

Research News...

1994 Seed Collection from Natural Stands of Fraser Fir and Plans for Breeding and Genetics Research at NCSU

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In September, 1994, a massive seed collection was made by scientists from North Carolina State University's Department of Forestry, the USDA Forest Service, the North Carolina Forest Service, the Cooperative Extension Service, and the University of Tennessee. With financial support from the North Carolina Christmas Tree Association and the above mentioned agencies, seeds from over 500 parent trees were collected from across the natural range of Fraser fir (Table 1). Every effort was made to sample trees at each of the six major populations (17 mountain peaks) and different elevations within each mountain where Fraser fir grows naturally. Most trees were located along roads (e.g. the Blue Ridge Parkway and state highways within the parks and national forests) and major trails, so that as many trees as possible could be sampled. Every effort was made to collect cones from the best possible trees. We evaluated trees for growth, vigor, straightness, and color, all important characteristics for Christmas tree production.

Plans will be developed for research and breeding uses for these seeds with input from the cooperating agencies during the next few months. The reasons for the collection and a discussion of some of the potential benefits from a breeding and genetics research program with Fraser fir are presented below.

Background

In indigenous stands, Fraser fir (*Abies fraseri* [Pursh.] Poir) is a small to medium size tree of up to 30m in height. It has a limited geographic range, occurring in isolated high mountain stands (generally above 4500 feet) in western North Carolina, southwestern Virginia, and eastern Tennessee. It is a primary component of the southern Appalachian spruce-fir forest type in association with red spruce (*Picea rubens*

Sarg.). The southern spruce-fir forests have special biological significance as the most southern extent of the eastern boreal forests.

The six major Fraser fir populations at Mount Rogers, Grandfather Mountain, Roan Mountain, the Black Mountains, the Balsam Mountains, and the Great Smoky Mountains were heavily logged until the 1930's. With reduced harvesting, populations have expanded since that time. However, environmental stresses arising from atmospheric pollutants and an introduced exotic insect pest, the balsam woolly adelgid (*Adelges piceae* [Ratzeburg]), are presently contributing to severe forest decline. In a survey of spruce-fir forests in the 1980's, mortality of fir trees greater than 5 inches in diameter ranged from 44% at Roan Mountain to 91% in the Great Smoky Mountain National Park (Dull et al. 1988). Because of this dramatic decline, Fraser fir is listed as a "Category 2" species on the Federal Register for Threatened Wildlife and Plants published by the Department of the Interior and has been given "Watch List" status in North Carolina by concerned conservationists. Fraser fir enjoys a high public visibility even among threatened species, because it is the premier Christmas tree species familiar to many.

Fraser Fir Genetics

A key to the production of high-quality, high-valued Christmas trees is the use of the best available genetic stock. Results from an intensive genetic variation study by NCSU scientists indicate that several important traits are under strong genetic control. Tree height, crown size, size of branches and, the number of buds per branch are all traits which show moderate to high degree of genetic control and are amenable to selection and breeding to improve both rate of growth and tree quality (Arnold et al. 1994a, 1994b, 1995a, 1995b). As an example, results following the eighth growing season in the field indicate that the 89 families ranged in average wholesale value from \$17 to \$24 per tree. Approximately 25% of the variation among individual trees for tree value is under genetic control. This amount of genetic variation will allow effective selection and breeding for this economically important trait.

Simply by using the best families for plantation establishment, wholesale value could be increased thousands of dollars per acre. For example, if under excellent management, the average wholesale value per tree is \$20 and 1500 trees are harvested per acre, then an acre of harvested trees would be worth \$30,000. By planting only the 4 best families, we can potentially increase the average value per tree to \$23 and realize an additional \$4,500 per acre at harvest. These data also indicate that shortening of the rotation length required to grow a Fraser fir Christmas tree by 1 to 2 years is feasible. If the best genetically improved trees were utilized industry-wide, income to North Carolina growers could increase by \$38.8 million annually, a tremendous payoff from a relatively modest investment in genetic research.

Additionally, the high dollar value of the low-elevation (5000 and 5500 feet) and southern sources was clearly demonstrated in the Fraser fir genetic variation study (Arnold et al. 1995a). Trees from these sources were the fastest growing and had the best form in the trial.

In view of the potential gains, a genetic improvement program to aggressively improve tree growth and quality and to reduce the length of time required to produce a marketable tree would yield tremendous benefits to the Fraser fir Christmas tree growers. It would also enhance the likelihood of capturing more of the national market share.

Fraser Fir Gene Preservation

Despite the tremendous potential to genetically improve Fraser fir for Christmas tree production, there exists a serious constraint. Tree improvement requires that a large genetic base be available from which to select outstanding trees for inclusion in a breeding program and to maintain genetic diversity. While there is currently genetic material available in grower plantations, from the Fraser Fir Genetic Variation Study, and in the N. C. Forest Service seed orchard for the immediate selection and breeding work, the natural Fraser fir gene pool is seriously threatened with a drastic reduction in size or even extinction in some areas. Since Fraser fir naturally exists only in

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small isolated populations, the loss of even one population can have a significant negative impact on the gene pool. Consequently, there was an urgent need to collect and preserve a broad sample of genetic material from the natural populations of Fraser fir. Previously, no governmental or private agency had made an effort to collect and preserve a broad sample of genetic material for this species. Time was of the essence if the Fraser fir gene pool was to be preserved.

Even though there is general agreement among studies as to the patterns of genetic variation in Fraser fir, results suggest different sampling strategies for commercial and conservation objectives. It is clear that further screening of Fraser fir populations for Christmas tree improvement should be aimed at populations at

lower elevations, and perhaps in the southwestern portion of the species range. The relatively large variation among trees within stands suggests that many mother trees should be screened for their ability to produce desirable progenies. Conversely, sampling for gene conservation or remediation should be done over the entire species range, paying particular attention to extreme or fringe stands where rare genes may be present. Because progenies of each mother tree are quite variable, the depth of the sample of subpopulations is less important than its breadth for conservation. The 528 trees that were sampled in 1994 represent the most extensive, range-wide collection of Fraser fir ever made. The seeds will be used for various genetics studies and will be an excellent base for future breeding.

If future reclamation of natural Fraser fir stands should become necessary, preserving and understanding the patterns of

genetic variation is critical. Under a worse-case scenario, if entire populations of fir are destroyed, a thorough sample of the gene pool will be necessary for remediation. Additionally, there is some evidence that sources of Fraser fir differ in their tolerance to adelgid attack (e. g. work by Dr. Fred Hain and his graduate students at NCSU). If genetic resistance to Balsam woolly adelgid could be identified, deployment of tolerant genotypes would be extremely valuable for re-establishment of "natural" stands as well as for Christmas tree production.

Conclusion

The seed collected in 1994 can make a vital contribution to North Carolina's Christmas tree industry. A comprehensive

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	PRICE PER 100	PRICE PER 1000		PRICE PER 100	PRICE PER 1000
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SPANISH GUADARRAMA	\$16.00	\$115.00	BERKEY'S SEED ORCHARD	87.00	625.00
92000 SCOTCH PINE 1-2 8-15"			90240 FRASER FIR 2-3 10-18"		
SPANISH GUADARRAMA	53.00	390.00	BERKEY'S SEED ORCHARD	94.00	675.00
93030 SCOTCH PINE 2YR 5-8"			90314 BALSAM FIR 2-3 8-16"		
BERKEY'S SEED ORCHARD	21.00	160.00	VERMONT	66.00	475.00
92030 SCOTCH PINE 1-2 8-14"			93410 CONCOLOR FIR 2YR 5-10"		
BERKEY'S SEED ORCHARD	70.00	515.00	CIBOLIA, NM	18.00	130.00
93051 MUGO PINE 2YR 2-4"			91410 CONCOLOR FIR 2-2 8-16"		
PUMILIO	15.00	105.00	CIBOLIA, NM	72.00	520.00
91051 MUGO PINE 2-2 2-6"			93420 CONCOLOR FIR 2YR 5-10"		
PUMILIO	53.00	390.00	SANTE FE, NM	18.00	130.00
93060 AUSTRIAN PINE 2YR 4-7"	16.00	110.00	91420 CONCOLOR FIR 2-2 8-16"		
92060 AUSTRIAN PINE 1-2 7-14"	56.00	415.00	SANTE FE, NM	72.00	520.00
93072 WHITE PINE 2YR 2-4"			93605 COL. BLUE SPRUCE 2YR 5-10"		
MANISTEE, MI	16.00	110.00	SAN JUAN, CO	19.00	135.00
91072 WHITE PINE 2-2 7-12"			93620 COL. BLUE SPRUCE 2YR 5-8"		
MANISTEE, MI	65.00	480.00	BERKEY'S SEED ORCHARD	49.00	350.00
93810 JAPANESE LARCH 2YR 12-24"	26.00	185.00	91620 COL. BLUE SPRUCE 2-2 8-12"		
93100 DOUGLAS FIR 2YR 7-12"			BERKEY'S SEED ORCHARD	89.00	640.00
LINCOLN, NM	13.00	95.00	93640 COL. BLUE SPRUCE 2YR 4-8"		
92100 DOUGLAS FIR 1-2 10-16"			PA SPECIMEN	28.00	200.00
LINCOLN, NM	58.00	430.00	91640 COL. BLUE SPRUCE 2-2 8-12"		
94110 DOUGLAS FIR 1YR 2-4"			PA SPECIMEN-HAND PICKED	73.00	525.00
LINCOLN, NM-HAND PICKED	30.00	225.00	93700 NORWAY SPRUCE 2YR 5-10"		
92110 DOUGLAS FIR 1-2 10-16"			CRAWFORD COUNTY, PA	19.00	135.00
LINCOLN, NM-HAND PICKED	78.00	575.00	92700 NORWAY SPRUCE 2-1 7-14"		
93150 DOUGLAS FIR 2YR 5-10"			CRAWFORD COUNTY, PA	49.00	350.00
SHUSWAP LAKE, BC	21.00	150.00	91700 NORWAY SPRUCE 2-2 10-18"		
91150 DOUGLAS FIR 2-2 8-14"			CRAWFORD COUNTY, PA	66.00	470.00
SHUSWAP LAKE, BC	48.00	355.00	93720 SERBIAN SPRUCE 2YR 3-8"		
91220 FRASER FIR 2-2 8-12"			YUGOSLAVIA	21.00	150.00
ROAN MT, NC	63.00	470.00	91720 SERBIAN SPRUCE 2-2 10-16"		
90220 FRASER FIR 2-3 10-18"			YUGOSLAVIA	79.00	575.00
ROAN MT, NC	71.00	520.00	93735 ENGLEMANN SPRUCE 2YR 4-8"		
93230 FRASER FIR 2YR 3-5"			PAL-SELECT	19.00	135.00
ROAN MT, NC-HAND PICKED	28.00	200.00	91731 ENGLEMANN SPRUCE 2-2 8-14"		
91230 FRASER FIR 2-2 8-12"			LINCOLN, NM	50.00	350.00
ROAN MT, NC-HAND PICKED	71.00	520.00	93711 WHITE SPRUCE 2YR 5-10"		
90230 FRASER FIR 2-3 10-18"			MANISTEE, MI	19.00	135.00
ROAN MT, NC-HAND PICKED	83.00	595.00	91711 WHITE SPRUCE 2-2 10-16"		
93240 FRASER FIR 2YR 3-5"			MANISTEE, MI	55.00	400.00
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genetic base must be established so that an effective Fraser fir Christmas tree genetics program can be initiated soon. Work is already underway in other states to genetically improve Christmas tree quality and vigor. Without a similar effort in North Carolina, the ability to compete in the national markets will be seriously compromised. We must collectively develop plans to obtain resources to have the best genetics program possible for Fraser fir.

Table 1. 1994 seed collection from natural populations of Fraser fir.

Population	Number of trees collected
1. Mount Rogers	37
2. Grandfather Mountain	90
3. Roan Mountain	66
4. Black Mountains	128
5. Great Smoky Mountains	133
6. Balsam Mountains	74
Total	528

Literature

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BARE-ROOT STOCK
(A Partial List)

SPECIES	AGE	SIZE
BALSAM FIR	2-3	12-18"
	3-2	9-18"
	P+2	9-15"
CANAAAN FIR	3-0	6-12"
	P+2	12-18"
	P+1	6-12"
CONCOLOR FIR	2-3	12-18"
	2-2	6-10"
	2-0	4-8"
DOUGLAS FIR (Lincoln)	2-3	24" & Up
	2-2	12-24"
	3-0	12-18"
FRASER FIR	2-0	6-12"
	3-2	9-15"
	3-0	6-10"
WHITE PINE	2-2	9-18"
	P+2	9-15"
	3-0	12-18"
SCOTCH PINE (French)	3-0	9-12"
	2-0	4-8"
	2-2	12-18"
(Spanish)	2-1	6-10"
	2-0	6-9"
	2-2	12-18"
(Lake Superior)	2-2	12-18"
	2-0	6-9"
	2-2	12-18"
COLORADO BLUE SPRUCE	2-2	12-18"
	2-2	9-15"
	3-0	9-12"
NORWAY SPRUCE	2-0	4-8"
	2-2	12-18"
	3-0	12-18"
WHITE SPRUCE	2-0	6-12"
	2-2	12-18"
	3-0	12-18"
	2-0	6-9"

PLUG STOCK
(A Partial List)

SPECIES	AGE	SIZE
BALSAM FIR	P2	5-10"
CANAAAN FIR	P2	5-10"
CONCOLOR FIR	P2	4-8"
FRASER FIR	P2	4-8"
WHITE PINE	P2	4-7"
COLORADO BLUE SPRUCE	P2	5-10"
MEYER SPRUCE	P2	3-6" ¹
SERBIAN SPRUCE	P2	5-10"
WHITE SPRUCE	P2	6-12"

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