Geographic Variation in Fraser Fir

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Introduction

One early and important step in the genetic improvement of a species is developing an understanding of its natural patterns of variation. This variation arises largely from adaptation to varying climatic, topographic and soil conditions and often can be associated with specific environmental gradients. Since differences among geographic sources in forest tree species may be substantial, frequently the largest, cheapest and fastest genetic gains in a species can be made simply by using the most appropriate geographic source(s). Fortunately, past research has provided a good general understanding of natural variation in Fraser fir. The purpose of this article is to discuss this knowledge and its implications for the Christmas tree industry. (See the previous issue of Limbs & Needles (3) for a discussion of general aspects of geographic seed sources.)

1983 Geographic Variation Study

In a geographic variation study conducted by North Carolina State University, wind-pollinated seed were collected from each of 10 trees from nine Fraser fir seed sources (elevation class/population combinations) (1). In 1983, thirty seedlings from each of these 90 trees were then planted at three sites: Bald Mountain, Crossnore and Purchase Knob.

Figures 1 and 2 summarize the results by seed source for total height and individual tree wholesale value (1991 prices), respectively, after eight years from field planting. Height and wholesale differences among seed sources were statistically significant ($P \leq 0.05$). Richland's Balsam from 5500 ft. was tallest at 7.7 ft. while Mt. Mitchell from 6500 ft. and Clingman's Dome from 6000 ft. were shortest at 7.2 ft. Similarly, Richland's Balsam from 5500 ft. had the highest wholesale value at $18.06/tree while Mt. Mitchell from 6500 ft. and Clingman's Dome from 6000 ft. had the lowest wholesale value at $15.74/tree and $15.73/tree, respectively. Other characteristics such as crown diameter, density score and USDA grade showed similar trends (1).

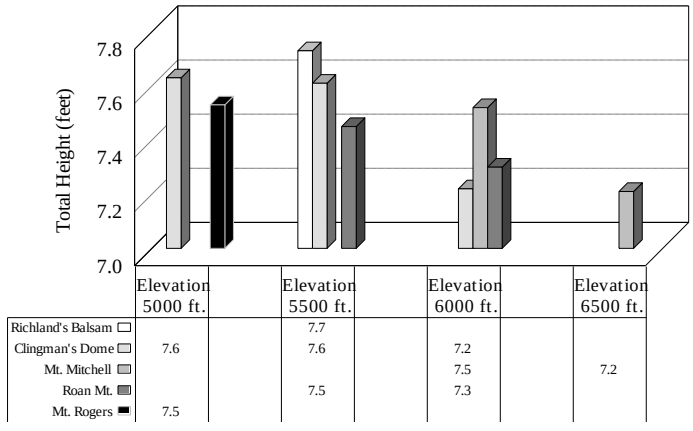

Figure 1. *Comparison of 8-year-old total height of nine Fraser fir seed sources averaged across three sites (1).*

Within a population, both height and wholesale value generally decreased with increasing elevation. These results are rational since the test sites and most commercial Christmas tree plantations are at elevations below the natural range of Fraser fir. Growers should use seed sources from lower elevations and, in particular, avoid using trees originating at or above 6000 ft. as seed sources. Mountain-top trees that have been transplanted or grafted to lower elevations will pass on to their seedling progeny the relatively slower growth adapted to higher elevations and should also be avoided as a seed source. Unfortunately, lower elevation populations of Fraser fir are usually sparse and logistically more difficult to locate than mountain-top trees.

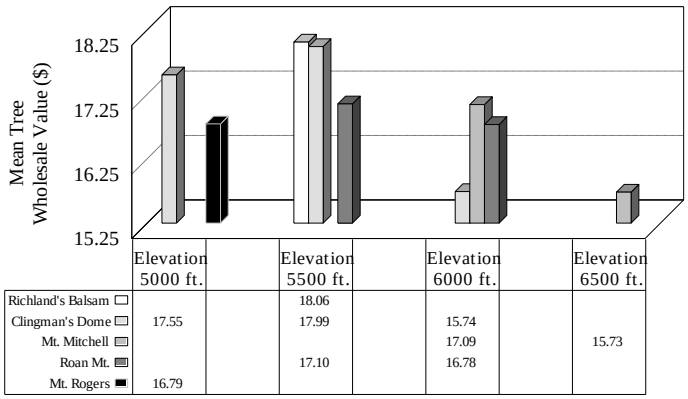

Figure 2. *Comparison of 8-year-old mean tree wholesale value (1991 prices) of nine Fraser fir seed sources averaged across three sites(1).*

Both height and wholesale value within an elevation class increased from northern to southern populations with one exception. While more comparisons are needed to be definitive, southern sources of Fraser fir, i.e., the Balsam and Great Smoky Mountains, appear to be more productive than northern sources.

These seed source differences render large potential income differences in Fraser fir Christmas tree production (Table 1). In this study, there was a potential difference of $2300 per acre between the best and worst seed sources. Further, there was a difference of $1120 per acre between the best seed source and Roan Mt., a widely used commercial source (1).

Prior to harvesting the trees at the three study sites, over 100 elite trees were selected and grafted into a clone bank in Macon County. These selections were from progeny of the best 18 of the original 90 trees included in the study. Select trees from the remaining 72 of the original 90 trees were also made and grafted into the clone bank for genetic

Table 1. *Potential wholesale value (1991 prices) at age 8 for an acre of Fraser fir Christmas trees established from three seed sources at two stocking levels (1).*

		Wholesale Value per Acre	
Population	**Elevation**	**800 Trees/Acre**	**1000 Trees/Acre**
Richland's Balsam	5500 ft.	$14,448	$18,060
Roan Mt.	5500 & 6000 ft. Average	$13,552	$16,940
Mt. Mitchell	6500 ft.	$12,584	$15,730

conservation purposes. The selections from the elite 18 trees will become part of the breeding population to further improve Fraser fir. With the decreasing availability of mature Fraser fir and increasing restrictions on collecting cones from natural stands, this material will also be invaluable as a source for establishment of improved Fraser fir seed orchards.

1994 Cone Collection

In 1994, taking advantage of an exceptionally productive cone year, NCSU conducted a range-wide Fraser fir cone collection (2). The seed resulting from this collection will be used for several purposes: 1) to establish additional Fraser fir progeny tests from which to select elite trees, 2) to further understand geographic variation patterns in Fraser fir and 3) to enhance Fraser fir genetic conservation efforts. During 1997, seedlings for additional Fraser fir progeny tests will be grown in the greenhouse. Since all seedlots collected cannot be tested, the present knowledge of geographic variation was used to select seedlots. Seedlots representing all six populations will be tested, but more seedlots will be tested from the Balsam and Great Smoky Mountains (Table 2). Within each source, those seedlots originating from the lowest elevations will be given preference. These seeds are currently in stratification and will be sown in the greenhouse during April. Progeny test establishment is anticipated to be late 1999.

Summary

Although the natural range for Fraser fir is rather limited, variation is sufficient to substantially impact Christmas tree production.. Based on current knowledge, lower elevation trees from southerly sources are recommended. Growers should use this information to obtain or produce planting stock with the highest expected productivity. NCSU has made and archived elite selections from the 1983 Geographic Variation Study. These selections will become part of the breeding population to further improve Fraser fir and will be invaluable as a source of material for improved seed orchard establishment. Seedling production for another series of Fraser fir progeny tests using seed from the

Table 2. *Fraser fir seedlots from 1994 Cone Collection being stratified for progeny testing. Contingency seedlots from each source have been included based on preliminary germination trials.*

	# Open-Pollinated Seedlots		
Source	**Available**	**Target**	**Stratified**
Grandfather Mountain	90	30	33
Mount Rogers	37	25	28
Mount Mitchell	128	25	28
Balsam Mountains	74	50	74
Roan Mountain	67	25	28
Smoky Mountains	133	50	60
Overall Total	***529***	***205***	***251***

1994 Cone Collection is underway.

Literature Cited

1) Arnold, R.J. and J.B. Jett. 1995. Seed source variation for growth and quality traits of Fraser fir Christmas trees: rotation age results. So. J. Appl. For. 17(1):5-9.

2) McKeand, S.E., F.E. Bridgwater, C.R. McKinley, J.B. Jett and R.J. Arnold. 195. 1994 Seed collection from natural stands of Fraser fir and plans for breeding and genetics research at NCSU. Limbs & Needles 22(1):5-7.

3) McKinley, C.R. 1996. Geographic seed source and Christmas tree plantings. Limbs & Needles 24(4):4,9.