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Direct Seeding of Pine and Spruce in Southwestern Maine

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The Author...

THOMAS W. McCONKEY took his bachelor's and master's degrees in forestry at Cornell University in 1933 and joined the U. S. Forest Service the same year. His research work has been almost entirely in the fields of timber management and silviculture. His interest in white pine silviculture dates from 1947, when the Northeastern Forest Experiment Station assigned him as forester in charge of its Massabesic Experimental Forest at Alfred, Maine.

Introduction

WHEN lands suitable for growing pine or other softwood species are burned in New England, direct seeding is frequently mentioned as a possible means of establishing desirable new stands over large areas. Closely related to this are the possibilities of converting abandoned farm lands or areas occupied by scrub growth to productive forest stands.

Interest in direct seeding in New England has been shown as early as 1925. At that time Baldwin[1] started a series of spot seeding tests, which extended over a 14-year period. Although he had some successes in these tests, he considered results too uncertain to recommend use on a large scale. Results of direct-seeding trials begun in the Lake States in 1926, using some of the species frequently planted in New England, were not successful with these species.[2] However, fairly effective chemicals for protecting seed from birds and rodents have been discovered during the past decade, and successful direct-seeding techniques now have been developed in other regions. Possibly these techniques can also be used in New England, with some modifications.

In guidelines prepared for direct seeding loblolly pine, Mann and Derr[3] emphasized the importance of selecting sites suitable for the desired species and of preparing suitable seedbeds. Both Baldwin and Shirley also recognized the importance of these factors.

In view of this continued emphasis on site and seedbed, a direct-seeding study involving five species on two sites was begun in the fall of 1958 in southwestern Maine. The intent was to gather some preliminary information, by species, about the influence of soil type and seedbed-preparation measures on initial seedling establishment.

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[1] Baldwin, H. I. DIRECT-SEEDING EXPERIMENTS. N. H. Forestry and Recreation Dept. Fox Forest Notes No. 14, 1 pp., 1939.

[2] Shirley, Hardy L. DIRECT SEEDING IN THE LAKE STATES. Jour. Forestry 35: 379-387, 1937.

[3] Mann, W. F. Jr., and H. J. Derr. GUIDELINES FOR DIRECT-SEEDING LOBLOLLY PINE. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 188, 23 pp., illus., 1961.

The Study

Five species, four of them commonly planted in the Northeast, were selected for this test: Norway spruce *(Picea abies* L.), white spruce *(Picea glauca* (Moench) Voss), red pine *(Pinus resinosa* Ait.), pitch pine *(Pinus rigida* Mill.), and white pine *(Pinus strobus* L.).

Plots were established at two locations representing distinct differences in site on land that had been burned over by a forest fire in May 1957. The poorer site — an Adams loamy sand — has very little organic matter in the 3-inch layer of topsoil. The texture changes with depth from loamy sand at the surface to coarse loamy sand, and then to medium sand. This soil is excessively drained and is as poor as any in the general area. The soil of the better site — a Gloucester stony sandy loam — is well-drained and has good moisture-holding capacity. Organic matter is well distributed throughout the upper soil layers.

A split-plot design was used for the study. Four main plots, each containing 12 subplots, were established on each area. The subplots were 3 by 4 feet in size; each provided space for five 1-foot-square seed spots — one spot for each of the five species. Two of the main plots were randomly selected for the 1958-59 fall and spring sowing; the other two were used for the 1959-60 fall and spring series.

Three seedbed-preparation measures, two degrees of shading, and two seasons of sowing — a total of 12 subtreatment combinations — were assigned at random to the 12 subplots within each main plot. The three seedbed-preparation measures were:

1. Check (no treatment) — vegetation was mowed but soil surface was left undisturbed.
2. Roughen — sod was cut and turned over, which left an uneven surface full of small roots.
3. Scalp—sod was removed together with the adhering soil.

Shading was provided by Lumite Saran shade cloth of 52 percent density; this was supported over the appropriate plots by shallow boxes made of 1/2-inch wire mesh. The two shade treatments were:

1. Check — no shade or box.
2. Shade — subplots were covered with box and shade cloth.

The third variable — season — was represented simply by fall and spring sowings.

Seeds of white spruce, pitch pine, and white pine were stratified for spring sowing, following recommendations of the Woody Plant Seed Manual. All seeds were treated with the Arasan-Endrin bird and rodent repellent developed by the U. S. Fish and Wildlife Service. One hundred seeds of each species were sown on a 1-foot-square spot on the 3- by 4-foot subplot; seeds were covered with about 1/4 inch of soil. Wire mesh boxes, without the shade cloth, were installed at the time of seeding over all subplots that were to be shaded. Cloth was placed over all boxes at the time of spring seeding in April. Because the unshaded plots were not protected with wire mesh boxes, some seed loss could have occurred due to birds and rodents; however, such losses appeared to be relatively unimportant.

Germination and seedling mortality were tallied periodically for each series of seedings from May through the first summer.

Rainfall and temperature records for the general locality were available from a fire-danger station maintained by the Maine Forest Service. Plot data on such factors as soil moisture and soil temperature were not obtained. Hence all subsequent references to these factors are based only on general observations and inference.

The effects of the different variables on germination and first-year seedling establishment were analyzed for individual species by split-plot analyses of variance. The main-plot factors were site and year of germination (fall-spring series). The subplot factors or treatments were season of sowing, seedbed preparation, and shading. Because the data were in percents, they were transformed for purposes of analysis by the arc-sine transformation.

Because of considerable variation in the quality and viability of the seed, it was impossible to tell whether or not the differences in behavior among species were attributable to true species differences. Therefore, species were not included in the analyses. However, gross differences among species are noted in discussing the results.

Results and Discussion

Seed germination tests were made, but results were erratic, generally averaging lower than the germination observed in the field. For example, the average of four tests of white pine was 23 percent, whereas the average field germination on scalped shaded plots was 56 percent. Therefore we made no use of the germination test results.

Norway spruce was particularly erratic, both in the germination tests and in germination observed in the field: in both situations germination ran much lower than that of the other species. Seedlings that did start on the plots seemed poorly adapted to cope with the rigors of field environment as exemplified by study conditions. Because of its erratic and generally poor performance, Norway spruce is omitted from the data summaries and analyses.

Effect of Cultivation and Shade

Both removal of the competing vegetation and shading resulted in marked increases in germination of all species on both soil types, regardless of sowing season or year when seeds germinated (tables 1 and 2). The increases were greater on the excessively drained Adams soil. Shading here and, to a lesser extent, removal of competing vegetation presumably increased length of time the soil surface was relatively moist during the critical germination period. Only pitch pine showed any appreciable germination on this site when no improvement measures were applied (table 1).

More seeds germinated on the scalped plots than on the roughened ones. The turned-over sods of the roughened plots were relatively loose, and the protruding brush-like roots would have facilitated water percolation. Consequently, the sods probably dried out faster than the smooth, scalped soil surfaces; and fewer seeds would have been in firm contact with moist soil at critical times.

As might logically be expected, more seedlings became estab-lished under the same conditions that were associated with better seed germination (table 1); and in the statistical appraisals both cultivation and shade generally were highly significant factors in establishment as well as in germination (table 3 vs. table 2). Even so, there was considerable variation in mortality among species

Table 1.—Percent of sown seeds that germinated and that produced established seedlings, by species, site, seedbed, and shading treatment (seasons and years combined)

Seedbed treatment	Shade treatment	Pitch pine		Red pine		White pine		White spruce	
		Germi-nated	Estab-lished	Germi-nated	Estab-lished	Germi-nated	Estab-lished	Germi-nated	Estab-lished
		ADAMS SOIL							
None	None	17	14	4	2	3	2	2	0
	Shaded	40	28	22	7	16	12	19	5
Roughened	None	30	27	13	9	9	6	5	2
	Shaded	60	51	45	35	25	20	26	11
Scalped	None	49	46	25	20	26	21	18	14
	Shaded	71	68	60	53	48	45	42	33
		GLOUCESTER SOIL							
None	None	36	26	22	11	27	21	9	1
	Shaded	49	27	39	19	40	35	25	10
Roughened	None	36	32	17	10	11	6	10	4
	Shaded	54	47	46	33	45	36	28	11
Scalped	None	53	48	37	33	27	19	23	7
	Shaded	67	58	52	47	64	57	39	25

Table 2.—Analysis of variance for germination of each species

Source of variation	Degrees of freedom	Pitch pine		Red pine		White pine		White spruce	
		Mean square	F	Mean square	F	Mean square	F	Mean square	F
Main plots:									
Site (Si)	1	274	4.6	778	*9.6	2,739	**152.2	232	2.0
Year (Y)	1	3,113	**51.9	5	—	242	*13.4	1,437	*13.4
Si x Y	1	345	5.8	75	—	369	*20.5	288	2.5
Main plot error	4	60	—	81	—	18	—	116	—
Subplots:									
Season (Se)	1	514	**7.9	989	**11.8	549	*3.6	0	—
Cultivation (C)	2	2,009	**30.9	2,231	**26.6	2,321	**15.2	1,714	**5.7
Shade (Sh)	1	4,338	**66.7	7,717	**91.9	6,717	**43.9	6,462	**323.1
Si x Se	1	0	—	145	1.7	95	—	15	—
Si x C	2	264	*4.1	385	*4.6	533	*3.5	71	*3.6
Si x Sh	1	342	*5.3	104	1.2	63	—	120	*6.0
Y x Se	1	11	—	4,650	**55.4	1,921	**12.6	2,013	**100.7
Y x C	2	174	2.7	74	—	57	—	172	**8.6
Y x Sh	1	50	—	99	1.2	122	—	1	—
Se x C	2	222	*3.4	898	**10.7	412	2.7	177	**8.9
Se x Sh	1	84	1.3	457	*5.4	5	—	252	**12.6
C x Sh	2	43	—	78	—	109	—	927	**45.4
Subplot error	71	65	—	84	—	153	—	20	—

* Significant at 5-percent level.
** Significant at 1-percent level.

Table 3.—Analysis of variance for seedling establishment of each species[1]

Source of variation	Degrees of freedom	Pitch pine		Red pine		White pine	
		Mean square	F	Mean square	F	Mean square	F
Main plots							
Site (Si)	1	351	—	1,227	2.6	152	—
Year (Y)	1	468	—	222	—	1,389	**49.1
Si x Y	1	3,753	5.1	5,619	*11.7	878	3.1
Main plot error	4	732	—	480	—	283	—
Subplots:							
Season (Se)	1	1,106	**8.3	3,538	**27.4	5,765	**77.9
Cultivation (C)	2	1,911	**14.3	9,668	**74.9	2,064	**27.9
Shade (Sh)	1	520	3.9	1,477	**11.4	9,590	**129.6
Si x Se	1	1,004	**7.5	33	—	1,154	**15.6
Si x C	2	355	2.6	792	**6.1	625	**8.4
Si x Sh	1	35	—	734	*5.7	2	—
Y x Se	1	93	—	1,536	**11.9	17,403	**235.2
Y x C	2	166	1.2	1,001	**7.8	760	**10.3
Y x Sh	1	179	1.3	11	—	0	—
Se x C	2	367	2.7	2,756	**21.4	1,892	**25.6
Se x Sh	1	75	—	49	—	3,498	**47.3
C x Sh	2	249	1.9	5,548	**43.0	1,092	**14.8
Subplot error	71	134	—	129	—	74	—

[1] Establishment as a percent of seeds germinated. Data for white spruce insufficient for analysis.

* Significant at 5-percent level.

** Significant at 1-percent level.

and treatments (tables 1 and 4). For unknown reasons, more pitch pine died on the shaded plots than on the unshaded ones. Mortality percents on untreated seedbeds generally were higher than on prepared ones, which simply affirms that competing vegetation is an unfavorable factor for both germination and survival after germination.

The combination of low germination and subsequent high mortality in white spruce so reduced the numbers of seedlings that a statistical analysis of establishment of this species could not be very meaningful. Therefore white spruce was not included in table 3.

Table 4.—Percent of seedlings lost during the first season by species, site, and treatment[1] (seasons and years combined)

Seedbed treatment	Shade treatment	Pitch pine	Red pine	White pine	White spruce
		ADAMS SOIL			
None	None	16	—	—	—
	Shaded	29	67	25	74
	Both	25	—	—	—
Roughened	None	8	—	—	—
	Shaded	16	22	20	59
	Both	13	—	—	—
Scalped	None	6	20	19	22
	Shaded	4	12	6	22
	Both	5	14	11	22
		GLOUCESTER SOIL			
None	None	28	51	22	—
	Shaded	46[2]	51	15	62
	Both	38	51	18	—
Roughened	None	10	42	—	—
	Shaded	13	27	21	61
	Both	12	31	—	—
Scalped	None	10	12	31	68
	Shaded	14	10	11	36
	Both	12	10	17	48

[1] Losses shown only where 15 percent or more of the seeds had germinated.
[2] This figure includes losses caused by intensive insect feeding on one plot.

Effects of Site

Germination tended to be higher on the better Gloucester soil than on the poorer Adams soil, but the differences were significant only for white pine and red pine (table 2). However, the interaction of site and cultivation was significant for the three pines and white spruce: scalping, as compared with no seedbed preparation, resulted in greater increases on the Adams soil than on the Gloucester.

On unshaded plots, germination was consistently higher on the Gloucester soil than on the Adams; on shaded plots, soil had less effect (table 1). The interaction of site and shade was significant only for pitch pine and white spruce: like scalping, shade resulted in greater increases on the Adams soil than on the Gloucester.

Site alone did not play a significant part in seedling establishment of any species (table 3). The interaction of site and cultivation was highly significant for both white and red pines but not for pitch pine; the direction of these interactions was the same for seeding establishment as for germination — greater effects on the Adams soil. A significant site-shade interaction occurred only with red pine.

Sowing Season and Year of Germination

Sowing season was a significant or highly significant factor affecting germination of the three pine species, and year of germination was significant or highly significant for all species except red pine (table 2). The effect of season was not consistent among species and years (table 5). For both years combined, spring was

Table 5.—Germination percent by sowing season and year of germination

Sowing season	Pitch pine		Red pine		White pine		White spruce	
	1959	1960	1959	1960	1959	1960	1959	1960
Fall	35	51	16	36	27	34	10	28
Spring	42	60	47	28	35	18	22	20
Both	39	56	32	32	31	26	16	24

the better time for pitch pine, red pine, and white spruce; fall was a little better for white pine. The effect of year of germination also was inconsistent. For the two sowing seasons combined, 1960 was the better year for pitch pine and white spruce; 1959 was better for white pine; neither year was better than the other for red pine.

These inconsistencies mean interactions in a statistical sense. In all species except pitch pine, the interactions between season and year were highly significant for both germination and first-year establishment (tables 2 and 3). The direction of these interactions in germination can be seen in table 5: spring sowing was better than fall sowing in 1959, and fall sowing was better than spring sowing in 1960. The pattern was similar for first-year establishment.

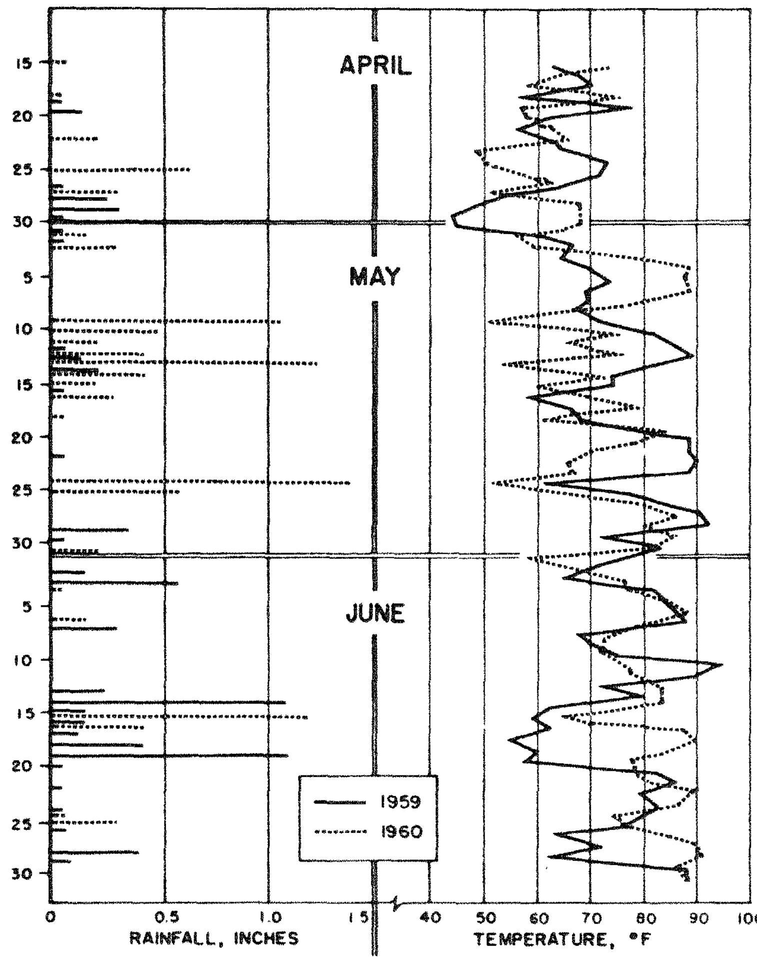
Little biological significance can be attached to these differences between seasons of sowing other than the observation that response to season may differ from year to year, presumably because of different weather conditions during the spring germination period. Thus the limited data from this study do not point to any one season as best for sowing.

Rainfall and temperature patterns during spring and early summer of the 2 years of the study no doubt account for at least some of the differences in germination and establishment. Records of rainfall and maximum daily temperatures at the nearby Maine

Table 6.—Average rainfall and maximum temperatures

Period covered	Days in period	Rainfall		Maximum temp.	
		1959	1960	1959	1960
		Inches	*Inches*	*°F.*	*°F.*
May 9 - 16	8	0.4	4.3	77	66
May 17 - 23	7	.0	.0	82	72
May 24 - 25	2	.0	2.0	70	66
May 26 - June 12	18	1.4	.3	80	78
June 13 - 16	4	1.5	1.6	66	78
June 17 - 20	4	1.9	.0	63	83
June 21 - 30	10	.7	.3	78	84

Figure 1.—Record of daily maximum temperatures and rainfall for 1959 and 1960.



Forest Service fire-danger station at Alfred are shown for the 2 years in figure 1. Although the weather was much the same both years until early May, the patterns were quite different later; and May 1959 was appreciably dryer and warmer than May 1960 (table 6).

According to records in another study and general observations, early May is the season when the main surge of seed germination normally occurs. For instance, in a seeding study made in 1962 with white pine, most of the seed had germinated during a 2-week period immediately after an early May rainfall pattern similar to that of May 1960.

Several general observations of sowing season and weather effects, and of species differences, are noted below:

Fall-sown seed germinated earlier than spring-sown seed.

In the dry spring of 1959, total germination tended to be lower for fall-sown seed than for spring-sown seed; in the wetter spring of 1960, this sowing-season relationship tended to be reversed.

Germination began earlier and ended earlier for pitch pine than for the other pines. Under the 1959 conditions of a dry May followed by a moist June, red and white pine germination continued through June and into July to a considerably greater degree than did pitch pine germination. The pattern of white spruce germination roughly paralleled that of pitch pine.

Red pine and white pine seemed somewhat more exacting in moisture requirements for germination than pitch pine.

Germination of all species tended to be later on untreated plots than on cultivated plots.

Summary

A direct seeding test was conducted in southwestern Maine to investigate the effects of seedbed preparation and shade on germination and first-year establishment of five conifer species: pitch pine, red pine, white pine, white spruce, and Norway spruce. The test involved the following variables: two sites — an excessively-drained loamy sand and a well-drained sandy loam; three seedbed treatments — scalped, roughened, and untreated check; two light intensities — shade and no shade; and two seasons of sowing — fall and spring — repeated through 2 years. The experimental unit for each species under each combination of conditions was a 1-foot-square spot on which 100 repellent-treated seeds were sown.

Norway spruce failed almost completely. For the other species,

both germination and establishment were consistently best on scalped, shaded plots. Here 45 to 68 percent of the pine seeds produced seedlings that were still alive at the end of the first growing season; comparable figures for white spruce were 25 to 33 percent. Roughened seedbeds were better than seedbeds with no treatment, but markedly inferior to scalped ones.

The main effect of site alone was not statistically significant in terms of first-year establishment, and it was significant for germination in only two species. However, various site-treatment interactions were significant. In general, seedbed preparation and shading were much more beneficial on the excessively-drained loamy sand than on the sandy loam.

Season of sowing was a statistically significant factor in both germination and first-year establishment, but the effects were not consistent among the four species analyzed; and there were various interactions with year and the other variables that, although statistically significant, probably meant little biologically.

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