

The Minnesota Tree Improvement Cooperative: 25 years of meeting tree improvement objectives for the forest products industry in Minnesota and Wisconsin

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Abstract

The Minnesota Tree Improvement Cooperative (MTIC) was established in 1981 in response to a surge in demand for seed for reforestation efforts. In its 25 years, membership has waxed and waned with the health of the forest products industry in the upper Midwest. The MTIC exists primarily from membership dues of which the majority is paid by public agencies. Orchard-produced seed is used exclusively in planting programs for several tree species, primarily jack pine and white spruce where demonstrable gains and abundant seed production in orchards has driven demand for improved seed. Advanced-generation orchards have been established for jack pine and white spruce, and are planned for red pine and white pine.

The Cooperative Model in Minnesota

Worldwide, tree improvement programs are often executed in a cooperative model to facilitate resource-sharing toward a common goal. In Minnesota, this model is especially applicable because of the high degree of public land ownership. In the state, 54 percent of forest land is managed by public agencies, including federal (14 percent), state (27 percent) and county-level (13 percent) ownership. Public agencies can cooperate openly due to a lack of proprietary issues concerning forest management. In addition, competition between private industries is minimal due to the diversity of products that are produced, i.e., no two mills are competing in the same market. The longevity of the tree improvement program has been achieved largely to the high degree of cooperation among its members.

The primary mission of the MTIC, as stated in its 1981 charter, is to “apply genetic principles through breeding and management to increase the quantity and quality of timber yields in Minnesota and Wisconsin.” Two levels of membership are offered within the MTIC. Full members generally manage at least one orchard, attend meetings, and have voting privileges. Supporting members are invited to attend meetings and workshops but are not entitled to a vote. An advisory committee, consisting of one representative per member agency, provides general direction for projects and budgets for the MTIC. Within the MTIC, decision-making power is not proportional to dues, and all full-members are entitled to one vote per agency. Voting is utilized to legitimize dues increases, and to assure cooperative support for projects. No bylaws are maintained; all decisions are made by consensus of the committee.

The MTIC is based at the University of Minnesota’s Cloquet Forestry Center, which is operated by the College of Food, Agricultural, and Natural Resource Sciences. The MTIC is staffed by one full-time Research Fellow who coordinates day-to-day activities, and one part-time Research Fellow who provides field and technical assistance. The University of Minnesota’s Department of Forest Resources assists with salaries, fringe, and funds the Forest Geneticist who serves as director. The director assists in setting long-range objectives and breeding designs. Two business

meetings are held annually, and one workshop is sponsored annually to promote education related to tree improvement or silviculture.

MTIC staff is responsible for assisting members with orchard design and management, along with conducting all tree breeding. Data and pedigree information of all orchard trees are maintained centrally in a database. MTIC staff also coordinates the planting of genetics tests, and is responsible for data collection, analysis, interpretation and distribution of findings. The staff maintains regular communication with cooperative members, distributes monthly and annual reports, and manages the budget. Finally, the MTIC serves to link members with resources at the University of Minnesota in St Paul.

Financial History

Membership in the MTIC has grown from three members in 1981 (Minnesota DNR, Potlatch Corp, Blandin Paper Company) to 20 in 2006. Twelve additional agencies initiated and later rescinded membership over the course of the MTIC's 25 years. In the early years, member dues were supplemented by seed money from the Blandin Foundation. By 1987, seed money expired and membership dues, with support from the University of Minnesota's Department of Forest Resources, became the sole source of funding. In 1998, the Minnesota legislature approved money for white pine blister rust research which continues to cover a portion of salaries and fringe for MTIC staff. In 2006, state agencies paid the highest share of MTIC dues (38 percent), followed by county land departments (33 percent), industry (25 percent), and tribal forest units (4 percent). A biennial contract with the DNR Division of Forestry accounts for the majority of state agency dues. Throughout the MTIC's history, additional dollars have been obtained for specific projects that helped leverage MTIC membership dues. Some of these funding sources included the Wilderness Research Foundation, Iron Range Resources, Blandin Paper Company and the Minnesota DNR Division of Forestry.

Genetic Gains: the value of a tree improvement program

Tree improvement programs are inherently expensive. In addition to dues, each member is required to fund costs associated with orchard establishment and maintenance. All costs related to tree improvement are theoretically offset by the added gains achieved from planting orchard seed. This added gain, or genetic gain, is calculated as the percent of additional wood that can be expected in a forest planting when orchard seed is utilized over woods run material. In general, tree improvement is usually justifiable in economic terms, although most tree improvement research takes place in warmer, subtropical climates. In Minnesota, the economic benefits of a tree improvement program are more difficult to justify due to the long rotation ages. Despite the extended growth required, genetic gains of up to 30 percent in volume have been demonstrated in white spruce which is economically justifiable in northern Minnesota. Additional benefits are possible in terms of improved tree form (straighter trees), survival (improved resistance to disease or superior adaptability), and increased wood density for papermaking. Again, these *gains* are difficult to quantify but can add significant value to a stand.

Seed orchards provide several advantages over woods-run collections. The amount of seed that is produced, the genetic diversity of seed and genetic gains can all be controlled through orchard design. The genetic makeup of the orchard can be changed by removing poor-performing sources while maintaining and propagating productive parent trees. Orchards also provide safe,

accessible places for seed collection where cone production can be monitored and manipulated through fertilization and irrigation. In addition, grafted orchards also serve to conserve genotypes that are either remote (i.e., superior white spruce genotypes from southeastern Ontario) or at risk from timber harvests, fire, and windstorms. Thus, the value of orchards from a seed production and gene conservation standpoint cannot be ignored.

Progress to Date

In its 25-year history, the MTIC has advanced programs for five tree species: black spruce, white spruce, jack pine, red pine and white pine. Projects with Norway spruce, Scotch pine, tamarack, and black walnut were initiated but not continued due to poor survival or waning interest. Early work with native tamarack was abandoned, but recent efforts to build a new seed orchard through the MN DNR began with seed collections made in fall 2006.

Black spruce - *Picea mariana*. Black spruce is commonly found in lowland areas across northern Minnesota. Its range extends into the far northern reaches of the east and west coasts of Canada. Black spruce is a relatively slow-growing species, compared with its upland cousin white spruce. Known for its broad genetic diversity and dense wood, black spruce is highly prized in some markets for its pulpwood.

The majority of artificial regeneration in Minnesota is accomplished through aerial seeding, using woods run seed exclusively. Because tree planting represents a small percent of black spruce regeneration, the MTIC has not advanced the black spruce program in recent years. Several orchards have been established and provide seed when it is needed. Four open-pollinated progeny tests, converted to seedling-seed orchards through roguing, have become the primary source of improved seed. In addition, seed is occasionally collected from four grafted orchards. Genetic gains in black spruce are approximately 9 percent for tree heights.

White spruce - *Picea glauca*. White spruce was the first species developed for tree improvement in Minnesota, thus great strides have been made. Plus-tree selections from wild trees in Minnesota, Wisconsin, and Michigan supplement selections from southeastern Ontario, a provenance that is notorious for producing the fastest growing genotypes. The MTIC program continues to measure and manage an open-pollinated progeny test planted in 1986, which features offspring of 292 genotypes. Orchards have been rogued based on early results and three new grafted orchards have been established with the top-ranking families. A second-generation population was created through controlled pollinations using an assortative, single-pair mating scheme. The resulting seedlings were out-planted in 2003 and 2005 at five different locations.

The first white spruce seed orchard was planted on land owned by Blandin Paper Company in 1976. Formerly known as the *Audette farm* and later the *Zigmund* orchard, the now *Latimer* seedling-seed orchard contains open-pollinated offspring from 239 seedlots selected from Minnesota. Originally planted as a progeny test, this site was later converted to a highly successful and productive seedling-seed orchard that is still in use today. Several selections from Latimer were included in the MTIC progeny test, and four trees tested within the top 10 percent of all progeny. Expected gains from newly established grafted orchards are approximately 12 percent for tree heights.

Several seed-source trials have been established to observe measured differences in tree volume between orchard and woods run material. Using ten-year data, tree volumes of improved seed exceeded a woods run source by approximately 30 percent. Gains are expected to be higher

with subsequent roguings that took place since seed was collected for this trial. In 2003 a similar trial was planted in order to compare seed from several orchards, including top-ranking trees, along with seed from a woods run source. Genetic gains are expected to meet or exceed those found in the previous trial.

Jack pine - *Pinus banksiana*. Jack pine tree improvement efforts were launched in 1974 with the first seedling-seed orchard *Kallstrom* on Potlatch land. Since then, 15 seedling-seed orchards have been established, and currently nine are actively maintained for seed production. Each orchard contains a set of unique families selected from nearby forests in addition to sources that are replicated at other orchards.

A vast breeding program was undertaken in 1993 and was completed in 1996. A total of 286 crosses were made from the top-performing trees unique to each of eight orchards using assortative single-pair mating. No genotype was used more than once within or across any orchard. In 1999, 143 unrelated full-sib families were out-planted at four sites. By 2000, only two sites remained due to biotic and abiotic calamities. One of the two remaining sites is located on land owned by Crow Wing County in partnership with the Minnesota DNR. The other site is located at the St Louis County orchard complex in partnership with Iron Range Resources. Both sites are in excellent condition with good survival. Eventually the second-generation populations will be thinned and function as seedling-seed orchards. Controlled pollinations will be performed to advance program further. In 2003, grafting of selected parents from first-generation orchards was begun, to build orchards that will provide a reliable seed source until the second-generation populations can be used for seed collections.

Red pine - *Pinus resinosa*. Three red pine orchards were planted in 1981 by Minnesota DNR (Cotton and Eaglehead) and Potlatch (Gillogly Rd). Additional orchards were later planted by St. Louis County, Cass County in partnership with Beltrami and Hubbard counties, and Wausau-Mosinee. Two orchards were established on land owned by Plum Creek Timber Company, one in northern Wisconsin (Bayfield) and the other in central Wisconsin near Wisconsin Rapids (Petenwell).

By this writing, all but two red pine orchards have been measured and rogued. Petenwell (owned by Plum Creek Timber Company) will be marked in summer 2006 for roguing in fall. Genetic gains are expected to be as high as 12 percent for volume. The remaining orchard, a partnership among Cass, Beltrami, and Hubbard counties, is slated for measurement in 2006 for roguing in 2007. In addition, a comparison trial is slated for planting in 2007 which will test seed from several MTIC orchards alongside a woods run source. Future breeding efforts are being considered and additional grafted orchards are planned.

White pine - *Pinus strobus*. White pine is a relatively new species of interest to the MTIC with the first seed orchards being established in 1985. Due to the close ties that white pine has to Minnesota's history, the state legislature created the white pine initiative in 1996. Designed to reduce the impact of white pine blister rust in Minnesota this funding not only helped jump start the MTIC's breeding and screening programs but also provided funding to state and county agencies for white pine planting and bud capping programs. Currently the MTIC has four grafted seed orchards, one breeding arboretum, and utilizes six progeny test/disease gardens established by the Wilderness Research Foundation.

Because of the introduced disease white pine blister rust, which is often fatal to younger seedlings and saplings, breeding work in this species is focused primarily on increasing disease resistance while growth and form improvements are secondary considerations. The breeding program has benefited from research by earlier researchers such as Cliff Ahlgren, Wilderness Research Foundation; Drs. A. J. Riker and R. Patton, University of Wisconsin; Drs. Scott Pauley and Carl Mohn, University of Minnesota; and Richard Meier and Bill Sery, USDA Forest Service. Their research sought out putative rust resistant individuals and used them to establish disease gardens, seed orchards, and the forerunners of our seedling screening programs. Because the true breeding value of these selected individuals remains unknown our white pine breeding program stresses controlled crosses and screening of progeny through exposure to white pine blister rust to determine which parents can produce seedlings with higher levels of resistance to the disease.

The Road Ahead

Anecdotal reports have indicated that improved seedlings generally perform well in forest tree plantings. In fact, foresters rely solely on improved seed, when available, for the vast majority of white spruce and jack pine tree plantings. In red pine, seed production in orchards is increasing, but demand cannot yet keep up with supply. Future orchards in red pine are being designed to maximize seed procurement efficiency. Ongoing research to improve the resistance of white pine to white pine blister rust has revealed some promising results. Orchards have been established, and are being expanded to incorporate the research results. A plan to incorporate improved black spruce seed into the aerial seeding program is being devised to help ensure that future seed supplies are adequate for future regeneration efforts.

The wood products industry has seen tremendous change in the last few years. Significant land sales and acquisitions have occurred. Several mills have closed, while others ponder expansion. Stumpage prices remain high, especially for *low-value* hardwoods. With all the shifts in the forest products industry that have occurred, conifers remain an important staple of the forest-products industry. Management of that resource is challenged with continued parcelization and fragmentation of existing forest lands. Increasing forest productivity will become essential to maintaining a healthy wood supply on a dwindling land base. The tree improvement program plays a critical role in meeting those increased productivity requirements. Additional progeny tests, seed source trials, and breeding are necessary to advance current tree improvement programs to adapt to future demand. Continued support for the MTIC is necessary for these projects to continue into the future.

References

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