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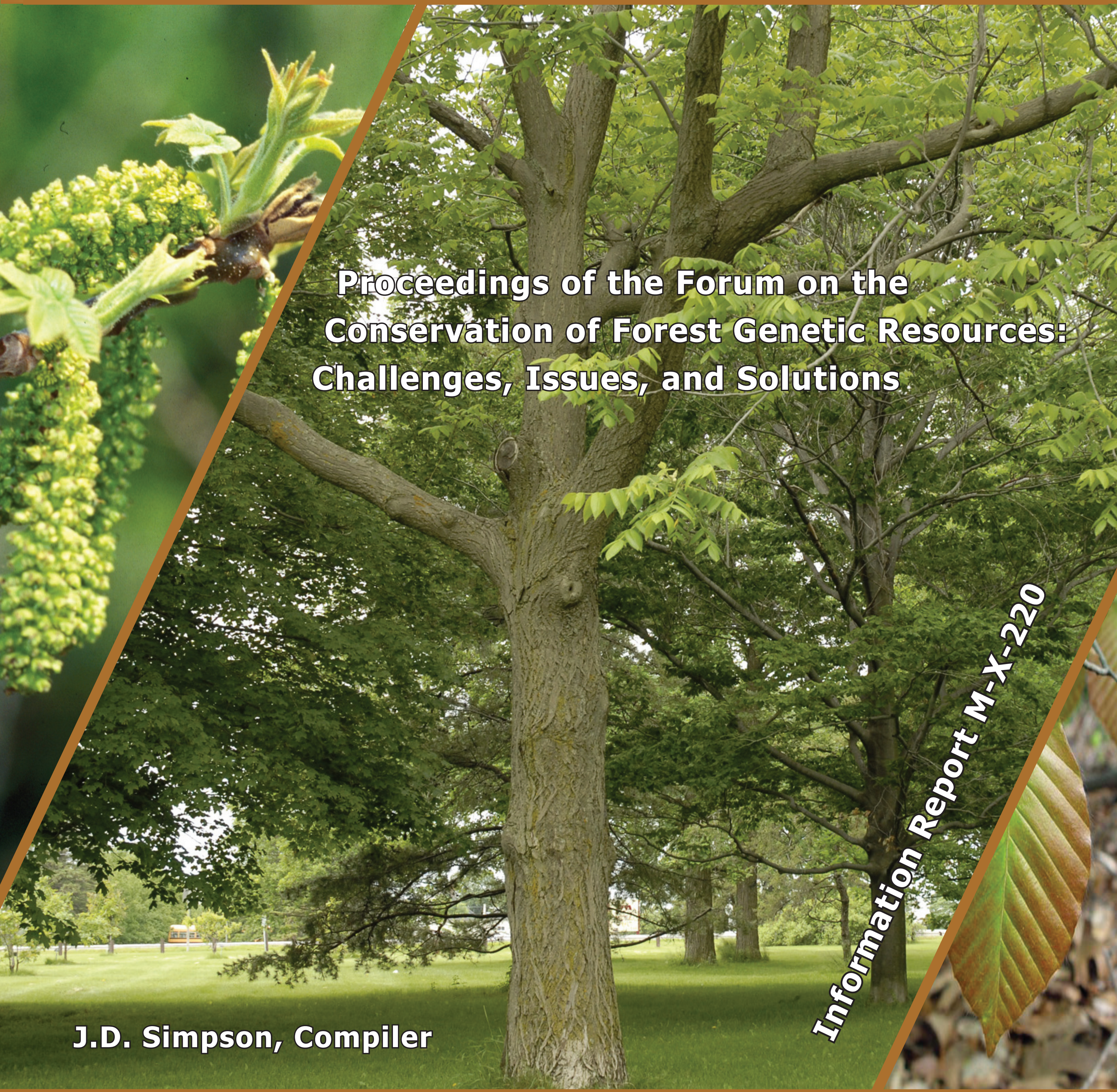
Proceedings of the Forum on the Conservation of Forest Genetic Resources: Challenges, Issues, and Solutions



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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.*

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The views and opinions expressed in the following papers are those of the authors and do not necessarily reflect the policy of the Government of Canada

Natural Resources Canada
Canadian Forest Service - Atlantic Forestry Centre

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Foreword

Forest genetic resources are important to the well-being of Canadians. They are essential for adaptation to changing environmental conditions. This means adapting to climate change, invasive alien species (e.g., newly introduced insect pests), and changes in air quality. Thus, ecosystem health and stability depend on forest genetic resources, and sustainable forest management depends on healthy gene pools of forest species.

Forest genetic resources have important economic values, both now and in the future. Genes are the source of variation used by tree improvement and breeding programs to improve the growth rate of commercial forest tree species, and to develop resistance to pests, drought, and temperature extremes. Genetic resources are vital for maintaining a viable forest industry. They represent potential economic value because of new products that will come from the forest in the future, including medicinal and other non-timber forest products. Development and sale of such products will bolster rural economies and will contribute to the health of Canadians.

There are significant threats to Canada's forest genetic resources. One such threat is climate change. Without a proactive response, populations near the southern limit of species' ranges will likely be lost, along with their valuable genetic resources. Another important threat is invasive alien species, such as the emerald ash borer (*Agrilus planipennis*), the brown spruce longhorn beetle (*Tetropium fuscum*) and the fungus that causes butternut canker. We risk losing entire tree species, such as butternut (*Juglans cinerea* L.), if we do not act quickly and appropriately. For introduced pests and diseases that are established now, development of genetic resistance may be the only long-term mechanism for survival of tree species. Forestry practices have improved greatly over the past few decades, but inappropriate forestry practices can threaten genetic resources. Genetic diversity may be influenced in less obvious ways as well, for example, harvesting practices for a commercial species of interest may be harmful to other associated species. Urban and cottage development affects species associated with specific habitats, often including the richest soils along rivers or lakefronts. Finally, development of mineral or petroleum resources dramatically alters habitat and, without proactive conservation measures, populations may be lost in some areas.

These challenges require a coordinated response. Several provinces have gene conservation programs for some species within their own boundaries, but forest genetic resources transcend provincial boundaries and planning horizons. The Canadian Forest Service works with provinces to identify the issues, research the threats, and develop and promote appropriate conservation methods. Research and gene conservation activities are carried out by universities and environmental non-governmental organizations as well as by provincial and federal government departments, but such efforts could be more effective if they were coordinated across provincial boundaries.

The following papers constitute the proceedings of a *Forum on the Conservation of Forest Genetic Resources* that was held in Charlottetown, Prince Edward Island on 28–29 July 2006. The forum showcased a number of presentations that highlighted various threats (invasive alien species and climate change) to genetic resources, summarized activities and issues involving genetic resource conservation in several provinces, announced the creation of CAFGRIS (Canadian Forest Genetic Resources Information System), and introduced the concept of a national program, CON**FOR**GEN (CONservation of FORest GENetic Resources in Canada).

Avant-propos

Les ressources génétiques forestières jouent un rôle important pour le bien-être des Canadiens. Elles sont essentielles à l'adaptation de la forêt aux conditions environnementales changeantes : changements climatiques, espèces exotiques envahissantes (p. ex. l'infestation par de nouveaux insectes nuisibles) et changements de la qualité de l'air. Ainsi, la stabilité et la santé de l'écosystème dépendent des ressources génétiques forestières, et une gestion forestière durable dépend d'un réservoir génétique sain d'essences forestières.

Les ressources génétiques forestières comportent une valeur économique considérable, tant aujourd'hui qu'à l'avenir. Pour cette raison, les gènes sont la variable ciblée par les programmes de sélection et d'amélioration génétique des arbres visant à améliorer le taux de croissance d'essences forestières commerciales et à créer une résistance aux ravageurs, aux sécheresses et aux températures extrêmes. Les ressources génétiques sont donc cruciales pour une industrie forestière viable. En effet, les nouveaux produits qui seront tirés de la forêt (p. ex. des produits médicinaux et d'autres cultures non ligneuses) confèrent une valeur économique potentielle aux ressources génétiques. L'exploitation et la vente de ces produits profiteront aux économies rurales et contribueront à la santé des Canadiens.

Cependant, des dangers considérables menacent les ressources forestières canadiennes. Les changements climatiques constituent l'une de ces menaces. Sans une intervention proactive, certaines populations situées à la limite sud des aires de répartition d'une espèce risquent en effet de disparaître, d'où la perte de leurs précieuses ressources génétiques. Les espèces exotiques envahissantes, dont l'agrile du frêne (*Agrilus planipennis*), le longicorne brun de l'épinette (*Tetropium fuscum*) et le champignon à l'origine du chancre du noyer cendré, représentent un deuxième danger. Sans une intervention rapide et appropriée, des espèces entières d'arbres, dont le noyer cendré (*Juglans cinerea* L.), sont menacées de disparition. Face aux ravageurs et aux maladies déjà présents, la résistance génétique pourrait bien être le seul mécanisme de survie à long terme des essences forestières. En outre, les pratiques de foresterie ont connu des améliorations considérables au cours des dernières dizaines d'années, mais des pratiques inappropriées peuvent toujours mettre en danger les ressources génétiques. Aussi certaines pratiques peuvent-elles entraîner des répercussions moins flagrantes sur la diversité génétique; par exemple, certaines pratiques de récolte d'une essence commerciale peuvent entraîner un effet néfaste pour d'autres espèces liées. L'expansion urbaine et la construction de chalets ont également un impact sur les espèces occupant certains habitats spécifiques, comprenant dans bien des cas les sols les plus fertiles le long des rivières et au bord des lacs. Enfin, l'exploitation des ressources minérales et pétrolières touche durement les habitats et risque, sans la mise en œuvre de mesures de conservation proactives, de causer la disparition de populations dans certaines régions.

Ces défis appellent une réaction coordonnée. Plusieurs provinces ont déjà adopté des programmes de conservation génétique pour certaines espèces se retrouvant sur leur territoire, mais les ressources génétiques forestières transcendent les frontières provinciales et les horizons de planification. En effet, bien que le Service canadien des forêts travaille en collaboration avec les provinces dans le but de définir les problématiques, de repérer les dangers et d'élaborer et d'appliquer des méthodes de conservation appropriées, et bien que des initiatives de recherche et de conservation génétique soient menées par des universités, des organisations non-gouvernementales à vocation écologique et des ministères provinciaux et fédéraux, tous ces efforts récolteraient un succès beaucoup plus remarquable s'ils étaient coordonnés à l'échelle du pays.

Les articles suivants constituent les délibérations du *Forum sur la conservation des ressources génétiques forestières : défis, enjeux et solutions* qui a eu lieu à Charlottetown, à l'Île-du-Prince-Édouard les 28 et 29 juillet 2006. Le forum comprenait des présentations portant sur différents dangers pour les ressources génétiques (espèces exotiques envahissantes et changements climatiques), présentait des résumés d'activités et de problématiques reliées à la conservation des gènes forestiers dans plusieurs provinces, annonçait la création d'un système d'information sur les ressources génétiques forestières du Canada, le CAFGRIS (Canadian Forest Genetic Resources Information System) et introduisait un programme national de conservation des ressources génétiques forestières, le CONFORGEN (**Con**servation of **For**est **Gen**etic Resources in Canada).

Canadian Forest Genetic Resources Information

Tannis Beardmore

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Abstract

A knowledge management prototype, called the *C*anadian *F*orest *G*enetic *R*esource *I*nformation *S*ystem (CAFGRIS), was developed to integrate and synthesize relevant spatial and non-spatial data for assessing, reporting, and making decisions on the status and management of native tree species. This prototype includes a mapping component that shows the distribution of specific species and offers a number of overlay options, such as ecozones, current and historical burn areas, and the location of seed stored by the Canadian Forest Service's National Tree Seed Centre. The prototype also incorporates a variety of species-specific information, including text pertaining to the biology and ecology of native tree species, threats to these species, and results from a survey to identify native tree species that may be in need of gene conservation measures. The goal of this prototype is to be able to provide information concerning native tree species and their current conservation requirements.

Résumé

Un modèle de gestion des connaissances appelé CAFGRIS (*C*anadian *F*orest *G*enetic *R*esource *I*nformation *S*ystem) a été élaboré dans le but d'intégrer et de faire la synthèse des données spatiales et non spatiales afin d'évaluer le statut et la gestion des essences indigènes, d'en faire le rapport et de prendre les décisions qui s'appliquent. Ce modèle comporte une composante de génération de carte présentant la distribution d'espèces spécifiques ainsi qu'un certain nombre d'options de superposition telles que les écozones, les secteurs de brûlage actuels et passés et les lieux d'entreposage des semences du Centre national de semences forestières du Service canadien des forêts (SCF). Le CAFGRIS contient également une série de renseignements spécifiques à certaines essences, dont des documents portant sur la biologie et l'écologie d'essences indigènes, les menaces contre ces essences, et les résultats d'un sondage signalant les essences indigènes qui pourraient nécessiter des mesures de conservation des gènes. L'objectif de ce modèle est d'arriver à fournir de l'information sur les essences d'arbres indigènes et sur leurs besoins de conservation actuels.

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Introduction

Canada—with about 41% of its land area covered with forest (Natural Resources Canada 2006)—is a forest nation. Its forests face a variety of threats, such as climate change and invasive alien species. An estimated 140 000 species, including plants, animals, and micro-organisms reside in Canada, two thirds of which are found in forests. Given the size of the forests and their diversity, obtaining an overview of how individual tree species in Canada are tolerating the various threats is challenging.

Genetic diversity enhances forest species' ability to tolerate these threats. Genetic diversity is the variation among genes either within individuals of the same species or between species. It is essential: 1) for adaptation to changing environmental conditions, including climate change, changes in air quality, and invasive alien species and 2) as a source of new variants of potential economic value to forestry.

We are in the process of developing the Canadian Forest Genetic Resource Information System (CAFGRIS), a knowledge management system that will provide information concerning forest genetic resources. The CAFGRIS is deployed through the National Forest Information System, which is an initiative of the Canadian Council of Forest Ministers (CCFM).

The purpose of CAFGRIS is to gather, integrate, and synthesize digital information, thereby generating new knowledge concerning native tree species and threats to these species. The prototype includes both spatial and non-spatial information. The system adheres to the Canadian Geospatial Data Infrastructure standards and principles, and international standards such as the Open GeoSpatial Consortium, which allows us access to various data sources—including U.S. geospatial data (e.g., species' distribution maps)—that would otherwise be inaccessible. As well, through the use of the CFSNet infrastructure, we are able to ensure that the information is accessible, current, and authoritative.

To date, we have released a prototype that contains information regarding the biology and ecology of native tree species and, where applicable, the threats to these species. Each tree species has a designation generated through a survey conducted by the Canadian Forest Service (CFS) that assessed the conservation requirements of native tree species. The official federal Species at Risk Act (SARA) designations and provincial or territorial designations are also included with supporting documentation. Information pertaining to *in situ* conservation is included, specifically the identification of protected areas, of which Canada has over 2800 (CCFM 2006). Information pertaining to *ex situ* conservation is also available for individual species. The CAFGRIS presently includes data from the CFS's National Tree Seed Centre, and will eventually include information from other *ex situ* collections from across the country.

Gene Conservation Survey

A survey was conducted in 2003 to identify native tree and shrub species that may be in need of gene conservation (Beardmore *et al.* 2006). This survey was initiated by the steering committee for the CFS's National Forest Genetic Resources Centre, which includes the National Tree Seed Centre. It was recognized that several provinces are actively pursuing programs to identify species requiring gene conservation measures. The purpose of this survey was not to duplicate on-going conservation efforts, but to: 1) provide a perspective on what the tree and shrub gene conservation needs are across the country, 2) identify areas in which more work can be done, and 3) assist the National Tree Seed Centre in identifying species for their *ex situ* gene conservation collections.

The survey contained a preliminary list of native tree and shrub species. Before sending out the survey, we identified, based on available information, those species that might require gene conservation measures using a set of criteria developed in an earlier process that included information from the Conservation Data Centres, provincial and territorial departments, and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). These criteria were: 1) species rarity; 2) lack of or uncertain viable seed source; 3) serious threat from an exotic disease or insect; 4) serious threat posed by environmental change; 5) species' regeneration threatened by certain harvesting practices; 6) substantial decrease in the range or frequency of the species; 7) high demand for other uses for the preferred habitat of the species; 8) high demand for the species for a special purpose; and 9) threat to species posed by hybridization or introgression. If any of these criteria applied to a species, it was then rated according to the following values:

- 0 – No apparent cause for concern
- 1 – Species may need attention, but there is incomplete information
- 2 – *In situ* conservation measures are required, e.g., specific management practices or inclusion in protected areas.
- 3 – *Ex situ* conservation measures are required, which may involve storage of germplasm, e.g., seed.

The survey was sent to experts at various agencies, and 30 people responded. Participants were asked to comment on the conservation needs of a list of species native to their respective geographical regions. In particular, we asked them to comment on the tentative criteria and rating values that were assigned to each species and to add any species that require conservation, but were not listed.

Results of the survey showed that, of the 124 tree species native to Canada, 77 tree species (18 coniferous and 59 deciduous) were identified in at least one province or territory as requiring either some level of gene conservation or additional information to determine whether conservation efforts are required (Beardmore *et al.* 2006). *Ex situ* conservation measures were recommended for 47 species, whereas *in situ* conservation was recommended for 20 species, and 10 species may need attention but there is insufficient knowledge to make a designation.

Many of the species identified in the survey are under pressure in only a portion of their range. The following species were identified as requiring conservation measures throughout their range because they are threatened by an exotic pest that could cause high mortality: American chestnut (*Castanea dentata*)–chestnut blight (*Cryphonectria parasitica*); beech (*Fagus grandifolia*)–beech bark disease (*Nectria coccinea* with *Cryptococcus fagisuga*); butternut (*Juglans cinerea*)–butternut canker (*Sirococcus clavigignenti juglandacearum*); three elm (*Ulmus*) species–Dutch elm disease (*Ophiostoma novo-ulmi*); and five ash (*Fraxinus*) species–emerald ash borer (*Agrilus planipennis*). Overall, the survey indicated that there is a clear need for a concerted and coordinated effort to conserve species and populations across jurisdictional boundaries before they receive official risk designations through the SARA. This survey information provided the basis for CAFGRIS.

CAFGRIS

The CAFGRIS incorporates a mapping component, through which information can be displayed for single or multiple tree species. Red dots on a map depict the location where seed has been collected and stored by the National Tree Seed Centre. By clicking on a red dot, the user can view information about the seed collected at that site, including whether bulk or single tree collections were made, and the age and germination ability of the seed. There are a number of overlay options that can be displayed on the map, including protected areas, current burn areas, and ecozones. These are shown on the upper right side of the mapping page.

Text information is also provided for each species. For example, *ex situ* conservation is recommended for butternut, based on the CFS survey results. This species has an official federal designation of “endangered” and its COSEWIC status report is available as a PDF file. Butternut is also designated as “endangered” in Ontario. The threats facing butternut, which have these designations, are listed, followed by photographs to assist in species and threat identification.

Conclusions

The CAFGRIS integrates and synthesizes the data required to provide a national perspective on the threats facing native tree species in Canada and their resilience to cumulative impacts, including climate change and invasive alien species. The system also allows users to access geospatial data needed to monitor native tree species and related conservation activities over time. It can be used as a tool for predicting the future conservation needs of these species. As such, it will facilitate decision making concerning identification of species requiring conservation measures, the threats facing the species, and the conservation measures to be employed.

As well, the CAFGRIS will synthesize current and authoritative data required for national reporting on the status of native tree species and related conservation efforts (e.g., reporting on the CCFM Criteria and Indicators and the UN Convention on Biological Diversity on Global Strategy for Plant Conservation).

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Conservation of Genetic Resources under Projected Climate Change

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Abstract

In situ reserves are an important conservation tool to ensure the adequate long-term protection of forest genetic resources. Long-lived forest tree species, in particular, depend on the maintenance of *in situ* populations with a sufficient effective population size to maintain genetic diversity and allow adaptation to new environmental conditions. Gap analysis is a common approach for assessing the level of protection, redundancy of protected areas, and the need for additional *in situ* reserves, and ecological niche modeling has been widely used to project potential species habitat under future climate change scenarios. In a British Columbia case study, gap analysis and niche modeling approaches were combined to evaluate whether suitable habitat for tree species is maintained under climate change scenarios. Preliminary results indicate that 15–65% of current tree populations in protected areas could be lost, depending on assumptions about species' capabilities to adapt and migrate.

Résumé

Les réserves *in situ* constituent un outil de conservation essentiel en matière de protection à long terme des ressources génétiques forestières. Les essences forestières longétives sont particulièrement dépendantes du maintien des populations *in situ* suffisamment nombreuses pour conserver leur diversité génétique et permettre leur adaptation à de nouvelles conditions environnementales. L'analyse de carence est un outil très répandu en matière d'évaluation du niveau de protection, de la redondance des aires protégées et de la nécessité d'aménager un plus grand nombre de réserves *in situ*; la modélisation des niches écologiques, quant à elle, est un outil largement utilisé pour visualiser l'habitat potentiel des espèces étudiées dans différents scénarios de changements climatiques futurs. Dans une étude de cas menée en Colombie-Britannique, l'analyse de carence et la modélisation des niches écologiques ont été combinées afin d'évaluer si un habitat adéquat pour les essences d'arbres subsisterait dans des scénarios de changements climatiques. Des résultats préliminaires ont laissé entendre qu'entre 15 et 65 % des populations occupant actuellement des aires protégées pourraient disparaître, en fonction des suppositions sur la capacité des essences à d'adapter et à migrer.

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Introduction

In situ reserves are an important conservation tool to ensure the adequate long-term protection of forest genetic resources. Long-lived forest tree species, especially, depend on the maintenance of *in situ* populations with a sufficient effective population size to maintain genetic diversity and allow adaptation to new environmental conditions (Ledig *et al.* 1998). Managed maintenance of evolutionary processes *ex situ* is complex and can only be accomplished for a small selection of commercially important tree species or for captive populations of a few critically endangered species (Namkoong 1984, Eriksson *et al.* 1993). It has long been recognized that global climate change, as a result of greenhouse gas emissions, constitutes a major challenge for *in situ* conservation (Peters and Darling 1985).

Global circulation models predict an increase in mean annual temperature of 3–5 °C by the end of the century. Even a moderate increase around 2 °C, predicted to occur over the next 50 years, would result in approximately a quarter of all species being on a path to extinction (Thomas *et al.* 2004). Several review papers suggest that directional global climate change has already affected species (Walther *et al.* 2002, Parmesan and Yohe 2003, Root *et al.* 2003, Walther 2004), including severe population declines and local extirpations (Pounds *et al.* 1999). If warming trends continue as observed, climate change could potentially surpass land conversion and other forms of habitat destruction by humans as a threat to biodiversity, and may even pose a problem for common species that are currently under no threat.

Assessing Conservation Status with Gap Analysis

Gap analysis is a common approach for assessing the level of protection, redundancy of protected areas, and the need for additional *in situ* reserves. Gap analysis can be carried out at global, national, or regional levels, determining species' habitat and the proportion of populations under protection. Gap analysis not only identifies lack of protection for rare species, but also helps ensure adequate representation of common species or genotypes in existing reserves. Although this type of analysis has been widely used used at the species level, it has only recently been applied in a gene-conservation context to spatially delineate populations that are genetically different (Hamann *et al.* 2004, Lipow *et al.* 2004, Hamann *et al.* 2005). Gap analysis was originally developed because the species-by-species approach to conservation was not efficient under continual loss of populations and landscape fragmentation. Gap analysis helps identify and concentrate conservation efforts on areas that simultaneously provide protection for multiple species or genotypes that most urgently require protection.

Gap Analysis of Projected Habitat

Potential habitat of species or genotypes under future climate scenarios can be predicted using niche modeling methodology. Although niche modeling (or bioclimate envelope modeling) has many limitations, it is well suited to assist conservation or ecosystem restoration programs in matching management objectives for specific sites with anticipated future climates or observed climate change trends for these locations. Such a gap analysis was conducted for British Columbia, modeling the potential habitat of 50 tree species in about 800 protected areas under three climate change projections (2025, 2055, and 2085). Niche modeling was carried out according to Hamann and Wang (2006), and gap analysis methodology is described by Hamann *et al.* (2005). Preliminary results indicate that between 15 and 65% of current tree populations in protected areas may lose suitable habitat, depending on assumptions about species' capabilities to adapt and migrate (Fig 1).

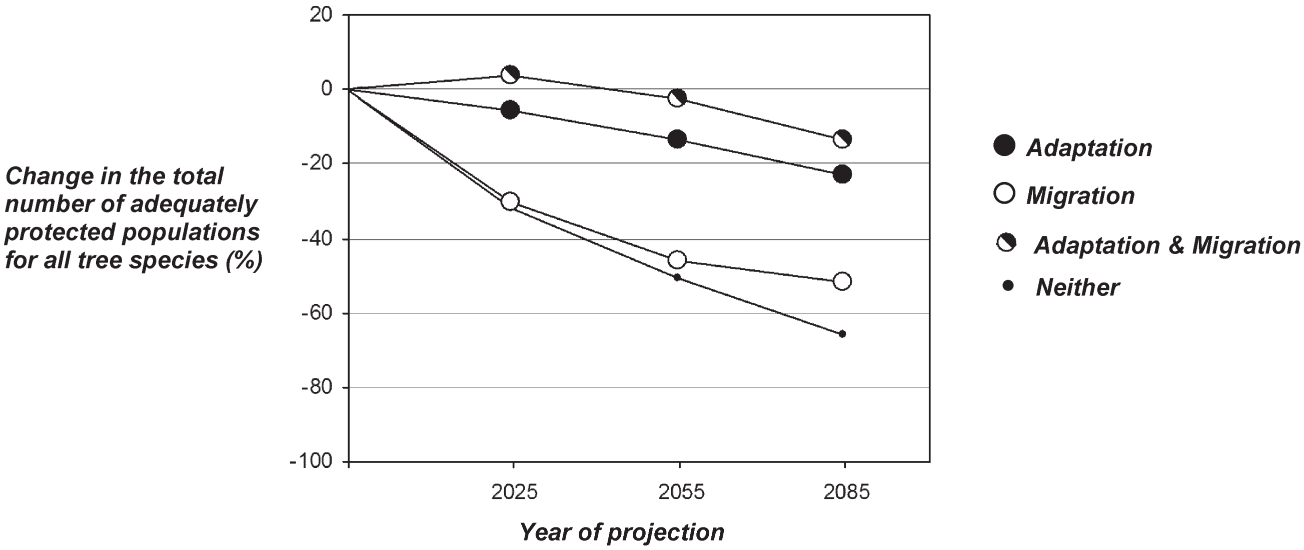

Figure 1. *Change in the number of tree species that are adequately protected (cumulative cover of 10 ha), under the assumption that populations are capable of adapting to changed climate within the limits of the rangewide realized niche of the species = ●; under the assumption that species are able to migrate to suitable habitat within a reserve = ○, both = ◔, or neither •.*

It is widely understood that shifts in vegetation zones are not entirely determined by shifts in climate. Among many other factors, the capacity of species to adapt and migrate has to be considered (Schwartz *et al.* 2001, Nathan *et al.* 2002). The value of climate envelope models, therefore, does not lie solely in literally predicting changes, but in quantifying the overlap and discrepancies between the current habitat and the potential habitat under future climate change scenarios (Pearson and Dawson 2003, Hamann and Wang 2006). By analyzing the overlap between current and future habitat, protected areas in British Columbia were identified that are most likely to sustain suitable habitat for each tree species under climate change scenarios of mean annual temperature increases of approximately 1.5, 2.5, and 4°C.

Acknowledgments

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Invasive Alien Species: Threats to Genetic Resources

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Abstract

Invasive alien species can displace native species and significantly alter ecosystem processes. The rate of introductions has increased greatly with increased world trade, but the recent adoption of international phytosanitary standards will help reduce (but not eliminate) the risk of new introductions of wood-boring species. The live plant pathway is the next big challenge. Prevention and early detection are critical. Once established, eradication is possible if detected early enough, but is difficult and expensive, requires an intensive, long-term commitment. Techniques to manage established invaders have often succeeded, but have been hampered by inconsistent funding. When eradication is no longer feasible, options should include regulatory controls to contain and slow the spread of the pest, combined with the best available management tools, including long-term methods such as biological control, genetic conservation, and host resistance.

Résumé

Les essences exotiques envahissantes risquent de déplacer les espèces et d'affecter considérablement les fonctions des écosystèmes. Le rythme des introductions est monté en flèche avec le développement du commerce mondial, mais l'adoption récente de normes phytosanitaires internationales contribuera à réduire (mais pas à éliminer) le risque d'introduire de nouvelles espèces de buprestidés. La voie d'introduction par les plantes vivantes est un défi majeur supplémentaire à relever. La prévention et le dépistage précoce sont cruciaux. Une fois le fléau établi, l'éradication est possible si le dépistage est suffisamment précoce, mais elle est difficile à réaliser et onéreuse. Le processus exige un engagement intensif et à long terme. Certaines techniques de gestion des ravageurs déjà établis ont connu du succès, mais ont été réfrénées par un financement irrégulier. Lorsque l'éradication n'est plus réalisable, des réglementations visant à contenir et à ralentir la propagation du ravageur devraient être adoptées, en plus des meilleurs outils de gestion disponibles, notamment des méthodes à long terme telles que la protection biologique, la conservation des gènes et la résistance de l'hôte.

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Introduction

Invasive alien species may be defined as those that become established in a new range where they proliferate, spread, and persist to the detriment of the environment (Mack et al. 2000). Alien species introductions have greatly accelerated over the last century because of the tremendous increase in world trade and intercontinental movement of goods (Sailer 1978)(Table 1). For example, the yearly number of containers received in the port of Vancouver alone has increased from 1.15 million in 2001 to 1.77 million in 2005, with most goods coming from China (http://www.portvancouver.com/statistics/2004_statistical.html). Softwood packing material used to brace heavy items, such as stone blocks or machine parts, during shipping has been associated with many interceptions of wood-inhabiting species, such as the emerald ash borer (*Agrilus planipennis* Fairmaire) and the Asian longhorned beetle (*Anoplophora glabripennis* Motschulsky) (Haack 2001, Humble and Allen 2004). Some of these alien "hitchhikers" carry their own hitchhikers, such as fungi, mites, or nematodes. For example, the brown spruce longhorn beetle is closely associated with a fungus, *Ophiostoma tetropii* Mathiesen (Jacobs et al. 2003). Longhorn beetles have been intercepted in a variety of other products, including Bonsai trees, bamboo garden stakes, and artificial Christmas trees. Urban forests, especially those near ports or industrial parks that receive high volumes of goods associated with wood packing material, are at high risk for establishment of alien wood-boring beetles and associated species. In addition to softwood packing material, the movement of live plants through nursery trade probably represents the largest risk of introducing alien species. Emerald ash borer, *Ramorum* blight ("sudden oak death"), and hemlock woolly adelgid (*Adelges tsugae*) are just three examples of alien species now present in North America that can be moved via the nursery/live plant pathway.

Table 1. *A partial list of some invasive alien species in North America and the dates of their introduction or earliest detection of establishment*

Species	Date introduced/detected
Gypsy moth, *Lymantria dispar*	1869
White pine blister rust, *Cronartium ribicola*	1890, 1910
Chestnut blight, *Cryphonectria parasitica*	1900
Hemlock woolly adelgid, *Adelges tsugae*	1920s
Dutch elm disease, *Ophiostoma ulmi*	1944
Ramorum blight (Sudden Oak Death), *Phytopthora ramorum*	1990s
Brown spruce longhorn beetle, *Tetropium fuscum*	1990
Asian longhorn beetle, *Anoplophora glabripennis*	1996, 1998, 2003
Emerald ash borer, *Agrilus planipennis*,	2002
Sirex wood wasp, *Sirex noctilio*	2004

Impact of Invasive Alien Species

Invasive species make up 27% of the major forest pests and 40% of the major agricultural crop pests in the United States, and cause an estimated annual loss of $138 billion (Pimental et al. 2000). Ecological impacts of invasive species include the displacement, reduction, or elimination of native species through predation, disease, competition, or hybridization. The brown tree snake, introduced to the island of

Guam in the 1940s, eliminated nine of the 11 species of native forest-dwelling birds. The American chestnut (*Castaneum dentata*), once the dominant hardwood species over much of the eastern United States, has been largely replaced by oaks (*Quercus* spp.), because of mortality caused by chestnut blight. The blight is caused by the fungus, *Cryphonectria parasitica* (Murill) Barr, which was accidentally introduced from Asia to New York on nursery stock around 1900. There is evidence that *Phytopthora alni* Brasier et al., first observed killing alders in England in the 1990s, is a new species that arose from hybridization of two other *Phytopthora* species, (Brasier et al. 2004) possibly as a result of close contact of host species in nurseries. The disease threatens the stability of riparian ecosystems and natural and managed alder stands in Europe, North America, and Asia.

Some invasive species, especially plants, alter fundamental ecosystem properties such as nutrient cycling, plant productivity, or disturbance regime (Liebhold et al. 1995, Mack et al. 2000). The paper bark tea tree, *Melaleuca quinquenervia* (Cav.) Blake, was intentionally introduced to Florida from Australia in 1906 to help dry up wetlands and provide fiber. Where it has formed dense pure stands (e.g., in the Everglades National Park), *M. quinquenervia* has displaced native species and reduced overall species diversity. The introduction of two specialist insect herbivores of *M. quinquenervia* from Australia appears to be slowing its spread (Silvers 2004). Although well intentioned and often the most effective and economic way to control alien pests if done with care and foresight, the introduction of non-indigenous species for classical biological control has sometimes backfired spectacularly. The cane toad, *Bufo marinus* (L.), was introduced to Australia from South America to control insect pests of sugar cane; however, it did not control the cane beetles and has instead become a noxious pest, eating almost any insect, snail, and small vertebrate it can catch. It produces two clutches of 8000 to 35 000 eggs each year, and squirts a milky toxin that can kill dogs, cats, lizards, and snakes. Scientists at CSIRO are working on biological controls (!) (Anonymous 2004).

Only a fraction of non-indigenous species introductions actually become invasive and cause serious economic and ecological problems. In fact, 99% of agricultural crop plants, as well as our domesticated farm animals are non-indigenous (e.g., cereals, apples, cherries, cows, goats, pigs, chickens). Most people would agree that honeybees are beneficial organisms, yet they are not native to North America. The challenge is to identify those species that pose the greatest risk of introduction, establishment, spread, and environmental damage. Biological traits of invasive species include natural mobility, affinity for humans, resistant life stages, high reproductive rate, wide host preference, tolerance of climatic extremes, and efficient mate location. However, it has proved very difficult to predict whether or not a species will become invasive based on species attributes (Liebhold et al. 1995, Mack et al. 2000). Few people would have predicted the devastating impact that the emerald ash borer has had on North American ash (*Fraxinus* spp.). It causes so little damage in its native Asia, that its biology was virtually unknown before its discovery in Michigan in 2002, and yet the emerald ash borer has killed millions of ash trees and is now established in Michigan, Ohio, Illinois, Indiana, and southern Ontario. A great deal of research is underway to detect, control, and slow the spread of this pest but eradication is no longer considered possible. Efforts to collect seeds and conserve the genetic diversity of North American ash species are critical, given the potential impact of emerald ash borer and its probable eventual spread throughout much of the ash forests in North America.

Sirex noctilio F., a wood wasp native to Europe and Asia, was discovered in Oswego, New York in 2004 and was confirmed in southern Ontario in 2005 and 2006 (http://www.inspection.gc.ca/english/sci/surv/sit2005e.shtml#euro). The wood wasp attacks needle pines, including ponderosa pine (*Pinus ponderosa Laws.*), lodgepole pine (*P. contorta Dougl.*), and jack pine (*P. banksiana Lamb.*).

In low population numbers, *S. noctilio* usually attacks suppressed or injured trees, but it has caused up to 80% mortality of pine stands in Australia and New Zealand (Haugen and Hoebeke 2005). When laying eggs into pine trees, *S. noctilio* also injects a toxic mucus and a symbiotic fungus, *Amylostereum areolatum*; the fungus kills the tree and the wood wasp larvae feed on the fungus as they tunnel through the wood. Fortunately a fascinating and effective biological control method has been developed and used successfully in Australia and other parts of the world. A nematode, *Beddingia siricidicola,* infects wood wasp larvae and sterilizes the adult female, which then vectors the nematode to other trees by laying nematode-filled eggs instead of fertile eggs (Bedding and Akhurst 1974). Research is underway to determine the feasibility of using the nematode for biological control of *S. noctilio* in Canada and the United States.

The preferred, lowest cost option for reducing the impact of invasive species is to prevent their introduction. Once established, the costs of eradication or long-term management are much greater. The best chances for preventing alien species movement between continents is through international cooperation and regulatory agreements on the phytosanitary requirements of goods (e.g., live plants) or packaging (e.g., softwood). The recent implementation of ISPM 15 (Secretariat of the International Plant Protection Convention 2006) requires that wood packaging must be either heat treated or fumigated to kill any pests that may be present, and must be stamped and certified as treated before being used to ship goods for international trade. This should greatly reduce the number of future introductions of wood-boring beetles and other species. Certification programs are currently being developed to control the movement of pests in live plants through the international nursery trade. (https://www.ippc.int/cds_upload/1152091663986_ISPM_15_2002_with_Annex1_2006_E.pdf). Once an alien species is established in a new habitat, early detection is critical for successful control and eradication. Exotic bark and wood borer early detection trapping programs have recently been established in Canada and the United States, targeting urban forests and other high risk sites, and using general host attractants that are not very sensitive but attract a broad range of bark and wood-boring species. Pheromones are species specific and much more sensitive at detecting low populations of a target species (e.g., Asian gypsy moth) than host attractants that have not been identified for many species of wood-boring beetles. Eradication is difficult but has been achieved in the past, e.g., Asian citrus blackfly in Key West, screwworm fly in Curaçao. However, attempts to eradicate the fire ant (*Solenopsis* spp.) cost $200 million over 20 years and made things worse, causing E.O. Wilson to call it "the Vietnam of entomology" (Brody 1975, as cited in Mack et al. 2000). Eradication may be possible without achieving 100% mortality as long as populations are reduced to a low enough density that extinction occurs because of failure to locate mates, inbreeding depression, and failure to satiate predators (Liebhold and Bascompte 2003).

Conclusion

In summary, invasive alien species can displace native species and significantly alter ecosystem processes. The rate of introductions has increased greatly with increased world trade, but the recent adoption of international phytosanitary standards will help reduce (but not eliminate) the risk of new introductions of wood-boring species. The live plant pathway is the next big challenge. Prevention and early detection are critical. Once established, eradication is possible if detected early enough, but is difficult and expensive, requires an intensive, long-term commitment. Techniques to manage established invaders have often succeeded, but have been hampered by inconsistent funding (Simberloff et al. 2005). When eradication is no longer feasible, actions taken should include regulatory controls to contain and slow the spread of the pest, combined with the best available management tools including long-term methods, such as biological control, genetic conservation, and host resistance.

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European Forest Genetic Resources Programme: a European Approach to Gene Conservation of Forest Trees

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Abstract

The European Forest Genetic Resources Programme (EUFORGEN) was established in 1994 to promote conservation and sustainable use of forest genetic resources among European countries. It is also an implementation mechanism for Resolution 2 (Conservation of forest genetic resources) of the First Ministerial Conference on the Protection of Forests in Europe (MCPFE), held in France in 1990. This short paper provides an overview of EUFORGEN and its activities and outputs. In addition, the paper highlights some lessons learned that could be useful for other similar regional or even national approaches, such as the development of the Canadian Forest Genetic Resources Program (CON**FOR**GEN).

The EUFORGEN program started its activities with pilot networks on a few model tree species; gradually, the program evolved into a collaborative platform focusing on broader groups of tree species. It has developed long-term gene conservation strategies for several tree species or groups of species. During recent years, species-specific technical guidelines, targeted at practical forest managers, have also been developed based on available knowledge of the species and on widely accepted methods for the conservation of forest genetic resources. The on-going efforts focus on how to support practical implementation of gene conservation in the member countries; for this purpose, so-called "common action plans" are being developed for several pilot tree species. The common action plans aim at sharing responsibilities in conservation of forest genetic resources among the countries, and identifying

Résumé

Le Programme européen des ressources génétiques forestières (EUFORGEN) a été lancé en 1994 afin de faire la promotion de la conservation et de l'utilisation durable des ressources génétiques forestières dans les pays européens. Il constitue également un mécanisme de mise en œuvre de la Résolution 2 (conservation des ressources génétiques forestières) de la première Conférence ministérielle pour la protection des forêts en Europe (CMPFE), qui a eu lieu en France en 1990. Ce bref article présente un survol du programme EUFORGEN, de ses activités et de ses résultats. En outre, on y tire certaines leçons qui pourraient profiter à d'autres initiatives semblables à l'échelle régionale ou même nationale, telles que l'implantation du programme de conservation des ressources génétiques forestières du Canada (CONFORGEN).

Le programme EUFORGEN a amorcé ses activités en mettant sur pied des réseaux pilotes sur quelques essences forestières témoins. Avec le temps, le programme est devenu une plateforme collaborative examinant un plus grand nombre d'essences. Il a permis l'élaboration de stratégies de conservation génétique à long terme pour plusieurs essences ou groupes d'essences forestières. Au cours des dernières années, des directives techniques spécifiques à chaque essence à l'usage des aménagistes forestiers ont été élaborées à partir de connaissances disponibles sur les essences et de méthodes reconnues de conservation des ressources génétiques forestières. Des efforts continus sont déployés afin de proposer des moyens pour soutenir la mise en œuvre pratique de

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gaps in these efforts at the pan-European level. This involves improving information management and obtaining geo-referenced data on the existing gene conservation units of forest trees throughout their entire distribution ranges in Europe for further analyses and strategy development.

More than 12 years of regional collaboration on forest genetic resources within EUFORGEN shows that European countries have recognized the benefits of working together in this area. Despite changes in administrative structures and senior policy makers, the level of commitment has remained high within the member countries and, especially, among the experts and scientists contributing to EUFORGEN activities. It is clear that the continuing support by national policy makers would not have been maintained without the political endorsement of a regional forest policy process, i.e., the MCPFE process. Moreover, keeping forest genetic resources on the MCPFE agenda has required on-going input from the EUFORGEN Steering Committee (National Coordinators). This has created a strong sense of ownership among the National Coordinators and the member countries. The experiences of EUFORGEN and other similar networks on plant genetic resources demonstrate that regional collaboration benefits from creating processes and structures that ensure wide participation, and from clear principles, objectives, and operating plans.

la conservation des gènes dans les pays membres. Pour y parvenir, des « plans d'action communs » ont été lancés pour certaines essences témoins. Le plan d'action commun a pour but de partager les responsabilités en matière de conservation des ressources génétiques forestières entre les pays membres et de déceler les lacunes dans les efforts au niveau paneuropéen. Cet objectif appelle l'amélioration de la gestion de l'information et la collecte de données géoréférencées sur les unités conservatoires d'arbres forestiers en place, et ce, sur toute l'aire de distribution européenne, pour des analyses et des stratégies futures.

Plus de 12 ans de collaboration à l'échelle régionale en matière de ressources génétiques forestières dans le cadre du programme EUFORGEN démontrent que les pays européens ont reconnu les avantages d'unir leurs efforts dans ce domaine. Malgré certains changements effectués sur le plan des structures administratives et des décisionnaires haut placés, le niveau d'engagement est demeuré élevé chez les pays membres, et spécialement de la part des experts et des scientifiques contribuant aux initiatives du programme EUFORGEN. Il est indéniable que le soutien continu des décisionnaires de chaque pays n'aurait pas été maintenu sans l'élaboration d'un processus régional d'élaboration des politiques forestières, à savoir la CMPFE. En outre, la possibilité de garder les ressources génétiques forestières à l'ordre du jour de la CMPFE a exigé un effort continu de la part du comité de direction du programme EUFORGEN (coordonnateurs nationaux). Cette implication a entraîné un fort sentiment de responsabilité chez les coordonnateurs nationaux et les pays membres. Les expériences du programme EUFORGEN et d'autres réseaux semblables étudiant les ressources génétiques végétales démontrent que la collaboration à l'échelle régionale tire profit de la création de processus et de structures exigeant une forte participation, et aussi de l'adoption de principes, d'objectifs et de plans d'action clairs.

Introduction

The European Forest Genetic Resources Programme (EUFORGEN) is a collaboration among European countries to promote conservation and sustainable use of forest genetic resources (FGR). It was established in October 1994 as an implementation mechanism for Resolution 2 (Conservation of forest genetic resources) of the First Ministerial Conference on the Protection of Forests in Europe (MCPFE), held in Strasbourg, France in 1990. This resolution called for the development of a functional but voluntary instrument of international collaboration to promote and coordinate *in situ* and *ex situ* conservation of FGR, the exchange of reproductive material, and monitoring of progress in these areas. Since the first conference, the MCPFE process has served well as a high-level forum for a continuous dialogue on forest policy issues and has contributed significantly to the further improvement of sustainable forest management in Europe (Mayer and Buck 2005).

EUFORGEN started its activities with four pilot networks: black poplar (*Populus nigra*), cork oak (*Quercus suber*), noble hardwoods, and Norway spruce (*Picea abies*) during Phase I (1995–1999). A fifth network, for social broadleaves (i.e., temperate oaks (*Quercus* spp.) and beech (*Fagus* spp.)), was launched in 1997. It was considered pragmatic to initiate the work through these pilot networks, which addressed a limited number of tree species and focused on different geographic and ecological conditions in Europe. During the second phase (2000–2004), the work continued through the five species networks but the scopes of the networks were broadened and some of them were renamed. The *Picea abies* Network evolved into the Conifers Network and the *Quercus suber* Network into the Mediterranean Oaks Network. In 2002, the name of the Social Broadleaves Network was also changed to the Temperate Oaks and Beech Network.

In 2003, at the Fourth Ministerial Conference in Vienna, Austria adopted a new resolution on forest biological diversity and urged the countries to continue the regional collaboration on FGR in Europe. Although the MCPFE process supported continued collaboration through EUFORGEN, it also highlighted the importance of linking conservation of FGR with sustainable forest management. Subsequently, the EUFORGEN Steering Committee decided to reorganize the network structure of the program for Phase III (2005–2009), but the overall goal of EUFORGEN remained the same, i.e., to promote conservation and sustainable use of FGR in Europe. A new thematic Forest Management Network was established in 2005 to promote closer integration of gene conservation into practical forest management and national forest programs. Furthermore, the work on broadleaved tree species was merged into two new networks, i.e., the Scattered Broadleaves Network and Stand-forming Broadleaves Network. The Conifers Network continues its work without major changes during the third phase.

The Steering Committee also adopted new objectives for Phase III of EUFORGEN as follows:

1. Promote practical implementation of gene conservation and appropriate use of genetic resources as an integral part of sustainable forest management;

2. Facilitate further development of methods to conserve genetic diversity of European forests; and

3. Collate and disseminate reliable information on FGR in Europe.

Mode of Operation

EUFORGEN operates as a multilateral trust fund; individual countries formally join the program by signing a Letter of Agreement with Bioversity International. As part of the agreement, countries nominate a National Coordinator and make annual financial contributions to the Program, which is fully financed by the member countries (currently 34). Bioversity International hosts the EUFORGEN Secretariat and coordinates program activities in technical collaboration with the United Nations Food and Agriculture Organization (FAO).

The EUFORGEN Steering Committee is composed of National Coordinators from all member countries and it has overall responsibility for the program. The Steering Committee reviews the progress made and decides upon future activities of EUFORGEN. The National Coordinators liaise between the Secretariat and various national institutes. They also nominate country representatives to the Networks, in which scientists, managers, and even policy makers exchange information, discuss needs, develop work plans, and implement jointly agreed-upon activities. EUFORGEN covers the travel costs of the Network members to meetings, whereas between the meetings, the members carry out agreed activities with their own resources as in-kind inputs.

The Secretariat coordinates the implementation of the Network activities and takes care of the financial management of the program. Together with the Networks, it also prepares publications and it represents EUFORGEN in various fora. Technical advice to the Secretariat is provided by a small Management Committee, which is composed of representatives of Bioversity International and the FAO.

Recent Activities and Outputs

The EUFORGEN Networks have developed long-term gene conservation strategies for several tree species or groups of species. The main objective of these strategies is to ensure continuous evolution of European forest trees. *In situ* conservation efforts are given first priority, but it is emphasized that *in situ* and *ex situ* conservation measures should be used in a complementary manner, according to threats and species-specific needs for genetic conservation.

The conservation strategies for various species have been published in meeting reports or species-specific technical publications. For example, the Conifers Network developed a gene conservation strategy for Norway spruce (Koski et al. 1997) and the same principles are also applicable for many other conifers with similar biological characteristics. The *Populus nigra* Network also produced a technical bulletin on the *in situ* conservation of black poplar (Lefèvre et al. 2001) and the Noble Hardwoods Network prepared gene conservation strategies for alders (*Alnus* spp.) (Krstinic et al. 2002), elms (*Ulmus* spp.) (Collin 2002), and walnut (*Junglans regia*) (Fernández-López et al. 2002). A conservation strategy is currently being finalized for cork oak (Varela et al. 2007).

In addition to the above-mentioned conservation strategies and technical bulletins, the EUFORGEN Networks have also developed species-specific technical guidelines that are targeted specifically at practical forest managers. These six-page guidelines provide summarized species-specific information on biology and ecology, distribution maps, importance and use, genetic knowledge, threats to genetic diversity, and guidelines for genetic conservation and use. The guidelines present commonly agreed recommendations based on available knowledge of the species and on widely accepted methods for the conservation of FGR.

Technical guidelines have been developed for eight conifer species: silver fir (*Abies alba*), Norway spruce, Swiss stone pine (*P. cembra*), Aleppo and Brutia pines (*P. halepensis* and *P. brutia*), European black pine (*Pinus nigra*), Maritime pine (*Pinus pinaster*), Italian stone pine (*Pinus pinea*), and Scots pine (*Pinus sylvestris*). In the case of broadleaves, similar guidelines have been finalized for: sycamore (*Acer pseudoplatanus*), field maple (*Acer campestre*), black alder (*Alnus glutinosa*), chestnut (*Castanea sativa*), common ash (*Fraxinus excelsior*), oriental sweet gum (*Liquidambar orientalis*), wild apple and pear (*Malus sylvestris* and *Pyrus pyraster*), black poplar (*Populus nigra*), wild cherry (*Prunus avium*), European white oaks (*Quercus petraea*, *Q. robur*), service tree (*Sorbus domestica*), wild service tree (*S. torminalis*), limes (*Tilia cordata*, *T. platyphyllos*), and white elm (*Ulmus laevis*).

All technical guidelines and distribution maps can be downloaded from the EUFORGEN website (www.euforgen.org). The guidelines are published in English and several countries are planning to translate them into their national languages.

Currently, the EUFORGEN Networks are developing so called "common action plans" for several pilot tree species. As indicated by the name, these plans are very much focused on how to implement the gene conservation strategies in practice. They can help to identify gaps and overlaps in gene conservation efforts at the pan-European level, and ultimately, countries can share their responsibilities in FGR conservation. The common action plans are an effort to create pan-European networks of primarily *in situ* gene conservation units for selected tree species within their entire distribution ranges. *Ex situ* conservation units outside species' natural distribution ranges can also be included if they contribute to dynamic gene conservation. The Conifers Network has also included exotic conifers (*Picea sitchensis* and *Pseudotsuga menziesii*) as their pilot species because these species have an important role in forestry in several European countries and because they have already formed distinct landraces since their introduction.

A necessary first step in the development of the common action plans is to obtain geo-referenced data on the existing dynamic gene conservation units of forest trees throughout their entire distribution ranges in Europe for further analysis and strategy development. However, the development of the common action plans has been hampered by a lack of common minimum requirements and information standards for the dynamic gene conservation units. In addition, there is no common understanding about what level of gene management can be considered sufficient to declare an area eligible for gene conservation purposes at the pan-European level.

A new project on the Establishment of a European Information System on Forest Genetic Resources (EUFGIS) was launched on 1 April 2007. It will focus on these obstacles, and harmonize the minimum requirements and information standards. In addition to the information system, the project will also create a network of national focal points on FGR documentation in all EUFORGEN member countries and several associated countries. The project is supported by the European Commission, and is coordinated by Bioversity International, which is already maintaining a similar Web-based information system for crop genetic resources, in the form of the European Plant Genetic Resources Search Catalogue (EURISCO) (http://eurisco.ecpgr.org). EURISCO provides information on nearly one million accessions in European genebanks, and also serves as a well-tested model in terms of information infrastructure for the new project.

EUFORGEN has also contributed to the implementation of other MCPFE commitments, such as Vienna Resolution 5 on climate change and sustainable forest management. In March 2006, Bioversity International and the International Union of Forest Research Organizations (IUFRO) organized a workshop on climate change and forest genetic diversity in Paris. The workshop recognized that climate change can have substantial impacts on the European forest sector as well as on conservation of forest biodiversity. The genetic diversity of forest trees plays a key role in maintaining the resilience of forests to threats and in taking advantage of the opportunities. The workshop also stressed that the use of genetic diversity provides flexibility with respect to forest management and adaptation strategies for climate change. Subsequently, the workshop made several recommendations for further work of the MCPFE process (see the EUFORGEN website or Koskela et al. 2007 for more details).

Lessons Learned

More than 10 years of regional collaboration on FGR shows that European countries have recognized the benefits of working together in this area. The commitment of each member country has made it possible to build and maintain EUFORGEN as a platform for both formal and informal collaboration and exchange of information on FGR in Europe. It is clear that this would not have been possible without the political support of the MCPFE process. The regional collaboration has also facilitated the development or strengthening of national programs and policies on management of FGR in many European countries. Furthermore, it has helped development and implementation of other efforts on FGR in Europe (e.g., bilateral projects or training courses).

The continued commitment of the member countries to EUFORGEN results from their participation not only in implementation of various activities but also in decision making. This has created a strong sense of ownership and generated concrete outputs and results. As a long-term program, EUFORGEN has also gone through organizational development and demonstrated its responsiveness to the needs of the member countries and their policy makers. The Steering Committee and the Secretariat have also made continuous efforts to highlight the importance of FGR as part of the MCPFE process. At the national level, however, management of FGR should be better incorporated into national forest programs, national biodiversity action plans, and national adaptation strategies to climate change.

Outside Europe, Biodiversity International and the FAO have used EUFORGEN as an example for similar regional initiatives on FGR, namely the Asia Pacific Forest Genetic Resources Programme (APFORGEN) and the Sub-Saharan Forest Genetic Resources Programme ((SAFORGEN). In 2006, the Latin America Forest Genetic Resources Programme ((LAFORGEN) was also initiated. The major difference between EUFORGEN and all other regional programs is that none of them enjoys similar political support from a regional forest policy process or ministers responsible for forests, as does EUFORGEN. Therefore, they often struggle to find enough resources to implement collaborative activities, which were agreed upon with high expectations when the regional programs were established. This provides further evidence about the importance of political support for the regional collaboration and long-term sustainability of networks or programs.

Bioversity International coordinates or collaborates with 19 regional networks or programs on plant genetic resources in different parts of the world. It is also closely involved in several commodity-based (e.g., coconut, banana, and cacao) networks. Based on these efforts, several successes and drawbacks have been identified for regional networks on plant genetic resources in general (Watts 2002, 2004). Important successes include creating processes and structures that ensure wide participation within a network and establishment of clear principles, objectives, and operating plans. Excessive external funding should also be avoided and any external funding should be balanced with financial contributions by network members. Successful networks also demonstrate flexibility and responsiveness to different needs.

Drawbacks often result from an incomplete understanding of the needs and interests of stakeholders, as well as lack of clear objectives and goals. It should also be kept in mind that there is often a long time lag between establishment of a network and any visible outputs. Networks can also suffer from domination by a few strong members, donors, or even coordinators, and far too often networks try to achieve ambitious goals with too few resources.

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Gene Conservation Pressures in Southern Ontario's Great Lakes–St. Lawrence Forest Region

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Abstract

Southern Ontario is a very diverse region in terms of landforms, soils, climate, and species. Land ownership, land use, and societal expectations in the province are also diverse, and exert pressure on the natural resources. Invasive species (fungi, insects, plants, and animals) and climate change (including warmer winters, earlier springs, and more frequent droughts and storms) exacerbate this pressure.

Increasingly, our ability to counteract or limit these effects is compromised by society's general ignorance of and detachment from the land and the forests that support their health and welfare. The result is a suffering forest landscape and declining future benefits.

Against this backdrop, the Forest Gene Conservation Association works with its many forest management and conservation partners to promote the value of conserving the genetic diversity of our native woody plants—the ultimate buffer to ensure sustainable forests and all their benefits. To accomplish this work, we rely on regional, provincial, and national governments and organizations to provide the information, science, tools, and incentives. Together, our job is to help society understand the basic principles at work—to help them see and save the forests

Résumé

Le sud de l'Ontario est une région très diversifiée sur le plan du relief, des sols, du climat et des espèces présentes. La propriété et l'utilisation des terres et les attentes sociétales de cette province sont également diversifiées et exercent une pression sur les ressources naturelles. En outre, les espèces envahissantes (champignons, insectes, végétaux, animaux) et les changements climatiques (y compris les hivers plus doux, les printemps plus hâtifs et les sécheresses et les orages plus fréquents) exacerbent cette pression.

De plus en plus, notre capacité d'éliminer ou de limiter ces changements est compromise par l'ignorance générale de la société et par notre détachement par rapport aux bienfaits de la terre et des forêts sur notre santé et notre bien-être. Le résultat est la détérioration des forêts et des avantages qu'elles pourraient nous procurer.

Dans ce contexte, la Forest Gene Conservation Association (FGCA) travaille en collaboration avec ses nombreux partenaires en conservation et en gestion forestière à promouvoir l'importance de conserver la diversité génétique des plantes ligneuses indigènes, qui constituent le tampon crucial assurant la durabilité des forêts et de tous les avantages qu'elles comportent. Nous dépendons d'organisations et de gouvernements régionaux, provinciaux et nationaux, qui collaborent à offrir de l'information, des connaissances scientifiques, des outils et des mesures incitatives. Ensemble, notre mission consiste à aider la société à comprendre les principes de base en jeu, à l'aider à réfléchir sur les forêts et les arbres, et à les sauver.

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Introduction

The Forest Gene Conservation Association (FGCA) program area is known as the Southern Region of the Ontario Ministry of Natural Resources—roughly 12.6 million ha, 80% privately owned (Fig. 1). The northern part, roughly east of Georgian Bay (Lake Huron), is on the Canadian Shield, with areas south of that underlain by limestone bedrock. That division is reflected in the settlement patterns, with the north being largely forested with an active forest-based economy that includes both wood products and recreation. The south is home to most of the area's 11 million people, and is mostly private land, with deeper, productive soils, a milder climate, and an urban/agricultural landscape.

In fact, the south was largely cleared for agriculture in the late 1800s to early 1900s. The mid-1900s saw much of the marginal farmland regenerated to forests. The forest cover in the south ranges from less than 3% in the far southwest to over 40% in a few central and eastern municipalities. Private landowners, mostly farmers, number approximately 160 000, but of those, the number of new forest landowners, absentees and retired people, is increasing.

Soil types include thin glacial till, deep outwash sands, heavy clays, and deep productive loams. The

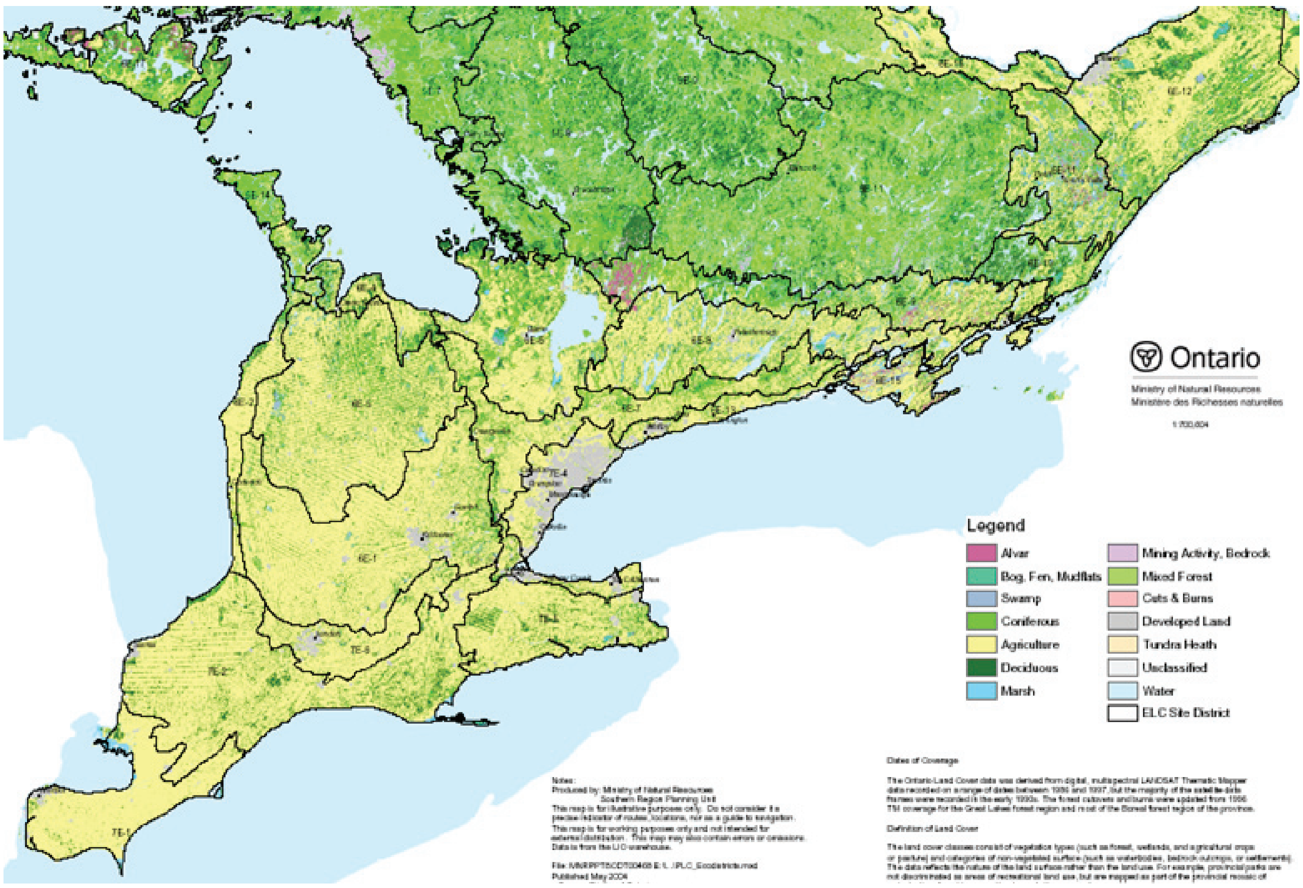

Figure 1. *Southern Region of Ontario, served by the Forest Gene Conservation Association.*

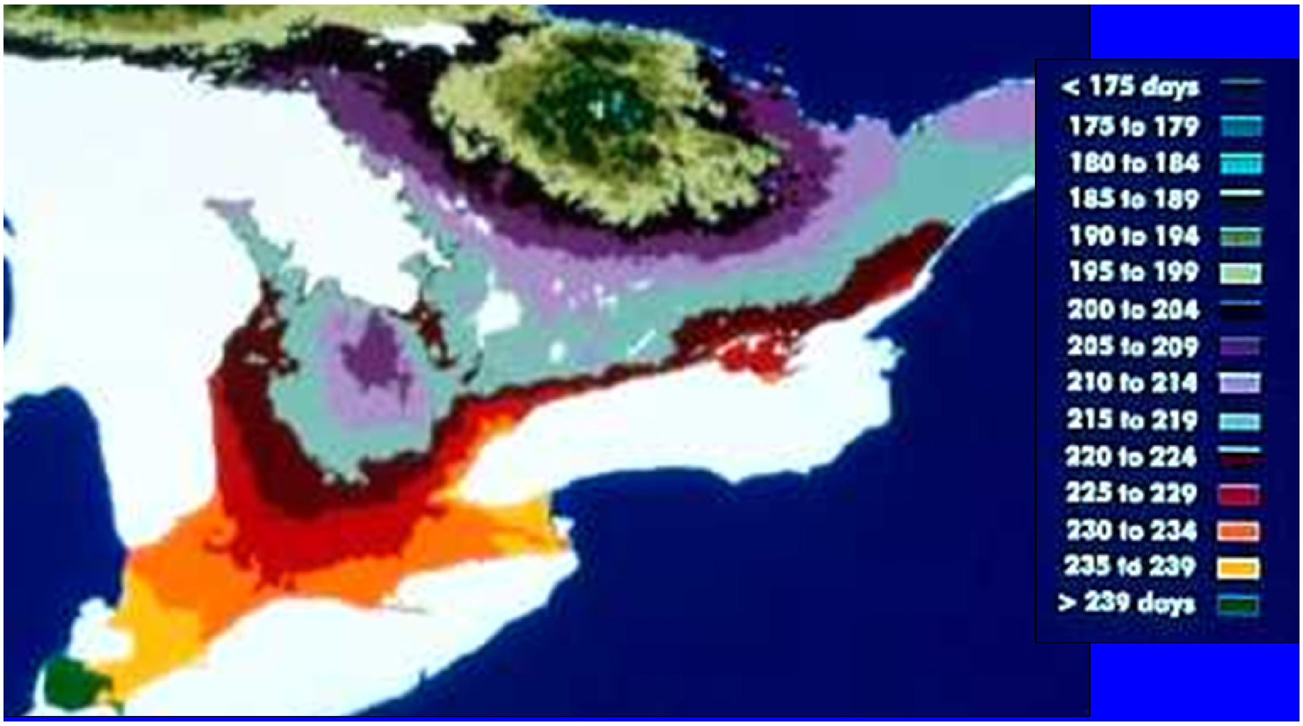

Figure 2. *Growing season length in 5-day classes (Source – Ontario Climate Model, Canadian Forest Service 1996).*

climate is variable, with minor differences in elevation, a moderate latitude range, and large effects caused by proximity to the Great Lakes. The length of growing season varies from only 175 days in the north on the Algonquin Dome to 240 on the Niagara Peninsula and in the far southwest corner (Fig. 2).

The variation in climate and physiography has resulted in great woody species diversity: 12 conifer species, more than 40 hardwood species, more than 100 shrubs, and 7 vines. They occur in diverse forest communities from rocky alvars to savannahs to lowland swamps to pine sand flats to highly diverse Carolinian hardwood forests.

The varied pressures on these forests are largely caused by the actions of many, many people, including more than a century of settlement and forest clearing, poor forest management and logging practices, introduction of invasive species (plants, diseases, insects), and pollution and climate change.

Increasingly, our ability to counteract or limit these effects is compromised by society's increasing level of ignorance of and detachment from the land and the forests that support their health and welfare. The result is a suffering forest landscape and declining future benefits.

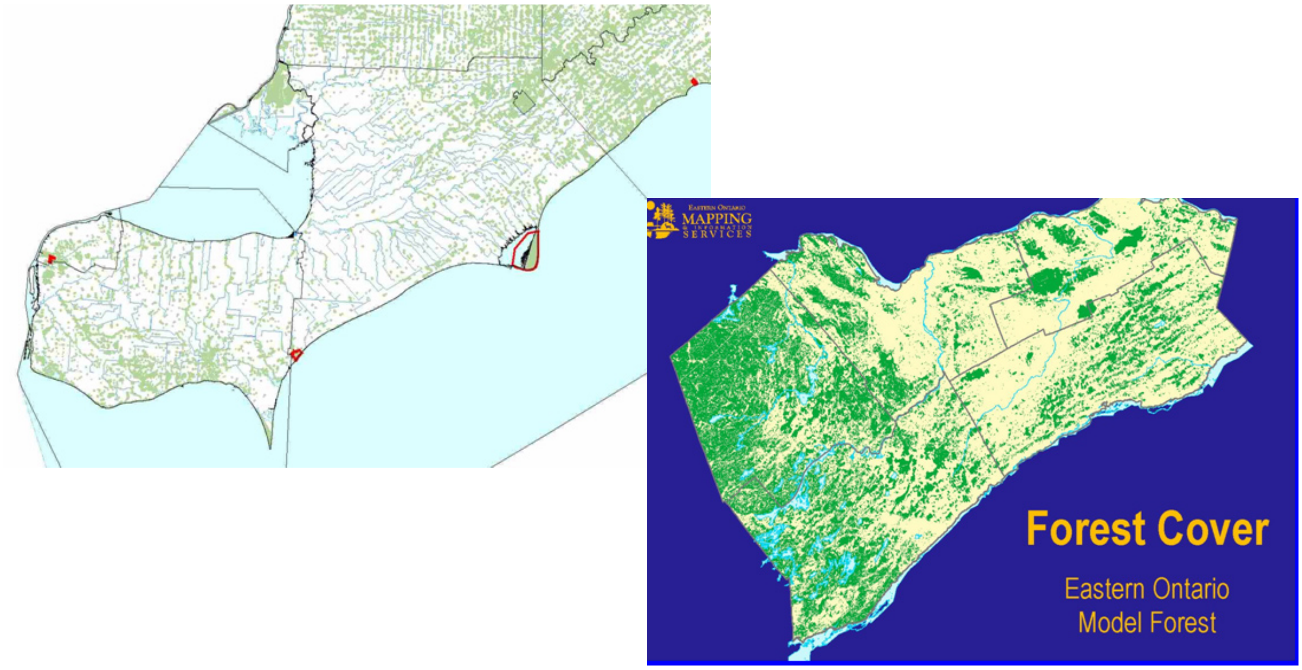

Figure 3. *Forest cover in southern Ontario: <3% in the southwest, >30% in the east.*

Settlement and Forest Clearing

This has resulted in reduced and fragmented forests, at worst less than 3% forest cover in the southwest (the lowest in eastern North America) (Fig. 3). The remaining forests are usually relegated to the less productive sites. Even in areas of more than 40% forest cover there are conservation issues regarding missing or rare forest communities on certain site types.

Although largely an historical effect, forest fragmentation is still continuing because of urban sprawl (roads, subdivisions, malls), recreation (golf courses, increasing cottage development), rural retirement (more homes in the forest), and agribusiness (larger fields, fewer fence rows and forests).

The total area of forests has not changed a lot recently but, because we are losing areas of older mature forest even as other areas are being planted or naturally regenerated, the effect is a landscape of moving, younger forests.

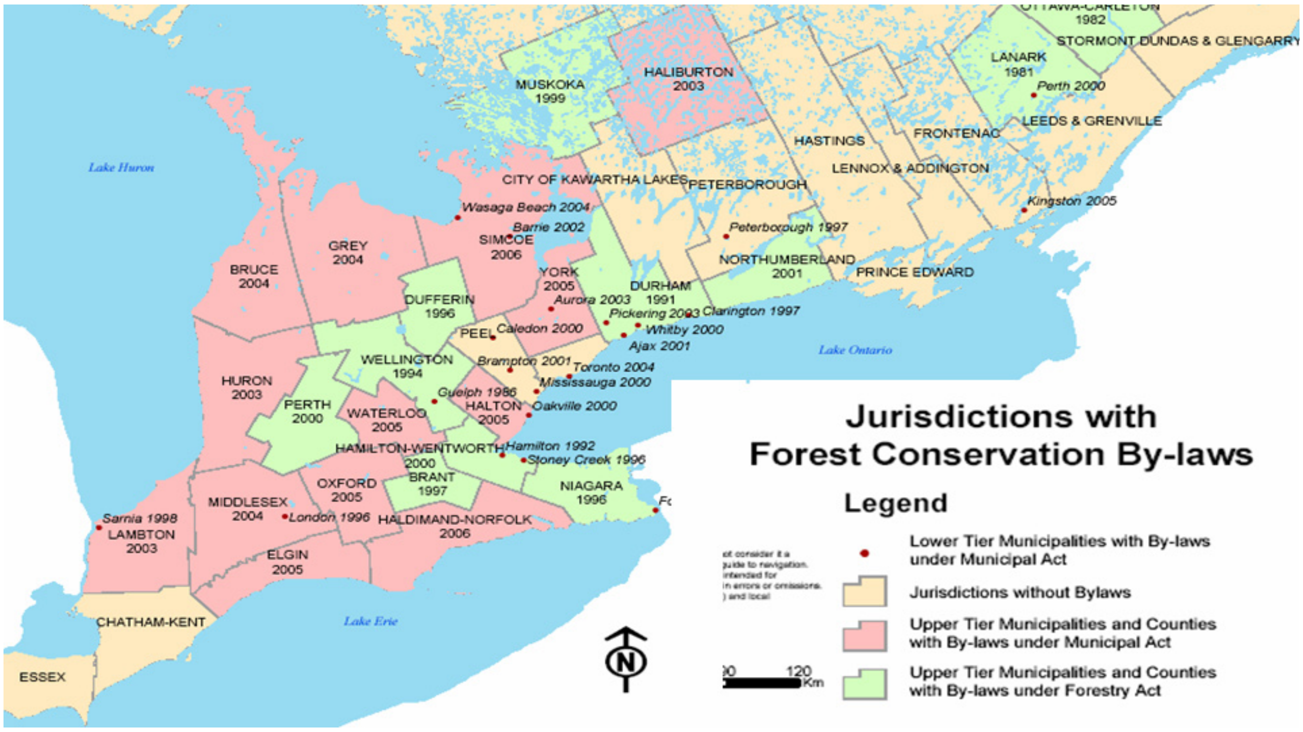

Figure 4. *Jurisdictions in southern Ontario with forest conservation bylaws.*

Poor Forest Management and Harvesting

There is a program for training and licensing "independent tree markers" and a slowly increasing number of forest conservation bylaws for southern Ontario. But, countering this good news, are landowners who are largely unaware of the bylaws or who are swayed by greed, loggers who are motivated by greed, and weak bylaws that use diameter-limit guidelines thatcan be interpreted as allowing high-grading. Unscrupulous loggers (including some U.S. companies) tend to target those municipalities without forest conservation (or "tree cutting") bylaws (Fig. 4). Anecdotal evidence suggests fewer than 25% of southern Ontario harvests are marked before logging.

Introduction of Invasive Alien Species

Invasive alien species (IAS) of fungi, insects, plants, and animals, are having increasingly negative effects, such as reduced growth and regeneration, and increased mortality and extirpation. Fungal IAS include chestnut blight (*Cryphonectria parasitica*), Dutch elm disease (*Ceratocystis ulmi*), butternut canker (*Sirococcus clavigignenti-juglandacearum*), and beech bark disease (*Nectria coccinea* var. *faginata*); insect IAS include gypsy moth (*Lymantria dispar*), emerald ash borer (*Agrilus planipennis*), Asian long-horned beetle (*Anoplophora glabripennis*), and Sirex wood wasp (*Sirex noctilio*); plant IAS include garlic mustard (*Alliaria petiolata*), buckthorn (*Rhamnus cathartica*), and dog strangling vine (*Vincetoxicum nigrum*); and animal IAS include earthworms (*Oligochaeta* spp.)!

Scots Pine in South-central Ontario

Scots pine (*Pinus sylvestris* L.) was introduced to southern Ontario to help restore some severely degraded sites, including blowsands, but also for Christmas tree production.

Genetic Quality Report Card—a failure

- ☑ Adaptation: Scots pine was adapted to both the climate and the degraded sites.
- ☒ Forest products: the wrong seed source meant poor form and growth, susceptibility to insect and disease problems, and increased costs, resulting in few economic benefits.
- ☒ Environmental fitness: Over-planting led to insect and disease problems for native species; it also invades natural areas and displaces native species.

The Urban Forest Experiment with Norway Maple

The landscape industry has widely promoted several cultivars of Norway maple (*Acer platanoides* L.) across North America for many decades as an urban street tree—to the extent that it is the most common urban species. It has also been planted along major highways, and urbanites relocating to rural areas are landscaping with it.

Genetic Quality Report Card—a failure

- ☑ Adaptation: Norway maple can survive in our climate and on the often degraded urban sites we have created (compacted soils, pollution, heat stress).
- ☒ Urban forest benefits: it is a relatively short-lived tree (<80 years), its full crown requires pruning to maintain a sound structure.
- ☒ Environmental fitness: Over-planting cultivars has reduced forest diversity and fitness; the heavy shade it casts causes problems for ground flora and results in soil erosion, and its invasiveness puts pressure on otherwise native forests.

Impact of Climate Change

In the future, we expect more frequent and more extreme droughts, more extreme storms, and consequently, more frequent and severe damage caused by insects, diseases, and forest fires. As well, regeneration may be impaired because of more infrequent seed crops and the effects of droughts or floods on seedling establishment. In the long term, we may also see species shifts and community disruptions. Mitigation will require using all the current sustainable management tools along with innovative forest management ideas, including better site information, planning, tending, and monitoring.

The FGCA and Gene Conservation Activities

Southern Ontario is home to millions of people, who live in large cities, many towns, counties, and townships. The forest management and conservation sector is divided into many government and non-government agencies, landowner associations, and special interest groups. Some have overlapping interests, but in other cases, there are gaps in terms of expertise or geographic influence.

The FGCA works with many of these groups as members or associates, including government, forest industry, conservation agencies, landowner groups, and individuals. It is a non-profit corporation, established in 1994 that covers southcentral Ontario, and is one of three regional members of Forest Genetics Ontario. Financial support includes an Ontario Ministry of Natural Resources staff position and fund-raising efforts for specific programs. Our mandate is forest genetic resource management in southcentral Ontario, with emphasis on conservation of genetic diversity of forest tree species. Three main goals include:

1) To promote the maintenance and restoration of the genetic diversity of woody plant species.

2) To increase the economic benefits of planting through planning and implementing tree breeding programs for selected woody plant species (e.g., white pine (*Pinus strobus* L.)).

3) To ensure the use of biologically appropriate seed sources in support of planting programs, e.g., *Ontario's Natural Selections*, which is a voluntary seed source certification program.

The overriding reality of our program is the many, often changing, private landowners. They have a tremendous influence on whether forest management efforts will provide ecological, social, and economic benefits for many, many future generations. The future is in their hands, but they could use our help.

Ignorance of and Detachment from the Land (Forests)

Communicating with landowners, local communities, and governments is key to conserving the genetic diversity of our forests.

In the 1990s, Ontario suffered a big setback in our ability to work with forest landowners, but a silver lining is a slowly growing trend among landowners to be more directly involved and do the right thing. When government programs "spoon-fed" people, no capacity was built to take over once government withdrew. More and more, local naturalists, anglers, and hunters, and woodlot owner groups are working together. "Local" is a key concept. It builds a more knowledgeable local constituency.

The role for regional, provincial, and national governments and organizations is to provide the information, science, tools, and incentives. Our job is to help the public understand the basic principles at work: to help them see and save the forests and the trees.

What's Happening with Forest Genetic Resource Conservation in New Brunswick?

Kathy Tosh
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Abstract

In New Brunswick (NB), approximately 50% of the 7.3 million ha of forest land is owned and managed by the Crown. A number of forest genetic resource conservation efforts in NB relate to the management of these Crown lands. The Crown Land and Forest Act, established in 1982, outlines conservation objectives—including maintaining ecosystem diversity, addressing forest community objectives, and establishing protected natural areas—and the ten Licensees develop management plans to meet them.

Another NB initiative is the NB Forest Gene Conservation Working Group, which was established in 1997. This group evaluates the need for gene conservation measures, providing expert advice to both federal and provincial governments and stakeholders on the full range of issues related to the conservation of genetic diversity of native forest tree and shrub species. Gene conservation strategies have been developed for four tree species, and various research projects have been initiated.

Résumé

Au Nouveau-Brunswick (N.B.), la Couronne possède et gère environ 50 % des 7,3 millions d'hectares de superficie. Une partie des initiatives en matière de conservation des ressources génétiques forestières dans la province porte sur la gestion de ces terres publiques. La *Loi sur les terres et forêts de la Couronne*, adoptée en 1982, définit les objectifs de conservation – y compris le maintien de la diversité des écosystèmes, la réalisation des objectifs de la communauté forestière et la délimitation d'aires naturelles protégées – et les dix titulaires de permis élaborent des plans de gestion pour atteindre ces objectifs.

Le Groupe de travail de conservation du patrimoine génétique forestier du NouveauBrunswick, fondé en 1997, est une autre initiative néobrunswickoise. Ce groupe évalue les besoins en matière de mesures de conservation des gènes et offre des conseils d'expert sur la conservation de la diversité génétique d'essences d'arbres et d'arbustes indigènes. Des stratégies de conservation des gènes ont été déployées pour quatre essences d'arbres, et divers projets de recherches ont été lancés.

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Introduction

In New Brunswick (NB), approximately 50% of the 7.3 million ha of forest land is owned and managed by the Crown. This Crown land is divided into ten Licenses, which are leased to six forestry companies. There are a number of forest genetic resource conservation efforts in New Brunswick that relate to the management of these Crown lands. The two specific efforts that will be discussed here are a review of the NB Crown land strategies that contribute to forest gene conservation, and a summary of the work and progress to date of the NB Forest Gene Conservation Working Group.

NB Crown Land Strategies

Since 1982, Crown lands have been managed under the Crown Land and Forests Act. The Act outlines the arrangement between the licensees and the provincial government. The Crown sets broad-based objectives and management standards, and the Licensees develop and implement management plans to meet these objectives. In addition to the Act and the objectives, which are outlined every 5 years, there are a number of other policies and strategies that benefit conservation of forest genetic resources and diversity.

At the forest ecosystem level, the goal of the NB Department of Natural Resources (DNR) is to maintain the diversity of forest ecosystems and their associated ecological values. This includes ensuring that the full range of naturally occurring forest types is maintained, identifying and protecting unique sites and their associated values, and using harvest practices that favor natural regeneration.

As part of the forest community objectives, DNR recognizes nine vegetation communities and four sub-communities within each of the province's seven ecoregions. To ensure that the full range of naturally occurring forest types and successional stages is maintained across the landscape, licensees must ensure at least 12% of each vegetation community is maintained in an old-forest condition through time.

In 2001, the province announced that ten large protected natural areas would be established; these were created by special legislation in 2003 (Protected Natural Areas Act and Regulations). A total of 149 290 ha are included in this coarse-filter class. Low-impact recreation is permitted in these areas. In addition, there are 20 smaller ecological reserves and conservation areas totaling 3061 ha, that are protected. Public access is not permitted in these 20 ecological reserves.

Another key conservation goal of the DNR is to maintain healthy populations of all forest-associated birds, mammals, amphibians, and reptiles across Crown land. To support this goal, objectives exist for six old-growth wildlife habitat areas. In addition, approximately 900 deer wintering areas (DWA) covering 280 000 ha of forest exist to maximize sustainable supplies of severe and moderate winter deer habitat (old forest). There are also watercourse buffer zones maintained next to all watercourses and wetlands. Approximately 8% of the forest is encompassed in buffer zones. Collectively these management initiatives contribute to maintaining the genetic diversity of our forest flora and fauna.

The DNR also has other initiatives that relate to forest gene conservation, including developing a NB biodiversity conservation strategy to support implementation of the goals of the Canadian Biodiversity Strategy. As well, several Acts have been legislated over the past 10 years that contribute to forest gene conservation (e.g., NB Endangered Species Act).

NB Forest Gene Conservation Working Group

The NB Forest Gene Conservation Working Group was formed in 1997 to evaluate the need for gene conservation measures in NB. Its goal is to provide expert advice to the federal and provincial governments and stakeholders on the full range of issues related to the conservation of genetic diversity within native forest tree and shrub species.

Active members of the committee include representaties of the Fundy Model Forest, NB Woodlot Owners Federation, JD Irving Limited, Southern NB Wood Cooperative, NB DNR, and the Canadian Forest Service. The meetings are consensus decision making in nature and technical experts are hired for specific assignments.

The specific objectives of the working group are:

1) To identify which tree and shrub species are of concern,
2) To assess the current status of all species that have significantly declined in range or frequency,
3) To develop and encourage the implementation of practical gene conservation strategies, and
4) To generate new information and develop techniques for *ex situ* conservation.

To date the working group has made considerable progress. A set of criteria to identify species of concern and a rating system to categorize the type of action required have been developed. Based on the criteria and rating system, gene conservation strategies have been developed for four tree species: *Juglans cinerea* (butternut), *Quercus macrocarpa* (bur oak), *Ulmus americana* (white elm), and *Fagus grandifolia* (American beech). For each of these species, the problem has been identified, the status in NB determined, and gene conservation strategies developed.

In addition to developing strategies, research requirements have been identified and projects initiated. The projects include:

1) Developing cryogenic storage techniques for butternut.
2) Investigating the genetic diversity of small populations of bur oak and seed storage and restoration methods.
3) Vegetatively propagating disease-free white elm and inoculating the ramets to test for disease resistance.
4) Developing vegetative propagation techniques for beech, testing for genetic resistance to the beech scale insect, and establishing a database of disease-free trees in NB.

Looking into the future, the working group will continue to work with government, woodlot owner associations, and other non-government organizations to implement strategies. The group will also investigate several shrub species that require conservation (i.e., *Betula glandulosa*). Another goal is to increase the knowledge base for species that have limited information. The working group may also expand to other jurisdictions where the capacity to carry our gene conservation activities is limited.

Conclusions

There are many good initiatives happening in New Brunswick with regard to forest gene conservation. This summary reviews only the key strategies and projects. There are other groups, such as the NB Tree Improvement Council, that also are a source for material and information on gene conservation.

Gene conservation efforts will continue into the future and, with such a dedicated group of individuals, much progress and success can be anticipated.

What's New in Forest Genetic Resource Conservation in Alberta

Leonard Barnhardt
Alberta Sustainable Resource Development[1]
and
Joyce Gould
Alberta Tourism, Parks, Recreation and Culture[2]

Abstract

The period from 2000 to the present has been quite active in terms of initiatives related to forest genetic resource management and conservation in Alberta. Several factors have driven these initiatives, including intensified land-use activities on forested public lands, increased use of artificial regeneration and maturing of tree improvement programs, sustainable forest management and biodiversity commitments, and issues related to climate change, pests, and diseases. Recent major initiatives include Alberta Tourism, Parks, Recreation and Culture's (ATPR&C) Special Places program to extend the network of protected areas, work by the interdepartmental Alberta Biodiversity Steering Committee on an Alberta Biodiversity Strategy, the formation of the Alberta Forest Genetic Resources Council to provide expert opinion and advice on forest genetic resources management matters to the Minister of Alberta Sustainable Resource Development (ASRD), development of the Standards for Tree Improvement in Alberta by ASRD and, based on the recommendation of the Alberta Forest Genetic Resources Council, development of the Gene Conservation Plan for Native Trees of Alberta by an ATPR&C and ASRD joint working group.

Résumé

Depuis 2000, les initiatives en matière de gestion et de conservation des ressources génétiques forestières se sont multipliées en Alberta. Plusieurs facteurs sont à l'origine de ces actions, notamment l'accroissement des activités d'utilisation des terres; l'accroissement de la régénération artificielle et l'élaboration de programmes d'amélioration des arbres, d'une gestion durable de la forêt et d'engagements en matière de biodiversité; et certaines questions liées aux changements climatiques, aux ravageurs et aux maladies. Parmi les principales initiatives lancées récemment se trouvent le Programme des endroits spéciaux du Ministère du Tourisme, des parcs, des loisirs et de la culture de l'Alberta (MTPLCA) visant à élargir le réseau d'aires protégées; le travail effectué sur une stratégie albertaine pour la biodiversité par le comité de direction d'Alberta Biodiversity; la création du Alberta Forest Genetic Resources Council, responsable d'offrir une opinion et des conseils d'expert sur les questions de gestion des ressources génétiques forestières au ministre du Développement durable des ressources de l'Alberta (ASRD); l'élaboration des normes pour l'amélioration des arbres en Alberta par l'ASRD; et, sur la recommandation de l'Alberta Forest Genetic Resources Council, la mise sur pied d'un plan de conservation des gènes pour les essences d'arbres indigènes de l'Alberta grâce à un groupe de travail composé de membres du MTPLCA et

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Introduction

The period from 2000 to the present has been active in terms of initiatives related to forest genetic resource management and conservation in Alberta. Several factors have driven these initiatives, including:

1) intensified land-use activities on public lands;
2) increased use of artificial regeneration and maturing of tree improvement programs;
3) sustainable forest management and biodiversity commitments; and
4) issues related to climate change, pests, and diseases.

Alberta has significant forested area in the north, along the Rocky Mountains, and in the Foothills to the west. Of the total provincial area of 66.1 million ha, approximately 60% is commonly reported as forested (ASRD 1996, Lowe *et al.* 1991), and 39.5 million ha are included in provincial forest inventories (ASRD 1996). In an attempt to broadly define both productive and non-productive forests across jurisdictions, Canada's Forest Inventory classified 38.2 million ha in Alberta as forested in 1991, of which 86% was provincial public lands, 9% was federal lands, and 5% was private land (Lowe *et al.* 1991).

As of 31 March 2005, Alberta's provincial annual allowable cut was 24.4 million m^3 (14.1 million m^3 coniferous and 10.3 million m^3 deciduous), and this figure has remained relatively stable over the last decade (Alberta Environment 2005). The annual harvested area is approximately 83 000 ha on publicly managed forest lands, and annual planting is currently about 77 million seedlings. The most commonly planted species is white spruce (*Picea glauca*), followed by lodgepole pine (*Pinus contorta*). The forest sector is important to the provincial economy, generating annual revenues of approximately $8.4 billion (Alberta Forest Products Association 2003).

Public forest lands that are managed for timber are coming under increased pressure from competing land-use activities, including oil and gas, agriculture, and recreation. Each year, about 35 000 to 40 000 ha are removed from the forest inventory or converted because of non-timber public land dispositions related to agricultural, commercial, and industrial activities (ASRD 2005). This constitutes a significant cumulative impact and additional challenge for forest genetic resource conservation.

Current Status

Recent major initiatives related to forest genetic resource management and conservation in Alberta in progress or undertaken since 2000 include the Special Places Program, the Alberta Biodiversity Strat-egy, the Alberta Forest Genetic Resources Council, Standards for Tree Improvement in Alberta, and a Gene Conservation Plan for Native Trees of Alberta.

The *Special Places Program* began in 1995 and concluded in 2001. It was an ATPR&C, Parks, Conservation, Recreation and Sport Division program that sought to fill ecological gaps in the existing Protected Areas network. As a coarse-filter approach to conservation, it added 81 new sites to the existing network, and expanded another 13, for a total of 518 sites covering 2.7 million ha (~4.2% of provincial area). Although this significantly expanded the area in provincial parks and protected areas and, in combination with federal parks, placed reasonable protection on 12.5% of total provincial area (ASRD no date), it failed to achieve an area-weighted balance in terms of ecological classification. Although there are various classes and levels of protection, from a forest genetic resource conservation perspective, the Parks and Protected areas network of Alberta captures and provides protection for significant populations of tree species.

The *Alberta Biodiversity Strategy* is a recent initiative, in its formative stages. Currently, there is an Alberta Biodiversity Steering Committee with an Interdepartmental Biodiversity Working Group under its direction developing an Alberta Biodiversity Strategy. This initiative is intended to meet Alberta's commitment to participate in the Canadian Biodiversity Strategy. The significance of this initiative to forest genetic resource conservation is the intent to manage for biodiversity on forest lands both inside and outside of existing protected and conservation areas.

The *Alberta Forest Genetic Resources Council* (AFGRC) was formed in 2000 with representation from the forest industry, provincial government, and scientific community. A major mandate of the Council is to provide advice and recommendations to the Minister of Sustainable Resource Development on management of Alberta's forest genetic resources. One of the Council's early recommendations was the development and implementation of a provincial plan for tree gene conservation.

In 2001, a task force with government and forest industry representation undertook the development of standards for management of the tree gene resources of Alberta. These standards were implemented in 2003 as the *Standards for Tree Improvement in Alberta* (STIA). They were revised in 2005, and will be reviewed again in 2007. The STIA are built around concepts of genetic adaptation, diversity, gain, and conservation. Adaptation is managed through seed zones for wild seed and vegetative materials. Deployment zones and breeding regions are used to manage adaptation for improved reforestation materials produced in orchards, stool beds, or other production facilities. Genetic diversity of wild and improved materials is managed by monitoring and controlling the numbers of parents or effective population size in deployed operational lots. Conservation elements contained in the STIA are primarily related to commercial species and tree improvement programs, and deal with establishment and management of *in situ* reserves, access to genetic materials and data, and responsibility for *ex situ* materials established in genetic tests, clone banks, and seed archives.

On recommendation from the AFGRC, and after significant preliminary work, preparation of a draft tree gene conservation plan for native trees was initiated in 2002. This endeavor was undertaken by the Working Group on Native Tree Gene Conservation formed under a joint conservation work agreement between ATPR&C's Parks, Conservation, Recreation and Sport Division and ASRD's Forestry Division. The draft plan is provincial in scope and is a fine-filter approach as it addresses the conservation needs of native tree species and populations. The plan has recently been endorsed by the AFGRC, and final steps for posting on the web and implementation are underway. The plan's four primary objectives are to assess the current status of gene conservation for Alberta's forest trees (GAP analysis); to state additional needs and provide guidance in meeting those needs; to establish and manage a network of forest tree gene conservation areas; and to develop a complementary *ex situ* plan.

Initial challenges in preparing for the GAP analysis phase of the plan included many questions and issues, e.g., how to define a tree; determining the number of native Alberta species; determining species' ranges and population status; determining species' conservation needs; and identifying the available tools we have to accomplish the GAP analysis.

With assistance from botanists, a tree was defined for working purposes to be "a perennial woody plant at least 5 m in height at maturity, whose stem (trunk or bole) supports a crown." Armed with this definition and basic inventory information, it was determined that Alberta has 28 native tree species with some interesting hybrid complexes. An initial step in determining distributions of these species and their populations was a review of their presence and abundance class according to the provincial ecological classification (Natural Regions and Subregions of Alberta 2005).

The next step undertaken by the Working Group was to assemble basic botanical, silvics, and genetic information on each species to assess its current status in terms of information. This information was then used in conjunction with a risk decision tree to determine conservation needs and priorities at the provincial level, recognizing that there would likely be regional conservation issues for many species, e.g., regional land-use pressures and pest and disease problems. A GAP analysis work schedule was then constructed, with species with higher perceived conservation needs given a higher priority. The schedule initiates work on approximately six species each year, beginning in 2006 and with completion of the GAP analysis phase planned for 2012.

A review of genetic information, genetic models, ecological classification, and species inventories was undertaken to determine availability of information required for GAP analysis. Although a substantial body of pertinent information—both electronic and hardcopy—is available, it is often fragmented, in different formats, managed by different agencies, or not structured in a way that is convenient or suitable for GAP analysis. Species distributions and inventories are not always spatial and, for some areas, only exist as species listings. Forest inventories often lump species into categories, as is the case with lodgepole pine, jack pine (*P. banksiana*) and their hybrids, reducing the usefulness of the inventory data unless supplementary information is available.

Recent revision of Alberta's Natural Regions and Subregions (Natural Regions and Subregions of Alberta 2005) at a larger scale, and release of digitized seed zones will assist GAP analysis work as it can be used to capitalize on the established relationship between genetic and environmental variation. This is very useful given the relative paucity of genetic information for most native species with the exception of several commercial species where models relating genetic variation to geography, ecology, and climate are available.

Until the GAP analysis portion of the plan is completed, it is difficult to envision or determine precisely how implementation should proceed. In general terms, the intent is to approach implementation on a prioritized species basis, with requests for candidate conservation areas and details of recommended need being sent to regional and local contacts. Candidate areas are to be submitted by the local contact back to the Working Group for review and, once reviewed, the Working Group will make recommendations back to the local contact. Land managers will work with local contacts to establish the conservation areas, arrange for protection, and develop management plans.

It is also difficult to reasonably estimate the total number of areas and allocation to Protected Areas, public lands, or private lands until the GAP analysis is completed. An initial best guess is about 300–500 areas. Preliminary estimates for the core population size where capture of 5000 individuals is desired is expected to be 7–10 ha for pure species stands. When a buffer is added, the size of each reserve is expected to be around 160–175 ha.

In summary, there have been a number of recent initiatives in the area of forest genetic resource management and conservation. Of particular note is the final draft plan to implement *in situ* reserves for Alberta's native trees, which is presently before the Alberta Forest Genetic Resources Council and stakeholders for final endorsement. Work is also being initiated on a draft *ex situ* tree gene conservation plan to complement the *in situ* conservation area network.

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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 diversity of most of the deciduous hardwood species located in southern Quebec. Promoting

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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the work taking place in British Columbia and Alberta, and the creation of CON**FOR**GEN, 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 CON**FOR**GEN, 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 CON**FOR**GEN, 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.

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CON**FOR**GEN: a Canadian Program for Conservation of Forest Genetic Resources

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Abstract

Initiation of a program to conserve forest genetic resources in Canada is proposed. The proposal is the fruit of many discussions and two workshops involving representatives from provincial governments and other federal government departments. The program, as envisioned, would be cooperative and collaborative, building on the strengths of those provinces that have already undertaken such work, and extending the work across provincial boundaries, and across departmental mandates.

Résumé

On propose la mise en œuvre d'un programme de lutte pour la conservation des ressources génétiques forestières au Canada. Cette proposition est le cœur de plusieurs discussions et de deux ateliers mettant en contact des représentants de ministères provinciaux et fédéraux. Le programme envisagé serait coopératif et collaboratif et fondé sur les atouts des provinces qui ont déjà entrepris de telles démarches, tout en s'étendant au-delà des frontières provinciales et des mandats ministériels.

Why Does Canada Need a Program for Conservation of Forest Genetic Resources?

After discussions with representatives from federal government departments and various provincial governments, we propose that a national program be established to conserve forest genetic resources. This program would be called the "Canadian Program for Conservation of Forest Genetic Resources," or CON**FOR**GEN. The rationale for the establishment of such a program is as follows.

1. Forest genetic resources have important current and future economic values.

2. There are significant threats to Canada's forest genetic resources.

3. A survey, conducted in 2003 by the Canadian Forest Service (CFS), indicates that 60% (75 species) of trees identified in one province or territory required either some level of gene conservation, or additional information to determine the need for conservation efforts.

4. Currently, work to understand and conserve forest genetic resources is fragmented, with strong programs underway in some provinces, but little cooperation across provincial borders and no national coordination.
5. Coordinated efforts could assist provinces by developing species-level guidelines for conservation and sustainable use of forest genetic resources, monitoring and reporting, and identifying emerging issues to prioritize research.

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Threats to forest genetic resources include invasive alien species (IAS; especially insect pests and pathogens), climate change, habitat loss, and disturbance as a result of human activities. Dramatic current examples of the threat to forest tree genetic resources posed by IAS are the assault on butternut (*Juglans cinerea*) by butternut canker (*Sirococcus clavigignenti-juglandacearum*) and on ash species (*Fraxinus* spp.) by emerald elm borer (*Agrilus planipennis*). In both cases, populations are in danger of extirpation, and entire species could face extinction. When populations are extirpated, locally adapted genes are lost. As well, climate change threatens population extirpation in cases where species ranges are near their northern limit in southern Canada. Adaptation to IAS and to climate change depends on availability of genetic diversity in affected species.

What Would CON**FOR**GEN Do?

The program will:

1. Promote conservation of forest genetic resources.

2. Define national science-based guidelines for conservation and sustainable use of forest genetic resources.

3. Monitor and report on forest genetic resources, and ensure that national level reporting is consistent and jurisdictionally representative.

4. Contribute to Canada's national and international reporting requirements.

5. Identify emerging issues and prioritize research.

Examples of CON**FOR**GEN's Potential Contributions

1. The Canadian Forest Genetic Resources Information System (CAFGRIS) (https://cfsnet.nfis.org/cafgris/index.html) is a CFS initiative intended to provide information necessary for assessing gene conservation requirements of native tree species of Canada in the face of threats to genetic diversity posed by IAS, species biology, and ecology. It is envisioned that CON**FOR**GEN will work closely with the CFS to populate CAFGRIS with consistent and accurate content.

2. The Forest Gene Conservation Association (FGCA) in Ontario is an example of a provincial initiative that could benefit from interaction with other provincial and pan-Canadian efforts to conserve forest genetic resources. The FGCA has developed brochures and articles that could be modified to be applicable to other regions, promoting gene conservation for species that are threatened in Ontario and other provinces.

3. The CFS carried out a survey in 2003 to identify the need and role for gene conservation (Beardmore et al. 2006). The survey provided data for the Canadian Council of Forest Minister's Criteria &Indicators reporting process, and it is anticipated that the survey will be repeated for each reporting cycle. Survey results will be strengthened through the involvement of CON**FOR**GEN. Collection and compilation of data by a Canada-wide organization with

representation from most if not all jurisdictions, will improve the data consistency and the acceptance of results.

4. Two articles recently published in *The Forestry Chronicle* in 2007, detail status and gene conservation guidelines for tree species of concern in New Brunswick (Loo et al. 2007a, b). Tables 1 and 2 provide excerpts from these papers, showing the level of information compiled for each of four species that were determined to be in need of gene conservation measures by the New Brunswick Forest Tree Gene Conservation Working Group. Information presented in the articles includes the relative effort required for different categories of gene conservation methods, the potential for restoration, education targets and messages, monitoring, and research required. This is an example of a small-scale initiative that could be expanded to encompass the Canadian ranges of all tree species of concern. Various provincial and other organizations have developed guidelines for species of concern, but with little or no coordination across provincial borders. Butternut canker is a growing problem in three provinces, and CON**FOR**GEN would provide a means for bringing together and standardizing guidelines for gene conservation across provincial boundaries. Butternut will receive attention from provinces in a coordinated way because the species has been designated as endangered under Canada's Species At Risk Act, but other species (e.g., all native ashes) are under serious threat, and there is currently no coordinated effort to develop conservation guidelines across provincial borders.

Table 1. *Elements of gene conservation guidelines for butternut in New Brunswick.*

Target populations to conserve	**Relative effort: *in situ* vs. *ex situ***	***In situ* conservation focus**	***Ex situ* potential methods, collections**	**Restoration**
Individual trees showing putative resistance	High *ex situ* effort required	All trees that do not show disease symptoms should be maintained; will require survey to establish location and disease status of individual trees and populations	Seed cannot be stored using conventional seed storage methods, but cryogenic storage of the embryo axis has proved successful	Poor, at present; need to develop genetically resistant stock

Table 2. *Education, monitoring and research requirements as elements of conservation guidelines for butternut in New Brunswick.*

Education targets	Main messages	Monitoring	Research required
Woodlot owners; other rural and urban dwellers; horticultural nursery managers	1. Species is endangered. 2. How to identify tree and canker. 3. Avoid cutting healthy trees. 4. Avoid importing nursery stock. 5. Monitor and report on condition.	Evaluate populations and individual trees in affected areas, at the edge and in areas that are still disease-free to monitor progress of the disease annually, and identify possible resistance	1. Does resistance to the canker exist? 2. Somatic embryogenesis and marker development to select resistant genotypes 3. Most efficient *ex situ* storage method for long-term viability of genetic material.

5. Another example of a local initiative that could be expanded to other parts of the country is the modeling work undertaken in British Columbia (BC) by Andreas Hamann and others to determine where, under various climate change scenarios, climatic optima may shift over the next 100 years for seed sources of species for which data are available. Similar work has been undertaken with other species in BC and has been initiated in Alberta during the past year. The biggest challenge in extending this and other work beyond the current provincial limits will be dealing with data gaps and discrepancies. Application of a similar approach to white pine throughout its Canadian range, for example, would necessitate using data collected at different scales and would result in varying levels of precision from province to province, but as more data is made available, the precision and consistency across provinces would be improved. Application of such a model across species' ranges will help identify populations needing special attention, even when the species as a whole appears to be secure.

Who Will be Involved in CON**FOR**GEN?

Our vision is that "membership" in CON**FOR**GEN will be open to government departments at both levels (provincial and federal), as well as to any other interested stakeholders. We expect CON**FOR**GEN to be of interest to a wide array of resource users, land managers, and conservation advocates. It will be of value to those responsible for measuring and reporting on the biodiversity of Canada's forests at both the federal and provincial levels, as well as those responsible for conserving diversity.

Potential members of CON**FOR**GEN may include representatives from provincial and federal government departments; First Nations; industry; woodlot owner associations; universities; and environmental non-government organizations (ENGOs).

Proposed Structure for CON**FOR**GEN

CON**FOR**GEN will be structured to include a secretariat, a steering committee, one or more technical committees, and a research advisory committee. The CFS is prepared to provide the secretariat role for at least 2 years. A description of the composition and function of each body within CON**FOR**GEN follows.

Secretariat: Make and maintain contacts, facilitate information exchange, and organize an annual forum.

Steering Committee: Identify relevant forest genetic resource conservation issues and prioritize responses; develop and approve business plans; and provide direction to the Secretariat and Technical Committees.

Technical Committees: Struck in response to relevant issues and priorities.

Research Advisory Committee: Identify important research questions, seek collaboration and funding, and facilitate cross-jurisdiction projects.

Table 3 presents a proposed timeline. Provincial and federal government "buy-in" will be sought by the present forum organizing committee and interested provincial representatives. The Steering Committee will consist of representatives from various jurisdictions and potentially other government departments and industry. Technical committees will consist of the people who are currently addressing or who have the capacity to and are interested in addressing those issues for which the committees will be created. It is expected that the technical committees will be hands-on working committees. The Research Advisory Committee will consist of scientists, who will guide the Steering Committee in identifying priorities and approaches for responding to them.

Table 3. *Timeline for establishing the structure of CON**FOR**GEN*

Goal	Timeframe for completion
Achieve provincial and federal buy-in	Winter 2006
Establish Steering Committee	Spring 2007
Identify issues, establish technical committees	Summer 2007
Second Annual Forum	Summer 2007
Establish Research Advisory Committee	Fall 2008

Literature Cited

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Loo, J.A., Beardmore, T.L., Simpson, J.D., and McPhee, D.A. 2007a. Tree species of concern in New Brunswick, Canada. I. Current status and threats. *The Forestry Chronicle* **83**: 393–401.

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Business Session
Summary of Discussion and Decisions

Moderator: Ken Mayhew

PEI Forests Fish and Wildlife,
Division of the Department of Environment, Energy and Forestry

There were 33 participants, representing all provinces except Newfoundland and Saskatchewan. In addition, representatives from Agriculture and Agri-Food Canada, several universities, First Nations, and the CFS were in attendance. Jarkko Koskela, the coordinator for EUFORGEN (European Forest Genetic Resources Program), also participated.

At the start of the session, all participants had the opportunity to comment on the concept and proposed objectives of CON**FOR**GEN. All agreed that the concept of a cross-country initiative for conservation of forest genetic resources (FGR) was worth pursuing. Positive comments from provincial representatives included:

- Mary Myers, PEI: "Smaller provinces will benefit from a tie to a larger effort."
- Alvin Yanchuk, BC: "In support. We have been talking about doing something like this for many years. Initiatives like this have been developed in other places in the world..…Provinces need to step to the plate and push this up to Deputy Ministers."
- Leonard Barnhardt, AB: "This does not add a burden and will help with conservation efforts.… There are challenges with determining which species require conservation. We need help with these issues."
- Howard Frame, NS: "Nova Scotia is looking for information. I am very supportive."
- André Rainville, QC: "Quebec conservation and maintenance of biodiversity is taken care of via coarse filter. However that is not enough.…CON**FOR**GEN is a good incentive for provinces to get into it."
- Kathleen Brosemer, ON: "I am in support. The initiative will help unite tree improvement and gene conservation."

The perspective from Ken Richards, Agriculture and Agri-Food Canada, was that a central source of information on forest genetic resources is important and timely.

First Nations are interested in conserving genetic resources of species of particular interest to them and the representative, Richard David, expressed his interest in seeing a nationally coordinated initiative undertaken to this end.

Jarkko Koskela considered that CON**FOR**GEN could provide some of the benefits provided to countries of the European Union, by following a similar model.

University representatives: Sally Aitken (University of British Columbia), Andreas Hamann (University of Alberta), and Marek Krasowski (University of New Brunswick) noted that few people would disagree that gene conservation should be carried out on a country-wide basis. They spoke of gap analysis across provincial boundaries as a priority.

Some concerns were raised; for example, Jack Woods, Program Manager, Forest Genetics Council of BC, noted that the proposed objectives included "guidelines for sustainable use". He pointed out that this may be taken to mean that CON**FOR**GEN would be developing guidelines for tree improvement programs, which is beyond the scope of CON**FOR**GEN. Another concern was that provincial and federal parks were identified as being missing and it was considered important that they should be brought into the discussion. It was pointed out that they were invited and encouraged to participate.

Discussion on the structure and purpose of CON**FOR**GEN: Several participants mentioned the need for federal involvement and support, in order to bring in provinces. CFS representatives offered to fill the secretariat role. It was agreed that the steering committee should consist of jurisdictional representatives (provinces, First Nations, CFS).

The need for an interim steering committee and development of short-term measurable objectives was noted.

Gap analysis, evaluating the present status of conservation of FGR and needs across the country, was a high priority for a number of participants.

Information management for FGR with a one-stop shopping approach for Canada was considered a priority by many members and CAFGRIS (Canadian Forest Genetic Resources Information System), a prototype information management system for FGR developed by the CFS, received broad endorsement from participants.

There was also agreement that the survey of forest gene conservation status and needs should be supported and continued.

Agreements included:

1. The concept of CON**FOR**GEN should be further developed.
2. An interim steering committee would be formed consisting of CFS, representatives from all the Forest Genetics Councils (BC, Alberta, Ontario, NB, and NS), a representative from the Quebec government, and a First Nations representative. The interim steering committee would continue to develop the concept and would identify a permanent steering committee.
3. Work will continue on developing CAFGRIS (CFS-led) and the survey.
4. Forums on conservation of FGR would be held either annually or biannually to bring scientists and practitioners together for information sharing.

Résumé des discussions et des décisions

Animateur : Ken Mayhew
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La séance a réuni 33 participants, qui représentaient l'ensemble des provinces, à l'exception de Terre-Neuve-et-Labrador et de la Saskatchewan. Des représentants d'Agriculture et Agroalimentaire Canada, de plusieurs universités, des Premières nations et du SCF étaient également présents. Jarkko Koskela, coordonnateur d'EUFORGEN (Programme européen des ressources génétiques forestières), a aussi pris part à la discussion.

Au début de la séance, les participants ont eu l'occasion de commenter le concept et les objectifs proposés de CON**FOR**GEN. Tous se sont entendus pour dire qu'il valait la peine de développer le concept d'une initiative pancanadienne de conservation des ressources génétiques forestières. Voici quelques commentaires positifs formulés par les représentants provinciaux :

- Mary Myers (Île-duPrince-Édouard) : « Les petites provinces gagneront à s'associer à un effort à plus grande échelle. »
- Alvin Yanchuk (Colombie-Britannique) : « Je suis d'accord. Nous parlons de mesures semblables depuis bien des années. Des initiatives de ce genre ont été lancées dans d'autres régions du monde... Les provinces doivent assumer leurs responsabilités et promouvoir ce dossier auprès des sous-ministres. »
- Leonard Barnhardt (Alberta) : « Cette initiative n'ajoute aucun fardeau et facilite nos efforts de conservation... Il n'est pas facile de déterminer sur quelles espèces nous devons concentrer nos efforts de conservation. Nous avons besoin d'aide dans ce domaine. »
- Howard Frame (Nouvelle-Écosse) : « La Nouvelle-Écosse est à la recherche d'information. Je suis très favorable à cette initiative. »
- André Rainville (Québec) : « Au Québec, la conservation et le maintien de la biodiversité sont assurés selon l'approche du filtre brut. Mais ce n'est pas suffisant... CON**FOR**GEN est un bon incitatif pour les provinces. »
- Kathleen Brosemer (Ontario) : « Je suis d'accord. L'initiative contribuera à la mise en commun des efforts d'amélioration des arbres et de conservation génétique. »

Ken Richards, d'Agriculture et Agroalimentaire Canada, a souligné à quel point il était important et opportun de mettre en place une source centrale de renseignements sur les ressources génétiques forestières.
Les Premières nations souhaitent conserver les ressources génétiques des espèces qui revêtent un intérêt particulier pour elles, et leur représentant, Richard David, a déclaré s'intéresser à toute initiative nationale de coordination lancée à cette fin.

Jarkko Koskela a indiqué que, en suivant un modèle semblable à EUFORGEN, CON**FOR**GEN pourrait procurer certains des avantages obtenus par les pays participants de l'Union européenne.

Les représentants des universités, à savoir Sally Aitken (Université de la Colombie-Britannique), Andreas Hamann (Université de l'Alberta) et Marek Krasowski (Université du Nouveau-Brunswick), estiment que la conservation génétique à l'échelle du pays fait l'unanimité à peu près partout. Ils ont parlé de l'analyse des écarts entre provinces, tâche qui, à leur avis, doit représenter une priorité.

Certaines réserves ont cependant été émises. Par exemple, Jack Woods, gestionnaire de programme au Forest Genetics Council de la Colombie-Britannique, a fait remarquer que l'élaboration de lignes directrices pour l'utilisation durable faisait partie des objectifs proposés. À son avis, cela pourrait signifier que CON**FOR**GEN est chargé d'élaborer des lignes directrices pour les programmes d'amélioration des arbres, ce qui dépasse la portée de l'initiative. D'autres membres ont dit déplorer l'absence des parcs provinciaux et nationaux, en soulignant l'importance de les faire participer aux discussions. Il a été précisé que les parcs avaient été invités et encouragés à participer.

La discussion a ensuite porté sur la structure et l'objet de CON**FOR**GEN. Plusieurs participants ont mentionné la nécessité pour le gouvernement fédéral d'appuyer l'initiative et d'y participer, afin de mobiliser les provinces. Les représentants du SCF ont proposé de s'acquitter des tâches de secrétariat. Il a été convenu que le comité directeur devait être composé de représentants des diverses administrations présentes (provinces, Premières nations, SCF).

Les participants se sont entendus sur la nécessité de créer un comité directeur provisoire et d'établir des objectifs mesurables à court terme.

Pour plusieurs participants, l'analyse des écarts figure parmi les principales priorités, tout comme l'évaluation de la situation et des besoins actuels au chapitre de la conservation des ressources génétiques forestières aux quatre coins du pays.

La gestion de l'information sur les ressources génétiques forestières selon une approche de type « guichet unique » pour le Canada est considérée comme une priorité par de nombreux participants. Le CAFGRIS, prototype d'un système d'information sur les ressources génétiques forestières canadiennes qui a été mis au point par le SCF, a reçu l'aval de tous les participants.

Les participants ont unanimement conclu à la nécessité d'appuyer et de poursuivre l'examen de la situation et des besoins au chapitre de la conservation des gènes forestiers.

Les participants se sont entendus sur les points suivants :

1. Le concept de CON**FOR**GEN doit être développé plus à fond;
2. Un comité directeur provisoire doit être mis sur pied et composé du SCF, de représentants de tous les conseils de génétique forestière (Colombie-Britannique, Alberta, Ontario, Nouveau-Brunswick et Nouvelle-Écosse), d'un représentant du gouvernement du Québec et d'un représentant des Premières nations. Ce comité doit continuer à développer le concept et nommer un comité directeur permanent.
3. Il faut poursuivre le travail de mise au point du CAFGRIS (sous la direction du SCF), de même que les travaux d'analyse de la situation et des besoins.
4. Des forums sur la conservation des ressources génétiques forestières se tiendront soit tous les ans, soit aux deux ans, afin de réunir scientifiques et praticiens dans une tribune favorisant l'échange d'information.

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