Ministère des Forêts, de la Faune et des Parcs

Tour of Grandes-Piles Forest Nursery and Experimental Plantations

August 23, 2019

2019 Canadian Forest Genetics Association Conference
August 19 to 23, 2019, Lac-Delage, Québec

Votre gouvernement

Québec

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Cover picture

Aerial view of Grandes-Piles Forest Nursery, 20 km north of Shawinigan.
Photo credit: MFFP

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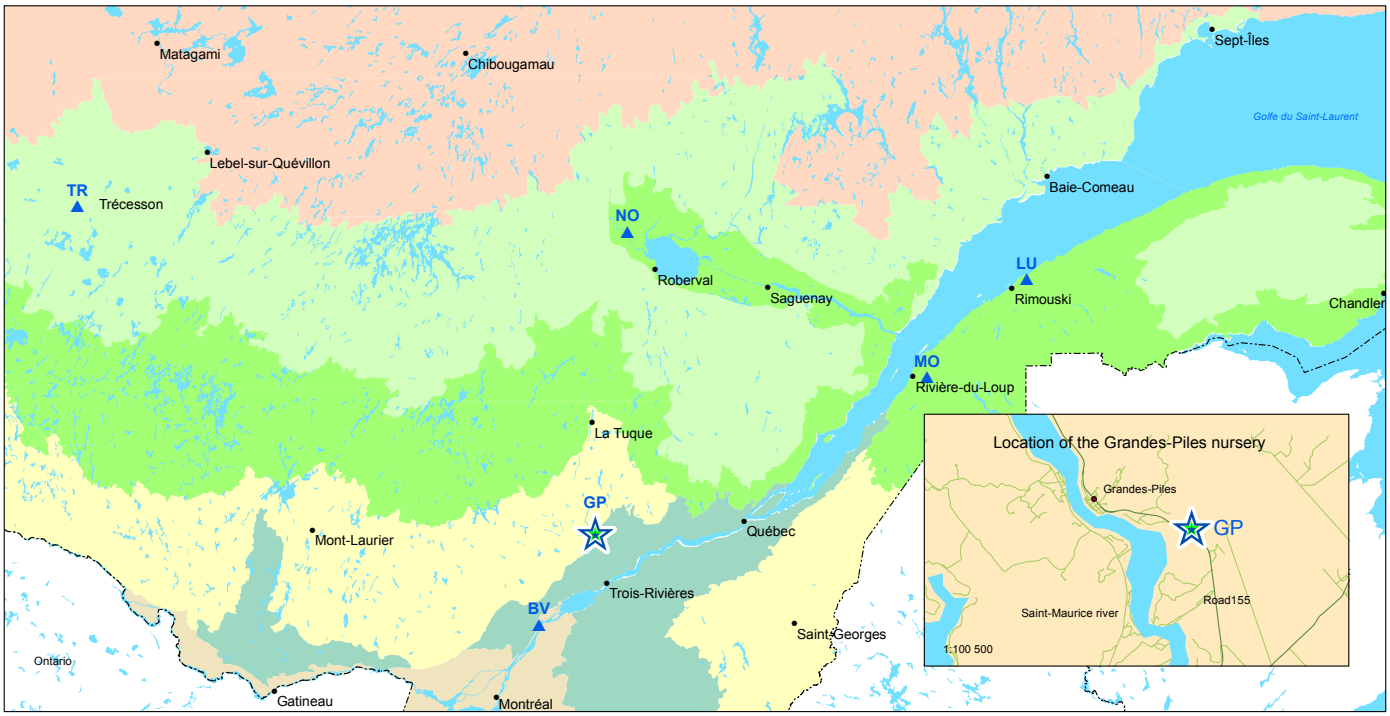
Location of Grandes-Piles Nursery and the five other public nurseries



Public forest nursery	Locality
BV	Berthier	Berthierville
GP	Grandes-Piles	Grandes-Piles
LU	Sainte-Luce	Sainte-Luce
MO	Saint-Modeste	Saint-Modeste
NO	Normandin	Normandin
TR	Trécesson	Trécesson

Figure 1. Public forest nursery locations.

A word from the Organizing Committee

Welcome to this tour planned by the Ministère des Forêts, de la Faune et des Parcs as part of the 2019 Canadian Forest Genetics Association Conference. We are pleased to welcome you to Grandes-Piles Forest Nursery. Located 20 km north of Shawinigan, it is one of six public nurseries reporting to the Direction générale de la production de semences et de plants forestiers (DGPSPF). The Direction de l'expertise et de la coordination (DEC), which is a part of the DGPSPF, manages forest seed production (implementation and tending of seed sources, seed collection, controlled pollination, somatic embryogenesis, seed distribution). The DEC is also in charge of collecting plant requests and planning seeding for the annual production of 150 million plants in Québec's 19 forest nurseries (6 public and 13 private). The DEC also provides scientific and technical support to the nurseries and regions.

During this guided tour, you will explore the 337-ha Grandes-Piles Nursery, of which 45 ha (including 25 mobile tunnel greenhouses) are dedicated to container seedling production. First- and second-generation seed orchards cover another 93 ha.

In addition to the nursery facilities and seed orchards, we will visit progeny tests and clonal tests of the Direction de la recherche forestière (DRF) related to Québec's genetic improvement programs for white spruce (*FastTRAC* project), black spruce, Norway spruce (*FastTRAC* project) and jack pine, as well as a hybrid poplar test. The DRF's mission is to actively participate in guiding research and improving forest practices in Québec, in keeping with sustainable forest management, by undertaking applied research. It develops new knowledge, know-how and biological material and contributes to their transfer or integration into forest practices. It also provides grants for university research, most often in fields that complement its own projects. The DRF's areas of research include genetic tree improvement and seed and forest seedling production.

Have a great tour!

Tour schedule

Time	Details	
8 a.m.	Bus departs from Lac Delage for Grandes-Piles Nursery (about a two-hour drive)	
Morning	**Stop 1**: Tour of Grandes-Piles Nursery facilities and crops	
	Group A	**Group B**
	Stop 2: Jack pine – Second-generation seed orchard	**Stop 4**: Hybrid poplars – Progeny tests established in 2015
	Stop 3: Black spruce – Clonal tests (cuttings) established in 2004 and 2005	**Stop 5**: White spruce – Clonal tests established from 2007 to 2016 (somatic embryogenesis)
		Stop 6: Norway spruce – Full-sib family test established in 2000
Noon	Lunch	
Afternoon	**Stop 4**: Hybrid poplars – Progeny tests established in 2015	**Stop 2**: Jack pine – Second-generation seed orchard
	Stop 5: White spruce – Clonal tests established from 2007 to 2016 (somatic embryogenesis)	**Stop 3**: Black spruce – Clonal tests (cuttings) established in 2004 and 2005
	Stop 6: Norway spruce – Full-sib family test established in 2000	
Around 3 p.m.	Bus departs from Grandes-Piles Nursery for Lac Delage	
Around 5:30–6 p.m.	Arrival at Lac Delage	

Map of stops

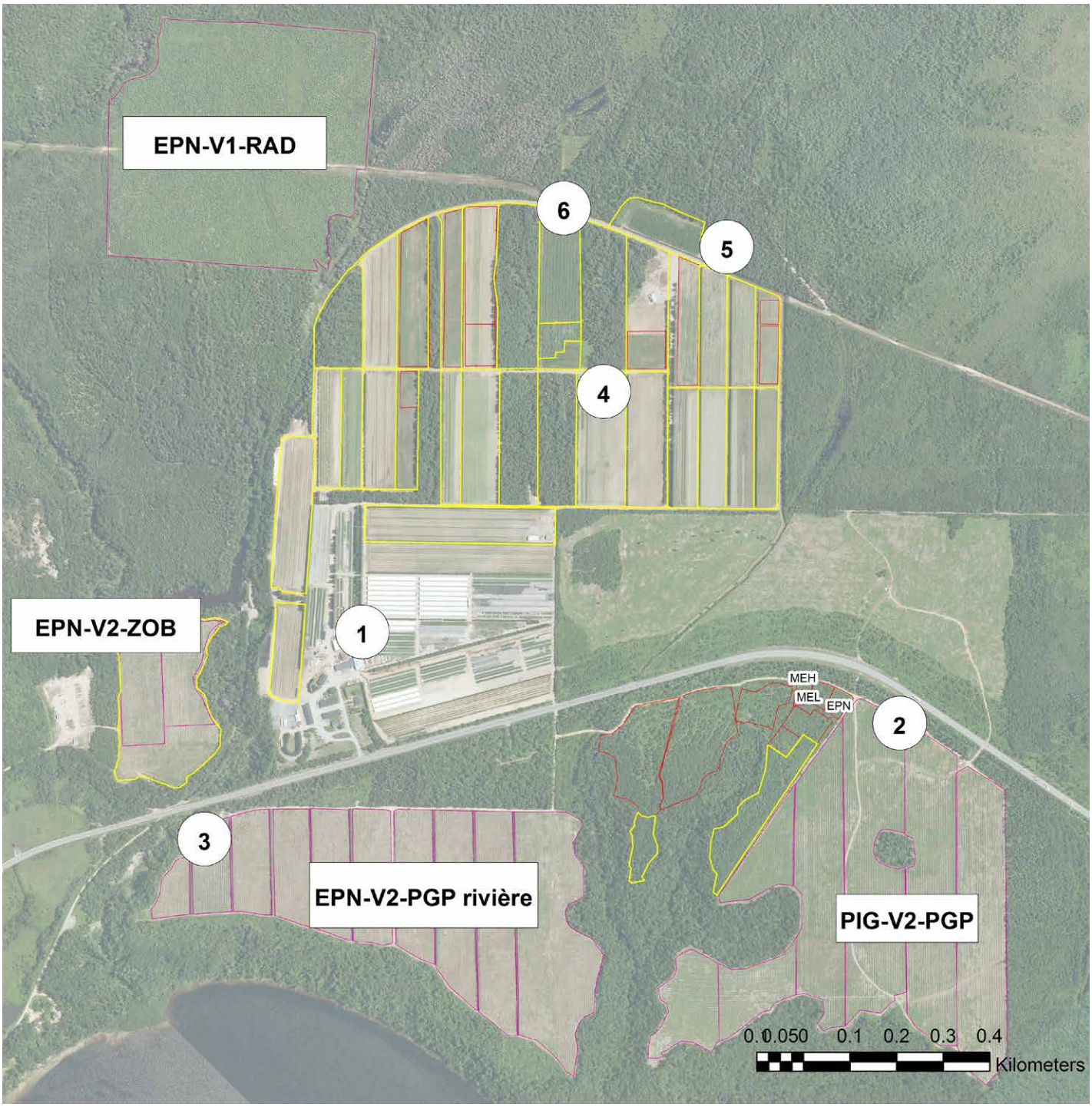


Figure 2. Aerial view of Grandes-Piles Nursery (V1: first generation orchard; V2: second generation orchard; RAD: Radnord; EPN: black spruce; PIG: jack pine; MEL: eastern larch; MEL: hybrid larch; ZOB: breeding zone B; PGP: Grandes-Piles nursery)

Stop 1: Facilities and crops at Grandes-Piles Nursery

By Josée Houde, MFFP – Grandes-Piles Forest Nursery and Martine Isabelle, MFFP – Direction de l'expertise et de la coordination, Direction générale de la production de semences et de plants forestiers

The Nursery operates from May 1 to November 25 and has 75 employees during its peak season. In the winter time, it employs 4 to 8 people to prepare for the upcoming season. The nursery averages 16 000 m^2 in seeding each year, which represents 3.5 million large-size seedlings.

The nursery's mission is to increase forest yield through efficient production of improved seed and forest seedlings.

The nursery facility tour will include five stations:

- Station 1:
  a) Presentation of the first steps of growing plants in containers: potting and sowing. The nursery sows about 6.5 million plants per year and uses a conventional potting line.
  b) Tour of the cold room, where the cone crop trays are stored.
- Station 2:
  a) Presentation of large white pine (Pinus strobus) and red pine (Pinus resinosa) seedlings grown in 15-320 containers (15 cavities of 320 cm^3 each). These seedlings are in their second growing year (2-0).
  b) Presentation of a nursery trial in which silica, the usual covering material, is replaced with gravel in 45-110 containers (45 cavities of 110 cm^3 each).
  c) Description of the mobile tunnels developed at Grandes-Piles Nursery to minimize moving of containers between the first year (1-0) and second year (2-0) of culture.
- Station 3: Presentation of large white spruce (*Picea glauca*) grown in 25-310 containers (25 cavities of 310 cm^3 each) and red pine (*Pinus resinosa*) grown in 15-320 containers. These seedlings are in their first growing year (1-0).
- Station 4: Illustration of how shipping date during the year of delivery influences management of large black spruce (*Picea mariana*) seedlings grown in 45-110 containers.
- Station 5: Presentation of the sectors used to cultivate bareroot hybrid poplar clones. We will see plants produced for delivery in spring 2020, stock plants and propagator plants used for the production of cuttings.

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Notes

Stop 2: Jack pine – Second-generation seed orchard

By Claude Gagné, Direction de l'expertise et de la coordination (DEC-DGPSPF)

DESCRIPTION

Administrative region: Mauricie
Coordinates – Altitude: 40°40'26" N; 72°40'52" W – 152 m
Soil: Sandy loam, well drained
Plant material: Grafts planted in 2005
Orchard design: 7 randomized blocks, 179 clones, 11 027 seed trees
Spacing: 5 m × 5 m
Total area: 35.6 ha
Deployment area: Maple–yellow birch and balsam fir–yellow birch bioclimatic domains (jack pine improvement zone A)
Predicted genetic gain: 12.6% in height
Viable seeds/hectoliter of cones : 65 300
Orchard production: 118 to 175 hectoliters of cones, i.e., 7.7 to 11.5 million viable seeds
Annual needs: Around 7 million viable seeds

OBJECTIVE

Provide a regular supply of improved seeds for reforestation of the deployment areas associated with the source.

TENDING

Weeding, brushing, staking, pruning, removal of dead trees.

1/3 of the orchard topped in 2015.

Presence of northern pitch twig moth (*Petrova albicapitana* [Busck]) and Western gall rust (*Endocronartium harknessii* [J.P. Moore] Y. Hiratsuka). Affected shoots pruned.

SUPPLEMENTAL INFORMATION

The second-generation population consists of superior trees selected in first-generation progeny tests. These trees were produced by grafting (4 orchards) or by seeding (2 orchards) to create 6 seed orchards in the 5 jack pine improvement zones in Québec. Average predicted genetic gain for height in these seed orchards is 10% to 15% at 10 years, compared to seedlings from a natural stand, which represents 13 to 20 m^3/ha in additional yield at 40 years.

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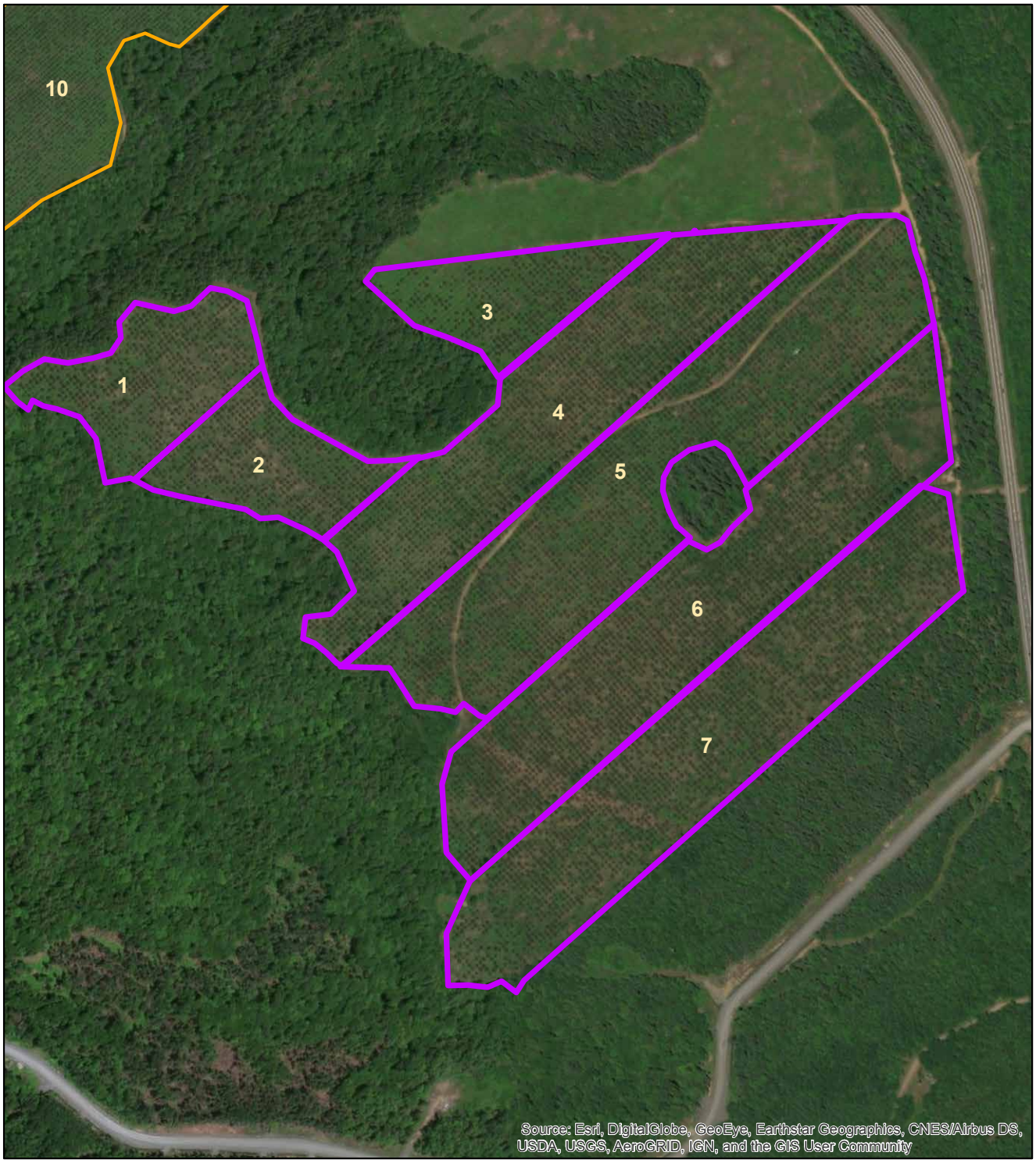

Figure 3. Aerial view of the jack pine orchard.

Figure 4. Second-generation jack pine seed orchard, July 2015. Photo credit: MFFP.

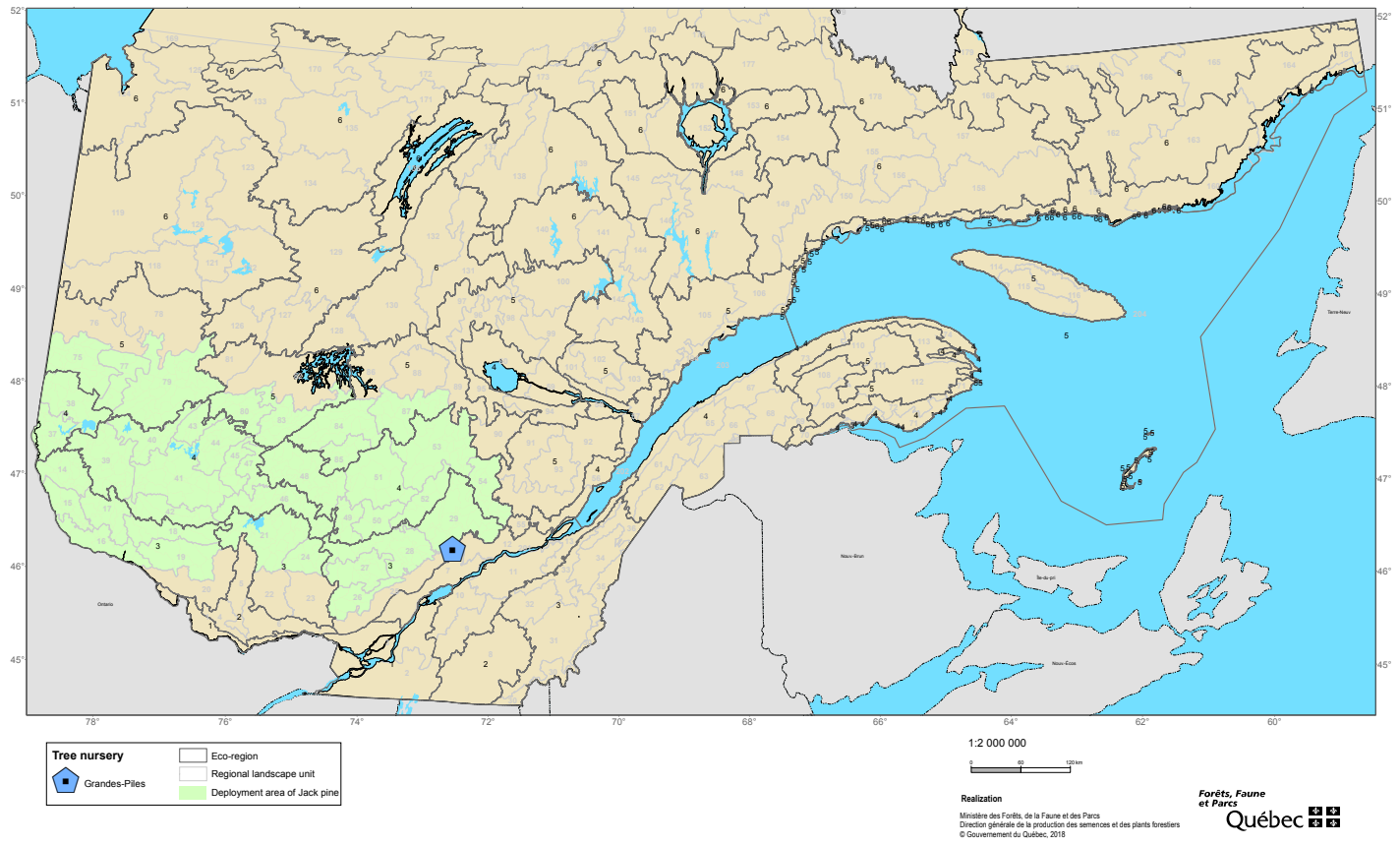

Figure 5. Deployment area (in green) for Grandes-Piles' jack pine second-generation seed orchard.

Notes

Stop 3: Black spruce – Clonal tests (cuttings) established in 2004 and 2005

By Mireille Desponts, Direction de la recherche forestière

DESCRIPTION

Soil: Sandy loam, well drained
Plant material: Cuttings from trees selected in progeny trials
Experimental design: 10 randomized complete blocks with single-tree plots. Tests of 110 and 74 clones
Spacing: 1.5 × 4 m
Total number: 1 079 and 715 trees

OBJECTIVE

Early trials were associated with two similar clonal trials established in forest areas. The aim was to compare, on a same site, trees selected in 11 progeny trials spread across the western balsam fir–white birch and western balsam fir–yellow birch bioclimatic subdomains.

TENDING

Tree removal: Approximately 18% of trees were removed in 2006 to reconstruct the Duchesnay breeding population after massive mortality.

Pollen collection: Harvest in 2013 for controlled crosses in the Duchesnay breeding population.

Topping of trees in fall 2013.

MEASUREMENT IN COMPARATIVE CLONAL TRIALS ESTABLISHED IN FOREST AREAS (5, 8, 10, and 15 years)

Mean values at age 15, 2004 trials: Height: 563 cm, DBH: 75 mm, density (Pilodyn): 19.8 mm, velocity (Director ST-300): 3.0 km/s, MoE (Director + Pilodyn): 4.5 GPa

Results: Compared to all clones, multi-trait selection with 10% of the population led to gains of 4.2% for height and 21.1% for MoE, while maintaining DBH and density. In the top 1/3, gains were smaller (2.4% and 11.4%), and DBH and density remained the same.

PUBLICATION

Desponts, M., M. Perron et J. DeBlois (2017). *Rapid assessment of wood traits for large-scale breeding selection in* Picea mariana *[Mill.] B.S.P.* Annals of Forest Science. *https://doi.org/10.1007/s13595-017-0646*

COLLABORATION

MFFP — DGPSPF

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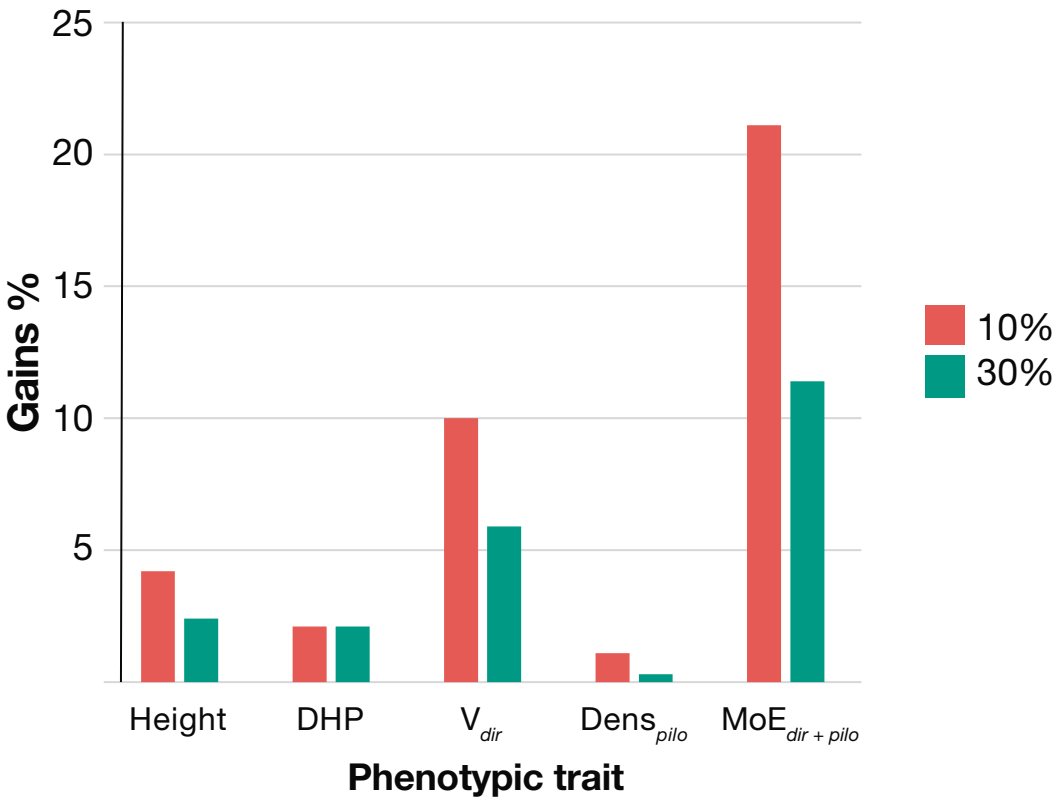

Figure 6. Relative gain (as a percentage, compared to the population mean) of phenotypic traits for the 10% and 35% top-ranking clones, based on the optimal index established according to height and V_{dir}. (DBH: diameter at breast height; V_{dir}: acoustic velocity evaluated with the Director ST-300; $Dens_{pilo}$: wood density evaluated with the Pilodyn; $MoE_{dir+pilo}$: linear elasticity evaluated by acoustic velocity and wood density).

Figure 7. Black spruce early trial established in 2004 at Grandes-Piles Nursery. Photo credit: Mireille Desponts, MFFP-DRF, 2005.

Notes

Stop 4: Hybrid poplars – Progeny tests established in 2015

By Martin Perron and Josianne DeBlois, Direction de la recherche forestière

DESCRIPTION

Identification: GPI67915 (eastern yellow birch–maple bioclimatic subdomain)
Identification of a related test: NOR68115 (eastern yellow birch–balsam fir bioclimatic subdomain)
Soil: Loamy sand, well drained
Plant material: 25 cm cuttings planted in May
Experimental design: 20 randomized complete blocks with single-tree plots for each family
Spacing: 2 m × 3.25 m
Total surface area: 1.1 ha

OBJECTIVE

Evaluate the *Populus maximowiczii* (M) and *Populus trichocarpa* (T) parents of the 2012 hybridization and estimate genetic parameters. 34 families (25 M × T and 10 T × M using a polymix).

ENTRETIEN

Herbicide: Summer 2015, 2016

Field mouse traps: Fall 2015, 2016

Thinning: July 2018 (1 in 2 trees)

Pruning: Planned for 2020

MEASUREMENT (2015 AND 2017)

Fall 2015: survival rate = 97%; height = 177 ± 61 cm;

Fall 2017: survival rate = 96% ; height = 777 cm ± 132 cm; DBH = 76 ± 20 mm; multiple stems = 12.3%; basal stems = 7.2%; multiple and basal stems = 1.8%; leader branch dieback = 14.8%; adventive branches = 7.3% and damage.

Results: Forthcoming

PUBLICATION

The approximation of non-biased genetic parameters (simultaneous analysis on both sites), at 3 years, indicates that growth and freeze resistance traits are under strong genetic control and that there is no genotype–environment (G × E) interaction (Table 1). However, quality traits (multiple stems, adventive branches and basal stems) are under slight to moderate genetic control, and G × E interaction ranges from low to high.

COLLABORATION

Pierre Périnet (now retired, in charge of the hybrid poplar genetic improvement program until February 2019) helped develop the mating design and supervised the operations of this series of plantations.

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Figure 8. Overview of the progeny test in October 2018. Photo credit: Alain Fauchon, MFFP – DRF.

Figure 9. Test after thinning in 2018. Photo credit: Alain Fauchon, MFFP – DRF.

Figure 10. Nice hybrid poplar specimen in the progeny test, September 2018. Photo credit: Alain Fauchon, MFFP – DRF.

Table 1. Multi-site genetic parameters at year 3 for Grandes-Piles and Normandin trials.

Variable	h^2_{ind}	$SE_{h^2_{ind}}$	h^2_{fam}	$SE_{h^2_{fam}}$	r_B	SE_{r_B}
TH17	0.6917	0.1587	0.9189	0.0277	0.9725	0.0399
DBH17	0.5426	0.1365	0.8848	0.0397	0.9402	0.0580
Pres_abs_MS17	0.2219	0.1476	0.5343	0.2321	0.4443	0.2603
Pres_abs_AB17	0.0455	0.1343	0.2748	0.6969	0.2744	0.8165
Pres_abs_BS17	0.1237	0.1275	0.6024	0.4127	0.7394	0.7889
Pres_abs_LBD17	0.5919	0.2151	0.8379	0.0972	0.8238	0.1550

Abbreviations: h^2_{ind} = individual heritability; **SE** = Delta method standard error; h^2_{fam} = half-sib heritability; r_B = type B genetic correlation (G × E); TH17 = height in 2017; DBH = diameter at breast height; Pres_abs = presence – absence; MS = multiple stems; AB = adventive branches; BS = basal stem; LBD = leader branch dieback (frost resistance).

Notes

Stop 5: White spruce – Clonal tests established from 2007 to 2016 (somatic embryogenesis)

By Martin Perron, Direction de la recherche forestière, and Laurence Tremblay, Direction de l'expertise et de la coordination, Direction générale de la production de semences et de plants forestiers

DESCRIPTION

Identification: GPI59107; GPI59708; GPI60209; GPI62110; GPI62611; GPI64312; GPI65113; GPI66014; GPI67415 and GPI69716 (eastern yellow birch–maple bioclimatic subdomain)
Identification of related tests: STM59007; STM60008; STM60309; STM62010; STM62511; STM64212; STM65013; STM65914; STM67315; STM69616 (eastern yellow birch–balsam fir bioclimatic subdomain)
Soil: Loamy sand, well drained
Plant material: Somatic plants (somatic embryogenesis) and seedling controls from recommended controlled crosses. Large-size plants (height: 30-40 cm) planted in May.
Experimental design: 8 randomized complete blocks with linear plots of 2 trees per clone
Spacing: 2.5 m × 2.5 m (2007); 1.5 m × 3 m (other years)
Total surface area : 11.2 ha

OBJECTIVE

Evaluate 1 517 clones from the 71 best full-sib families in two sites and two bioclimatic domains to select the 30 best clones for somatic embryogenesis propagation.

Evaluate genetic parameters and quantify clonal genetic gain compared to full-sib families and orchards.

TENDING

Cleaning: Seasons 2 and 3

Thinning: Genetic thinning (1 tree/plot) between the ages of 6 and 8 years

MEASUREMENT (GPI59708)

Evaluation of 131 clones 10 years after planting (2017): Survival rate = 98%; height = 479 ± 79 cm; DBH = 75 ± 19 mm

Overall results: Each year, the top 30 clones are recommended for deployment, based on 5-year growth data for all clones.

FastTRAC PROJECT

Year 2018: Selection using genomic selection among the entire clonal bank.

Genotyping: 3 171 clones were genotyped including the 1 517 clones already in clonal tests.

Measurement at 15 years in two progeny tests including the same parents (ASS35799 and SCA36099): Model construction and application of genomic selection for the following traits: wood rigidity (indirect measurement using the Director ST-300), wood density, microfibril angle, height, diameter at breast height (DBH), total under-bark volume.

Methods and results: Clones were classified using an index based on genomic predictions of genetic values (GBLUP) of the total under-bark volume and acoustic velocity at 15 years of age, with each trait weighted 50%. In addition, we selected only clones with a positive GBLUP prediction for wood density. This was our first operational recommendation resulting from prediction by genomic selection. (See Table 2 for details.)

REFERENCE

Perron et al. (2018). *Sélection de lignées clonales d'épinette blanche à l'aide des prédictions génomiques.* Gouvernement du Québec, ministère des Forêts, de la Faune et des Parcs, Direction de la recherche forestière. Avis technique nº SGRE-17. 8 p. *https://mffp.gouv.qc.ca/documents/forets/recherche/AT-SGRE-17.pdf*.

COLLABORATION

FastTRAC project and Saint-Modeste Nursery (somatic seedlings were produced in the somatic embryogenesis laboratory).

CONTACTS

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Table 2. Genetic gain at 15 years (relative values in brackets) for various selection scenarios of 30 white spruce clones using genomic-predicted genetic values (GBLUP), compared to progenies measured in the ASS35799 and SCA36099 tests.

Scenario	ST300 ($km \cdot s^{-1} \times 10^2$)	Wood density ($kg \cdot m^{-3}$)	Microfibril angle (degrees)	Height‡ (cm)	DBH (mm)	VOL (dm^3)	Number of families
Average*	2.97	376.7	26.31	759.1	111.3	33.52	
Direct selection	0.33 (11.0)	29.8 (7.9)	–3.52 (13.4)	89.6 (11.8)	13.9 (12.5)	12.8 (38.1)	3-6
Selection index	0.17 (5.7)	4.8 (1.3)	–1.06 (4.0)	85.0 (11.2)	12.0 (10.6)	11.4 (34.0)	3
2017 laboratory selection	–0.008 (–0.3)	–1.4 (–0.4)	0.31 (–1.2)	20.1 (2.6)	2.9 (2.6)	2.9 (8.5)	13
Scenario 1**	0.21 (7.0)	8.5 (2.3)	–2.11 (8.0)	55.4 (7.3)	8.7 (7.8)	7.8 (23.2)	10
Scenario 2§	0.21 (7.0)	8.2 (2.2)	–2.05 (7.8)	55.7 (7.3)	8.5 (7.7)	7.7 (22.9)	11
Final selection†	**0.20 (6.8)**	**8.3 (2.2)**	**–1.80 (6.8)**	**55.5 (7.3)**	**7.8 (7.0)**	**7.1 (21.2)**	**15**

Abbreviations: ST300 = measurement of acoustic velocity in wood (rigidity); DBH = diameter at breast height; VOL = total under-bark volume.
‡ The gain in height excludes the 15% gain compared to an unimproved population.
* Average of trees measured at 15 years in the ASS35799 and SCA36099 progeny tests.
** Positive breeding value for wood density and maximum 4 clones per family.
§ Positive breeding value for wood density and maximum 3 clones per family, except one family with 4 clones.
† Positive breeding value for wood density, 1 family with 3 clones and 14 families with 1 or 2 clones.
Modified from Perron et al. (2018)

Figure 11. White spruce germination from somatic embryogenesis after 5 weeks' culture. Photo credit: Julie Gingras, Saint-Modeste Nursery, MFFP.

Figure 12. White spruce clonal test established in 2008 in Saint-Antonin (10 years old – STM60008). Photo credit: Patrick Lemay, DEC-DGPSPF, MFFP

Notes

Stop 6: Norway spruce – Full-sib family test established in 2000

By Marie-Josée Mottet, Direction de la recherche forestière

DESCRIPTION

Soil: Sandy loam, well drained
Plant material: 3-year-old bareroot seedlings planted in May 2000
Experimental design: 5 randomized complete blocks with linear plots of 3 trees per family.
Spacing: 2 m × 2.5 m
Total area: 1.5 ha

OBJECTIVE

Selection mainly for growth and white pine weevil (*Pissodes strobi*) resistance.
193 full-sib families derived from crosses among 112 parents from the Québec breeding population.
Controls: The Proulx M.P. plantation is one of the 9 controls included in the test (see at the jack pine seed orchard stop).

TENDING

Thinning: 2010 (1 in 3 trees), 2018 (70 worst families removed), 2020 (forthcoming)
Pruning: 2010

MEASUREMENT

Measurement years: 2004, 2009, 2014, 2019 (forthcoming)

Mean values at age 15 : Height: 858 cm, DBH: 142 cm, annual weevil attack in 2015: 35%. More than 70% of the trees were attacked at least once between ages 5 and 15.

Results: The estimated family and individual heritability values for the cumulative weevil attack (CWA) rate were high and moderate, respectively. Positive genetic correlations were detected between CWA and DBH, but selection for resistance is possible without too much impact on diameter growth.

FastTRAC PROJECT - GENOMIC SELECTION

By Patrick Lenz, Natural Resources Canada (NRCan)

Subsamples: Sampling of 40 full-sib families (35 parents), with 20 rated more weevil resistant and 20 rated susceptible based on measurements at ages 10 and 15. Trees were also sampled in a similar test at Saint-Modeste.

Measurement at age 15: Height, DBH, weevil attack, acoustic velocity (Director ST-300), wood density and microfibril angle.

Results: The estimated genomic predictions for resistance to weevil attack, tree height, height/DBH ratio and wood quality traits allow for accurate and quicker selection of superior genotypes based on genomic profiles.

COLLABORATION

NRCan and Laval University

PUBLICATIONS

Mottet, M.-J. et al. (2015). *High genetic variation and moderate to high values for genetic parameters of* Picea abies *resistance to* Pissodes strobi. Tree Genetics and Genomes: 11:58. *https://doi.org/10.1007/s11295-015-0878-6*

Lenz, P. et al. (2019). *Multi-trait genomic selection for weevil resistance, growth, and wood quality in Norway spruce (*Picea Abies*).* Evolutionary Applications. *https://doi.org/10.1111/eva.12823*

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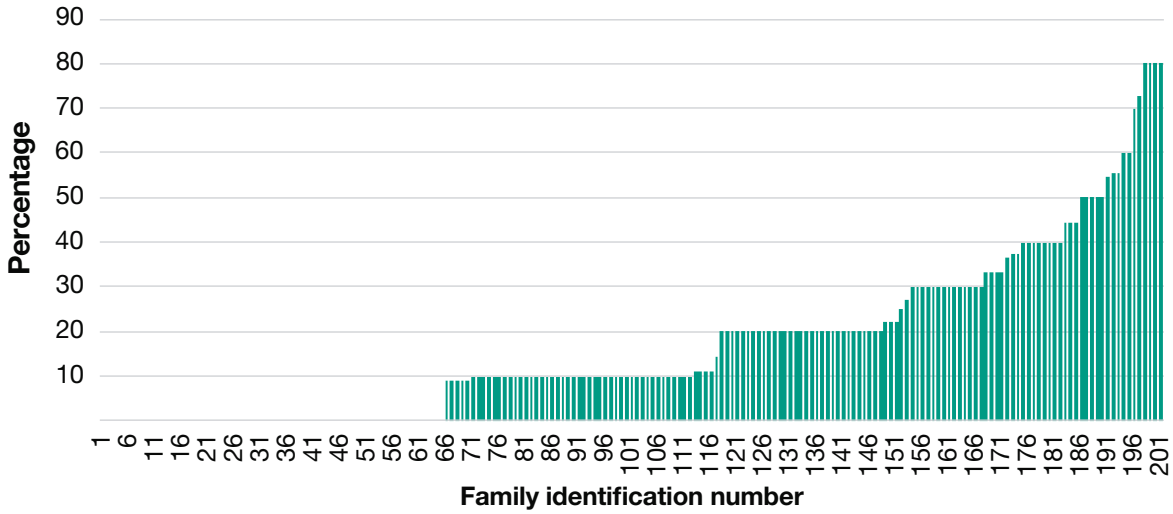

Figure 13. Percentage of trees without weevil attack for each family aged 5 to 15 years.

Figure 14. Trees showing superior growth and white pine weevil resistance. Full-sib family test at 19 years. Photos credit: Jean-Sébastien Joannette, MFFP-DRF.

Notes

Conclusion

The Direction de l'expertise et de la coordination of the Direction générale de la production de semences et de plants forestiers and the Direction de la recherche forestière of the Ministère des Forêts, de la Faune et des Parcs will continue to work together closely on genetic tree improvement. In the context of climate change, this close link between research and production will support the deployment of adapted and resilient trees. This will ensure that silvicultural investments, which exceed $200 million per year in Québec, will yield the most benefits. Advances in research, production techniques and the flexibility of improvement and production populations will be key to maintaining maximum productivity of quality wood from reforested areas. We thank all the MFFP employees who contribute each year to the success of reforestation activities.

We wish you a safe trip back and hope we have inspired you!

The Tour Team

Forêts, Faune
et Parcs
Québec