Minnesota Tree Improvement Cooperative

2019 Annual Report

Prepared for the MTIC Annual Meeting
February 13, 2020
NCROC, Grand Rapids

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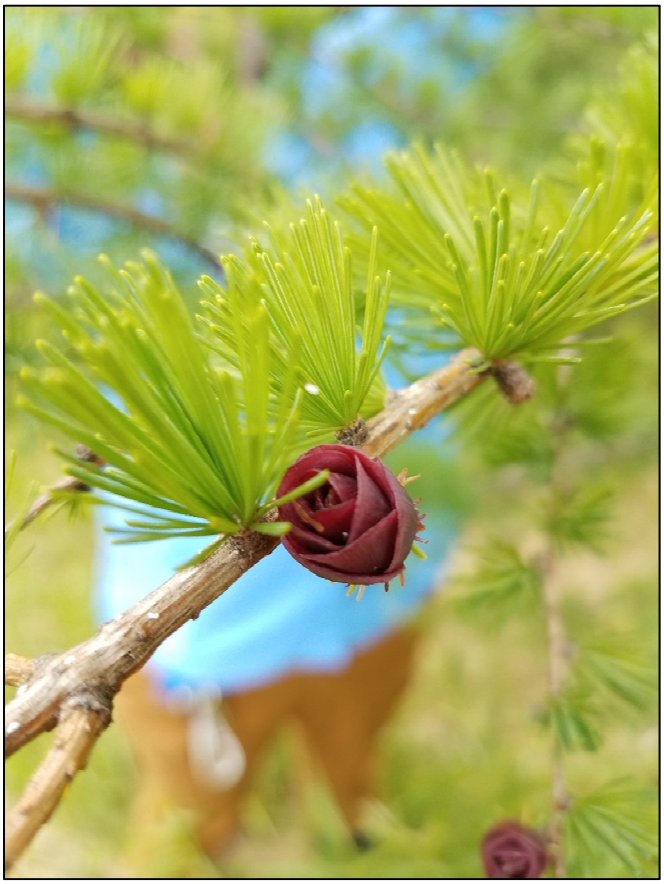
Andrew David, Director

http://mtic.cfans.umn.edu/



MTIC Membership 2019

Full Members

Beltrami County
Carlton County
Cass County
Crow Wing County
Hancock Forest Management - NEW
Itasca County
Koochiching County
Lake County
Minnesota Department of Natural Resources
Red Lake Nation
St. Louis County
University of Minnesota Department of Forest Resources
UPM Blandin Paper Company

Supporting Members

Bureau of Indian Affairs
Clearwater County
Hubbard County
Superior National Forest - NEW

Executive Summary

The Minnesota Tree Improvement Cooperative (MTIC) was created in 1981 by the University of Minnesota because local industries and forestry units wanted genetically improved seedlings for planting. MTIC completed its 38th year in 2019 with 13 full members and 4 supporting members. Hancock Forest Management and the Superior National Forest joined in 2019 while long time member Hedstrom Lumber left the co-op. Dues payments in the amount of $61,980 were collected, including the contract with the Minnesota Department of Natural Resources. Julie Hendrickson conducted day-to-day activities as the Tree Improvement Specialist and Andrew David was the director. One business and planning meeting was held on March 7, 2019 in Cloquet, MN.

In 2019, 2nd generation white spruce populations were measured and a fall workshop was held on October 15. Julie visited 39 orchards and genetic trials throughout the year, and attended the Southern Forest Tree Improvement Conference (SFTIC) in Lexington, KY in June. Both Julie and Andy attended the Lake States Tree Improvement Meeting in Rhinelander, WI on October 8.

Department of FOREST RESOURCES
UNIVERSITY OF MINNESOTA

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A Letter from the Director

Dear Cooperative Members,

Welcome to the Minnesota Tree Improvement Cooperative's 38th year annual report. If you are reading this you likely have an interest in sustainable management of our natural resources, and forests in particular. You may be a practicing forester in charge of reforestation, or someone a bit more removed from the field with a keen understanding of what your organization wants in a reforestation seedling. Regardless, you want the best seedling possible, one that can be successful in the field long after planting.

Over the past year I have noticed regional organizations are asking some hard questions about access to seed that is genetically diverse, well adapted and appropriate for their reforestation efforts. As a cooperative we welcome this concern because these are hallmarks of the seedlings our members produce. When people ask me for a description of what the MTIC does I tell them that we advise cooperators on how to establish and manage their orchards to provide seedlings that have greater survival, greater growth, better form and improved disease resistance while being adapted to their growing conditions.

Is your organization concerned about putting out the best seedlings possible? Are you? If you belong to the cooperative that answer is a resounding "Yes" and others recognize that you and your organization hold reforestation to a higher standard.

Thank you for belonging to the Minnesota Tree Improvement Cooperative.

Sincerely,

Andy

Andrew David
Director, Minnesota Tree Improvement Cooperative

Introduction

The Minnesota Tree Improvement Cooperative (MTIC) completed its 38th year of operation in 2019. Andy David served as the Director and Julie Hendrickson served as the Tree Improvement Specialist. Priorities included taking 15 year measuring the 2005 2nd generation white spruce sites, discussing member needs, visiting as many orchards and trials as possible, and conducting a fall workshop.

This report summarizes activities and accomplishments during the 2019 calendar year (January 1 to December 31, 2019), reports finances for the 2019 fiscal year (July 1, 2018 to June 30, 2019), and includes a projected budget for the 2020 fiscal year (July 1, 2019 to June 30, 2020.) It was written by Julie (unless otherwise indicated) and is organized into five major sections: Administration, Finances, Seed Orchards, Species Reports, and Appendix.

Administration

Julie Hendrickson is the Tree Improvement Specialist and conducts day-to-day operations for the co-op. She is based in Cloquet, MN. Andy David is the Director of MTIC. He is also the Director of Operations for the Cloquet Forestry Center (CFC) and an Associate Professor with the Department of Forest Resources, dividing his time among Grand Rapids, Cloquet, and St. Paul.

The 2018 Annual Meeting was held on March 7, 2019 at the Cloquet Forestry Center in Cloquet, MN after it was rescheduled from the original date due to a snow storm. It was led by Julie and attended by 20 people representing most of MTIC's member organizations.

Julie attended the Southern Forest Tree Improvement Conference (SFTIC) in Lexington, KY June 3-6, 2019 using travel support from the Western Forest Conservation Association (WFCA) through a grant agreement with USDA Forest Service State & Private Forestry. Julie and Andy attended the first ever Lake States Tree Improvement Meeting in Rhinelander, WI on October 8, 2019. The purpose of this meeting was to foster communication about tree improvement, seed needs, and seed transfer among forest geneticists in Wisconsin, Minnesota, and Michigan.

MTIC's fall workshop and field tour was held on October 15, 2019 in the Grand Rapids area. We visited Blandin's College White Spruce Orchard and Bobber Road/Feeley 2nd generation white spruce population along with Andy David's slow ruster white pine and jack pine epigenetics research sites at Grimsbo. 11 people attended.

Seed Orchards

The MTIC maintains approximately 50 active conifer seed orchards covering approximately 138 acres (Table 5).

Carlton County prepared the site and planted grasses in their pollinator garden at **Gillogly Road**. Seeds from this garden will be used in road projects, and the garden will be shared as a demonstration area.

Discussions continue about developing oak seed collection areas, but no action has been taken yet. Some members have expressed interest in using fertilizer or hormone treatments to stimulate cone production

The current status of all *Picea* orchards is shown in Table 6**.** Current *Pinus* and *Larix* orchards are shown in Table 7**.** All active research trials related directly to the MTIC are shown in Table 8**.**

Table 5. Seed orchard acreage by species and orchard type.

Orchard Type	***Black spruce***	***White spruce***	***Jack pine***	***White pine***	***Red pine***	***Tamarack***	***Total acreage***
First Generation Clonal	1.1	22.4	---	18.0	3.3	---	***44.8***
First Generation Seedling Seed	7.7	---	19.1	---	25.5	4.3	***56.6***
Improved First Generation Clonal	10.0	9.6	---	---	---	---	***19.6***
Second Generation Full Sib	---	10.7	6.4	---	---	---	***17.1***
Total acreage by species	***18.8***	***42.7***	***25.5***	***18.0***	***28.8***	***4.3***	***138.1***

Table 6. *Picea* spp seed orchards actively managed by the MTIC.

Species	***Orchard Type***	***Organization***	***Planting***	***Date Planted***	***Size (ac)***	***Live Trees***
Black spruce	1st Gen. Seedling	Minnesota DNR	Eaglehead	5/17/1978	2.7	487
		UPM-Blandin	Blackberry	5/22/1978	2.5	596
		U of M CFC	Plantation "U"	5/22/1978	2.5	3,168
	1st Gen. Clonal	U of M CFC	Airport 40	5/1/1995	1.1	238
	Improved 1st Gen. Clonal	Koochiching County	Big Falls	5/19/1989	2.3	79
		Koochiching County	Ditch 7	5/27/1998	4.0	50
		Minnesota DNR	Sturgeon Lake	5/1/1979	1.3	812
		Minnesota DNR	Split Rock	5/27/1992	2.4	262
			Totals:	***8 Orchards***	***18.8***	***5,692***
White spruce	1st Gen. Clonal	Itasca County	Fig. 8 Lake	9/2/1987	1.1	175
		Lake County	Two Harbors	9/2/1987	1.0	183
		Minnesota DNR	E3	5/12/2012	2.5	172
		Minnesota DNR	E4	5/12/2012	2.8	192
		St. Louis County	Ellsburg Rd.	5/11/1988	1.5	189
		UPM-Blandin	Arbo	5/1/1976	1.5	121
	1-1/2 Gen. Clonal	Carlton County	Gillogly Road	4/1/2003	2.1	122
		Minnesota DNR	Split Rock	9/2/2001	3.7	209
		Red Lake	Redby	4/1/2004	0.9	125
		UPM-Blandin	College	9/5/2000	2.9	762
	2nd Gen. Seedling	Lake County	Ostman Pit Road	6/6/2005	1.3	804
		Itasca County	Wabana Lake	5/20/2003	1.8	689
		Minnesota DNR	Eaglehead	6/3/2003	1.8	396
		Minnesota DNR	Eaglehead	5/1/2005	1.3	398
		St. Louis County	Ellsburg Rd. East	6/6/2003	2.1	368
		UPM-Blandin	Feeley	5/1/2005	2.4	1,530
			Totals:	***17 Orchards***	***42.7***	***6,641***

Table 7. *Pinus* spp and *Larix laricina* orchards actively managed by the MTIC.

Species	***Orchard Type***	***Organization***	***Planting***	***Date Planted***	***Size (ac)***	***Live Trees***
Jack pine	1st Gen. Seedling	Carlton County	Gillogly Rd.	6/28/1983	5.5	183
		Crow Wing County	Crow Wing	6/4/1985	2.1	247
		Iron Range Resources	Calumet	9/16/1982	1.7	220
		Minnesota DNR	Longprairie	5/18/1984	4.0	465
		Minnesota DNR	Nickerson	5/15/1984	2.4	387
		Red Lake Nation	Redby	4/29/1987	1.8	516
		St. Louis County	Ellsburg Rd.	5/10/1988	1.6	279
	2nd Gen. Seedling	Crow Wing Co. / MN DNR	County Line	5/1/1999	2.6	526
		St. Louis / Iron Range Resources	Ellsburg Rd. East	5/12/1999	3.8	895
			Totals:	***9 Orchards***	***25.5***	***3,718***
White pine	1st Gen. Clonal	Itasca County	Bass Lake	5/19/1998	5.7	498
		Minnesota DNR	D2	6/29/2017	2.5	84
		Minnesota DNR	Split Rock	5/25/1993	1.0	88
		Minnesota DNR	St. Francis	5/15/1985	3.0	319
		Red Lake Nation	Cooks Rd.	5/5/2011	2.2	193
		St. Louis County	Ellsburg Rd.	5/2/1990	1.1	233
		St. Louis County	Ellsburg Rd. East	6/21/1999	2.5	183
			Totals:	***7 Orchards***	***18***	***1,598***
Red pine	1st Gen. Seedling	Carlton County	Gillogly Rd.	7/10/1981	6.6	38
		Cass / Beltrami/ Hubbard Counties	Blind Lake	9/10/1991	5.3	400
		Hancock FM	Mosinee	5/23/1990	5.7	1260
		Minnesota DNR	Cotton	7/29/1981	4.5	462
		Minnesota DNR	Eaglehead	6/25/1981	3.6	128
		St. Louis County	Ellsburg Rd.	5/9/1988	5.5	473
	1st Gen. Clonal	Carlton County	Gillogly Rd.	5/1/2011	0.5	51
		Red Lake Nation	Cooks Rd.	5/5/2011	1.3	50
		St. Louis County	Ellsburg Rd. West	6/1/2011	1.5	84
			Totals:	***8 Orchards***	***28.8***	***1,686***
Tamarack	Seed collection area	Minnesota DNR	Split Rock	5/12/2008	4.3	1,795
			Totals:	***1 Orchard***	***4.3***	***1,795***

Table 8. Active MTIC research trials.

Species	*Planting Type*	*Year planted*	*Organization*	*Planting Name*	*Last measured*	*Next Scheduled*
Black spruce	Full-sib progeny test	1995	U of M	CFC-Airport 40	1995	--
	Comparison trial	2008	Koochiching County	Manitou	2017	2027
White spruce	Comparison trial	1993	Minnesota DNR	Dago Lake Rd	2012	2022
		1993	Potlatch Forest Holdings, Inc.	Orr	2012	2022
		1993	Plum Creek Timber Company	Gordon	2012	2022
		1993	Blandin Paper Company	Hwy 61	2012	2022
		1995	U of M	CFC-Airport 40	2005	?
		2003	Koochiching County	Little Fork	2012	2022
		2003	Minnesota DNR	Side Lake *	2012	2022
		2003	Potlatch Forest Holdings, Inc.	Brookston	2012	2022
		2003	St Louis County	Jean Duluth Rd	2012	2022
		2003	UPM-Blandin	Wilson Lake *	2012	2022
	Progeny test	1986	Lake County	Finland	2015	2025
		1986	Minnesota DNR	Nickerson	2015	2025
		1986	Minnesota DNR	Ross Lake	2015	2025
		1986	St Louis County	Rabbit Lake	2005	?
		1986	UPM-Blandin	Nine-mile	2015	2025
	2nd generation population	2003	Itasca County	Wabana Lake	2017	-
		2003	St. Louis County	Ellsburg East	2017	-
		2003	Minnesota DNR	Eaglehead	2017	-
		2005	Lake County	Ostman Pit	2019	-
		2005	Minnesota DNR	Eaglehead	2014	2019
		2005	UPM-Blandin	Feeley	2019	-
Red pine	Comparison trial	2007	Beltrami County	Lake Bemidji	2017	2027
		2007	Potlatch Forest Holdings, Inc.	Lake George	2017	2027
		2007	U of M	CFC	2017	2027
		2007	St Louis County	NE Grade	2017	2027
White pine	Zambino Progeny test for blister rust resistance	1999	St Louis County	Ellsburg Rd	2008	--
		1999	USFS	Grand Marais	2008	--
		1999	ORSO	ORSO	2008	--
Tamarack	Seed source trial	2008	MN DNR	Split Rock	2012	2019

Cone Collections

There is continued interest among members to swap and sell their improved seed. The **Available Seed List** was created in 2019 and a link is posted at http://mtic.cfans.umn.edu/member-resources . This is a list of cleaned seeds that MTIC co-op members have made available to other members.

St. Louis County had a logger remove competing trees from the perimeter and interior of the **Ellsburg Road** orchard complex.

MN DNR obtained two rolling 8-foot step ladders (see photo below by Theresa Dobosenski) and used them while topping trees and picking cones at the **Split Rock** orchard.

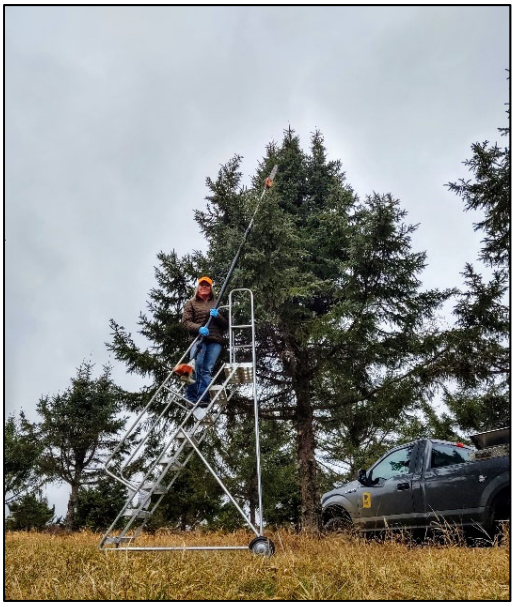

Table 9. Cones collected by MTIC members in 2019.

Species	***Agency***	***Orchard***	***# bushels***
White spruce	St. Louis County	Ellsburg Road	12.5
White spruce	Red Lake	Redby	2
White spruce	Carlton County	Gillogly Road	2
White spruce	MN DNR	Split Rock & GAN E3/E4	21.3
Black spruce	Blandin	Blackberry	12
Black spruce	MN DNR	Split Rock	15.9
Jack pine	MN DNR	Long Prairie	14.7
		Total bushels collected	*80.4*

Species Reports

Black spruce

Black spruce cone crops were moderate to high in 2019 and members collected almost 28 bushels from their orchards. There was no cone crop at Koochiching County's **Big Falls** and **Ditch 7** orchards due to topping and cone collection in 2018. **Ditch 7** was mowed and unused posts were removed to facilitate future mowing. Trees at **Blackberry** were topped to facilitate cone picking. MN DNR used new rolling 8-foot stepladders to pick cones at **Split Rock**.

In January 2020 the MN DNR put out a request to the public for 800 additional bushels of black spruce cones.

The **Manitou** black spruce comparison trial was measured after the 2017 growing season and the data was analyzed recently. A summary of the trial begins on page 25.

White spruce

Some white spruce orchards produced cones in 2019 while others did not. Members collected almost 38 bushels this year.

15 year height and diameter measurements were taken at **Ostman Pit** and **Feeley** 2nd generation populations in fall 2019. The 2005 2nd generation planting at **Eaglehead** will be measured in spring 2020, which will complete the 15 year measurements on all six sites. Survival, mean heights, and mean diameters by site are indicated in Table 10. Julie will proceed with the full data analysis after the final site is measured.

Table 10. Survival, mean heights, and mean diameters for five white spruce 2nd generation sites

Site	Survival	15 year mean height (ft)	ht stdev (ft)	15 year mean DBH (in)	DBH stdev (in)
Wabana Lake	88%	19.7	2	3.7	0.9
Ellsburg Rd E	39%	11.7	2.2	2.2	0.7
Eaglehead 2003	51%	16.1	3.8	3.2	1.2
Feeley	93%	20.5	3	4.2	0.9
Ostman Pit	87%	10	4.4	1.6	0.9

30 year white spruce progeny test data was collected at **Finland, Nickerson, Ross Lake,** and **Nine-mile** after the 2015 growing season. This very large data set has been entered electronically but in some cases the recent measurements do not align with previous measurements. Julie will visit the sites this summer to confirm the data and then proceed with analysis.

College Orchard was row thinned in late 2018 to facilitate access, allow more growing space, and improve conditions for cone production. Every 4th row was removed.

The **Cotton** white spruce orchard was officially retired in January 2019 and will be managed by the MN DNR's Hibbing office as a plantation.

Jack pine

Scion was collected from the **Ellsburg Road East** 2nd generation orchard and used for field grafting tests at **General Andrews E5**. In this informal test, different graft types and wrapping techniques were implemented to see what might work best in jack pine. Unfortunately none were successful so the planted rootstock trees were removed and new plans will be made. In the General Andrews shade house, potted rootstock prepared for 2020 bench grafting was killed by an unknown environmental factor, possibly *P. nemorensis* mentioned below.

Pollen cones were collected from the top tree in each family at both **Ellsburg Road East** and **County Line** 2nd generation orchards. The pollen was extracted in Grand Rapids and will be used for future jack pine breeding activities.

The jack pine at **Gillogly Road** were mapped using GIS information to facilitate tree identification for targeted cone picking.

Red pine

The red pine cone crop was minimal this year. In some orchards cones were visible high in the trees but these were open cones from 2018.

At **Ellsburg Road West**, the rootstock-only trees were identified and removed. These were grafted trees where the scion died and the rootstock took over. Plans exist to expand this grafted red pine orchard to the south where the Zambino white pines were recently removed.

2018 field grafting in General Andrews **E1** was unsuccessful, so the planted rootstock trees were removed in 2019. In the General Andrews shade house, potted rootstock prepared for 2020 bench grafting became infested with eastern pine weevil (*Pissodes nemorensis*) and died. This is a native insect that attacks stressed trees.

The Hancock Forest Management's **Mosinee** red pine orchard was measured in fall 2019. This is a seedling seed orchard that was planted in 1990 for Wausau-Mosinee Paper Corporation. The raw data was shared with Hancock and they had their genetics consultant analyze it.

Tamarack

Split Rock had a large tamarack cone crop in 2018 but very few cones in 2019. One of the incomplete blocks was topped in 2018 in an effort to stimulate cone production. This topping did not lead to increased cone production in 2019, so we will observe the block again in 2020. This site was not measured in 2019 as planned, but will be measured in 2020 before further topping is done.

There is much interest in using the seed collection area at **Split Rock** as a model for developing seed collection areas for other species. It was designed as a rolling block orchard where removing one of the 83 blocks to harvest cones will not affect the amount of genetic diversity remaining in the orchard.

White pine

The Zambino white pine planting was removed from **Ellsburg Road West**. It is likely that the nearby grafted red pine orchard will expand into this space.

The USFS Oconto River Seed Orchard (ORSO) gave MTIC some extra grafted white pine seedlings in 2019. They consisted of genotypes that showed some level of resistance to white pine blister rust in ORSO's screening program. The seedlings were divided between **General Andrews D2** and the Red Lake **Cooks Road** orchard. White pine aphids (*Cinara strobi*) and black sooty mold were found on some of the already established white pines at **Cooks Road**. Insecticidal soap is recommended for controlling these aphids.

In October Julie and Andy met with City of Duluth and Hartley Park staff to re-identify P327, the white pine tree important to blister rust work. A GPS point was taken but it was decided not to monument or label the tree at this time.

White Pine Activities 2019

By Andy David and Jared Gottlieb

Breeding slow rusting genotypes

In the early 2010's we scored all living eastern white pine in the open-pollinated progeny trial at the large Moose Fence site near Tofte, Minnesota. In particular we were looking for trees that exhibited linear cankers with rolled edges that signified an ability to partially resist blister rust. These trees are known as 'slow rusters' because of their ability to co-exist with the fungus by slowing down the rate of canker growth on the bole. In 2012 we planted nine grafts of 51 genotypes and began noticing female cones about four years later.

In 2018 we began collecting pollen and making controlled crosses among these 51 genotypes with the goal of enhancing the slow rusting trait among the offspring (Table 11). Crosses made in 2018 were protected with nylon bags during the summer of 2019 until the cones were removed. Ten of 14 crosses produced cones and seed with an average of 45 seeds per cone (Table 11). Of the four crosses that produced no cones three were from a single female (511). Two other crosses that utilized 511 as a female parent were successful although the seed per cone was lower than the average for all crosses made in 2018. It is too early to tell if genotype 511 can be used successfully as a female parent or if its pollen can be used in crosses instead. In 2019 genotype 511 was used as a pollen parent in eight crosses which should provide a suitable assessment of its ability to be a pollen donor.

Table 11. Cone and seed yield for 2018 eastern white pine slow ruster crosses collected in fall of 2019.

Rep	Position	Female	Male	# Cones	# Seed	Avg. Seed/Cone	
1	10	175	300	2	76	38	
1	51	1124	767	3	225	75	
2	6	63	300	1	45	45	
2	6	63	403	6	332	55	
2	26	511	634	1	40	40	
2	26	511	728	2	62	31	
2	26	511	742	0			
2	26	511	922	0			
2	44	1013	403	1	53	53	
2	51	1124	778	1	29	29	
3	2	22	Control	0			
3	6	63	446	0			
3	23	449	300	3	116	39	
3	24	497	403	2	93	47	
3	26	511	1011	0			
						45	Average # seed/cone

In summer 2019 a bud survey of slow rusters showed additional genotypes with developing female cones and a total of 54 crosses were made with fresh pollen (Figure 1). Most of the new crosses were designed as full dialleles to maximize the amount of information that can be deduced about the performance of individual parents whether they are used as males or females in controlled crosses (some genotypes have been used as both male and female parents, for example genotype 511). During spring of 2020 these developing cones will have to be protected from cone insects with nylon bags and removed in fall when the cones are harvested. In the future we expect to make additional crosses as female and male cones permit and include these crosses as part of a larger field-based progeny trial and/or a blister rust resistance screening trial in cooperation with U.S.F.S. Oconto River Seed Orchard.

Figure 1. Eastern white pine crosses among slow rusting genotypes in 2018 (X) and 2019 (1).

Female \ Male	300	403	446	63	634	728	767	778	1049	511	192	446	1092	1011	1048
63	X	X						1	1	1					
511	1				X	X	1	1							
1124							X	X							
175	X			1	1	1	1	1		1					
497		X			1	1	1	1							
1013	1	X							1	1	1				
12									1	1	1	1			
22									1	1	1	1			
152									1	1	1	1			
243						1	1	1	1						
446						1	1	1	1						
516						1	1	1	1						
609						1	1	1	1						
1048										1	1		1	1	
1059										1	1		1		1
449	X														

Field Trial Measurements - 2001 Regional Provenance / Progeny Trial

In 2019 we finished measuring a regional provenance / progeny trial of eastern white pine put out at three different locations (USFS ORSO, Pike Bay, Eveleth) in 2001. The last location to be measured was a 66 family trial located at the USFS Oconto River Seed Orchard. Originally conceived as a way of testing adaptability of white pine in a local to regional context it can also serve as a source of breeding material and/or grafts. Additionally, the Forest Service is interested in these three sites as a way of evaluating climate change response in eastern white pine and a copy of the data was provided to Carrie Pike.

Traditional data on survival, height, dbh were collected in addition to blister rust, tip weevil and form. After 17 years in the field (18 years from seed) survival averaged 48.5% (family range: 20.0%-77.5%), average height was 6.5 m (5.6 m – 7.1 m) and average dbh was 15.8 cm (10.9 cm – 20.4 cm). While the range of survival values and dbh appears to be typical of a trial in its second decade the range of height values seems suppressed. This is likely a function of high tip weevil presence which tends to shorten trees but has less of an impact on diameter. The tallest family also had the

largest dbh and the lowest survival percentage. Since this trial was installed as single tree plots, instead of the traditional four tree row plot, low family survival does not improve sibling growth through increased resource availability.

Seed and Pollen Testing

As reported last year the Forest Biology flood that occurred in January 2017 has caused us to re-evaluate the viability of our stored pollen and seed. It bears noting that any stored seed and pollen impacted by the flood was related to research and not seed for operational planting.

During 2019 we finished pollen and seed testing and determined that all of our stored pollen is unusable or untrustable. In most cases the pollen was either dead or possessed such low viability that its ability to germinate and fertilize an ovule in the wild was questionable. Occasional pollen lots were still viable and germinated with vigor. Unfortunately, this was the exception and because there were so few of them the decision was made to move forward with new pollen collections. In the case of jack pine we began collecting new pollen sources from top individuals at the Crow Wing County / MN DNR second generation population this past spring.

Germination testing of seed was also finalized in 2019. We targeted both seedlots for which we had previous, pre-flood germination results and seedlots with sufficiently high seed counts that running a germination test would not compromise the number of seed needed for a future genetic trial. In general, seeds were stratified prior to being placed on potting soil in clay saucers and allowed to germinate under glass, on moist soil with a 12+ hour photoperiod. Under these conditions we found that only jack pine and red pine meet the target germination value of 50% on a regular basis. The white pine, spruce and European larch seed did not meet the threshold and is deemed unusable.

Of note to MTIC members the red pine and white pine seed represents crosses that were to be used for future genetic trials, *i.e*. red pine inbreeding test and white pine progeny test and blister rust trial. Seed of other species are not related to future MTIC projects (for example jack pine epigenetics research). In white pine, crosses will have to

be remade with pollen that has to be recollected. Some red pine seedlots should be augmented with additional open pollinated collections or controlled crosses or the experimental design will have to be amended with fewer replications or sites because the 50% viable seed estimate has limited the usable number of seeds.

2008 Manitou Black Spruce Comparison Trial – 10 year summary

Purpose of the trial

Compare the following: 1) planted Blackberry seedlings vs. planted woods run seedlings; 2) hand seeded areas vs. open areas; 3) black spruce establishment using seedlings vs. seeding.

Materials and Methods

Open pollinated seed for this trial was collected in 2006. There were two black spruce seed sources: Blandin's Blackberry orchard and woods run seed from Itasca Greenhouse. The Blackberry black spruce orchard is one of four progeny tests planted in 1978 and later converted to seedling seed orchards. (The others include MN DNR Eaglehead, Potlatch, and two plantings at the Cloquet Forestry Center.) Blackberry was lightly rogued in 1987 and has been used by Blandin for seed collection ever since.

This trial was established on one site in Koochiching County. This site was cut in March shortly before the trial was installed. Black spruce, tamarack, and aspen were the main species harvested.

Double-flushed seedlings were grown at Itasca Greenhouse in Cohasset in fall 2006. Seedlings were planted and seeds were spread in May 2008.

There were four treatments: planted Blackberry seedlings (3 blocks), planted woods run seedlings (2 blocks), hand seeded (2 blocks) and open (2 blocks). Each block is 63ft x 63ft and there are 9 blocks total. Seedlings were planted at 7ft x 7ft spacing, 100 trees per block. For the hand seeded treatment, Blackberry seed was mixed with floor dry and spread using an EV-N-Seed Monkey Grinder at the rate of 1 oz seed per acre. For the open treatment, nothing was applied. The design was randomized incomplete blocks with each rep containing three of the four treatments (see Figure 2.)

Mortality was assessed and heights were measured in May 2011 after three growing seasons. A brief summary of the 2011 data can be found in the 2012 MTIC Annual Report. Heights and diameters were measured in October 2017 and May 2018

after ten growing seasons. Three 1/500th acre circular plots were taken in each of the hand seeded and open blocks. Heights were measured on all trees located within these plots.

Figure 2. Manitou Black Spruce Comparison Trial layout

hand seeded rep 1	**woods run seedlings** rep 1	**Blackberry seedlings** rep 1
Blackberry seedlings rep 2	**open** rep 2	**woods run seedlings** rep 2
open rep 3	**Blackberry seedlings** rep 3	**hand seeded** rep 3

↑ N

Results

Table 12. Survival and mean values for planted black spruce seedlings at Manitou

		2011 data				2017 data					
source	# seedlings planted	2011 trees remaining	2011 survival	2011 mean height (cm)	2011 mean ht st dev (cm)	2017 trees remaining	2017 survival	2017 mean height (cm)	2017 mean height st dev (cm)	2017 mean diameter (mm)	2017 mean diameter st dev (mm)
woods run	200	153	77%	76.5	24.5	132	66%	187.3	86.9	17.4 (n=87)	8.6
Blackberry	300	162	54%	69.5	22.1	132	44%	179.7	69.2	14.1 (n=87)	6.9
total	500	315	63%			264	53%				

Overall survival of planted seedlings was 63% in 2011 and 53% in 2017 (Table 12). Survival in 2017 was higher for the woods run source than the Blackberry source, at 66% and 44% respectively.

Heights and diameters of woods run and Blackberry planted seedlings were compared using a 1-way ANOVA in SAS with rep and source as fixed factors. A log transformation was required for the 2017 diameter data. Here are the results using 2017 data:

- For **2017 height** the woods run lsmean was 192.3 cm (SE=8.7) and the Blackberry lsmean was 179.7 cm (SE=7.1). The woods run source is higher but this difference is not significant at α=0.05.
- For **2017 diameter** the woods run lsmean was 18.3 mm (SE=1.1) and the Blackberry lsmean was 14.7 mm (SE=0.9). The woods run source is higher and this difference is significant at α=0.05.

Table 13. Density and heights of four different treatments in 2017

treatment	2017 trees per acre	2017 mean height (cm)
hand seeded	833	100.5
open	500	57.5
planted seedlings- woods run	725	187.3
planted seedlings- Blackberry	484	179.7
planted seedlings- Blackberry and woods run combined	579	183.5

Observations from density and heights of all four treatments (Table 13):

- In 2017, the density of black spruce seedlings was higher in the hand seeded blocks than the open blocks
- In 2017, the overall density of the planted seedlings was closer to the density of the open blocks. The density of planted woods run seedlings was higher than planted Blackberry seedlings.
- In 2017, mean heights were greater in planted seedlings (both sources) than in hand seeded or open blocks.

Discussion

Blackberry vs woods run seedlings: For the planted seedlings, 2017 survival, 2017 height, and 2017 diameter were all greater for the woods run source than for the Blackberry source, though the only significant difference here was for 2017 diameters.

This may be a bit surprising given that Blackberry is an improved seedling seed orchard. It is important to point out that the Blackberry orchard is located on an upland black spruce site and the Manitou black spruce trial is a lowland black spruce site. Because of this, the seed coming out of Blackberry is likely better suited to upland sites. We don't know exactly where the woods run seed was collected but if it came from a lowland site, it may have had a slight advantage at Manitou. When data was collected in 2017 this trial was only ten years old, and it will be interesting to see if these trends continue as the trees age.

At 53%, survival was low for planted seedlings in 2017. These seedlings were planted on a 7 x 7 ft grid, and there is high variation within the Manitou site. Seedlings planted in inhospitable microsites wouldn't survive very long, helping to explain the low overall survival of seedlings in the trial.

Regarding the significant difference in 2017 diameters between woods run and Blackberry seedling sources, note that we don't have diameter measurements for all of the remaining trees. This is because 34% of them were shorter than breast height. So the number of individuals with heights is small. It will be interesting to see if significant differences in diameter persist in these trees when they are next measured at age 20.

Hand seeded vs open areas: In 2017 black spruce density was higher in the hand seeded treatment (simulating aerial seeding) than the open treatment (simulating natural regeneration from the existing seed bank.) In Minnesota, most of the artificial regeneration in black spruce by aerial seeding.

Seedlings vs seeding: One of the questions that led up to this trial was whether planting black spruce seedlings gives any advantage over aerial seeding or natural regeneration. At age ten, we find that there are more trees in the hand seeded treatments (simulating aerial seeding) than open treatments (simulating natural regeneration) or planted seedling treatments. However, the planted seedlings are much taller than the hand seeded or open treatments at this age. There is some planting of black spruce seedlings in Minnesota, but it most likely occurs on upland sites. Black spruce are long lived trees, and we plan to measure this trial every ten years, so it will be interesting to see if trends change or remain the same.

2020 Cooperative Work Plan

- visit all cooperators
- update orchard maps
- plan and conduct a fall workshop
- pick cones

Black spruce
- Pick cones

White spruce
- Spring- measure 2005 Eaglehead 2nd generation population
- Analyze 15-year 2nd generation white spruce data from all six sites.
- Use the 2nd generation data to evaluate expected gains from General Andrews E3/E4
- Visit white spruce progeny test sites to clarify conflicting data.
- Analyze 30 year white spruce progeny test data.
- Visit CFC-Airport 40 white spruce comparison trial and decide what to do with it

Jack pine
- Plan for new Beltrami County 2nd generation orchard (working name is Lammers Seed Orchard)
- Work toward developing production orchards for Beltrami County and MN DNR
- Acquire seedlings from Beltrami County and MN DNR and plant them in pots – to be grafted in 2021 and/or 2022. These will be for Beltrami County and MN DNR clonal orchards.

Red pine
- Acquire seedlings from MN DNR and plant them in pots – to be grafted in 2021. These will be for St. Louis County, MN DNR, and Red Lake clonal orchards.
- Determine the status of the inbreeding study seedlots.

White pine
- Determine the status of the progeny test seedlots.

Hemlock
- Review plan for the hemlock planted in Carlton County orchard

Tamarack
- Spring- measure trees in Split Rock seed collection area and update map

New things
- Oak seed collection areas

Appendix 1 – MTIC history

1950s- Scott Pauley joins UMN School of Forestry faculty and "forest genetic research begins in MN in earnest"

1960s- UMN genetics projects like NC-51 and NC-99 (Cottonwood studies in Rosemount, MN) stimulate enthusiasm for tree improvement

1970s- MN DNR, Blandin, and Potlatch were producing almost all of MN's seedlings. Reps from these organizations were already meeting with Carl Mohn (UMN) regularly to coordinate their tree improvement projects. Examples of these projects include MN DNR's Cotton, Blandin's Arbo, and Potlatch grafted white spruce orchards and Blandin's Blackberry, MN DNR's Eaglehead, and Potlatch's black spruce seedlings seed orchards. As these projects grew, Dr. Mohn felt they were taking time away from his teaching and other research duties so he obtained a grant from the Blandin Foundation, hired Bob Stine, and formally started MTIC

1981- MTIC was formed. Conifer planting in MN was at an all-time high (partly due to federal incentives after the BWCA was expanded) and tree improvement efforts were ready to move from the research phase to the application phase. A substantial amount of work was being done on silvicultural practices for conifers, so MTIC focused on implementation of genetic principles and practices.

1980s- MTIC's first priority was to establish and manage orchards that produce a large amount of seed with modest genetic improvement as soon as possible.
--Seed orchards were produced for red pine, jack pine, white spruce, black spruce, scotch pine, and white pine. Most were seedling seed orchards but some were grafted.
--Progeny tests were established right away for white spruce and jack pine.
--Early on MTIC included projects in aspen, scotch pine, black walnut, and European larch. Some of these programs were taken up by other coops (Aspen Larch Genetics Coop, North Central Fine Hardwoods Coop) but we no longer work with these species
--Eventually MTIC narrowed their focus to white pine, red pine, jack pine, white spruce, and black spruce. White pine improvement work is focused on finding resistance to blister rust. For the other species, improvement is focused on growth and form.

1990s- MTIC started breeding work in black spruce, jack pine, white spruce. A white pine breeding arboretum is developed at CFC to facilitate white pine breeding.

2000s-Grafted orchards were made from the top ranking families in the original black spruce, white spruce, and red pine progeny tests.
-White spruce and jack pine 2nd generation populations were planted out and being measured.
-A tamarack rolling block orchard was constructed at MN DNR's Split Rock Orchard. This model may be used for developing seed collection areas for other species.

2010s- Jack pine 2nd generation population families were ranked and rogued. This material is ready to be propagated into new orchards for members.
--Breeding continued in red pine (an inbreeding study) and white pine (blister rust resistance work)

2020- TODAY - White spruce 2nd generation population families are about to be ranked and rogued. New orchards can be made from this material. Discussions continue about developing seed collection areas for additional species such as oak, hemlock, and butternut.

2020s- SEEDS SEEDS SEEDS. Members want seeds. Genetic trials converted to seed orchards currently aren't producing large amounts of cones so we can focus on making **production orchards** (seedlings or grafted trees planted at wide spacing and managed solely for seed production.) **The product of a production orchard is locally adapted, genetically diverse, abundant, and improved seed.**

Why a cooperative? Because several organizations can work together toward a common goal of improved material. An arrangement like this reduces costs and efforts for each organization compared to each one working alone, while still making improved material readily available to all cooperators. **The needs of the members drive the activities of the co-op.**

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David, A. 2002. The Minnesota Tree Improvement Cooperative. In: Dumroese, RK; Riley, LE; Landis, TD; technical coordinators. National Proceedings: Forest and Conservation Nursery Associations-- 1999, 2000, and 2001. Proceedings RMRS-P-24. Ogden, UT; USDA Forest Service, Rocky Mountain Research Station: 128-131.
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Appendix 2 - Glossary

1st generation orchard
An orchard that usually consists of phenotypically selected trees from natural stands

1½ generation orchard
A 1st generation orchard becomes a 1½ generation orchard after it has been rogued of lesser individuals identified as a result of progeny tests (is this true??)

2nd generation orchard
Initial selected trees (the 1st generation) were intermated to produce offspring (2nd generation) and individuals are selected from those offspring which are then planted into a new orchard

Clonal seed orchard
An orchard that was established by propagating selected trees by grafting

Comparison trial
Compares growth of different bulked seed sources. Seed from different sources (or orchards) are planted at multiple sites and include a woods run source as a control to test whether the seed orchard seed is better than an average wild source

Generation
The number of selection, intermating, and genetic testing cycles that the program has gone through

Progeny test
A field trial to estimate the genetic worth of parent trees based on the performance of their offspring

Rogue
To remove inferior genotypes (i.e. cut out whole trees) from an orchard based on the results of a progeny test

Seedling seed orchard
Orchard was established by planting seeds from selected trees. May be rogued later to remove the poorest trees, leaving the best trees from the best families for seed production

Seed orchard
A collection of selected clones or families established in one physical location and then managed to produce genetically improved seed for operational reforestation

Seed production area
A natural stand or plantation that is thinned by removing poorer phenotypes; the good trees are left to intermate and produce seed that can be collected for operational forestation

Tree improvement
Involves the application of forest genetic principles along with good silviculture to produce high yielding, healthy and sustainable forests by developing genetically improved seedlings in an economically efficient manner by maximizing genetic gain per unit time at the lowest possible cost

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MTIC Mission

The Minnesota Tree Improvement Cooperative makes genotype recommendations for cooperator seed orchards that will produce seedlings that grow faster, straighter, and with less disease than wild seedlings and provides technical support on how to manage those seed orchards.

Advisory Committee 2019

Full Members

Beltrami County	Nick Ronning
Carlton County	Mark Westphal
Cass County	Erik Lindquist
Crow Wing County	Mitch Lundeen
Hancock Forest Management	David Wilkinson, Florian Deisenhofer
Itasca County	Ryan Newman
Koochiching County	Danae Schafer
Lake County	Rachel Mason
Minnesota DNR - Forestry	Deb Pitt
Red Lake Nation	Tony Arola
St. Louis County	Rob Benson
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Dept. of Forest Resources	Mike Kilgore
UPM Blandin Paper Co.	Sawyer Scherer

Supporting Members

Bureau of Indian Affairs	Michael Benedict
Clearwater County	Bruce Cox
Hubbard County	Allen Lysdahl
Superior National Forest	Katie Frerker

Photo on cover – Tamarack cone at MN DNR Split Rock Orchard – by Julie Hendrickson