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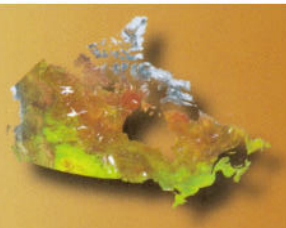

Proceedings of the Forum on the Conservation of Forest Genetic Resources: Challenges, Issues, and Solutions

Information Report M-X-220

J.D. Simpson, Compiler

Canada

Conservation of Forest Genetic Resources: Challenges, Issues and Solutions

July 28-29, 2006 Charlottetown, PEI

1st Forum on the Conservation of Forest Genetic Resources

The Forum will provide a channel for communication among jurisdictions, promote visibility, and maintain the momentum of forest genetic resources activities.

It will be an introduction to CAN**FOR**GEN, *a proposed program for the conservation of forest genetic resources.*

ISSN 1195-3799
ISBN 978-0-662-46716-8
Catalogue No. Fo103-2/220E

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Fredericton, N.B. Canada E3B 5P7
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A PDF of this publication is available online at:

Editing, design and layout: C.M. Simpson, ELS

Library and Archives Canada Cataloguing in Publication

Forum on Conservation of Forest Genetic Resources (2006: Charlottetown, P.E.I.).
Forum on Conservation of Forest Genetic Resources: challenges, issues, and solutions / compiled by J.D. Simpson.

(Information report ; M-X-220)
Includes bibliographical references: p.
Available also on the Internet.
Includes some text in French.
ISBN 978-0-662-46716-8
Cat. no.: Fo103-2/220E

1. Forest genetic resources conservation--Canada--Congresses.
2. Forest genetic resources conservation--Congresses.
I. Sinmpson, John Dale, 1955-
II. Atlantic Forestry Centre
III. Title.
IV. Series: Information report (Atlantic Forestry Centre) ; M-X-220.

SD399.5.F67 2007 333.95'34 C2007-980225-7

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Natural Resources Canada
Canadian Forest Service - Atlantic Forestry Centre

2007

Forest Genetic Resource Conservation Issues in Quebec

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Abstract

In 1996, the Quebec government adopted a strategy and an action plan to meet its commitments with regard to the objectives of the Convention on Biological Diversity. Action took place in 2000 with the creation of protected areas, aimed at conserving species and ecosystems. Six years later, 4.79% of the land base has been designated as protected area, mainly located in northern Quebec. In the future, new protected areas will be needed in southern Quebec, where there is high human pressure on existing forest ecosystems and where species at risk are located. From a forest genetic resource point of view, it is not yet clear how many protected areas should be created to ensure that most of the genetic diversity of each species is maintained. Recently, Quebec adopted a forest management strategy aimed at maintaining the biodiversity and viability of all of the forest ecosystems. Ecosystem-based management, as it is called, will help to maintain the genetic integrity of natural populations within a broader diversity of forest structural classes at the landscape level.

For now, Quebec is relying on these conservation measures, which act as a coarse filter, to conserve the genetic diversity, but it has no strategy targeting the specific requirements of each species. Most current knowledge has been obtained through genetics and tree improvement programs and relates mainly to boreal forest conifer species. Genetic marker studies, which began toward the end of 1980s, show that most of these species have a high level of genetic diversity that is little impacted by forest practices. However, there is little or no basic knowledge about the genetic

Résumé

En 1996, le gouvernement du Québec a adopté une stratégie et un plan d'action visant à respecter ses engagements en regard des objectifs de la convention sur la diversité biologique. Les premières actions ont été posées au début des années 2000 par la création d'aires protégées, dont l'objectif était d'assurer la conservation des espèces et des écosystèmes. Six années plus tard, 4,79% du territoire est constitué en aires protégées, principalement localisées au nord du Québec. Les futures aires protégées devront être situées au sud du Québec, où la pression humaine est grande sur les écosystèmes forestiers et où se retrouvent principalement les espèces à risque. Du point de vue des ressources génétiques forestières, une question persiste à savoir combien d'aires protégées devraient être créées afin de maintenir la diversité génétique de chacune des espèces. Le Québec a récemment adopté une stratégie d'aménagement des forêts dans le but de maintenir la biodiversité et la viabilité de l'ensemble des écosystèmes; à l'échelle du paysage, l'aménagement écosystémique aidera à maintenir l'intégrité génétique des populations naturelles dans une plus grande diversité de classes structurales forestières.

Québec mise actuellement sur ces mesures, qui agissent comme filtre brut, pour assurer la conservation de la diversité génétique, mais n'a pas de stratégie spécifique à chaque espèce. Nos connaissances actuelles ont été acquises grâce aux programmes de génétique et d'amélioration des arbres, et se limitent principalement aux espèces résineuses de la forêt boréale. Les études réalisées à l'aide de marqueurs génétiques ont débuté à la

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diversity of most of the deciduous hardwood species located in southern Quebec. Promoting the work taking place in British Columbia and Alberta, and the creation of CONFORGEN, could be of great help in informing decision makers, and could lead to concrete action in Quebec.

fin des années 1980; elles ont permis d'observer que la plupart de ces espèces avaient une grande diversité génétique, et que cette dernière était peu influencée par les pratiques forestières. Pour la plupart des espèces feuillues située au sud de la province, les connaissances de base sur leur diversité génétique sont par contre inexistantes ou insuffisantes. La promotion des actions entreprises en Colombie-Britannique et en Alberta, de même que la création de CONFORGEN, pourraient grandement aider à informer les décideurs et mener à des actions concrètes au Québec.

Introduction

The province of Quebec covers 1 667 929 km^2 and encompasses more than 18° of latitude. Forests cover nearly half this area, 85% of which are owned by the Crown (Ministère des ressources naturelles et de la faune du Québec (MRNF) 2002). The annual allowable cut on Crown forests is estimated at nearly 42 million m^3, of which balsam fir (*Abies balsamea* (L.) Mill.), spruces (*Picea* spp.), jack pine (*Pinus banksiana* Lamb.), and eastern larch (*Larix laricina* (Du Roi) K. Koch) comprise up to 70%.

In 1994, 2 years after the Rio de Janeiro Summit and 3 years after a public consultation on its forest management and goals, the Quebec government adopted the "Stratégie de protection des forêts," which contained 73 recommendations and commitments to ensure forest renewal, protect forest resources, harmonize the multiple uses of the environment, and eliminate the use of pesticides by the year 2001 (MRNF 1994). In 1996, the province adopted a strategy and an action plan to meet its commitments with regard to the biological diversity convention objectives. Of the five principles developed for the forest management strategy, two had an indirect impact on genetic diversity: 1) respect natural dynamics of ecosystems and 2) maintain natural biological diversity of ecosystems. These decisions implied that reforestation was to be used only as a complementary tool to natural regeneration.

Conservation of biological diversity in Quebec first materialized with the creation of protected areas. In 2002 alone, 31 435 km^2 were set aside as protected area. Over the years, the protection of biological diversity also became one of the mandatory objectives of management practices; ecosystem-based management, as we call it today. It is being progressively implemented and will be fully in place by 2013.

Ecosystem-based Management

Ecosystem-based management, which takes an ecological approach to forest management, aims at maintaining the biodiversity and viability of all forest ecosystems, while meeting socioeconomic needs with respect to social values attributed to forests. Compared with the traditional management approach, which focuses on industrial wood supply, ecosystem-based management focuses on maintaining the basic attributes of a forest growing under a natural disturbance regime—or at least minimizing the impacts of human intervention—while meeting the demand for wood (Têtu 2006). forest attributes are defined in terms of structure and composition (Thiffault et al. 2007).

Twelve main priorities were identified for the implementation of ecosystem-based management objectives. For example, mixed forests—that, after a precommercial thinning operation and depending on the industrial needs, traditionally were converted to pure conifer or hardwood forests—would have to be managed in order to retain their main attribute, multi-species occurrence. Loss of mature and old-growth forests, leading to associated species loss, was identified as another problem. Maintaining clumps of mature forest, of different sizes and different distribution models on the landscape, is one of the methods proposed by ecosystem-based management.

For forest genetic resource conservation purposes, this shift toward ecosystem-based management is good news, as it helps maintain the genetic integrity of natural populations within a broader diversity of forest structure classes at the landscape level. However, it will likely have an impact on forest productivity in some areas over the short and long term, as preserving more mature and old-growth forests means reducing the allowable cut. Intensive silviculture, targeting wood production, could alleviate such an impact.

Protected Areas

Two objectives support the creation of protected areas: 1) conservation of species and their genetic variability, and 2) preservation of natural processes and ecosystems. There are actually 19 categories of protected areas (habitats of threatened or vulnerable species, parks, ecological reserves, etc). They are intended to cover 8% of Quebec's land base by 2008. These protected areas represent the coarse filter on which we rely to protect threatened or vulnerable species, as well as genetic diversity.

Six years after it first committed to create protected areas, Quebec has designated 4.79% of its area as protected areas. They are mainly located in the northern part of the province. Between 2002 and 2006, most of the new protected areas were created in the continuous boreal forest, in the tundra, and in the low-arctic zones. Northern Quebec is Crown land and there is relatively little impact on the general population. However, part of this region is covered by continuous boreal forest and this is where forest industry conducts most of the harvesting, and concomitantly, most of the reforestation.

The real challenge for the future is to create new protected areas in southern Quebec, where human impacts (mainly agriculture and housing construction) are high on existing forest ecosystems. This will require additional resources for negotiation and public education. It will not be an easy task. There is one crucial question regarding the conservation of forest genetic resources: how many protected areas should be created in southern Quebec to ensure that most of the genetic diversity of each species is maintained? Better knowledge about each species' genetic diversity, its magnitude, and distribution is essential to answer this question.

Current Knowledge about Quebec's Forest Tree Genetic Diversity

Conifer Species of the Boreal Forest

Most knowledge about forest genetic diversity concerns conifer species of the boreal forest, and was obtained through genetics and tree improvement programs started in the 1970s and early 1980s

(Corriveau and Vallée 1981). Genetic tests established throughout the range of these species in Quebec showed that genetic variation was high within species, that it was associated with the geographic origin of the material, and that differences between individuals within a population explained most of the variation within a species (Beaulieu et al. 1996). Breeding zones were defined in order to ensure that material used for reforestation is well adapted. These zones certainly offer us the first clues for the establishment of a conservation strategy for these species (i.e., at least we have an idea about the number of zones to be sampled in a conservation plan). Seed source transfer guidelines were adopted, based on mathematical models relating the variation pattern in adaptive traits of provenances observed in genetic tests to actual climatic conditions (Matyas and Yeatman 1992, Li et al. 1997, Beaulieu et al. 2004). A model was also developed to predict the potential impact of climate change on the performance of white spruce (*Picea glauca* (Moench) Voss) plantations (Andalo et al. 2005).

Genetic tests give us an indirect evaluation of genetic diversity, but by measuring the adaptation of different sets of genes to varying environments, genetic marker studies (biochemical and molecular), which began at the end of the 1980s, provide us with a direct measure. Again, most of the studies were carried out for the major commercial tree species. They reported the occurrence of a high level of genetic diversity in most of the species. Using mitochondrial DNA markers, four genetically different but overlapping populations covering the range of black spruce (*Picea mariana* (Mill.) B.S.P.) were identified (Jaramillo-Corea et al. 2004), the same number of zones as for jack pine. However, jack pine populations in central Quebec formed a distinct group that included populations present in the previous three groups and had a higher level of haplotype diversity per population and lower population differentiation (Godbout et al. 2005).

Other studies were conducted to evaluate the impact of forest practices on genetic diversity. Fragmentation at the landscape level caused by logging operations (Perry and Bousquet 2001), and isolation of populations on islands located in the Abitibi region (Gauthier et al. 1992) or in the tundra (Gamache et al. 2003) had no effect on genetic diversity of mature forests of black spruce and jack pine. Selection of individuals from superior provenances in a tree improvement program did not cause a significant loss of genetic variability compared with natural populations (Desponts et al. 1992) The level of hybridization between natural populations and exotic species used in plantations is currently under evaluation (N. Isabel, pers. comm.).

Tree Species of the Mixed and Deciduous Forest

Although most of our current knowledge about forest genetic resources concerns the most important reforestation species, the first molecular studies carried out in Quebec focused on alder (*Alnus* spp.;Bousquet et al. 1987a, b, c, Bousquet et al. 1988, Bousquet et al. 1990). They showed high levels of genetic diversity, predominantly within populations, and little interpopulation differentiation. Estimations of phylogenies in the Betulaceae family later demonstrated that the family was divided into two major clades, Betulae (*Alnus* and *Betula*) and Corylae (*Carpinus*, *Corylus*, and *Ostrya*) (Bousquet et al. 1992). Other species of the mixed and deciduous forest, such as red spruce (*Picea rubens* Sarg.) or white pine (*Pinus strobus* L.) were studied. Perron et al. (2000) observed that the genetic diversity of red spruce was reduced, and that it was a subset of that found for black spruce. Beaulieu et al. (1996) showed that white pine had high genetic diversity in the Ottawa River region and a small loss in the St. Lawrence valley; the species has a fragmented distribution due to intensive harvesting in some parts of its range (Li et al. 1997, Beaulieu and Simon 1994). Some hardwood species have also been studied, such as sugar maple (*Acer saccharum*

Marsh.) (Simon et al. 1995) and butternut (*Juglans cinerea* L.) (Morin et al. 2000), the latter showing a reduced level of genetic diversity in Quebec.
There is insufficient basic knowledge about the genetic diversity of most of the tree species of the deciduous forest located in southern Quebec, as well as in other jurisdictions in Canada. Such knowledge is necessary to establish specific protection or reintroduction measures. A list of threatened or vulnerable species, based on forest inventory data, has been published (http://www.mddep.gouv.qc.ca/biodiversite/especes/protection/index.htm) and could be used as a starting point for an eventual effort in this direction.

Conservation Measures in Quebec

Seventy-seven percent of the seedlings used for reforestation in Quebec are genetically improved, mainly from seed orchards established with tested material from tree improvement programs. Over time, the proportion coming from collections made in natural stands has decreased. Every collection in the province is treated at the Berthier seed extraction facility, where it is stored for future reforestation needs. The mandate of the Berthier facility does not include a conservation objective; rather, it focuses on meeting reforestation needs. However, annual shipments of seed lots collected in natural stands are sent to the National Tree Seed Centre in Fredericton, NB, which has expanded its mandate to include gene conservation. In addition, since the beginning of genetic population studies and tree improvement programs in Quebec (late 1950s and early 1960s), research organizations (DRF and CFS) have considered conservation of genetic resources as being a priority; part of the collections made in natural stands, used as checklots in experimental field tests, are also being stored to meet this objective. Again, this practice has been put in place only for the main reforestation species. For now, there is no protection measure in place for species of the mixed and deciduous forest, or for those for which the seed cannot be stored for a long period of time.

Conclusion

Although conservation of forest genetic resources is part of the strategy for the conservation of biological diversity in Quebec, both the scientific community and policy makers need to recognize that genetic diversity must also be conserved to allow both species and ecosystems to adapt to changing environments. Since 2000, steps have been taken to conserve species and ecosystems in Quebec, but genetic diversity is conserved only through a coarse filter, and there is no conservation strategy targeting the specific requirements of each species.

During the last year or so, public awareness about the impacts of climate change has prompted the government to look at possible adaptation measures; transfer of provenances, based on genetic tests results, is now perceived as an important adaptation measure that can be rapidly applied. The timing has never been better to promote the importance of conserving forest genetic resources. In this task, the creation of CONFORGEN, a program aimed at promoting and defining pan-Canadian guidelines for the conservation of genetic resources, could be of great help. The promotion of activities that are taking place in British Columbia and Alberta , directed toward better knowledge about genetic diversity of native tree species as well as the development of specific conservation strategies, could have a significant political impact and lead to concrete action in other provinces.

Acknowledgments

The author is grateful to Denis Blanchet of the Direction de l'environnement et de la protection des forêts, MNRF, who provided updated information on protected areas and species at risk, and Jean-Pierre Jetté of the same organization for ecosystem-based management information. Thanks also to Dr. Jean Beaulieu of the Canadian Forest Service, Laurentian Forestry Centre, who suggested publications and kindly agreed to review this paper. Finally, forest tree breeders of the Direction de la recherche forestière, MRNF, participated in many aspects; their observations and suggestions helped improve the content of both the presentation and this paper.

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