



College of Food, Agricultural
and Natural Resource Sciences

UNIVERSITY OF MINNESOTA

Department of Forest Resources

MINNESOTA TREE IMPROVEMENT COOPERATIVE

2006

ANNUAL REPORT

Carolyn C. Pike
Coordinator

James C. Warren
Research Fellow

Andrew David
Director

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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
UPM-Blandin
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) completed its twenty-fifth year in 2006 with fifteen full members and six supporting members. A total of \$64,167 was paid in dues including the contract with the MN DNR. Two business meetings were held, one on January 12, 2006 at the Cloquet Forestry Center and another on March 29th at the North Central Research and Outreach Center (NCROC) in Grand Rapids. During 2006, Carrie Pike served as Coordinator, Dr. Andrew David was Director and Jim Warren provided field and technological assistance. Kathy Haiby and Egon Humenburger (both based in Grand Rapids) also provided field assistance.

In 2006, priorities included locating sites for an upcoming red pine trial, collecting white pine pollen, and completing measurements of white spruce progeny tests. One red pine orchard was marked and rogued and measurements were begun on a second orchard. Cones were collected from 11 different seed orchards. The MTIC hosted the third meeting of the Northern Forest Genetics Association (NFGA) at the Cloquet Forestry Center on September 5-7. Pike and Warren visited over 40 different MTIC plantings, including orchards and research trials throughout the year.

Jack pine and white pine are slated for grafting in 2007. Breeding in white pine will continue in 2007 to advance the blister rust genetics program. A red pine seed-source trial is planned for 2007. Seedlings for an upcoming black spruce seed source trial were germinated at Itasca Greenhouse in September 2006 for outplanting in spring 2008.

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INTRODUCTION

The Minnesota Tree Improvement Cooperative (MTIC) celebrated its 25th year in 2006, a remarkable achievement for forest genetics in the Lake States. In 1981 the MTIC was started with seed money from the Blandin Foundation and was supported largely by the Minnesota DNR, University of Minnesota, and two paper companies: Potlatch Corporation and Blandin Paper Company. By 2006 the MTIC had grown to 15 full members (including the University of Minnesota's Department of Forest Resources) and six supporting members. In 25 years, the MTIC has facilitated the production of seed orchards for five conifer species: black spruce, white spruce, jack pine, red pine and white pine.

Accomplishments during 2006 include completion of 20-year measurements of the MTIC's white spruce progeny test, the advancement of two red pine seedling-seed orchards through measurements and roging, and co-sponsorship of the 3rd Conference of the Northern Forest Genetics Association (NFGA) in September. This marked the first gathering of the NFGA since 1993. The MTIC was proud to co-host the meeting with the Sustainable Forest Education Cooperative (SFEC), under the leadership of Louise Levy at the Cloquet Forestry Center, the first cooperative effort of its kind with the SFEC.

Climatologically, 2006 will be remembered for a significant drought. Below-average snowfall was followed by a moisture deficit that continued into the summer and fall months. A series of mild winters has contributed to the proliferation of the white tailed deer and rabbits which are devastating tree planting efforts statewide. In addition to the drought, 2006 was noteworthy for a state-wide bumper crop in white and black spruce cones.

In 2006 the College of Natural Resources (CNR) merged with the College of Food, Agricultural and Environmental Sciences (COAFES) to form the College of Food, Agricultural and Natural Resource Sciences (CFANS). This and other re-structuring within the University of Minnesota aims to fulfill President Bruininks' goal of becoming a "Top 3" University. CFANS Dean, Allen Levine, was hired and began work in November 2006. The new college encompasses 14 academic departments, seven research centers throughout the state, 275 faculty and almost 800 staff. No immediate changes in the MTIC are expected from this merger, but it stands to benefit by the added proximity to the agricultural plant breeders through this enlarged collegiate unit.

This report summarizes activities and accomplishments from January 1 to December 31, 2006. It is organized into five major sections: Administration, Finances, Seed orchards, Species reports, and Outlook. An Appendix, containing progress reports from current and future projects that involved MTIC staff or resources, follows the Outlook section. The summaries provided have not been peer-reviewed or published, and thus the results may be subject to change upon final analysis.

A Letter from the Director

Dear Cooperative Members,

As we put the close on another year of Cooperative activity it is good to take notice of what has been accomplished in the past year as well as where we are as a cooperative. It was a great year for white spruce cone collection and nearly everyone who needed cones had a chance to collect them. We are beginning a long overdue red pine comparison trial which will not only provide realized genetic gains from our own seed orchards but also help other researchers model nutritional requirements and early seedling growth. An upcoming black spruce trial will answer questions related to realized gains from improved stock on lowland sites and the effectiveness of artificial regeneration on lowland sites. As we look to the near future our second generation orchards continue to grow. In particular, the jack pine orchards are approaching 10 years old and are beginning to produce cones. In another year the white spruce comparison trial will have completed its first five years. Time sure does fly!

In the past year we have also celebrated 25 years of MTIC existence by hosting the 3rd Northern Forest Genetics Association meeting at the Cloquet Forestry Center. I would like to thank Carrie Pike, Jim Warren and Louise Levy for the time and effort they expended to make the NFGA meeting a total success. In retrospect twenty-five years is a long time for a cooperative but the MTIC has succeeded because it serves the needs of its members who are willing to work together for a series of common goals. Congratulations to you all.

On a more somber note we learned recently that some of the original data from the Vegetation Management Cooperative has been discarded. Although no one had thought about or used that data in over a decade the Cooperative saw an opportunity to use it in estimating age-age correlations for red pine. At this point we are still trying to find out if a second copy of this data exists. The lesson to be learned is that all original data is important and decisions should not be made in a vacuum. As cooperative members change job descriptions within their respective organizations, and as land parcels with trials and seed orchards are sold, we need to be vigilant in ensuring that the data, institutional knowledge and individual genotypes are preserved.

Onward to the next 25 years!

Sincerely,

Andrew David
Director, MTIC
Associate Professor of Forest Genetics

ADMINISTRATION

Carrie Pike remains Coordinator of the MTIC, based at the CFANS 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 based in 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 MTIC. It met twice during 2006 for business meetings, once on January 12 at the Cloquet Forestry Center, and again on March 29th at the North Central Research and Outreach Center in Grand Rapids. In addition, cooperators were invited to attend the third conference of the Northern Forest Genetics Association (NFGA) on Sept 5-7, 2006 at the Cloquet Forestry Center, which was co-sponsored by the MTIC and the Sustainable Forest Education Cooperative. Registration was \$100/day or \$175 for the entire conference and covered costs for meals, room rental, and speakers. The meeting was attended by 39 people from eight US states and Ontario.

On-site visits were made to over 40 different MTIC plantings in 2006 by Pike and Warren. Pike and David attended the winter meeting of SAF in February. Pike and David gave presentations at the NFGA conference and Pike also attended the annual workshop of Superior-Woods Tree Improvement Association in Dryden. Pike attended a one-week class in "Forest Roads and Timber Appraisal" in early June at the Cloquet Forestry Center, along with a two-day short-course in SAS (Statistical Analysis Software) in December. Warren attended a two-week GIS short-course at La Selva Biological Station in Costa Rica in October. This short-course was funded through a separate grant and the MTIC did not incur any expenses from his attendance.

SEED ORCHARDS

Seed orchards are the means by which the MTIC produces genetically improved seed for use in commercial-scale planting programs. Since 1967, members of the Co-op have established 59 seed orchards, of which approximately 43 are still managed for seed collection. All first-generation jack pine orchards have been rogued. Five red pine orchards have been rogued and a sixth (Cass-Beltrami-Hubbard County's Blind Lake orchard) is being measured this winter, for roguing in 2007 or 2008. A summary of the types and sizes of orchards is shown in Table 4. Tables 5 & 6 list all orchards by species and owner for *Picea* spp. and *Pinus* spp. orchards respectively. All "research" trials that have no function as a seed orchard are listed in Table 7. Cone collections made in 2006 are shown in Table 8.

These tables were updated since the 2005 report to include Itasca Greenhouse's new white pine grafted orchard, "Sayward." Plum Creek Timber Company's Ashwabay orchard was removed from the list due to a change in its ownership.

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

<i>Orchard Type</i>	<i>Black spruce</i>	<i>Jack pine</i>	<i>Red pine</i>	<i>White pine</i>	<i>White spruce</i>	<i>Total Acreage</i>
First Generation Clonal	7.6	---	---	14.1	20.4	42.1
First Generation Seedling Seed	8.2	26.6	36.7	---	4.1	75.6
Improved First Generation Clonal	---	---	---	---	9.6	9.6
Second Generation Full Sib	3.5	6.4	---	---	10.7	20.6
<i>Total acreage by species</i>	19.3	33.0	36.7	14.1	44.8	147.9

Table 2. *Picea* seed orchards actively managed by the MTIC.

Species	Orchard Type	Organization	Planting	Date Planted	Size (ac)	Live Trees
Black spruce	1st Gen. Clonal	Koochiching Co.	Big Falls	May-89	2.3	61
		Koochiching Co.	Larsaybow	May-98	4.0	59
		Minnesota DNR	Sturgeon Lake	May-79	1.3	812
	1st Gen. Seedling	Minnesota DNR	Eaglehead	May-78	2.7	582
		Potlatch Corp.	Cloquet	May-78	3.0	580
		UPM - Blandin	Blackberry	May-78	2.5	596
		Minnesota DNR	Split Rock	May-92	2.4	262
2nd Gen. Full Sib	U of M CFC	Airport 40	May-95	1.1	608	
		Totals	7 orchards	19.3 acres	3560 trees	
White spruce	1st Gen. Seedling	Itasca County	Fig. Eight Lake	Sep-87	1.1	176
		Lake County	Two Harbors	Sep-87	1.0	198
		Minnesota DNR	Cotton	May-77	12.0	206
		Potlatch Corp.	Cloquet	May-77	3.3	140
		St. Louis County	Ellsburg Rd.	May-88	1.5	212
		UPM - Blandin	Arbo	May-76	1.5	121
	1st Gen. Seedling	UPM - Blandin	Latimer	May-67	4.1	224
	1-1/2 Gen. Clonal	Minnesota DNR	Split Rock	Sep-01	3.7	253
		Potlatch Corp.	Gillogly Rd	Apr-03	2.1	187
		Red Lake	Redby	Apr-04	0.9	196
		UPM - Blandin	College	Sep-00	2.9	780
	2nd Gen. Full Sib	Lake County	Ostman Pit Road	Jun-05	1.3	882
		Itasca County	Wabana	May-03	1.8	784
		Minnesota DNR	Eaglehead	May-05	1.3	877
		Minnesota DNR	Eaglehead	Jun-03	1.8	784
St. Louis County		Ellsburg Rd. East	Jun-03	2.1	896	
UPM - Blandin		Feeley	May-05	2.4	900	
		Totals	17 orchards	44.83 acres	7816 trees	

Table 3. *Pinus* orchards actively managed by the MTIC.

<i>Species</i>	<i>Orchard Type</i>	<i>Organization</i>	<i>Planting</i>	<i>Date Planted</i>	<i>Size (ac)</i>	<i>Live Trees</i>
Jack pine	1st Gen. Seedling	Cass/Beltrami/Hubbard Co.	Deep Portage	Oct-82	3.4	492
		Crow Wing County	Crow Wing	Jun-85	2.1	294
		IRRR Agency	Calumet	Sep-82	1.7	220
		Minnesota DNR	Longprairie	May-84	4.0	465
		Minnesota DNR	Nickerson	May-84	2.4	403
		Potlatch Corp.	Gillogly Rd.	Jun-83	5.5	183
		Red Lake Nation	Redby	Apr-87	1.8	516
		St. Louis County	Ellsburg Rd.	May-88	1.6	280
		Wausau-Mosinee Paper Corp.	Barnes	May-88	4.1	549
	2nd Gen. Full Sib	Crow Wing Co./MN DNR	County Line	May-99	2.6	1705
		St. Louis County/IRRRB	Ellsburg Rd. East	May-99	3.8	2574
			Totals	11 orchards	32.98 acres	7681 trees
Red pine	1st Gen. Seedling	Cass/Beltrami/Hubbard Co.	Blind Lake	Sep-91	5.3	2249
		Minnesota DNR	Cotton	Jul-81	4.5	466
		Minnesota DNR	Eaglehead	Jun-81	3.6	390
		Plum Creek Timber Company	Petenwell	Apr-90	5.5	1732
		Potlatch Corp.	Gillogly Rd.	Jul-81	6.6	586
		St. Louis County	Ellsburg Rd.	May-88	5.5	557
		Wausau-Mosinee Paper	Mosinee	May-90	5.7	1174
				Totals	7 orchards	36.7 acres
White pine	1st Gen. Seedling	Itasca County	Bass Lake	May-98	5.7	498
		Itasca Greenhouse	Sayward	Jun-05	0.8	425
		Minnesota DNR	Split Rock	May-93	1.0	88
		Minnesota DNR	St. Francis	May-85	3.0	319
		St. Louis County	Ellsburg Rd.	May-90	1.1	233
	St. Louis County	Ellsburg Rd. East	Jun-99	2.5	237	
			Totals	6 orchards	14.12 acres	1800 trees

Table 4. Research trials (non-orchards) planted by the MTIC.

<i>Species</i>	<i>Planting Type</i>	<i>Year planted</i>	<i>Organization</i>	<i>Planting Name</i>	<i>Last measured</i>
White spruce	Comparison trial	1993	MN DNR	Dago Lake Rd	2002
White spruce	Comparison trial	1993	Plum Creek Timber	Gordon	2002
White spruce	Comparison trial	1993	Potlatch	Orr	2002
White spruce	Comparison trial	1993	UPM-Blandin	Hwy 61	2002
White spruce	Comparison trial	1995	Potlatch	Hill City	2000
White spruce	Comparison trial	1995	U of M	CFC-Airport 40	2005
White spruce	Comparison trial	2003	Koochiching County	Little Fork	2007
White spruce	Comparison trial	2003	MN DNR	Side Lake	2007
White spruce	Comparison trial	2003	Potlatch	Brookston	2007
White spruce	Comparison trial	2003	St louis County	Jean Duluth Rd	2007
White spruce	Comparison trial	2003	UPM-Blandin	Wilson Lake	2007
White spruce	Progeny test	1986	Lake County	Finland	2005
White spruce	Progeny test	1986	MN DNR	Nickerson	2005
White spruce	Progeny test	1986	MN DNR	Ross Lake	2005
White spruce	Progeny test	1986	St louis County	Rabbit Lake	2005
White spruce	Progeny test	1986	UPM-Blandin	Nine-mile	2005
White pine	Progeny test	1999	St Louis County	Ellsburg Rd	2003
White pine	Progeny test	1999	USFS	Grand Marais	2003
White pine	Progeny test	1999	ORSO	ORSO	2003
Black spruce	Full-sib progeny test	1995	U of M	CFC-Airport 40	1995
Red pine	Comparison trial	2007	Beltrami County	Lake Bemidji	
Red pine	Comparison trial	2007	Plum Creek Timber	Manistique	
Red pine	Comparison trial	2007	Potlatch	Lake George	
Red pine	Comparison trial	2007	U of M	CFC	

Table 5. Cones collected by MTIC Cooperators in 2006.

Agency	Orchard	Species	# bushels
Crow Wing Co.	Crow Wing	Jack pine	8
Red Lake	Redby	Jack pine	7+
MN DNR	Eaglehead	Red pine	2
Plum Creek Timber Co.	Petenwell	Red pine	14
MN DNR	St Francis	White pine	40
Itasca County	Bass Lake	White pine	1
Itasca County	Fig. 8 Lake	White spruce	3
MN DNR	Cotton	White spruce	57.6
UPM-Blandin	Latimer	White spruce	15
UPM-Blandin	Arbo	White spruce	29
UPM-Blandin	College	White spruce	5.25

SPECIES REPORTS

Black spruce

Status

Black spruce cone crops in 2006 were moderate to high at most orchards, although cones were not harvested from any MTIC orchard. Seed reserves are full and tree planting remains an uncommon practice for this species. Five orchards are monitored annually and cones are picked as needed. Trees at **Koochiching County's Big Falls** orchard are generally healthy and have produced several good cone crops over the past few years. Trees at the new orchard **Larsaybow** on Dentybow Rd in Big Falls remain in good health. The **MN DNR's Sturgeon Lake** orchard was thinned last year to ease tight spacing. This orchard was used extensively for controlled crosses in the past, but has not been utilized for open-pollinated seed in recent years. **MN DNR's Eaglehead** and **Split Rock** are monitored annually and picked as cones are needed. **Blandin's Blackberry** orchard remains in excellent condition, and cones are picked when needed.

Short and long-term planning

Orchards are visited and monitored annually, but demand for improved seed remains low. Seed for a future comparison trial was collected and germinated at Itasca Greenhouse in fall 2006. Sources include woods run (supplied by MN DNR), and open-pollinated seed from Blandin's Blackberry orchard. Three sites will be selected, two sites on lowland *Sphagnum* types, and a third on an upland site. The primary objective of this trial is to evaluate the performance of seed orchard material vs woods run on lowlands and uplands. On the lowland sites, a hand-seeded and unseeded control area will be incorporated into the design to observe the contribution of natural seeding to the stand. This planting is slated for spring 2008.

White spruce

Status

In 2006, a bumper cone-crop was seen on white spruce trees across the state. Cones were abundant at **MN DNR Cotton**, **St Louis County's Ellsburg Rd**, and at **Blandin's Latimer**, **Arbo**, and **College** orchards. **Itasca County's Figure 8-Lake** orchard, which was injected with GA last spring, produced its largest crop to date. The cone crop at Lake County's **Two Harbors** orchard was low in 2006, but received additional fertilizer and GA in the spring. Cone and seed insects have begun to take hold of cone crops, and control measures are being planned for the future.

The shadehouses at the DNR's General Andrews Nursery and Itasca Greenhouse were cleared of all white spruce grafts this past spring. Ramets were planted into **Potlatch's Gillogly Rd**, **MN DNR's Split Rock**, **Red Lake's Redby**, **Itasca County's Figure 8 Lake**, and **Lake County's Two Harbors** seed orchards. **Blandin's College orchard** has received intensive

maintenance and has produced an early crop. Grafting is nearly completed at Itasca Greenhouse for the College orchard, except for one clone that will be produced in 2007.

The 2005 second-generation plantings at **MN DNR's Eaglehead, Lake County's Ostman Pit Rd, and Blandin's Feeley** orchard received additional seedlings this spring to replace those that died since planting in 2005. Thus far, survival at all three sites is excellent. The 2003 second-generation populations at **St Louis County's Ellsburg East, MN DNR Eaglehead and Itasca County's Wabana Lake** are faring well also. In 2008 all six sites will be formally surveyed for survival.

Short and long-term planning

White spruce remains an important component of forest tree planting programs in Minnesota. Containerized seedlings are increasingly used over bare-root stock, and demand for improved seed remains high. In seed orchards, seed crops are increasingly more vulnerable to insect damage and control efforts will be implemented in the future. The development of improved first-generation orchards will help meet demand while second-generation orchards mature. If grafting becomes necessary to replace dead trees, then rootstock should be potted up in fall 2007 or spring 2008.

Measurements were completed at **MN DNR's Nickerson** (white spruce progeny test) in March. This data will be used to further rogue improved first-generation orchards and to analyze age-age correlations. One replication of the white spruce progeny test, **MN DNR's Ross Lake**, is slated for thinning in 2007. This site was overlooked when DNR regional offices were re-organized in early 2000. The site will be re-measured in fall 2007 after thinning is completed.

2007 will mark the fifth growing season for the white/black spruce comparison trial planted in 2003. At that time a complete mortality survey will be conducted at each site.

Jack pine

Status

Cone crops in jack pine orchards were sparse in 2006. However, cones were collected from trees removed to ameliorate tight spacing. In 2006 40 trees were removed from **Crow Wing County**, and eight bushels of cones were harvested in the process. Spacing issues are also being addressed at **Red Lake's Redby** where seven bushels of cones have been harvested so far, with picking continuing into December. **MN DNR Nickerson, Potlatch Gillogly Rd, and St Louis County Ellsburg Rd** are in excellent condition and would also benefit from thinning efforts. Reclamation at **Cass, Beltrami and Hubbard County's joint Deep Portage** orchard did not take place this fall, but is planned for 2007. **Iron Range Resources Calumet** was visited this summer and is in excellent condition. Ownership of **Potlatch's** long-standing **Kallstrom** orchard has been formally transferred to a private owner. Scion will hopefully be collected in spring 2007 from the remaining trees at that orchard.

The two remaining second-generation jack pine plantings, **Crow Wing Co/MN DNR County Line Rd, and St Louis Co/Iron Range Resources Ellsburg Rd East**, are both in excellent condition. Cone crops have become a regular occurrence at these sites but cones are

not being picked to protect trees from damage. Following ten-year measurements in 2008 some initial roguing will take place and a breeding plan will be developed.

Short and long term planning

High deer populations remain a significance hindrance to planting jack pine in Minnesota. In addition to deer browse, many mature stands have sustained damage from jack pine budworm in recent years. Demand for jack pine seed in the future is expected to be high, as these stands are regenerated. Improved first-generation orchards developed from grafted stock are planned to provide seed in the near future. Grafting success to date has been poor, and was postponed in 2006 due to the small stature of the rootstock. That rootstock was held over and grafting success will likely improve on the larger stock. Grafting will take place in spring 2007 at the MN DNR's General Andrews Nursery in Willow River.

Both second-generation plantings have reached reproductive maturity, thus pollen collections for future crosses should begin soon after ten-year measurements are taken in 2008.

Red pine

Status

In 2006, the red pine cone crop was low for the second year in a row. Overstocking in red pine orchards is necessitating additional thinning. At **MN DNR's Eaglehead** orchard 40 trees were removed and the cones harvested. At the **MN DNR Cotton** orchard 40 trees were fertilized with 1000 # of N per acre and are slated for removal in 2008. It is hoped that the fertilization will enhance the existing cone crop on trees that are slated for removal. At **St Louis County's Ellsburg Rd**, 40 trees were fertilized with moderate amounts of fertilizer this spring. These trees will be targeted for cone collections in 2008 as well, but will not be removed from the orchard. At **Potlatch's Gillogly Rd** eleven trees were injected with a range of GA_{4/7} concentrations and fertilized to enhance flower production next year. The goal of this effort is to determine the maximum amount of GA_{4/7} that can be applied without adversely affecting tree health. Data will be collected through a visual inspection of subject trees in 2007.

Two orchards are coming on-line for seed production. **Plum Creek Timber Company's Petenwell** orchard was marked and rogued in 2006. A sizeable crop was harvested from the rogued trees. Future roguings are planned to prevent crowding. Measurements were started at **Cass-Beltrami-Hubbard Countys' Blind Lake** orchard and are expected to be completed this winter/spring, with roguing to begin as early as fall 2007.

Short and long-term planning

Most MTIC red pine orchards have reached maturity, with four to five years between bumper crops. Despite the presence of cones, cone-harvesting is prohibitively expensive for most organizations. Felled-trees provide the cheapest access to cones, and thinnings are increasingly being used as a tool to reduce crown closure and obtain seed. In general, red pine orchards have been rogued conservatively providing ample trees for future thinning. Methods to enhance

flower/cone production through fertilization and injections of gibberellic acid are still being explored.

Grafted orchards will likely replace the first-generation seedling-seed orchards. In April, 30 rootstock were planted behind the Gillogly Rd orchard for experimental field-grafting in 2007. As soon as grafting is perfected, a new series of grafted orchards should be planted to replace first-generation orchards. Breeding will also follow to advance the red pine program into the next generation.

Seedlings for the upcoming red pine comparison trial, growing at Itasca Greenhouse, will be out-planted in spring 2007 at five locations in Minnesota, Wisconsin and Michigan. More details about this project are provided in the Appendix.

White pine

Status

In 2005, a state-wide bumper crop in white pine was observed. In 2006, most trees were devoid of cones except at two MTIC orchards where cones were abundant. Approximately 40 bushels of cones were collected at the **MN DNR St Francis** orchard near Zimmerman, Minnesota. A bumper cone crop at **St Louis County's Ellsburg Rd** was unfortunately missed, but seed supplies in white pine are adequate. A smaller crop was picked at **Itasca County's Bass Lake** orchard. Survival at Bass Lake is very good, with older ramets tall enough now to require top-pruning. Additional grafts were planted at the **Itasca Greenhouse Sayward** orchard. That orchard is almost fully stocked, and was irrigated this summer to offset drought. Additional grafts will be added in the future to replace dead grafts. The deer enclosure surrounding the Sayward orchard has been largely successful at eliminating damage from wildlife.

Three of the four blister rust field trials planted in 1999 remain in good standing. These trials will enter their ninth growing season in 2007. Tree size, mortality and blister rust cankers will be assessed in 2008, after which a thinning will likely become necessary due to the tight spacing (most sites were planted at 4 ft x 4 ft). In Grand Marais, cage-clips were placed by a Forest Service crew to secure poultry netting that was placed in 2005. Seasonal mowing has helped to reduce the incidence of collisions of unsuspecting mammals with the fence, resulting in fewer breaches.

Interest in P327, a genotype with higher than average resistance to white pine blister rust, remains high. This clone was originally selected out of a plantation in Duluth by Dr. Robert Patton and donated to the U.S.D.A. Forest Service's Oconto River Seed Orchard when Dr. Patton retired. We have had access to this clone for several years through the Forest Service and it exists in each of our clonal white pine seed orchards (with the exception of Itasca County's Bass Lake orchard). Several reports on its performance can be found in former annual reports and in recently published articles (see the section on Plant Pathology in the Appendix of this report). Earlier this year an application to patent P327 through the University's Patent Office, was rejected due to difficulties in patenting this type of material. Instead, the Minnesota Nursery Research Corporation, a non-profit organization, will propagate and release it through various nurseries. This action will make P327 (trade-named Patton's Silver Splendor) available to the public where its anticipate use is in urban landscaping. There is an outside possibility that in the

future this group will provide additional funding for research projects related to white pine blister rust if sales of Patton's Silver Splendor are successful.

Short and long-term planning

Demand for white pine seed has waned in recent years due to problems with deer browse, but orchards remain in good standing and seed is being collected. New selections from Red Lake and Tofte are anticipated to add to our "clone bank" in Cloquet, and controlled crosses will be continued at the CFC breeding arboretum. Sites for future progeny tests will need to be identified to test full-sib seed.

In 2007 grafting is planned at Iron Range Resources using scion collected from selections at Tofte. Additional field and laboratory research is planned with P327 and a grant has been secured from the Wilderness Research Foundation to accomplish this research. For details see the Appendix "Advancing White Pine Blister Rust Research in Minnesota" in this report.

OUTLOOK

The MTIC remains in good financial standing in 2007, with no anticipated changes in membership roles. The DNR's contract is slated for renewal in 2007 as well, and is expected to remain at its current level. Warren's appointment with the Cloquet Forestry Center is expected to continue, and the state-appropriated money for blister rust research is expected to be renewed. A new contract with the Wilderness Research Foundation was secured which will provide additional resources for conducting research related to eastern white pine.

Improved seed has become a mainstay for reforestation programs, especially for cooperators who are investing in containerized seedlings. The advancement of genetic programs for five conifer species, along with orchard development and maintenance, remain top priorities for the MTIC. Cooperators and their orchards are visited annually, and orchard needs are assessed. Second-generation jack pine populations have reached reproductive maturity and will be bred and progeny-tested in the near future. Second-generation white spruce populations are planted and will be measured in the near future as well. Red pine and white pine are slated for future breeding efforts as well. The program in black spruce is lagging, but future investments in low-cost orchards to supplement aerial seeding program might re-invigorate the program.

In 2007 the red pine comparison trial will be out-planted, representing an important step towards understanding the genetic potential of this important species. The 2003 white spruce comparison trial will surpass its fifth growing season, and a mortality survey is planned. In 2008 a seed-source trial of black spruce will be out-planted. This project will demonstrate the potential for genetic gains on the lowlands in which reforestation efforts are most concentrated. The MTIC is poised to march into its 26th year with a strong and supportive core of membership, and a program that is producing a steady supply of improved material for the future forests of the lake states region.

APPENDIX

White Pine Blister Rust Research (Plant Pathology) 2006.

Robert Blanchette, James Jacobs, Jason Smith and Todd Burnes. Department of Plant Pathology, University of Minnesota, St. Paul, Minnesota

Research has continued to further elucidate the mechanisms of resistance in selected families to blister rust in eastern white pine. Needle tissues from controlled crosses with P327 are being sectioned and significant differences have been observed when compared with the susceptible H111 seedlings. Collapsed mesophyll cells within the needles as well as an increased production of phenolics which were previously reported by Jurgens et al. 2003 have been observed in the needles of these controlled crosses. In addition to the general reactions previously seen in the needles, we have begun to measure the extent of hyphal growth within the needle at both 4 weeks and 6.5 weeks post inoculation. In general it appears that the central hyphal bundle found near the vascular cylinder of the needle has a significantly different shape and size when infected needles from cross P327 x P327 are compared with infections found in H111 open-pollinated.

Investigations are also underway to better understand resistance mechanisms that are occurring in stem and branch tissues. These studies using stem tissue of P327 and stem tissue from wild open-pollinated clones were initiated early in 2005. Measurement of canker expansion from the field trials is showing large differences between canker development in P327 and the open-pollinated clones. Continued monitoring of these trees will be made next year to measure canker expansion and the study will likely be removed in late spring 2007. Following removal of the cankered tissue, samples will be fixed and embedded for histological examination and the morphological and chemical barriers produced during the resistance response will be identified.

In addition to histological studies, investigations are being done to identify putative resistance genes important in resistant phenotypes such as P327. Studies are underway to survey for segregation of resistant phenotypes in controlled crosses between P327 and H111. From this population, molecular markers (AFLP) will be generated. The resistance proteins that are identified are being further characterized in order to obtain gene sequences.

Studies on the susceptibility and resistance of *Ribes* cultivars have also been completed in cooperation with Professor Jim Luby, Department of Horticulture, University of Minnesota. This work has evaluated a number of cultivars that resist infection using our urediniospore inoculation methods in the green house.

Table 2. Number of uredinial sori on leaves of *Ribes nigrum* cultivars inoculated under controlled conditions with *Cronartium ribicola*.

<i>Ribes nigrum</i> L. Cultivar identification	Mean number of uredinial sori on <i>Ribes</i> leaves ¹
‘Ben Sarek’	135.4 a
‘Consort-MN-1’	121.6 a
‘WI-1’	107.1 a
‘Ben Lomond’	106.2 a
‘C2-2-1’	5.1 ab
‘Golubka’	0.7 ab
‘Consort-HRC’	0.0 ab
‘9908 P66’	0.0 ab
‘9907 P66’	0.0 ab
‘Nadezhnaya’	0.0 ab
‘D-16-8-14’	0.0 ab
‘Titania’	0.0 ab
‘D-16-6-54’	0.0 ab
‘9908 P45’	0.0 ab
‘Consort-OR’	0.0 ab
‘Crusader’	0.0 ab

¹Means followed by the same letter were not significantly different using Tukey’s (HSD) comparison of means ($P=0.05$).

The good progress over the past year and research publications that have appeared demonstrates the success that can be achieved on selecting resistant eastern white pine to blister rust and identifying resistance tree defense reactions. We are eager to expand our investigations as new funds become available so that this important work continues to provide information about new selections and resistance traits as well as to expand our evaluations of controlled crosses to better understand the inheritance of resistance genes.

We are pleased to report that Dr. Jason Smith has accepted a position and is now assistant professor and forest pathologist at the University of Florida in Gainesville. Jason continues to collaborate on blister rust research and we are searching for funds to keep him involved with the project. James Jacobs has returned from a year of duty in Iraq with the Wisconsin National Guard and is now continuing his thesis research on defense reactions in needles of seedlings from control crosses and in stems and branches of various clones in the field.

Publications:

Smith, J.A., Blanchette, R.A., Jacobs, J.J., Higgins, L., Witthun, B. A., Gillman, J. H. and A. J. David. 2006. Proteomic comparison of needles from blister rust-resistant and susceptible *Pinus strobus* seedlings reveals up-regulation of putative disease resistance proteins. *Molecular Plant-Microbe Interactions* 19: 150-160. pdf reprint available at: <http://forestdpathology.coafes.umn.edu/pdf/mpmi2006.pdf>

Smith, J.A., Blanchette, R.A., Burnes, T.A., Gillman, J.H. and A. J. David. 2006. Epicuticular wax and white pine blister rust resistance in selections of *Pinus strobus* L. *Phytopathology* 96: 171-177. pdf reprint available from: <http://forestdpathology.coafes.umn.edu/pdf/phytopathology2006.pdf>

For additional information on current activities please visit our University informational web site at: <http://forestdpathology.coafes.umn.edu/default.htm> or contact Bob Blanchette at email: robertb@umn.edu

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

Final Report to WRF documenting accomplishments from 2003-2006

A. David, J. Warren, C. Pike

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 July 12, 2003 to June 30, 2006.

- **Objective I.** Re-evaluate surviving individuals at Tofte and expand current Global Positioning System (GPS) map.

All surviving trees were visited and assessed for condition relative to blister rust. The majority are afflicted with active, severe blister rust cankers on their main stem precluding them from inclusion in a breeding program. However, our rescoring efforts identified 520 trees (64%) that remained disease free and interestingly 32 trees that converted from diseased in 1993, to disease-free in 2003. Although they may not be resistant to white pine blister rust, the 32 trees represent genotypes that can overcome some level of infection.

Trees that were missed in the production of the GPS scale map in 1999 and those that were disease free but were not tagged were retagged with unique numbers and their positions entered into the GPS scale map. Due to the heavy canopy cover throughout much of the stand and the closeness of the original tree spacing in the trial, we found that the GPS coordinates alone were not reliable replacements for permanent monumentation of individual trees. Therefore, we have painted identifying numbers on trees as a backup system for “permanent” field tags. The GPS coordinates remain a very useful tool in providing a spatially-accurate overview map and for quickly locating a single tree on the ground, but the error in the GPS coordinates preclude us from identifying trees that are close together, necessitating more permanent monumentation.

- **Objective II.** Make 50 additional selections for inclusion in the white pine breeding arboretum.

Our initial plan to revisit grafting records to determine if any of the 32 trees that converted from diseased to disease free (Objective I above) were already grafted into the breeding arboretum at Cloquet Forestry Center was complicated by the fact that the nomenclature system utilized for the Tofte trial, the initial blister rust scoring, the grafting records and the MTIC database system were all independent. After working with the various keys, numbering systems and databases all these record keeping systems have been reconciled and we now know that two of these 32 trees are already in the Cloquet breeding arboretum.

Sixty-three new trees, including the remaining 30 that converted from diseased to disease free in our rescoring efforts, were then identified for inclusion in the white pine breeding

arboretum. Scion was collected from five trees and grafted in winter 2005 by a private nursery. Progress in getting selected trees grafted into the breeding arboretum has been delayed by both the closure of the Potlatch nursery, which originally agreed to host the grafts until they could be outplanted, and the subsequent poor condition of available root stock. Steps have been taken to improve the condition of future root stock and we have identified a new nursery partner (Iron Range Resources in Chisholm, Minnesota). The remaining trees are targeted for scion collection and grafting in spring 2007.

- **Objective III.** Collect seed from 250 rust-free trees and screen seedlings for resistance to white pine blister rust.

Open pollinated seed was collected from a total of 101 rust-free trees and the seed extracted and sent to St. Paul for screening seedlings in the greenhouse. Forty-three of the families were fully screened. Of the 43 families screened none had the seedling survival rate of the positive control, a white pine named P327. Seed from the remaining 58 families are in storage at -20°C . These open-pollinated families will be screened in the greenhouse for blister rust resistance in the near future. The 250 tree target was not reached because we missed the 2004 collection season. Unseasonably cold weather in August 2004 and unusually warm weather in September 2004 meant that predicting cone ripeness was at best a calculated guess and on our last trip to Tofte we found the cones had already opened and released seed.

Advancing White Pine Blister Rust Resistance in Minnesota

Proposal to Wilderness Research Foundation, July 8, 2006

A. David, C. Pike and J. Warren

Introduction and Background

Recent advances in the previous funding cycle and newly reported research results provide new opportunities for advancing white pine blister rust resistance in Minnesota. The work in this proposal takes advantage of established long-term WRF field trials, newly published information on white pine P327, and a needle color based selection method. These methods will be used to identify white pine trees with increased blister rust resistance and graft them into the Minnesota Tree Improvement Cooperative's (MTIC) white pine breeding arboretum at the Cloquet Forestry Center. The activities will augment the Cooperative's existing breeding and selection work in white pine and will increase the genetic diversity of the breeding population.

Some of the earliest white pine breeding work in Minnesota was accomplished by Cliff and Isabel Ahlgren of the Wilderness Research Foundation, who were interested in increasing blister rust resistance in eastern white pine. To advance this goal they established a white pine grafted seed orchard at the WRF center on Fall Lake using trees that were untested but selected based on their putative rust resistance. Once these trees were sexually mature the Ahlgren's made controlled crosses among them but also included pollen from a white pine named P327, which showed promise in a Wisconsin testing program. The resulting 'hybrid' seedlings were planted in a series of field trials across northern Minnesota at Fall Lake, Itasca County, Cloquet Forestry Center, Isabella Lake, McCabe and Heartbreak Ridge to formally test the blister rust resistance of the parents.

The fact that P327 was included in these crosses is of interest because recent research has indicated that P327 is more resistant to white pine blister rust than susceptible genotypes of white pine. More importantly P327 produces seedlings with higher resistance to the rust in both greenhouse screening trials and field trials, indicating that this increase in resistance is transferable to the seedlings. The six WRF field trials provide a unique opportunity to measure survival and rust incidence in mature trees derived from controlled crosses either with or without P327. Measuring these field trials is an excellent way to evaluate the ten unique parents in the Fall Lake seed orchard for their value to the blister rust resistance breeding program.

Recent research attributed the increased rust resistance of P327 to the production of excess needle wax that occludes the stomates. They suggested that stomatal occlusion effectively prevents infection by blocking the blister rust germ tubes from entering the needle. Morphologically, needles of P327 are characterized by a blue-green color, a hallmark of the excess wax. If a strong correlation between needle color and stomatal occlusion can be demonstrated it would be possible to use needle color as a practical selection method for bringing additional high rust resistant genotypes like P327 into the breeding program. As a practical method, needle color screening offers an enormous savings in time, space and money, over traditional greenhouse or field screening efforts for bringing highly rust resistant trees into the breeding program.

This proposal spans several years and seeks funding for travel, supplies, and salaries for field work. Expected results include evaluation of individual white pine trees from the Fall Lake

orchard for their ability to produce seedlings with increased blister rust resistance, identification of additional trees that produce excessive amounts of needle wax, and the addition of 20 white pine trees with above average resistance to white pine blister rust to the MTIC breeding arboretum at the Cloquet Forestry Center.

Objectives

1. Rescore the Ahlgren (WRF) white pine ‘hybrid’ trials.
2. Assess the potential of needle color screening to identify trees that produce excessive needle wax and occluded stomates.
3. Graft an additional 20 trees into the white pine clonal breeding arboretum at the Cloquet Forestry Center.

Objective 1: Rescore the Ahlgren WRF ‘hybrid’ white pine trials.

Six white pine ‘hybrid’ seedling field trials were produced from crosses made among trees at Fall Lake seed orchard. In 1998 the field trials were remonumented, and the underbrush removed with funding from WRF. Individual trees in the trials will be measured for survival and presence or absence of blister rust. Because the parentage of the trees in these trials is known a breeding value for the parents can be determined based on the performance of their progeny. Parents of seedlings that perform well will be grafted into the Cloquet Forestry Center breeding arboretum (see Objective 3 below) and integrated into the MTIC blister rust resistance breeding program.

Objective 2: Assess the potential of needle color screening to identify trees that produce excessive needle wax and occluded stomates.

To assess the potential of needle color screening we will identify 60 individual white pine trees with blue-green colored needles and assay their needles in the laboratory for excessive needle wax. These individuals will consist of P327 as a positive control, H111 as a negative control, and additional trees from the Tofte trial, the MTIC breeding program, and the U.S. Forest Service. Individuals that produce excess needle wax that occlude stomates similar to P327 will be brought into the clonal breeding arboretum at Cloquet (see Objective 3 below) and integrated into the MTIC blister rust resistance breeding program.

Objective 3: Graft an additional 20 trees to the white pine clonal breeding arboretum at Cloquet Forestry Center.

A breeding program is only as good as the individuals in the breeding population and although P327 is a proven genotype it would be short sighted to rely extensively on one tree. Based on the results of the WRF field trial measurements, and needle wax assays, trees with increased blister rust resistance should be grafted into the breeding arboretum at the Cloquet Forestry Center. This objective will increase the genetic diversity of our breeding population and augment existing MTIC breeding efforts by adding trees that a) produce seedlings with above average rust resistance determined from field trials, or b) possess a morphological trait that limits rust infection.

2007 Red pine comparison trial

Project objectives:

- Determine realized genetic gains for a variety of MTIC seed orchards
 - Estimated gains are approximately 8-12% for volume
- Define “upper limits of productivity” for red pine plantations by combining improved material with silvicultural prescriptions
- Collaborate with U of Minnesota researchers (Dr. ’s Tom Burke and Rebecca Montgomery) to address other silvicultural questions about modeling tree growth and resource utilization.

Material:

1. *Potlatch’s Gillogly Rd orchard (5 sites, 1500 YELLOW flags)*
2. *MN DNR’s Eaglehead orchard (3 sites, 900 BLUE flags)*
3. *St Louis Co’s Ellsburg Rd orchard (5 sites, 1500 GREEN flags)*
4. *One woods run source (5 sites, 1500 WHITE flags)*

Design:

- 1200 trees on each of two sites will be planted at an 8 x 8 ft spacing (1.7 acres)
 - Plum Creek Timber Company, Potlatch, St Louis County
- 900 trees on each of three sites (1.3 acres)
 - Cloquet Forestry Center, Beltrami County
- Randomized complete block design with three 100-tree blocks of each of four (or three) seed sources.

Sites (5):

1. University of Minnesota (Cloquet Forestry Center)
2. Plum Creek Timber Company (north of Manistique, MI)
3. Beltrami County (East of Lake Bemidji)
4. Potlatch (Lake George area)
5. St Louis County (NE Grade, east of Whiteface Reservoir)

Timeline:

- Seeds germinated at Itasca Greenhouse in fall 2005.
- Planting slated for spring 2007.
- Mortality surveyed after three years.
- Tree heights measured after five, 10, and 20 years.
- Tree heights and diameters after 10 and 20 years.

2008 Black Spruce Genetics Trial

Project objectives:

1. Estimate gains in productivity for improved black spruce seedlings vs. unimproved black spruce seedlings on lowland sites. Currently there is no information in the literature regarding the potential advantage of planting improved black spruce seedlings on lowland sites (i.e. bogs). Operationally, these sites are clearcut and regenerated through aerial seeding or natural regeneration.
2. Estimate differences in stems/acre for natural and artificial (broadcast) regeneration on lowland black spruce sites. Typically these harvested black spruce lowland sites are aerially seeded to aid regeneration. However, there is evidence to suggest that this practice is unnecessary due to sufficient natural regeneration from seed rain outside the harvest zone and/or indigenous seed banks.

Material:

1. Blandin's Blackberry orchard
2. Woods Run (obtained from MN DNR)

Design:

Randomized complete block

- 4 treatments
 1. improved planted
 2. unimproved planted
 3. **control – not seeded or planted – natural regeneration only (2 sites)
 4. **broadcast seeded with improved seed (equal to 1 oz seed/acre) (2 sites)
- 5 replications per site
- 3 sites

For the planted treatments each receives a block of 64 trees planted at 7' x 7' spacing. Each treatment in each replication is 56' x 56' or 0.07 acres. Total trial size at each site is 224' x 280', roughly 1.4 acres.

** Upland site would NOT receive the broadcast or unseeded treatment.

Sites:

1. Koochiching County – Upland or Lowland
2. MN DNR Little Fork office – Upland or Lowland
3. Itasca or northern St Louis County - Lowland

Timeline:

Seed was germinated fall 2006 at Itasca Greenhouse. Slated for planting spring 2008.

2007 Cooperative Work Plan

Black spruce

- Identify three sites for black spruce trial (Koochiching County Land Department, MN DNR at Littlefork, and St Louis or Itasca County)
- Visit all orchards, assess management needs.
- Update map at MN DNR Sturgeon Lake orchard.

White spruce

- Grafting at Itasca Greenhouse for Blandin
- Complete analysis on progeny tests and submit to journal.
- Thin and measure Ross Lake white spruce progeny test.
- Visit 2003 second-generation populations and conduct fifth-year mortality surveys.
- Visit 2003 white spruce comparison trial sites and conduct fifth-year mortality surveys.

Jack pine

- Grafting at General Andrews Nursery
- Pest management at MN DNR's Long-prairie orchard
- Visit first-generation orchards and make recommendations for thinning.

Red pine

- Field grafting this winter at Gillogly Rd.
- Measure, analyze, mark and rogue Cass-Beltrami-Hubbard County red pine orchard.
- Plant additional rootstock?
- Thin orchards and harvest cones.
- Collect pollen for tree breeding.

White pine

- Grafting at Iron Range Resources
- Tree breeding
- WRF project- various jobs
- Cultivate *Ribes* and collect rust spores at Grand Rapids.

Minnesota Tree Improvement Cooperative

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