UNIVERSITY OF MINNESOTA
College of Natural Resources
Department of Forest Resources

MINNESOTA TREE IMPROVEMENT COOPERATIVE

2005

ANNUAL REPORT

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Director

January 3, 2006

MEMBERS
Beltrami County
Cass County
Crow Wing County
Iron Range Resources
Itasca County
Itasca Greenhouse Inc.
Koochiching County
Lake County
Minnesota DNR
Division of Forestry
Plum Creek Timber Company
Potlatch Corporation
Red Lake Nation
St. Louis County
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University of Minnesota,
Department of Forest Resources

SUPPORTING MEMBERS
Carlton County
Clearwater County
Hedstrom Lumber Company
Hubbard County
Minnesota Nursery and Landscape Association
Pine County

TECHNICAL ADVISORS
USDA Forest Service State and Private Forestry
USDA Forest Service North Central Forest Experiment Station
University of Minnesota College of Food, Agricultural and Natural Resource Sciences

EXECUTIVE SUMMARY

The Minnesota Tree Improvement Cooperative (MTIC) entered its twenty-fifth year in 2005 with fourteen full members and six supporting members. A total of $58,957 was paid in dues including the contract with the MN DNR. Two business meetings were held, one on January 13, 2005 at the North Central Research and Outreach Center in Grand Rapids and another on March 24th at Cloquet Forestry Center. The annual workshop was held on December 2, 2004 at Cloquet Forestry Center. During 2005, Carrie Pike served as Coordinator, Dr. Andrew David was Director and Jim Warren provided field and technological assistance.

Priorities for 2005 included planting three replications of a second-generation white spruce population, collecting white pine pollen, and measuring field trials. Thirty-year data was collected from two replications of a jack pine range-wide provenance trial and twenty-year data was collected from three replications of a white spruce progeny test. At the "Moose fence" planting in Tofte, tagged trees were re-monumented. The deer exclosure surrounding the white pine blister rust trial in Grand Marais was repaired and improved. Pike and Warren visited 40 different MTIC plantings, including orchards and research trials.

Second-generation breeding is now complete for two species, white spruce and jack pine. A red pine genetics trial is planned for 2007 and seedlings were germinated at Itasca Greenhouse in September 2005. Jack pine and white pine are slated for grafting in 2006. Rootstock for future red pine grafting should be planted as early as spring 2006 in preparation for field grafting in 2007-2008. Breeding in white pine will continue in 2006 to advance the blister rust genetics program further. Black spruce seed should be collected and stored for a future comparison trial.

In 2006 the University of Minnesota and the MTIC will host the third meeting of the Northern Forest Genetics Association at the Cloquet Forestry Center in early September. This meeting will serve as an annual workshop, and commemorate the 25th anniversary of the MTIC.

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INTRODUCTION

The Minnesota Tree Improvement Cooperative was formed in 1981 in response to an increasing desire to use improved seed for reforestation in Minnesota. In 2005, 14 full members and six supporting members paid dues to the Cooperative. The Co-op's primary objective, building seed orchards, has resulted in first-generation seed orchards for five conifer species: black spruce, white spruce, jack pine, red pine and white pine. Second-generation seed orchards are in place for black spruce, white spruce and jack pine.

High-priority activities for 2005 included planting a second-generation white spruce population at three sites, planting grafts into three white spruce orchards, measuring two genetics trials, and collecting pollen for future white pine crosses. All but four actively managed Co-op seed orchards were visited in 2005.

This report describes the Co-op's program and summarizes activities and accomplishments from January 1 to December 31, 2005. It is organized into five major sections: Administration, Finances, Seed orchards, Species reports, and Outlook. An Appendix follows the Outlook section. It contains progress reports from a variety of projects that involved MTIC staff or resources. The summaries are provided as an update but have not been peer-reviewed or published, and thus the results may be subject to change upon final analysis.

A Letter from the Director

As you peruse this 2005 annual report I would like to draw your attention to a few important highlights and milestones. Each of these is a benefit to the cooperative that accrues as a result of the efforts and dedication of the employees and individual cooperators.

We are approaching an era when our earliest plantings are providing extremely useful data. Case in point is the 20-year measurement of our white spruce progeny test. This data will provide excellent mid-rotation information on family growth and stem form as well as juvenile-mature correlations that will guide the selection process in our advanced generation breeding work. Also we present the final report on a 20-year old white pine progeny test of putative blister rust resistant clones from the U.S. Forest Service seed orchard at Oconto River. Results from this trial are providing the best field data to date on blister rust resistance of specific genotypes. Approaching the issue of blister rust resistance from a different, but complimentary angle, the research coming out of Dr. Blanchette's laboratory in St. Paul is looking for practical, molecular applications for identifying resistance to blister rust in eastern white pine.

In addition to measuring trials and analyzing data we have also been laying the foundation for advanced breeding work in various species. This spring we reached a milestone as the last of our white spruce second generation materials were planted. The second generation jack pine materials have already begun to produce cones and will be bred in the near future.

The budget outlook has improved since the last annual meeting and now we are projected to end the year with a small surplus. There are four changes that have improved the financial situation; the DNR has increased dues from 15K to 20K per year, Jim Warren accepted a 25% appointment at the Cloquet Forestry Center as an IT specialist, the university-imposed IRS tax has been dropped, and we are no longer paying for secretarial support.

Finally, next year is the 25th anniversary of the MTIC! As part of this celebration we will host a meeting of the Northern Forest Genetics Association for our fall workshop. It promises to be an exciting meeting and I look forward to seeing all of you there. An early announcement with more information will come out in January 2006.

Sincerely,

Andrew David

ADMINISTRATION

Carrie Pike remains Coordinator of the Co-op, operating out of the University of Minnesota's Cloquet Forestry Center. Jim Warren continues a full time appointment providing technological and field assistance on projects for the MTIC, the white pine blister rust program, and the Cloquet Forestry Center.

Dr. Andy David, Director, continues to assist with long-term directives and consultation. His time is divided between the Aspen/Larch Genetics Cooperative in Grand Rapids, the MTIC in Cloquet, and teaching duties in St. Paul. Kathy Haiby and Egon Humenburger, also operating out of Grand Rapids, are partially funded by the state-legislated funding for white pine blister rust research, and assist on work pertaining to the genetic improvement of white pine.

The Advisory Committee consists of representatives from each member of the Co-op. It met twice during 2005 for business meetings, once on January 13 at the University of Minnesota's North Central Research and Outreach Center (NCROC) in Grand Rapids, and again on March 24th at the Cloquet Forestry Center. One workshop entitled "Maximizing efficiency and productivity of black spruce aerial seeding in Minnesota" was held on December 2, 2004 at the Cloquet Forestry Center. Registration was $25 and covered costs for lunch and room rental. Dr. Art Groot of the Great Lakes Forestry Center in Sault Ste. Marie, Ontario was invited as a guest speaker. Other speakers included John Wizik, Mike Albers, Keyth Wallin, Keith Jacobson, all from the Minnesota Department of Natural Resources. Costs for Art's travel, meeting room, and lunch were covered by registration fees. The workshop was attended by 61 people representing 11 different agencies.

On-site visits were made to 40 different Co-op plantings in 2005 by Pike and Warren. In addition to regular orchard visits, Warren and Haiby traveled extensively to Tofte and Grand Marais for white pine work. Jack pine scion was collected from Longprairie seed orchard, and travel to Grand Rapids was needed for measuring jack pine regional provenance trials, and the MTIC white spruce progeny test.

SEED ORCHARDS

Seed orchards are the means by which the Co-op produces genetically improved seed for use in commercial-scale planting programs. Since 1967, members of the Co-op have established 53 seed orchards, of which 45 are still used for seed collection. All first-generation jack pine orchards have been rogued. Six red pine orchards have been rogued, and a seventh is slated to be rogued in 2006 (Petenwell). A summary of the types and sizes of orchards managed by members of the Co-op is shown in Table 4. Table 5 lists all orchards by species and owner. Cone collections made in 2005 are shown in Table 6.

Table 1. Acres of seed orchard by species and orchard type.

Orchard Type	Black spruce	Jack pine	Red pine	White pine	White spruce	Total acreage
First Generation Clonal	7.6	---	---	13.3	22.7	***43.6***
First Generation Seedling Seed	8.2	26.6	42.2	---	4.1	***81.1***
Improved First Generation Clonal	---	---	---	---	9.6	***9.6***
Second Generation Full Sib	3.5	6.4	---	---	10.7	***20.6***
Total acreage by Species	***19.3***	***33.0***	***42.2***	***13.3***	***47.1***	***154.9***

Table 2. Seed orchards actively managed by the MTIC.

Species	Orchard Type	Organization	Planting	Date Planted	Size (ac)	Live Trees
Black Spruce	First Generation Seedling Seed	Blandin Paper Co.	Blackberry	5/22/1978	2.5	596
	First Generation Clonal	Koochiching Co.	Big Falls	5/19/1989	2.3	61
	First Generation Clonal	Koochiching Co.	Larsaybow	5/27/1998	4.0	59
	First Generation Seedling Seed	Minnesota DNR	Eaglehead	5/17/1978	2.7	582
	First Generation Clonal	Minnesota DNR	Sturgeon Lake	5/1/1979	1.3	812
	Second Generation Full Sib	Minnesota DNR	Split Rock	5/27/1992	2.4	262
	First Generation Seedling Seed	Potlatch Corp.	Cloquet	5/1/1978	3.0	580
Jack Pine	First Generation Seedling Seed	Cass/Beltrami/Hubbard Co.	Deep Portage	10/8/1982	3.4	492
	Second Generation Full Sib	Crow Wing Co./MN DNR	County Line	5/1/1999	2.6	1705
	First Generation Seedling Seed	Crow Wing County	Crow Wing	6/4/1985	2.1	294
	First Generation Seedling Seed	Iron Range Resources	Calumet	9/16/1982	1.7	220
	First Generation Seedling Seed	Minnesota DNR	Longprairie	5/18/1984	4.0	495
	First Generation Seedling Seed	Minnesota DNR	Nickerson	5/15/1984	2.4	403
	First Generation Seedling Seed	Potlatch Corp.	Gillogly Rd.	6/28/1983	5.5	183
	First Generation Seedling Seed	Red Lake Nation	Redby	4/29/1987	1.8	516
	First Generation Seedling Seed	St. Louis County	Ellsburg Rd.	5/10/1988	1.6	280
	Second Generation Full Sib	St. Louis Co/Iron Range Res.	Ellsburg Rd. East	5/12/1999	3.8	2574
	First Generation Seedling Seed	Wausau Paper	Barnes	5/27/1988	4.1	549
Red Pine	First Generation Seedling Seed	Cass/Beltrami/Hubbard Co.	Blind Lake	9/10/1991	5.3	2249
	First Generation Seedling Seed	Minnesota DNR	Cotton	7/29/1981	4.5	466
	First Generation Seedling Seed	Minnesota DNR	Eaglehead	6/25/1981	3.6	390
	First Generation Seedling Seed	Plum Creek Timber Co.	Ashwabay	9/17/1985	5.5	401
	First Generation Seedling Seed	Plum Creek Timber Co.	Petenwell	4/24/1990	5.5	1732
	First Generation Seedling Seed	Potlatch Corp.	Gillogly Rd.	7/10/1981	6.6	586
	First Generation Seedling Seed	St. Louis County	Ellsburg Rd.	5/9/1988	5.5	557
	First Generation Seedling Seed	Wausau Paper	Mosinee	5/23/1990	5.7	1174
White Pine	First Generation Clonal	Minnesota DNR	St. Francis	5/15/1985	3.0	319
	First Generation Clonal	Rajala/Itasca County	Bass Lake	5/19/1998	5.7	498
	First Generation Clonal	St. Louis County	Ellsburg Rd.	5/2/1990	1.1	233
	First Generation Clonal	St. Louis County	Ellsburg Rd. East	6/21/1999	2.5	237
White Spruce	First Generation Seedling Seed	Blandin Paper Co.	Latimer	5/15/1967	4.1	224
	First Generation Clonal	Blandin Paper Co.	Arbo	5/1/1976	1.5	121
	Improved First Generation Clonal	Blandin Paper Co.	College	9/5/2000	2.9	780
	Second Generation Full Sib	Blandin Paper Co.	Feeley Orchard	5/24/2005	2.42	900
	First Generation Clonal	Itasca County	Fig. Eight Lake	9/2/1987	1.1	175
	Second Generation Full Sib	Itasca County	Wabana Lake	5/20/2003	1.8	784
	First Generation Clonal	Lake County	Two Harbors	9/2/1987	1.0	206
	Second Generation Full Sib	Lake County	Ostman Pit Road	6/9/2005	1.32	1645
	First Generation Clonal	Minnesota DNR	Cotton	5/1/1977	12.0	206
	Second Generation Full Sib	Minnesota DNR	Eaglehead	6/3/2003	1.8	784
	Second Generation Full Sib	Minnesota DNR	Eaglehead	5/11/2005	1.29	877
	First Generation Clonal	Potlatch Corp.	Cloquet	5/1/1977	3.3	140
	Improved First Generation Clonal	Potlatch Corp.	Gillogly Rd.	6/26/2003	2.1	228
	Improved First Generation Clonal	Red Lake Nation	Redby	6/14/2004	0.9	196
	First Generation Clonal	St. Louis County	Ellsburg Rd.	5/11/1988	1.5	212
	Second Generation Full Sib	St. Louis County	Ellsburg Rd. East	6/6/2003	2.1	896

Table 3. Cones collected by MTIC Cooperators in 2005.

Agency	Orchard	Species	# bushels
Red Lake	Redby	Jack pine	5
MN DNR	Long prairie	Jack pine	20
Potlatch	Gillogly Rd	Jack pine	8
Crow Wing	Crow Wing	Jack pine	9.5
Lake County	Two Harbors	White spruce	5

SPECIES REPORTS

Black spruce

Status

The Co-op maintains several black spruce orchards in good standing. **Koochiching County** currently has two seed orchards, **Big Falls** and **Larsaybow**. Big Falls produces cones periodically, and Larsaybow is still maturing. Some expansion at Larsaybow will likely take place in the future, after grafting success can be improved. The **MN DNR** maintains three orchards: **Sturgeon Lake**, **Eaglehead** and **Split Rock**. Eaglehead and Split Rock are picked periodically, and the seed stored for future planting. Trees at Sturgeon Lake are tall and tightly spaced. The DNR is thinning the orchard to improve solar access and facilitate management efforts. **Blandin's Blackberry** orchard remains in excellent condition, and is picked periodically. **Potlatch** no longer has regular access to their **Cloquet** orchard, which is now located on SAPPI land.

Early in 2005, Pike and Warren discussed the possibility of a trial to test the effectiveness of aerial seeding, and the genetic gains that may be realized by using improved seed in aerial seeding. It was decided that the cost of such a test would be prohibitive, and require substantial field support. After talking to field foresters and other cooperators, who view the aerial seeding program as relatively successful, several recurring questions arose:

1. If a site is not seeded, will natural regeneration be adequate?
2. Can the current seeding rate be reduced?
3. Should improved seed, when available, be utilized for seeding on prime sites?
4. Are genetic gains on lowlands realized?

The MTIC may be able to address the last question with a comparison trial of improved and woods run black spruce on lowlands. This is especially important since genetic trials of black spruce in Minnesota have been planted exclusively on upland sites. The objectives of this trial would be to establish a "ceiling" for genetic gains on lowlands. It would require a well-designed trial on several prime sphagnum sites combining containerized, improved and woods run material. The use of planted material could be combined with a hand-seeded treatment to observe genetic gains and economic benefits of these regeneration practices.

Short and long-term planning

Orchards should be maintained, and cones picked when available. No plans for advanced breeding will be made until the cooperative deems it necessary. Cones should be picked when ready and banked for future planting/aerial seeding. Additional orchards may be needed in the future and will be built on demand. A comparison trial should be established on lowland sphagnum sites to determine realized genetic gains.

White spruce

Status

Ramets were planted into **Potlatch's Gillogly Rd**, and **MN DNR's Split Rock**, both of which are improved first-generation orchards. The crew at **Red Lake** administered extensive vegetation control at the new **Redby** orchard which is in excellent condition.

Final second-generation plantings were established at three sites: **MN DNR's Eaglehead**, **Lake County's Ostman Pit Rd**, and **Blandin's Feeley** planting. The white spruce cone crop was variable in 2005, but unfortunately cone/seed insects are starting to become established. **Lake County's Two Harbors** orchard had a sizeable crop especially on trees that were injected with $GA_{4/7}$ and fertilized last spring. **Itasca County's Figure 8 Lake** is still not very productive, and would benefit from GA and fertilization next spring. **Blandin's Latimer** orchard is approaching retirement, but **Arbo** remains productive and the new improved first-generation **College** orchard is coming on line as well. **MN DNR's Cotton** had a sizeable crop, as did **St Louis County's Ellsburg** Rd. Unfortunately, cones were not collected at Cotton, and cone/seed insects populations were high at Ellsburg Rd, precluding collection.

Survival at the three second-generation populations planted in 2003 looks good so far. At **St Louis County's Ellsburg East**, a border row was planted this spring. **MN DNR Eaglehead** sustained some mechanical damage last year, but is recovering. **Itasca County's Wabana Lake** has a bumper crop of thistle but overall, vegetation control has been achieved and survival is expected to be high.

All five of the white/black spruce comparison trial sites planted in 2003 are still viable. Survival at **Koochiching County's Little Fork** was excellent. **Blandin's Wilson Lake** had an approximately 60% survival rate. **St Louis County's Jean Duluth Rd** and **MN DNR's Shannon Lake** were not visited in 2005 but visits are planned for 2006. Seedlings at **Potlatch's Brookston** planting generally look healthy, but no systematic survey was conducted. A formal mortality survey should be done on all sites in 2007, after five growing seasons have elapsed.

Short and long-term planning

Badgers have claimed several grafts at the expansion of **Lake County's Two Harbors** orchard, and additional grafts will be required for planting next spring. Additional grafts are slated for planting at **Itasca County's Figure Eight Lake** orchard as well. Insect control will need to be considered in the near future and monitored routinely at all orchards. Vegetation control should be a priority on all young plantings.

The comparison trial planted in 2003 will be monitored and mortality surveyed after five growing seasons. Corner stakes have been placed at Brookston, Wilson Lake, and Little Fork. Shannon Lake and Jean Duluth Rd. will also need to be staked.

As of this writing, two of three white spruce progeny tests (**Lake County's Finland** and **Blandin/Itasca County's Nine-Mile**) have been measured after their 20th growing season. Measurements will be completed at **MN DNR's Nickerson** this winter/early spring and results will be posted in the 2007 annual report. This data will be used to rogue improved first-generation orchards. Plans are being made to collect core samples from select trees at white spruce progeny tests for wood quality testing.

Jack pine

Status

Jack pine continues to be a prolific cone producer in seedling-seed orchards. **Crow Wing County** removed 21 trees in an effort to increase spacing at their first-generation orchard, and picked 9.5 bushels in the process. **Potlatch** continues to collect from the **Gillogly Rd orchard** as cone crops are available. In the past year, a clean-up effort (brushing, pruning and thinning) at the **MN DNR Nickerson** orchard was done to reclaim the planting for collections. **Cass, Beltrami and Hubbard County's** joint **Deep Portage** orchard is being reclaimed as well. This fall orchard trees were located, flagged, and the map updated. Competing trees are slated for removal next year to increase accessibility to the crowns of remaining trees. Roguing was completed at **Red Lake's Redby** orchard. **Iron Range Resources Calumet** orchard is suffering from porcupine damage, and collections have been temporarily halted. The property that **Potlatch's** long-standing **Kallstrom** orchard is on will be sold this fall, and the orchard will no longer be available for seed or scion collection.

Two of the second generation plantings continue to thrive: **Crow Wing Co/MN DNR County Line Rd**, and **St Louis Co/Iron Range Resources Ellsburg Rd East**. Both plantings have high survival, are protected by a deer exclosure, and have low amounts of gall rust.

Short and long term planning

Deer browse remains a major impediment to planting jack pine, but demand for seed is expected to remain high due to the many mature jack pine stands that have been hit with jack pine budworm in the last several years. The MN DNR initiated jack pine grafting in 2003 to start building the next generation of improved first-generation seed orchards. Grafting success has been mixed, but is expected to improve with experience. In winter 2006, scion collections are slated for Potlatch's Kallstrom seed orchard to graft the best trees before the property is sold.

Both second generation plantings are producing cones, thus pollen collections for future crosses should begin soon. Breeding will start soon after the ten-year measurements are completed in 2008.

Red pine

Status

In 2005, the red pine cone crop was poor. Five MTIC orchards are mature and producing crops regularly: **Potlatch's Gillogly Rd**, **MN DNR's Eaglehead**, **MN DNR's Cotton**, **Plum Creek Timber Company's Ashwabay**, and **St Louis County's Ellsburg Rd**. **Cass-Beltrami-Hubbard Countys' Blind Lake** orchard is ripe for roguing and access will hopefully be finalized in the next year so measurements can be taken. **Wausau Paper** did not renew membership in 2004 or 2005, but hopefully in the future they will renew, and their **Mosinee** orchard will be measured and rogued. In fall 2004, Pike and Warren measured the **Petenwell** orchard but the orchard was not marked for roguing this fall. Marking this orchard is a priority in 2006 so that roguing may begin in the fall.

Topping remains an elusive practice. Potlatch leads the way by experimenting with six trees last fall. Roughly ½ to 1/3 of the crown from each tree was removed. These trees will be monitored and hopefully additional trees will be topped in this and other orchards.

Short and long-term planning

Red pine orchards are now producing cones on an annual basis, with four to five years between bumper crops. Cone collections remain difficult, and in the absence of squirrel caches or destructive collections, cone pickers are hard pressed to collect even a small percentage of cones in a bumper crop. Lifts are required to access the crowns of older orchards, adding substantial expense to collections. In the next generation, orchards should originate from grafted material to offset some of these problems. Rootstock seedlings will be planted at Gillogly Rd orchard this spring for future grafting. Other agencies should follow suit, managing red pine grafted orchards intensively to prevent trees from growing too tall, too soon, and should administer $GA_{4/7}$ to intensify existing crops.

Cone and seed insects are starting to appear in red pine orchards. Timing pesticide applications to effectively target these insects is difficult. A controlled burn in orchards with large trees that are pruned high offers the best chance to kill the red pine cone beetle while they are over-wintering in the ground. Potlatch had planned a controlled burn this fall, but weather conditions weren't favorable. It will hopefully be tried again in the spring.

Seed from Ellsburg Rd, Eaglehead, and Gillogly Rd was germinated this fall for an upcoming red pine comparison trial. It was sown at Itasca Greenhouse, and will be planted in spring, 2007 at six locations in Minnesota and Wisconsin. These sites will be determined in 2006.

White pine

Status

A bumper crop of white pine cones occurred state-wide, although the **MN DNR's St Francis** orchard was devoid of a cone crop. At St Francis, trees have begun to outgrow orchard ladders, and future topping efforts are planned. Cones have been observed at **Itasca County's Bass Lake** orchard for the second consecutive year and vegetation management has been a continuing effort. A moderate cone crop at **St Louis County's Ellsburg Rd** was not picked, but the orchard remains productive on a regular basis. At **Ellsburg Rd East**, grafts are maturing and survival is excellent. Open-pollinated cones were collected from plus-trees at **Red Lake** Indian reservation for future progeny testing. Pollen was collected at **CFC breeding arboretum** for future crosses, although no new crosses were made.

Blister rust field trials have passed their seventh growing season. The site at St Louis Ellsburg Rd is still in excellent condition. The Itasca County site has largely been abandoned due to deer browse. The site at ORSO has undergone extensive vegetation management and remains a viable study as well. In Grand Marais, Haiby and Warren repaired the fence surrounding the planting to make it deer-proof. Fence posts were tightened and secured, and a layer of poultry netting was added above the existing netting to decrease porosity of the fence. A perimeter was cleared around the outside and inside of the fence to make it more visible to wildlife.

Short and long-term planning

Orchards should be topped, and cones collected when available. In Red Lake, plus-tree selections will be grafted at their nursery once rootstock is available.

A top priority in the white pine research program is to continue making selections and controlled crosses on surviving trees at Tofte "Moose Fence" planting. Crosses will be made either on site or at the breeding arboretum in Cloquet. The progeny of these crosses will be screened for blister rust resistance either in St Paul or Grand Rapids.

Seed collections for a future progeny test have already begun from trees selected at Red Lake. Seed also needs to be collected from other clones selected for improved growth. This population is represented at the Bass Lake orchard in Grand Rapids. This progeny test will evaluate improvements in growth as well as blister rust resistance. This trial will require intensive site preparation, primarily due to the need for deer exclosures. Preparations for this effort will be discussed at a future business meeting.

OUTLOOK

Second-generation breeding is now complete for two species, white spruce and jack pine. A red pine genetics trial is planned for 2007 and seedlings are growing at Itasca Greenhouse. This important trial will also serve as a valuable silvicultural trial, with assistance from faculty at the University of Minnesota. No aerial seeding trial is planned for black spruce, but a genetics trial should be conducted to demonstrate the productivity potential of improved material on lowlands.

Grafting jack pine and white pine will continue in 2006. In red pine, field grafting may offer the best chance to increase accessibility to improved seed. Rootstock should be planted as early as 2006 in preparation for grafting in 2007. Crosses in white pine will continue in conjunction with screening for resistance to white pine blister rust. Test crosses at the second-generation jack pine sites should also begin to keep that program on track. Breeding efforts in red pine should begin to advance gains for this species even further.

For the first time in several years, the Co-op has budgeted a small surplus in the current fiscal year. No members were lost in 2005, and the supporting membership might increase somewhat in 2006. The DNR's contract is slated for renewal in 2007.

In 2006 the University of Minnesota/MTIC will host the third meeting of the Northern Forest Genetics Association at the Cloquet Forestry Center in early September. This workshop will highlight 25 years of genetic progress in the lake states as well as introduce the new as-yet-to-be-named college to the genetics community. We look forward to your attendance. A call for papers will be submitted in mid-January, 2006 to the genetics community across the US and Canada to participate in this event.

APPENDIX

Impact of Light Quantity, Quality and Overstory Type on White Spruce Seedling Growth

It seems intuitive that increased levels of light would be responsible for increased seedling growth. However, seedling response to the quantity and quality of light varies by species and is not necessarily linear. The nature of these interactions makes it difficult to actively manage forest overstories to maximize the growth potential of seedlings without testing a particular species over a variety of light levels and overstory types. The goal of this project was to quantify the growth response of white spruce seedlings over a range of light levels and two different overstory types. Understanding how to maximize white spruce seeding growth would be invaluable to common forest management practices such as thinning operations, shelterwood prescriptions, underplanting, and establishment of mixed species stands.

Specifically the objectives of this study were to (1) examine how the growth of white spruce seedlings are affected by varying amounts of light quantity (percent light transmittance of photosynthetically active radiation) and light quality (red light:far red light (R:FR) ratio), (2) evaluate how the growth of white spruce seedlings differ under a deciduous and a coniferous overstory, and (3) investigate the difference in seasonal percent light transmission reaching white spruce seedlings under different overstories.

The two sites selected were both in Itasca County approximately 40 miles north of Grand Rapids, MN. The first site on Blandin Paper Company land had a deciduous overstory of aspen while the second site on Itasca County land had a coniferous overstory and was dominated primarily by red pine. The aspen dominated site had a strong component of beaked hazel in the understory and a few super-dominant white spruce with an occasional paper birch (*Betula papyrifera*), balsam fir (*Abies balsamea*), or red pine (*Pinus resinosa*) present. The red pine dominated second site also had white spruce, black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), balsam fir, trembling aspen, paper birch, and balsam poplar (*Populus balsamifera*) present in the overstory.

To measure the relative amount of light available to each seedling the percent light transmittance was calculated. This involves taking measurements of PAR, or photosynthetically active radiation, over each seedling and dividing it by the amount of PAR taken at a similar time in an open field. The R:FR ratio was calculated by taking simultaneous measurements of red and far red light over each seedling. To avoid errors due to sunflecks or temporal changes in light availability all measurements of percent light transmittance and R:FR ratio were done under conditions of complete cloud cover.

A note of caution about percent light transmittance; it is *not* the same as percent full sunlight although the two are similar and the calculations used to make them are similar. In general percent light transmittance underestimates percent full sunlight. That is any value of percent light transmittance likely corresponds to a higher value of percent full sunlight.

In late summer of 2003 and 2004 after leader growth had ceased the following measurements were taken on 160 naturally regenerating seedlings at each site: seedling height, current leader length, current leader diameter, ground cover, basal area by species, percent light transmittance and R:FR ratio (2004 only). Each seedling was marked with a survey pin and the latitude and longitude coordinates were recorded to make subsequent visits easier. After the 2003 measurements were taken a lateral leader was removed from a stratified sample of 108 seedlings and taken back to the laboratory to measure needles per centimeter and the specific leaf area of three randomly chosen needles. Percent light transmittance was taken over a subset of 30 seedlings at each site during spring and fall of 2004.

Overall seedling height was positively correlated with percent light transmittance under both the aspen and red pine overstories in 2003 and 2004. During both of these years current leader length and current leader diameter were positively affected by percent light transmission although white spruce seedlings growing under the aspen overstory had larger leader lengths and leader diameters than seedlings growing under the red pine overstory.

Measurements in 2004 indicated that there were significant seasonal differences in percent light transmittance at the aspen site for spring vs. summer and fall vs. summer although the red pine dominated site did not exhibit these differences. The lack of overstory aspen leaves and understory beaked hazel leaves during spring and fall allow for increased light levels to reach white spruce seedlings. During these leaf off periods environmental conditions are suitable for photosynthesis and it is likely that the seedlings, while not actively growing, are increasing their photosynthetic reserves. This may account in part for the increased growth at the aspen site relative to the red pine site where there was no significant difference for percent light transmittance between leaf on and leaf off periods.

The R:FR ratio was significantly higher under the red pine overstory than the aspen overstory and was positively correlated at both the aspen and red pine sites with a) total seedling height, b) leader height, and c) leader diameter (data not shown). However, because the R:FR ratio accounted for less variation than percent light transmittance further discussion will be limited to percent light transmittance.

A multiple linear regression model of leader length and percent light transmission that accounted for initial differences in seedling height was used to explore the effect of percent light transmission on leader length for an 85 cm tall white spruce seedling under both overstories in 2003 (Figure 1) and 2004 (Figure 2). This particular seedling size was chosen because it is the composite average of all seedlings at both sites in 2003 and 2004. Using this same method the correlation of leader diameter and percent light transmission was graphed for both overstories in 2003 (Figure 3) and 2004 (Figure 4) with similar results.

Collectively these results indicate that leader length and leader diameter in white spruce seedlings is positively correlated to increases in percent light transmittance across the entire range of values (0-100%). However, seedlings respond most strongly to increasing light levels from 0% to 20%, and less so to levels between 20% and 40%. Above 40% the response, although still positive, is minimal. These data suggest that the growth response of white spruce seedlings is effectively maximized at 20-40 percent light transmittance and that additional light increases growth but not greatly.

A comparison of leader length growth versus percent light transmission using three different seedlings sizes, 30 cm, 85 cm and 140 cm, which correspond to the shortest, average and tallest seedlings at the site showed that the larger seedlings would have the greatest response across all light levels (Figure 5). Results were similar across years and sites with both leader length and leader diameter (data not shown). From a practical forestry perspective this result indicates that although all seedlings benefit from increased light levels, larger seedlings are more likely to benefit from increasing light levels than smaller seedlings. Of course this phenomenon is transient; as small seedlings become larger seedlings their ability to respond to increased quantities of light increases.

The results here indicate that both leader length and leader diameter are maximized at 100% light transmittance but that increases above 40% do not add much to growth potential. Forest operations that seek to maximize white spruce seedling growth while maintaining an overstory should attempt to provide canopy coverage that allows for 20% to 40% light transmittance to the seedlings. These results were applicable to both hardwood dominated (aspen) sites and coniferous dominated (red pine) sites and were valid for the two years the experiment was conducted.

Summary provided by Andy David from Sarah Worrall's MS Thesis

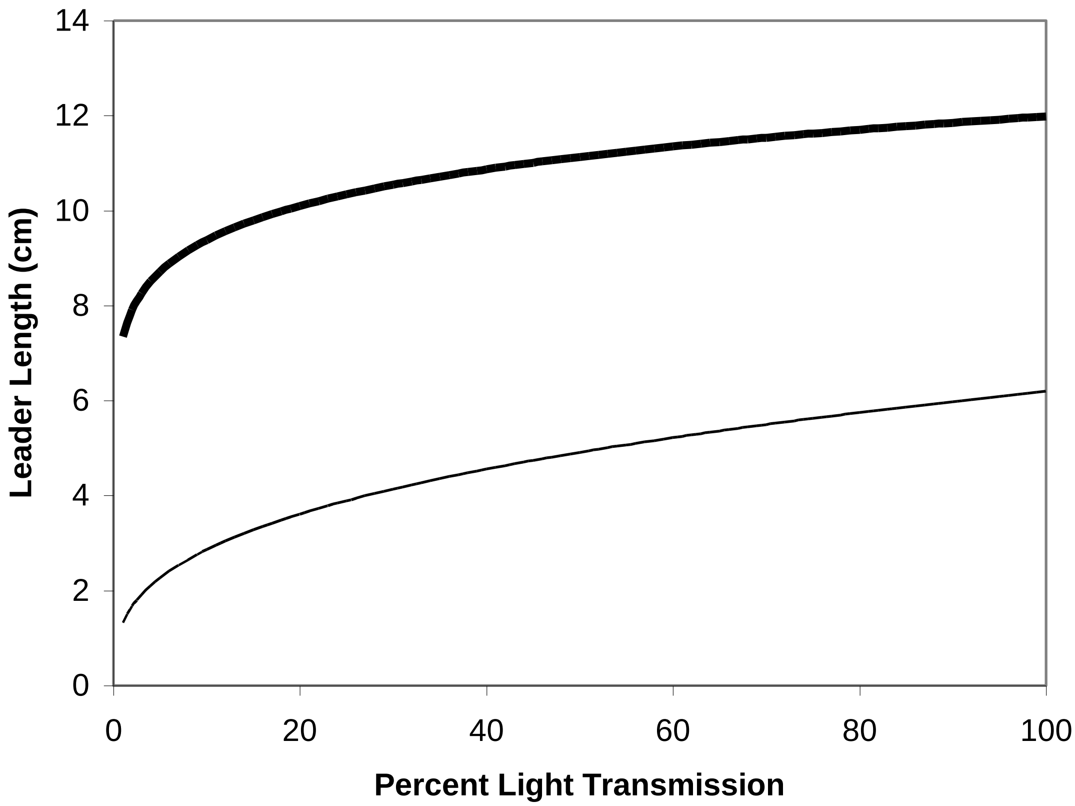

Figure 1. Growth in leader length of an average 85 cm tall white spruce seedling under an aspen and a red pine overstory as influenced by percent light transmission in 2003. (— = 85 cm tall white spruce seedling under an aspen overstory, □□□ = 85 cm tall white spruce seedling under a red pine overstory)

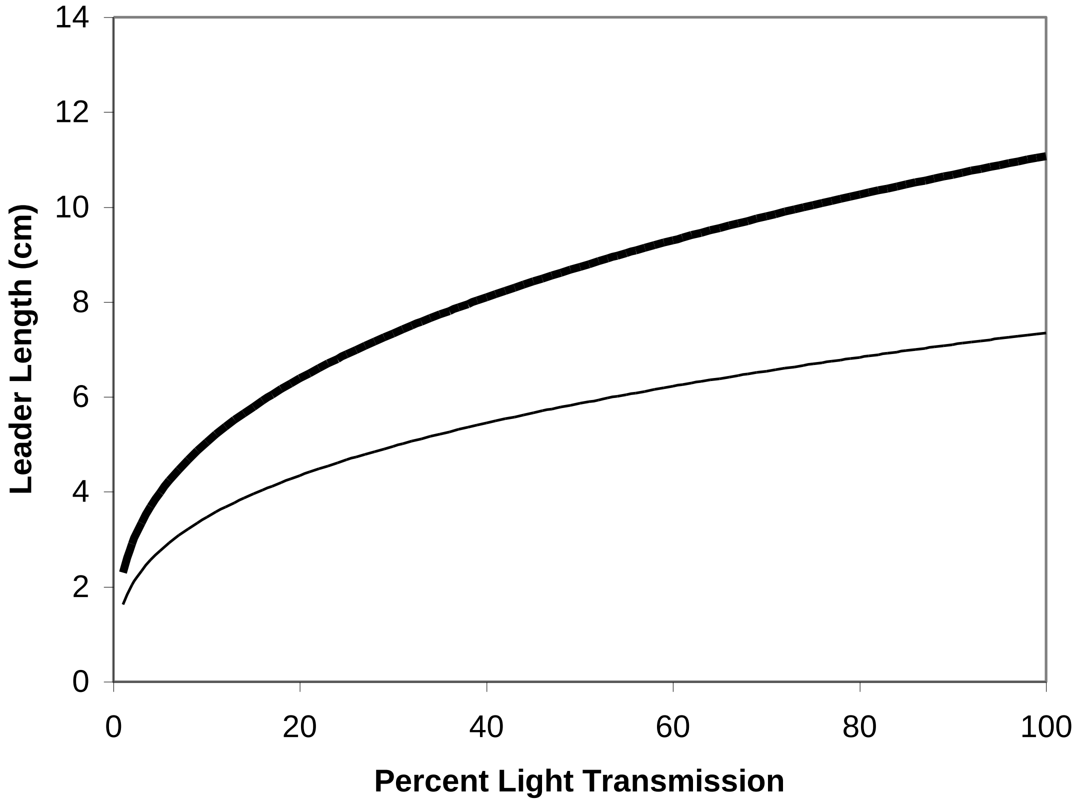

Figure 2. Growth in leader length of an average 85 cm tall white spruce seedling under an aspen and a red pine overstory as influenced by percent light transmission in 2004. (— = 85 cm tall white spruce seedling under an aspen overstory, □□□ = 85 cm tall white spruce seedling under a red pine overstory)

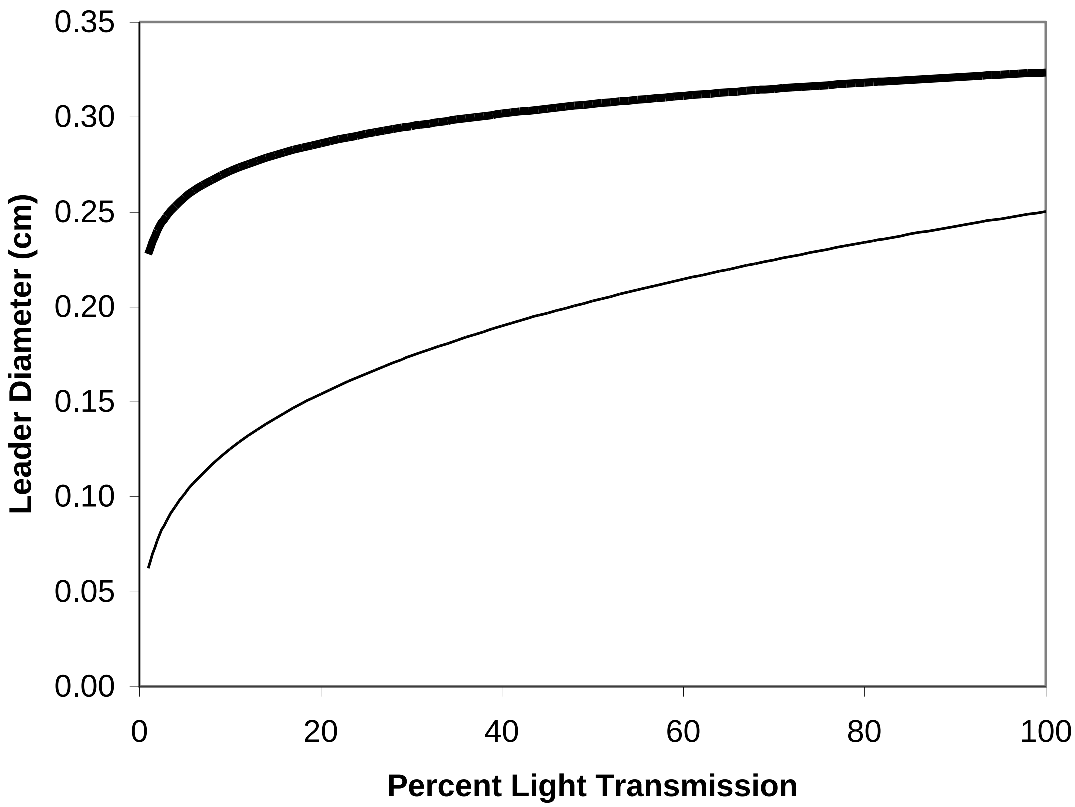

Figure 3. Growth in leader diameter of an average 85 cm tall white spruce seedling under an aspen and a red pine overstory as influenced by percent light transmission in 2003. (▬▬ = 85 cm tall white spruce seedling under an aspen overstory, □□□ = 85 cm tall white spruce seedling under a red pine overstory)

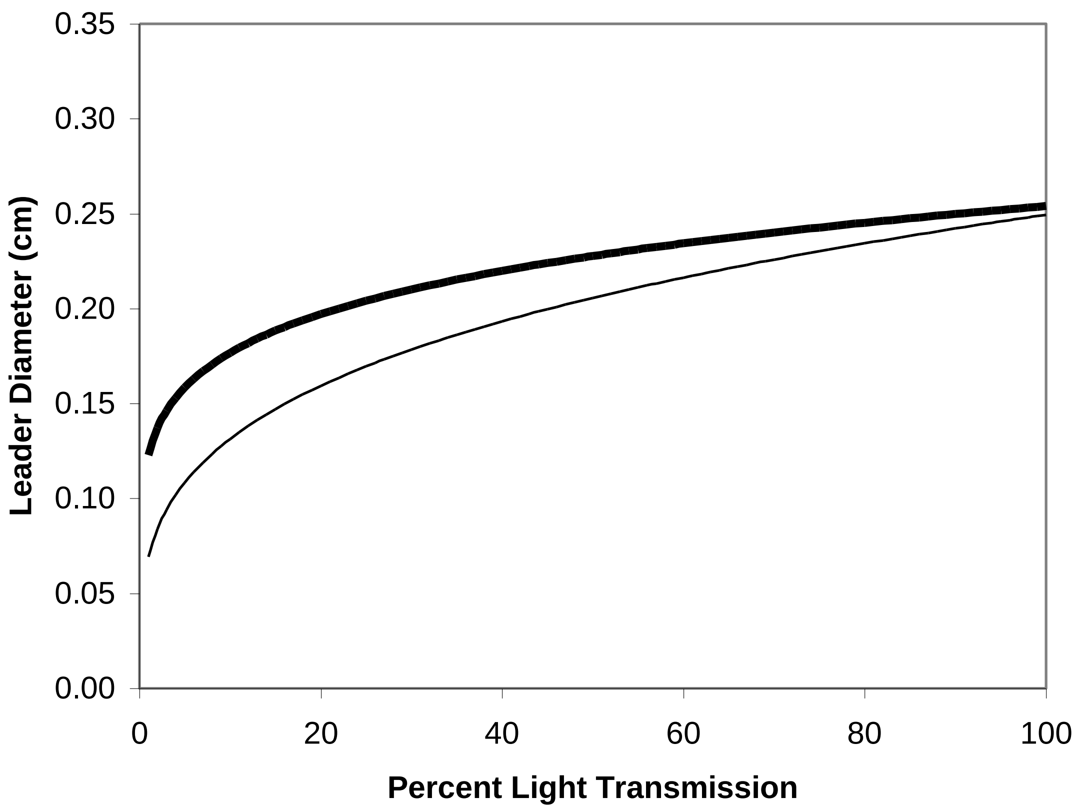

Figure 4. Growth in leader diameter of an average 85 cm tall white spruce seedling under an aspen and a red pine overstory as influenced by percent light transmission in 2004. (▬▬ = 85 cm tall white spruce seedling under an aspen overstory, □□□ = 85 cm tall white spruce seedling under a red pine overstory)

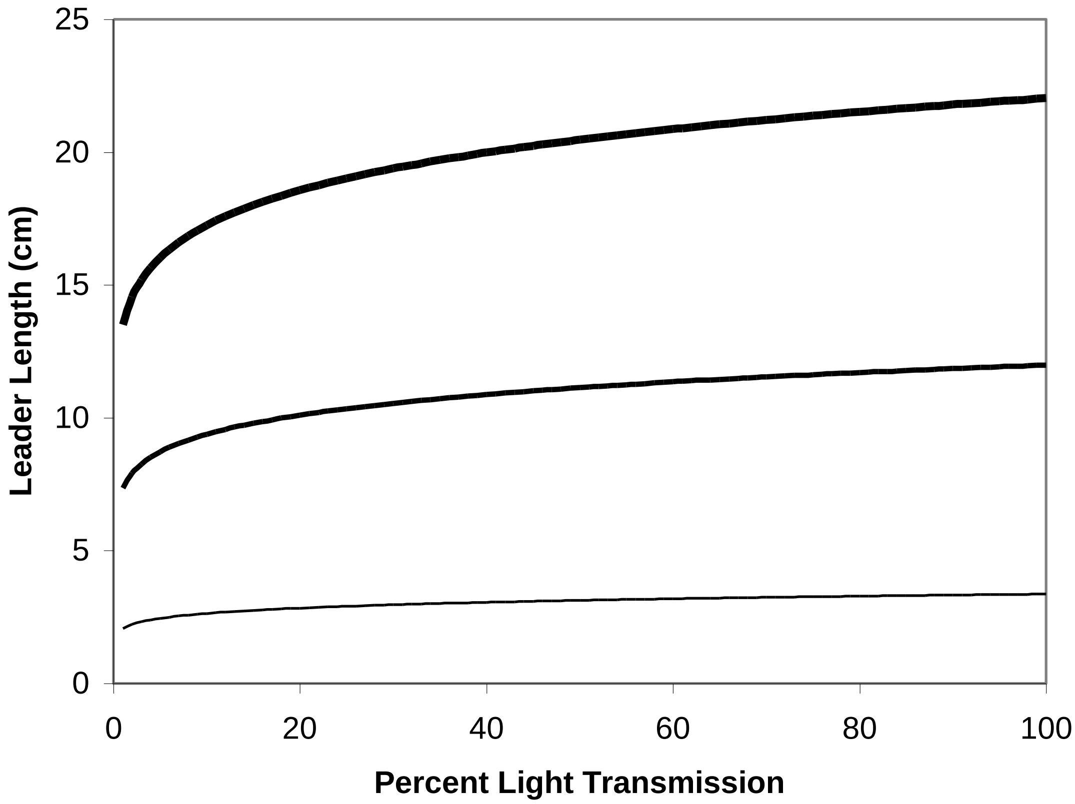

Figure 5. A comparison of the growth in leader length of 30 cm, 85 cm, and 140 cm tall white spruce seedlings as influenced by varying percent light transmissions under an aspen overstory in 2003. (▬▬ = 140 cm tall white spruce seedling, □□□ = 85 cm tall white spruce seedling, □□□ = 30 cm tall white spruce seedling)

White Pine Blister Rust Research

By: Jason Smith and Robert Blanchette
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This past year was a productive year for research on developing blister-rust resistant white pines at the University of Minnesota. During 2005, Dr. Jason Smith successfully completed his Ph.D. under the direction of Robert Blanchette with a major portion of his dissertation research being dedicated to describing mechanisms of resistance to *Cronartium ribicola* in *Pinus strobus* selections. Two publications from this work have been prepared and accepted for publication (publication to be January 2006) from this research. The first publication, entitled "Epicuticular wax and white pine blister rust resistance in resistant and susceptible selections of eastern white pine (*Pinus strobus* L.)" by J.A. Smith, R.A. Blanchette, T.A. Burnes, J.H. Gillman and A.J. David is being published in Phytopathology. In this paper, epicuticular wax is described as a physical barrier to *C. ribicola* spore germination and penetration on resistant selection P327, but not susceptible selection H111. In addition, biochemical analyses reveal qualitative differences in wax biochemistry between susceptible and resistant selections. This work provides important insight into how resistant phenotypes may function to reduce infection and severity of disease and this information can facilitate breeding efforts.

The second paper, "Proteomic comparison of needles from blister rust-resistant and susceptible *Pinus strobus* reveals up-regulation of putative disease resistance proteins" by J.A. Smith, R.A. Blanchette, T.A. Burnes, J.J. Jacobs, L. Higgins, B.A. Witthuhn, A.J. David and J.H. Gillman is being published in *Molecular Plant-Microbe Interactions*. This paper describes a comparison of the proteome of infected and non-infected resistant and susceptible *P. strobus* needles 4 weeks after infection. In this work, several disease resistance proteins are identified (as up-regulated) and sequenced. The sequences reveal similarity to known classes of resistance proteins such as heat-shock proteins and LRR-type resistance proteins. This work is significant because it is the first such report for *P. strobus* and it provides evidence and a framework for molecular-level resistance in *P. strobus*.

Mr. James Jacobs has continued to pursue his M.S. and the histology of resistance, especially in stem reactions is the focus of his thesis. Samples were prepared for histology, sectioned, stained and observed microscopically. New methods have been tested to improve microscopic studies of tissue reactions to *C. ribicola* in *P. strobus*. Mr. Jacobs has been called to active duty in Iraq with the Wisconsin National Guard. He will return in 2006 and will continue with these important studies. Mr. Jacobs and Dr. Smith, with the cooperation of the MN DNR, initiated a stem reaction study at the Zimmerman/Sand Dunes State Forest white pine seed orchard in May, 2005. In this study, stems (branches) were inoculated (by a grafting procedure developed by Smith) with infected and uninfected tissue. The inoculations were monitored and data were recorded on canker development in September 2005 (Fig. 1). The inoculations will be measured in May and September 2006 and the branches will be carefully pruned in September to remove the pathogen and provide samples for stem histology studies by Jacobs.

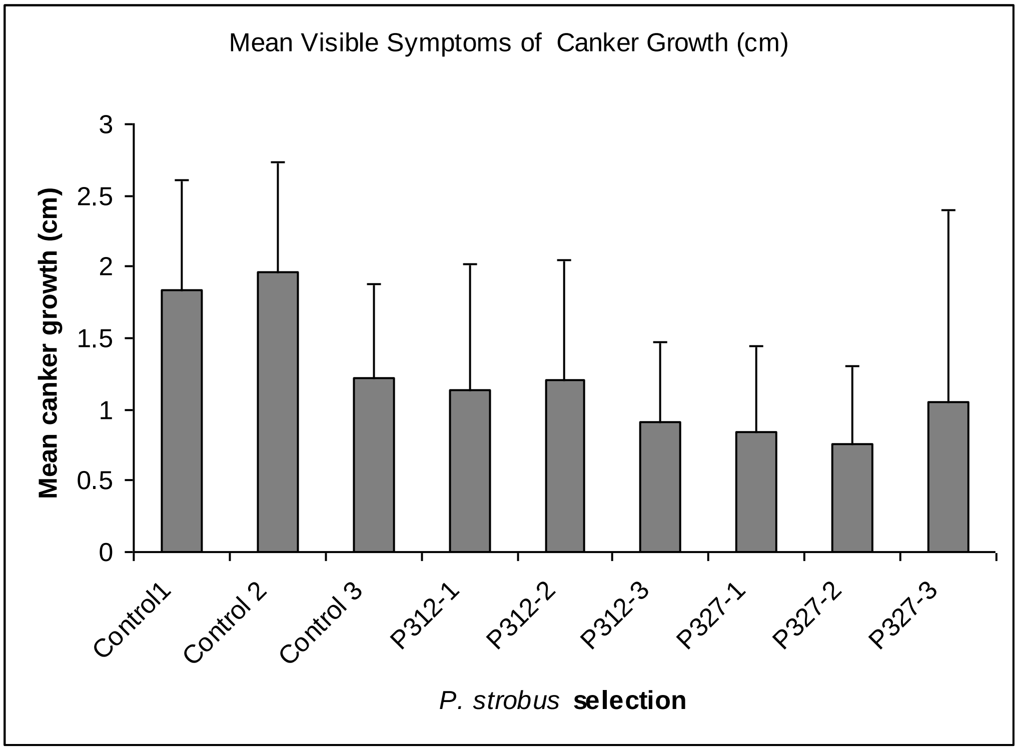

Figure 1. Bar graph depicting canker elongation at 4 months post-inoculation at Zimmerman Field Site.

In addition to the studies described above, Mr. Todd Burnes continues to screen seedlots for resistance to WPBR. During 2005 several more lots were tested including seed from the Tofte plantation and several wild collected seedlots. During 2005, Todd was involved in technology transfer to the Oconto River Seed Orchard to facilitate the development of an operational screening program. This important work continues to provide information about resistance traits, inheritance of resistance and which crosses provide the best resistance.

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USDA Forest Service white pine progeny test: 20-year results on survival and rust resistance

Introduction

In the early 1980s, the USDA Forest Service established eight replications of a white pine progeny test. Open-pollinated seed for the trial was collected from twenty-eight genotypes of white pine from the Forest Service's Oconto River (ORSO) clonal white pine orchard. The ortets in the orchard were selections made by two geneticists: Bob Patton and Carl Heimburger. Patton's selections (genotypes with a 'P' prefix) were taken from trees within a planting on Woodland Avenue in Duluth. The planting was a reforestation project on former agricultural land, but the source of seed is unknown. The origin of Heimburger's selections (with an 'ON' prefix) is also unknown. Open-pollinated seed was collected from trees originating in the Lake States. Seedlings were grown and infected with blister rust prior to outplanting at one site, "Pointe Platon." Seed collected from survivors at Pointe Platon were then planted at another site "Connaught Range." Survivors identified from Connaught Range were selected, propagated clonally, and planted at ORSO. Parentage of the seedlings at Pointe Platon and Connaught Range were not maintained, and it is likely that some genotypes are half-sibs.

The objective of this trial was to field-test Patton and Heimburger selections for resistance to blister rust. Each site was established as a randomized complete block design with 12 replications per site and one four-tree row plot per source in each replication. The test was replicated in each of two years, in each of four National Forests for a total of eight plantings. In the 1983 plantings, 25 families were tested; in 1984, 28 families were tested. Spacing was 8 x 8 ft at three sites, but was variable at site 912 (Gunflint, Superior National Forest). All seedlings were 3-0 bare-root grown at Toumey Nursery in Watersmeet Michigan. Seedlings were lifted in May of the year planted.

Methods

By 2003, four sites in Michigan and Minnesota, two from each of the two planting years, had adequate survival for assessment. In fall 2003 and 2004 Pike, Warren and Haiby measured heights and diameters from surviving trees at all four plantings. Sites planted in 1983 were measured in 2003, and those planted in 1984 were measured in 2004 so all trees were subjected to the same number of growing seasons. Tree heights were measured to the nearest decimeter using a Haglof® hypsometer, and diameters were measured with a d-tape to the nearest millimeter. In addition, incidence of blister rust was visually scored using a four-point scale (0=no rust, 1= minor rust infection, 2=major stem canker, 3=dead with visible stem canker at base). Tree volume was calculated as:

$$Volume = \frac{1}{3}\prod\left(\frac{1}{2} DBH^2 * height \right)$$

Results

Tree volumes were not significantly different among families but differed among sites and reps (Table 1). Differences among families were significant for blister rust scores. The site*family interaction was also significant for both volume and rust scores.

Table 1. ANOVA results across sites for volume and rust score. *=significant at p<0.05 **=highly significant with p<0.001 NS=not significant (p>0.05).

	df	Vol.	Rust
Site	3	**	*
Rep	11	**	NS
Family	28	NS	*
Site*Family	74	**	**
Error	2430		
Total	2546		

Rust scores differed significantly by family for sites 912 and 922 (both sites located in Superior National Forest), but was not significant in sites 914 and 924 (both sites located in the Hiawatha National Forest) (Table 2). Only 1% of trees in site 914 had any signs of blister rust (Table 3). Cankers were found on living trees at approximately 2% of trees at the other Michigan site.

Mean rust scores for all families tested are shown in Table 4. Mean scores for the four most resistant and susceptible clones at three of the four sites are displayed in Figure 1. Means from site 914 are not shown due to a paucity of rust at that location.

Table 2. ANOVA results by site for rust. Degrees of freedom "df" (number of trees – 1) is shown for each site. For site 912, no trees at one rep could be located, thus the df for rep differed from all other sites. Significance is indicated with ** (p < 0.001), * (p < 0.05) or NS (p > 0.05, effect not significant).

	Site							
	912		**914**		**922**		**924**	
	df	**Sig.**	**df**	**Sig.**	**df**	**Sig.**	**df**	**Sig.**
Rep	10	**	11	NS	11	**	11	**
Family	24	**	24	NS	27	*	27	NS
Error	399		626		607		609	
Total	433		660		645		647	

Table 3. List of sites measured, with survival and percent of trees in each rust category. Sites with a “0” had less than 1% of trees in that category. For the rust category, a score of 0 indicated no rust; a score of 1 indicated the presence of a minor canker; a score of 2 indicated the presence of a major canker on the bole and dead trees with a canker scored a 3.

				% by rust category			
Site	**Forest**	**Ranger District**	**Survival**	**0**	**1**	**2**	**3**
912	Superior	Gunflint	43%	54%	16%	22%	8%
914	Hiawatha	St Ignace	61%	99%	0%	1%	0%
922	Superior	LaCroix	50%	80%	1%	15%	4%
924	Hiawatha	St Ignace	48%	85%	0%	2%	13%

Table 4. Mean rust score in Site 912 (Gunflint) by family. Higher means indicate the increased presence of rust. (Families with lowest scores show the most resistance.) Families with different letters are significantly different at $p<0.05$ using Tukey’s HSD test. N=number of living trees in each family.

Family	**Rust Mean**	**N**	**Tukey**
P-327	0.250	16	C
ON-491	0.280	25	C
ON-466	0.462	13	BC
P-343	0.480	25	ABC
ON-4	0.500	18	ABC
ON-645	0.571	14	ABC
ON-646	0.619	21	ABC
ON-469	0.621	29	ABC
ON-519	0.700	20	ABC
ON-500	0.714	14	ABC
ON-644	0.733	15	ABC
ON-504	0.826	23	ABC
P-312	0.833	12	ABC
ON-492	0.850	20	ABC
P-30	0.895	19	ABC
ON-549	0.900	20	ABC
ON-538	1.035	29	ABC
ON-477	1.050	20	ABC
ON-615	1.100	20	ABC
ON-2	1.105	19	ABC
ON-638	1.133	15	ABC
ON-516	1.177	17	ABC
ON-624	1.588	17	AB
ON-70	1.625	16	AB
P-18	1.643	14	A

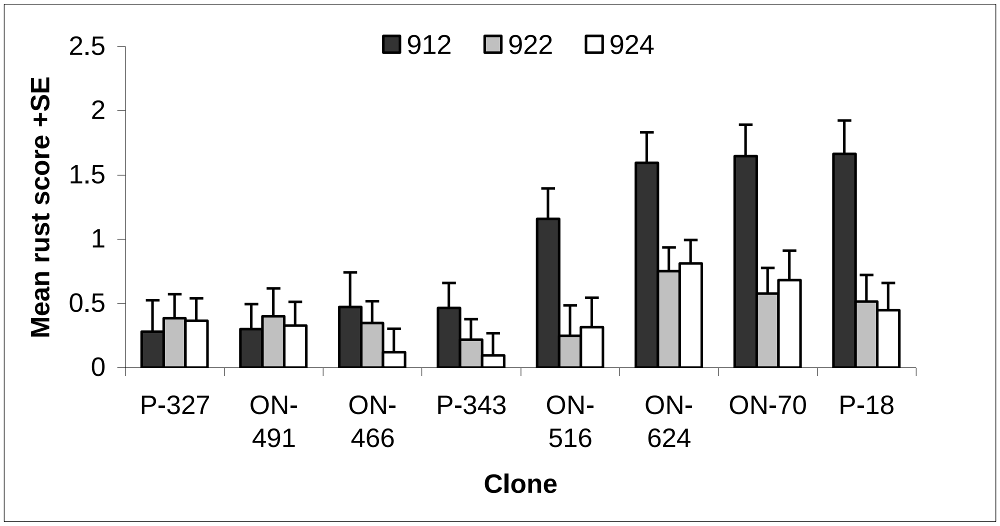

Figure 1. Least-squared means for blister rust score at sites 912, 922, and 924 for eight clones. For rust score, 0=no infection, 1=minor infection, 2=major infection or 3=dead with canker. P-327, ON-491, ON-466 and P-343 ranked 1, 2, 3 and 4 respectively for rust score (ie least infected). ON-516, -624, -70 and P-18, were the most susceptible to blister rust.

Discussion

All genotypes tested in this trial were selected on the basis of possessing possible resistance to blister rust, and not on the basis of tree size. Thus it is not surprising that tree volumes were statistically similar among families. Unfortunately, no wild controls were included in this study so it is impossible to make comparisons to local material.

Field observations revealed the highest incidence of blister rust at site 912, located in the Superior National Forest off the Gunflint Trail. This site is located in a high blister rust hazard zone along Lake Superior in Minnesota. The other planting in the Superior National Forest, site 922, was located inland from the high hazard zone associated with the north shore, and the reduced incidence of blister rust reflected this difference in location. Both sites in the Hiawatha National Forest in Michigan's Upper Peninsula were underplanted, and little rust was found. Hazard risk assessment for these sites is not available although based on a cursory observation of dead trees and the paucity of rust on remaining live trees they are believed to be low-risk sites. For example, infection was so infrequent that at site 914, less than 1% of mortality could be attributable to blister rust.

Mortality at these four plantings was clearly not attributable to rust alone. Even at the Michigan sites, survival did not exceed 61% at the best site, thus factors due to either silviculture or deer browse affected survival. Rust data from ten-year measurements was available for the Gunflint site (912). At that time, 247 of the now 580 dead trees showed some level of infection, thus mortality of roughly half of all dead trees was likely due to rust. Data was not available for the other three sites, but infection rates at those sites were relatively low, and rust probably did not contribute significantly to mortality at those sites.

Two Patton selections, P-327 and P-343, were among the top families for field resistance. Two of Heimburger's selections, ON-491 and ON-466, also showed good resistance and should be considered for inclusion in laboratory screenings to verify these findings. Both ON-466 and P-343 demonstrated high survival at site 912 where the blister rust risk was the highest.

It is highly unfortunate that the parentage of families tested in this trial was not maintained. Several of the distinct genotypes in this progeny test may, in fact, be half-sibs. The planting in Duluth was a reforestation effort not intended to become a nursery for developing blister-rust resistant white pine. As a result, the original seedlots used to reforest the property on Woodland Avenue were not recorded. It is likely that some or many of the trees planted there have the same parents. Similarly, the exact parentage is unknown for trees in the Pointe Platon and Connaught Ridge sites, and the ON-genotypes may also share similar parentage. To prevent inbreeding, all "ON" and "P" genotypes should be treated as half-sibs in any future breeding program.

Acknowledgments

We would like to thank the USDA Forest Service for providing maps and data to measure and analyze this data. Dick Meier, now retired, established these trials, and Paul Berrang is the new Regional Geneticist.

30-year results from a range-wide jack pine regional provenance trial

Introduction

This project was established in Cooperation with Michigan State University (MSU), Petawawa Forest Experiment Station and Blandin Paper Company as an NC-51 project. One seedlot was collected from each of 99 different provenances across the range of jack pine and planted at multiple sites in the United States, Canada and Europe. A subset of 88 seedlots was included in the two plantings located in Minnesota. As a provenance trial, seed was collected from "average" trees from each provenance, not necessarily the "best" trees. Thus, results provide an indication as to how, on average, trees from different locations will perform at a variety of planting sites. Two plantings are located in Minnesota, and are the focus of this analysis.

In 1966 one planting was established each in Grand Rapids on Blandin's Blackberry Experimental Area and at the University of Minnesota's Cloquet Forestry Center's "Airport 40." The design was a randomized complete block with five replications on each site, and one four-tree row plot per each of 88 seedlots in each replication. The spacing was 8 x 8 feet with a single border row surrounding the plantings. Each source was fully replicated at each site. Stock was supplied by MSU as 1-0 stock in spring 1965, and grown in the North Central Experiment Station Nursery in Grand Rapids for planting in mid-May of 1966.

Methods

In fall 2005, after 30 growing seasons, Pike and Warren measured tree heights and diameters at Cloquet, with Humenburger assisting in Grand Rapids. Diameters were measured at breast height (dbh) using a metric d-tape to the nearest millimeter and tree heights were measured using a Haglöf® hypsometer to the nearest decimeter. Tree volumes were estimated using height and diameter measurements with the equation:

$$Volume = \frac{1}{3}\prod\left({}^{1}\!/_{2}\,DBH^{2} * height\right)$$

where dbh and height are expressed in a common unit. The absolute distance of each provenance to each plantation was calculated from latitude and longitude values. Analysis of variance was performed to compare height, dbh, and volume means for planting sites, replications in each site, and seedlots. Least-squared means for tree volumes were calculated at each planting. Mean seedlot volumes were correlated between planting sites using Pearson correlations. In addition, mean volume for each seedlot was correlated to its distance from the planting site.

Results

Overall survival, plantation means, and ranges for height, dbh and volume are shown in Table 1. Survival was roughly 50% at both sites. Mean provenance volumes were significantly and negatively correlated with distance from site ($r^2 = -0.22$ at CFC and $r^2 = -0.29$ at Blackberry, $p<0.001$ for each) (Figures 1 & 2). Survival for local provenances (Minnesota and Wisconsin) exceeded 60% (Table 2). Seedlot volumes for sources originating in MN and WI exceeded the plantation average by 26% in Cloquet and 18% in Blackberry (Table 2). Survival by provenance, sorted in descending order, is shown in Table 3. Survival of provenances from Minnesota and Wisconsin all exceeded 50%. The highest mortality occurred among sources from Northwest Territories and Quebec.

Table 1. Survival and size statistics from plantings in Cloquet and Blackberry.

	Cloquet	**Blackberry**
No. Live Trees	846	832
Overall Survival	47%	52%
Mean height in meters (feet)	16.6 (53)	17.4 (57)
Range of tree heights	8.9-20.9 (29-68)	9.1-22.0 (30-72)
Mean dbh in cm (inches)	19.9 (7.8)	19.6 (7.7)
Range of tree dbh	10.0-32.5 (3.9-12.8)	8.1-29.9 (32-11.8)
Mean volume in meters^3 (ft^3)	0.0018 (0.063)	0.002 (0.065)
Range of volumes	0.00029-0.005 (0.0104-0.176)	0.00016-0.0046 (0.005-0.162)

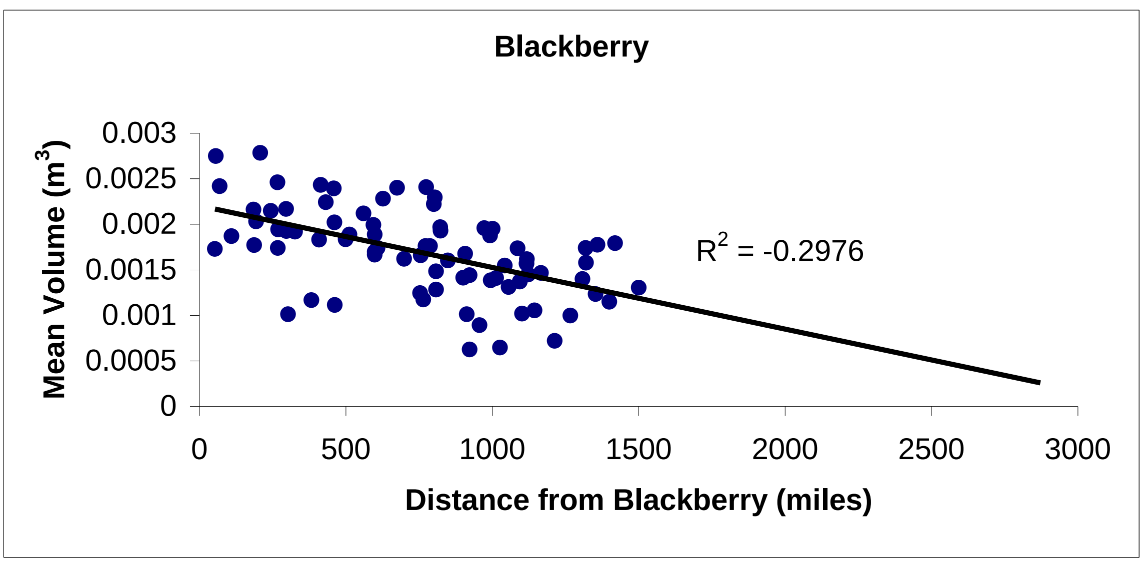

Figure 1. Mean provenance volume plotted against the distance from the planting site in Blackberry.

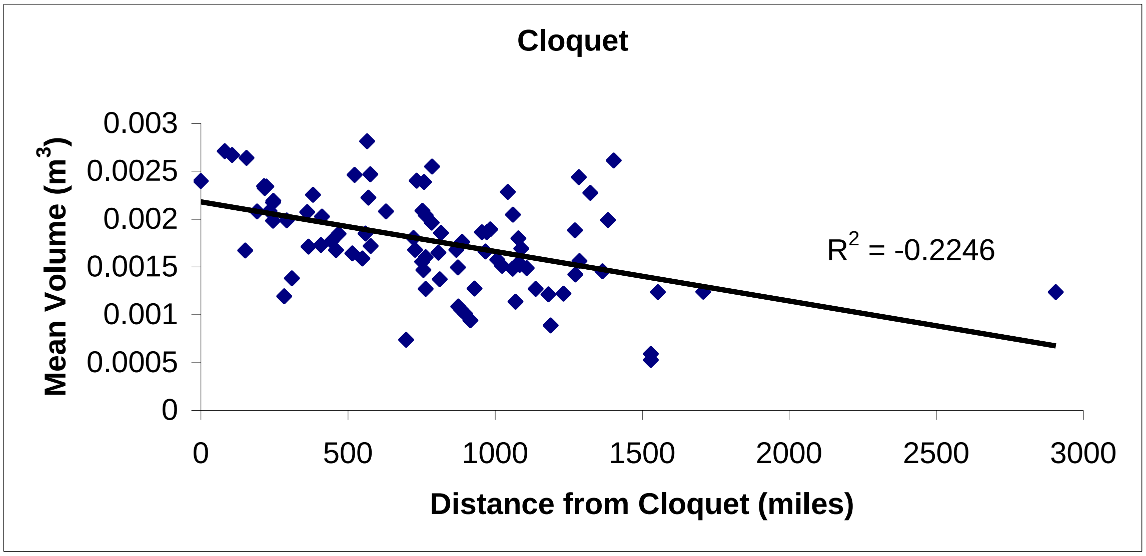

Figure 2. Mean provenance volume plotted against the distance from the planting site in Cloquet.

Table 2. Mean height, dbh, and volume for Cloquet and Blackberry sites. Seven sources (Minnesota: #78 Brainerd, #79 Cloquet, and #80 Cass Lake; Wisconsin: #70 Nokomis, #68 Waupaca, #42 Douglas, and #69 Mosinee) represent "local sources." Arithmetic, un-weighted, means were calculated from these seven provenances.

		Cloquet	**Blackberry**
Height	Plantation Average (meters)	1.66	1.75
	Average for local sources	1.74	1.81
	% difference in height	**5%**	**4%**
DBH	Plantation Average (cm)	20.0	20.0
	Average for local sources	22.7	21.6
	% difference in diameter	**12%**	**8%**
Volume*	Plantation Average (meters3)	0.066	0.070
	Average for local sources	0.090	0.085
	% difference in volume	**26%**	**18%**

* Volume estimated with $D^2 * H$

Table 3. Seedlot origins sorted in descending order by survival.

ID #	Location	State/ Province	Surv-ival
46	Petawawa Plains	ON	80%
68	Waupaca	WI	80%
47	Harry Lake	PQ	80%
71	Freesoil	MI	78%
72	Fife Lake	MI	73%
66	Wisconsin Dells	WI	73%
82	Kenora	ON	73%
70	Nokomis	WI	70%
80	Cass Lake	MN	68%
48	Baskatong Lake	PQ	68%
67	Nekoosa	WI	68%
69	Mosinee	WI	68%
83	Hadashville	MAN	68%
60	Goulais river	ON	68%
57	Miller Lake	ON	68%
54	Kettle Point	ON	65%
61	Benny	ON	65%
79	Cloquet	MN	65%
75	Gladstone Bay	MI	65%
74	Marl Lake	MI	65%
8	Turtle Creek	NB	63%
65	Lone Rock	WI	63%
16	Pelletier Station	PQ	63%
37	Lac de Loutres	PQ	63%
78	Brainerd	MN	60%
49	Capitachouane River	PQ	60%
55	Clark Point	ON	60%
62	Gowganda Lake	ON	58%
42	Douglas	ON	58%
63	Nellie Lake	ON	58%
50	Lac Villebon	PQ	58%
76	Terrace Bay	ON	58%
56	Wasaga Beach	ON	55%
32	Alex River	PQ	55%
31	Taillon Peninsula	PQ	55%
51	McKinnon Lake	PQ	55%
33	Lake Valade	PQ	55%
84	Vermillion Bay	ON	53%
44	Fort Coulonge	PQ	53%
73	Marl Lake	MI	53%
58	Silver Water	ON	53%
26	Spencer Lake	ME	53%
81	Fort Frances	ON	53%
40	Clare River	ON	53%
12	Allardville	NB	53%
30	Port Alfred	PQ	53%
23	Upper Jay	NY	53%

Legend:
MAN=Manitoba
ME=Maine
MI=Michigan
MN=Minnesota
NB=New Brunswick
NH=New Hampshire
NS=Nova Scotia
NWT=Northwest Territories
NY=New York
ON=Ontario
PEI=Prince Edward Island
PQ=Province of Quebec
SASK=Saskatchewan
WI=Wisconsin

27	St Louis de France	PQ	50%
10	Marcelville	NB	48%
9	Grand Lake	NB	48%
39	Twin Lakes	ON	48%
28	Chateau d'Eau	PQ	48%
34	Manouan Lake	PQ	48%
29	Murray Bay	PQ	45%
18	St. Alexandre	PQ	45%
7	East Bideford	PEI	45%
90	Cowan	MAN	43%
20	Toulnoustook River	PQ	43%
6	Thompson Station	NS	40%
77	Caramat	ON	40%
41	Kalandar	ON	40%
86	Sandy Lake	ON	38%
35	Downs Lake	PQ	38%
11	Cains River	NB	38%
15	Patapedia Depot	PQ	38%
36	Ducharme River	PQ	38%
14	Nepisiquis River	NB	35%
85	Red Lake	ON	33%
87	Macdowall	SASK	30%
24	Mt. Chocorua	NH	30%
22	Geraldine	PQ	30%
64	Smoky Falls	ON	25%
88	Big River	SASK	25%
13	Lobster Lake	ME	25%
94	Lac la Biche	ALB	23%
38	Mistassini Post	PQ	20%
21	Little Calumet River	PQ	20%
95	Fort McMurray	ALB	18%
89	Nipekamew River	SASK	18%
4	Highland Park	NS	18%
25	Welch Mt	NH	13%
92	Reindeer Lake	SASK	13%
97	Yellow Knife	NWT	10%
5	Neils Harbour	NS	10%
91	Kississing Lake	MAN	8%
98	Fort Simpson	NWT	5%
19	Lac Sault-au-Cochon	PQ	5%
99	Wrigley	NWT	3%
53	Kanaauopscow Lake	PQ	3%

Discussion

Overall survival at the two plantations was moderate and slightly better in Blackberry. In Cloquet, many trees had densiometer bands at breast height, and showed constricted growth at that point. Several large trees with densiometers were dead. These bands had been in place for an unknown period of time and were removed from all living trees during the fall 2005 survey.

Local provenances outperformed remote sources at both sites in terms of volume gain and survival. The results of this study underscore the need for exercising seed source control in jack pine when considering artificial regeneration and support the recommendation of King (1966), that local sources should be used in Minnesota. Following this recommendation jack pine orchards in the MTIC have relied upon a combination of general selections as well as local selections made by each cooperator. Operational plantings of seedlings derived from these seed orchards have high survival and excellent growth indicating that they are well adapted to local growing conditions. Exactly how elastic the species is within the state of Minnesota has never been fully elucidated, and would require additional research to establish precise seed transfer guidelines. A graduate student of Dr. Bill Parker, Lakehead University, is charged with analyzing a subset of these trials in Ontario, Quebec, New Brunswick, Minnesota and Michigan. They are comparing growth of provenance to climate to model seed source transfers (setting up seed zones). A portion of this research may be presented at the MTIC fall workshop in 2006.

References

King, James P. 1966. Ten-year height growth variation in lakes states jack pine. IN. Joint Proceedings of the Second Genetics Workshop of the SAF and the Seventh Lakes States Forest Tree Improvement Conference. USDA Forest Service Res. Pap. NC-6; 84-88.

Investigating Resistance to White Pine Blister Rust in Eastern White Pine Selections from Tofte, Minnesota

On July 11, 2003 the Wilderness Research Foundation approved a research project to investigate resistance to white pine blister rust in eastern white pine selections from Tofte, Minnesota. This progress report details accomplishments in the three objectives for the period 1 January 2005 – 30 December 2005.

For this project there are three broad objectives:

- **Objective I.** Re-evaluate surviving individuals at Tofte and expand current Global Positioning System (GPS) map.
- **Objective II.** Make 50 additional selections for the white pine breeding arboretum.
- **Objective III.** Collect seed from 250 rust-free trees and screen seedlings for resistance to white pine blister rust.

During 2005 it was decided that due to the heavy canopy cover throughout much of the stand, the closeness of the original tree spacing in the trial, and the desire to locate individual trees quickly, the GPS coordinates alone were not reliable replacements for permanent monumentation of individual trees. Therefore, numbers have been painted on trees for easy visual identification and as a backup system for "permanent" field tags.

Previously, all surviving tagged trees were visited and assessed for blister rust status. This rescoring effort identified 36 trees that had improved blister rust scores between 1993 and 2003. Of these 36 trees, 32 converted from diseased to disease-free and four additional trees changed from active cankers to slow rusting cankers. After translating and then reconciling the keys from the Tofte genetic trial, the initial blister rust scoring, the grafting records and the MTIC database system (which were all independent) it was determined that these 36 trees had not been grafted into the Cloquet breeding arboretum.

In 2005 scion was collected from five trees and grafted for eventual placement in the Cloquet breeding arboretum. Grafting of the remaining genotypes (45) will target the better examples of the 36 trees with improved blister rust scores and additional trees that show promise based on blister rust score, form and/or vigor. Scion collection is planned for spring 2006 with the subsequent grafting to be done at the Iron Range Resources greenhouse in Chisholm, Minnesota. These additional grafts will be added to the white pine breeding arboretum at Cloquet in approximately two years.

The past year was an exceptional one for cone production in white pine at Tofte, and open-pollinated cones were collected from 58 trees. The seed was extracted and is currently in storage at –20^{0}C. These open-pollinated families will be screened in the lab for blister rust resistance in the near future.

To date, 22 trees from the Tofte plantation have been included in full-sib crosses made at the Cloquet Forestry Center's white pine breeding arboretum. Cones from these full-sib seedlings were collected in fall, 2005 and the seed was extracted and stored. These seeds are also candidates for the blister rust laboratory screening program.

Insufficient numbers of female cones were available for breeding in the white pine breeding arboretum in Cloquet this spring. However there was an abundance of pollen cones, and pollen was collected from 32 different genotypes. This pollen was extracted and will be stored until there are sufficient female cones for breeding.

2006 COOPERATIVE WORK PLAN

Black spruce

- Seed collection/orchard monitoring
- Start collecting seed for future comparison trial

White spruce

- Seed collection/orchard monitoring
- Survey second generation material at Blandin, DNR, Lake County and make replacements as necessary
- Visit and continue monumenting 2003 comparison trials
- Out-plant additional grafts
- Fertilize and inject orchard trees with $GA_{4/7}$

Jack pine

- Seed collection/orchard monitoring
- Scion collection at Kallstrom and bench grafting at MN DNR in March
- Monitor 2nd generation jack pine populations for cone and pollen production

Red pine

- Seed collection/orchard monitoring
- Mark and rogue Petenwell seedling-seed orchard
- Locate and prepare sites for comparison trial (out-plant in spring 2007)
- Out-plant rootstock for grafted improved first-generation seed orchards
- Fertilize, inject with $GA_{4/7}$, and top trees when possible

White pine

- Seed collection/orchard monitoring
- Controlled crosses at CFC, St Louis, Bass Lake or St Francis
- Repair deer exclosures as needed
- Graft selections from Tofte at Iron Range Resources
- Mortality survey blister rust field trials
- Collect open-pollinated seed for future progeny test

Minnesota Tree Improvement Cooperative

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