



INSTITUTE OF FOREST BIOTECHNOLOGY

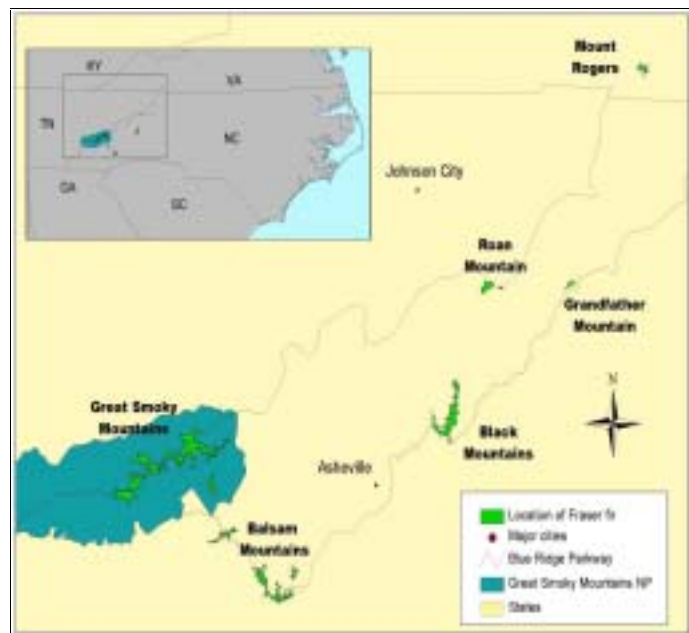
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The Fraser Fir Heritage Tree Program

Fraser fir is a native North Carolina forest tree species that is economically important to the state, but currently threatened in its natural range. For these reasons, the Institute of Forest Biotechnology (IFB) has identified Fraser fir as an ideal candidate for its Heritage Trees Program. IFB will facilitate efforts to use biotechnology to improve Fraser fir by developing and maintaining a broad-based network of scientists and interested parties focused on attacking problems of the species. This document briefly summarizes 1) the current status of the natural Fraser fir stands, 2) the economic impact of the Fraser fir Christmas tree industry and 3) immediate research needs for serving the species through biotechnology.

Status of the Natural Fraser Fir Stands

Fraser fir is the only fir species native to the South and one of the dominant species of the spruce-fir ecotype of the Southern Appalachians, which covers approximately 30,588 ha. These forests are an extremely valuable resource in the South because of their unique natural beauty and importance for recreation. They occur as a series of island-like stands at high elevations in western North Carolina, eastern Tennessee and southwestern Virginia. These unique forests are generally associated with popular recreational areas, including the Great Smoky Mountains National Park, the Balsam Mountains, the Black Mountains (including Mount Mitchell, the highest point in the eastern U.S.),



Grandfather Mountain, Roan Mountain and Mount Rogers National Recreation Area. The Appalachian Trail and Blue Ridge Parkway pass through some of these extraordinary areas. Collectively, tens of millions of tourists a year visit these areas.



Due primarily to the introduced balsam woolly adelgid (BWA) and, secondarily, to harmful atmospheric depositions, *old growth Fraser fir has been almost entirely decimated and the prospects for regenerated younger trees are bleak*. BWA infestations were first discovered in the Southern Appalachians in the late 1950's near Mt. Mitchell and, subsequently, damage has quickly spread throughout the entire Fraser fir range. A field survey conducted in 1988 found that mortality of standing Fraser fir ranged from 44% on Roan Mountain to 91% in the Great Smoky Mountains National Park and mortality has continued unchecked since the survey. Human efforts to reduce the spread of the adelgid by cutting infested trees, applying various pesticides and introducing adelgid predators have failed. Although fir reproduction is abundant in some areas, the long-term prospects for survival of the young trees range from uncertain to dismal. In addition, the character of the forest has been drastically changed. Overall, the future survival of Fraser fir is threatened. *Found nowhere else in the world, Fraser fir has a global rank of G2, indicating that it is imperiled and vulnerable to extinction.*

Fraser fir plays a vital role in the ecology and survival of the spruce-fir ecotype. It reduces erosion and provides watershed protection by holding shallow soils to steep mountainside slopes. Fraser fir enhances the texture and nutrition of these forest soils and provides shade and wind protection to the forest flora and fauna. Largely as a result of Fraser fir's demise, there are viability concerns for 1 bird, 5 invertebrate, and 12 plant species of the Southern Appalachian spruce-fir ecosystem.

The Christmas Tree Industry

In addition to its aesthetic and ecological value, Fraser fir is economically important to the people of the Southern Appalachians. In North Carolina, 5.5 to 6.0 million Christmas trees (over 98% Fraser fir) are harvested annually (2nd in nation) with estimates of annual revenue from the state's Christmas tree industry exceeding \$100 million. Fraser fir Christmas tree plantations are outside of the species' natural range and provide a critical source of income in rural areas of the region.



Fraser fir has been widely accepted as the premier Christmas tree species in much of the United States due to a combination of attributes including pleasing aroma, dark blue-green foliage, natural Christmas tree shape, strong branches for holding ornaments and excellent post-harvest foliage retention. The later characteristic allows Fraser fir to be harvested early and shipped to markets primarily along the Atlantic seaboard but, also, to the nation's interior and west coast as well as to Caribbean and Latin American markets.

Fraser fir Christmas tree production is intensive including: 1) planting five-year-old stock, 2) fertilizing in accordance with soil and foliage nutrient analyses, 3) shearing annually starting around age three from field planting, and 4) practicing integrated pest management, including scouting for pests and applying pesticides only when required. The average 6-7 foot Christmas tree is 13 years from seed or 8 years in the field at the time of harvest.

The most damaging pest of the Fraser fir Christmas-tree industry is phytophthora root rot (caused by the water mold, *Phytophthora cinnamomi*). Annual losses are estimated to be \$6-7 million and the long-term viability of the industry is in doubt. Once sites become heavily infested with the pathogen, the land must be abandoned for Fraser fir production. Development of disease resistant planting stock is urgently needed since chemical methods for controlling this disease in infested plantations is largely ineffective or uneconomical. Other pest problems in Christmas tree plantations include balsam woolly adelgids, balsam twig aphids, spruce spider mites, and rosette bud mites among others.

Biotechnology Research Needs

Successful amelioration of Fraser fir problems via biotechnology could potentially produce both ecological and economic benefits, from preservation of the threatened natural population to improved income for Christmas-tree farmers, wholesalers and retailers. The two most important objectives would be the development of resistance to BWA and phytophthora root rot. Recent advances using model plant species have increased our understanding of plant defense mechanisms against insects and diseases. This knowledge, combined with plant biotechnological techniques, makes it feasible to attempt to introduce novel forms of pest resistance into Fraser fir. However, while some research has begun on the biology of host-pest interactions, little biotechnological research has been conducted on the species.

To make meaningful progress, a focused research program is needed. Objectives of the program would be to:

- 1) develop somatic embryogenesis (SE) techniques. SE is a means of cloning trees from individual cells. SE technology will be valuable not only for the commercial and research benefits derived from cloning per se, but also because a workable SE system is a necessary tool for the introduction of novel genes into this species. SE has successfully been developed for other conifers, including *Abies* species, but a reliable technique has not yet been developed for Fraser fir.
- 2) develop genetic transformation techniques. Genetic transformation is the process whereby novel genes are incorporated into the chromosome of a plant cell. When combined with SE (the regeneration of a tree from that cell), it could result in novel forms of resistance for Fraser fir. Genetic transformation and regeneration have been documented for other conifer species, but not yet for Fraser fir.
- 3) better understand the genetic interactions between Fraser fir and its pests. Information is needed to better understand how pests are attracted to Fraser fir and how defense mechanisms are regulated. This information can be combined with novel defense

genes from other species to produce trees with appropriately regulated and effective defenses against BWA and phytophthora root rot.

While these are not trivial endeavors, it is anticipated that through a sustained and coordinated effort by a team of researchers and interested parties, the status of the natural Fraser fir stands and the Christmas tree industry will ultimately be significantly enhanced.

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