# Provenance Variability in Nursery Growth of Subalpine Fir

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**Abstract:** Subalpine fir (*Abies lasiocarpa* [Hook] Nutt.) is a wide-ranging, high-elevation species in the interior of British Columbia. It is commonly harvested for lumber, but replanting of it is limited. Some reticence is based upon wood quality and rate of growth, but there are also seed and nursery culturing difficulties. This study investigated seedling growth traits of 111 provenances grown in four nurseries. Considerable variation in growth potential was found. The strength of nursery effects and correlations of nursery height to height growth at 5 years in the field are reported. Recommendations for use of genotypes more amenable to nursery culture are presented.

**Keywords:** subalpine fir, provenance effects, nursery culture

## Introduction

Subalpine fir (*Abies lasiocarpa* [Hook] Nutt.) is a common lumber species for the interior region of British Columbia. It is found at higher elevations in the south, but the population increases at lower elevations in more northerly latitudes. It is very cold hardy and both shade and drought tolerant. Subalpine fir accounts for roughly 6% of products billed in the interior but only 1% of seedlings planted (BCMFR 2007). Part of the reason for this is the fact that wood properties of the species are considered less desirable than the congenial Englemann spruce (*Picea engelmanni* [Parry] Engelm.) and lodgepole pine (*Pinus contorta* var. *longifolia* [Dougl.] Loud.). In addition, subalpine fir is not as amenable to nursery culture as other species, with lower harvest observed on seedlings grown in Styroblock™ 410A containers (80 $cm^3$ [4.9 $in^3$]) at 7 cm (2.8 in) (BCMFR 2010).

In recent years, much of the lodgepole pine in the southern two thirds of the province below 1500 m (4920 ft) elevation has been decimated by mountain pine beetle. This event will mean the Interior cut is likely to move north and higher in elevation in search of green logs, resulting in more subalpine fir being harvested. At the same time, ecologists are recommending greater species richness in forests in order to produce more resilient stands (Campbell and others 2009). Both of these factors are likely to result in greater numbers of subalpine fir being planted; that will only exacerbate the nursery culturing problems with this species.

The nature of subalpine fir seed present several characteristics that make it difficult to harvest and process for nursery culture (Koletelo 1997). First, since *Abies* spp. cones are dehiscent, collectors tend to collect early so that cones do not disintegrate during operations. This often leads to seedlots where much of the seeds are immature, resulting in lower or abnormal germination and more variable germination speed. Second, seeds are prone to mechanical damage due to a thin seed coat with presence of resin vesicules. Third, dead filled seeds, where there is no embryo but a center containing dark material of similar density, are common. Even sound seeds are problematic because most are locked in deep dormancy, and some are contaminated with *Caloscypha fulgens* or *Fusarium* spp.

Koletelo (1997) described how thorough cone and seed processing can alleviate some of the problems. Cones are dried in a manner mimicking natural conditions, and care is taken to screen out impurities that might damage the seeds in the de-winging process. The removal of wings is done gently at lowered temperature and moisture contents that render the wings brittle and easily broken off. Non-viable seeds and fine debris are removed by cleaning with an air separator or gravity table, and may be upgraded by further density separation processing. Long (90-day) stratifications with an initial high moisture content (45%) phase, followed by a drying and lower moisture content (35%) phase, all at relatively high temperatures (22 to 28 °C [72 to 82 °F]), are effective in breaking deep dormancy. With the above thorough and time-consuming procedures, the species can average 70% germination; although, that is still low relative to the other species with which it is planted.

Nursery concerns for subalpine fir also abound. These include poor cavity fill due to low germination capacity (van Steenis 1997) and variable germination speed (Knapp and Smith 1982). This leads to lack of canopy closure in the containers, resulting in open-grown seedlings that are slower in height growth. Another problem is that crop uniformity is compromised by the tendency of the species to stall. Individual plants are prone to switch between leaf and bud scale initiation throughout the growing season, independent of the physiological state of adjacent seedlings. Though this may represent a preferred strategy in the harsh climates from which subalpine fir originates, it adds difficulties in greenhouse operation. A related problem is that there may be premature terminal budset in the season and problems with failed terminal budburst if a crop is held over as 2+0; holding over of subalpine fir is commonly done for summer planting or where lower cull was not achieved in the first growing season.

Van Steenis (1997) recommended earlier sowing dates and higher density stocktypes in order to achieve canopy closure. He states that this is vital because of its ameliorating effect buffering the extremes that may occur in the larger greenhouse environment. To try to balance growth and differentiation, stalls can be minimized by manipulations of the growing environment, including partial shade, daylight extension, higher temperatures, slightly positive differential between day and night temperature, and passive versus active venting. Many of these factors help to avoid vapour pressure deficit. Higher fertilization levels may be used to help push plants through the stall phases when they do occur.

The practices just described have been known for over a decade, but problems still persist. Growers have found much variability in the growth performance of different subalpine fir seedlots. Some seedlots grow almost as easily as spruce (*Picea* spp.), while others are plagued with the numerous problems described above. Because of these concerns, it is important to establish some baseline knowledge about nursery effects on provenance growth. This study compares the growth of 111 seed sources, quantifying differences between them, between different nurseries growing them, and the subsequent effects on field growth.

## Methods

The provenance study encompassed 111 subalpine fir seed sources from Yukon Territory, British Columbia, Alberta, and from adjacent Sates of Washington and Idaho (Figure 1). The collections ranged in latitude from 48° 06' N to 60° 12' N, and in elevation from 200 to 1859 m (660 to 6100 ft). Three sources of corkbark fir (*Abies lasiocarpa* var. *arizonica* [Merriam] Lemmon) from within a degree of 34° N and from 2700 m (8860 ft) elevation in New Mexico were also included. The subalpine fir collection likely represents the largest provenance sampling for this species ever assembled.

Seedlots were sown at four British Columbia nurseries into standard Styroblock™ 410A containers (80 $cm^3$ [4.9 $in^3$]). All 111 provenances were sown at Woodmere Nursery in Telkwa BC; 104 provenances were sown at Sylvan Vale Nursery in Black Creek near Campbell River, BC; and 58 provenances were sown at both Skimikin Nursery (Tappen, BC) and Cowichan Lake Research Station (Mesachie Lake, BC). Each provenance was represented by 5 to 10 families or a bulked seedlot. Each of these appeared in each of four replications, except at Skimikin and Cowichan, where there were only two replications.

For each seedlot, the number of seeds sown per cavity was determined by germination tests prior to sowing. Lots were soaked, treated for fungi, and put into the long two- stage stratification as recommended by Koletelo (1997). Seedlings were cultured under the customary growing regimes for each facility, and heights were measured at the end of the first two growing seasons at each site. From this point, stock was lifted and randomized for farm field tests. Heights (5 years from sowing) were then measured at Prince George, Telkwa in the BC Interior, and at Black Creek on Vancouver Island.

## Results

Provenance effects were found to be significant at all nurseries for heights at 1 and 2 years, with the best provenances yielding heights twice that of the overall mean. Surprisingly, there was no overall trend in growth by latitude (Figure 2). The correlation for the 111 provenances appearing on the Woodmere site was not significant at either age. A few data points are, however, of note. Seedlings from all 5 provenances from north of 59° were below average in height; in contrast, the 3 corkbark fir provenances were average or greater in seedling height. These outlying populations are irrelevant to our consideration of nursery culture, and it was clear that the fastest growing sources arose from a broad range of latitudes; the fastest growing seedlings from ten provenances ranged in source latitude from 50° to 59° N.

Second-year nursery height was weakly correlated with seed source elevation (R = -0.26), indicating seedlings from lower elevations had a slight advantage in growth properties (Figure 3). Despite this, the ten fastest growing sources originated from between 300 and 1800 m (985 and 5900 ft). These best performers came from a climate with a mean annual temperature ranging from -1 to 6 °C (30 to 43 °F) and mean annual precipitation ranging from 600 to 1200 mm (24 to 47 in).

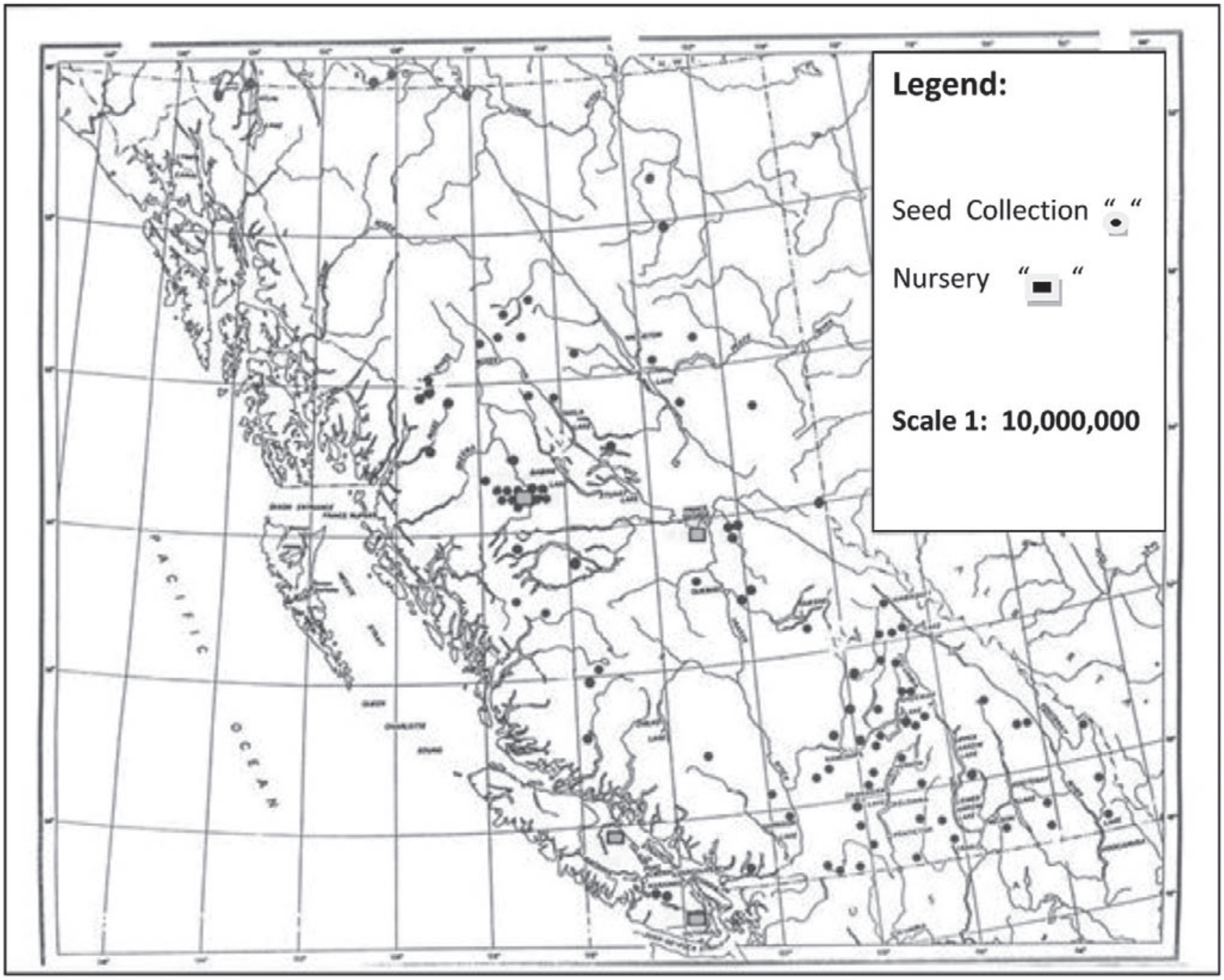


**Figure 1.** Seed collection sites for the subalpine fir provenances tested and the location of nurseries used in culturing trials.

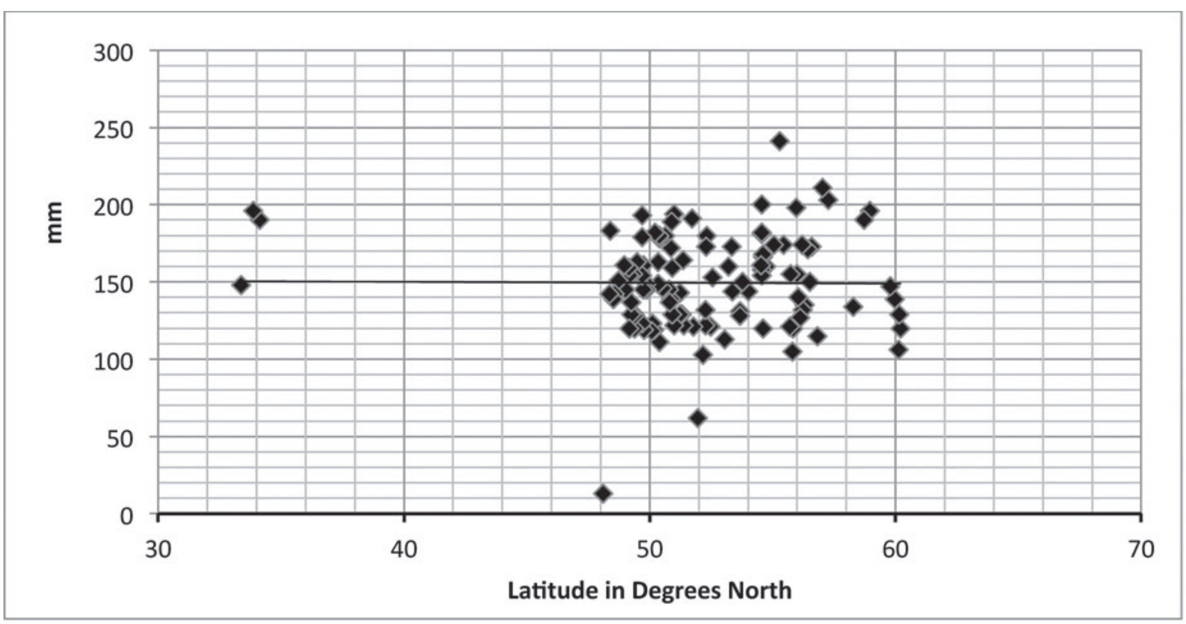


**Figure 2.** The relationship of seedling height and seed source latitude after 2 years growth at the Woodmere nursery (10 mm = 0.4 in).

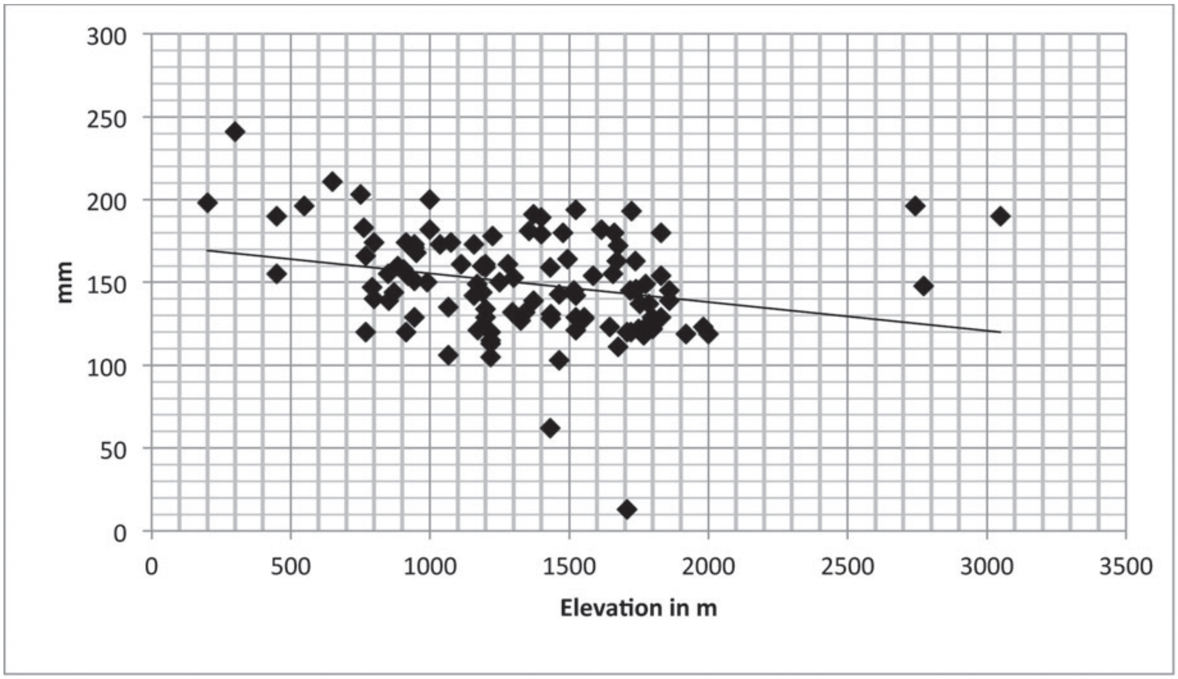


**Figure 3.** The relationship of seedling height and seed source elevation after 2 years growth at the Woodmere nursery (10 mm = 0.4 in; 500 m = 1640 ft).

Conservative growth could be found in the coldest environments north of 59° and likely at the highest elevations had they been sampled. Since the range of the species drops in elevation to the north, the effects of elevation and latitude are confounded. Although fast-growing families could be found in any region, growth performance was strongest between 55° N and 59° N in the west at elevations under 1000 m (3280 ft).

Two and 5 year outplanting height data were compared at the Telkwa farm field site; seedlings at this outplanting site were from the Woodmere nursery. The correlation for height after 2 years in the nursery to height at 5 years in the field was moderate (R=0.6) and positive (Figure 4).

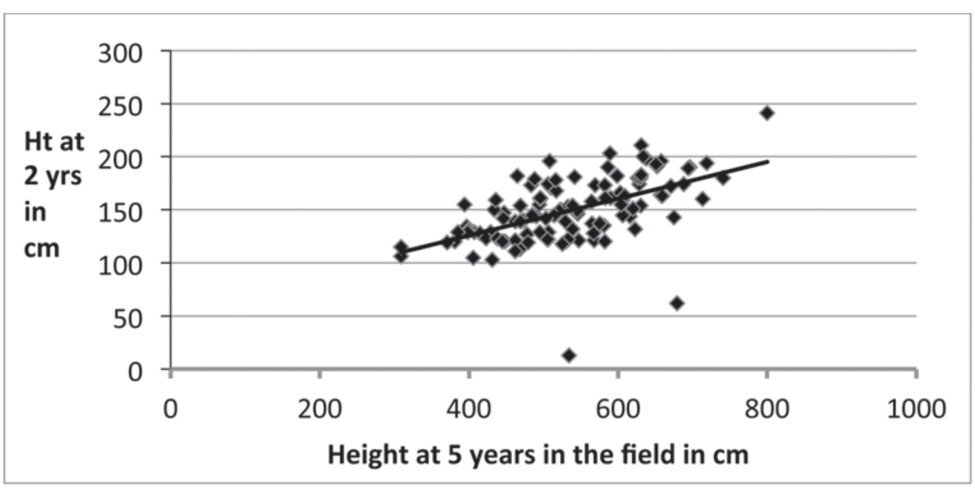


**Figure 4.** Correlation of nursery height at 2 years and height at 5 years in the field (1 cm = 0.4 in).

## Conclusions

Strong provenance level effects were found for nursery growth of subalpine fir. No correlations between nursery height at 1 or 2 years with latitude of seed source were observed, and only a weak but significant correlation to elevation of origin was detected. Since there was little influence of geographic factors on nursery growth, fast-growing provenances were found across the area sampled; finding acceptably adapted sources that meet seed transfer guidelines and grow well should not be problematic.

Whether the provenance will show a weak influence of geographic location of origin in long term field trials is still to be determined, but there were some indication that it may not. All three corkbark fir sources were average or above in nursery growth, but below average in the farm field tests at 5 years. In general, nursery and field performance were moderately positively correlated. Results among the nurseries were generally consistent, despite being in different growing regions; the best ranked seed sources performed well regardless of where they were grown. These materials might be made available if the superior sources in the wild can be selectively collected and seeds extracted for use. Eventually, parent trees could be collected in order to take advantage of better families within provenances.

Given strong provenance effects and wide variability in growth traits, faster growing wild stand seedlots could be selected to avoid some of the problems associated with nursery culture of subalpine fir. Field trials have been established with the same sources, and eventually genetic gains could be ascribed to the provenances with superior growth traits, further enhancing their value.

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