DIRECT SEEDING IN NORTHERN FOREST TYPES

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Abstract

Two direct-seeding experiments were established to determine the effect of time of seeding (spring 1962 versus fall 1962), type of seedbed (prepared versus unprepared), and species (red pine (Pinus resinosa Ait.) versus white spruce (Picea glauca (Moench) Voss)) upon the success attained in the reforestation of a pine-barren site and a recently burned-over forest site in eastern Maine. A split-split-plot experiment with 0.75-acre treatment plots was replicated three times on each site. Seedbeds on the pine barren were prepared by disking with a Rome disk harrow and seedbeds on the burn, by scarifying with a bulldozer. Treatment plots were broadcast sown by hand at a seeding rate of 50,000 viable seed per acre. All treatments on the pine barren except those established on unprepared seedbeds, all of which were failures, resulted in the establishment of moderately-stocked to over-stocked stands five years after seeding. All treatments on the burn produced adequately stocked stands initially, however, by the fifth growing season competing vegetation had reduced the average milacre stocking percent of most treatments to less than 50 percent.

Publication of guidelines for direct seeding loblolly pine (Pinus taeda L.) by Mann and Derr (1959, longleaf pine (Pinus palustris Mill.) by Derr and Mann (1961), and a paper on the direct seeding of conifers presented at the Winter Meeting of the New England Section of the Society of American Foresters in March 1961 by Abbott (1961) resulted in stimulating anew an interest in direct seeding among forest land managers in Maine. Sufficient interest was generated for the Maine Agricultural Experiment Station, Bureau of Forestry, Bureau of Sport Fisheries and Wildlife, St. Regis Paper Company, Standard Packaging Corporation, and Georgia-Pacific Corporation to collaborate in the establishment of two experiments in the spring of 1962

to study the applicability of direct seeding in northern forest types. The experiments were established specifically to determine the respective effects of time of seeding (spring 1962 versus fall 1962), type of seedbed (prepared versus unprepared), and tree species (red pine (Pinus resinosa Ait.) versus white spruce (Picea glauca (Moench) Voss)) upon the success attained in the reforestation of a pine-barren site and a recently burned-over forest site. Early results of both experiments have been reported by Griffin, DeCoster, and Collom(1965 and Collom(1965). This paper summarizes the results of the experiment on the pine-barren site through the 1967 growing season and the results of the experiment located on the burned-over forest site through the 1966 growing season.

LOCATION AND DESCRIPTION OF EXPERIMENTAL AREAS

The experiment on the pine barren was located in the northeast corner of Township 30 M.D., Washington County, Maine. The soil, a well- to excessively-drained Colton sandy loam supported a dense stand of vegetation composed principally of lowbush blueberry (Vaccinium angustifolium Ait.), lambkill (Kalmia angustifolia L.), wintergreen (Gaultheria procumbens L.), sweet fern (Comptonia peregrina (L.) Coult.), and reindeer moss (Cladonia rangiferina (L.) Web.)

The experiment on the burned-over area was located near the southeast side of Duck Lake in Township 4 N.D., Hancock County, Maine. The soil was a well-drained Hermon very stony loam. Previous to a wildfire in the summer of 1960, the area supported a forest stand composed principally of eastern hemlock (Tsuga canadensis (L.) Carr.) red spruce (Picea rubens Sarg.) and balsam fir (Abies balsamea (L.) Mill.). Trees of merchantable size were being harvested when the fire occurred. The fire, covering approximately sixty acres, burned to the mineral soil. Vegetation was still quite sparse in the spring of 1962. Many of the fire-killed trees had been blown down and others were in the process of falling. Sarsaparilla, (Aralia hispida Vent.), bracken fern (Pteridium aquilinum var. latiusculum (Desv.) Underw.), raspberry (Rubus idaeus var. aculeatissimus Regel and Tiling), fireweed Epilobium angustifolium L.) and numerous grasses began to appear on the burn in the summer of 1962. Tree species consisted principally of quaking aspen (Populus tremuloides Michx.), bigtooth aspen (Populus grandidentata Michx.), pin cherry (Prunus pensylvanica L. f.), paper birch (Betula papyrifera Marsh.) and

yellow birch (Betula alleghaniensis Britton). Sprout clumps of American beech (Fagus grandifolia Ehrh. and red maple (Acer rubrum L.) occurred sporadically.

PROCEDURE

Experimental Design

A split-split-plot experiment was replicated three times on each experimental area. Each major block was divided into two 3-acre main plots; each main plot, into two 1.5-acre subplots; and each subplot, into two 0.75-acre minor plots. Within a major block, times of seeding were assigned at random to the main plots; types of seedbed, to the subplots; and tree species, to the minor plots.

While the respective treatments were applied as uniformly as possible over the entire acreage of each minor plot, measurements of results were confined to a 0.5-acre area in the center of the minor plot. Thus, each treatment was surrounded by a 0.25-chain buffer strip.

Preparation of Seedbeds

Seedbeds on the pine barren were prepared with a Rome disk harrow pulled by a D-7 Caterpillar. The plots were disked twice. The second disking accomplished an almost complete break-up of the thick root mass turned up by the first disking. Plots sown in the spring were disked in May and those sown in the fall, in September.

Seedbeds on the Duck Lake Burn were prepared by working a bulldozer through the plots in a zigzag pattern by alternately locking the tracks. The partial turning of the bulldozer chewed up much of the debris and exposed some mineral soil. However, large boulders and down timber precluded the attainment of a uniformly prepared seedbed similar to that obtained with the Rome disk harrow on the pine barren. Plots seeded in the spring were prepared in June 1962 and those seeded in the fall, in September 1962.

Treatment of Seed

Seed from red pine and white spruce seed lots collected in the Lake States was used in both spring and fall seedings. Germination percents of the red pine

and white spruce seed sown in the spring were 78 percent and 70 percent and of those sown in the fall, 85 percent and 51 percent respectively.

The seeds were coated for protection against losses to mammals and birds with 50 percent wettable endrin powder (2 percent to weight of seed), 75 percent wettable Arasan powder (1 percent to weight of seed), Dow Latex 512-R (1 part latex to 9 parts water) and enough aluminum paint flakes to cover the seed uniformly.

Seeding of Minor Plots

Within each minor plot, twenty square milacre observational plots were established at one-half chain intervals. While the observational milacres on the pine barren could be located systematically, some of those on the Duck Lake Burn had to be located irregularly to avoid heavy accumulations of debris.

Within each observational milacre, twenty seed spots were located systematically and marked with wooden dowels. The seed spots were seeded by dropping five seeds around each dowel. Thus, the seeding rate on the observational milacres in terms of viable seed per milacre was the same as the germination percent of the seed sown as given above.

The remaining 730 milacres in each minor plot was broadcast sown at the rate of 50 viable seeds per milacre. To obtain an even distribution of seed, the minor plots were divided into four strips of equal size and each strip was broadcast sown by hand with one-fourth of the total amount of seed sown on the plot. On the pine barren, spring-sown plots were sown May 30-June 5, and fall-sown plots, October 1-2. On the Duck Lake Burn spring-sown plots were sown June 12-14, and the fall-sown plots, October 10-13.

Small Mammal Populations

Small mammal census plots were established on an undisturbed site in each experimental area in May 1962. The census plot on the pine barren measured 100 by 125 feet and the one on the Duck Lake Burn, 125 by 175 feet. Sherman live traps were stationed at the intersections of a 25 by 25-foot grid system. Population censuses were conducted during the spring and fall of 1962, 1963, and 1964 (Ladd 1965).

No animals were trapped on either the census plot or additional spot-check trapping sites located on the pine barren. The absence of small mammals on the pine barren was attributed to a lack of suitable cover.

The small mammal population on the Duck Lake Burn increased as the density of the herbaceous vegetation increased. The censuses indicated a population per census plot of one deer mouse (Peromyscus maniculatus) in May 1962, three red-backed voles (Clethrionomys gapperi) in October 1962, no animals in June 1963, sixteen deer mice plus four red-backed voles in October 1963, and thirteen deer mice in August 1964 (Ladd 1965).

Weather

Since both experimental areas were within a twenty-mile radius of the Fire Danger Weather Station maintained by the Bureau of Forestry at Beddington, Maine, the weather was probably quite similar to that recorded at the Station. The weather during the 1962 and 1963 growing seasons was noticeably different in two respects. Rainfall in May 1963 (6.44 inches) totaled 4.74 inches more than that in May 1962 (1.70 inches). The average air temperature in July 1963 ($69^{\circ}F$) averaged eight degrees higher than that in July 1962 ($61^{\circ}F$). Thus, the weather was probably more favorable for prompt germination and early establishment of seedlings in 1963 than in 1962.

Inventories

Inventories were made of germination, seedling survival, and seedling mortality on the observational milacres of both experiments in the spring and fall of 1962, 1963, and 1964 (Collom 1965). The final inventory of the observational milacres on the pine barren was made in late July 1967 when the spring-sown and fall-sown plots were in their sixth and fifth growing season respectively. The final inventory of the observational milacres on the Duck Lake Burn was made in late August 1966 when the spring-sown and fall-sown plots were in their fifth and fourth growing season respectively. Concurrently with the last inventory of the observational milacres, inventories were made of an additional 100 circular milacre plots (hereinafter referred to as inventorial milacres) located systematically in each of the 0.5-acre minor plots. When an inventorial milacre overlapped an observational milacre, the location of the inventorial milacre center was moved eight feet

from the boundary of the observational milacre.

RESULTS

Pine Barren

Germination on spring-sown prepared seedbeds began prior to June 29, 1962 and on fall-sown prepared seedbeds prior to May 26, 1963. In both years, germination on unprepared seedbeds was not evident until after germination on prepared seedbeds was well underway.

By the fall of 1964, seedling mortality expressed as a percentage of stocking ranged from a low of 36 percent for red pine on prepared seedbeds to a high of 82 percent for white spruce on unprepared seedbeds. Twenty-four percent of the total seedling mortality on prepared seedbeds and 29 percent of the total seedling mortality on unprepared seedbeds were attributed to unknown causes. Seventy-three percent of the total seedling mortality on prepared seedbeds was attributed to frost heave (54 percent), drought (12 percent), and heat injury (7 percent). Seventy percent of the total seedling mortality on unprepared seedbeds was attributed to drought (47 percent), insects (18 percent) and heat injury (5 percent). In September 1964, red pine tree percentages, i.e. the number of live seedlings present for each 100 viable seeds sown, averaged 5.3 on unprepared seedbeds and 24.6 on prepared seedbeds. White spruce tree percentages averaged 1.9 on unprepared seedbeds and 12.7 on prepared seedbeds (Collom 1965).

The average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five, and ten seedlings respectively in August 1963, September 1964, and July 1967 are recorded for each treatment on the pine barren in Table 1. Analysis of variance of the 1967 data found the effect of type of seedbed and the effect of species to be highly significant. Although more seedlings usually resulted from fall-sown seed than from spring-sown seed, the effect of time of seeding proved to be nonsignificant.

The inability of white spruce to become established on an undisturbed pine-barren seedbed and the relative poor vigor of the white spruce seedlings that managed to become established on prepared seedbeds were readily apparent in August 1963. Nevertheless, in July 1967 -

Table 1. - Average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five and ten seedlings respectively for each treatment on the pine barren in August 1963, September 1964, and July 1967.

Time of observation and stocking level	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
	P[a]	S[b]	P	S	P	S	P	S
	Number[c]							
Oct. 1962	13.4	7.1	6.3	1.5	-	-	-	-
Aug. 1963	20.3	6.6	5.5	0.7	36.2	23.5	5.1	1.6
Sept. 1964	16.0	3.3	4.8	0.6	24.5	10.5	3.8	1.5
July 1967	11.4	1.8	2.5	0.1	16.2	7.5	1.5	0.2
	Percent[d]							
Aug. 1963								
One seedling	100	95	92	40	100	98	90	58
Two seedlings	100	88	85	20	100	98	83	32
Five seedlings	98	65	47	27	100	97	58	15
Ten seedlings	93	30	15	0	97	83	30	2
Sept. 1964								
One seedling	100	87	90	33	100	95	85	50
Two seedlings	100	72	75	13	100	90	78	33
Five seedlings	100	25	38	0	98	73	37	7
Ten seedlings	87	5	13	0	93	48	5	0
July 1967								
One seedling	100	68	72	7	95	85	55	12
Two seedlings	98	48	53	0	95	72	37	3
Five seedlings	83	12	15	0	92	45	7	0
Ten seedlings	58	0	3	0	75	18	0	0

[a]Red pine.
[b]White spruce.
[c]Average of sixty observational milacres (twenty milacres in each of three replications) per treatment.
[d]Percent of the sixty observational milacres stocked with the specified minimum number of seedlings.

the sixth and fifth growing season for the spring-sown and fall-sown plots respectively - the number of white spruce seedlings on the spring-sown and fall-sown prepared seedbeds combined averaged 4.7 seedlings per observational milacre with 77 percent and 60 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively.

In July 1967, the number of red pine seedlings on the spring-sown and fall-sown unprepared seedbeds combined averaged 2.0 seedlings per observational milacre with 64 percent and 45 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively. In contrast, the number of red pine seedlings on the combined spring-sown and fall-sown prepared seedbeds averaged 13.8 seedlings per observational milacre with 88 percent and 67 percent of the milacres being stocked with a minimum of five and ten seedlings respectively.

Regardless of species, the growth in height of seedlings on prepared seedbeds was greater than that of seedlings on unprepared seedbeds. In October 1964, the average maximum height (based on measurements of the tallest seedling on each observational milacre) of seedlings on prepared seedbeds (0.18 feet) was significantly greater than that of seedlings on unprepared seedbeds (0.11 feet) and the average maximum height of red pine seedlings was significantly greater than that of spruce seedlings (Collom 1965). In July 1967, the average maximum heights of red pine seedlings on prepared and unprepared seedbeds were 1.36 feet and 0.28 feet respectively. At that time the average maximum heights of white spruce seedlings on prepared and unprepared seedbeds were 0.66 feet and 0.35 feet respectively. By June 1976, red pine on the prepared seedbeds had reached a maximum height of around 15 feet while most of the white spruce on prepared seedbeds and most of the red pine on unprepared seedbeds were still less than 5 feet tall.

The average number of seedlings per inventorial milacre and percent of inventorial milacres stocked with a minimum of one, two, five, and ten seedlings respectively in July 1967 are recorded for each treatment on the pine barren in Table 2. While the effects of both type of seedbed and species were highly significant, the effect of time of seeding was nonsignificant.

Table 2. - Average number of seedlings per inventorial milacre stocked with a minimum of one, two, five and ten seedlings respectively for each treatment on the pine barren in July 1967.

	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
Stocking level	P[a]	S[b]	P	S	P	S	P	S
	Number[c]							
	9.81	1.60	1.01	0.04	11.30	4.58	0.14	0.04
	Percent[d]							
One seedling	85	50	32	3	81	61	5	3
Two seedlings	78	32	17	0	77	50	2	1
Five seedlings	59	7	6	0	59	28	1	0
Ten seedlings	24	2	2	0	39	13	0	0

[a]Red pine.
[b]White spruce.
[c]Average of 300 inventorial milacres (100 milacres in each of three replications) per treatment.
[d]Percent of the 300 inventorial milacres stocked with the specified minimum number of seedlings.

The number of red pine seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged only 0.5 seedlings per inventorial milacre with only 19 percent and 10 percent of the milacres being stocked at the one- and two-seedling level respectively. On spring-sown and fall-sown prepared seedbeds, the number of red pine seedlings averaged 10.6 seedlings per inventorial milacre with 83 percent and 78 percent of the milacres being stocked at the one- and two-seedling level respectively.

Duck Lake Burn

On the Duck Lake Burn, germination on prepared and unprepared seedbeds began apparently at about the same time. The spring-sown seed began germination soon after June 29, 1962 and the fall-sown seed sometime prior to May 26, 1962.

By the fall of 1964, seedling mortality expressed as a percentage of stocking ranged from a low of 28 percent for red pine on both prepared and unprepared seedbeds respectively to a high of 53 percent for white spruce on prepared seedbeds. Thirty-one percent of the total seedling mortality on prepared seedbeds and 46 percent of the total seedling mortality on unprepared seedbeds were attributed to unknown causes. Fifty-four percent of the total seedling mortality on prepared seedbeds was attributed to drought (22 percent), frost heave (20 percent) and heat injury (12 percent). Forty-two percent of the total seedling mortality on unprepared seedbeds was attributed to drought (27 percent), heat injury (11 percent) and frost heave (4 percent). In September 1964, red pine tree percentages averaged 13.6 on unprepared seedbeds and 24.8 on prepared seedbeds. White spruce tree percentages averaged 11.8 on unprepared seedbeds and 12.7 on prepared seedbeds (Collom 1965).

The average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five, and ten seedlings respectively in September 1963, September 1964, and August 1966 are given for each treatment on the Duck Lake Burn in Table 3. Analysis of variance of the 1966 data showed the effect of type of seedbed to be significant and the effect of species to be highly significant. The effect of time of seeding was not significant.

In August 1966, - the fifth and fourth growing season for the spring-sown and fall-sown plots respectively - the number of white spruce seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 3.1 seedlings per observational milacre with 63 percent and 55 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively. In contrast, the number of white spruce seedlings on spring-sown and fall-sown prepared seedbeds combined averaged 3.9 seedlings per observational milacre with 83 percent and 63 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively.

Table 3. - Average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five, and ten seedlings respectively for each treatment on the Duck Lake Burn in September 1963, September 1964, and August 1966.

Time of observation and stocking level	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
	P[a]	S[b]	P	S	P	S	P	S
	Number[c]							
Oct. 1962	17.8	3.7	19.1	6.9	-	-	-	-
Sept. 1963	16.2	4.1	15.0	5.8	33.5	14.3	10.4	8.9
Sept. 1964	13.8	3.2	12.0	4.9	27.1	10.6	9.6	8.4
Aug. 1966	10.1	2.0	4.9	2.7	14.1	5.8	2.7	3.5
	Percent[d]							
Sept. 1963								
One seedling	98	88	98	82	97	100	95	87
Two seedlings	98	73	98	70	97	98	80	83
Five seedlings	88	32	88	47	97	83	57	62
Ten seedlings	70	12	73	23	95	62	40	40
Sept. 1964								
One seedling	97	75	92	75	95	97	87	85
Two seedlings	97	65	92	58	95	90	73	77
Five seedlings	87	20	78	42	95	72	50	60
Ten seedlings	58	12	57	23	88	42	40	38
Aug. 1966								
One seedling	98	75	82	63	100	90	60	63
Two seedlings	95	53	68	52	100	73	55	58
Five seedlings	80	5	40	25	88	48	23	28
Ten seedlings	38	0	15	5	60	17	5	7

[a]Red pine.
[b]White spruce.
[c]Average of sixty observational milacres (twenty milacres in each of three replications) per treatment.
[d]Percent of the sixty observational milacres stocked with the specified minimum number of seedlings.

In August 1966, the number of red pine seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 3.8 seedlings per observational milacre with 71 percent and 62 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively. In contrast, the number of red pine seedlings on spring-sown and fall-sown prepared seedbeds combined averaged 12.1 seedlings per observational milacre with 98 percent and 67 percent of the milacres being stocked with a minimum of two and five seedlings respectively.

The average number of seedlings per inventorial milacre and percent of inventorial milacres stocked with a minimum of one, two, five and ten seedlings respectively in August 1966 are recorded for each treatment on the Duck Lake Burn in Table 4. Analysis of variance indicated the effect of type of seedbed to be significant. The effects of time of seeding and species were nonsignificant.

The number of white spruce seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 1.25 seedlings per inventorial milacre with 37 percent and 22 percent of the milacres being stocked at the one- and two-seedling level respectively. On spring-sown and fall-sown prepared seedbeds combined, the number of white spruce seedlings averaged 1.71 seedlings per inventorial milacre with 41 percent and 27 percent of the milacres being stocked at the one- and two-seedling level respectively.

The number of red pine seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 1.54 seedlings per inventorial milacre with 35 percent and 27 percent of the milacres being stocked at the one- and two-seedling level respectively. On spring-sown and fall-sown prepared seedbeds combined, the number of red pine seedlings averaged 3.43 seedlings per inventorial milacre with 59 percent and 44 percent of the milacres being stocked at the one- and two-seedling level respectively.

Table 4. - Average number of seedlings per inventorial milacre and percent of inventorial milacres stocked with a minimum of one, two, five, and ten seedlings respectively for each treatment on the Duck Lake Burn in August 1966.

	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
Stocking level	P[a]	S[b]	P	S	P	S	P	S
				Number[c]				
	3.89	1.27	2.05	1.51	2.96	2.14	1.03	0.99
				Percent[d]				
One seedling	63	40	43	41	54	41	27	32
Two seedlings	53	25	33	25	45	28	20	19
Five seedlings	29	7	16	9	22	15	5	4
Ten seedlings	15	3	5	3	8	7	2	1

[a]Red pine.
[b]White spruce.
[c]Average of 300 inventorial milacres (100 milacres in each of three replications) per treatment.
[d]Percent of the 300 inventorial milacres stocked with the specified minimum number of seedlings.

DISCUSSION

The experiments were established in the spring and fall of the same year because of circumstances rather than by choice. Seeding in the fall and in the spring of the following year, inasmuch as the germination of both seedings would have then occurred under the same environmental conditions, would have provided a more valid test of the effect of season of sowing. Nevertheless, the results of both experiments indicate strongly that the season of sowing has little, if any, effect upon the success attained in the reforestation of pine-barren sites and recently burned-over forest sites. On sites where excessive losses of seed to small mammals and birds might occur, which apparently was not the case on the areas direct seeded in this study, fall seeding of untreated seed would be quite likely to

result in failure. Fall seeding exposes seed to depredation by destructive agencies for longer periods of time than spring seeding. On the other hand, fall seeding not only eliminates the need to stratify seed prior to sowing but also ensures that seed will be in place on the site and ready to germinate as soon as conditions are favorable, thereby providing the resultant seedlings with the full length of the growing season in which to become firmly established. In practice, spring seeding may be accomplished too late, as happened in this study, to enable seedlings to make full use of the first growing season.

Pine barrens reforest so slow naturally that the process is almost imperceptible yet broadcast sowing white spruce and red pine seeds on disked seedbeds in the spring and fall at rates of 50,000 viable seeds per acre resulted in the establishment of moderately- to well-stocked stands of white spruce and over-stocked stands of red pine in the fifth and sixth growing season for spring-and fall-sown plots respectively. Red pine has the inherent ability to become established and to grow reasonably well on disked seedbeds. A surprising number of red pine seedlings was able to become established on unprepared seedbeds. On the other hand, white spruce, being much less drought resistant than red pine, failed to become established on unprepared seedbeds and white spruce seedlings on prepared seedbeds grew much more slowly in height than red pine seedlings on comparable seedbeds. Thus, white spruce cannot be recommended as being a species suitable for use in the reforestation of pine barrens.

The striking success obtained with red pine indicates strongly that pine barrens can probably be reforested successfully by broadcast sowing red pine seed at rates less than 50,000 viable seed per acre on seedbeds prepared less thoroughly than the seedbeds were in this study.

On the Duck Lake Burn, the average number of seedlings per milacre was significantly greater on prepared seedbeds than on unprepared seedbeds, however, the difference was not as great as that on the pine barren. Furthermore,both prepared and unprepared seedbeds were apparently suitable for the germination and establishment of both species for all treatment plots were adequately stocked with seedlings at the end of the third and second growing season for the spring-and fall-sown plots respectively. However, by the fifth growing sea-

son, severe competition of overtopping hardwood growth had reduced the seedling milacre stocking percents on the broadcast sown portions of all treatment plots, except the red pine on prepared seedbed plots, to below 50 percent. An adequate stocking of established seedlings could probably have been maintained on all treatment plots had the seedlings been released promptly by either cutting or deadening the overtopping vegetation with a herbicide. Such cultural treatments will usually be required to maintain an adequate stocking of a direct-seeded species on sites favorable to the natural establishment of other faster growing species.

Successful techniques for direct seeding the southern pines were developed only after many years of study involving experimentation followed by numerous field trials. The results of this study give no reason to doubt that an effort in the Northeast similar to that in the South would result in the development of reliable techniques for direct seeding the northern conifers.

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