CPC/PCC 2007

Poplar culture: a collaborative effort from clone to mill

2007 Annual Meeting of the Poplar Council of Canada

Conference Handbook/Manuel de conférence

Rivière-du-Loup and Québec City, September 16-21, 2007

POPLAR COUNCIL CANADA CONSEIL DU PEUPLIER

Ressources naturelles et Faune Québec

Conference program at a glance

2007 Annual Meeting of Poplar Council of Canada (PCC / CPC)

Poplar culture: a collaborative effort from clone to mill

Sunday Sept. 16	Monday Sept. 17	Tuesday Sept. 18	Wednesday Sept. 19	Thursday Sept. 20	Friday Sept. 21
AM	**Opening and general information:** Hôtel Lévesque, Rivière-du-Loup **Témiscouata Field Tour Stop #1:** Poplar farm Norampac Cabano	**Témiscouata Field Tour Stop #1:** Demo. poplar plantation PAC48103 / Packington – *Agence forêt privée* **Stop #2:** DRF poplar tests & collections / Packington	**PCC and IUFRO Larix$_{2007}$** Plenary session joint with Larix 2007: four invited speakers (Québec City Convention Centre)	**PCC** Conferences & posters (Québec City Convention Centre)	**IUFRO Larix$_{2007}$** Tree improvement programs at the DRF (Duchesnay)
Lunch (on your own)	Agora, Cabano	Saint-Marc-du-Lac-Long	(Provided at the Convention Centre)	(Provided at the Convention Centre)	(Provided at Duchesnay)
PM **15:00 –** Bus departure from Sainte-Foy (Université Laval) towards Rivière-du-Loup	**Témiscouata Field Tour Stop #2:** St-Modeste provincial nursery & propagation centre – MRNF **17:00 Cocktail hour** offered by VALORITREMBLE Hôtel Lévesque	**Témiscouata Field Tour Stop #3:** Norampac plantations St-Eusèbe **Stop #4:** DRF clonal test CAB21196 / St-Eusèbe	**PCC** Conferences & posters (Québec City Convention Centre)	**PCC** Posters (Québec City Convention Centre) **Carrefour** **15 h – 17 h** **PCC / CPC** business meeting	Return to Québec City after lunch
(Supper on your own)	(Supper on your own)	(Provided on tour) Saint-Jean-Port-Joli	Banquet provided at the Québec City Convention Centre	(Supper on your own)	
Evening *Registration and Ice breaker (Hôtel Lévesque)*		Arrival in Québec City at 20:30	**PCC/CPC and IUFRO Larix$_{2007}$**		
(Hôtel Lévesque, Rivière-du-Loup)	(Hôtel Lévesque, Rivière-du-Loup)	(Lodging in Québec City)	(Lodging in Québec City)	(Lodging in Québec City)	

CPC/PCC
2007

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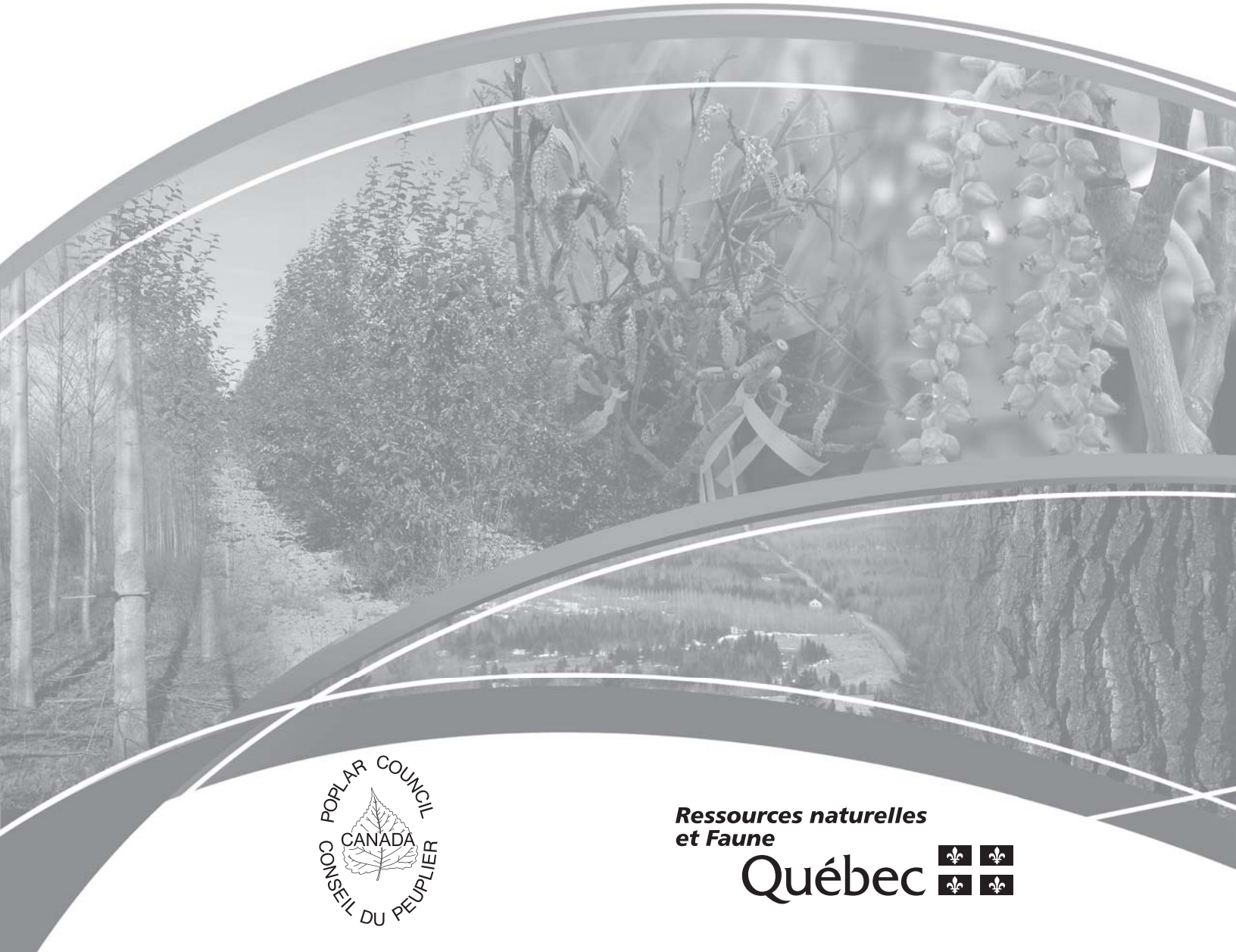

POPLAR COUNCIL
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Ressources naturelles et Faune
Québec

Important note/À noter :

The text presented in this handbook has been compiled by Pierre Périnet. The texts are the sole responsibility of the authors.

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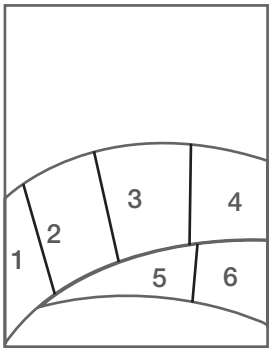

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Context

Forêt Québec, one of the sectors within the *ministère des Ressources naturelles et de la Faune du Québec*, has the mandate of administering the various facets of sustainably managing Québec's public forests, and of contributing to the development of the forest products industry and private woodlots. Within this broad framework, the mission of the *Direction de la recherche forestière* (DRF) is to participate in improving forest practices in Québec by undertaking research and development projects in diverse fields and by ensuring the transfer of know-how to practising foresters.

The Poplar Council of Canada (PCC) is a national non-profit organization committed to the wise use, conservation, and sustainable management of Canada's poplar resources. PCC, first established in 1977, has members from industry, wood lot owners, universities, research establishments, and provincial and federal governments. The principal objective of the CPC/PCC 2007 meeting is to share advances in poplar research in Canada and other countries, and to present various aspects of poplar culture with a number of cases from the Témiscouata area. This year's theme, "*Poplar Culture: a Collaborative Effort from Clone to Mill*", emphasizes the synergy achieved from cooperative efforts shared among poplar growers in the Bas-Saint-Laurent region.

In 1998, under the leadership of Hervé Gagnon (DRF) with the collaboration of the *Direction régionale des forêts du Bas-Saint-Laurent* and three organisms involved with poplar culture, a new research project was initiated to evaluate poplar varieties obtained from breeding for the region. Since the beginning, funding was provided through the *Programme de mise en valeur des ressources du milieu forestier (Volet 1)*. Ten years later, we have the opportunity to visit some plantations established in the Témiscouata area, where over 500 trees were selected in 2006 with in the hybrid progenies planted in Packington. The best ones will eventually replace the old clones planted in the area, and new parent trees will also be selected from the introduced species collections for future breeding.

Contexte

Le mandat de Forêt Québec, un des secteurs du ministère des Ressources naturelles et de la Faune du Québec, est de gérer les différentes facettes de l'aménagement durable des forêts publiques et de concourir au développement de l'industrie des produits forestiers et à la mise en valeur des forêts privées. Dans ce cadre, la mission de la Direction de la recherche forestière (DRF) est de participer à l'amélioration de la pratique forestière au Québec en réalisant des projets de recherche et de développement dans divers domaines et en assurant l'intégration de ce savoir-faire par les forestiers.

Depuis 1977, le Conseil du peuplier du Canada (CPC), une association nationale à but non lucratif, vise à promouvoir l'utilisation, l'aménagement et la conservation de la ressource « peuplier » au Canada, dans une perspective de développement durable. L'objectif principal de la réunion CPC/PCC 2007 est d'échanger sur l'avancée de la recherche sur les peupliers au Canada et ailleurs dans le monde, et, plus spécialement, de présenter des facettes variées de la populiculture par le biais d'exemples au Témiscouata. Le thème de la rencontre, « *La populiculture : un projet collectif, du clone à l'usine* », illustre bien comment la coopération accroît la synergie entre les différentes organisations engagées dans la culture du peuplier hybride au Bas-Saint-Laurent.

En 1998, grâce à la détermination de M. Hervé Gagnon, la DRF, de concert avec la Direction régionale des forêts du Bas-Saint-Laurent et trois organismes de gestion en commun, initie un programme spécifique de recherche pour évaluer de nouvelles variétés de peupliers hybrides produites pour la région. Le Programme de mise en valeur des ressources du milieu forestier (Volet 1) finance ces activités depuis le début. Une dizaine d'années plus tard, nous avons l'occasion de visiter des tests et des plantations établies au Témiscouata, où plus de 500 nouveaux arbres ont été sélectionnés en 2006 dans les descendances hybrides établies à Packington. D'ici quelques années, les meilleurs clones permettront de renouveler la liste des clones recommandés pour la région. En outre de nouveaux géniteurs, choisis parmi les espèces parentales introduites, serviront aux prochains programmes d'hybridation.

A word from the organizers

The *Direction de la recherche forestière* (DRF) of *Forêt Québec*, in collaboration with the Poplar Council of Canada, the *Réseau Ligniculture Québec*, *Norampac – Division Cabano*, the *Direction régionale des forêts du Bas-Saint-Laurent*, the *Direction générale des pépinières et des stations piscicoles*, the *Agence de mise en valeur des forêts privées du Bas-Saint-Laurent*, the *Corporation Agro-forestière Transcontinental inc*. and the *Groupement forestier et agricole Taché*, welcomes participants to the 2007 Annual meeting of the Poplar Council of Canada to Québec. We hope that the CPC/PCC 2007 meeting will meet your expectations through the program activities we have organized, starting with two days of field visits.

Participants to the CPC/PCC 2007 will have the opportunity to discover the region of Bas-Saint-Laurent and to visit hybrid poplar plantations in the Témiscouata area. Cultural techniques for production of hybrid poplar and spruce and larch-improved stock will be presented at the Saint-Modeste nursery, where cutting propagation and somatic embryogenesis are integrated to standard nursery practice. Afterwards, participants will present the results of their research during poster and communication sessions, which will be held in Québec City as part of the *Carrefour de la recherche forestière*.

This year, the annual meeting of the Poplar Council of Canada is being held in conjunction with the Larix 2007 Symposium by holding the plenary session of invited speakers, a banquet at the Carrefour, as well as a visit to the *Centre d'expérimentation et de greffage de Duchesnay*, where the DRF's tree improvement programs will be presented. These two events are designed to emphasize two of our star species, poplar and larch, which have been the subject of the DRF's research programs since the early 1970^{s}. In passing, we mention that the DRF is celebrating its 40th anniversary this year. Hosting events like these can be traced back to the actions of visionary pioneers such as Messrs. Gilles Vallée and Jean Ménétrier, inititiators of the research projects in tree improvement and intensive silviculture.

Everywhere in the world we see a clear tendency of meeting the increasing demand for wood through the establishment of plantations. In Québec, the *ministère des Ressources naturelles et de la Faune* Act was modified in 2005 to include principles of forest ecosystem management associated with the functional zoning of the territory. Intensive silviculture therefore meets specific production issues on a reduced area, while reducing pressures on our natural forests. In addition, in the spring of 2006 the Québec government announced a silvicultural investment program funded with a $75 M budget over four years. These investments will allow us to carry out intensive silviculture on high-potential sites, especially the establishment of fast-growing species. Holding this CPC/PCC 2007 meeting integrates well with this thinking.

We wish you a pleasant stay in Québec, *la belle province*, and a successful and fruitful meeting!

The Organizing Committee

Mot des organisateurs

La Direction de la recherche forestière (DRF) de Forêt Québec, en collaboration avec le Conseil du peuplier du Canada, le Réseau Ligniculture Québec, Norampac – Division Cabano, la Direction régionale des forêts du Bas-Saint-Laurent, la Direction générale des pépinières et des stations piscicoles, l'Agence de mise en valeur des forêts privées du Bas-Saint-Laurent, la Corporation Agro-forestière Transcontinental inc. et le Groupement forestier et agricole Taché, souhaite la bienvenue au Québec aux participants de la Réunion annuelle 2007 du Conseil du peuplier du Canada. Nous espérons que la rencontre CPC/PCC 2007 vous plaira par sa programmation particulière, débutant par deux jours de visite sur le terrain.

Les participants au CPC/PCC 2007 auront l'occasion de découvrir la région du Bas-Saint-Laurent en visitant des plantations de peupliers hybrides au Témiscouata. Les techniques de production de plants de peupliers hybrides et des variétés améliorées d'épinettes et de mélèzes, dont celles issues de croisements dirigés et multipliées par bouturage ou embryogenèse somatique, seront présentées à la pépinière de Saint-Modeste. Par la suite, les participants nous feront part des résultats de leurs recherches lors des séances de communications et d'affichage, lesquelles auront lieu lors du colloque à Québec, dans le cadre du Carrefour de la recherche forestière.

Cette année, la Réunion du Conseil du peuplier du Canada s'associe au Symposium Larix 2007 pour tenir la séance plénière des conférenciers invités, un banquet lors du Carrefour ainsi qu'une visite au Centre d'expérimentation et de greffage de Duchesnay, où seront présentés les programmes d'amélioration génétique de la DRF. Ces deux évènements mettent l'accent sur deux de nos essences « vedettes », le peuplier et le mélèze, qui font l'objet de recherches à la DRF depuis le début des années 1970. Soulignons au passage que la DRF célèbre cette année ses 40 ans. La tenue de ces évènements découle des actions de pionniers visionnaires comme MM. Gilles Vallée et Jean Ménétrier, initiateurs des projets de recherche en amélioration des arbres et en ligniculture.

Partout dans le monde, on note une tendance manifeste à combler la demande croissante en bois au moyen des plantations. Au Québec, la Loi sur le ministère des Ressources naturelles et de la Faune a été modifiée en 2005 pour y inclure les principes d'aménagement écosystémique de la forêt, associé au zonage fonctionnel du territoire. La ligniculture satisfait ainsi certains enjeux de production sur des superficies réduites, tout en diminuant la pression sur la forêt naturelle. Par ailleurs, le gouvernement du Québec a annoncé au printemps 2006 un programme d'investissements sylvicoles doté d'un budget de 75 M$ sur quatre ans. Ces investissements permettront d'entreprendre des travaux de sylviculture intensive sur des sites à fort potentiel, notamment la culture d'essences à croissance rapide. La tenue de la Réunion CPC/PCC 2007 s'inscrit dans cet ordre d'idée.

Nous vous souhaitons bon séjour au Québec et bon colloque!

Le comité organisateur

Acknowledgments

We extend our thanks to the Carrefour de la recherche forestière and the *Direction de la recherche forestière* (DRF) who host the 2007 Annual Meeting of the Poplar Council of Canada as part of the joint seminars of the Carrefour. Our financial partners played a key role by providing necessary material support for this regionally based multi-day event. Thanks for your support!

We acknowledge the contribution of all our collaborators in the Bas-Saint-Laurent region, specially for the Norampac – Cabano field visits. In addition to the organizing committee, several persons participated in organizing the meeting, in the regions as well as at the *Carrefour*, and we cordially thank them for their contributions: Stéphan Mercier, Maripierre Jalbert, Marie Dussault, Sabrina Morissette, Mireille Desponts, Daniel Robert and Jean Noël. Particular thanks to Jean Ménétrier and Jim Richardson for their help in developing the theme for the meeting.

We particularly thank Martin Perron, Clarence Dubé, Pierre Bélanger, Brigitte Bigué, Alain Fauchon, François Caron and Gaston Lapointe for their collaboration and constant support. Our thanks also are directed to DRF genetics and tree reproduction personnel, as well as to Nathalie Langlois, Jessica Groleau and Guillaume Plante for their help with publications. Also, our thanks go to the other persons who participated in organizing the meeting, particularly to the personnel of the Saint-Modeste nursery.

We recognize the invited speakers, authors, moderators and CPC/PCC 2007 participants for their contributions.

We acknowledge with gratitude the leadership of Hervé Gagnon, recently retired, with the special poplar tree improvement project in the Bas-Saint-Laurent region. We also thank Pierre Drolet and the *Direction régionale des forêts du Bas-Saint-Laurent* for providing the funding since 1998 through the "*PMVRMF – Volet 1*".

Lastly, we wish to underline the indispensable contribution of the organizing committee members and the major support given by *Forêt Québec* managers for this event.

Remerciements

Nous remercions le Carrefour de la recherche forestière et la Direction de la recherche forestière (DRF) qui ont rendu possible la tenue de la Réunion annuelle 2007 du Conseil du peuplier du Canada dans le cadre des colloques conjoints du Carrefour. Nos partenaires financiers ont joué un rôle capital en soutenant matériellement cet événement échelonné sur plusieurs jours en région, merci pour votre appui !

Soulignons la contribution de nos collaborateurs au Bas-Saint-Laurent et plus particulièrement celle de Norampac – Cabano pour les visites de terrain. En plus du comité organisateur, plusieurs personnes ont participé à l'organisation du Symposium tant en région qu'au Carrefour et nous les remercions cordialement pour leur contribution : Stéphan Mercier, Maripierre Jalbert, Marie Dussault, Sabrina Morissette, Mireille Desponts, Daniel Robert et Jean Noël. Un merci particulier à Jean Ménétrier et Jim Richardson pour leur concours dans la composition du thème de la réunion 2007.

Nous remercions particulièrement Martin Perron, Clarence Dubé, Pierre Bélanger, Brigitte Bigué, Alain Fauchon, François Caron et Gaston Lapointe pour leur collaboration et leur support constant. Nos remerciements s'adressent également au personnel de la DRF en génétique et en reproduction des arbres, ainsi qu'à Nathalie Langlois, Jessica Groleau et Guillaume Plante pour leur aide à la publication. Nos remerciements s'adressent aussi aux autres personnes ayant participé à l'organisation du Symposium, et plus spécialement au personnel de la pépinière de Saint-Modeste.

Nous sommes reconnaissants aux conférenciers(ères) invités(es), aux auteurs, aux modérateurs ainsi qu'aux participants de leurs apports à la Réunion annuelle 2007.

Nous remercions chaleureusement Hervé Gagnon, maintenant à la retraite, pour son engagement dans le projet du peuplier au Bas-Saint-Laurent. Nous sommes spécialement reconnaissants à Pierre Drolet et à la Direction régionale des forêts du Bas-Saint-Laurent de leur appui et du financement du projet par l'entremise du Volet 1 (PMVRMF).

Finalement, nous désirons souligner la contribution indispensable des membres du comité organisateur et l'appui majeur des gestionnaires de Forêt Québec à cet événement.

Pierre Périnet,

Président du comité organisateur

Thanks to our sponsors!/Merci à nos partenaires financiers !

The organisers of the 2007 Annual Meeting of the Poplar Council of Canada thank all the contributors for their valued collaboration and their support for funding./Les organisateurs de la Réunion annuelle 2007 du Conseil du peuplier du Canada tiennent à remercier chaleureusement tous les partenaires financiers pour leur précieuse collaboration et leur appui.

Category Platinum/Catégorie Platine

Ressources naturelles et Faune Québec

Norampac
Division Cabano

Category Silver/Catégorie Argent

RÉSEAU LIGNICULTURE QUÉBEC

VALORITREMBLE

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NBG

Les Industries ST-MICHEL
1995
USINE DE TOURNAGE DE BOIS
Spécialités:
Composantes de meubles et d'escaliers,
Reproduction de moulures, etc.

Abstracts or papers of scientific communications/ Résumés ou articles des communications scientifiques

Notes

Poplar Breeding Strategies and Poplar-Rust Interactions (*Melampsora larici-populina*)

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Poplar breeding strategies: lessons from the past, recent advances and perspectives for the future

Poplar breeding programs around the world have achieved substantial increases in growth and yield potential through careful combination of intra/interspecific hybridization and clonal selection. Major challenges of future poplar breeding include (1) continuous genetic gains for recognized economic traits while addressing new breeding goals, (2) optimization of large-scale deployment of the selected genetic variation to limit economical and environmental risks associated to clonal forestry, (3) bringing genomic technologies to application in conventional poplar breeding.

Breeding strategies defined for the French Poplar Breeding Program (GIS Peuplier) will be analysed in the light of significant developments of the past ten years in the following areas:

(1) Intra/interspecific hybridization: performances and heterosis level in different hybrid combinations including *Populus deltoides*, *P. trichocarpa* and *P. nigra*; respective levels of among- and within-family variations for a suite of traits of interest; relationships between intra and interspecific combining abilities.

(2) Relationships between traits of interest (growth, phenology, disease resistance, branching habit, water use efficiency, wood properties)

(3) Optimal selection age and development of stepwise selection

(4) GxE interaction

(5) Development of marker/gene-based selection: a marker-based recurrent selection to balance genetic diversity and multitrait genetic gains, when non-pedigree association genetics needs to replace pedigree populations to detect QTL, genome sequence and development of a genome-wide selection approach for an optimal construction of elite genotypes.

The breeder's efforts will not stop at designing genetically improved trees, but need to define rational deployment strategies that do not neglect the potential impacts that improved material may have on the environment and for end-users in the context of climate change and diversification of poplar cultivation schemes.

Poplar-Rust interactions: a multiscale/ multidisciplinary research approach to develop higher durability of poplar resistance to *Melampsora larici-populina (Mlp)*.

Durable resistance to *Melampsora larici-populina (Mlp)* leaf rust is a major challenge for poplar breeding in Northern Europe. When no rust epidemic was evident in the natural *Populus nigra* populations, cultivation of interspecific clones carrying qualitative resistances have strongly modified both qualitative and quantitative pathogenicity components of *Mlp* populations in cultivated areas (Pinon and Frey 2005). The mixed, sexual/asexual reproduction system of *Mlp* and the high ability of dispersion of its uredospores place *Mlp* in the highest position of Mc Donald and Lande (2002) scale of evolution risk. In monoclonal poplar plantations, durability of rust resistance will depend strongly on (1) resistance mechanisms associated in a given genotype, (2) genetic diversity present in *Mlp* populations submitted to these high selection pressures and (3) possibility of recombination rate associated with sexual reproduction on larch.

Recent results on genetic control of *Mlp*-poplar interaction and multidisciplinary research projects in development will be presented under the following categories:

(1) Laboratory and field resistances in pure species (*P. deltoides*, *P. trichocarpa*, *P. nigra*), F1/F2 hybrids and backcrosses.

(2) Relationships between rust resistance and rust tolerance in field experiments

(3) Qualitative and quantitative resistances: frequency, genetic and molecular controls, towards cloning genetic relationships between qualitative and quantitative resistances

(4) Exapted vs natural resistances: strain-specificity, comparison of nucleotide polymorphisms and associated phenotypic variation in *P. trichocarpa* and *P. nigra*

(5) Relationships with other pest resistances in poplar

(6) Other alternatives linked to plant characteristics with limited action on pathogen populations

(7) Evaluation of selection pressures of different resistance constructions on *Mlp* populations in onoclonal plantations and clonal mixtures

Breeding strategies for durable rust resistance developed in the French Breeding Program will then be discussed.

Acknowledgements

All results and projects represent the collective efforts of a large team of collaborators from the genetic team at INRA-UAGPF Orléans (A. Dowkiw, V. Jorge, V. Guérin, F. Lefèvre, M. Villar, L. Sanchez), the forest pathology team at INRA-IAM (J. Pinon, B. Thoirain, P. Frey, C. Husson, S. Duplessis) and INRA-Angers (M. Ménard), the genomic team at INRA-URGV (P. Faivre-Rampant, A. Bresson), the entomology team at INRA-URZF (S. Augustin), the ecophysiology team of Orleans University-LBLGC (F. Brignolas, N. Marron, R. Monclus) and of INRA-EEF (E.Dreyer). The genetic material present in these experiments has been developed by the technical team from INRA-UE Orléans and is tested in collaboration

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Gene Flow Between Exotic Plantations and Natural Populations of Larch and Poplar

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When genes are exchanged between native and introduced species through the process of introgressive hybridization, the genetic integrity of the native populations can be impacted. As a first step to assess the frequency and consequences of this potential exchange, we developed diagnostic molecular genetic markers and tested whether exotic genes derived from plantations of introduced tree species can be found in surrounding natural populations of poplar (*Populus balsamifera* and *P. deltoides*) and larch (*Larix laricina*). Over three consecutive years, we genotyped nearly 5 000 seeds from two populations of native mother trees for each of both genera. The percentage of hybrid seeds that contained genes from different exotic species showed substantial variation among populations and species, though relatively little year-to-year variation. In larch, hybrid seed was infrequently formed (mean 2%), while in poplar, the rate of hybridization was higher and more variable (5% to 66%). Our results clearly demonstrate that hybridization between introduced and native trees can occur. The next step will be to determine whether hybrid trees establish themselves in natural populations and successfully reproduce. In addition to the implications for regulation and management, our study furnished copious DNA markers that have proved valuable for the verification of plant material used in tree breeding.

Notes

Adaptation of forest trees to climate change

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Will populations of temperate and boreal forest trees be able to adapt sufficiently rapidly to avoid extirpation during rapid climate change? What genetic factors should forest managers consider to increase the probability of maintaining healthy, viable forests for production or conservation objectives as climates warm? What can we learn from the genetic and genomic architecture of local adaptation in forest tree populations, and how will this knowledge aid our ability to predict response to climate change and inform management strategies? The high levels of genetic diversity and substantial population differentiation of forest trees for phenotypic traits related to adaptation to climate provide genetic resources for adaptation; however, the long generation length of forest trees will greatly hinder their ability to adapt. Seed transfer and deployment strategies for improved and wild stand seed lots need to be entirely re-thought, moving away from traditional views of "local is best" and towards finding and planting genotypes with temperature response curves indicating tolerance of both current and predicted future conditions in a given location. Bioclimatic models can predict the future distributions of potential habitat for species and populations, but these models are accompanied by a great deal of uncertainty, as actual migration will depend on reproduction, dispersal, and biotic interactions, thus predictions need to be empirically tested in the field. Facilitated migration of populations and species to increase levels of gene flow from milder to colder climates, and to nucleate long-distance migration event, should commence on a controlled, experimental basis. A better understanding of the genomics of complex traits such as growth and adaptation to biotic and abiotic stresses will aid in the understanding of local adaptation to temperature and genetic constraints to rapid adaptation. Isolated, peripheral populations may be important sources of genotypes adapted to extreme conditions, and thus should be of high priority for conservation.

Notes

Exotic Tree Species and Forest Management Certification

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Within a decade, forest management certification has become an essential tool used by forestry companies around the world to demonstrate to the global markets their compliance to recognized voluntary sustainable forest management standards.

These standards address a number of concerns including social, economical, and ecological aspects. Three main standards are used by the forest industry in North America: CSA Z809, FSC and SFI, while two are used in Europe: PEFC and FSC.

Natural forest management and plantation forestry are covered in the standards by specific requirements.

Each of the standard addresses exotic tree species and the use of Genetically Modified material in different ways. FSC is generally more specific and prescriptive while the other standards allow more flexibility. However, during the audit process, it appear that there is a need to clarify the status of exotic species. The auditors responsible to assess the conformity of the forest practices, often have to request on a case by case basis, a justification from the forester of the status of the exotic species.

In order to give more consistency and credibility to the audit process, a list of species considered exotic and “naturalized” should be developed and made available by the appropriate authorities.

Notes

Sixty Years of Poplar Breeding for Shelterbelts

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Since the commencement of the Prairie Shelterbelt program in 1901, significant advances have been made in the selection of adaptable tree species for the program. The shelterbelt tree improvement program, designed specifically to develop adapted, genetically superior tree and shrub species for prairie shelterbelts was initiated in 1947 at Indian Head, Saskatchewan. 2007 marks the 60th anniversary of shelterbelt tree improvement at Indian Head. During this period program has continued under the direction of Bill Cram (1947 – 1975), Gordon Howe (1975 – 1981) and Bill Schroeder (1981 – present). The genus *Populus* has been one of the principal target species in this breeding program. The poplar breeding program has included international exchange of poplar genetic material, classical breeding and selection as well as ex situ conservation of *Populus* species endemic to the Canadian prairies. Since its inception the poplar program has developed over 25 clones that have been or are still utilized in tree planting programs. This represents the longest running poplar breeding program in Canada.

This paper will present an overview of the AAFC-PFRA poplar breeding program, its current activities, accomplishments and impacts on agroforestry and plantation forestry in Canada as well as other regions of the world with similar biotic and abiotic challenges.

Notes

Breeding new hybrid poplars for the Prairies – meeting multiple objectives

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In 1999 a joint initiative began between Alberta-Pacific Forest Industries Ind. (Al-Pac) and Agriculture and Agri-Food Canada's Prairie Farm Rehabilitation Administration (PFRA) Agroforestry Division in Indian Head Saskatchewan. While PFRA's objectives for this program was to improve poplars for afforestation on agricultural land, farmstead and field shelterbelts, phyto-remediation, carbon sequestration through maximizing biomass and riparian protection (buffers) in the prairie region of Canada (provinces of Manitoba, Saskatchewan, Alberta), Al-Pac's goal was to select well adapted fast growing, disease resistant hybrid poplars with specific wood quality characteristics ideal for pulping. Through our collaboration, each group has been able to select for further testing, hundreds of new genotypes from thousands of seedlings produced from three years of breeding effort.

We will present the overall breeding design, success and selection regime, and show preliminary results from the initial field trials. To date, more than 1000 genotypes are being field tested in both Alberta and Saskatchewan. This program represents the largest breeding effort of its kind in the last 20 years geared specifically for the boreal and prairie regions of Canada.

Notes

Eight-year results from an aspen provenance trial in Western Canada

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A provenance trial of aspen (*Populus tremuloides* Michaux) was established on five sites in Western Canada in 1998. This paper reports the results of eight-year height growth.

The five test sites spanned 5.7 degrees of latitude from 58.5°N in Fort Nelson, BC to 52.8°N at Medicine Lake, AB. Forty-three seed sources were grouped into six provenances for purposes of this analysis. The provenances span 11.1 degrees of latitude from 58.4°N in British Columbia to 47.3°N in Minnesota.

There were large site differences in growth response. The best height growth was observed on the Athabasca test site (5.3 m average) and the poorest on the Fort Nelson site (3.0 m average).

There were clear and consistent responses to latitudinal transfer :

a) Southward transfers are detrimental. The greater the transfer southwards, the poorer the relative height growth. The BC sources ranked last on all five test sites.
b) Northward transfers are beneficial. The relative growth response is significantly larger with all northward transfers, although transfers greater than 7-8 degrees of latitude may show some maladaptation. The Minnesota sources were top ranked on the three southern test sites. They would probably have been top ranked on the northernmost (Fort Nelson) test site as well, were it not for moose damage.
c) There is little provenance differentiation within Alberta based on height. The three Alberta sources are close in rank on the three mid-latitude test sites.

With climate change, it is expected that there will be a shift in environmental conditions resulting in an effective southward transfer for local aspen populations. Some implications for material transfers and the necessity of further genecology work will be discussed.

Notes

Breeding Success and Range of Incompatibility among *Populus* Hybrids in Sections *Aigeiros* Duby and *Tacamahaca* Spach

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Interspecific hybrids within the genus *Populus* have resulted from natural hybridization and planned breeding efforts. Heterosis (i.e. hybrid vigor) of interspecific hybrids, along with traits such as disease/pest resistance and elevated rooting ability, has supported their use in a variety of applications. Nevertheless, difficulties in producing such hybrids have resulted from pre- and post-fertilization barriers, along with hybrid inviability. Incompatibility often precludes successful hybridization. Compatible crosses in our previous breeding between *P. maximowiczii* A. Henry 'M' (Japanese poplar) and *P. deltoides* Bartr. ex Marsh 'D' (eastern cottonwood) that did not require embryo rescue corroborated the potential of such hybrids, despite low seed set. Our objective was to test the range of incompatibility among intraspecific and interspecific crosses using parental germplasm from the sections *Aigeiros* Duby [D and *P. nigra* L. 'N' {European black poplar}] and *Tacamahaca* Spach [M and *P. trichocarpa* Torr. & Gray 'T' {western black poplar}]. We determined the success rate of crosses, along with seed production and seedling viability. The D × M (100%) and D × D (83%) crosses were compatible, exhibiting the greatest number of seeds per capsule (33, 31, respectively). The M × N crosses (50%) produced significantly ($P < 0.0001$) fewer seeds (two), but the seeds were viable. The M × D crosses exhibited 31% success. Some M × D crosses produced 2 to 4 viable seeds not requiring embryo rescue, while others produced two nonviable seeds or were completely incompatible. The NM × D crosses were incompatible (0%), while NM × N (50%) and NM × T (100%) produced viable seedlings. From a practical standpoint, it is possible to exploit the benefits of interspecific crosses involving M and D. Selection of favorable genotypes within such crosses may greatly increase the success of deployment for a variety of applications.

Notes

A metapopulation model for the introgression from Genetically Modified Plants into their wild relatives

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Most likely, the first Genetically Modified trees that will be released for commercial use in Canada will be poplars. This necessitates research on the possible negative ecological effects that may arise from gene flow between the GM trees and natural populations, leading to introgression of the transgene. Most models on introgression from Genetically Modified plants have focused on small spatial scales, modelling gene flow from a field containing GM-plants into a single adjacent population of a wild relative. Few models have addressed the effect of introgression from multiple plantations into the whole metapopulation of the wild relative. Here, we present a metapopulation model to study the effects of continuous introgression from GM plants into natural populations of a wild relative. The most important result of the model is that the overall frequency of the transgene in the metapopulation, after a certain number of generations of introgression, is strongly dependent on the population structure. If there is a high rate of migration between natural populations the overall transgene frequency is much higher than when there is limited migration. This means that studies on the potential ecological risks of introgression from GM plants should not only look at the rate of introgression and selection acting on the transgene, but also at the population structure of the wild relative.

Notes

The use of single nucleotide polymorphism to survey genetic variation in natural populations of *Populus balsamifera*

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Balsam poplar (*Populus balsamifera* L. ssp. *balsamifera*), one of only a few hardwood species hardy to northern Canada, displays extensive intraspecific variation in a range of physiological and traits related to the annual growth cycle. In ongoing studies we have described the latitudinal patterns of ecophysiological trait variations among populations and across resource and environment gradients. Understanding the population genetics of genes associated with those traits will provide insight into adaptation and patterns of range expansions. We are working on a systematic and comprehensive survey of molecular variation to assess the nature, pattern and frequency of single nucleotide polymorphisms (SNPs) in 15 candidate genes of interest. For this, we have adopted the mismatch SNP discovery method known as "*Ecotilling*". These SNPs which form the most common type of sequence differences between alleles, may alter and affect gene function. Under study are the phytochrome genes (*PhyB* & *PhyA*) implicated in growth cessation and photoperiodic dormancy induction; putative transpiration efficiency gene (*Erecta*) responsible for water use; and gene families related to uptake and utilization of nitrogen, both NO_3^- (*Nrt1* & *Nrt2*) and NH_4^+ (*Amt1* & *Amt2*). Candidate genes chosen affecting the traits of interest may reveal how environmental forces acting at these loci contribute to phenotypic variation in natural populations.

Notes

Genetic Variation in British Columbia's Black Cottonwood (*Populus trichocarpa*) natural populations as revealed by microsatellite markers

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Genetic variation within and among 16 natural populations of black cottonwood (*Populus balsamifera* L. ssp. *trichocarpa*) from British Columbia is evaluated using 9 SSRs markers to investigate the species' recent evolutionary history and determine the presence/absence of any concordance between populations' genetic structure and geographical distribution. The number of alleles ranged between 14 and 32 with an average of 22.22 alleles per locus. Populations exhibited low observed (H_o = 0.58) compared to expected hetrozygosity (H_e = 0.88), indicating that these populations could experienced inbreeding. Genetic variation determined according to infinite allele model (F_{st}) as well as stepwise mutation model (R_{st}) yielded similar results and most of the genetic variance occurred within (0.96) rather than among populations (0.04). According to infinite allele model (IAM), with the exception of two populations; population 28 (N=22, latitude 50° 14̀ and longitude 123° 59̀) and population 31 (N= 18, latitude 49° 44̀ and longitude125° 05̀) all populations experienced either single or multiple bottleneck events. Cluster analysis revealed lack of concordance between populations' genetic structure and geographic origin, indicating that gene flow was effective in harmonizing the genetic variability among populations and geographic distances among populations were not effective barriers for promoting isolation that was supported by further lack of significant correlation between (F_{st}) pairwise genetic distances and geographic distances (r = 0.045; P = 0.24). The breadth and depth of the observed within populations genetic variation; although it is for neutral markers, represents a wealth of diversity for selection for breeding programs. The present neutral markers preliminarily analysis is part of a larger study that will utilize Eco-tilling for assessing SNPs variation in the species adaptive, defense, and wood attributes.

Notes

A method for estimating the root biomass of poplars grown in plantations in northern Alberta

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Our ability to determine root biomass of hybrid poplars grown in plantations is rather limited and tree root biomass data is of primary importance in calculating annual carbon budgets and estimating carbon stocks in hybrid poplar plantations. Currently no reliable generalized predictive models are available to estimate root biomass from aboveground tree size measurements for various ecosystems. Furthermore, work completed in eastern Ontario and on the west coast has generated region-specific aboveground biomass models, but no such models are available for hybrid poplars grown in a boreal region such as northern Alberta. We excavated two entire root systems for each of five poplar types, including three hybrids and two species, grown in a plantation. A high pressure water truck was used to excavate the roots. Both root biomass and root diameter five centimeters from the stump were measured. Based on these measurements, a model was then developed for each poplar type; the models explained 83 – 93% of the variation in the respective datasets. Ten additional stumps of each poplar type were also excavated to include all roots with a section at least 10 cm from the base of the stump. This would allow the root diameter five centimeters from the stump to be measured for each root. Total root biomass was then calculated based on the models developed from the whole root excavations. All 60 trees sampled (12 per poplar type) were also measured for height, DBH, and dried to determine aboveground biomass. Predictive models were then developed and both aboveground biomass and DBH were found to be good predictors of root biomass for four of the five poplar types. Our results indicate that there is a strong relationship between aboveground tree size and belowground root biomass for the poplar types we studied. Further research is needed to improve the predictive ability of models for root biomass based on aboveground tree size measurements.

Notes

Intraspecific Competition in Hybrid Poplar
Compétition intra spécifique chez le peuplier hybride

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Les processus éco-physiologiques qui affectent la réaction des clones de peuplier hybride (*Populus spp*.) à la densité des peuplements sont peu connus. Dans une perspective agroforestière, il se peut qu'on doive faire varier l'espacement entre les plants ou la densité des blocs de plantations par rapport aux espèces compagnes. Ainsi, il devient impératif de mieux comprendre la compétition intraspécifique chez le peuplier hybride par l'évaluation des variations morphologiques et physiologiques liées à la diminution de l'espacement entre les arbres et des rapports de biomasse entre différentes parties selon le degré de compétition. Ces informations sont essentielles dans le choix des clones utilisés et dans la gestion de l'espacement entre les arbres pour maximiser la productivité. Trois parcelles expérimentales ont été installées en 2003 selon un même dispositif (blocs aléatoires) contenant deux clones de peuplier hybride, le 747215 (*P. balsamifera* × *P. trichocarpa*) et le 915319 (*P. maximowiczii* × *P. balsamifera*) et trois différents espacements entre les arbres: 1 m × 1 m , 3 m × 3 m et 5 m × 5 m. Les mesures effectuées portent sur la caractérisation morphologique (cime et branches) et physiologique: (photosynthèse (An), respiration, conductance stomatique (Gs), concentrations en éléments nutritifs et en protéines solubles et insolubles, sur 9 feuilles situées à différents emplacements de la cime : trois en bas, trois à mi-hauteur et trois au sommet). La présentation portera sur les changements morpho-physiologiques induits par la réduction de l'espacement entre les arbres.

Notes

FSC and ISO Certification of Short Rotation Poplar Plantations: Is certification good for business?

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GreenWood Resources manages 13,000 hectares of hybrid poplar in the Columbia River drainage of Oregon and Washington, USA. These plantations are being managed for multiple products including high grade saw logs, pulp chips, and residuals for bioenergy. Rotation length is twelve to fifteen years and the program is currently six years into the second rotation.

In 2001 the Boardman Tree Farm (previously owned by Potlatch Corp.) became the first plantation of any species in North America to be certified as a Well-Managed Plantation by the Forest Stewardship Council (FSC). The poplar farm also achieved ISO 14001 certification of its Environmental Management System (EMS) in 2003. Last year the tree farm completed recertification audits for both standards and will now enjoy certification through the rest of the decade.

Last May the GreenWood Tree Farm Fund was capitalized and the poplar farms previously owned by Potlatch Corp. and GreenWood Resources were consolidated. In addition a saw mill was capitalized to process the wood coming off of the farms and Collins Companies will operate the mill. Currently all of the tree farms are being managed by GreenWood Resources and all of the farms are expected to be brought under one FSC certificate by the end of the year.

Initially certification brought with it anticipation of higher margins for the wood products sold. This has not proven to be the case as the market place has not been willing to pay for the company's commitment to elevate environmental standards. As we look to the future with an experienced saw mill partner who has marketed FSC wood products for many years, market entry and premiums for FSC poplar may ultimately be realized. Regardless, certification has brought with it intangible benefits including positive ENGO recognition, enhanced contractor and employee satisfaction, and improved structure to the way we conduct our everyday business.

Notes

Site productivity gradient and trembling aspen clonal structure

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Many conceptual models have been developed to explain the pattern of plant diversity and gradients of productivity but few empirical studies have demonstrated a relationship between plant diversity and a natural gradient of by site quality. In the present study we were interested to test the relationship between trembling aspen (*Populus tremuloides*) clonal diversity and a natural gradient of forest productivity. We hypothesize a decline in aspen clonal diversity along the site productivity gradient as few more competitive clones will dominate the stand in the most productive sites. Nineteen naturally established, even-aged aspen stands were sampled and grouped into four productivity classes, representing site indexes ranging from 6.6 to 29.9 m. Using molecular markers, a total of 62 unique multilocus genotypes were detected in the nineteen populations. Assuming that ramets within each site that share a multilocus genotype belong to the same genet, the number of ramets per genet varied form one to 13. The clones were generally small and represented by 1 to 3 trees. Two clones only consisted of 13 trees in 2 stands. The proportion of single ramet clones is higher in class IV though differences in G/N ratios between productivity classes were not significant. Overall aspen sampled in this study showed a high level genetic diversity which is typical of an outbreeding species. Genotypic (clonal) diversity and evenness increased with productivity and differences between productivity classes were significant. These results and their impact on development of aspen stand management scenarios will be discussed.

Notes

Growth Performance of Clonal Hybrid-Aspen in Northern Germany

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An increasing demand for wood as raw material for industrial purposes and especially as source for renewable energy has raised the interest in short rotation woody cultures (SRWC) on former agricultural land in Europe. Subsidies equal to those for food production are a driving force for SRWC. An increasing demand for suitable reproductive material stimulated this study. Fast-growing willow, poplar and also Aspen species hybrids showing significant heterotic effects are of interest. The heterosis found in the species combination, *Populus tremula* and *P. tremuloides*, in a factorial seven by seven crossing scheme resulted in 29 to 76 % increased increments. Interspecific breeding in both directions is equally possible and shows no preference with respect to growth. Better performance was found also on set-aside land of low quality, which are more abundant for SRWC. Among several of the superior hybrid progenies, 50 well performing individuals were micro-propagated by tissue culture and field-tested. Evaluations after twenty years show an increased growth performance and higher survival rates than seedling derived trees.

Notes

Thermomechanical hardening of hybrid poplar wood
Durcissement par thermocompression du peuplier hybride

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Le procédé de durcissement par thermocompression permet d'améliorer considérablement certaines propriétés physicochimiques, mécaniques, biologiques, phytosanitaires et esthétiques du bois, comme la dureté, la résistance aux champignons, la couleur etc.

Le durcissement par thermocompression, qui rivalise avec les procédés de durcissement chimique telle que la densification avec le méthyle méthacrylate, le polystyrène et d'autres résines, vise à conférer au bois mou comme le peuplier hybride une dureté en surface comparable à celle de l'érable. Ce traitement est utilisé, en particulier, pour valoriser les essences de bois qui sont abondantes dans les forêts québécoises et qui sont en faible demande en raison de leur qualité inférieure.

Un traitement hydrofuge qui répond aux exigences environnementales, est appliqué au bois thermocompressé pour qu'il ne reprenne pas ses dimensions initiales en présence de l'humidité.

Les conditions de thermocompression ainsi que celles du traitement hydrofuge seront décrites. Les résultats des tests mécaniques comme le MOR et le MOE en flexion, la dureté, la résistance à l'abrasion, la chimie de surface, la stabilité dimensionnelle et la résistance antifongique seront discutés lors de la présentation.

Le produit de peuplier hybride thermocompressé et hydrofugé est un bon substitut pour les bois nobles comme l'érable à sucre, le mélèze, le merisier etc. qui sont utilisés pour le recouvrement des planchers et pour la fabrication de meubles de qualité esthétique supérieure. En effet, le traitement suggéré fait ressortir les cernes du bois et lui donne l'aspect d'un bois noble comme le merisier ou l'érable.

Notes

Survey on the interest of rural landowners of the Appalachian region, Québec, in afforestation of hybrid poplar

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This scientific survey was developed as part of the pilot project of the *Agence de mise en valeur des forêts privées des Appalaches*. Created in 2002 through a venture of Natural Resources Canada, this pilot project was implemented in cooperation with the *ministère des Ressources naturelles et de la Faune du Québec* (MRNF). Its primary objective involves testing the use of pig manure to fertilize hybrid poplar plantations intended for the production of durable goods and carbon sequestration. This approach provides an incentive for some of the landowners whose land is likely to be forested.

The survey is a telephone survey. It covers the four regional municipality counties (Bellechasse, Les Etchemins, l'Islet and Montmagny) and the new town of Lévis (following the integration of neighbouring municipalities). The targeted population is landowners who possess non-forested land with no agricultural crops, primarily uncultivated land and pastures.

The main objective of the survey is to obtain accurate information on the following:

- Characteristics of land likely to be forested under the Kyoto Protocol;
- Landowner interest in afforestation;
- Landowner interest in the afforestation of fast growing species such as the hybrid poplar;
- Deforestation phenomenon;
- Socio-economic characteristics of landowners.

The survey was performed in two steps: the pre-survey of 100 respondents in 2005, and the main survey of 300 respondents in 2006.

The survey data will be analyzed beginning in the spring of 2007. The presentation will outline the methodology and provide highlights of the results.

Enquête sur l'intérêt de propriétaires ruraux des Appalaches pour le boisement du peuplier hybride

Cette enquête scientifique est réalisée dans le cadre du Projet pilote de l'Agence de mise en valeur des forêts privées des Appalaches. Créé en 2002 par le biais d'une initiative du ministère des Ressources naturelles du Canada, ce projet pilote est mis en œuvre de concert avec le ministère des Ressources naturelles et de la Faune du Québec (MRNF). Son orientation principale consiste à mettre à l'essai l'utilisation du lisier de porc pour fertiliser des plantations de peuplier hybride destinées à la production de biens durables et à la séquestration du carbone. Cette approche se veut un incitatif au boisement pour une partie des propriétaires de terres susceptibles d'être boisées.

L'enquête est de type téléphonique. Elle porte sur le territoire de quatre MRC (municipalités régionales de comtés de Bellechasse, Les Etchemins, l'Islet et Montmagny) et de la nouvelle ville de Lévis (suite à l'intégration de municipalités voisines). La population visée est constituée des propriétaires de terres sur lesquelles on retrouve des secteurs non boisés où il ne se fait pas de récolte agricole, particulièrement des friches et des pâturages.

Les principaux objectifs de l'enquête sont d'obtenir des informations fiables sur les sujets suivants :

- les caractéristiques des terres susceptibles d'être boisées au sens du Protocole de Kyoto;
- l'intérêt des propriétaires pour le boisement;
- l'intérêt des propriétaires pour le boisement d'essences à croissance rapide comme le peuplier hybride;
- Le phénomène du déboisement;
- Les caractéristiques socio-économiques des propriétaires.

L'enquête a été effectuée en deux phases : une pré-enquête de 100 répondants en 2005 et l'enquête principale de 300 répondants en 2006.

Les données de l'enquête seront analysées à partir du printemps 2007. La présentation décrira les grandes lignes de méthodologie et les faits saillants des résultats.

Notes

Why not aspen? *Valoritremble* is dedicated to developing the aspen end-uses in Québec

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Aspen wood offers many great benefits from its white colour and lightness, to its resistance to heat and great stain finishes. Over the last ten years, the use of aspen for wood caskets, hockey sticks, and snow boards has been increasing in Québec. These industries have been making the best out of aspen wood. But aspen is ideal for far more: studies conducted in Canada and in the US have shown that aspen is still under-used by the manufacturing industries of North America.

In order to obtain the best value out of aspen logs, a group of seven sawmills in the Bas-Saint-Laurent region (located in the Eastern part of Québec), have joined together as Valoritremble to develop the market for aspen wood products. This unique initiative has never been attempted before in the aspen wood industry in Québec. The mandate of Valoritremble is to promote the use of aspen in the industries of mouldings, wall-panelling, furniture, door frames.

Why not aspen? We hope this conference will inform you about how seven companies of Valoritremble will work to broaden the use of Aspen.

Posters/Affiches

Notes

In vitro propagation of poplar and aspen clones using axillary-buds

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Hybrid poplars are usually propagated using stem cuttings. Hybrids from the *Populus* section, however, do not respond well to this technique, but can successfully be propagated in vitro from axillary bud. In order to produce equivalent planting stocks for subsequent testing in controlled and field conditions, we thus decided to use in vitro culture to establish our clones: *Populus tremuloides* x *Populus tremula*, *Populus alba* x *Populus grandidentata*, *Populus balsamifera* x *Populus trichocarpa*, *Populus balsamifera* x *Populus maximowiczii*, *Populus tremuloides* and *Populus balsamifera*.

The main objective of this study was to evaluate the effect of 4 cytokinins at 3 concentration levels: BAP (6-benzylaminopurine: 0.25 - 0.5 - 1 µM), kinetin (0.25 - 0.5 - 1 µM), 2ip (isopentenyladenine: 2 - 4 - 6 µM) and zeatin (1- 2 - 4 µM). MS basal medium (Murashige and Skoog, 1962) was used for all experiments, supplemented with 3% sucrose and solidified with 0.25% Gelrite. Axillary buds were placed vertically in 100 mm polystyrene Petri dishes containing 20 ml of medium, and the produced elongated shoots were dissected and subcultured in the same medium every three weeks. Proliferation rates for each treatment and clones will be discussed.

Notes

Early selection and clonal variation of hybrid poplar clones in a Québec forest nursery

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Abstract

Early selection in the nursery for desirable morpho-physiological characteristics offers substantial savings in terms of time and cost, compared with conventional breeding programs. For example, the sensitivity of certain clones to early (autumn) frost in the nursery can negatively affect the growth and survival of seedlings after planting. There is also lack of information about the clonal variation of hybrid poplar produced in Québec nurseries with respect to several morpho-physiological variables including: root initiation and development, shoot and foliage architecture, number of first-order branches, mineral nutrient and water use efficiency, mathematical growth models and carbon allocation between shoot and root systems. Knowledge of nutrient and water needs during the seedlings' first growing season in the nursery can help nurserymen to significantly reduce water use and nutrient leaching.

The objectives of this study were i) to characterize clonal variation of growth and physiology for several clones; ii) to evaluate carbon and biomass allocation between shoot and root systems; iii) to determine the degree of hardening of hybrid poplar clones and their sensitivity to early frost and crown dieback.

Our results showed that variations in growth and physiology reflect genetically determined differences among clones. The mathematical logistic models indicated that several clones differed significantly in growth parameters for both height and root-collar diameter. The slope in the allometric equation for dry mass and carbon allocation between shoots and roots were 0.5533 and 0.5503, respectively. This indicates a greater allocation for both dry mass and carbon to the roots during the first growing season in the nursery. The rate of acquisition of frost tolerance in the autumn also differed among clones. Differences among clones in the rate of acquisition of frost tolerance can be used by nurserymen and foresters during the selection of new hybrid clones less sensitive to seedling tip dieback as well as those intended for use in more northerly nurseries and plantation sites. This early selection approach can be used to select fast growing hybrid poplar clones and efficient clones in carbon sequestration, water and nutrient use.

Introduction

In Québec, more than 150 million seedlings are planted each year. Reforestation is an efficient way to increase the productivity of our forests and thereby obtain increased yields. Choosing the best-performing multi-clones, and using fast-growing species such as poplars and larches increases forest productivity. Such fast growing plantations could increase the rate of carbon storage and be used as a viable carbon sequestration strategy. This strategy offers major opportunities to develop a specific carbon market throughout North America (Isebrands and Karnosky 2001, Samson *et al.* 1999).

In 1969, the *ministère des Ressources naturelles et de la Faune du Québec* initiated a genetic improvement program for hybrid poplar with the goal of conserving and improving the genetic resources of the species in growth, adaptability, and disease resistance. Early selection in the nursery for desirable morpho-physiological characteristics offers substantial savings in terms of time and cost, compared with conventional breeding programs. For example, the sensitivity of certain clones to early (autumn) frost in the nursery can negatively affect the growth and survival of seedlings after planting. There is also a lack of information about the clonal variation of hybrid poplar produced in Québec nurseries with respect to several morpho-physiological variables including: root initiation and development, shoot and leaf architecture, number of first-order branches, carbon content, mineral nutrient and water use efficiency, mathematical growth models, and carbon allocation between shoot and root systems. Knowledge of nutrient and water needs during the clones' first growing season in the nursery can help nurserymen to significantly reduce water use and nutrient leaching.

Objectives

i) To characterize clonal variation of growth and physiology for several clones;

ii) To evaluate carbon and biomass allocation between shoot and root systems;

iii) To determine the degree of hardening of hybrid poplar clones and their sensitivity to early frost and crown dieback.

Material and methods

In November 2003, woody stem cuttings, 13-15 cm long and 9-13 mm diameter, were taken from 10 hybrid poplar clones used for reforestation programs in Québec. They were stored in cold storage at temperature ranging from -1 to -4°C. In May 2004, 1200 dormant stem cuttings/clone were planted as bare-root seedlings in five completely randomized blocks in the Grande-Piles provincial forest nursery (Québec, Canada). Within each block (1.5 m x 10 m), 240 ramets were planted in five rows at a spacing of four ramets/m with the exception of the middle row where this density was doubled. Surplus ramets in the middle row was used during four sampling dates (June 14, 21 and 28, July 5) to evaluate root growth of each clone (4 ramets/clone/block/sampling date) during the rooting period.

For each clone, height and root-collar diameter of four randomly selected ramets/block/clone were measured

bi-weekly from July 13 to October 4, 2004. Stem, root and leaf biomass, number of first-order branches, and the nutrient (N, P, K, Ca and Mg) and carbon (C) contents of each clone (4 ramets/ block) were evaluated at the end of the growing season (September 1, 2004). For leaf architecture (leaf area, perimeter, petiole length, specific leaf area, etc.), the largest fully expanded sun leaves on an upper shoot (12 leaves/clone/4 ramets/ block) were randomly selected at the end of vegetative growing period. To quantify dry mass and carbon allocation between shoot and roots, allometric equations were developed from individual ramet data using logarithmic transformation (Ledig et al. 1970, Lamhamedi et al. 2001).

We also used a non linear approach to adjust mathematical logistic models for height and root-collar diameter growth for each clone during the growing season. The parameters (a, b and c) of these models were compared among clones.

To determine the degree of hardening of hybrid poplar clones and their sensitivity to early frost and crown dieback, artificial frost treatments (control: 4°C; -4°C and -8°C), were applied to ramets (5 ramets/clone/block) harvested on September 7 and 20; and October 4 and 18, 2004 using a programmable freezer. The relative electrical conductivity (CR) and the index of injury (It) was then calculated for the apices subjected to a given frost temperature.

The data were subjected to various statistical analyses and homogenous groups were determined using the Scott-Knott cluster analysis method (Scott and Knott 1974) to identify groups of nonoverlapping means after the variances were found to be homogenous.

Results and discussion

Under similar growing conditions, there were significant differences among clones for several growth and physiological variables. The mathematical logistic models indicated that several clones differed significantly in growth parameters (a: asymptote, b: inflexion point, c: growth rate) for both height (a: P<0.0017, b: P<0.0001, and c: P<0.0003; Figure 1), and root-collar diameter (a: P<0.0398, b: P<0.0001, and c: P=0.0839). Clonal variation between clones was also observed in the number of first-order branches/clone and in leaf architecture (leaf area, perimeter, petiole length and specific leaf area). The number of first-order branches of all clones tested varied between 0 and 14 branches/clone. We also observed that the means of leaf area and petiole length of the 10 clones ranged from 62 cm^2 to 188 cm^2 and from 2.1 cm to 7.2 cm, respectively. Leaf growth characteristics (e.g. individual leaf area, shape, petiole length, leaf growth rate, specific leaf area, etc.) alter light-interception efficiency and are correlated with growth rates and trees productivity (Harrington et al. 1997, Marron et al. 2005, Niinemets et al. 2004, Ridge et al. 1986). Clonal homogenous groups for carbon content (Figure 2a), and leaves, stem and root dry masses (Figure 2b) were separated using Scott-Knott cluster analysis. The slope in the allometric equation for dry mass and carbon allocation between shoots and roots were 0.5533 and 0.5503, respectively. This indicates a greater allocation for both dry mass and carbon to the roots during the first growing season in the nursery. The rate of acquisition of frost tolerance in the autumn also differed among clones.

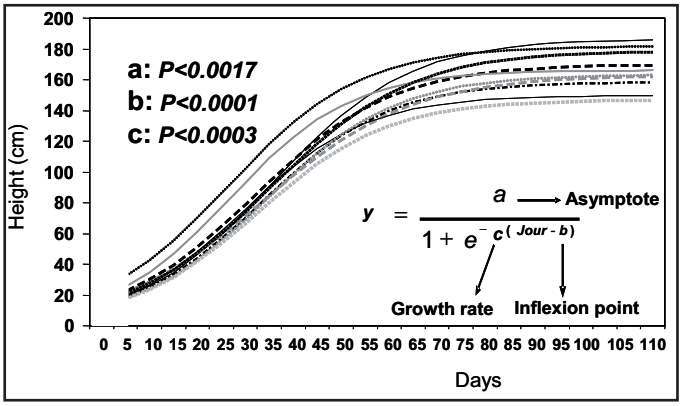

Figure 1. Logistic height growth models of 10 hybrid poplar clones.

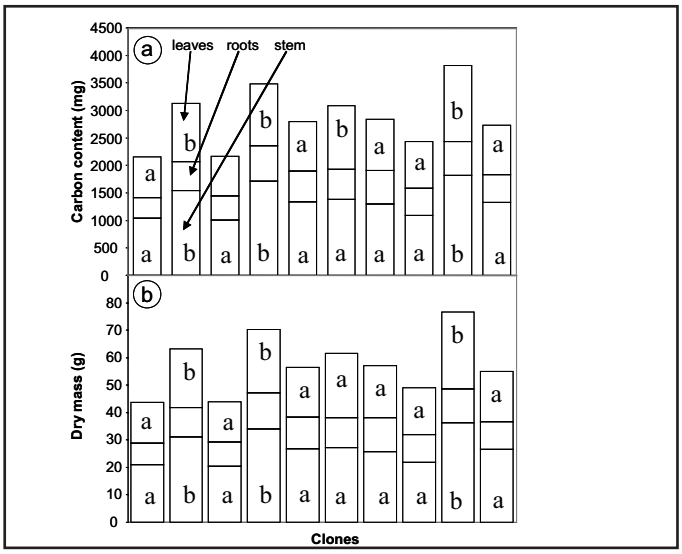

Figure 2. Comparison of means for stems, roots and leaves a) carbon content and b) dry masses of 10 hybrid poplar clones. Means followed by different letters did not belong to the same group according to the Scott-Knott cluster analysis method.

Intraclonal uniformity as well as the uniformity of growth conditions for all clones suggests that differences among clones were of genetic origin. Our results indicate that some growth and physiological traits can be improved by clonal selection. This early selection approach can be used to select fast growing hybrid poplar clones and efficient clones in carbon sequestration, water and nutrient use. Differences among clones in the rate of acquisition of frost tolerance can be used by nurserymen and foresters during the selection of new hybrid clones less sensitive to seedling tip dieback as well as those intended for use in more northerly nurseries and plantation sites.

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Notes

The Potential of Aspen Clones and Hybrids for Enhanced Forest Management in Alberta

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Tree Improvement, used with enhanced forest management, has potential to increase allowable cut on crown licenses, as well as provide suitable material for use in aforestation and support climate change strategies. Seventeen genetic test established on five test sites across Alberta between 1999 to 2002 using material from 700 native aspen *P. tremuloides* selections and hybrids through breeding with exotic pollen form *P. davidiana* and *P. tremula* sourced form South Korea, China and Finland respectively are examined to determined superior sources for use in planting programs in Alberta. Thresholds for movement of material as well as material adapted to changing climate are investigated based on genotype by environment interactions.

Notes

Asymmetrical natural hybridization between *Populus deltoides* and *P. balsamifera* (Salicaceae)

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Natural hybridization has long been recognized as a means for gene flow between species and has important evolutionary consequences. Although hybridization is generally considered to be symmetrical, with both hybridizing species being equally likely to be the male or female parent, several studies have demonstrated the presence of asymmetrical hybridization and introgression from one species to the other. We investigated the direction of natural hybridization between two sympatric forest tree species in North America (*Populus deltoides* and *P. balsamifera*) using species-specific single nucleotide polymorphism (SNP) markers in both the nuclear and chloroplast genomes. All natural hybrid individuals, identified based on morphological traits, had nuclear alleles corresponding to both parental species, while the chloroplast genotypes showed similarity to *P. deltoides*, indicating asymmetrical hybridization with *P. deltoides* as the maternal and *P. balsamifera* as the paternal donor species. This observed asymmetrical hybridization may be attributable to cytonuclear interactions.

Notes

Risk Management of Septoria Canker in Québec Hybrid Poplar Plantations

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Given that Septoria canker (*Septoria musiva*) is the most damaging disease in hybrid poplar plantations in southern Québec, several approaches are used to minimize its impact. The cankers cause serious damage from trunk deformations and crown breakage to tree mortality. Using resistant varieties remains the best approach in preventing this disease. For this reason, resistance to Septoria canker is one of the most important selection criteria in Québec's hybrid poplar tree improvement program. Since 1986, artificial inoculation techniques have been used so that an earlier decision can be made regarding the resistance of improved varieties. A second approach consists of doing annual intensive surveys in the surrounding area for the risk assessment of Septoria infections in new regions. Since 2000, the disease has been observed outside its usual zone, the St. Lawrence River valley in Québec. In 2005 and 2006, an eradication program was undertaken in a plantation located near Normandin, Lac-Saint-Jean, to limit the propagation of *S. musiva* in this region. Work consisted of cutting down the trees, burying the litter layer and destroying the stumps, sprouts and suckers. By monitoring the presence of spores on the site, we noted that eradication operations have almost completely eliminated the pathogen one year later. Through this work, and for the first time in Québec, the teleomorph stage *Mycosphaerella populorum* was identified in 2004 in the leaf litter. A third approach is to limit as much as possible the spread of *S. musiva* via the movement of disease-susceptible material (cuttings and plants) from infected sites to Septoria-free zones. Indeed, the analysis of samples done from 2005 to 2007 confirm the potential for contamination by material originating from high incidence sites, even though the material had been thoroughly inspected. An other strategy to be considered is the reduction of the primary inoculum found in the overwintering leaf litter. Our epidemiological studies support the hypothesis that this source of inoculum plays an important role in the disease life cycle in the Québec boreal areas. The combination of these approaches helps us to choose the most appropriate strategy for deploying improved varieties for each ecological region of Québec, where hybrid poplar is planted.

Key words : Septoria canker resistance, screening, risk management, hybrid poplar plantation, *Septoria musiva*, *Mycosphaerella populorum*

Le chancre septorien du peuplier : comment minimiser son impact en plantation

Le chancre septorien (*Septoria musiva*) étant la maladie la plus importante dans les plantations de peupliers hybrides du Québec méridional, plusieurs approches sont utilisées afin de minimiser son impact. Celui-ci peut être majeur puisque les chancres causent d'importants dégâts allant des déformations du tronc et des bris de cime jusqu'à la mortalité des arbres. Utiliser des variétés résistantes demeure la meilleure approche pour prévenir cette maladie. C'est pourquoi la résistance au chancre septorien est un des critères de sélection les plus importants pour l'amélioration génétique des peupliers hybrides au Québec. Depuis 1986, des techniques d'inoculation artificielle sont employées afin de juger plus tôt de la résistance des variétés améliorées. Un deuxième moyen consiste à effectuer un suivi intensif dans les zones périphériques afin de dresser un portrait annuel des risques d'infections dans de nouvelles régions. À partir des années 2000 au Québec, la maladie est observée de plus en plus hors de sa zone habituelle, la vallée du Saint-Laurent. En 2005 et 2006, des travaux d'éradication ont eu lieu dans une plantation située près de Normandin au Lac-Saint-Jean afin de limiter la propagation de *S. musiva* dans cette région. Les travaux consistaient en la coupe des arbres, l'enfouissement de la litière et la destruction des souches, des rejets et des drageons. À l'aide du suivi de la présence de spores sur le site, nous constatons que les travaux d'éradication ont permis l'élimination presque complète du champignon pathogène après un an. Ces travaux ont aussi permis d'identifier en 2004, pour la première fois au Québec, le stade téléomorphe *Mycosphaerella populorum* dans la litière de feuilles. Une troisième approche est de limiter le plus possible la dissémination du champignon pathogène via l'échange de matériel végétal susceptible (boutures et plants) vers les zones où *S. musiva* est encore absent. En effet, l'analyse d'échantillons, effectuée de 2005 à 2007, confirme le potentiel de contamination par les plants ou boutures provenant de sites hautement infectés, même après l'inspection minutieuse du matériel végétal. Finalement, une dernière stratégie consiste à réduire l'inoculum primaire présent dans la litière de feuilles. Nos études épidémiologiques confirment le rôle important de cette source d'inoculum dans le cycle de la maladie en région boréale au Québec. La combinaison de ces différentes approches permet de choisir la stratégie de déploiement des variétés améliorées la plus appropriée pour chacune des régions écologiques du Québec où le peuplier hybride est cultivé.

Mots-clés : Chancre septorien, sélection, évaluation du risque, plantation de peupliers hybrides, *Septoria musiva*, *Mycosphaerella populorum*

Notes

Intensive forest management implementation in northwestern Quebec, Abitibi-Témiscamingue region: early results

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The long term objective of this project is to test, at the landscape level, the applicability and feasibility of implementation of Intensive Forest Management as part of a zoning or TRIAD strategy to the Abitibi-Temiscamingue (A-T) region (NW Quebec) while focusing on the identification, characterisation and use of zones to be devoted to intensive forest management (IFM). Despite the existence of such potential, IFM implementation is complex in practice. It is thus necessary to develop tools and indicators to help localise these sites and to characterise their potential productivity. Several experimental hybrid poplar plantations were established at different locations in Abitibi-Témiscamingue in order; 1) to select which genetic material is best suited for reforestation, 2) to compare the productivity of pure plantations of different hybrid poplar clones with that of hybrid poplar clones mixed with genetically improved spruce species on short rotation, 3) to determine the extent to which used of genetically improve material significantly increase biomass production in plantations, 4) to study the effects of different sylvicultural treatments and evaluate nutritional needs on different site conditions. Growth measurements were made each year after the plantation that included both absolute and relative growth rates in diameter at stump height and stem height. Results on early tree establishment and growth will be presented. This work will help identify the best hybrid poplar clones and genetically improved material to be grown under boreal conditions.

Notes

Hybrid poplar on Quebec forest soils - lime and fertilizer effects

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In Quebec, hybrid poplar plantations are often established on formerly logged forest sites, rather than on agricultural land as is more common elsewhere. These forest soils are often quite acidic (pH < 5). In 2003 we began a study to determine the effects of lime and fertilizers on growth and nutrition of three hybrid poplar clones on forest sites in southern Quebec. We established 5 large experimental blocks (100m x 400m) near Ham Sud (Lac Nicolet site) in the Eastern Townships region, and 5 blocks near St-Hilaire-de-Dorset in the Beauce / Chaudière-Appalaches area. The sites had been logged about 10 years earlier, and had pH values of 4.7 and 5.0 respectively before treatment. Following site preparation in 2003, lime was applied at 0, 2 or 4 metric tonnes per hectare (T/ha). Three hybrid poplar clones were planted in 2004 (clones 3729, 915311, and 915508, hybrids of *P. nigra* x *maximowiczii*, *P. maximowiczii* x *balsamifera*, and *P. euramericana* x *maximowiczii*), using 1- to 2-m tall rooted stock at 3 m x 3 m spacing. Fertilizer was applied near the base of each tree in 2006, at the start of the third growing season, at rates of 0, 250 or 500 g/tree of DAP (18-46-0). At one site we added potassium as well (0, 50 or 100 g/tree of K_2SO_4, 0-0-60). (Statistics are done separately for the two sites.) Trees improved tree growth as of the 2nd growth year (2005), especially at the Lac Nicolet site. Lime also significantly improved 3-year survival rates at the Nicolet site. Lime increased calcium levels in soil and leaves, but did not substantially affect availability of N, P or K, which remained low prior to fertilizer application. Growth responded positively to fertilizer as of 2006.

Notes

Hybrid poplar productivity and site characteristics in forest soils in southern Quebec

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Short rotation forestry is increasingly viewed as a way for the forestry industry to achieve both conservation and production goals. By intensifying production on some land, pressure on other land can be decreased. In Quebec, due to a shrinking supply of appropriate agricultural sites, hybrid poplar plantations are increasingly being established on forest soils where they may be less productive and less is known about optimizing their growth. To maximize the productivity of hybrid poplar plantations, foresters must have at their disposal simple, cost efficient methods of evaluating site productivity. This information can help decide whether or not the sites should be planted with hybrid poplar, or indicate whether nutrient supplements or other amendments will be needed to optimize production. Our study is investigating relationships between site characteristics and hybrid poplar performance, using data from permanent sampling plots established by Domtar inc. (Windsor, QC) in hybrid poplar plantations in forest sites in Quebec's Estrie and Beauce regions. We are assessing relationships between hybrid poplar performance and leaf nutrient status, soil data and other site characteristics, for plantations up to 5 years old. We hope to be able to facilitate site selection and management decisions for hybrid poplar on forest sites in southern Quebec.

Notes

Development of CVA, DRIS and CND norms for three hybrid poplars adapted to acidic soils of southern Quebec

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Each year in Quebec, plantations of hybrid poplar adapted to the acidic and moderate climatic conditions of the province are established. However, little is known about the nutritional requirements of these various hybrids. The objective of this study was to develop nutritional norms for three such poplar clones established on agricultural soils in southern Quebec.

In 2000, two plantations of 250 trees at a square spacing of 3 m were established at three sites (Saint-Camille, Sainte-Catherine-de-Hatley, and L'Avenir). At L'Avenir, both plantations were of the same poplar clone (915508), while at Saint-Camille and Sainte-Catherine-de-Hatley, the two plantations were planted with different clones (3729 and 915303, respectively). In the spring of 2004, each plantation was fertilized with N, P, K, Ca, and Mg (3 levels, factorial design, 3^5 = 243 different treatments). Fertilizers were applied within a radius of 1.5 m of each tree. The diameter at breast height (1.3 m aboveground), total height, unit foliar mass and foliar chemistry (N, P, K, Ca, and Mg) for each tree, was measured in the fall of 2003, 2004 and 2005. Nutritional norms were developed using factorial scores for growth that were derived from a PCA conducted on three variables: the increase in total height from 2003-2005, square of diameter at breast height, and the unit foliar mass of 2005. Nutritional norms based on CVA, DRIS, and CND were determined using a boundary-line approach. At each site, norms were developed for each plantation and validated on the other.

CVA norms could be established for all combinations of clones and nutrients except Ca for clone 3729. All clones have low requirements for K, clones 3729 and 915303 have low requirements for N whereas 915303 and 915508 have low requirements for Mg and P, respectively. DRIS norms could be developed for all three clones and were generally consistent with CVA results, emphasizing the low requirements of 3729 for N, of 915303 for Mg and of 915508 for P. CND norms were also developed for all elements and clones. An average norm was developed for the three clones for P, K, and Ca. Clone specific norms were developed for N for 3729 and for Mg for 915303. As expected, clones 3729 and 915508 are respectively the least and most nutrient demanding, respectively. The low K requirements of all three clones make them particularly well adapted for plantation in relatively K-poor soils of southern Quebec.

Key words: PCA (Principal component analysis) - CVA (Critical value approach) – DRIS (Diagnosis and recommendation integrated system) – CND (Compositional nutrient diagnosis) – Boundary line

Notes

Leaf, Woody, and Root Biomass of *Populus* Irrigated with Landfill Leachate

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Poplar (*Populus spp*.) trees can be utilized for ecological leachate disposal when applied as an irrigation source for managed tree systems. Our objective was to evaluate differences in tree height, diameter, volume, and biomass of leaf, stem, branch, and root tissues of *Populus* trees after two seasons of irrigation with municipal solid waste landfill leachate or well water (control with added N, P, K). The trees were grown at the Oneida County Landfill located 6 km west of Rhinelander, Wisconsin, USA (45.6 °N, 89.4 °W). Eight clones belonging to four genomic groups were tested: NC13460, NC14018 [(*P. trichocarpa* Torr. & Gray × *P*. d*eltoides* Bartr. ex Marsh) × *P. deltoides* 'BC_1']; NC14104, NC14106, DM115 (*P. deltoides* × *P. maximowiczii* A. Henry 'DM'); DN5 (*P. deltoides* × *P. nigra* L. 'DN'); and NM2, NM6 (*P. nigra* × *P. maximowiczii* 'NM'). Mortality for each treatment was 22% across the 2005 and 2006 growing seasons. The total aboveground biomass averaged 1.57 Mg ha^{-1} and ranged from 0.51 to 2.50 Mg ha^{-1}. The treatment × clone interaction was significant for height, total tree dry mass, aboveground dry mass, belowground dry mass, and dry mass of the leaves, stems + branches (woody), and lateral roots ($P < 0.05$). The BC_1 and DM genomic groups expressed broad clonal variation with genotypes performing differently for treatments. In contrast, the NM and DN genomic groups were stable across treatments, and the clonal response to irrigation treatments was similar. NC14104 had greater biomass when irrigated with leachate compared with water, while NC14018 grew better with water than leachate. Overall, these results are instrumental to researchers and resource managers when making decisions and clonal selections for future leachate remediation projects.

Notes

Sodium and Chloride Concentration in Leaf, Woody, and Root Tissue of *Populus* Irrigated with Landfill Leachate

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There are few reports in the literature about the response of different genomic groups and clones of *Populus* to elevated levels of sodium (Na^+) and chloride (Cl^-). In addition, there is an increasing need to understand the variation in salt tolerance and tissue composition of such genotypes over multiple growing seasons in field settings. Therefore, field trials of a mixture of genotypes representing numerous genomic groups offers an opportunity to identify and select clones that exhibit broad variation in tolerance to salt environments. Such information is important for making recommendations to resource managers that will help to increase the successful utilization of landfill leachate as a fertilization and irrigation source for species and interspecific hybrids of the genus *Populus*. We irrigated eight *Populus* clones (NC13460, NC14018, NC14104, NC14106, DM115, DN5, NM2, NM6) with fertilized well water (control) (N, P, K) or municipal solid waste landfill leachate weekly during 2005 and 2006 in Rhinelander, Wisconsin, USA (45.6 °N, 89.4 °W). During Aug. 2006, we tested for differences in total Na^+ and Cl^- concentration in preplanting and harvest soils, and in leaf, woody (stems + branches), and root tissue. The leachate-irrigated soils at harvest had the greatest Na^+ ($P < 0.0001$) and Cl^- ($P = 0.0013$) levels. The irrigation × clone × tissue interaction influenced the distribution of Na^+ ($P = 0.0240$) and Cl^- ($P = 0.0073$). Clones exhibited elevated total tree Cl^- concentration and increased biomass (NC14104, NM2, NM6), elevated Cl^- and decreased biomass (NC14018, NC14106, DM115), or mid levels of Cl^- and biomass (NC13460, DN5). Tissue concentrations with leachate were 17 (Na^+) and four (Cl^-) times greater than water. Sodium and Cl^- levels were greatest in roots and leaves, respectively. The broad variation among genotypes for tissue Na^+ and Cl^- concentrations substantiated the need for extensive genotypic screening before deployment.

Notes

Using Low Energy X-ray Radiography to Evaluate Root Initiation and Growth of *Populus*

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Populus roots have been studied less than aboveground tissues. However, there is an overwhelming need to evaluate root initiation and growth in order to understand the genetics and physiology of rooting, along with genotype × environment interactions. The Plant Root Visualization and Characterization System (PRVCS; Phenotype Screening Corporation, Seymour, TN, USA) is a novel imaging technique for non-destructive root studies using low energy x-rays to characterize roots as the plants develop. We compared the PRVCS with traditional rooting study methods to test whether the x-ray technique had validity for rooting studies of *Populus*. Our objective was to compare root initiation and growth between trees grown in traditional media (i.e. sand and peat + vermiculite) with those grown in substrates having low- and medium-water retention properties (LWR, MWR, respectively). We grew four trees of *Populus* clones DN70 (*P. deltoides* Bartr. ex Marsh. × *P. nigra* L.), NC14104 (*P. deltoides* × *P. suaveolens* Fischer subsp. *maximowiczii*), and NM6 (*P. deltoides* × *P. suaveolens* subsp. *maximowiczii*) in each of the four media and harvested the trees at leaf plastochron index of nine. Height, leaf area, and total dry mass were determined for all trees, while eleven and six rooting traits were examined for those grown in traditional media and substrates, respectively. Root systems in the substrates were imaged using the PRVCS. Trees grown in the substrates exhibited 70% of the leaf area of those grown in the traditional media, while rooting in the substrates was <50% of the sand and peat + vermiculite. Despite differences in magnitude of root length and number of roots, clonal ranking was consistent between traditional and x-ray analysis methods. The PRVCS yielded rooting data that were fundamentally similar to traditional methods (despite magnitude differences), which validated its potential to increase our fundamental knowledge of *Populus* root systems.

Annex/Annexe

Notes

Additional Texts published in the CPC/PCC 2007 Field Trip Guide:

Poplar Culture: a Collaborative Effort from Clone to Mill
2007 Annual Meeting of the Poplar Council of Canada
Field Trip Guide
Rivière-du-Loup and Québec City
September 16-21, 2007

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- **Portrait des plantations de la région Bas-Saint-Laurent,** Carl Gagnon
- **The Poplar Breeding Program in Québec,** Pierre Périnet
- **The Culture of Hybrid Poplar at Norampac – Cabano,** Clarence Dubé
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- **The white spruce tree improvement program in Québec,** André Rainville
- **Managing second-generation seed orchards and integration of somatic embryogenesis in orchard management,** Fabienne Colas, Mohammed S. Lamhamedi and Mireille Desponts

Textes publiés dans le Guide des visites de terrain du CPC/PCC 2007

La populiculture : un projet collectif, du clone à l'usine
Réunion annuelle 2007 du Conseil du peuplier du Canada
Guide des visites de terrain
Rivière-du-Loup et Québec, 16 au 21 septembre 2007

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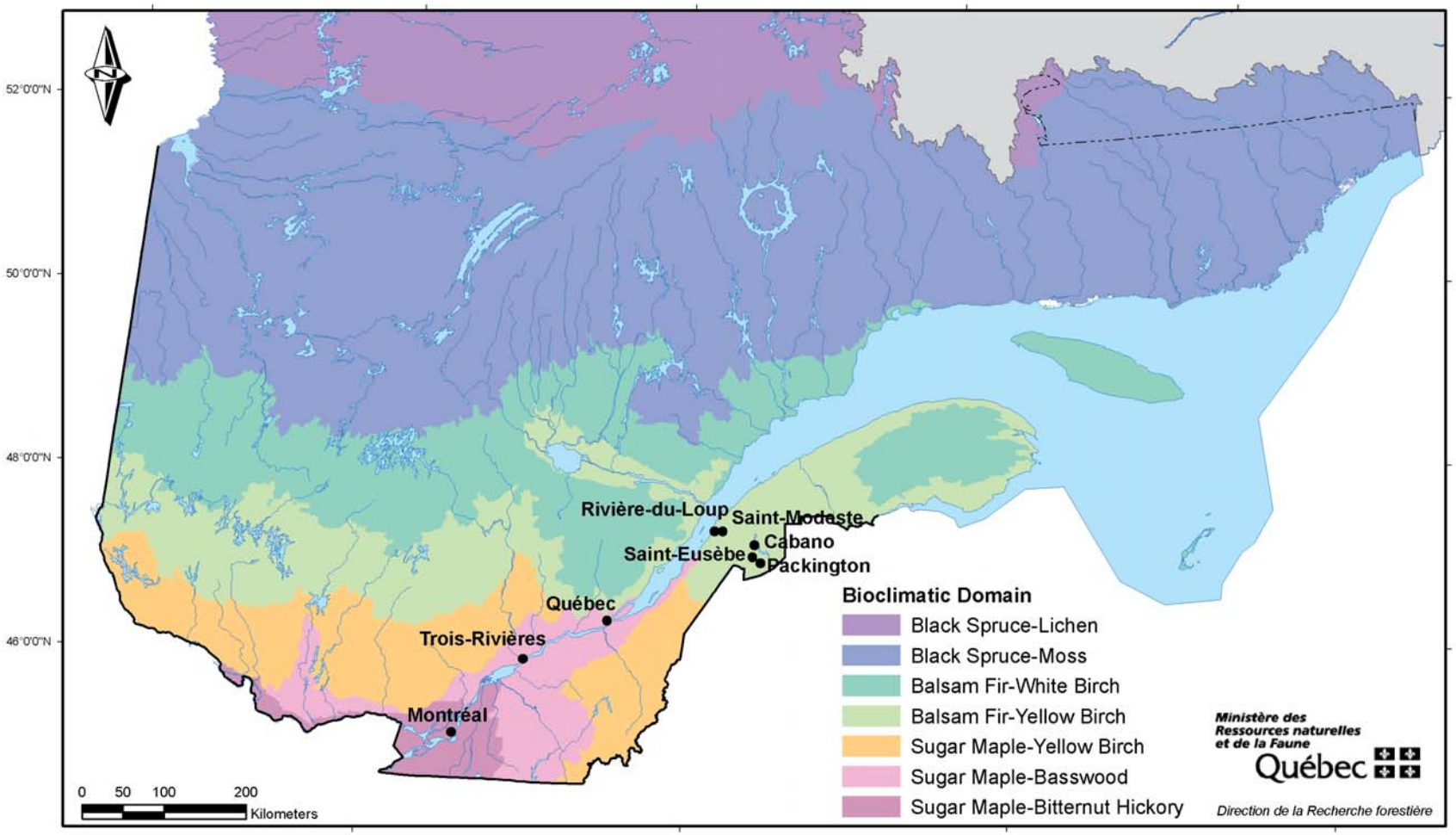
- **Aménagement des vergers à graines de 2e génération et intégration de l'embryogenèse somatique dans l'aménagement des vergers,** Fabienne Colas, Mohammed S. Lamhamedi et Mireille Desponts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Bioclimatic Domain
Black Spruce-Lichen
Black Spruce-Moss
Balsam Fir-White Birch
Balsam Fir-Yellow Birch
Sugar Maple-Yellow Birch
Sugar Maple-Basswood
Sugar Maple-Bitternut Hickory
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