# White Spruce Seed Dispersal in Central British Columbia


**R. C. Dobbs**

Department of the Environment,
Canadian Forestry Service,
Pacific Forest Research Centre,
Victoria, B.C.



### Abstract

Seed dispersal of white spruce (*Picea glauca*) (Moench) Voss) from stands bordering a large clearcut and a strip cut was studied. Seedfall fell sharply with distance from the clearcut edge to 100 m, but even at 300 m the average dispersed seed density exceeded 740 000 seeds/ha or 3% of that recorded within the stand. Dispersed seed density in the middle of the 200-metre-wide strip cut exceeded 1 300 000 seeds/ha or 20% of that recorded within the bordering stands. About one-third of the seeds was disseminated by the end of September.



### Résumé

L'auteur étudia la dispersion des graines d'Epinette blanche *(Picea glauca)* (Moench) Voss) depuis des peuplements limitrophes d'une grande coupe à blanc et d'une coupe par bandes. Le nombre de graines qui atteignirent le sol déclina fortement à mesure que la distance de la limite du peuplement debout augmentait jusqu'à 100 m dans le terrain coupé à blanc, mais même à 300 m, la densité excédait 740 000 graines/ha ou 3% de celle notée dans le peuplement debout. Au milieu de la bande (coupée) large de 200 m, la densité des graines tombées au sol dépassait 1 300 000 graines/ha ou 20% de celle notée dans les peuplements debout adjacents. Vers la fin de septembre, environ ⅓ des graines avaient été libérées des cônes.


## Introduction

An important limitation on the natural regeneration of clearcut areas is the distance which dispersed seeds travel. Informed decisions regarding clearcut size, seedbed preparation, and whether or not to regenerate artificially depend on having a good measure of this limitation. Current reviews (Jarvis *et al,* 1966; Zasada and Gregory 1969; Dobbs 1972) cite Rowe's (1955) figure of 330 ft (101 m) as the greatest dispersal distance of white spruce *(Picea glauca* (Moench) Voss) seeds which has been accurately measured in the field, although Rowe suggested, as have others (Show 1913; cited by Gordon 1970). that late-falling seeds may be blown for a considerable distance over a snow crust.

This study, carried out in central British Columbia, is concerned with the time and distance of white spruce seed dispersal into 1) a large clearcut and 2) a strip clearcut bordered on either side by mature spruce stands.

## Study Areas

A 400 ha clearcut and a 200-metre-wide strip clearcut oriented in a northwest-southeast direction (hereafter "strip cut") were selected for the study. The areas were located 48 and 80 km east of Prince George, respectively, near latitude 54° N. Both were in the Montane Transition Section (M.4) (Rowe 1972). The stands bordering both areas were mixed white spruce and subalpine fir *(Abies lasiocarpa* (Hook.) Nutt.). At the edge of the clearcut were 205 spruce trees per hectare (basal area, 24 $m^2$/ha); the stands bordering the strip cut contained an average of 77 spruce trees per hectare (basal area, 17 $m^2$/ha). Overstorey spruce were around 200 years old and ranged in height from 30 to 38 m in both areas. The cone crop in both areas was rated as medium to heavy, based on the California rating system (Schubert and Baron 1960).

## Methods

Seed dispersal data were obtained from transects of seed traps extending from within the bordering stands into the cut areas. On the south side of the clearcut, three parallel transects extended from 20 m inside the stand into the cut area to a distance of 300 m; the nearest other stand edge (west side) was 700 m. Traps were located along each transect at distances of −20, 0, 10, 30, 60, 100, 120, 140 . . . 300 m from the stand edge. In the strip cut, four parallel transects extended across the strip and 10 m into the stands on either side. Traps were located at 10 m intervals along each transect. Distance between transects was 60 m in both areas. Seed traps were simple square frames with fly screen bottoms and hardware cloth lids (1/4-inch mesh). The trap area was 0.4 $m^2$.

The traps were set out in early August, 1970, before seed dissemination. Contents were collected at the end of August, September and October, 1970 and May, 1971. Following sorting and counting, a cutting test was performed on seeds collected from the clearcut. For this test, seeds were grouped by collection time and dispersal distance. Dispersal distances for this purpose were 0-100 m, 120-200 m and 220-300 m.

A regeneration survey was conducted in August, 1971 on the strip cut which had been scarified prior to seed dispersal. Seedlings were counted within 110 quadrats located on scarified seedbeds at 20 m intervals across the strip cut. The quadrat area was 1.0 $m^2$.

## Results

### Time of dissemination

Significant quantities of seed fell in September and continued into November in both areas. In the clearcut, 5, 40 and 70% of seed had fallen by the end of August, September and October, respectively. In the strip cut, 32 km to the east, 4 and 27% of seed had fallen by the end of August and September. (Freezing weather prevented the October collection in the strip cut.)

### Dispersal in the clearcut

Total amount of seed trapped in the clearcut during the study period declined rapidly with distance from the stand (Fig. 1; Table 1). The data were found to fit the quadratic equation:

$\log_e$ (seeds/ha) $= 16.671 - 0.0208D + 0.00004D^2$

where D = distance (in metres) from the stand edge; $r^2$ was 0.973.

Twenty per cent of the winter-dispersed seeds were trapped beyond 100 m, while only 13% of the seeds travelled this distance in the fall months; 9% of winter seeds were trapped beyond 200 m compared to only 5% of fall seeds.

### Dispersal in the strip cut

A U-shaped distribution of total dispersed seed was registered across the strip cut (Fig. 2). The rate of seedfall within the bordering stands exceeded 6.6 million seeds/ha. Near the middle of the strip, seedfall was 1 300 000 seeds/ha, or about 20% of the levels within the stands.

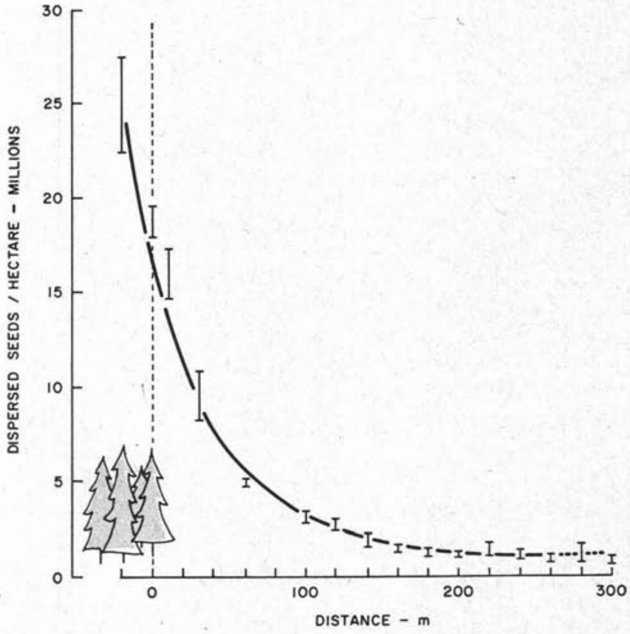


**Figure 1.** Seed dispersal regression curve for the clearcut area. Vertical line segments represent ranges of sample data.

**Table 1. Dispersal of seeds into the clearcut by collection period as indicated by seed trapping data**

| Distance from edge of stand (metres) | Seeds (in thousands)/ha | | | | | |
|---|---|---|---|---|---|---|
| | Aug. | Sept. | Oct. | Fall (Aug. thru Oct.) | Winter (Nov. thru June) | Totals (Aug. thru June) |
| −20 | 1 285 | 8 451 | 9 447 | 19 183 | 6 284 | 25 467 |
| edge | 783 | 6 234 | 5 641 | 12 658 | 6 160 | 18 818 |
| 10 | 684 | 5 476 | 5 206 | 11 376 | 4 489 | 15 865 |
| 30 | 478 | 3 410 | 2 916 | 6 804 | 2 372 | 9 176 |
| 60 | 279 | 1 846 | 1 253 | 3 378 | 1 490 | 4 868 |
| 100 | 156 | 1 112 | 798 | 2 066 | 1 045 | 3 111 |
| 120 | 124 | 1 013 | 576 | 1 713 | 496 | 2 659 |
| 140 | 91 | 660 | 477 | 228 | 642 | 1 870 |
| 160 | 32 | 593 | 124 | 749 | 618 | 1 367 |
| 180 | 74 | 544 | 205 | 823 | 462 | 1 285 |
| 200 | 49 | 487 | 205 | 741 | 346 | 1 087 |
| 220 | 67 | 452 | 264 | 783 | 587 | 1 370 |
| 240 | 42 | 272 | 297 | 611 | 544 | 1 155 |
| 260 | 25 | 371 | 166 | 562 | 329 | 891 |
| 280 | 25 | 321 | 180 | 526 | 635 | 1 161 |
| 300 | 32 | 272 | 67 | 371 | 378 | 749 |
| % | 5 | 35 | 30 | 70 | 30 | 100 |

A similar distribution of natural seedlings prevailed at the end of the first growing season following seed dissemination (Fig. 2). Seedling density on scarified seedbeds fell steadily from 292 000/ha at the southwest edge of the strip cut to 25 000/ha at the center of the strip, then increased toward the northeast edge to a density of 126 000/ha.

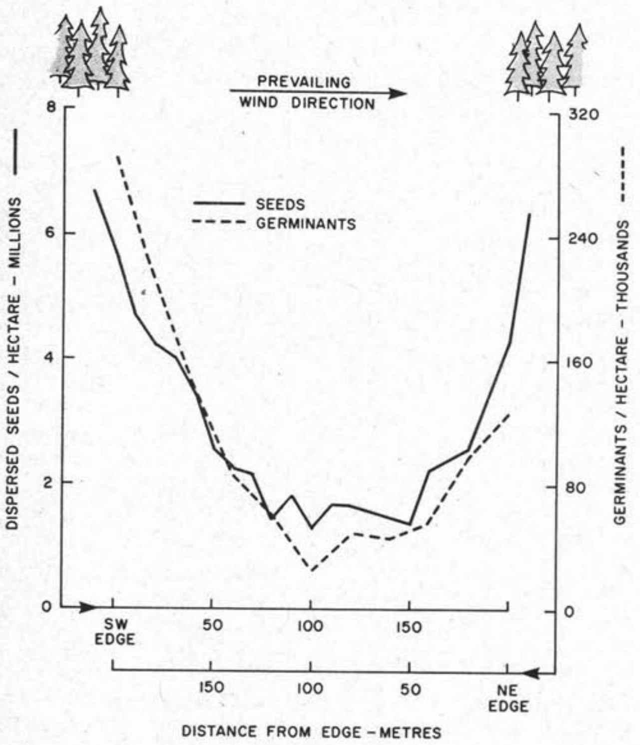


**Figure 2.** Distribution of dispersed seeds and germinants across the strip cut.

### Seed quality

Forty per cent of the seeds collected from the clearcut area were judged sound on the basis of cutting tests (Table 2). Empty seeds constituted 21% of those tested and the remaining 39% had watery or discolored contents. An average of 23% of the August collection was sound; seed collected in September, October and June were 55%, 32% and 31% sound, respectively. The greatest percentages of sound seed and the lowest percentages of empty seed were collected within 100 m of the stand edge.

## Discussion

The dissemination period for the 1970 white spruce seed crop in the study areas was more protracted than one would expect. At Verdun Mountain, in British Columbia's Prince Rupert Forest District, 85% to 90% of the total 1968 seedfall occurred between August 20 and October 15, with the peak in mid-September (Armit 1969). Very little over-winter seedfall was recorded. Crossley (1955) reported that during a good year in the Subalpine Region of Alberta, about 88% of spruce seeds fell in the first month of dispersal, although seeds continued to fall during the winter and spring. In this study, as much as a third of the seeds remained in cones at the end of October. Undoubtedly, weather conditions are the important determinants of the temporal distribution of seedfall.

Seed quality varied according to time of dissemination; the lowest quality seeds fell in August (23% sound) and the best quality fell in September (55% sound); seeds of intermediate quality fell thereafter (33% sound). This is in accord with conditions observed in Riding Mountain, Manitoba (Jarvis *et al.* 1966) which were attributed to the fact that seeds falling during peak dissemination time tended to come from well-developed central cone scales, while more of those falling earlier and later come from less-developed basal and apical scales.

The dispersal data conform to the generally observed pattern for conifer seed dispersal, whereby total seedfall decreases precipitously from within the stand to the stand edge and beyond into the clearcut (Alexander 1969; Gordon 1970; Roe 1967; Roy 1960, and others). The data were found to best fit a quadratic model (*i.e.,* $\log Y = a + bX + cX^2$), whereby the regression *rate* decreases with distance from the stand with the result that modest seedfall densities extended well into the clearcut. This is in contrast to the regression model presented by Roe (1967) for Engelmann spruce of the form $\log Y = a + bX$. The initially rapid decrease, followed by a gradual "tailing-off" for a considerable distance, suggests that significant quantities of seed were released in high winds.

A greater proportion (48% compared to 31%) of sound seed fell within 100 m of the stand edge. While this is partly due to the tendency for light, empty seed to be carried farther, it also reflects

**Table 2. Percentages of sound and empty seed according to collection period and distance from edge of the stand (clearcut area only)**

| Distance from edge of stand (metres) | August Sound % | August Empty % | August Basis | September Sound % | September Empty % | September Basis | October Sound % | October Empty % | October Basis | Winter Sound % | Winter Empty % | Winter Basis | Averages Sound % | Averages Empty % | Averages Basis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-100 | 27 | 35 | (200) | 63 | 12 | (600) | 40 | 21 | (122) | 37 | 17 | (196) | 48 | 18 | (1118) |
| 120-200 | 13 | 36 | (45) | 44 | 22 | (200) | 25 | 24 | (190) | 26 | 20 | (191) | 31 | 23 | (626) |
| 220-300 | 4 | 35 | (23) | 40 | 29 | (150) | 28 | 23 | (116) | 31 | 24 | (195) | 32 | 26 | (484) |
| Averages | 23 | 25 | (268) | 55 | 17 | (950) | 32 | 22 | (428) | 31 | 20 | (582) | 40 | 21 | (2228) |

greater dispersal of unsound but filled seeds *(i.e.,* seeds with watery or discolored contents). Why unsound, but filled seeds would be blown further than sound seeds is not clear.

Although the higher proportion of winter-dispersed seeds trapped beyond 100 m is consistent with the hypothesis that dispersal may be enhanced by seeds blowing across the surface of a snowpack, this evidence is indirect and does not provide significant support.

Seeds and germinants were distributed across the strip cut in a U-shaped pattern skewed to the prevailing windward side. The distribution of germinants indicates a higher success rate on the southwest (windward) side than in the center or on the northeast side of the strip. Seed: germinant ratio was 21:1 on the southwest side and 33:1 in the center and on the northeast side. The higher success rate on the southwest side of the stand is probably due to the afternoon shade afforded by the stand.

Interpretation of seed dispersal regressions for forest management purposes requires that the number of seeds adequate for natural regeneration be defined. In this study, an average of 26 seeds were required for each germinant surviving to the end of the first growing season on blade scarified seedbeds in the strip cut. If we apply this seed: germinant ratio to the study areas (notwithstanding the fact that the clearcut was not scarified), together with a theoretical full stocking minimum of 7400 germinants/ha[1], full stocking would require about 192 000 seeds/ha. Dispersed seed density greatly exceeded this amount across the strip cut and, in the clearcut, to at least 300 m from the stand edge. Theoretical computations based on these results indicate that square clearcuts of at least 36 ha will be satisfactorily restocked by seed dispersed from surrounding white spruce stands bearing a medium to heavy cone crop, provided that dispersal is preceded by adequate seedbed preparation. For rectangular clearcuts; this minimum area increases directly with length-width ratio. Even in much larger clearcuts, natural regeneration of a perimeter 300 m in width would substantially reduce overall reforestation costs.

This study confirms the oft-reported precipitous decrease in conifer seedfall with distance from the source, but it suggests much more effective dispersal of white spruce seeds than reported heretofore. Potentially adequate quantities of seed for natural regeneration were recorded 300 m into a clearcut, three times the distance that Rowe (1955) asserted to be the maximum dispersal distance for white spruce seed that had been accurately measured in the field.

[1]Based on B.C. Forest Service standards for full stocking which require a theoretical minimum of 1000 seedlings per acre with 3 germinants regarded as equivalent to one established seedling.

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