ESTABLISHMENT AND EARLY DEVELOPMENT OF WHITE SPRUCE IN THE INTERIOR OF BRITISH COLUMBIA

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RESUME

En Colombie Britannique centrale, l'auteur étudie le degré de survivance et le taux de croissance de semis et de gaulis d'Epinette blanche (Picea glauca) *dans deux champs de culture et trois stations écologiques diversement éclairées. La germination optimale a lieu dans un endroit ombreux, en sol purement minéral, humide ou détrempé; le meilleur degré de survivance en sol minéral, station "sèche", partiellement à l'ombre; la meilleure croissance elle aussi en sol minéral, mais terrain humide et nullement ombragé.*

ABSTRACT

Survival and growth of white spruce seedlings and juvenile trees were compared on two seedbeds, three forest sites, and a range of light conditions in the central interior of British Columbia. For germination, the most favourable seedbed was mineral soil in shade on moist and wet sites; for survival, mineral soil, dry habitats, partial shade; for growth, mineral soil, moist habitats, full light exposure.

INTRODUCTION

Spruce forests in the interior of British Columbia cover approximately 13 million acres of productive forest land and supply annually 260 million cubic feet of timber (B.C. Dept. Lands and Forests, 1957). These forests are extremely difficult to regenerate. Generally, exposed mineral soil is considered to be necessary for the successful establishment of spruce regeneration from seed; consequently, scarification is becoming an established practice.

Smith and Clark (1960) reported that of 100 viable seeds sown in the spring of 1953 on scarified seedbeds, an average of 4.7 seedlings had survived on dry sites and 2.6 on moist sites to the fall of 1959. Survival on litter on all sites averaged 0.9 percent. The authors attributed the greatest seedling mortality to competition from lesser vegetation. The best growth occurred on mineral and burnt soil surfaces in full light. Prochnau (1963) found that 4 years after sowing, surviving seedlings corresponded to 14 percent of viable seed sown on mineral soil in 1953 and 30 percent of seed sown in 1954. Both studies provide information on survival of spruce seedlings and their total height at the end of the experiments, but data on annual mortality and height growth beyond the first few years, do not seem to exist in the literature.

METHODS

In the spring of 1962, an experiment was established in the central interior of British Columbia to determine (a) the mortality of white spruce seedlings

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in different habitats, (b) the age at which seedlings may be considered established, (c) the rate of growth of juvenile white spruce, and (d) the age when seedlings reach stump height and breast height. The experiment included 60 plots on mineral soil and 15 on undisturbed litter, distributed in three forest sites — Alluvium, Aralia-Dryopteris, and Cornus-Moss (Illingworth and Arlidge, 1960). Each plot on mineral soil was seeded with 100 seeds, that on litter with 2,000 seeds; seed germinative capacity was 70 percent. At the end of each growing season all surviving seedlings were counted and measured and the three tallest seedlings on each plot marked. In addition, approximately 750 young trees 1 to 8 feet high were dissected and analyzed for annual height increments. These were open-grown, healthy individuals, each apparently the best trees on an area of approximately 20 x 20 feet.

Results

A previous report (Eis, 1965) described the area, climate, soils and vegetation as well as the establishment of the experiment; it summarized the first year's growth and survival.

The present study generally confirms the results of previous studies on spruce regeneration in the interior of British Columbia (Smith and Clark, 1960; Prochnau, 1963). Germination on mineral soil averaged 43 percent of viable seed sown, whereas that on litter was less than 4 percent. Table 1 shows annual seedling mortality by forest sites in percents of the seedlings present at the end of the previous growing season. Seedling mortality in all years except the first was greater in moist habitats of Alluvium (lowland) and Aralia-Dryopteris (lateral seepage), both on mineral soil and litter, than it was in dry habitats of Cornus-Moss. Drought was the principal cause of mortality on all sites during the first growing season, because of the shallow root penetration of germinants (Eis, 1965); however, in moist habitats, frost heave and competition from ground vegetation became major causes in subsequent years. In dry habitats, after the first season, surviving seedlings appear to have a much better chance of living than those in moist and wet habitats. At the end of the fourth growing season 12 and 15 seedlings remained on mineral soil from 100 viable seeds on moist and dry habitats, respectively; in contrast, to produce one seedling on litter in dry habitats required 800 seeds and in moist habitats 1,000 seeds.

The data suggest that in dry habitats, both on mineral soil and litter, a 3-year-old seedling may be considered established (Table 1). In moist habitats

TABLE I

Annual Mortality of White Spruce Seedlings in percents of Previous Year's Survivals

Forest site	% of viable seed germinated		Annual Mortality (percents)							
			1st year		2nd year		3rd year		4th year	
	Min. soil	litter	Min. soil	litter	Min. soil	litter	Min. soil	litter	Min. soil	litter
Alluvium	47	5	34	99	39	46	27	33	12	20
Aralia-Dryopteris	49	4	30	92	36	34	18	24	9	18
Cornus-Moss	37	3	46	95	28	16	7	4	1	1

4-5 years may be necessary for establishment on mineral soil and possibly longer on litter.

At the end of the first growing season seedling height growth differed very little within or between plots. During the second year the heights of the three tallest seedlings on each plot were recorded separately. Usually the three seedlings retained their dominance in subsequent years. At the age of 4 years the average height of all living seedlings was 69 mm whereas, the average of the three best on each plot was 115 mm (Table 2).

TABLE 2
HEIGHT GROWTH OF WHITE SPRUCE — TOTAL HEIGHT MM

Forest Site	1st year		2nd year		3rd year		4th year	
	Average	Best	Average	Best	Average	Best	Average	Best
Alluvium								
Mineral soil	14		26	35	50	80*	82*	137*
Litter	14		22	36	44	72	70	117
Aralia-Dryopteris								
Mineral soil	15		24	35	43	75	71	120*
Litter	15		21	31	42	68	63	111
Cornus-Moss								
Mineral soil	15		26	29	43	64*	70*	109*
Litter	15		23	30	37	53	61	94

Not measured

* Significantly (5% level) better growth on mineral soil than on litter.

The rate of growth increased with increased light; seedlings on plots with 60 percent light were almost twice as high at 4 years as seedlings in shade (20 percent light). Raising the light intensity above 60 percent increased height growth of seedlings only slightly but gave better diameter growth (three best seedlings 3.4 mm against 2.6 mm), more branches (8 against 6), and greater oven-dry weight (6.5 g against 4.5 g). Height growth was generally better on mineral soil than on litter. However, because of large variations in height, the difference became significant only after three or four growing seasons.

The slow initial development of spruce appears to accelerate after a height of approximately 1 foot has been attained. Under favourable light, breast height is reached after about 13 years on Alluvium and 20 years on Cornus-Moss sites (Table 3). Natural regeneration of spruce under lodgepole pine or aspen was found to have been as much as 50 years old at the time its height had averaged 4.5 feet. It appears that environmental conditions under which spruce regeneration can persist must permit at least 1 inch of annual height increment with a corresponding expansion of the crown and leaf area.

The data in Table 3 correspond with the height growth of the best three seedlings in Table 2, rather than with the averages, suggesting that dominance is established early in life. Because it is from these trees that the mature forest probably will develop, data on the two or three tallest individuals in a group may provide more significant guides to stand development than would averages based on random selection.

TABLE 3

AVERAGE HEIGHT OF BEST OPEN-GROWN WHITE SPRUCE TREES FROM NATURAL REGENERATION

Years	Alluvium	Aralia-Dryopteris	Cornus-Moss
4	5.1″	4.6″	4.0″
6	11.6″	7.9″	5.6″
8	1′ 8″	1′ 1″	9.1″
10	2′ 9″	1′ 9″	1′ 2″
12	4′ 1″	2′ 6″	1′ 8″
14	5′ 6″	3′ 5″	2′ 3″
16	7′ 2″	4′ 4″	3′ 0″
18	8′10″	5′ 5″	3′ 9″
20	10′ 7″	6′ 6″	4′ 8″
22		7′ 8″	5′ 9″

CONCLUSION

The present study stresses the superiority of mineral seedbed for regeneration of white spruce by seeding. Depending on the habitat, 7-9 viable seeds produced 1 established seedling on mineral soil, but about 1,000 seeds were necessary on litter. In dry habitats a 3-year-old seedling may be considered established; in wet habitats the competition from ground vegetation keeps the mortality high for several more years. It appears that on mineral soil, regeneration of white spruce by direct seeding is feasible and that scarification is advisable wherever direct seeding is to be the practice.

Dominance is established early in white spruce regeneration but early growth is slow. Depending on the habitat, it takes 13-20 years for the dominant trees to reach breast height.

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