RESEARCH NOTES

BRITISH COLUMBIA FOREST SERVICE

VICTORIA, B.C., CANADA

No. 49 1969

DIRECT SEEDING EXPERIMENTS IN THE SOUTHERN INTERIOR REGION OF BRITISH COLUMBIA

by

M.B. Clark

FOREST SERVICE

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

8213

DIRECT SEEDING EXPERIMENTS
IN THE
SOUTHERN INTERIOR REGION
OF BRITISH COLUMBIA

by

M.B. Clark

TABLE OF CONTENTS

APPENDIX II

Table

ABSTRACT

Douglas-fir and spruce seed was spot- and broadcast-sown on small experimental areas within the sub-alpine and interior wet belt regions of the Shuswap and Salmon Arm Public Working Circles.

Satisfactory germination and survival was obtained in two out of three years of sowings.

The average stocking for all years of broadcast sowing was 42.5 per cent with a large proportion of the sample plots being overstocked. The 42.5 per cent stocking was equivalent to 3,078 established seedlings per acre. In addition there was an average of 419 naturally established spruce, alpine fir and Douglas-fir per acre.

The stocking in prepared, sown and covered spots was 25 per cent for spruce and 46 per cent for Douglas-fir following a sowing rate of 7 to 10 treated seeds per spot. Based on estimates of seed viability and field germination obtained in this study, it is suggested that sowing rates of 20 spruce seeds and 11 Douglas-fir seeds per spot would be required to produce 80 per cent stocking at 8' by 8' spacing.

The physiographic site is of great importance when broadcast seeding extensive areas because of the variation in the texture and moisture relationships of seedbeds. The maximum difference in stocking with germinants was 35 per cent between years of broadcast sowing. It was only 2 per cent between years for spot sowing - a method which permits the placing of seed on favourable seedbeds. If approximately 60 per cent of the area is in favourable seedbed then broadcast sowing may be successful, lesser amounts will suggest the use of spot sowing.

Aspect is not a factor limiting germination and survival at higher elevations and in the Interior Wet Belt, but shade and the interacting effect of various types of shade may have a limiting effect.

Other results corroborated again that a mineral seedbed is best for germination and survival, that all seed must be protected against loss to rodents and that good quality seed should be used.

INTRODUCTION

A large number of areas burned intentionally or unintentionally, require artificial reforestation in the southern interior region of British Columbia.

The method of reforestation at the present time is planting of bare-root stock but direct seeding may become an acceptable method once the variables affecting its success or failure are properly identified, and methods of determining the sites and conditions favourable to seeding are established.

These trials are undertaken to demonstrate that direct seeding is a means of attaining artificial reforestation and to define the factors limiting success.

It was also borne in mind that the criteria used to judge an area suitable for direct seeding would have to be adaptable to air photo interpretation and practical field survey techniques.

THE SEEDING AREAS

The areas are within the Sub-alpine and Columbian zones of the Southern Interior. Mean annual precipitation varies between 20-30 inches per year, much of this falling as snow. The frost-free period is from 50 to 100 days per year. During the growing period between May and September maximum daily temperatures may reach 95^{o} Fahrenheit. Periods of drought, some of long duration, are common during July and August. Drought periods of short duration are not uncommon in May at the lower elevations near valley bottom. Temperature and precipitation data averaged for sub-alpine and wet belt seeding areas are presented in tables 1 and 2, appendix II.

Soils are glacial till with a gravelly to sandy loam and loamy texture. Occasionally there are small deposits of organic muck. Drainage varies from excessive to restricted within small areas. Areas with excessive drainage combined with hot, dry, periods in the summer make availability of soil moisture an important limiting factor in seedling establishment.

Prior to devastation by fire in 1961, the sub-alpine area supported a forest cover principally composed of Engelmann spruce and Alpine fir, most commonly in association with a shrub layer of *Rhododendron albiflorum, Sorbus sitchensis, Ribes lacustre, Vaccinium membranaceum, Vaccinium ovalifolium,* and *Pachystima myrsinites.* The shrub and herb layers quickly re-invaded the area following the fire and during the post-burn period *Epilobium angustifolium* was very much in evidence.

Prior to logging and prescribed burning in 1962-63, the Columbian zone areas supported a forest-type which was essentially a hemlock-cedar climax, with variations in quantities of western hemlock, western red cedar, Douglas-fir, Engelmann spruce, western white pine, western larch, and Alpine fir. Minor quantities of western white birch (*Betula papyrifera* (Hook) sarg.), Pacific Yew (*Taxus brevifolia,* Nutt.), and Vine Maple (*Acer circinatum,* Pursh.) were present in the stands. These species were in association with a shrub layer principally composed of *Pachystima myrsinites, Vaccinium membranaceum, Rubus ideous, Rubus leucodermis, Ribes lacustre.* A thick layer of mosses covered the forest floor.

THE TRIALS

The trials are in two localities, one on the Adams Plateau within the Shuswap Public Sustained Yield Unit, and one on three areas (Eagle Bay, Larch Hills, Mara Meadows) in the Salmon Arm Public Sustained Yield Unit. The first experiment was located in an area partially logged and burned by wildfire in 1961 and was active from 1962 to 1967. The second set of experiments was located in areas clearcut and prescribed burned between 1962-63 and was in progress from 1964 until 1968. The two series were commenced independently, but the similarity of objectives and methods subsequently led to co-ordination of results.

Attention was focused upon what were considered to be the factors which might limit germination and survival of different species. Season and seedbed preparation were common factors to all trials within which treatments were adequately replicated in a randomized design.

The first trial was a test of spot and broadcast sowing of two species, Engelmann spruce and Douglas fir, replicated over three years. Six hundred spots were sown for each species each year and approximately 3 acres were broadcast-sown for each species each year. All seed were treated with Endrin.

The second trial was a test of spot and broadcast sowing of two species, Engelmann spruce and Douglas fir, replicated over three years. Six hundred spots were sown for each species each year and approximately 3 acres were broadcast-sown for each species each year. All seed were treated with Endrin.

The second trial was a test of spot seeding for six species, Douglas fir, Engelmann spruce, western white pine, western hemlock, western red cedar, and western larch, replicated over three years. Untreated and Endrin-coated seed were sown. Three hundred spots were sown for each species on each area each year.

Analyses were based upon enumerations of germination and survival in the fall of each year. Treatments were tested and compared in terms of survival at the end of three years, or twoyears when third-year survival was not available.

Table 1 describes the trials in brief. For greater descriptive detail consult the annual reports for E.P.'s 606 and 632 in the Research Review (Clark, 1964-1968 inclus.).

SEED QUALITY

Seed of appropriate provenances for the first trial were supplied by the Reforestation Division of the British Columbia Forest Service. Germinative capacity of the spruce was 69 per cent in a laboratory test in 1963, and the germinative capacity of the Douglas fir was 92 per cent. Seed for the second trial were collected from stands adjacent to the areas to be sown. The germinative capacity was 86 per cent for Douglas fir, 85 per cent for western red cedar, 90 per cent for white pine, 73 per cent for Engelmann spruce, 50 per cent for western hemlock and 22 per cent for larch.

A few small tests on the seed for the second trial indicated a reduction in viability after treatment of seed with Endrin, but all species were not tested.

RESULTS

Spot Seeding

Species

In the first trial Douglas fir was sown during the first year only, therefore comparisons with spruce sown in each of 3 years are only a guide to species-site adaptability. In the second trial Douglas fir was sown on all areas for the full period of the trial and the results were equivalent to those for spruce. Germination was lower but survival was better than for spruce.

In the second trial the differences in germination and survival between species are shown in table 2 (appendix 1) and were partially due to the ability of some species to withstand drought conditions better than other species, partially to seed quality of some species, and partially due to smothering of small seeded, slow growing, species by leaf litter.

Site Preparation

Every year in each trial the sowing-spots were split into three seedbed treatments to determine effectiveness of type of seedbed on germination. Site preparation methods were: (1) screefing to prepare a mineral seedbed and covering of seed with ¼ to ½-inch of soil; (2) screefing to mineral soil and leaving seeds uncovered; (3) unprepared seedbeds, i.e., natural forest floor conditions after burning. The treatment which included covering of seed was a counterpart of nature's method and at the same time was a partial test of rodent control.

Engelmann spruce was the only species common to both trials for the full period of the study. Although no difference in germination or survival between prepared seedbeds was evident, it was once again demonstrated that mineral seedbeds are necessary to obtain good germination of this species.

Small seeded species sown in the second trial performed similarly to spruce with respect to seedbed whereas larger seeded species produced their best germination and survival on prepared and covered seedbeds. This also indicated that losses to rodents of larger seed would be more severe than for species with small seed unless extra protection is provided.

Poor results were obtained in both trials for unprepared seedbeds, ranging from 2 to 14 per cent of spots stocked compared with the 6 to 49 per cent for prepared seedbeds.

The best germination and survival on this type of seedbed was obtained where the site was a moist to fresh mineral or burned mineral soil.

Table 2 (appendix I) compares the germination and survival of the different species by site preparation treatment.

Seed Protective Treatment

In trial I all seed were coated with Endrin prior to sowing but additional measures were taken to determine whether losses were occurring through small mammal activity. In addition to a third of the spots in each sowing being covered with mineral soil, a number of spots for each site preparation treatment were protected by wire mesh screens which were removed after the first year. Screens were placed on approximately every tenth spot but arranged so as to include equal representation of site preparation treatments. In trial II a similar program of protective treatments was initiated but the screened spots were adjacent to the experimental treated and untreated spots. Also the site preparation treatments were equally represented. The selection of paired spots for screening treatment was by randomization.

In trial I the difference between screening and no screening for germination, 70 and 61 per cent, was not significant ($p = .05$). Similarly, covering of seed was no more effective than leaving seeds uncovered, 75 per cent as compared with 77 per cent (appendix I, table 3A). The major effect of screening appeared to be one of creating a micro-site favourable for increased survival.

In trial II the result of screening, for spruce and all species, was opposite to that in trial I. Screening and covering of seed were more effective than no screening or no covering. This was true for both treated and untreated seed but was more noticeable for untreated seed (appendix I, table 3B). However, it was also apparent that covering of seed was almost as effective as screening. Unscreened but covered seed averaged 64 per cent germination compared with 80 per cent for screened and covered seed. The additional germination obtained by screening would not warrant the cost of screening over an extensive area of spot seeding.

Years of Sowing

In trial I the difference in germination and survival between years was very small, ranging from 2 to 4 per cent, but in trial II the variation was more pronounced, ranging from 11 to 14 per cent (appendix I, table 4). A prolonged period of drought in 1967 severely affected the 1966 sowing in trial II and killed a number of the two and three-year-old seedlings from the 1965 and 1964 sowings. The germination of the 1964 sowing was affected by a period of high temperatures and low precipitation in May of 1965.

Delayed germination was not a factor in the between years' results. Delayed germination of white pine occurred regularly but not significantly more in one year than in any other year.

Seedbed and Physiographic Site

The desirability of a mineral seedbed as a germination medium, for all species, was evidenced by the results on prepared seedbeds as compared with unprepared seedbeds (table 2). The effectiveness of unprepared seedbeds was heavily weighted by site, particularly in trial I. Fresh to moist seedbeds on unprepared spots were favourable for germination and survival where the spot was either a mixture of mineral soil and humus, mineral, or a light covering of moss over mineral. Because of the more uniform topography on the areas within trial II the differences between physiographic sites were not as distinct as in trial I, but results for unprepared spots were similar.

Each spot, in addition to the general area covered by the seeding, was classified by physiographic site on the basis of topography, exposure, and vegetation. This was to determine the effect of site on germination and survival, and to determine whether mapping of sites was a practical method of determining areas suitable for seeding. In general, the spots on fresh and moist sites, regardless of site preparation, produced better germination and survival than dry sites (appendix I, table 5). The stocking after 3 years on moist and fresh sites, on all areas, averaged 29 per cent as compared with only 16 per cent on dry sites. In some cases factors such as shade may have had as much effect on germination and survival on individual spots as had physiographic site.

Shade

In trial II an attempt was made to determine the effect of shade on survival. Spots were classified as either having *no shade; seasonal shade* - vegetation; *permanent shade* - logs, stumps, etc.; or *artificial shade* - holes through duff and rotted wood to reach mineral soil.

The spots with permanent shade produced significantly better survival than spots with other types of shade. Where seed were sown in holes the germination and survival were poor. Two years after sowing the stocking on artificially shaded spots was only 26 per cent, compared with the 40 per cent on permanently shaded spots. Seasonal shade was only slightly better than no shade because of the losses by leaf smothering on seasonally shaded spots.

Aspect

There was no apparent effect on germination or survival due to aspect in either of the trials. The reason for this was probably a combination of gentle slopes and climatic conditions throughout the major part of the growing season.

Stocking Problems with Spot Sowing

In both trials there were many spots which were overstocked with seedlings at the end of two and three years (appendix I, table 6). For example in trial I, 69 per cent of the spots stocked with spruce contained more than 2 established seedlings and 20 per cent contained 10 or more established seedlings. A lesser number of Douglas fir seed were sown per spot than spruce and only 35 per cent of stocked Douglas fir spots contained more than 2 established seedlings. This occurred as a result of seeding in excess of scheduled amounts and from microsite conditions which favoured high survival of germinating seedlings on some spots. It is also affected by chance sowing of more viable seed on one spot than on a second spot, and by chance loss of seed to rodents and other causes from one spot and not from a second spot.

Although it is possible, with seed of known viability, to sow a predetermined number of seed per spot which will yield a stocking figure within certain limits of probability, there will probably be a number of spots requiring cleaning due to overstocking. This is one of the disadvantages which must be considered. If cleaning is required, it probably should not be performed until at least 5 years after germination to allow for unforeseen losses, or until dominance has been asserted.

In table 6 the number of spots with none, one, or more than one seedling are shown for spruce in trial I and for spruce and Douglas fir in trial II as examples of overstocking conditions which might be expected. It is to be noted that a larger number of seed were sown per spot in trial I (10 plus) than in trial II (7-10) and that in each trial excessive amounts were sometimes inadvertently sown on a spot.

The spots shown are those on which seed were treated, spots were screefed and seed covered, that is, the best possible combination for spot sowing.

Theoretically, the probability of obtaining one or more seedlings per spot can be estimated by expansion of the binomial $(P+Q)^n$, in which P equals the probability-of-success, Q the probability-of-failure, and n equals the number of seeds sown per spot.

At an average, say, of 15 seeds sown per spot in trial I the germination was 45.4 per cent and percentage survival (percent of total number germinated) was 40.6. The combination of germination and survival (.454 x .406) produces a probability-of-success of 18 per cent (Krewaz, 1958; Schubert & Fowells, 1964). With the probability-of-success of only 18 per cent, and with seed of the same viability as used in the trial, one would need to sow 10 seeds per spot on 680 spots per acre to obtain

80 per cent stocking at 8- by 8- foot spacing. Similarly, for the spruce and Douglas fir in the wet-belt sites, one would be required to sow 20 and 11 seeds per spot on 680 spots per acre to obtain 80 per cent stocking at 8- by 8-foot spacing.

At lower or higher stocking requirements the number of seeds required per spot would alter accordingly. For example, using the *probability risk* of 14 per cent for Douglas fir in trial II, and requiring only 60 per cent stocking at 8- by 8-foot spacing, one would sow 6 seeds per spot. Ninety per cent stocking would require the sowing of approximately 16 seeds per spot. The extra five seeds per spot required to increase stocking from 80 to 90 per cent would not be worthwhile in terms of amount of seed and the number of overstocked spots.

In trial II, only 4 Douglas fir seeds per spot need have been sown per spot to have obtained the actual stocking figure of 44 per cent. This would have resulted in spots with only one to four seedlings per spot rather than the actual one to ten seedlings per spot.

Broadcast Seeding

Averaging all yearly replications there was no difference in per cent stocking after three years for either broadcast or spot sowing of spruce, but, for the one year it was used, Douglas fir broadcast sowing produced better stocking than spot sowing, 27 per cent as compared with 18 per cent after 3 years. For Engelmann spruce the average survival after 3 years was 35.6 per cent by spot sowing as compared with 42.5 per cent by broadcast sowing.

There was a greater variation in germination and survival between years of sowing for broadcast seeding than for spot seeding (appendix I, table 7). The maximum difference in stocking with germinants was only 2 per cent between years for spot sowing, for broadcast sowing it was 35 per cent. This was because of variation in seedbed and physiographic site on the areas which were broadcast-sown. The best germination and survival were obtained on moist to fresh seedbeds, and seedbeds which were either mineral, moss over mineral, or mixtures of mineral (appendix I, tables 8 and 9). The distribution of fresh and moist seedbeds was better in 1963 than in either of the two other years, 71 per cent of seedbed as against 58 and 53 per cent in 1962 and 1964.

In the broadcast seeding the average stocking for all years of sowing was 42.5 per cent but a large proportion of the sample plots were over-stocked. The 42.5 per cent stocking was equivalent to 3,078 established seedlings per acre. In addition there were an average of 419 naturally established spruce, alpine fir and Douglas fir per acre.

CLIMATE

Climate, especially during the germination period and for first year survival, is one of the most important factors affecting the success of either spot or broadcast seeding. Its limiting effect can be minimized by sowing only on those sites which offer the best chance of success.

In both trials there was at least one year out of the three when climatic conditions were not favourable for germination or survival. There was also at least one year out of the three when climatic conditions were better than for the other two years.

In the general area of the study the seasonal (May-September) precipitation can be expected to be in the range of 8 to 10 inches but it is also expected that, 2 years out of every 10, this range will be less than the minimum of 8 inches (Marshall, 1969). As noted from the table of precipitation in appendix II, only 5 inches of seasonal precipitation were received in 1967. This was below the requirements of the germinated seedlings and a number of the one- and two-year-old seedlings.

SUMMARY AND CONCLUSIONS

During direct seeding trials from 1962 to 1968 inclusive, studies were made of some of the factors affecting germination and survival of Engelmann spruce, Douglas fir, western hemlock, western red cedar, western white pine, and western larch in the sub-alpine and wet-belt areas of the Southern Interior of British Columbia. Factors investigated included seedbed, seed treatment, physiographic sites, rodents, years of sowing, and shade.

The following conclusions may be helpful in future spot and broadcast seeding on similar areas in the Interior.

Engelmann spruce and Douglas fir, in addition to the other species studied, require a mineral seedbed for optimum germination. It is preferable for this seedbed to be loose rather than compact. Mixtures of mineral soil with humus and not too severely burned mineral soil also make satisfactory seedbeds. The selection of a seeding method for an area will depend upon the amount of these favourable seedbeds which are present. If approximately 60 per cent or more of the area is in favourable seedbed then broadcast sowing may be successful, lesser amounts will suggest the use of spot sowing.

A basic requirement in spot sowing is the preparation of a mineral seedbed. At the same time care must be exercised to ensure that the spot is not too concave. This might create survival problems due to flooding, soil sloughing, or smothering of seedlings by dead vegetal matter.

Losses of seed to rodents may be severe when seed are concentrated on spots, particularly for species such as Douglas fir with large seed, but losses can be minimized by treating of seed with repellents, for example, Endrin, and by covering of seed with mineral soil. This, in most cases, will result in a significant increase in germination over that of untreated or uncovered seed. Loss of Engelmann spruce seed to rodents may not be as serious as for Douglas fir but these losses can be made even smaller by treating the same as Douglas fir.

The number of seed which should be sown per spot and the number of spots which should be sown per acre will depend upon the viability of the seed, the rate of stocking required, and the spacing. In general, more seed of Engelmann spruce than of Douglas fir will need to be sown on each spc_ for equivalent stocking.

Whether spot or broadcast seeding is employed only high quality seed should be used to ensure success. The higher the viability the less the amount of seed necessary to obtain the desired level of stocking.

All areas, regardless of size, should be examined with the aid of aerial photographs and ground checking prior to seeding. Aerial photographs may suffice for rough mapping of sites and delineation of those areas which are unsuitable because of drainage or topography, but the areas must be checked on the ground to determine the amount of favourable seedbed, i.e., the seeding method to be employed, and the amount of vegetative competition. Whether or not some areas can be excluded, or should be excluded, will depend on size and the method of seeding. This method of mapping sites for seeding is very elementary and only a preliminary step towards more informative techniques. The extension of photo interpretation to include the mapping of geomorphic units (landscape and drainage) holds great promise for delineation of sites suitable for seeding (Keser, 1968).

Although the best quality seed may be used on the most favourable seedbeds, and seed are protected from rodents, the germination and early survival of seedlings depends very largely on the climatic conditions during the first growing season. Consequently, the effectiveness of seeding as a method of reforestation may vary from year to year even within a homogeneous area. The optimum condition for germination and survival is where short periods of medium to heavy precipitation are interspersed with warm dry weather from May through September. However, optimum conditions seldom occur and it is therefore of the utmost importance that seeding be used only on those areas where there is a good probability of satisfactory moisture occurring during the growing season. In some years even these areas will fail to produce satisfactory results.

REFERENCES

Clark, M.B., 1964. E.P. 606, Direct Seeding of Douglas-fir and Engelmann Spruce. Forest Research Review 1964-68, B.C. Forest Service, Victoria, B.C.

Clark, M.B., 1968. E.P. 632, Exploratory Direct Seeding Trials in the Wet-Belt Type of the Southern Interior. Forest Research Review 1968, B.C. Forest Service, Victoria, B.C.

Marshall, J.R., 1969. Personal communication, Project Supervisor, A.R.D.A. Agroclimatology, B.C. Department of Agriculture, Victoria, B.C.

Keser, N., 1968. E.P. 651, Geomorphic and Soil Studies as Related to Douglas-fir Growth in Sayward Forest, Forest Research Review, 1968, B.C. Forest Service, Victoria, B.C.

Krewaz, J., 1958. A Standard for Spot Seeding. Forestry Chronicle, Vol. 34, No. 4, p. 380-381.

Schubert, G.H. and H.A. Fowells, 1964. Sowing Rates for Reforestation by the Seed-Spotting Method. U.S. Dept. of Agriculture - Forest Service. Southwest Forest & Range Experiment Station Research Note No. 44.

APPENDIX I

Table 1. Description of the Trials.

Experimental Project No.	Location	Elevation (ft.)	Year Fall Sown	Seeding Method	Species	Sowing Rate (seeds per spot or acre)	Factor Compared
606	Adams Plateau	4,600	1962	Spot	Douglas-fir	10	
					Spruce	10	
				Broadcast	Douglas-fir	1 lb.	Seedbed
					Spruce	1 lb.	Method
			1963	Spot	Spruce	10	
				Broadcast	Spruce	1 lb.	Year
			1964	Spot	Spruce	10 +	
				Broadcast	Spruce	1 lb.	
632	Eagle Bay	2,000	1964	Spot	Western Hemlock	7-10	Seedbed
	Larch Hills	4,000			Western Red Cedar	7-10	
	Mara Meadows	2,200			Douglas-fir	7-10	Seed Treatment
							Seed covering
			1965		Western White pine	7-10	Year
					Engelmann spruce	7-10	
					Western larch[1]	7-10	Locality
			1966			7-10	
						7-10	
						7-10	

[1] Western larch was not sown at Eagle Bay and Mara Meadows during 1964 and 1965.

Table 2. Germination and Survival by Site Preparation Treatment[1]

			Per cent of Spots with one or more Germinants			Survivors		
Trial	Species	Seed Treatment	Prepared Covered	No Covering	No Preparation	Prepared Covered	No Covering	No Preparation
I	Douglas-fir	Treated	71.0	13.5	7.0	43.5	6.5	3.0
	Spruce	Treated	75.7	77.3	32.9	46.5	49.2	11.2
II	Douglas-fir	Treated	70.0	48.7	24.4	46.0	30.2	12.0
		Untreated	54.4	38.2	15.6	32.9	19.3	6.9
	Spruce	Treated	84.4	79.8	30.5	25.3	27.8	7.6
		Untreated	77.3	72.0	21.8	24.0	22.4	3.8
	White pine	Treated	71.0	42.3	19.1	48.8	29.8	13.8
		Untreated	55.8	27.5	10.9	38.2	17.8	7.8
	Hemlock	Treated	60.4	61.3	13.6	8.2	8.7	1.5
		Untreated	59.7	61.0	8.4	5.3	5.6	1.5
	Cedar	Treated	82.6	82.2	20.2	23.4	25.1	7.1
		Untreated	81.4	83.7	14.5	23.9	25.7	4.7
	Larch	Treated	64.0	60.2	24.4	18.2	17.8	2.5
		Untreated	65.0	40.0	15.0	20.5	15.5	3.0

(1) Basis: 200 spots for each site preparation treatment for each year of sowing in trial I.

450 spots for each seed treatment for each site preparation treatment for each species for each of three years of sowing in trial II.

Table 3A. Germination and First-Year Survival of Spruce by Protective Treatment, Trial I.

Treatment	Protection	No. of Spots	Per cent with one or more Germinants	Survivors
Soil Covering	Covered	541	74.9	56.3
	Uncovered	539	77.0	63.4
Screening	Screened	180	69.8	62.0
	Unscreened	1,819	60.9	47.5
Screening and Soil Covering	Screened, Covered	59	82.8	72.4
	Screened, Uncovered	61	80.3	73.8

Table 3B. Germination and First-Year Survival of All Species by Protective Treatment, Trial II.

Treatment	Protection	No. of Spots	Per cent with one or more Germinants		Survivors	
			Treated	Untreated	Treated	Untreated
Soil Covering	Covered	150	66.7	60.6	35.3	34.6
	Uncovered	300	35.7	26.0	20.0	17.0
Screening	Screened	450	60.9	56.7	42.2	39.1
	Unscreened	450	46.0	38.7	25.1	22.9
Screening and Soil Covering	Screened, Covered	150	82.0	78.7	60.0	52.0
	Screened, Uncovered	300	50.3	45.7	33.3	32.3

Table 4. Germination and Survival by Years of Sowing (All Site Preparation and Seed Treatments).

Trial No.	Years of Sowing	Per cent of Spots with one or more Germinants	Survivors
I[1]	1962	63.0	35.8
	1963	63.1	37.4
	1964	61.0	33.3
II[2]	1964	39.9 (46.9)[3]	19.4 (18.8)
	1965	52.7 (67.4)	23.1 (27.4)
	1966	53.6 (62.9)	12.0 (12.7)

1 Basis: 600 spots per year for spruce only.

2 Basis: 900 spots per year for each species on all areas, larch excluded.

3 Figures in brackets for spruce only.

Table 5. Relationship Between Physiographic Site and Stocking.

Physiographic Site	Trial I (Spruce) No. of Spots	Per cent with one or more Germinants	Survivors	Trial II (All Species) No. of Spots	Per cent with one or more Germinants	Survivors
Moist-Wet	115	66.1	31.3	211(37)[1]	49.8(75.7)	19.9(24.3)
Fresh	1,004	62.9	41.1	3,537(638)	53.4(73.0)	25.4(30.7)
Dry-Arid	680	60.9	27.6	11,064(2,024)	45.2(56.0)	15.1(14.4)

1 Figures in brackets are for Spruce.

Table 6. Multiple Seedling Spots in Spot Sowing
(All Years of Sowing Combined)

No. of Seedlings per Spot	Spruce (Trial I)		Spruce (Trial II)		Douglas Fir (Trial II)	
	Number of Spots with					
	Germinants	Survivors	Germinants	Survivors	Germinants	Survivors
0	143	339	74	354	136	251
1	65	52	57	38	49	71
2	34	28	65	26	53	58
3	34	32	55	11	49	34
4	28	13	44	10	51	13
5	26	18	45	4	37	10
6	22	17	30	1	27	4
7	16	16	26	2	19	3
8	31	17	11	1	14	3
9	21	14	14	0	5	2
10	17	6	7	1	4	1
11	24	7	6	0	2	0
12	21	8	3	1	4	0
13	12	4	2	0		
14	21	3	1	0		
15+	85	26	10	1		
Total	600	600	450	450	450	450

Table 7. Relationship Between Years of Sowing and Stocking.
Trial I

Year of Sowing	Sowing Method	Per Cent of Spots or Area with one or more Germinants	Survivors
1962	Spot	63.0	35.8
	Broadcast	56.7	45.0
1963	Spot	63.1	37.4
	Broadcast	83.3	55.0
1964	Spot	61.0	33.3
	Broadcast	48.3	26.7
Average 1962-4	Spot	62.4	35.5
	Broadcast	62.8	42.5

Table 8. Stocking by Physiographic Site, Broadcast Seeding

Physiographic Site	No. of Plots	Per Cent with one or more Germinants	Survivors
Moist-Wet	32	59.3	43.8
Fresh	186	67.7	46.8
Dry-Arid	142	57.0	35.2

Table 9. Relationship Between Seedbed and Stocking, Broadcast Seeding

Seedbed	No. of Plots	Per Cent with one or more Germinants	Survivors
Mineral	60	66.7	51.7
Mixture	142	66.2	45.1
Burned Mineral	43	51.2	30.2
Burned Duff	95	58.9	45.2
Unburned Duff	10	20.0	0.0
Other (Moss, Rotted Wood)	10	90.0	70.0

APPENDIX II

Table 1. Distribution of Precipitation and Extremes of Temperature from May through September, 1963-65. Average for Sub-Alpine Seeding Area

Month	1963 Precipitation (inches)	1963 Absolute Temp. °F Max.	1963 Absolute Temp. °F Min.	1964 Precipitation (inches)	1964 Absolute Temp. °F Max.	1964 Absolute Temp. °F Min.	1965 Precipitation (inches)	1965 Absolute Temp. °F Max.	1965 Absolute Temp. °F Min.
May	0.39	82	24	1.11	74	28	1.04	79	23
June	1.57	88	35	2.88	79	34	0.52	83	34
July	1.52	85	38	2.36	90	40	1.72	90	41
August	2.01	92	44	2.71	78	38	3.05	94	38
September	1.56	85	33	2.95	67	28	0.76	71	25

Table 2. Distribution of Precipitation and Extremes of Temperature from May through September, 1965-68. Average for Areas in Wet-Belt Seeding Areas

Month	1965 Precipitation (inches)	1965 Absolute Temp. °F Max.	1965 Absolute Temp. °F Min.	1966 Precipitation (inches)	1966 Absolute Temp. °F Max.	1966 Absolute Temp. °F Min.	1967 Precipitation (inches)	1967 Absolute Temp. °F Max.	1967 Absolute Temp. °F Min.
May	0.86	72	28	1.73	79	29	1.06	76	28
June	1.56	82	33	3.15	81	34	1.27	88	35
July	2.04	89	42	3.51	82	41	1.00	89	40
August	4.82	82	32	1.74	88	35	0.65(1)	95	41
September	1.21	64	27	1.37	82	33	1.10	90	35

(1) All precipitation during the first week of August, no further precipitation until second week in September.