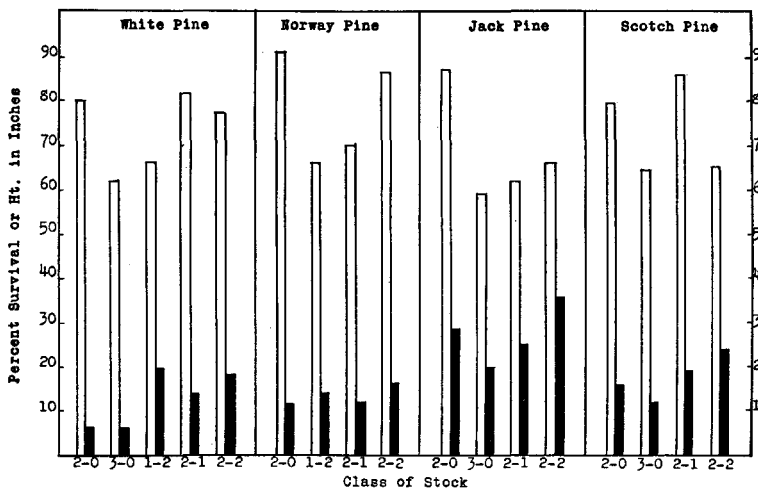


Fig. 9. Survival and Growth After 5 Years under Mature Open Jack Pine

Norway pine has survived best under the mature open jack pine, even better than the more tolerant white pine, but it has grown more slowly than the others. Jack pine, with the poorest survival, has the best rate of growth. The development apparently varies inversely with the survival.

Figure 10 compares the planting of all four species on cut-over barren areas. Norway pine, jack pine, and Scotch pine are all very nearly equal in survival. White pine is markedly below the other species in this respect. Jack pine has grown best, with Scotch pine, white pine, and Norway pine following in the order named.

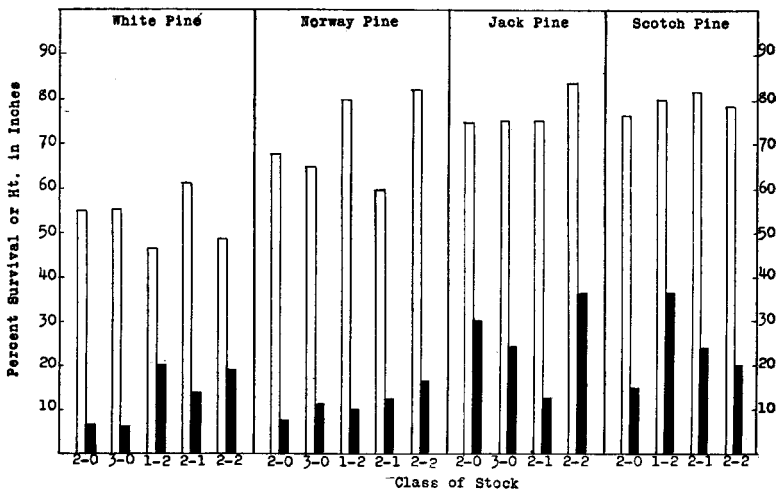


Fig. 10. Survival and Growth After 5 Years on Cut-over Barren Areas

Figure 11 compares all four species planted on sweet fern areas. In this instance, white pine has the best survival, with Scotch pine second, Norway pine third, and jack pine fourth. In rate of growth jack pine is first, followed by Scotch pine, white pine, and Norway pine.

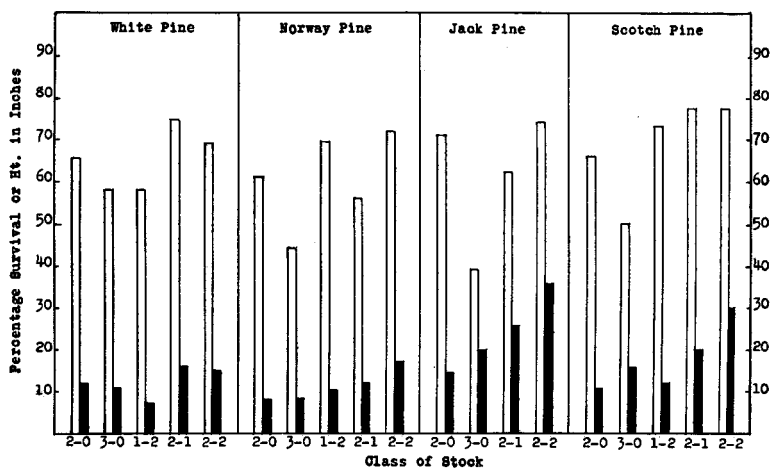


Fig. 11. Survival and Growth After 5 Years on Sweet Fern Areas

In all three sites the difference in survival between the four species is not striking. It is often so small that other indeterminate variables may have been important in bringing the difference about. If we assume 600 trees as a satisfactory stand, in only three instances did the survival fall below a percentage which would provide such a stand of well established seedlings. From the standpoint of survival, any class of stock of the four species tried can be used on these sites. If we consider growth, however, transplant stock is to be preferred.

SEASON OF PLANTING

Spring time, before plant activity has begun, has always been considered the natural time for planting. The time during which spring planting is possible is limited. In this region it is coincident with the spring fire season in the north and with the busy nursery season at the station. The shortness of the season, together with necessary duties, made it advisable to try some other season for planting. The logical second choice is the fall season, after growth has stopped and just before winter sets in. If the planting could be done with a reasonable degree of success at that time, the pressure of work in the spring would be less. Accordingly, 80 plots were planted on two sites during the latter part of October and early November. The two sites used were sweet fern and thick brush, both similar to the sites used in the spring plantings and illustrated by Figures 6 and 7. Table XII gives the average height of the seedlings and the survival five years after planting.

TABLE XII

SURVIVAL OF FALL PLANTINGS AFTER 5 YEARS ON TWO SITES

Class of stock	White Pine		Norway Pine		Jack Pine		Scotch Pine	
	Alive 5 yr.	Average height	Alive 5 yr.	Average height	Alive 5 yr.	Average height	Alive 5 yr.	Average height
Sweet Fern	per cent	in.	per cent	in.	per cent	in.	per cent	in.
2-0	78	11	73	10	70	24	67	27
3-0	63	10	47	10	42	14	42	14
1-2	74	18	73	14	82	27	56	27
2-1	71	15	71	17	62	19	60	19
2-2	82	19	86	27	57	33	71	33
Thick Brush								
2-0	39	6	19	4	11	12	21	24
3-0	24	10	8	6	12	10	11	14
1-2	59	10	21	12	18	4	30	27
2-1	9	8	2	9	8	10	22	19
2-2	14	9	7	..	14	12	13	33

As can be seen from Table XII, fall planting of white pine on the sweet fern site has resulted in a good survival and a fair rate of growth. The 2-2 stock had a slightly higher survival and better rate of growth than any of the other classes. All the transplant classes were better than the seedling classes. There was no rabbit injury.

Planting on the thick brush site was almost a total failure. The 1-2 stock has a fair survival, but this is because of the uneven character of the brush. The surviving trees are all in the open spaces. Variation in site explains the variation in survival, rather than ability of the class of stock to endure severe conditions. Rabbit injury was 100 per cent in the thick brush, both lateral and terminal shoots being severely injured.

The transplant stock shows up to a much better advantage in the fall planting of Norway pine than the seedlings; 2-2 stock is ahead in survival and far ahead in rate of growth. There was no rabbit injury here.

In the thick brush all classes of stock can be considered a total failure, the highest survival being 21 per cent for the 1-2 stock which was planted in a more favorable location. Rabbit injury was found on all the trees in thick brush, both lateral and terminal injury being severe.

The fall planting of jack pine does not bring out any marked difference between seedlings and transplants, either in survival or rate of growth; 1-2 stock has the best survival, followed closely by 2-0 stock. The latter has grown better than the other classes. There was no rabbit injury.

In thick brush all classes of stock were almost a complete failure, being under 20 per cent in survival. Rabbit injury, both terminal and lateral, was found on all the trees.

In the Scotch pine fall plantings, 2-2 stock leads and 2-0 stock is second in both survival and growth. Except for that discrepancy there is a distinct progression from the 3-0 stock to the 2-2 stock. There was no rabbit injury.

Success was poor with all classes of Scotch pine stock in thick brush. It is only where there are distinct openings in the brush that the survival has been over 20 per cent. It is interesting to note that the rate of growth is apparently only one-third the rate on the sweet fern. Actually, the difference is not so great, but the 100 per cent terminal and lateral rabbit injury tends to dwarf the trees in thick brush.

Figure 12 compares the results of planting all four species in the fall on the sweet fern site. In general, Norway pine seems to lend itself best to fall planting, followed by white pine, Scotch pine, and jack pine in the order named. Jack pine and Scotch pine exceed Norway and white pine in rate of growth.

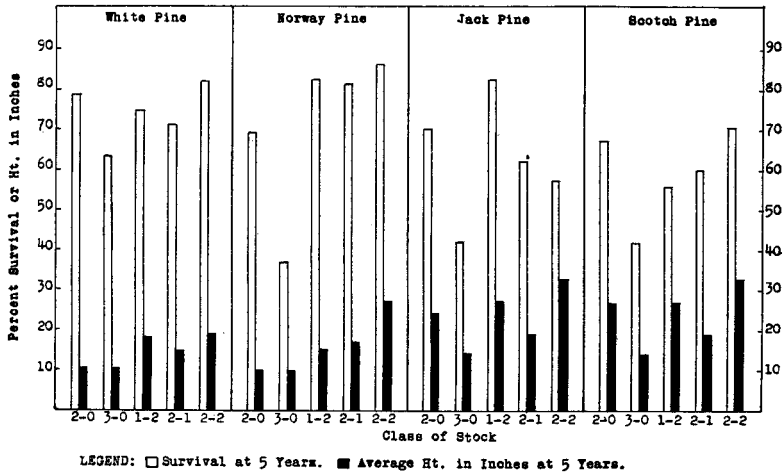


Fig. 12. Survival and Growth After 5 Years on Sweet Fern Site (Fall Planting)

Figure 13 compares the results of fall planting of the four species on thick brush sites. All four species have low survivals. The 1-2 white pine stock is the only successful planting. All through this series of plots the 1-2 stock shows up best because it was planted under more favorable conditions of brush cover where the openings in the brush made it possible for more trees to survive.

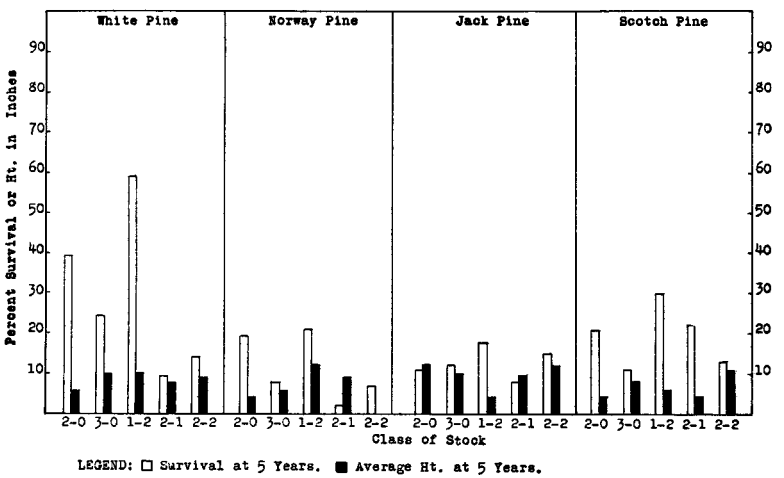


Fig. 13. Survival and Growth After 5 Years on Thick Brush Site (Fall Planting)

COMPARISON OF FALL AND SPRING PLANTING

The sites for fall planting were selected as nearly similar to those used in spring planting as was possible. This has facilitated a comparison between the plots planted during the two seasons and, so far as possible, has left the effect of season as the only variable.

Figure 14 compares the spring and fall planting of white pine on the sweet fern site. In all except the 2-1 stock, the fall plantings have a slightly higher survival than the spring plantings. The transplant stock planted in the fall has grown better than the same stock planted in the spring, but in the seedling stock conditions have been reversed.

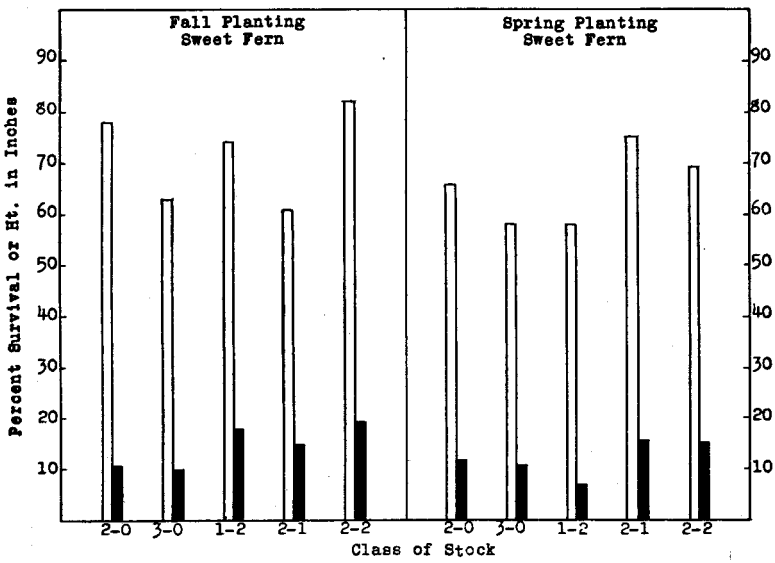


Fig. 14. Survival and Growth of White Pine (Fall and Spring Planting)

Figure 15 compares the results of spring and fall planting of Norway pine on the sweet fern site. All classes of stock planted in the fall have a better survival and rate of growth than the same class planted in the spring.

Figure 16 compares the spring and fall planting of jack pine on sweet fern. Except for the 2-2 stock, where the spring planting has the advantage, the survival and growth are identical for the two plantings.

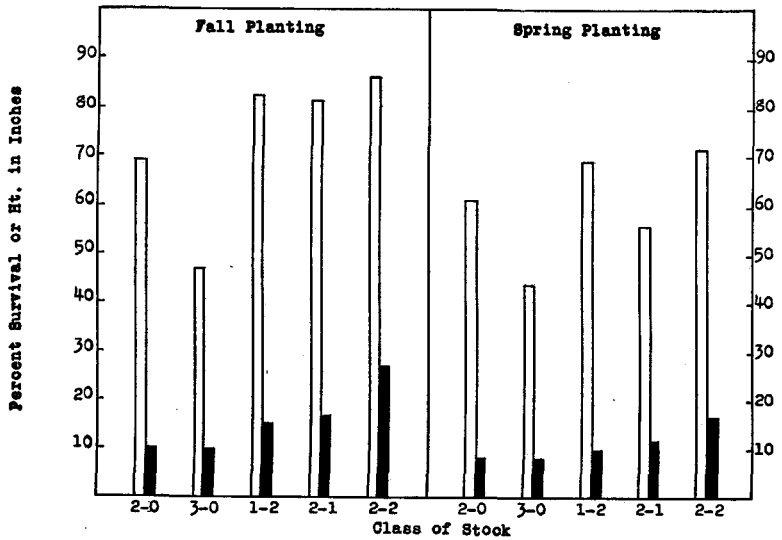


Fig. 15. Survival and Growth After 5 Years of Norway Pine (Fall and Spring Planting)

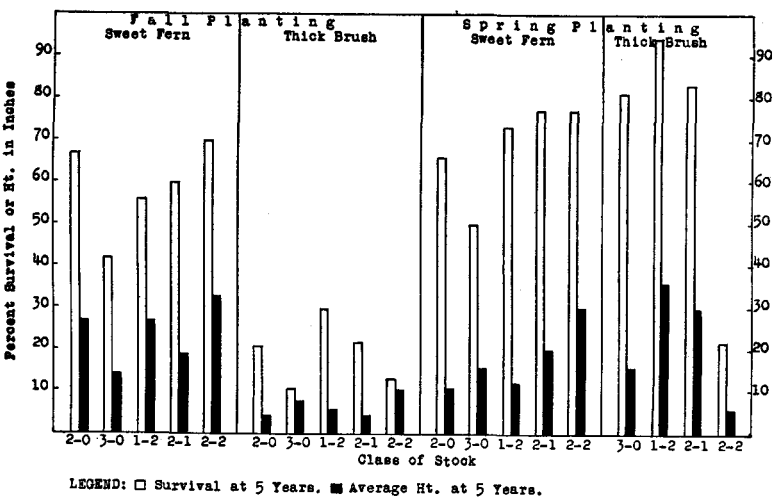


Fig. 16. Survival and Growth After 5 Years of Jack Pine on Sweet Fern Areas

Figure 17 compares the spring and fall planting of Scotch pine. The survival of the spring plantings on the sweet fern and brush areas is better than that of the fall plantings. The fall plantings on sweet fern have grown more rapidly than the spring plantings, while the spring

planting under brush has developed more rapidly than the fall planting. This is due to more favorable brush conditions rather than a variable effect of the season.

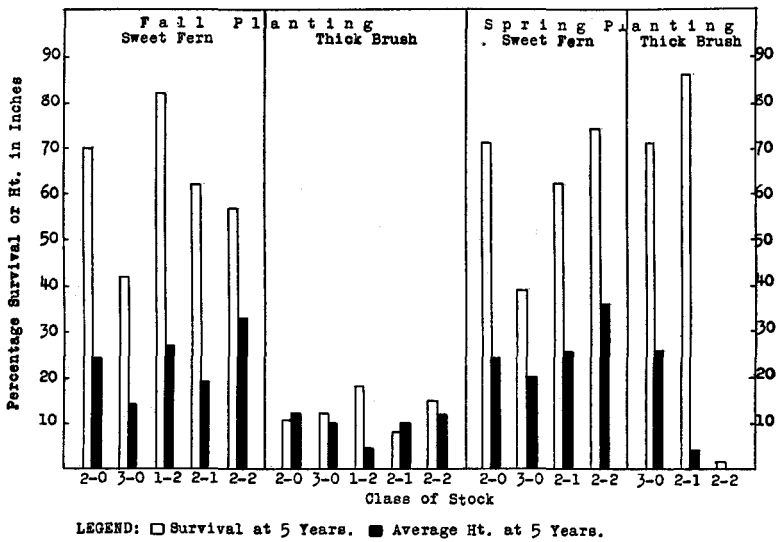


Fig. 17. Survival and Growth After 5 Years of Scotch Pine (Fall and Spring Planting)

Fall planting is entirely feasible from the standpoint of survival. In only three instances did the survival drop to less than 600 to 700 trees per acre. Scotch pine and jack pine are the least desirable for fall planting.

UNDERPLANTING OF JACK PINE

Three classes of jack pine stands were selected for underplanting. They were designated as young dense, medium sized, and mature open. The young dense jack pine was about 15 years old at the time of underplanting, with a density of almost 3000 trees per acre. This site is illustrated by Figure 3, which was taken when the stand was twenty-seven years old. The medium size jack pine was a 35-year-old stand with a volume of about ten cords per acre. The mature open jack pine was a very scattering stand about 70 years old. Figures 18 and 19 illustrate these two sites. This was a sufficient variety that the questions of the proper age and density of jack pine stands for underplanting could be determined.

Fig. 18. Medium Sized Jack Pine

In connection with this part of the study only three species were used—white pine, Norway pine, and Scotch pine. The advisability of converting jack pine stands to Scotch pine is open to question. However, the results of such work are of interest. Table XIII gives the survival of the various classes of stock of the three species and the average height at the end of five years. Ninety plots were planted to determine the percentage survival in young dense, medium sizd, and mature jack pine.

White pine is a relatively tolerant tree, especially in the early stages. The five-year survival count under jack pine bears out this fact. Strangely enough, there is a better survival of some of the classes of stock under the young dense jack pine than under the other stands. In general, however, the condition of the plantings is better as the density of the overhead shade lessens. This fact is reflected also in the rate of growth. The best classes of stock are 2-2 and 1-2.

Fifty per cent of the planting in the dense young jack pine was injured by rabbits, while injury was very light in the medium sized jack pine, and was absent under the mature open jack pine.

Norway pine responds to the overhead shade in rate of growth more than in survival. The 1-2 stock has a high survival in all three sites but shows a better rate of growth in the more open stands. If 2-2 stock is taken as an indicator, there is a regular increase in survival and rate of growth from the denser stands to the more open.

The Norway pine plantings were almost entirely free from rabbit injury in all three sites.

TABLE XIII

SURVIVAL OF UNDERPLANTING OF JACK PINE AT 5 YEARS

Class of stock	White Pine		Norway Pine		Scotch Pine	
	Alive 5 yr.	Av. height 5 yr.	Alive 5 yr.	Av. height 5 yr.	Alive 5 yr.	Av. height 5 yr.
	per cent	in.	per cent	in.	per cent	in.
Young Dense Jack Pine						
2-0	62	8	52	3	61	7
3-0	77	6	48	6	..	..
1-2	84	10	87	10	73	12
2-1	75	7	30	7	75	12
2-2	72	12	56	13	85	12
Medium Sized Jack Pine						
2-0	72	10	39	4	60	9
3-0	51	6	68	11	..	..
1-2	78	11	80	15	82	15
2-1	50	11	62	10	93	13
2-2	75	18	68	19	63	..
Mature Open Jack Pine						
2-0	75	12	19	7	72	12
3-0	72	12	56	10	..	..
1-2	67	12	87	16	87	24
2-1	62	12	46	9	89	22
2-2	84	18	85	19	83	24

Scotch pine is relatively intolerant. In spite of this fact there is a very good survival under all three stands of jack pine. The best survival and growth are under mature open jack pine. Transplant stock has survived and grown much better than the seedling stock. There is no one class of stock that stands out superior to the rest in all instances.

The plots under the young dense jack pine showed 75 per cent rabbit injury, while the other two sites were free from injury.

Figure 20 compares the survival and growth of the three species when planted under dense young jack pine. White pine has the best average survival for all classes, followed by Scotch and Norway pine. The highest individual survival is found in the case of the 1-2 Norway pine stock. Scotch pine has grown best, with white pine second and Norway pine third.

Figure 21 compares the survival and growth of the three species planted under medium sized jack pine. Under this type of stand Scotch pine has taken the lead. Norway and white pine do equally well in both survival and growth.

Fig. 19. Mature Open Jack Pine
The extreme right of the picture is the only part of the stand that falls in this class.

Figure 22 compares the survival and growth of the three species planted under medium open jack pine. Scotch pine gives the best results, followed by white pine and then Norway pine.

In only five instances did any class of stock fail to establish an adequate stand five years after planting, but under the younger stands very little growth was made. The mature open jack pine did not have this limiting effect on the rate of growth.

Scotch pine has done best under the jack pine stands. In a sense this is surprising, because of its relative intolerance. It is, however, better adapted to light soils than white and Norway pine, consequently it might be expected to thrive better on light soil than these species.

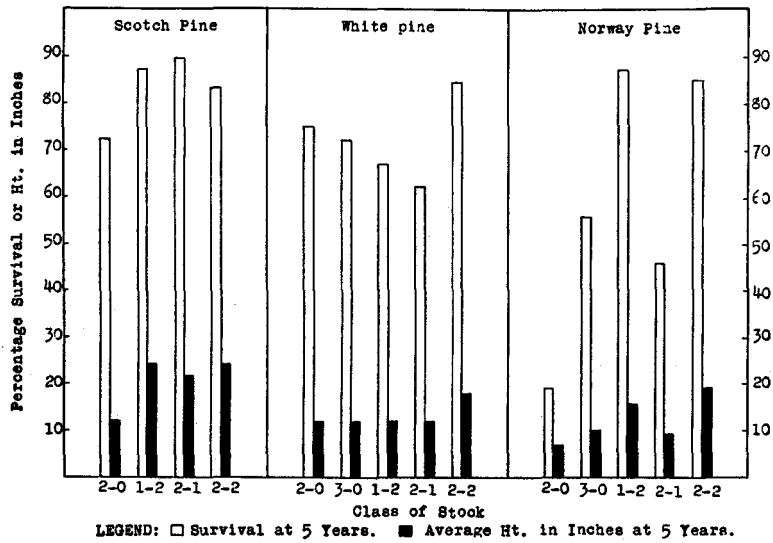


Fig. 20. Survival and Growth After 5 Years of 3 Species Under Dense Young Jack Pine

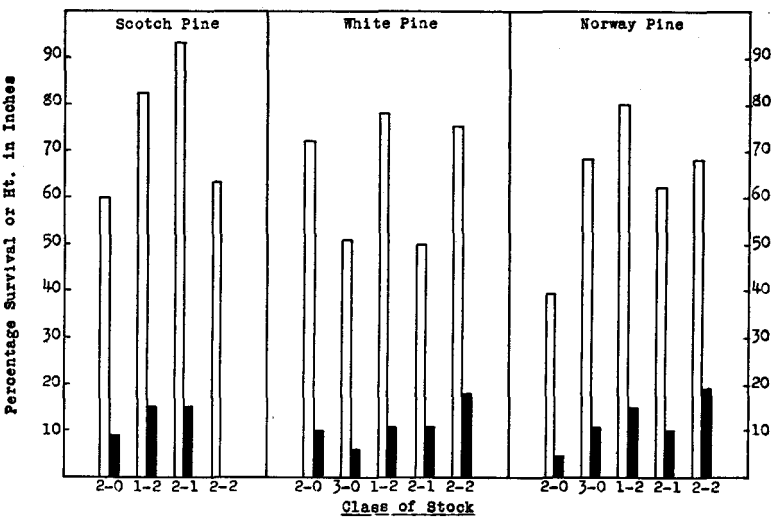


Fig. 21. Survival and Growth After 5 Years of 3 Species Under Medium Sized Jack Pine

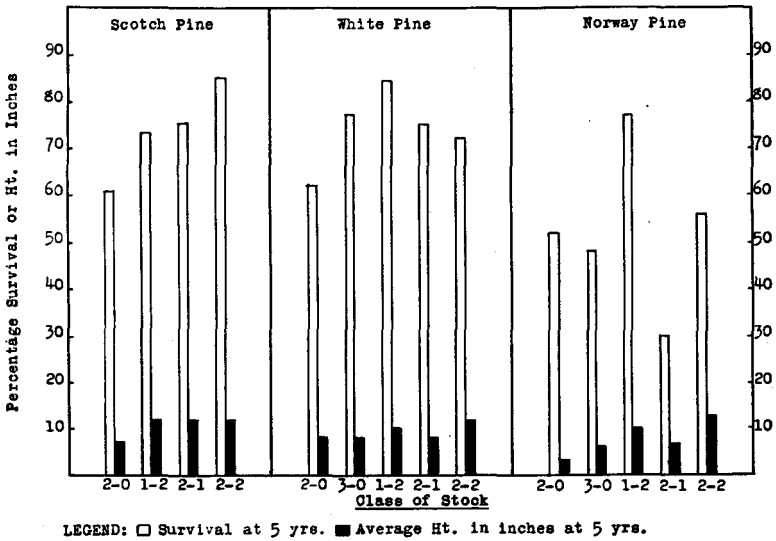


Fig. 22. Survival and Growth After 5 Years of 3 Species Under Medium Sized Open Jack Pine

The above plantings fall into 31 groups of five age classes. Table XIV gives an analysis of the rank in survival between seedlings and transplants. All species are grouped together.

TABLE XIV

COMPARISON BETWEEN SEEDLING AND TRANSPLANT SURVIVAL

Rank in survival	Seedling		Transplant		Total instances
	No. of instances	Per cent	No of instances	Per cent	
1st	2	7	29	93	31
2nd	13	42	18	58	31
3rd	15	48	16	52	31
4th	14	49	15	51	29
5th	12	60	8	40	20

This table shows that transplants have a higher survival than seedlings at the end of a five-year period. It is also evident that transplants have a greater rate of growth than seedlings at the end of a five-year period. It remains to be seen whether or not this difference will continue or whether the seedlings will overtake the transplants.