The Minnesota Tree Improvement Cooperative

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INTRODUCTION

As the director of the Minnesota Tree Improvement Cooperative (MTIC) based in Cloquet, Minnesota, I would like to tell you a little about our strategy for creating improved seed, and how individual nurseries or nursery associations can interact with tree improvement programs to the benefit of both parties. MTIC is approximately 15 miles west of Duluth, at the University of Minnesota's Cloquet Forestry Center. The other employees of MTIC are Carrie Pike, the only full time employee and Jim Warren, a part-time research fellow.

The MTIC was formed out of a unique set of circumstances. The Boundary Waters Canoe Area Wilderness (BWCA) is a vacation destination wholly contained in northern Minnesota and nestled along the Canadian border. In 1979 an addition to the BWCA, called the portal zone, brought the BWCA to its current size of approximately 1 million acres. As a result of this land taking and the corresponding loss of timber income, the State of Minnesota was compensated $1 million/year for a period of 10 years by the Federal government. As part of the plan, the state was to undertake a huge replanting program within and around this new wilderness area to compensate for trees that would no longer be available. As the DNR was responsible for much of the planting, their reforestation program increased tenfold over the next several years. Because similar reforestation efforts were occurring on Federal, State, and county lands it became obvious to many that there was a need for a central organization to address tree improvement needs in Minnesota.

In 1981, Dr. Carl Mohn of the University of Minnesota, St. Paul, recognized the need for improved seed in regeneration efforts. He wrote a grant to the Blandin Foundation to hire an applied tree improvement specialist and establish the MTIC. The Division of Forestry within the DNR, along with several members from industry, became charter members. The DNR provided some of their Federal buyout dollars and MTIC used monies from the original Blandin Foundation grant until approximately 1986, when the MTIC became self-supporting on dues alone.

Currently, the MTIC consists of 25 private and public organizations in the States of Minnesota and Wisconsin. Our membership is divided in 2 groups, “members” and “supporting members.” Member organizations typically have at least 1 seed orchard and or progeny test of their own that they physically manage while MTIC tracks the growth and health of each tree within the plantation, makes recommendations on removals, and conducts breeding activities within the orchards. Supporting members are smaller organizations who generally do not participate directly but who voice their support for tree improvement through their dues and participation at annual meetings and workshops.

Public and private entities are represented at both the full and supporting levels. Public members consist of county land departments, the Iron Range Resources Rehabilitation Board, DNR, the USDA Forest Service, Minnesota Association of Soil and Water Conservation Districts, and the Minnesota Nursery and Landscape Association. Private companies include pulp and paper companies such as Blandin Paper Company, Georgia-Pacific Corporation, Potlatch Corporation, Wausau-Mosinee Paper Corporation, and Champion International Corporation and lumber companies such as Hedstrom Lumber Company, Rajala Companies, and Itasca Greenhouse. The MTIC oversees about 65 different seed orchards and test sites, which encompass over 90,000 trees and 200 acres (80 hectares) of land. Every tree has a unique identification number that allows MTIC to track the lineage of a particular tree and its location.

The diverse nature of our members and their interest in several different species means that a tree improvement program for each species of interest is beyond the ability of any single cooperator. As a result, decisions are made by consensus of an advisory board, which is composed of every full member. Other “boards” are formed as needed to investigate specific issues and report back to the advisory board. Granted, this is a fairly loose organizational structure, but it works because the members are committed to tree improvement in general, and they recognize the value of pooling resources to accomplish what they cannot do individually. Indeed, some of our cooperators had worked jointly on projects before MTIC was formed, and some continue to do so today and share their findings with the entire group.

The Ecological Classification System divides Minnesota into 3 provinces, the Laurentian Mixed Forest, the Eastern Broadleaf Forest, and the Prairie Parkland. All our activities and cooperators in Minnesota are located in the Laurentian Mixed Forest, which is characterized by a wide variety of soils, climactic conditions, and several different species. This is the forest “breadbasket” of Minnesota, and forestry and forest products are an important sector of the economy.

The vast majority of commercial forest land in Minnesota is located in the Laurentian Mixed Forest province and is divided roughly as 50% private ownership, mainly pulp and timber companies, and 15% to 20% State, county, and Federal lands. Native American Reservations are part of the Federal grouping under the Bureau of Indian Affairs. The MTIC membership has enabled all these groups to incorporate improved seed into their reforestation programs.

The creation of improved seed is neither technically difficult nor a very stimulating research topic like genetically modified organisms, but it does require time, a dedication to the process, and a steady influx of dollars. What follows is a generalized version of a tree improvement program that MTIC has followed with certain deviations for different species.

Any tree improvement plan must start with seeds collected from the wild. Typically, trees are selected that are superior in stem form, disease tolerance, and volume when compared to individuals in the immediate vicinity. These are known as plus trees. Open-pollinated (OP) seeds collected from each plus tree constitute a family, and seeds from each family are kept separate to preserve the genetic identity. Ample OP seeds are collected from these plus trees to grow seedlings in an experimental design amenable to statistical analysis by the analysis of variance method (ANOVA). Measurements on height, diameter, stem form, and disease incidence are made over 5 to 15 years, and the data are analyzed to identify the best individuals. The poorer performers are rogued and the result is a seedling seed orchard that produces seeds that are 5% to 12% better than wild seeds for volume production, depending on species and selection intensity. Gains in other traits, such as stem form and disease tolerance, are often higher than those for volume due to their higher heritability. The best performers in the best families can be selected to make crosses for the next generation, starting the breeding cycle all over again. This type of breeding plan is known as recurrent selection or forward selection because the parents of the next generation are moved forward without being progeny tested. Individuals from the seedling seed orchard can also be progeny tested using OP seeds in a manner very similar to that used to score the seedling seed orchard. The progeny test is a separate test of the ability of individual trees to produce good progeny, or what we call a test of general combining ability. The OP seeds are collected from individuals, keeping families separate, and planted in a replicated fashion on multiple sites. Measurements are taken and the data analyzed. The results indicate which trees in the seedling seed orchard are good general combiners. The original seedling seed orchard can then be rogued based on this information, and grafts can be taken from these parent trees to establish a grafted seed orchard. This type of selection is known as backward selection because from the progeny generation one goes back to the parents to create the seed orchard. These selected parents can also be used to create second generation material for advanced generation breeding.

A brief overview of the status of MTIC species of interest follows. Although there is very little genetic variation in red pine because it is the most planted tree species in the upper Great Lakes region, there is a constant demand for seeds. Cooperators selected plus trees from Minnesota and Wisconsin and created 8 seedling seed orchards of varying ages. Six of these have undergone an initial rogueing and are close to reaching sexual maturity as plantations. Because of poor seed crops in the past 8 to 10 years, shortages of red pine seeds are becoming problematic. Short-term interests are to finish initial rouging in seedling seed orchards and to determine a methodology for inducing seed production using gibberellic acid in these orchards to alleviate seed shortages. Long-term interests are to create grafted orchards and determine whether breeding for volume gains is practical. Although red pine has low levels of genetic variation as detected by genetic markers, if gains in volume of as little as 2% to 4% can be realized, then a breeding program can be justified based on the sheer volume of seedlings planted.

Jack pine is a popular reforestation tree because of its rapid growth and ability to survive on xeric sites. Plus trees were selected from Minnesota and 15 seedling seed orchards were established. These have been rogued based on height and stem form and produce seeds on a regular basis due to jack pine's precocious flowering nature. The best individual trees in these orchards were crossed and planted on 4 sites in 1999 to make a second generation population for advanced generation breeding.

The MTIC white spruce program is a hybrid of better Minnesota selections from a seedling seed orchard and superior clones from other tree improvement programs in the Midwest. These superior clones are primarily from Southeast Ontario sources in the Ottawa Valley and were used to establish 7 grafted seed orchards. An OP progeny test was initiated using individuals from the grafted seed orchards and the seedling seed orchard of Minnesota plus trees. Results of the progeny test have been used to rogue the grafted orchards and the seedling seed orchard and determine which individual trees to select for creating improved seed orchards and which trees to cross to generate our second generation population for advanced generation breeding.

Minnesota was once home to towering white pines, but the subsequent generations have been plagued with blister rust, white pine weevil, and deer browse. The MTIC has 1 grafted breeding arboretum of putative rust resistant selections and 3 grafted seed orchards, 2 of putative rust resistant material and 1 with selections for growth and form. Renewed interest in this species has resulted in substantial funding from the legislature and the DNR for a project to increase the tolerance of white pine to white pine blister rust and aid regeneration efforts. The goal is to identify low-to-intermediate rust hazard areas, and then plant seedlings with the highest level of rust resistance possible. Our strategy for increasing rust resistance is to create an early seedling screening system that will identify parents with increased tolerance to blister rust, use histological methods to identify mechanisms of resistance, and then breed individuals with complimentary mechanisms of resistance. Concurrently, we are investigating flower induction methods using gibberellic acid on grafted material to reduce the time to sexual maturity and accumulating putative rust resistant breeding material for screening purposes and deployment into seed orchards.

Early screening work done by Paul Zambino of the Forest Service indicates that resistant seedlings can be identified in 1 to 1.5 years from seed. Histological research by Robert Blanchette of the University of Minnesota has identified 4 to 5 potential resistance mechanisms and Paula Pijut of the Forest Service has demonstrated that foliar applications of $GA_{4/7}$ induce flowering in grafted white pine. The MTIC has put out 4 trials designed to field test the validity of greenhouse screening experiments, expanded the breeding arboretum, and grafted new putatively resistant germplasm and deployed it into seed orchards and the breeding arboretum. The MTIC is also responsible for the coordination of all field trials and design of seed orchards.

A white pine blister rust hazard map was created by T.N. Brown, M.A. White, and G.E. Host of the Natural Resources Research Institute, University of Minnesota, Duluth. It was created using inventory information, climate, topography, distance to water, and several other factors. It updates the original 1961 rust hazard map using modern GIS techniques and therefore works at a smaller scale. For example, some areas rated as "very high hazard" in the old map are now classified as intermediate or low hazards. This map can be found at http://oden.nrri.umn.edu/rustmap/final/BITSreport.html.

Black spruce was one of the first species MTIC worked with using plus tree selection to establish 4 seedling seed orchards and clonal selections to establish 3 grafted seed orchards. All of these orchards produce copious amounts of seed that currently meet the needs of the individual cooperators.

The reason that I, as a tree improvement person, and the Northeast Area Nursery Conference should be interested in tree improvement programs is that they provide seeds that are improved for growth rate, stem form, and disease resistance. In the case of exotic species, where adaptability to local climates is an issue, tree improvement cooperatives can provide information on the best available seed sources. The traits of interest to pulp and lumber companies are the same traits of interest to nursery growers. Organizations join and remain members of MTIC not out of some altruistic sense of duty but rather because they realize that improved seed is a better alternative, and better alternatives increase profits.

You are all encouraged to investigate tree improvement cooperatives and decide for yourself what level of participation is best for your organization. Some nurseries do participate at the full level and host or cohost seed orchards with another member. They can help to shape the direction and research that the cooperative undertakes. Others prefer to participate at a sustaining level, and this provides them with access to research information that the cooperative generates. Regardless of the level of participation, your involvement in a tree improvement cooperative sends a clear message to others in your profession and to State and local governments that tree improvement is a worthwhile activity and economically beneficial.

Another benefit of participation is that there is a constant need for someone to grow seedlings for progeny tests and comparison trials and to graft scions for seed orchards. And as most pulp and timber companies close down their in-house nurseries, there is a need to grow seedlings for operational plantings. In short, belonging to a tree improvement cooperative can be good for business.

Even if you decide not to participate directly in a tree improvement cooperative, you can still seek out and purchase improved seed or seedlings for your nursery operations. State nurseries often have access to improved seed, and other cooperative members may be willing to sell their surplus seed. Generally the increased cost is nominal and it can be retailed as improved seed.