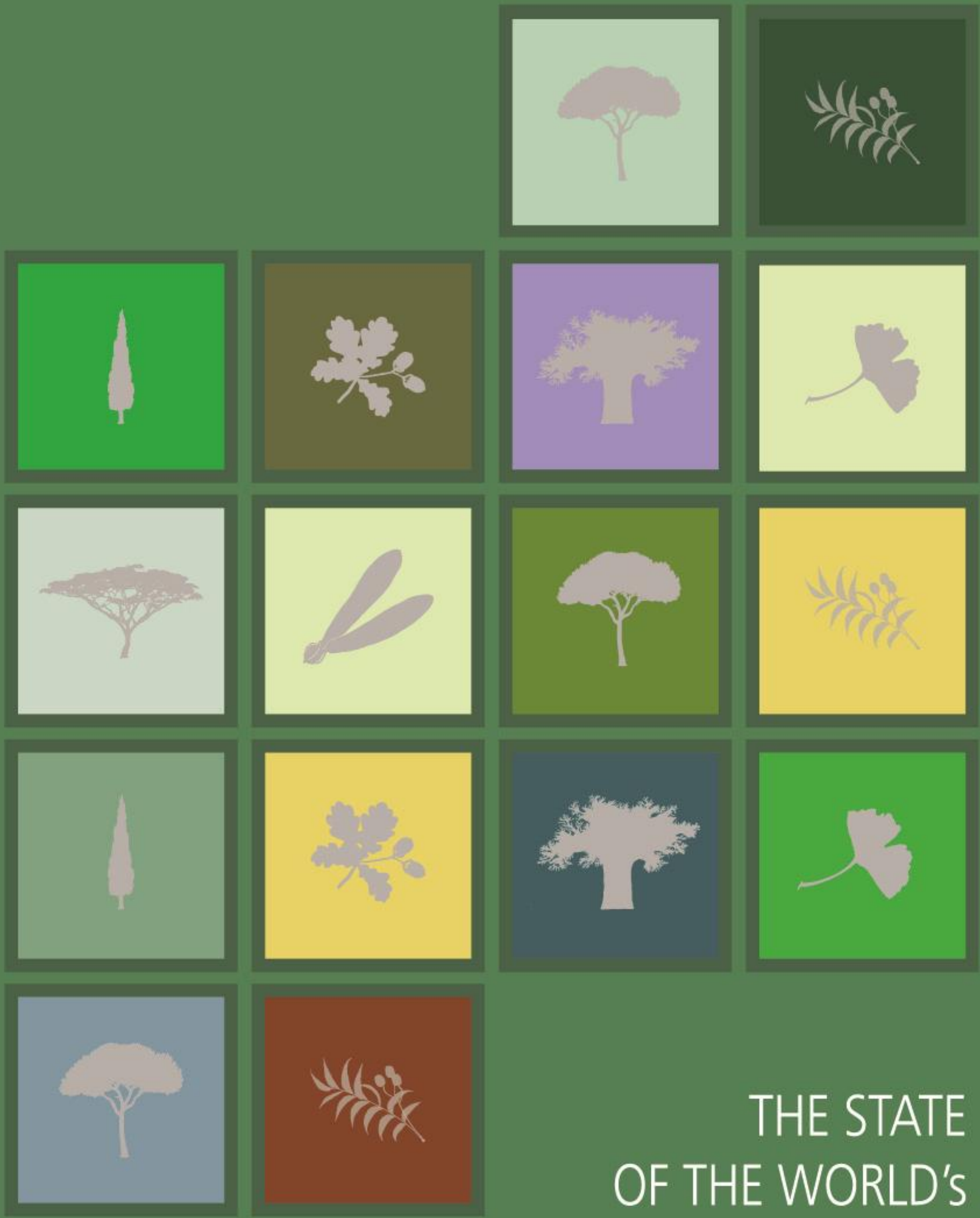

THE STATE OF THE WORLD's FOREST GENETIC RESOURCES

COUNTRY REPORT

CANADA

This country report is prepared as a contribution to the FAO publication, The Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document Guidelines for Preparation of Country Reports for the State of the World's Forest Genetic Resources (2010). These guidelines set out recommendations for the objective, scope and structure of the country reports. Countries were requested to consider the current state of knowledge of forest genetic diversity, including:

- Between and within species diversity
- List of priority species; their roles and values and importance
- List of threatened/endangered species
- Threats, opportunities and challenges for the conservation, use and development of forest genetic resources

These reports were submitted to FAO as official government documents. The report is presented on www. fao.org/documents as supportive and contextual information to be used in conjunction with other documentation on world forest genetic resources.

Report

On *The State of Canada's*

Forest Genetic Resources

Canada

April 2012

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The contributions of Caroline Simpson, Debby Barsi, and Jessica Thomson, Natural Resources Canada, Canadian Forest Service are gratefully acknowledged.

Contents

Preface

Scientific names used through out the report are the current (2012) accepted names according to the Integrated Taxonomic Information System (ITIS). Chapter 1, Table 1.13B. Shrub species scientific names are according to *Wild Species Canada*. Information presented in this report was obtained through literature searches, personal communication with experts and reflects the data that is available as of 2012 unless otherwise stated. A jurisdictional survey was conducted with participation from Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec and Saskatchewan, in order to obtain data pertaining to such areas as *ex situ* and *in situ* conservation and this data is current as of 2010.

Executive Summary

Canada is one of a few countries that still have large tracts of forests that are relatively undisturbed by human activity and are believed to contain much of their native biodiversity. In Canada approximately 400 million hectares of land is forested or has forest cover, representing 10% of the world's forest cover and 30% of the world's boreal forest. Of this forested land, 93% is owned by the public (77% provincial/territorial and 16% federal), while the remaining 7% belongs to private landowners who range from woodlot owners to forest companies. The provinces and territories have legislative authority over the management and conservation of provincial/territorial owned forest land. The federal government is responsible for matters related to the national economy, trade and international relations, and federal lands and parks, and has constitutional, treaty, political and legal responsibilities related to Aboriginal peoples.

Forest ecosystems in Canada contain approximately 126 native tree species, depending on the definition of large shrub vs. small tree. In general, actions taken to survey and inventory intraspecific variation of tree species vary greatly depending on the organization conducting the work and much of the research assessing intraspecific variation is collaborative across various federal and provincial agencies, universities, and industry. Organizations such as the Canadian Forest Genetics Association (formerly the Canadian Tree Improvement Association, which was established in 1939) have had a significant impact in fostering collaborations to—among other research areas—assess intraspecific variation within Canada. Also the pan-Canadian group CON**FOR**GEN (Canadian program for the Conservation of Forest Genetic Resources), a federal–provincial/territorial collaborative group that monitors and reports on genetic resources of native tree species in support of Canada's national and international commitments promotes, where possible, research assessing intraspecific variation. At a national level, information systems that contain data pertaining to intraspecific variation include NatureServe Explorer and the Canadian Forest Genetic Resources Information System (CAFGRIS) which is deployed through the National Forest Information System. Many jurisdictions and universities maintain databases with information pertaining to intraspecific genetic variation patterns (e.g. University of British Columbia's Centre for Forest Conservation Genetics and Arborea (Laval University)).

Improving the understanding of intraspecific variation is recognized as important for the sustainable management of forest genetic resources. It is recognized that monitoring changes below the species level provides necessary information for ensuring that the species' adaptive potential is maintained so that species can evolve in response to changing environmental conditions. Ensuring that species can respond to environmental change is a priority for much of the forest genetic resources research conducted within Canada. Furthermore, although it is recognized that landscape-level management of forest genetic resources will ensure the conservation of genetic diversity in some cases, there are forest types occurring over small areas where this approach is not appropriate. Capacity building needs include stable investments in research to develop methods for assessing interspecific and intraspecific variation, and for monitoring this variation. This includes the resources to maintain personnel working in the field and laboratories.

Canada has numerous priority setting exercises for identifying species at risk, including at the level of the Government of Canada where the *Species at Risk Act* (SARA) has the goal to prevent wildlife species, including forest associated species, in Canada from disappearing, to provide for the recovery of wildlife species that are extirpated (no longer exist in the wild in Canada), endangered, or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened. As of 2011, there are 10 tree species with official risk designation of either "endangered", "threatened" or "of special concern".

NatureServe Canada ranks species status using information from diverse sources including regional Canadian Conservation Data Centres, to guide conservation action and natural resource management. CON**FOR**GEN has conducted a national-level survey that assesses tree species and their conservation requirements. At the jurisdictional level, most provinces and territories also have priority-setting exercises for assessing tree species vulnerabilities. Ranking criteria are fairly consistent across most federal and jurisdictional organizations with “endangered”, “threatened” and “vulnerable” status determinations made.

The threats to forest genetic resources in Canada vary depending on location; however most forest professionals in Canada consider impacts of climate change, forest practices, forest conservation and invasive alien species to be the primarily challenges at both the national and regional level. Climate change is perhaps the most serious of these threats that will result in local populations of forest species no longer being adapted to their local environmental conditions.

Multiple strategies are used to conserve tree species. *In situ* conservation is a primary strategy for the long-term conservation of forested areas in Canada. Approximately 975 816 km^2 or 6.5%, of Canada’s land area lies within currently designated park or other reserves. In 1992, it was estimated that approximately 225 000 km^2 of forests were within the various park or reserve systems, representing approximately 4.9% of the total forested area, and areas considered ‘highly protected’ (in which no disturbance is permitted) represented 100 000 km^2 or 2.1% of the total forested area.

Ex situ conservation of forest trees has probably never been as important as it is today, given climate change and the challenges for forests that it creates regarding impacts from insects and disease. There are four main *ex situ* conservation reserves for tree species: three jurisdictional seed banks (Alberta Ministry of Sustainable Resource Development, British Columbia’s Ministry of Forests, Lands and Natural Resource Operations and Manitoba Conservation (Forestry Branch)) and one national seed bank (the National Tree Seed Centre) and additional smaller *ex situ* reserves that are not considered herein. The four main reserves currently store germplasm for 82 tree species (38 softwoods and 44 hardwoods) for *ex situ* conservation. Based on a jurisdictional survey with participation from Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec and Saskatchewan it was determined that germplasm from 23 conifer and 14 hardwood species is conserved in trials/plantations and clone banks, and that there are 481 trials/plantations established on approximately 268 hectares and 37 clone banks containing 2,326 clones and 20505 seedlings.

Tree improvement programs were initiated in several Canadian provinces in the 1960s in response to expanding reforestation programs with objectives including increased productivity (volume) and other traits such as wood quality and pest resistance are often targeted. Based on a jurisdictional survey, 23 tree species and one genus with hybrids were identified as having genetic improvement programs that use traditional breeding and selection methods. Timber production, for the purpose of producing solid wood products, is the most common program objective, with pulpwood production also being important.

Canada has a number of institutions actively engaged in forest genetic resources. These range from universities and colleges, federal and provincial departments, industry, and non-governmental organizations to tree improvement councils. Canada does not have a national program for forest genetic resources. However, the Canadian Council of Forest Ministers is an entity that provides leadership on national and international issues and sets the direction for stewardship and sustainable management of Canada's forests. The two networks type groups that specifically address forest genetic resources at a national level are the Canadian Forest Genetics Association and CON**FOR**GEN. Both groups, although predominantly addressing national issues, also address issues relevant to North America either by fostering collaboration or through the exchange of knowledge (e.g., conferences, seminar series).

Six provinces (Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia and Ontario) have established tree improvement and/or conservation of forest genetic resources councils to coordinate and promote the coordination of forest gene conservation and tree improvement activities. For some provinces, such as Quebec, the staff in the forest research directorate of the Ministère des Ressources naturelles et de la Faune are responsible for coordinating provincial tree improvement and gene conservation activities. All provincial and territorial governments have departments of natural resources, environment or forestry that address forest genetic resources in some capacity. The Aboriginal peoples of Canada have a diverse range of regional thematic type networks and organizations that address forest genetic resources and their conservation, among other areas. In general, their approach to resource management encompasses the principle of stewardship of the Earth, with attendant responsibilities and obligations, and their thematic type networks reflect this.

Priorities for improving the monitoring of genetic erosion and for assessing species' vulnerability based on a survey completed by the following jurisdications: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec and Saskatchewan, include supporting continued research to assess and monitor species' genetic diversity, and their adaptive potential to various stressors and to identify native tree species' resistance to high-impact stressors. Continued efforts for *ex situ* and *in situ* conservation of species at risk at both national and jurisdictional levels are essential, as is continued research in Gap analysis to investigate how well each species is covered by protected areas. The knowledge gained from Gap analysis would greatly enhance Canada's ability to respond to threats before they significantly impact species' adaptive capacity and ultimately their viability. Another priority is the need for research to support the assessment of species' vulnerabilities. Vulnerability assessments are a systematic analysis of species, habitats, or ecosystem at risk and use information pertaining to species sensitivity, adaptive capacity and exposure to threats such as climate change. Species' vulnerability assessments require diverse information pertaining to species habitat, physiology, phenology, biotic interactions, and genetic parameters such as the species' ability to respond to such threats as a changing climate, where the ability of the species to adapt in place, ability to move, etc. is important knowledge for the decision-making process for mitigating the impacts of climate change and other stressors, and for assisting land managers to prioritize efforts. It is important to continue basic research assessing species biology and ecology, as this knowledge will enhance the vulnerability assessments and will assist in decreasing uncertainty.

Furthermore, survey results identified the need for rapid and informative exchange on threats to forest genetic resources and mitigation protocols associated with major national issues such as climate change, invasive alien species, and impacts of forestry, across governmental levels and among agencies involved in responding to these threats.

Overall, continued long-term investments in research are critical for improving the monitoring of genetic erosion and vulnerability and, the response to these impacts. This includes research conducted by the various levels of government, academia, and industry. Teaching undergraduates and graduate students is also important to ensure that we have the future human capacity for continued research in these areas, particularly in quantitative and molecular genetics.

The Food and Agriculture Organization's, North American Forest Commission, Forest Genetic Resources Working Group is an example of a regional forest genetic resource network that has had multiple benefits for Canada including promoting research and the dissemination of knowledge. International programs that have been beneficial for Canada include the International Union of Forestry Research Organizations (IUFRO) which addresses numerous issues either directly or indirectly related to forest genetic resources, and the Taiga Rescue Network which supports local issues and strengthens cooperation amongst diverse group concerned with the protection, restoration and sustainable use of the world's boreal forests. Canada is engaged in a number of agreements, treaties and conventions that pertain to the sustainable use, development and conservation of forest genetic resources. Examples include the Convention on Biological Diversity, where Canada is an active participant in the meeting of the Conference of the Parties and the Subsidiary Body on Technical and Technological Advice. The Agreement between Canada and the United States on the Cooperation in the a) Boreal Ecosystem-Atmosphere Study and b) Boreal Ecosystem Research and Monitoring Sites addresses climate change and forest ecosystems, with a focus on understanding the interactions between the boreal forest biome and the atmosphere.

Canada has a number of international projects that contribute to Millennium Development goals (10) eradicate extreme poverty and hunger and (7) ensure environmental sustainability. These projects, such as the *Sustainable Management and Production of Forest Resources in Honduras* have to goal to improve rural living by strengthening forestry cooperatives and in establishing sustainable forest practises.

This report provides the first comprehensive review of Canadian forest genetic resources. The information in this report provides new knowledge that can be used to identify regional and national forest genetic resource priorities. This report also serves to show that there is a concerted effort in Canada to conserve and sustainably use forest tree species.

Introduction

Canada is a federation with the federal government, ten provincial governments (Alberta, British Columbia, Ontario, Manitoba, Newfoundland and Labrador, New Brunswick, Nova Scotia, Prince Edward Island, Quebec, Saskatchewan) and three territorial governments (Northwest Territories, Nunavut and Yukon) (Fig. 1). The federal, provincial and territorial governments differ not only in their geographical scope, but also in their powers and responsibilities (Bakvis and Skogstad 2002).

Canada is one of the world's largest countries and is the largest country in North America with a land mass of 9 million km^2 or 900 million ha. The population of Canada is over 33 million. About four-fifths of the population live within 150 km of the border with the United States (Statistics Canada 2009). About 400 million ha of land is forested or has forest cover; this represents 10% of the world's forest cover and 30% of the world's boreal forest. About 93% of the forested land is owned by the public (77% provincial/territorial and 16% federal). The remaining 7% belongs to private landowners, who range from woodlot owners to forest companies (Table 1). The provinces and territories have legislative authority over the management and conservation of provincial/territorial-owned forest land. The federal government is responsible for matters related to the national economy, trade and international relations, as well as federal lands and parks, and has constitutional, treaty, political, and legal responsibilities related to Aboriginal peoples (Natural Resources Canada 2011a).

Figure 1. Political map of Canada[1]

[1], Wikipedia (2012)

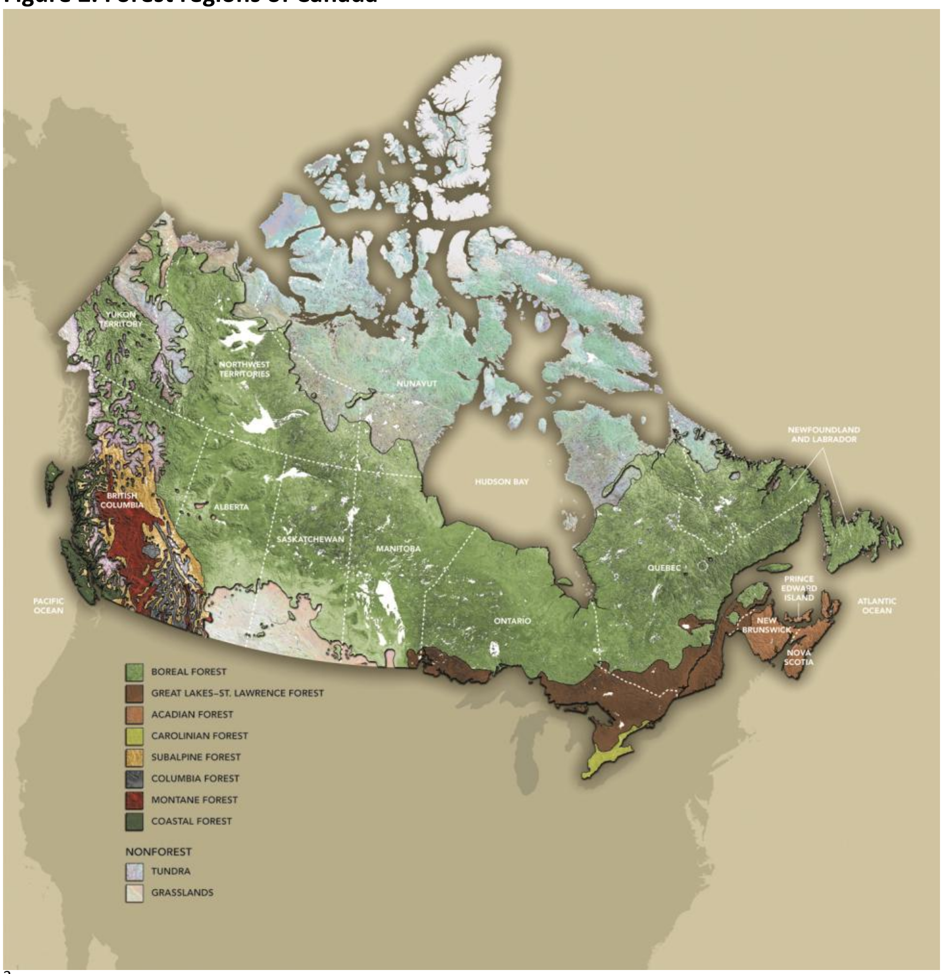
Table 1. Forest ownership and area in Canada[2]

Ownership	Area (ha)
Provincial/Territorial	305 891 740
Federal	63 561 920
Private	27 808 340
Total	397 262 000

[2] Natural Resources Canada (2011).

Canada is divided into 15 terrestrial ecozones, but the majority of the forest lies within eight ecozones (Wiken 1986). There are 126 tree species that can be found in forest ecosystems. There are 10 forest regions in Canada. The largest of these is the boreal forest, which is mainly coniferous but includes several deciduous species (Fig. 2). The province of British Columbia with its varied landscape of mountains and valleys is home to four forest regions. Most of the tree species found in these regions are not found anywhere else in Canada. The deciduous forest of southern Ontario contains many tree species that are at the northern limits of their ranges. North of this region is the Great Lakes – St. Lawrence, which contains a mixture of conifers and hardwoods. The Acadian forest is found in three eastern provinces and is characterized by late-successional coniferous and deciduous species (Canadian Forestry Association 2012).

Figure 2. Forest regions of Canada[3]



[3,] Natural Resources Canada (2012a)

Canada is the third-largest exporter of forest products in the world (Natural Resources Canada 2012b). The forest sector is the third-largest contributor to Canada's balance of trade, after energy and minerals, and contributes 1.8% to Canada's gross domestic product by value. In 2009 the natural resources sector contributed

11.1% of Canada's gross domestic projects, with forestry contributing 1.8% and, minerals and metals, and energy contributing 2.8% and 6.7%, respectively (Natural Resources Canada 2011b). Major forest products include softwood lumber, structural panels, newsprint, pulp, and various paper products. The industry is an important employer in many regions of Canada, particularly in rural and remote communities. The forest sector makes up about 50% of the economic base for about 200 communities (Natural Resources Canada 2011a). Canada's forest industry is recovering from a number of major challenges over the last decade. These include a worldwide economic downturn, strengthening of the Canadian dollar against the currencies of key competitors, a structural decline in North American newsprint demand, and increased competition from other forest product suppliers (Natural Resources Canada 2012b).

Canada's forest industry varies across the country: (1) eastern Canada is dominated by pulp-and-paper product manufacturing, (2) western Canada is dominated by wood-product manufacturing, (3) British Columbia, Ontario, and Quebec have the greatest numbers of forest workers, (4) the Atlantic provinces, British Columbia, and Quebec are the most forest-dependent regions, with a large share of their economy based on the sector, and (5) northern territories have a small forest industry presence, but it is limited due to climate conditions (Natural Resources Canada 2012b).

Forest management and harvesting activities on public forest land are conducted by forestry companies with wood-processing facilities (pulp and/or paper mills, sawmills) under license from the provincial/territorial governments. Less than 1% of the forest is harvested annually, and legislation requires that public land must be successfully regenerated, either naturally or artificially. At least 400,000 ha are planted annually (Natural Resources Canada 2011a). Seed from unimproved sources is still used, but the proportion of genetically improved seed is steadily increasing (currently 50%) as seed orchards reach reproductive maturity. Management of forested land in private woodlots is variable and generally depends on external funding and other government incentives. Most of the forested land in private woodlots occurs in the central and eastern provinces. Management of these woodlots is often conducted through cooperative organizations such as marketing boards, which negotiate stumpage and roadside prices on a larger scale rather than each woodlot owner dealing with all these issues. Independent certification of forest management may be one of the most important changes in forestry during the past 50 years. Canada is a world leader in forest certification, with about 150 million ha of forest certified by one or more of three globally recognized certification standards. The principal driver for certification is the ability to sell wood products on the global market.

Non-timber forest products (NTFPs) make a significant contribution to the economy and are particularly important for private owners and First Nations people as a supplemental source of income. The production of Christmas trees and products from maple syrup are the principal NTFP commodities. Christmas trees generate over $40 million and maple syrup products produce over $350 million in annual sales (Natural Resources Canada 2011a). Other sources of income are derived from food-based plants, such as wild berries and mushrooms, and extracts from plants used for pharmaceuticals.

Aboriginal communities own or control approximately 3 million ha of forested lands across Canada (Canadian Council of Forest Ministers 2007). Conservation and use of traditional knowledge is a key component of their management of forest genetic resources. Traditional knowledge encompasses the beliefs, knowledge, practices, innovations, arts, spirituality, and other forms of cultural experience and expression that belong to indigenous communities (National Aboriginal Forestry Association 2012). The rationale for protecting traditional knowledge centres on questions of fundamental justice and the ability to protect, preserve, and control one's cultural heritage (National Aboriginal Forestry Association 2012). Traditional knowledge is used to understand climate change implications in the North, assist land-claim negotiations, and understand and develop a consensus on species of significance. Several initiatives are being developed with First Nations to exchange information and to protect, preserve, and control their cultural heritage: (1) First Nations Forestry Programs, (2) Centre for Indigenous Environmental Resources, (3) National Aboriginal Forestry Association, and (4) the Boreal Initiative. Greater Aboriginal participation in the forest sector could benefit Canada's sustainable forest management and help build stronger Aboriginal communities (Canadian Council of Forest Ministers 2007).

Forest management plans must be developed by forest companies operating on public land. These plans are reviewed and approved by the jurisdictions (provinces and territories). Such plans take into account many aspects of land management other than harvesting trees, such as clean water, protection of wildlife habitat, riparian buffers, and other non-commercial values.

Forest genetic resources has been defined as the 'the genetic variation in trees of potential or present benefit to humans' (International Plant Genetic Resources Institute 2004). The forest can denote a stand, population or landscape of trees and other associated woody plants and animals (Food and Agriculture Organization (FAO) 2004), while 'genetic' refers to variation of genetic origin (DNA, deoxyribonucleic acid) and variation of genes at different levels. This variation can be 1) between species, 2) between populations within species and 3) between individual trees within populations (FAO 2004). Resources in this definition refer to the use of genetic variation that is considered to be of potential value for humans in the present or future (FAO 2004). This report will focus on tree species; however, it is recognized that Canadian forests provide habitat to a wide array of plant and animal species. The Canadian Museum of Nature conducted a taxonomic census and determined that Canada is home to approximately 140,000 species, only half of which have been described (Mosquin et al. 1995). Approximately two thirds of these species, most of which are insects or other arthropods, occur in forest ecosystems (Canadian Council of Forest Ministers 2006).

There has been an increased effort at conserving forest genetic resources over the past 10 years through the establishment of protected areas that include national and provincial parks, national wildlife areas, migratory bird sanctuaries, wildlife reserves, and ecological reserves (Environment Canada 2011). Protected areas are lands or waters where laws or agreements limit the amount and type of human activity. The purpose of these laws is to conserve natural environments for the benefit of present and future generations of Canadians. Protected areas can be chosen to represent parts of the Canadian landscape, such as the boreal forest, or created to conserve endangered wildlife species, wildlife habitats, and unique or ecologically sensitive areas (Environment Canada 2011). As of 2010, 9.8% of Canada's land area has been protected, which is approaching the Convention on Biological Diversity target, set in 2004, of having 10% of each ecological region protected by 2010. Forest genetic resources are a significant component of these protected areas; however, not all unique populations of trees occur in these protected areas.

With respect to protected areas, a new target was set by the Parties to the Convention in October 2010 to set aside 17% of terrestrial areas by 2020. This will require continued coordination, cooperation, and commitment by all levels of government as well as the forest industry and other NGOs.

Another achievement was the proclamation of the *Species at Risk Act* (SARA) in 2003, the purpose of which is to prevent wildlife species from becoming extinct and to provide for their recovery. SARA protects species at risk and their habitats. However, it only applies to migratory birds, aquatic species, and species on federal lands. Most land in Canada is under provincial jurisdiction. All provinces and territories either have Endangered Species Acts or have amended existing Wildlife Acts to include species at risk.

The Canadian Program for the Conservation of Forest Genetic Resources (CON**FOR**GEN) was created in 2006 to provide a coordinated approach to the conservation of forest genetic resources through a pan-Canadian network. National activities focus on assessing and reporting on the status of forest genetic resources and developing conservation guidelines.

The demand for forest products will continue to grow. This will result in increasing demands on the forest as a source of raw material to produce these products as well as many other products and values such as clean air, clean water, wildlife, and recreation. Consequently, there will be a growing emphasis on sustainably managing the forest to achieve these goals. The impact of climate change represents a lot of uncertainty, e.g., its impact on growth, survival, and adaptation of trees and other plants, on insect population dynamics including non-native insects, and on the incidence and severity of forest fires.

Climate change is a challenge that is and will continue to affect Canada's forests in a range of complex ways by impacting tree growth rates, mortality rates, disturbance patterns, and the distribution of tree species after disturbances (Natural Resources Canada 2010). These impacts will be cumulative and interconnected. For example, insect damage can increase the risk of wildland fires occurring and drought can stress trees, making them more susceptible to attack by insects and disease. Furthermore, the decision-making context for forest management will be increasingly complex and uncertain in addressing threats such as climate change.
The understanding of forest genetic resources—in particular, how to use the diversity now available—is key to preventing the loss of populations, species, and representatives of existing ecosystems (Namkoong 2008), and this is a vital component of sustainable forest management. Canada has a rich history of numerous efforts in this area through the endeavors of the provincial, territorial and federal governments, non-governmental agencies, academia, Aboriginal groups, and industry.

The status of forest genetic resources in Canada has been described by other authors, including Boyle (1992), Mosseler (1995), Reid and Mosseler (1995), and Rogers (1996); however, this is the first comprehensive pan-Canadian assessment of forest genetic resources that reviews multiple components including state of *in situ* and *ex situ* conservation, sustainable management of these resources, national and international policies pertaining to forest genetic research through to collaboration and research.

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Chapter 1: The Current State of Forest Genetic Resources in Canada

Canada's forests represent approximately 10% of the world's forest cover and 30% of the world's boreal forest. Approximately 8% of Canada's forest areas are protected by legislation and approximately 40% of the total forest landbase is subject to varying degrees of protection, including integrated land-use planning or defined management areas such as certified forests. These forest genetic resources generate a wide range of benefits, including timber and non-timber products, and recreation and service-based industries that are important both nationally and internationally (Natural Resources Canada 2010a).

Canada is one of a few countries that still have large tracts of forests that are relatively undisturbed by human activity and are believed to contain much of their native biodiversity (Federal, Provincial and Territorial Governments of Canada 2010). Yet, how intact our forests are very much depends on how they are measured (Long et al. 2010). Often assessments of Canadian forests do not consider species diversity, and changes below the species level can be critical for ensuring that the adaptive potential of the species is maintained. This is particularly important when considering threats such as climate change, invasive pests and pathogens, and the ability of species to adapt to these changing conditions.

The information presented in this chapter represents the current state of forest genetic resources in Canada as of 2011 and has been obtained through consultation with the jurisdictions, literature searches, and by personal communication with various agencies. Information presented in section 1.2.1 was obtained through a survey completed by the following jurisdictions: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec and Saskatchewan and data is current as of 2010.

1.1 DIVERSITY WITHIN AND BETWEEN FOREST TREE SPECIES

1.1.1 (FAO Annex Question 1.4) Main (a) Ecosystems and (b) Tree Species in Canada

(a) Ecosystems

The 1996 National Ecological Framework divided Canada into 15 terrestrial ecozones, 53 ecoprovinces, 194 ecoregions, and more than 1000 ecodistricts, which are delineated based on the interactions of geological, landscape, soil, vegetation, climate, wildlife, water, and human factors (Table 1.1.) (Ecological Stratification Working Group 1996). The majority of Canada's forests lie within eight ecozones: Taiga Plains, Boreal Cordillera, Boreal Plains, Boreal Shield, Pacific Maritime, Montane Cordillera, Mixedwood Plains, and Atlantic Maritime (Table 1.2) (Wiken 1986).

Currently, Canada does not have a national forest ecosystem classification system. Most provinces or territories have adopted their own ecological land classification schemes (Table 1.4). However, a collaborative effort is under way by Natural Resources Canada to develop a Canadian Forest Ecosystem Classification system that will integrate, at the national level, knowledge of vegetation communities in relation to environmental gradients, such as regional climate site-specific moisture and nutrient regimes (Natural Resources Canada 2007).
The Canadian Forest Ecosystem Classification will be effective for a broad range of applications, from exchanging forest management information across provincial and territorial boundaries, to identifying ecosystems with high potential for biodiversity conservation.

Table 1.1. Canadian ecological land classification[1]

Ecological Level	Often Defined By:	Typical Map Scale	No. of Units in Canada
Ecozone	- climate - landforms - regional vegetation patterns	1:1 000 000	15 Terrestrial
Ecoprovince	- surficial forms	1:500 000 to	

	- hydrology - climate - landforms	1:1 000 000	53
Ecoregion	- climate - vegetation - soils - hydrology - landforms	1:250 000 to 1:500 000	194
Ecodistrict	- relief - geology - vegetation - soils - hydrology	1:100 000 to 1:500 000	1021
Ecosection	- soils - hydrology - climate - landforms - relief	1:50 000 to 1:250 000	N/A
Ecosite	- vegetation - soils - site features	1:20 000 to 1:50 000	>4000
Ecoelement	- vegetation - soils - topography	1:10 000	N/A

N/A, not available.

1. Adapted from *A National Ecological Framework for Canada* (Ecological Stratification Working Group 1996).

Table 1.2. Canadian terrestrial ecozones and tree species

Ecozones	Total Area (km^2)	Percentage of land area[1]	Percentage protected[2]	Native tree species by ecozones
Arctic Cordillera	230 873	2.5	24.25	N/A
Northern Arctic	1 361 433 (14% of Canada's landmass)	14.8	6.69	N/A
Southern Arctic	773 010	8.4	15.89	stunted *Picea mariana*
Taiga Cordillera	264 480	3.0	9.28	stunted *Abies lasiocarpa* *Betula papyrifera* *Picea glauca* *Picea mariana* *Pinus contorta* var. *latifolia* *Populus tremuloides* *Populus balsamifera*
Taiga Plains	580 139	6.4	6.92	*Alnus viridis* ssp. *crispa* *Betula papyrifera* *Larix laricina* *Picea glauca* *Picea mariana* *Pinus banksiana* *Populus balsamifera* *Populus tremuloides*

				Salix spp.
Taiga Shield	1 253 887	13.6	6.97	*Alnus viridis* ssp. *crispa* *Betula papyrifera* *Larix laricina* *Picea glauca* *Picea mariana* *Pinus banksiana* *Populus tremuloides* *Salix* spp.
Hudson Plains	353 364	3.8	11.65	*Betula papyrifera* *Larix laricina* *Picea mariana* *Picea glauca* *Populus balsamifera*
Boreal Cordillera	459 680	5.0	15.28	*Abies lasiocarpa* *Betula papyrifera* *Picea glauca* *Picea mariana* *Populus balsamifera* *Populus tremuloides*
Boreal Plains	679 969	7.4	7.96	*Abies balsamea* *Acer negundo* *Larix laricina* *Picea glauca* *Picea mariana* *Pinus banksiana* *Populus tremuloides* *Populus deltoides* ssp. *deltoïdes*
Boreal Shield	1 782 252	19.3	9.06	*Abies balsamifera* *Acer negundo* *Acer saccharum* *Betula alleghaniensis* *Betula papyrifera* *Fraxinus nigra* *Larix laricina* *Picea glauca* *Picea mariana* *Pinus banksiana* *Pinus resinosa* *Pinus strobus* *Populus tremuloides* *Thuja occidentalis* *Viburnum trilobum*
Prairies Ecozone	520 000	5.0	3.3	*Acer negundo* *Amelanchier alnifolia* *Populus balsamifera* *Populus tremuloides*
Montane Cordillera	459 680	5.0	18.33	*Abies lasiocarpa* *Picea engelmannii* *Picea glauca* *Pinus contorta* var. *latifolia* *Pinus monticola*

				Pinus ponderosa *Populus tremuloides* *Pseudotsuga menziesii* var. *glauca* *Thuja plicata* *Tsuga heterophylla*
Pacific Maritime	205 175	2.2	18.87	*Abies amabilis* *Alnus rubra* *Callitropsis nootkatensis* *Cornus nuttalli* *Picea sitchensis* *Pseudotsuga menziesii* var. *glauca* *Thuja plicata* *Tsuga heterophylla* *Tsuga mertensiana*
Atlantic Maritime	183 978	2.0	5.33	*Abies balsamifera* *Acer rubra* *Acer saccharum* *Alnus incana* *Betula alleghaniensis* *Betula papyrifera* *Fagus grandifolia* *Fraxinus nigra* *Picea mariana* *Picea rubens* *Picea glauca* *Pinus banksiana* *Pinus resinosa* *Pinus strobus* *Prunus pensylvanica* *Quercus rubra* *Tsuga canadensis*
Mixedwood Plains Ecozone	175 963	2.0	1.3	*Acer saccharum* *Betula alleghaniensis* *Juglans cinerea* *Pinus resinosa* *Pinus strobus* *Quercus bicolor* *Quercus rubra* *Tilia americana* *Thuja occidentalis* *Tsuga canadensis* *Ulmus americana* Other species at the northern limit of their range: *Fraxinus quadrangulata* *Gymnocladus dioicus* *Juglans nigra* *Liriodendron tulipifera* *Magnolia acuminata*

				Morus rubra *Platanus occidentalis*

1. Data were obtained from *Percent of ecozones that are protected in Canada* (2009). [online] URL: http://www.ec.gc.ca/indicateurs-indicators.htm
2. Percentage protected corresponds to the International Union of Conservation of Nature (IUCN) catagories I–VI.

(b) Tree Species in Canada

Forest ecosystems in Canada contain approximately 126 native tree species, depending on the definition of large shrub vs. small tree (Farrar 1995). This list of Canadian native tree species was derived by including all native species described in *Trees in Canada* (Farrar 1995) as 10 m or greater in height when mature (Table 1.3).

Table 1.3. Native Canadian tree species[1]

Genus	Common names	No. of species	Species names
Gymnosperms			
Abies	Fir	4	*amabillis, balsamea, grandis, lasiocarpa*
Callitropsis	Cypress	1	*nootkatensis*
Juniperus	Juniper	2	*virginiana, scopulorum*
Larix	Larch	3	*laricina, lyallii, occidentalis*
Picea	Spruce	5	*engelmannii, glauca, mariana, rubens, sitchensis*
Pinus	Pine	9	*albicaulis, banksiana, contorta, flexilis, monticola, ponderosa, resinosa, rigida, strobus*
Pseudotsuga	Douglas-fir	1	*menziesii* [var. *menziesii*, var. *glauca*]
Taxus	Yew	1	*brevifolia*
Thuja	Cedar	2	*occidentalis, plicata*
Tsuga	Hemlock	3	*canadensis, heterophylla, mertensiana*
Summary Totals	10 genera; 31 species		
Angiosperms			
Acer	Maple	10	*circinatum, glabrum, macrophyllum, negundo* [var. *negundo*, var. *violaceum*], *nigrum, rubrum, pensylvanicum, saccharinum, saccharum, spicatum*
Aesculus	Buckeye	1	*glabra*
Alnus	Alder	4	*rubra, rugosa,* [syn. *incana* ssp. *Rugosa*], *sinuata* [syn. *viridis* ssp. *sinuata*], *incana* ssp. *tenuifolia* (syn. *tenuifolia*)
Arbutus	Arbutus	1	*menziesii*
Asimina	Pawpaw	1	*triloba*
Betula	Birch	8	*alleghaniensis, cordifolia, lenta, lutea, neoalaskana, occidentalis, papyrifera* [var. cordifolia], *populifolia*
Carpinus	Blue Beech	1	*caroliniana*
Carya	Hickory	4	*cordiformis, glabra* [var. *odorata*], *laciniosa*, ovata
Castanea	Chestnut	1	*dentata*
Celtis	Hackberry	1	*occidentalis*
Cercis	Redbud	1	*canadensis*[2]
Cornus	Dogwood	3	*alternifolia, florida, nuttallii*
Crataegus	Hawthorns	4	*crus-galli, coccinea, douglasii, mollis*
Fagus	Beech	1	*grandifolia*
Fraxinus	Ash	5	*americana, nigra, pennsylvanica, profunda,*

			quadrangulata
Gleditsia	Honey Locust	1	*triacanthos*
Gymnocladus	Kentucky Coffee-Tree	1	*dioicus*
Hamamelis	Witch Hazel	1	*virginiana*
Juglans	Walnut	2	*cinerea, nigra*
Liriodendron	Tulip Tree	1	*tulipifera*
Magnolia	Cucumber Tree	1	*acuminate*
Malus	Wild Apple	2	*coronaria, fusca*
Morus	Mulberry	1	*rubra*
Nyssa	Black Gum	1	*sylvatica*
Ostrya	Ironwood	1	*virginiana*
Plantanus	Sycamore	1	*occidentalis*
Populus	Poplar	6	*augustifolia*, *balsamifera*, *deltoids* [var. *deltoids*, var. *occidentalis*], *grandidentata*, *tremuloides, trichocarpa*
Prunus	Cherry	6	*americana, emarginata, nigra*, *pensylvanica*, *serotina*, *virginiana* [var. *virginiana*]
Ptelea	Hop-tree	1	*trifoliate*
Quercus	Oak	11	*alba*, *bicolor*, *ellipsoidalis*, *garryana*, *macrocarpa*, *muehlenbergii*, *palustris*, *prinoides*, *rubra*, *shumardii*, *velutina*
Rhamnus	Buckthorn	1	*purshiana*
Salix	Willow (trees only)	2	*amygdaloides*, *nigra*
Sambucus	Elder	2	*cerulea, glauca*
Sassafras	Sassafras	1	*albidum*
Sorbus	Mountain Ash	2	*americana, decora*
Tilia	Basswood	1	*americana*
Ulmus	Elm	3	*americana*, *rubra*, *thomasii*
Summary totals:	37 genera; 95 species		

1. Adapted from Beardmore et al. (2005).
2. This species is most likely extirpated.

1.1.2. Methods of Species Characterization (Ecological Zonation, Delimitation of Provenance Zones)

A number of provinces and territories have developed jurisdictional ecological zonation systems to assist in managing their forests or terrestrial ecosystems (Table 1.4). Below is a brief description of these jurisdictional classification systems; the ecological land classifications for each jurisdiction are presented in Table 1.4. Some jurisdictions have developed a forest ecosystem classification scheme (e.g., Manitoba) whereas others have developed broader schemes that include forested areas (e.g., Ontario and Quebec).

Jurisdiction Ecological Land Classifications:

British Columbia: In British Columbia, a Biogeoclimatic Ecosystem Classification System has been developed to assist in the research and management of British Columbia's ecosystems (Meidinger and Pojar 1991). This hierarchical system uses climate, soil, and vegetation to group ecosystems at regional and local levels. There are 14 biogeoclimatic or ecological zones recognized across the province. Zones are divided into subzones on the basis of differences in regional climate. Variants are finer climatic subdivisions within subzones.

Alberta: In Alberta, six regions have been delineated geographically. These regions are the largest ecological units mapped in the province and are based on landscape pattern, soil, and physiographic features, along with the combined influences of climate, topography, and geography. These regions are further divided into 21 subregions (Downing and Pettapiece 2006).

Saskatchewan: Saskatchewan has four ecozones: Taiga Shield, Boreal Shield, Boreal Plain, and Prairie. There are 81 ecosites that span these ecozones (McLaughlan et al. 2011). Geology, topography, soils, climate, and vegetation were considered in developing this classification.

Manitoba: Manitoba has a forest ecosystem classification system for their commercial forest areas that consists of 33 vegetation types and 22 soil types; these are identified using site classification keys (Zolandeski 1995). Additionally, 5 river bottom forest classifications have been delineated for the flood plains of southern Manitoba (Marr Consulting and Communications Ltd. and Synthen Resources Services, 1995)

Ontario: The ecological land classification system of Ontario's Ministry of Natural Resources (OMNR) is based on bedrock, climate (temperature and precipitation), physiography (soil, slope, aspect), and corresponding vegetation. There are 14 ecoregions in Ontario (OMNR 2007).

Quebec: Quebec is divided into three vegetation zones, which are divided into subzones according to vegetation type dominating the landscape at the final stage of succession. Quebec has 10 bioclimatic zones, which are delineated primarily by climate, soil, and precipitation (Ministère des ressources naturelles de la faune et des parcs (MRNFP) 2003). In southern regions of the province, these zones are further divided into subdomains.

New Brunswick: New Brunswick's Ecological Land Classification System uses information on its geology, soils, climate, and vegetation to delineate the various ecosystems present within the province's boundaries. Seven ecoregions have been delineated in New Brunswick according to the New Brunswick Department of Natural Resources (NBDNR) (2007).

Nova Scotia: Nova Scotia is developing an ecosystem-based management planning system (Government of Nova Scotia 2011), part of which will be based on Nova Scotia's Ecological Land Classification and will incorporate biophysical attributes (topography, soil drainage, and texture) (Neily et al. 2003). Nine ecoregions have been identified in Nova Scotia through this classification system.

Prince Edward Island: According to Canada's Ecozonation System, Prince Edward Island comprises one ecoregion and has no further ecological-level subdivisions (Agriculture and Agri-Food Canada 2009).

Newfoundland and Labrador: Newfoundland and Labrador has a forest ecosystem classification system with two levels: ecoregions and subecoregions. They define an ecoregion as a distinctive pattern of recurring vegetation and soil development controlled by regional climate. The island of Newfoundland has nine ecoregions and 18 subecoregions; Labrador has 10 ecoregions (Department of Forest Resources and Agrifoods 2003).

Yukon: The Yukon's Department of Environment has published a "Terrestrial Zone and Ecoregions" map for the Yukon. According to a government document published in 2005, an ecological site classification system was being developed for southeastern Yukon in 1999. It is unclear according to the website whether the system has been developed for the entire territory. According to Canada's national ecological classification system, there are 23 ecoregions within Yukon's borders (Lipovsky and McKenna 2005).

Northwest Territories: The Northwest Territories is developing an ecologically based landscape classification system that will include multiple ecoregions (Northwest Territories Department of Environment and Natural Resources (NWTDENR) 2011).

Nunavut: There is no Nunavut-specific ecological zonation currently developed (Natural Resources Canada 2010b).

Table 1.4. Jurisdictional ecological land classifications[1]

Jurisdiction	**Ecological Zonation: Jurisdictional Ecoregions**
British Columbia: Bioclimatic Ecosystem Classification Zones[2]	- Coastal Douglas-fir - Coastal Western Hemlock - Mountain Hemlock - Bunchgrass - Ponderosa Pine - Interior Douglas-fir - Montane Spruce - Sub-boreal Pine

	- Sub-boreal Spruce - Engelmann Spruce–Subalpine Fir - Boreal White and Black Spruce - Spruce–Willow–Birch - Alpine Tundra - Non-Tidal Wetlands
Alberta: Natural Regions and Subregions of Alberta[3]	- Rocky Mountain Alpine - Rocky Mountain Subalpine - Rocky Mountain Montane - Upper Foothills - Lower Foothills - (Grassland) Dry Mixedgrass - (Grassland) Mixedgrass - (Grassland) Northern Fescue - (Grassland) Foothills Fescue - Foothills Parkland - Central Parkland - Peace River Parkland - (Boreal Forest) Dry Mixedwood - (Boreal Forest) Central Mixedwood - Lower Boreal Highlands - Upper Boreal Highlands - Athabasca Plain - Peace-Athabasca Delta - (Boreal Forest) Northern Mixedwood - Boreal Subarctic - Kazan Upland (Can. Shield)
Saskatchewan[4]	Example of Ecosites in one of the four ecozones, the Taiga Shield: TS1 - Jack pine / bearberry / lichen: Dry nonsoil TS2 - Jack pine–black spruce / lichen: Moderately dry sand TS3 - White birch / lingonberry / lichen: Moderately dry loamy sand TS4 - Black spruce / lingonberry / feathermoss: Moderately dry silty sand TS5 - Trembling aspen / prickly rose - twinflower: Moderately dry sand TS6 - White birch–spruce / green alder: Moderately fresh sand TS7 - White birch–black spruce / lingonberry: Moderately dry loamy sand TS8 - White birch / river alder / feathermoss: Very moist clay loam TS9 - Black spruce treed bog: Moderately wet mesic organic TS10 - Labrador tea shrubby bog: Very wet humic organic TS11 - Graminoid bog: Moderately wet fibric organic TS12 - Open bog: Moderately wet mesic organic TS13 - Tamarack treed fen: Very moist fibric organic TS14 - Labrador tea shrubby fen: Very moist fibric organic TS15 - Graminoid fen: Very wet fibric organic TS16 - Open fen: Moderately wet mesic organic TS17 - Lichen rocky shore: Very wet nonsoi
Manitoba[5]	- Aspen Parkland - Boreal Transition - Churchill River Upland - Coastal Hudson Bay - Hayes River Upland - Hudson Bay Lowland - Interlake Plain - Kazan River Upland - Lac Seul Upland

	- Lake Manitoba Plain - Lake of the Woods - Maguse River Upland - Mid-Boreal Lowlands - Mid-Boreal Uplands - Selwyn Lake Uplands
Ontario[6]	- 0E - 1E - 2E - 3E - 4E - Georgian Bay 5E - Lake Simcoe 6E - Lake Erie-Lake Ontario 7E - 2W - 3W - 3S - 4S - 4W - 5S
Quebec: Bioclimatic Domains[7]	-Herbaceous arctic tundra domain - Shrub arctic tundra domain - Forest tundra domain - Spruce–lichen domain - Spruce–moss domain - Balsam fir–white birch domain - Balsam fir–yellow birch domain - Sugar maple–yellow birch domain - Sugar maple–basswood domain - Sugar maple–butternut hickory domain
New Brunswick: Ecoregions[8]	- Highlands - Northern Uplands - Central Uplands - Fundy Coast - Valley Lowlands - Eastern Lowlands - Grand Lake Lowlands.
Nova Scotia[9]	- Cape Breton Taiga - Cape Breton Highlands - Nova Scotia Uplands - Eastern Ecoregion - Northumberland Bras D'Or Lowlands - Valley & Central Lowlands - Western Ecoregion - Atlantic Coastal - Fundy Shore
Prince Edward Island	-Prince Edward Island
Newfoundland and Labrador[10]	**In Newfoundland:** - Western Newfoundland Forest - Central Newfoundland Forest - North Shore Forest - Northern Peninsula Forest - Avalon Forest - Maritime Barrens

	- Eastern Hyper-Oceanic Barrens - Long Range Barrens - Strait of Belle Isle Barrens **In Labrador:** - Low Arctic Tundra–Cape Chidley - Arctic-Alpine Tundra–Torngat - High Subarctic Tundra–Kingurutil/Fraser - Coastal Barrens–Okak/Battle Harbour - Mid Subarctic Forest–Michikamau - Mid Boreal Forest–Lake Melville - Mid Boreal Forest–Paradise Lake - Low Subarctic Forest–Macatina River - String Bog–Eagle River Plateau - Forteau Barrens
Yukon[11]	-Yukon Coastal Plain - Peel River Plateau - Fort McPherson Plain - Muskwa Plateau - British-Richardson Mountain - Old Crow Basin - Old Crow Flats - North Olgilvie Mountains - Eagle Plains - Mackenzie Mountains - Selwyn Mountains - Klondike Mountains - St. Elias Mountains - Ruby Ranges - Yukon Plateau–Central - Yukon Plateau–North - Yukon Southern Lakes - Pelly Mountains - Yukon–Stikine Mountains - Boreal Mountains and Plateaus - Liard Basin - Hyland Highland - Mount Logan
Northwest Territories[12]	- Taiga Plains High Subarctic - Taiga Plains Low Subarctic - Taiga Plains High Boreal - Taiga Plains Mid Boreal - Taiga Shield High Subarctic - Taiga Shield Low Subarctic - Taiga Shield High Boreal - Taiga Shield Mid Boreal - Tundra Cordillera High Subarctic - Tundra Cordillera Low Subarctic - Boreal Cordillera High Boreal - Boreal Cordillera Mid Boreal
Nunavut	N/A

N/A, not available.
1. Information presented in this table was obtained by contacting the jurisdictions and through literature searches.
2. Meidinger and Pojar 1991.
3. Downing and Pettapiece 2006.

4. Canadian Plains Research Centre 2006.
5. Manitoba Wildlands 2006
6. OMNR 2007.
7. Ministère des ressources naturelles du Québec 2003.
8. NBDNR 2007.
9. Neily et al. 2003.
10. Government of Newfoundland and Labrador 2003.
11. Flynn and Francis 2011.
12. NWTDENR 2011.

1.1.3 (FAO Question 1.4) Methods Used to Analyze and Assess Intraspecific Variation in Canada

The scientific literature from 1987 to 2011 was assessed to identify methods used in Canada to analyze and assess intraspecific variation of native tree species (Table 1.5). In the 1980s–1990s, most analyses were conducted by allozymes and isozymes, accounting for 62% and 28%, respectively, of studies surveyed. In the late 1990s to early 2000s, random amplified polymorphic DNA markers were used, and from 2000 to 2011, a shift is seen from RAPD markers to other DNA-based markers, including mitochondrial and chloroplast DNA, single nucleotide polymorphisms (SNPs), and choloroplastic sequence specific primers (cpSSPs). From 2000 to 2011, DNA markers were used in 81% of studies surveyed, whereas usage of allozyme and isozymes markers declined to 19%. The uses of provenance tests and phenotypic analyses have been used consistently throughout the 24 years surveyed. Analysis of intraspecific variation has been conducted for a large number of species based on this survey, including both commercial and non-commercial tree species. Typically, the reason for which the non-commercial species were studied is because there are already ongoing conservation efforts or they are targeted for future conservation activities (e.g., *Alnus rubra*, *Quercus garryana*, *Juglans cinerea*).

Table 1.5. Survey of the scientific literature assessing intraspecific variation of native tree species in Canada, 1987–2011

Species	Research Paper Title	Method for analyzing intraspecific variation
Acer saccharum	• Allozyme variation in sugar maple at the northern limit of its range in Ontario, Canada. (Perry and Knowles 1989) • Genetic variation and structure at three spatial scales for *Acer saccharum* (sugar maple) in Canada and the implications for conservation. (Young et al. 1993)	Allozyme Allozyme
Alnus crispa	• Genetic differentiation among 22 mature populations of green alder (*Alnus crispa*) in central Quebec. (Bousquet et al. 1987b) • Genetic diversity within and among 11 juvenile populations of green alder (*Alnus crispa*) in Canada. (Bousquet et al. 1987c) • Allozyme variability in natural populations of green alder (*Alnus crispa*) in Quebec. (Bousquet et al. 1987a) • Allozyme variation within and among mature populations of speckled alder (*Alnus rugosa*) and relationships with green alder (*Alnus crispa*). (Bousquet et al. 1988)	Allozyme Allozyme Allozyme Allozyme
Alnus rubra	• Genetics of red alder (*Alnus rubra* Bong.) populations in British Columbia and its implications for gene resources management. (Xie et al. 2002)	Allozyme
Arbutus menziesii	• Genetic structure and mating system of northern *Arbutus menziesii* populations. (Beland et al. 2005)	Amplified Fragment Length Polymorphisms
Crataegus spp.	• Fine-scale comparisons of genetic variability in seed families of asexually and sexually reproducing *Crataegus (*Hawthorn; *Rosaceae*). (Lo et al. 2010)	Microsatelite DNA

Fagus grandifolia	• Regional differentiation in genetic components for the American beech, *Fagus grandifolia* Ehrh., in relation to geological history and mode of reproduction. (Kitamura and Kawan 2001)	Isozyme
Juglans cinerea	• Low genetic diversity at allozyme loci in *Juglans cinerea*. (Morin et al. 2000) • Genetic diversity of butternut (*Juglans cinerea*) and implications for conservation. (Ross-Davis et al. 2008)	Allozyme Nuclear microsatellite DNA
Larix laricina	• Patterns of allozyme variation in tamarack *Larix laricina* from northern Ontario. (Liu and Knowles 1991) • The Population structure of *Larix laricina* in New Brunswick, Canada. (Ying and Morgenstern 1991) • Genetic relationship among Eurasian and American *Larix* species based on allozymes. (Semerikov and Lascoux 1999)	Allozyme Allozyme Allozyme
Larix occidentalis	• Genetic variation of western larch in British Columbia and its conservation. (Jaquish and El-Kassaby 1998) • Genetic relationship among Eurasian and American *Larix* species based on allozymes. (Semerikov and Lascoux 1999) • Development and characterization of microsatellite loci in western larch. (*Larix occidentalis* Nutt.) (Chen et al. 2009)	Allozyme Allozyme Microsatellite DNA
Picea glauca	• Extensive long-distance pollen dispersal in a fragmented landscape maintains genetic diversity in white spruce. (O'Connell et al. 2007) • Enhancing genetic mapping of complex genomes through the design of highly-multiplexed SNP arrays: application to the large and unsequenced genomes of white spruce and black spruce. (Pavy et al. 2008) • Multivariate analysis of digital gene expression profiles identifies a xylem signature of the vascular tissue of white spruce (*Picea glauca*). (Albouyeh et al. 2010) • QTL mapping in white spruce: gene maps and genomic regions underlying adaptive traits across pedigrees, years and environments. (Pelgas et al. 2011)	Allozyme Single nucleotide Polymorphisms Cloned DNA Single Nucleotide Polymorphisms
Picea mariana	• Near-saturated and complete genetic linkage map of black spruce (*Picea mariana*). (Kang et al. 2010) • Clonal and nonclonal genetic structure of subarctic black spruce (*Picea mariana*) populations in Yukon Territory. (Viktora et al. 2011)	Amplified Fragment Length Polymorphisms Microsatellite DNA
Picea rubens	• Genetic diversity and population structure of red spruce (*Picea rubens*). (Hawley and Hayes 1994) • Indicators of population viability in red spruce, *Picea rubens*. II. Genetic diversity, population structure, and mating behavior. (Rajora et al. 2000)	Allozyme Allozyme
Picea sitchensis	• Optimal sampling strategies for capture of genetic diversity differ between core and peripheral populations of *Picea sitchensis* (Bong.) Carr. (Gapare et al. 2007) • Widespread ecologically-relevant genetic markers developed from association mapping of climate-related traits in Sitka spruce *(Picea sitchensis*). (Holliday et al.2010) • Local adaptation at the range peripheries of Sitka spruce. (Mimura and Aitken 2010)	Genomic DNA Single nucleotide Polymorphisms Phenotypic Analysis
Pinus albicaulis	• Biogeography and population genetics of whitebark pine (*Pinus albicaulis*).(Jorgensen and Hamrick 1997)	Allozyme

	• Inbreeding and conservation genetics in whitebark pine. (Krakowski et al. 2003) • Mating system and inbreeding depression in whitebark pine (*Pinus albicaulis* Engelm.). (Bower and Aitken 2007)	Isozyme Allozyme
Pinus banksiana	• Boreal forest provenance tests used to predict optimal growth and response to climate change. 1. Jack pine. (Thomson and Parker 2008) • Effect of interannual climate variations on radial growth of jack pine provenances in Petawawa, Ontario. (Savva et al. 2008) • Phylogeographic structure of jack pine *(Pinus banksiana; Pinaceae)* supports the existence of a coastal glacial refugium in northeastern North America. (Godbout et al. 2010)	Provenance Provenance Mitochondrial & Chloroplast DNA
Pinus contorta var. latifolia	• The organization of genetic variability in central and marginal populations of lodgepole pine *Pinus contorta* spp. *latifolia.* (Yeh and Lavton 1979) • Allozyme variability and evolution of lodgepole pine *Pinus contorta* var. *latifolia* and jack pine *Pinus banksiana* in Alberta Canada. (Dancik and Yeh 1983) • Genetic variability among and within closely spaced populations of lodgepole pine. (Knowles 1984) • Glacial vicariance in the Pacific Northwest: evidence from a lodgepole pine mitochondrial DNA minisatellite for multiple genetically distinct and widely separated refugia.(Godbout et al. 2008) • Climate impacts on lodgepole pine (*Pinus contorta*) radial growth in a provenance experiment. (McLane et al. 2011a) • Modeling lodgepole pine radial growth relative to climate and genetics using universal growth-trend response functions. (McLane et al. 2011b)	Isozyme Allozyme Isozyme Microsatellite DNA Provenance Provenance
Pinus monticola	• Identification and characterization of the WRKY transcription factor family in *Pinus monticola*. (Donini et al. 2009)	Genomic DNA
Pinus resinosa	• Genetic diversity in red pine evidence for low genetic heterozygosity. (Fowler and Morris 1977) • Isozyme uniformity in populations of red pine (*Pinus resinosa*) in the Atibiti Region, Quebec. (Simon et al. 1986) • Lack of allozymic variation in disjunct Newfoundland populations of red pine (*Pinus resinosa*). (Mosseler et al. 1991) • Low levels of genetic diversity in red pine confirmed by random amplified polymorphic DNA markers. (Mosseler et al. 1992) • Chloroplast microsatellites reveal population genetic diversity in red pine, *Pinus resinosa* Ait. (Echt et al. 1998) • Microsatellite analysis reveals genetically distinct populations of red pine (*Pinus resinosa*, Pinaceae). (Boys et al. 2005) • Geographic pattern of genetic variation in *Pinus resinosa*: contact zone between descendants of glacial refugia. (Walter and Emerson 2005)	Isozyme Isoenzyme Allozyme Random Amplification of Polymorphic DNA Microsatellite DNA Chloroplast Microsatellites Microsatellite DNA
Pinus rigida	• Reproductive and genetic characteristic or rare, disjunct pitch pine populations at the northern limits of its range in Canada. (Mosseler et al. 2004)	Allozyme
Pinus strobus	• Genetic structure and variability in *Pinus strobus* in Quebec. (Beaulieu and Simon 1994)	Microsatellite DNA

	• Genetic structure and variability in *Pinus strobus* in Quebec. (Beaulieu and Simon 1994) • Genetic diversity and population structure of disjunct. Newfoundland and central Ontario populations of eastern white pine (*Pinus strobus*). (Rajora et al. 1998) • Genetic diversity and population structure of disjunct Newfoundland and central Ontario populations of eastern white pine (*Pinus strobus*). (Rajora et al. 1998)	Allozyme Allozyme & Chloroplast DNA Allozyme
Populus balsamifera	• Isozyme variation in balsam poplar along a latitudinal transect in northwestern Ontario. (Farmer et al. 1988) • Species-specific single nucleotide polymorphism markers for detecting hybridization and introgression in poplar. (Meirmans et al. 2007) • An efficient single nucleotide polymorphism assay to diagnose the genomic identity of poplar species and hybrids on the Canadian prairies. (Talbot et al. 2011)	Isozyme Single nucleotide Polymorphisms Single nucleotide Polymorphisms
Populus deltoides	• An efficient single nucleotide polymorphism assay to diagnose the genomic identity of poplar species and hybrids on the Canadian prairies. (Talbot et al. 2011)	Single nucleotide Polymorphisms
Populus tremuloides	• RAPD variation within and among natural populations of trembling aspen (*Populus tremuloides*) from Alberta. (Yeh et al. 1995) • Microsatellite analysis of genetic diversity in four populations of *Populus tremuloides* in Quebec. (Wyman et al. 2003) • Quantitative-genetic variation in morphological and physiological traits within a quaking aspen (*Populus tremuloides*) population. (Kanaga et al. 2008) • Genetic adaptation of aspen (*Populus tremuloides*) populations to spring risk environments: a novel remote sensing approach. (Haitao et al. 2010)	Random Amplification of Polymorphic DNA Microsatellite DNA Phenotypes Remote sensing
Populus trichocarpa	• Ecotypic mode of regional differentiation caused by restricted gene migration: a case in black cottonwood (*Populus trichocarpa*) along the Pacific Northwest coast. (Xie et al. 2009)	Provenance
Pseudotsuga menziesii	• Enzyme variations in natural populations of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, from British Columbia. 1. Genetic variation patterns in coastal populations. (Yeh and O'Malley 1980) • Heritability, phenotypic and genetic correlations of coastal Douglas-fir (*Pseudotsuga menziesii*) wood quality traits. (Ukrainetz et al. 2008)	Isozyme Phenotypic Traits
Quercus garryana	• Isozyme variation and the conservation genetics of Garry oak. (Ritland et al. 2005)	Isozyme
Thuja occidentalis	• Allozyme variation of *Thuja occidentalis* L. in northwestern Ontario. (Perry et al. 1990) • Sources of Allozymic variation in *Thuja occidentalis* in Southern Ontario Canada. (Mathes-Sears et al. 1991) • Genetic structure, variability, and mating system in eastern white cedar (*Thuja occidentalis*) populations of recent origin in an agricultural landscape in southern Quebec. (Lamy et al. 1999)	Allozyme Allozyme Isozyme
Thuja plicata	• Isozyme variation of *Thuja plicata* (Cupressaceae) in British Columbia. (Yeh 1988) • Post-glacial colonization of western redcedar (*Thuja plicata*,	Isozyme

	Cupressaceae) revealed by microsatellite markers. (O'Connell et al. 2008)	Microsatellite DNA

1.1.4 (FAO Question 1.5) Actions Taken to Survey and Inventory Intraspecific Variation

In general, actions taken to survey and inventory intraspecific variation of tree species vary greatly depending on the organization conducting the work, and there can be direct or indirect measures.

At the federal level, the Canadian Council of Forest Ministers' *Criteria and Indicators of Sustainable Forest Management in Canada: National Status 2005* identifies progress toward sustainable forest management using a framework of six criteria and 46 indicators (Canadian Council of Forest Ministers 2006). Under criterion 1, Biological Diversity, indicator 1.3.1: genetic diversity of reforestation seed lot, addresses the variation of genes within a species by ensuring that seed used to regenerate harvested areas has sufficient genetic diversity to respond to changing environmental conditions. Approximately 15% of the area harvested requires planting or seeding for regeneration; most areas regenerate naturally. The genetic diversity of seed used for reforestation is a result of both the number of areas where seed is collected and the parental composition of those areas. Most of the seed used in reforestation programs across Canada is collected from natural stands where the number of parent trees is typically in the hundreds to thousands (Canadian Council of Forest Ministers 2006). This seed likely has genetic variation that is representative of the natural populations where it was collected. In some jurisdictions, a significant portion of the seed for reforestation also comes from seed orchards.

At the jurisdictional level, there are a number of provinces that survey and inventory intraspecific variation for tree species native to their jurisdiction. For example, the University of British Columbia Centre in conjunction with British Columbia's Ministry of Forests, Lands and Natural Resource Operations (BCMFLNRO) (formerly Ministry of Forests and Range (BCMFR)) have developed the Centre for Forest Conservation Genetics, which has multiple projects assessing the intraspecific variation of tree species native to British Columbia (University of British Columbia 2011). For example, ongoing projects include: (1) assessing the genetic structure and gene flow in natural and managed forest tree populations of the interior spruce hybrid zone; (2) developing sampling strategies and identifying the geographic scale for capture of diversity and for the conservation of rare alleles and (3) genetic diversity studies are ongoing for species for which information on the amount and distribution of genetic variation is lacking (e.g., *Acer macrophyllum, Cornus nuttalli*, *Pinus albicaulis*, *Quercus garryana*) (University of British Columbia 2011). Additional research efforts promote the genetic conservation of trees, including Sitka spruce (*Picea sitchensis*) (Holliday et al. 2008) and coastal Douglas-fir (*Pseudotsuga menziesii*) (Ukraninetz et al. 2008), and much of this research has been in collaboration with the BCMFLNRO. Furthermore, the BCMFLNRO has also conducted extensive research assessing and inventorying genetic diversity for commercially important tree species (e.g., *Larix occidentalis, Pinus contorta, Pseudotsuga menziesii*, *Tsuga heterophylla*) and those with conservation requirements (e.g., *Callitropsis nootkatensis, Thuja plicata*)(reviewed by BCMFR 2009a). Other jurisdictions, such as Alberta and Quebec, have conducted collaborative research assessing and inventorying intraspecific variation on commercial and non-commercial tree species (e.g., in Alberta, *Alnus rubra* (Hamann et al. 1998), *Larix lyallii* and *Larix occidentalis* (Khasa et al. 2000) and *Populus tremuloides* (Li et al. 2010, Schreiber et al. 2011); in Quebec, *Juglans cinerea* (Morin et al. 2000), *Picea glauca* and *Picea mariana* (Carles et al. 2009, Pelgas et al. 2011, Prunier et al. 2011), and *Pinus banksiana* (Godbout et al. 2010)). Associations such as the Forest Gene Conservation Association recognize the importance of the genetic resources of the forests in south-central Ontario, with emphasis on conservation of genetic diversity of native forest tree species (Forest Gene Conservation Association 2011), and their activities include surveying intraspecific variation of targeted tree species at the jurisdictional level.

Research conducted at a number of Canadian universities (e.g., Lakehead University, Laval University, University of Alberta, University of British Columbia) surveys and inventories intraspecific variation of native tree species. For example, Arborea, located at Laval University, focuses on eastern white spruce (*Picea glauca*) and black spruce (*Picea mariana*) (Arborea 2006), whereas Treenomix, located at the University of British Columbia, focuses on interior spruce (white and Engelmann complex) and Sitka spruce (*Picea sitchensis*) (FoResTTraC 2011). This research targets several ecologically and economically important traits, including drought resistance and cold acclimation, growth and carbon fixation, wood properties, and their interconnections at the genetic level. Both projects develop common genomic resources, such as a gene catalogs that contains so far more than

29 000 unigenes, an oligo-array chip for expression profiling, and anchor markers to integrate gene maps. High-throughput sequencing and genotyping are used to deploy association studies and genome scans of natural populations involving hundreds of candidate genes and thousands of short nucleotide polymorphisms (SNPs) (FoResTTraC 2011). Furthermore, collaborative research is being conducted among universities, provinces, industry, and the Canadian Forest Service to assess intraspecific variation, such as the recent study that analyzed the range-wide genogeographic variation of eastern hemlock (*Tsuga canadensis*) and assessed the implications for genetic conservation (Lemieux et al. 2011).

The federal department, Natural Resources Canada, Canadian Forest Service also conducts research assessing the intraspecific variation of native tree species, and much of this research has been centred at the Atlantic and Laurentian Forestry Centres. Studies have been conducted on such commercial and non-commercial species such as eastern and western white pine (*Pinus monticola* and *Pinus strobus*) (Rajora et al. 1998, Liu et al. 2003), bur oak (*Quercus macrocarpa*) (McPhee and Loo 2009), American beech (*Fagus americana*) (Ramirez et al. 2007), butternut (*Juglans cinerea*) (Morin et al. 2000), red pine (*Picea resinosa*) (DeVerno and Mosseler 1997, Mosseler et al. 2004), *Populus* spp. (Meirmans et al. 2007, Talbot et al. 2011), and extensive research has been conducted with *Picea* spp. (Cheliak et al. 1988, Isabel et al. 1995, Perry et al. 1999, Major et al. 2007; Barsi et al. 2009).

Collaborative efforts through the North American Forest Commission, Forest Genetics Working Group, have resulted in studies assessing the intraspecific variation of tree species in Canada, the United States, and Mexico (e.g., Wei et al. 2011). Studies that cross national borders are important as all of our native tree species have distributions that span the borders of Canada and the United States and a few species have distributions that cross into Mexico (e.g., *Pseudotsuga menziesii*).

It should be noted that much of the research assessing intraspecific variation is collaborative across various federal agencies, universities, and industry. Organizations such as the Canadian Forest Genetics Association (formerly the Canadian Tree Improvement Association, which was established in 1939) have had a significant impact in fostering collaborations to—among other research areas—assess intraspecific variation within Canada. Also the pan-Canadian group CON**FOR**GEN (Canadian program for the Conservation of Forest Genetic Resources), a federal–provincial/territorial collaborative group that monitors and reports on genetic resources of native tree species in support of Canada's national and international commitments promotes, where possible, research assessing intraspecific variation. The activities of this group include integrating jurisdictional data pertaining to forest genetic resources associated with intraspecific variation (e.g., *inter situ* conservation data, where *inter situ* is the collecting of germplasm and re-establishing it in field trials or plantations located within the same geographical areas, allowing it to continue to undergo natural selection under prevailing climate conditions. This form of conservation can also be considered as *ex situ* conservation) into the knowledge management system, CAFGRIS (Canadian Forest Genetic Resource Information System) (CON**FOR**GEN 2010).

1.1.5 (FAO Question 1.6) Information Systems Established on Intraspecific Genetic Variation Patterns

At a national level, information systems that contain data pertaining to intraspecific variation include NatureServe Canada (NatureServe Canada 2011a) and CAFGRIS (National Forest Information System 2010). NatureServe Canada, in conjunction with the eight independent Canadian Conservation Data Centres, provides multiple information products and data management tools, including the information system *NatureServe Explorer*, that contains species-specific information pertaining to general overviews and, where available, may include references on intraspecific genetic variation patterns of multiple species, including trees (NatureServe Canada 2011a). An initiative has been developed to convey national-level information pertaining to intraspecific variation for tree species of concern through the knowledge management system CAFGRIS.

Many jurisdictions maintain databases with information pertaining to intraspecific genetic variation patterns. For example, provinces such as British Columbia and the University of British Columbia's Centre for Forest Conservation Genetics maintain databases and information systems containing data on intraspecific genetic variation patterns of tree species indigenous to British Columbia. Furthermore, academic projects such as Arborea (Laval University) and Treenomix (University of British Columbia) have knowledge management systems that contain data pertaining to intraspecific genetic variation for a selection of tree species (Arborea 2006, Treenomix 2011).

1.1.6 (FAO Question 1.7) Objectives and Priorities for Improving the Understanding of Intraspecific Variation

Improving the understanding of intraspecific variation is recognized as important for the sustainable management of forest genetic resources, in particular trees (Namkoong et al. 1988; White et al. 2007). It is recognized that monitoring changes below the species level provides necessary information for ensuring that the species' adaptive potential is maintained so that species can evolve in response to changing environmental conditions (e.g. Gayton 2008; Johnston et al. 2009). Ensuring that species can respond to environmental change is a priority for much of the forest genetic resources research conducted within Canada (e.g. Berteaux et al. 2010; Genome British Columbia 2012). Furthermore, although it is recognized that landscape-level management of forest genetic resources will ensure the conservation of genetic diversity in some cases, there are forest types occurring over small areas where this approach is not appropriate. Examples include the Carolinian forests of southern Ontario, the southern coastal regions of British Columbia, and forest ecosystems occurring as "outliers" consisting of small and potentially valuable and genetically unique populations (Boyle 2005). For these areas, an approach that relies solely on landscape management and that does not monitor changes below the species level risks the irreversible loss of adaptive potential. The amount of intraspecific genetic variation a species contains, and the distribution of that variation both among and within populations, is important information for ensuring that the appropriate *ex situ* collections are made and for identifying the *in situ* conservation areas for capturing most of the genetic variation (adaptive or selectively neutral variation) within a species (Canadian Council of Forest Ministers 2006).

Tree improvement programs for the major commercial species have led to substantial investments in intraspecific variation studies (see Chapter 5 for a description of jurisdictional tree improvement programs, councils and working groups). Given that there are limited financial resources available, priority species—that is those with official federal or Jurisdictional conservation risk rankings—or those species that are commercially important tend to be the species where much of the effort associated with understanding intraspecific variation is focused.

Priorities for improving the understanding of intraspecific variation have also been directed through the funding agency Genome Canada, a non-profit organization established in 2000. Genome Canada's mandate is to develop and implement a national strategy in genomics research for the benefit of all Canadians in sectors of strategic importance including the forestry sector, in addition to others (e.g., agriculture, fisheries, etc.) (Genome Canada 2012). Genome Canada funding priorities have in part defined and focused on large-scale projects that have included assessment of intraspecific variation in native tree species.

Examples of forestry projects that received Genome Canada funding in the last competition that directly or indirectly address tree species intraspecific variation include *Arborea II: Genomics for Molecular Breeding in Softwood trees. Discovery of Gene Markers to Enhance the Productivity and Value of Spruce through Integrated Functional Genomics and Association Mapping* (Arborea 2010). The goal of this project is to create an inventory of the natural variability and expression of thousands of spruce genes. By identifying specific genes associated with growth and wood quality, the project will develop tools and protocols to make it possible to select well-adapted high-performance spruce trees with better-quality woods. Another recently funded project is *AdapTree: Assessing the Adaptive Portfolio of Reforestation Stocks for Future Climates* (University of British Columbia and University of Alberta)(Genome British Columbia 2012). Scientists are sequencing seedlings to better understand what genes are involved in adaptation to local climate conditions. This will lead to ensuring that the right trees get planted in the right climactic area, improving the long-term health of forests and generating economic benefits.

It is also important to be able to convey information pertaining to intraspecific variation at a national level, as species ranges do not stop at jurisdictional borders. As such, the integration of the various sources of data from the jurisdictions, academia etc. into a common platform, could aid in providing a pan-Canadian perspective, which is important for decision making pertaining to tree species conservation.

<u>1.1.7 (FAO Question 1.8) Capacity Building Needs to Enhance Assessment and Monitoring of Interspecific and Intraspecific Variations</u>

Capacity building needs include stable investments in research to develop methods for assessing interspecific and intraspecific variation and for monitoring this variation. This includes the resources to maintain personnel working in the field and laboratories. Given the global economic situation, long-term financial commitment to programs may be challenging as governments at the jurisdictional and federal levels are exploring ways to reduce their deficits.

British Columbia established a comprehensive program on the management of forest genetic resources that is characterized by excellent research, directly relevant to the major environmental issues facing the forest sector in the province. However, in 2010, the Province of British Columbia announced significant cuts to their public service and its programs. The BCMFLNRO suffered a 23% reduction in their operating fund that has resulted in the loss of personnel and programs (Canadian Centre for Policy Initiatives 2010). These cuts resulted from multiple factors, including a decline in forest revenue, on-going weakness in the U.S. housing market that is having a significant impact on demand for Canadian lumber, and enhanced volatility of global markets (British Columbia Ministry of Finance 2010). Furthermore, these factors affect other jurisdictions, so further budget cuts may occur in the future in other jurisdictions and at the federal level.

Another capacity-building need is the requirement for information management concerning the status of species and distribution and trends in genetic diversity (including inter- and intraspecific variation) in a pan-Canadian context to assist decision making pertaining to the conservation and management of forest genetic resources. Species distributions do not correspond to political boundaries, so there is a need for cooperation and coordination on the management of forest genetic resources. CON**FOR**GEN is a federal–provincial/territorial mechanism that monitors and reports on genetic resources of native tree species in support of Canada's national and international commitments. CON**FOR**GEN includes 22 partners from federal and provincial/territorial government departments (primarily jurisdictional forest genetic resource managers), First Nations, and academia. The Canadian Forest Service and other CON**FOR**GEN members have developed and agreed to adhere to data standards that allow for the integration of federal and jurisdictional data for generating national-level data. This is in part achieved through the knowledge management system CAFGRIS. The purpose of this system is to gather, integrate, and synthesize digital information, thereby generating new knowledge concerning native tree species and threats to these species. CAFGRIS does contain data pertaining to inter- and intraspecific genetic variation of tree species. Continued support of the efforts to populate CAFGRIS with data would assist in developing a resource, thereby contributing to the enhancement of assessments of monitoring of inter- and intra-specific variation in tree species.

1.2. THE MAIN VALUE OF FOREST GENETIC RESOURCES

<u>1.2.1. (FAO Questions 1.9–1.12 and Annex 1.3) The Main Forest Tree Species Actively Managed for Productive Aims or Ecosystem Services</u>

Based on the results of a jurisdictional survey in which Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec and Saskatchewan participated; the following tree species and hybrids were identified as being actively managed for productive aims in their jurisdictions (Table 1.6). Commercial uses included reforestation, silviculture, and Christmas tree production, and other purposes included carbon sequestration, ecosystem preservation, species conservation, land reclamation, resistance trials, species historical value, and the *Trees for Tomorrow* program (helping urban and rural communities plant trees in public spaces, including schoolyards, hospital grounds, civic parks, campuses, parking lots in British Columbia and helping private landowners with afforestation efforts in Manitoba) and as part of the mitigation strategies for addressing the Emerald ash borer (*Agrilus planipenni*) and eastern larch beetle (*Dendroctonus simplex*).

Table 1.6. Main forest tree species actively managed for productive aims or ecosystem services

Species	Commercial purposes: Reforestation	Silviculture	Other purposes: Carbon Sequestration	Ecosystem preservation	Species conservation	Other
Abies amabilis	X	X				
Abies balsamea	X	X		X		Christmas tree production and essential oils
Abies grandis	X	X				
Abies lasiocarpa	X	X				
Abies procera	X	X				
Acer marcrophylum	X	X				
Acer rubrum		X		X		X
Acer saccharum	X	X		X		X
Alnus rubra	X	X				
Betula alleghaniensis	X	X		X		X
Betula neoalaskana		X				Reclamation
Betula papyrifera		X		X		Reclamation
Callitropsis nootkatensis	X	X				
Carya cordiformis					X	
Carya ovata					X	
Celtis occidentalis					X	
Fraxinus Americana	X	X				Urban forestry
Fraxinus nigra	X			X	X	Snow shoes
Fraxinus pennsylvanica				X	X	Emeral ash borer mitigation
Juglans cinerea				X		
Larix laricina	X	X			X	Eastern larch beetle mitigation and reclamation
Larix lyalli				X	X	
Larix occidentalis	X	X			X	
Larix spp.				X		
Ostrya virginiana					X	
Picea abies	X	X				
Picea engelmannii	X	X				
Picea glauca	X	X		X	X	Reclamation
Picea glauca x	X	X				

Engelmanii						
Picea mariana	X	X	X	X		Reclamation
Picea rubens	X	X				X
Picea sitchensis	X	X				
Pinus albicaulis				X	X	
Pinus banksiana	X	X		X		Reclamation
Pinus contorta				X		
Pinus contorta var. *latifolia*	X	X		X		Reclamation
Pinus flexilis				X	X	
Pinus monticola	X	X				
Pinus ponderosa	X	X				
Pinus rigida	X	X	X	X		
Pinus resinosa	X	X		X		X
Pinus strobus	X	X		X		X
Pinus sylvestris				X	X	Historical value
Populus balsamifera	X	X		X		Reclamation
Populus balsimifera x *trichocarpa*	X	X				
Populus deltoides	X			X		Reclamation
Populus grandidentata		X				Reclamation
Populus native hybrids			X			Trees for Tomorrow
Populus non-native hybrids		X				
Populus tremuloides	X	X				Reclamation
Pseudotsuga menziesii var. *menziesii*	X	X				
Pseudotsuga menziesii var. *glauca*	X	X				
Quercus alba				X		
Quercua bicolour			X	X		
Quercus garryanna				X	X	
Quercus macrocarpa	X			X		
Quercus rubra	X	X		X	X	Urban forestry
Salix spp.			X			Trees for Tomorrow
Thuja occidentalis	X	X				X

Thuja plicata	X	X				
Tilia Americana				X		
Tsuga Canadensis	X	X				X
Tsuga heterophylla	X	X				
Ulmus Americana				X	X	Resistance trials
Ulmus rubra				X		

1.2.3 (FAO Question 1.15 and Annex 1.5 – 1.7, 1.11, 1.12) Documented Forest Tree Species Priority-setting Exercises

1.2.3.1 National-level priority setting exercises

(a) Government of Canada

At the federal level, forest tree species priority-setting exercises are addressed through the existing federal policies and procedures for listing a species at risk (endangered, threatened, or of special concern) in Canada. Conservation policy has shifted from protecting the individual species to protecting habitats. Initially, in 1977, the provincial, territorial, and federal governments recognized the requirement for an official, national, science-based body responsible for the classification of Canadian species at risk. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent body of experts (i.e., federal, provincial, and territorial government and non-governmental scientists), was formed to address this need, and it is responsible for assessing and identifying species at risk (Environment Canada 2002b). A species assessment is submitted to and reviewed by COSEWIC, which then determines, based on science, whether the species is at risk. If the species is considered to be at risk, it is assigned to one of five categories: extinct, extirpated, endangered, threatened, or of special concern.

In 1988, the first national recovery program, *Recovery of Nationally Endangered Wildlife*, was established to develop and implement strategies for the recovery of endangered species, and to prevent further deterioration in the condition of threatened species (Environment Canada 2003a). This program included COSEWIC-listed species. Both COSEWIC and the recovery program continue to function and have been incorporated into the Government of Canada's *National Strategy for the Protection of Species at Risk*. This strategy, which covers species and habitats at risk, contains three components: (1) the *National Accord for the Protection of Species at Risk*, which recognizes that cooperation among the various political jurisdictions is essential for protecting species at risk (Environment Canada 1996); (2) the *Habitat Stewardship Program*, a voluntary stewardship and incentive program (Environment Canada 2003b); and (3) the *Species At Risk Act* (SARA), which identifies relevant regulations and orders-in-council (Environment Canada 2002b).

The *National Accord for the Protection of Species at Risk* was the first agreement that committed different levels of government to implementing their own legislation and programs for the protection of species at risk and their habitats. The Accord was signed by all provinces, territories, and the federal government in 1996 (Environment Canada 1996). The Canadian Endangered Species Conservation Council was created under the Accord, with the responsibility for the listing and recovery of species at risk. The Council's contribution to identifying species at risk was reported in *Wild Species 2000: the General Status of Species in Canada* (Canadian Endangered Species Conservation Council 2001). This list ranks over 1600 species, with classifications ranging from "extirpated/extinct" to "not assessed" or "exotic." It was to be used to prioritize conservation efforts; however, it did not include any tree species, not even the tree species listed at that time by COSEWIC or SARA. The second component of the National Strategy is the *Habitat Stewardship Program*, established in 2000 to contribute to the recovery and protection of species listed as endangered, threatened, or of special concern (Environment Canada 2003b). This program allocates funding for COSEWIC threatened and endangered species and their habitats, and for species and habitats in which recovery plans, identified through such programs as the *Recovery of Nationally Endangered Wildlife*, have been produced. This program is currently one of three federal programs that provide funding for work on species at risk.

The third component of the National Strategy deals with protection of these species under the SARA, which was proclaimed in June 2003. Its purpose is to prevent wildlife species from becoming extinct and to provide for their recovery (Environment Canada 2002b). SARA protects species at risk and their habitats. However, it only applies to migratory birds, aquatic species, and species on federal lands. Most land in Canada is Crown or public land under provincial jurisdiction. The Act does include a “safety net" mechanism; where there is federal action if the provinces do not provide protection equivalent to that available under the Act. This “safety net” addresses the protection of remaining habitat and species at risk, and not the steps necessary for species recovery. In addition, use of the “safety net” is discretionary.

The SARA process starts with a species assessment conducted by COSEWIC, which produces a “Status Report” and gives the species a preliminary designation (e.g., extinct, endangered, threatened, species of concern). This is forwarded to Canadian Endangered Species Conservation Council with the recommended designation. A consultation process occurs with the provinces or territories in which the species is found, and with Aboriginal peoples, stakeholders, and the public to determine whether the species should be added to the List of Wildlife Species at Risk. The Minister of the Environment reviews the results of the consultation and makes recommendations to Governor in Council (Governor General of Canada acting by and with the advice and consent of the Queen's Privy Council for Canada), who makes the final decision. Once a species has been listed, a recovery strategy is produced, including an action plan, with timelines, identifying the measures necessary for species recovery.

As signatories of the Accord, all provinces and territories are required to establish complementary legislation and programs for the protection of species at risk, including forest tree species. Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Ontario and Quebec have Endangered Species Acts, and the Alberta, British Columbia, Prince Edward Island, Saskatchewan and Yukon Territory have amended existing Wildlife Acts to include species at risk**.** Nunavut is in the process of modifying its existing Wildlife Act. In addition, British Columbia’s *Forest and Range Practices Act*, which took effect in 2004, provides some protection in areas where forest and range licensees operate (BCMFR 2004). It should be noted that there is substantial variation in the types of legislation and in their implementation. For example, not all provinces and territories have programs in place for the protection of species at risk (e.g., requirement for a recovery plan and implementation of plan, effective enforcement for protection of species or habitat).

Canada’s *National Strategy for the Protection of Species at Risk* illustrates the commitment of the federal, provincial, and territorial governments to conserve species at risk and their habitats. Although tree species at risk of extinction throughout their Canadian range are addressed by the National Strategy, specifically SARA, species at risk in specific jurisdictions are addressed by many provinces.

At the federal level, a species priority-setting process that includes tree species is conducted by COSEWIC at least once a year (COSEWIC 2011) (Table 1.7). Wild Species Canada produces reports every 5 years on the general status of species in Canada as a requirement of the *Accord for the Protection of Species at Risk*. This report is a general status assessment for a large number of native species in Canada, including tree species (Table 1.8). The Wild Species report serves as the basis to fulfill a requirement under the *Species at Risk Act of Canada* that stipulates in section 128 that "five years after this section comes into force and at the end of each subsequent period of five years, the Minister must prepare a general report on the status of wildlife species" (Environment Canada 2002a). The first report was tabled in Parliament in 2008. Reports from the Wild Species series, thereafter, continue to serve as the basis to fulfill this requirement (Environment Canada 2009).

(b) CON**FOR**GEN **survey**

CON**FOR**GEN was created in 2006 in response to a need for concerted and coordinated effort to conserve species and populations across jurisdictional boundaries before they receive official risk designations (CON**FOR**GEN 2010). “Silent extinctions” associated with loss of genetically distinct populations, or loss of locally adapted gene complexes, are not considered in federal or provincial legislation, yet may have devastating consequences for tree species faced with increasing environmental change. In addition, many of the reasons for designating a tree species as being of concern (i.e., preferred habitat of the species in demand for other uses, and harvesting practices that prevent regeneration)—and many of the drivers for these reasons (e.g., land-use change caused by extensive human development and activity)—are not under the jurisdiction of the federal government. Thus, there are multi-jurisdicational challenges, involving federal, provincial, territorial, and municipal governments that can result in disparate and fragmented conservation efforts.

CON**FOR**GEN undertakes a priority-setting exercise to assess conservation needs of native tree species through a national-level survey and provides species-specific conservation recommendations, based on species biology and species-specific threats (CON**FOR**GEN 2010)(Table 1.9). The purpose of this survey was not to duplicate on-going conservation efforts, but to provide a national perspective on the need for the genetic conservation of tree species across the country, determine how these species' needs are presently being met, and identify what areas need more work. This survey was conducted in 2003 in order to identify native tree species (woody perennial ≥10 m tall) that may be in need of genetic conservation (Beardmore et al. 2005). Respondents from provinces, territories, academia, and Conservation Data Centres were asked to rank the tree species in their respective geographic regions based on a criteria score that assessed nine potential reasons for conservation (e.g., species rarity, uncertain seed source, etc.) and then to provide a rating score, which identified the type of conservation that may be required (species is in good shape, insufficient knowledge for a designation, *in situ* or *ex situ* conservation measures are required). Results of the survey are presented in Table 1.15. This survey will be conducted again in 2012.

(c) NatureServe Canada

NatureServe Canada also has a priority-setting process where information is collected from multiple sources, including the Conservation Data Centres (CDCs) of the Natural Heritage Information Centres of NatureServe Canada and from naturalists, museum specialists, provincial, territorial, and federal wildlife departments, to generate information that pertains to species biology, threats to the species, and species abundance (NatureServe Canada 2011a) (results not presented). The CDCs conduct annual inventories in order to identify and document populations of rare species, study ecological communities, and recommend analysis on conservation issues. The priority conservation assessments are made using a suite of factors, and these assessments result in a conservation status rank for each species that is assessed. The purpose of these priority-setting exercises is to help guide conservation action and natural resource management (NatureServe Canada 2011b).

All tree species native to Canada have ranges that cross into the United States, and a few cross into Mexico. An advantage of NatureServe is that status is assessed and documented at three distinct geographic scales: global (G), national (N), and state/province (S), and as such, the information is relevant across political borders and provides wider species range conservation information pertaining to Canada, the USA, and Mexico (NatureServe 2011b).

It should be noted that there are no national-level priority setting exercises for identifying tree species for sustainable use and development. Jurisdictional management plans and strategies identify priority species for this purpose (e.g. Nova Scotia Department of Natural Resources 2011; Government of Newfoundland and Labrador 2003, Ontario Ministry of Natural Resources 2009; Saskatchewan Ministry of the Environment 2007). Criteria for selecting species varies by jurisdiction but typically is based on managing forests as complete ecosystems that provide a number of services beyond timber production.

Table 1.7. Tree species with official federal risk designation based on the *Species at Risk Act* (SARA)

Species at Risk	COSEWIC Ranking[1]	SARA Ranking[2]	Jurisdiction identified as being at risk	Species' Natural Range in Canada
Betula lenta	Endangered	Endangered	Ontario	Ontario
Juglans cinerea	Endangered	Endangered	Ontario	Ontario, Quebec, New Brunswick
Castanea dentata[3]	Endangered, Threatened	Endangered	Ontario	Ontario
Cornus florida	Endangered	Endangered	Ontario	Ontario
Morus rubra	Endangered	Endangered	Ontario	Ontario

Pinus albicaulis	Endangered	No Status Assigned	British Columbia, Alberta	British Columbia, Alberta
Magnolia acuminata	Endangered	Endangered	Ontario	Ontario
Gymnocladus dioicus	Threatened	Threatened	Ontario	Ontario
Ptelea trifoliata[4]	Threatened, Special Concern	Special Concern	Ontario	Ontario
Fraxinus quadrangulata	Special Concern	Special Concern	Ontario	Ontario
Quercus shumardii	Special Concern	Special Concern	Ontario	Ontario

1. Data collected from COSEWIC's Wildlife Species Search: http://www.cosewic.gc.ca/eng/sct1/index_e.cfm Accessed July 2011.
2. Data collected from SARA's A to Z species index http://www.sararegistry.gc.ca/sar/index/default_e.cfm Accessed July 2011. However, the schedule numbers are inconsistent.
3. *Castanea dentata* is designated as **endangered** under Schedule 1, Part 2 and **threatened** under Schedule 2, Part 2.
4. *Ptelea trifoliata* is designated as **threatened** under Schedule 1, Part 3 and **of special concern** under Schedule 3.

Table 1.8. Tree and woody perennial species assessed as being at risk by Wild Species Canada[1]

Wild Species Canada Listings	National ranking (2005)[2]	National ranking (2010)[3]	Jurisdiction where species is at risk and species risk designation in 2010
Abies balsamea	Green		Sensitive in Nunavut. Undetermined in British Columbia.
Aesculus glabra	Orange		May be at risk in Ontario.
Alnus serrulata	Yellow		May be at risk in Ontario, Quebec. Sensitive in New Brunswick, Nova Scotia.
Amelanchier bartramiana	Green		May be at risk in Nunavut.
Amelanchier fernaldii	Orange	Undetermined	Undetermined in Quebec, Nova Scotia, Prince Edward Island. May be at risk in New Brunswick, Newfoundland.
Amelanchier nantucketensis	Orange		May be at risk in Nova Scotia.
Asimina triloba	Yellow		Sensitive in Ontario.
Betula glandulosa	Green		May be at risk in New Brunswick, Nova Scotia.
Betula lenta	Orange	Red	At risk in Ontario.
Betula minor	Green		May be at risk in Ontario. Sensitive in New Brunswick, Nova Scotia.
Betula neoalaskana	Green		May be at risk in Nunavut, Ontario.
Betula occidentalis	Green		Sensitive in Ontario. Undetermined in Nunavut.
Betula papyrifera	Green		Not assessed in Nunavut.
Betula pumila	Green		Sensitive in Yukon, Northwest Territories, Nova Scotia, Prince Edward Island. Not assessed in Nunavut.
Carya laciniosa	Yellow		Sensitive in Ontario.
Carya ovata	Green		Sensitive in Quebec.
Castanea dentata	Red		At risk in Ontario.
Ceanothus americanus	Green		May be at risk in Quebec.
Ceanothus herbaceous	Green		May be at risk in Quebec. Sensitive in Manitoba.
Celtis occidentalis	Green		At risk in Manitoba. Sensitive in Quebec.
Celtis tenuifolia	Red		At risk in Ontario.
Cephalanthus occidentalis	Green		Sensitive in New Brunswick, Nova Scotia.
Cornus alternifolia	Green		Sensitive in Manitoba, Newfoundland.
Cornus florida	Orange	Red	At risk in Ontario.
Cornus obliqua	Green		Sensitive in New Brunswick.

Cornus racemosa	Green		Sensitive in Manitoba, Quebec.
Cornus rugosa	Green		Sensitive in Manitoba. May be at risk in Prince Edward Island.
Cornus unalaschkensis	Green		Sensitive in Yukon. Undetermined in Alberta.
Corylus americana	Green		May be at risk in Quebec.
Crataegus apiomorpha	Orange	Undetermined	May be at risk in Ontario. Undetermined in Quebec.
Crataegus ater	Orange	Undetermined	Undetermined in Ontario.
Crataegus brainerdii	Orange		May be at risk in Ontario, Quebec.
Crataegus chrysocarpa	Green		Undetermined in Prince Edward Island. May be at risk in Newfoundland.
Crataegus compta	Orange	Undetermined	Undetermined in Ontario.
Crataegus corusca	Orange	Undetermined	Undetermined in Ontario.
Crataegus crus-galli	Green		May be at risk in Quebec. Exotic in Nova Scotia.
Crataegus dilatata	Orange	Undetermined	Undetermined in Ontario. May be at risk in Quebec.
Crataegus disperma	Orange	Undetermined	Undetermined in Ontario.
Crataegus dissona	Yellow		Sensitive in Ontario.
Crataegus douglasii	Green		May be at risk in Saskatchewan. Undetermined in Manitoba.
Crataegus flabellata	Green		Sensitive in Nova Scotia.
Crataegus fulleriana	Orange		May be at risk in Ontario.
Crataegus grandis	Orange	Undetermined	Undetermined in Ontario.
Crataegus jonesiae	Orange	Undetermined	May be at risk in New Brunswick. Undetermined in Nova Scotia.
Crataegus macrosperma	Green		Undetermined in Quebec, New Brunswick. May be at risk in Newfoundland.
Crataegus perjucunda	Orange	Undetermined	Undetermined in Ontario.
Crataegus persimilis	Orange	Undetermined	Undetermined in Ontario.
Crataegus scabrida	Green		Sensitive in Ontario, New Brunswick. Undetermined in Quebec.
Crataegus submollis	Green		Sensitive in New Brunswick. Undetermined in Nova Scotia.
Crataegus suborbiculata	Orange		May be at risk in Ontario, Quebec.
Crataegus succulenta	Green		May be at risk in Saskatchewan. Sensitive in New Brunswick. Undetermined in Quebec, Nova Scotia, Prince Edward Island.
Dirca palustris	Green		May be at risk in New Brunswick, Nova Scotia.
Elaeagnus commutata	Green		Undetermined in Nunavut. May be at risk in Quebec.
Fraxinus nigra	Green		May be at risk in Prince Edward Island. Sensitive in Manitoba, New Brunswick, Newfoundland.
Fraxinus pennsylvanica	Green		May be at risk in Alberta, Nova Scotia. Exotic in Prince Edward Island.
Fraxinus profunda	Orange		May be at risk in Ontario.

Fraxinus quadrangulata	Yellow		Sensitive in Ontario.
Gleditsia triacanthos	Orange		May be at risk in Ontario. Exotic in Nova Scotia, Prince Edward Island.
Gymnocladus dioicus	Red		At risk in Ontario.
Hamamelis virginiana	Green		Sensitive in Quebec. May be at risk in Prince Edward Island.
Juglans cinerea	Red		At risk in Ontario, New Brunswick. May be at risk in Quebec. Considered an exotic in Manitoba, Nova Scotia, Prince Edward Island.
Juniperus horizontalis	Green		Sensitive in Nunavut. May be at risk Prince Edward Island.
Juniperus scopulorum	Green		May be at risk in Saskatchewan.
Juniperus virginiana	Green		May be at risk in Quebec.
Larix occidentalis	Green		May be at risk in Alberta.
Lonicera oblongifolia	Green		May be at risk in Saskatchewan. Sensitive in New Brunsick.
Magnolia acuminata	Red		At risk in Ontario.
Morus rubra	Red		At risk in Ontario.
Nyssa sylvatica	Yellow		Sensitive in Ontario.
Ostrya virginiana	Green		May be at risk in Manitoba, Prince Edward Island.
Picea rubens	Green		Sensitive in Ontario.
Pinus albicaulis	Green	Yellow	Sensitive in British Columbia. May be at risk in Alberta.
Pinus banksiana	Green		Sensitive in Nunavut, British Columbia, Prince Edward Island. May be at risk in Newfoundland.
Pinus flexilis	Yellow		Sensitive in British Columbia. May be at risk in Alberta.
Pinus resinosa	Green		May be at risk in Manitoba, Newfoundland. Sensitive in Prince Edward Island.
Pinus rigida	Orange		May be at risk in Ontario. At risk in Quebec. Considered an exotic in Nova Scotia.
Pinus strobus	Green		May be at risk in Manitoba. Sensitive in Newfoundland.
Populus angustifolia	Yellow		May be at risk in Saskatchewan. Sensitive in Alberta.
Populus balsamifera	Green		Sensitive in Prince Edward Island.
Populus deltoides	Green		Sensitive in Alberta. Exotic in British Columbia.
Populus grandidentata	Green		May be at risk in Manitoba.
Populus tremuloides	Green		May be at risk in Nunavut.
Ptelea trifoliata	Red		At risk in Ontario. Considered an exotic in Quebec.
Quercus alba	Green		Sensitive in Quebec.
Quercus bicolor	Green		May be at risk in Quebec. Exotic in Nova Scotia.
Quercus ellipsoidalis	Yellow		Sensitive in Ontario. Undetermined in Manitoba.
Quercus ilicifolia	Orange		May be at risk in Ontario.
Quercus macrocarpa	Green		Undetermined in Alberta. May be at risk in New Brunswick.
Quercus palustris	Yellow	Green	

Quercus prinoides	Orange		May be at risk in Ontario.
Quercus shumardii	Yellow		Sensitive in Ontario.
Rhododendron lapponicum	Green		Sensitive in British Columbia, Alberta. May be at risk in Manitoba, Nova Scotia.
Rhus aromatica	Green		At risk in Quebec.
Rhus glabra	Green		Extirpated from Quebec. May be at risk in Saskatchewan.
Rhus typhina	Green		May be at risk in Prince Edward Island.
Salix alaxensis	Green		May be at risk in Manitoba. Sensitive in British Columbia, Alberta, Quebec.
Salix amygdaloides	Green		May be at risk in British Columbia. Sensitive in Alberta, Quebec. Not assessed in Saskatchewan.
Salix arbusculoides	Green		May be at risk in Ontario, Quebec. Sensitive in Manitoba.
Salix arctica	Green		Sensitive in Ontario. Not assessed in Saskatchewan.
Salix arctophila	Green		May be at risk in Yukon, Saskatchewan.
Salix athabascensis	Green		Sensitive in Yukon, British Columbia, Albeta, Manitoba. Undetermined in Saskatchewan.
Salix ballii	Yellow		May be at risk in Nunavut, Ontario. Sensitive in Quebec, Newfoundland.
Salix bebbiana	Green		Sensitive in Nunavut.
Salix boothii	Green		Sensitive in British Columbia.
Salix brachycarpa	Green		Sensitive in Nunavut, Manitoba, Quebec. Not assessed in Yukon.
Salix calcicola	Green		May be at risk in Alberta. Sensitive in Manitoba.
Salix candida	Green		May be at risk in Nova Scotia, Prince Edward Island. Sensitive in Yukon, Nunavut, New Brunswick.
Salix chamissonis	Yellow		Sensitive in Yukon, Northwest Territories.
Salix chlorolepis	Orange	Red	At risk in Quebec.
Salix commutata	Green		Sensitive in Yukon, Northwest Territories, Alberta.
Salix cordata	Green		Sensitive in Quebec, Newfoundland.
Salix fuscescens	Green		May be at risk in Manitoba.
Salix herbacea	Green		May be at risk in Manitoba.
Salix jejuna	Red		At risk in Newfoundland.
Salix lemmonii	Orange		May be at risk in British Columbia.
Salix lutea	Green		May be at risk in Ontario.
Salix maccalliana	Green		May be at risk in Yukon, Quebec. Sensitive in Ontario.
Salix myricoides	Green		Sensitive in Nunavut, Ontario. Undetermined in Newfoundland.
Salix myrtillifolia	Green		May be at risk in New Brunswick, Newfoundland. Sensitive in Nunavut.
Salix nigra	Green		Sensitive in New Brunswick.
Salix pedicellaris	Green		May be at risk in Yukon. Sensitive in Nova Scotia, Newfoundland.
Salix petiolaris	Green		May be at risk in Prince Edward Island. Sensitive in Northwest Territories, British Columbia. Undetermined in Newfoundland.
Salix pseudomonticola	Green		May be at risk in Quebec. Sensitive in Ontario.
Salix pyrifolia	Green		May be at risk in Yukon. Undetermined in Saskatchewan.
Salix raupii	Orange		May be at risk in Yukon. Northwest Territories, British Columbia, Alberta.
Salix reticulata	Green		May be at risk in Saskatchewan, Nova Scotia. Sensitive in Manitoba, Newfoundland.

Salix sericea	Green		Sensitive in Quebec. May be at risk in Nova Scotia.
Salix serissima	Green		May be at risk in New Brunswick, Newfoundland. Sensitive in British Columbia.
Salix sessilifolia	Yellow		Sensitive in British Columbia.
Salix setchelliana	Yellow		Sensitive in Yukon, British Columbia.
Salix silicicola	Orange	Yellow	May be at risk in Nunavut. At risk in Saskatchewan.
Salix sitchensis	Green		May be at risk in Alberta.
Salix sphenophylla	Orange		May be at risk in Yukon, Northwest Territories.
Salix stolonifera	Green		May be at risk in Alberta.
Salix tweedyi	Yellow		Sensitive in British Columbia.
Salix uva-ursi	Green		May be at risk in Nova Scotia.
Salix vestita	Green		May be at risk in Nunavut, Nova Scotia. Sensitive in Manitoba.
Shepherdia canadensis	Green		Sensitive in Nunavut, Nova Scotia, New Brunswick.
Sorbus decora	Green		Undetermined in Prince Edward Island.
Sorbus scopulina	Green		May be at risk in Saskatchewan. Sensitive in Yukon, Northwest Territories.
Taxus brevifolia	Green		Sensitive in Alberta.
Taxus canadensis	Green		Sensitive in Manitoba, Newfoundland
Thuja occidentalis	Green		At risk in Nova Scotia. Sensitive in Prince Edward Island.
Thuja plicata	Green		May be at risk in Alberta.
Tsuga heterophylla	Green		Sensitive in Alberta.
Ulmus americana	Green		Sensitive in Prince Edward Island.
Ulmus rubra	Green		Sensitive in Quebec.
Ulmus thomasii	Green		At risk in Quebec.
Viburnum acerifolium	Green		May be at risk in New Brunswick.
Viburnum edule	Green		Sensitive in Nunavut, Nova Scotia.
Viburnum lantanoides	Green		May be at risk in Prince Edward Island.
Viburnum lentago	Green		May be at risk in Saskatchewan.
Viburnum recognitum	Green		May be at risk in Quebec.

1. Note: bold text denotes tree species defined as ≥10 m in height.
2. Data from the Wild Species series represent the most comprehensive look at the state of Canada's species and contain the general status assessments for a broad cross-section of species, from all provinces, territories, and ocean regions. Originating from the collaboration of all provincial and territorial governments in Canada and the federal government, reports from the Wild Species series represent a huge accomplishment that summarizes the monitoring efforts of species in the country. The Wild Species reports are released every 5 years. The general national status rank per species is assigned by reviewing the ranks and associated information received from the provinces and territories. Where ranks vary across the country, the regional rank that represents the lowest level of risk is used as the national rank for Canada. However, a species' geographic distribution is also taken into account so that a region harboring the majority of a species' range carries more weight in determining the national rank than a region where the species is only marginally represented. Taken from *Regional to National General Status Assessments*, http://www.wildspecies.ca/wildspecies2010/data-regnat.cfm?lang=e Accessed July 2011.
3. The changes in status were listed only if they differed from the 2005 status. Source: Canadian Endangered Species Conservation Council (CESCC). 2011.

Table 1.9. Tree species of concern as identified by the CONFORGEN survey: system used to list species in need of conservation first by (a) descriptive criteria and then by (b) rating values

(a) Criteria	Description
1	Species rarity is a concern
2	There is no or an uncertain viable seed source
3	There is a serious threat from an exotic disease or insect
4	There is a serious threat as a result of environmental change
5	Certain harvesting practices prevent the regeneration of the species
6	The range or frequency of the species is substantially decreasing
7	The preferred habitat of the species is in high demand for other uses
8	There is a high demand for the species for a special purpose
9	The species is threatened because of hybridization or introgression
(b) Rating Value	**Description**
0	The species is considered to be in good shape with no apparent cause for concern
1	The species may need attention, but current knowledge is inadequate due to: (a) insufficient data (b) direct evidence of a potential problem (c) indirect evidence of a potential problem
2	The species requires *in situ* conservation
3	Specific gene conservation measures (*ex situ*) are required to ensure the integrity of the native gene pool

[1] Adapted from Beardmore et al. (2005).

Table 1.10. Native trees of Canada and conservation requirements based on a national survey conducted in 2003[1]

Genus	Common names	No. of species	No. of species in need of conservation	Species' names (rating values (RV) in brackets)[2]
Conifers				
Abies	Fir	4	1	*amabillis, balsamea, grandis* (2), *lasiocarpa*
Callitropsis	Cypress	1	0	*nootkatensis*
Juniperus	Juniper	2	2	*Virginiana* (2*), scopulorum* (2)
Larix	Larch	3	2	*laricina* (1,2), *lyallii* (1), *occidentalis* (3)
Picea	Spruce	5	1	*engelmannii, glauca, mariana, rubens (*3), *sitchensis*
Pinus	Pine	9	7	*albicaulis* (3), *banksiana* (2,3), *contorta, flexilis* (2,3), *monticola* (3), *ponderosa, resinosa* (3), *rigida* (2), *strobus* (3)
Pseudotsuga	Douglas-fir	1	0	*menziesii* [var. *menziesii*, var.

				glauca]
Taxus	Yew	1	1	*brevifolia (2)*
Thuja	Cedar	2	2	*occidentalis* (3), *plicata* (3)
Tsuga	Hemlock	3	2	*canadensis* (1a,2), *heterophylla* (3), *mertensiana*
Summary Totals		10 genera; 31 species	8 genera (80%); 18 species (58%)	RV of 1 or 1a: 1 species RV of 2: 7 species RV of 3: 11 species
Hardwoods				
Acer	Maple	10	1	*circinatum, glabrum, macrophyllum, negundo* (1a,2) [var. *negundo* (1a), var. *violaceum* (1a)], *nigrum, rubrum, pensylvanicum, saccharinum, saccharum, spicatum*
Aesculus	Buckeye	1	0	*Glabra*
Alnus	Alder	4	0	*rubra, rugosa,* [syn. *incana* ssp. *rugosa*], *sinuata* [syn. *viridis* ssp. *sinuata*], *incana* ssp. *tenuifolia* (syn. *tenuifolia*)
Arbutus	Arbutus	1	1	*menziesii* (1a,2)
Asimina	Pawpaw	1	1	*triloba* (2,3)
Betula	Birch	8	3	*alleghaniensis* (3), *cordifolia* (1a), *lenta* (3), *lutea, neoalaskana, occidentalis* (3), *papyrifera* (1a), *populifolia*
Carpinus	Blue beech	1	1	*caroliniana* (2)
Carya	Hickory	4	3	*cordiformis, glabra* [var. *odorata* (3)], *laciniosa* (2,3), ovata (2)
Castanea	Chestnut	1	1	*dentata* (3)
Celtis	Hackberry	1	1	*occidentalis* (2)
Cercis	Redbud	1	0	*canadensis*[3]
Cornus	Dogwood	3	1	*alternifolia* (2,3), *florida, nuttallii* (1a)
Crataegus	Hawthorns	4	0	*crus-galli* (1a), *coccinea* (1a), *douglasii* (1a), *mollis*
Fagus	Beech	1	1	*Grandifolia* (3)
Fraxinus	Ash	5	5	*americana* (3), *nigra* (3), *pennsylvanica* (3), *profunda* (3), *quadrangulata* (3)
Gleditsia	Honey Locust	1	1	*triacanthos* (3)
Gymnocladus	Kentucky Coffee-tree	1	1	*dioicus* (3)
Hamamelis	Witch Hazel	1	1	*virginiana* (2,3)
Juglans	Walnut	2	2	*cinerea* (3), *nigra* (3)
Liriodendron	Tulip-tree	1	1	*tulipifera* (3)
Magnolia	Cucumber tree	1	1	*acuminate* (3)

Malus	Wild Apple	2	0	*coronaria, fusca*
Morus	Mulberry	1	1	*rubra* (3)
Nyssa	Black gum	1	1	*sylvatica* (3)
Ostrya	Ironwood	1	0	*Virginiana*
Plantanus	Sycamore	1	0	*occidentalis*
Populus	Poplar	6	4	*augustifolia* (1a,2), *balsamifera* (1a,2), *deltoids* (2,3) [ssp. *deltoids* (2,3), ssp. *occidentalis* (2,3)], *grandidentata* (3), *tremuloides, trichocarpa*
Prunus	Cherry	6	1	*americana, emarginata, nigra* (3), *pensylvanica*, *serotina* (1a), *virginiana* [var. *virginiana* (1a)]
Ptelea	Hop-tree	1	1	*trifoliata* (2)
Quercus	Oak	11	10	*alba* (2), *bicolor* (2), *ellipsoidalis* (2,3), *garryana* (2,3), *macrocarpa* (1a, 3), *muehlenbergii* (3), *palustris* (2,3), *prinoides* (2,3), *rubra* (3), *shumardii* (2,3), *velutina* (1a)
Rhamnus	Buckthorn	1	0	*purshiana*
Salix	Willow (trees only)	2	2	*amygdaloides* (3), *nigra* (3)
Sambucus	Elder	2	0	*cerulean, glauca*
Sassafras	Sassafras	1	0	*Abidum*
Sorbus	Mountain Ash	2	0	*americana, decora* (1a)
Tilia	Basswood	1	1	*americana* (1a,2)
Ulmus	Elm	3	3	*americana* (3), *rubra* (3), *thomasii* (2)
	Summary totals:	37 genera 95 species	26 genera (70%) 49 species (52%)	RV of 1a[4]: 9 species, 3 varieties RV of 2[4]: 12 species, 0 varieties RV of 3[4]: 37 species, 3 varieties

1. Adapted from Beardmore et al. (2005).
2. Rating values refer to the highest score for the species within its range in Canada. Those species listed without a number in brackets received either a rating of 0 (species is considered to be in good shape) or no rating was given, so the assumption was made that there is no concern for this species.
3. This species is most likely extirpated.
4. Only the highest RV for a species is considered for these summary values.

1.2.3.2 Jurisdictional- and regional-level priority-setting exercises

At the jurisdictional level, most provinces and territories also have priority-setting exercises for assessing tree species vulnerabilities (Table 1.10 and 1.11). The criteria used to rank species (as identified in Table 1.11 under threat level) are fairly consistent across the jurisdictions (see Table 1.12 for a description of the different risk categories).

NatureServe Canada includes eight independent regional CDCs that cover all ten provinces and the Yukon Territory (NatureServe Canada 2007). The CDCs conduct biological inventories to find and document populations of rare species, study and classify ecological communities, analyze critical conservation issues, provide customized information products and conservation services, and make their data widely available to the public via the Internet. Each CDC serves as a clearinghouse for reliable and current scientific information about plants, animals, and ecological communities within its respective jurisdiction, and information is collated to provide national-level perspectives through NatureServe Canada (see above). The CDC rankings are not present herein.

Table 1.11. Jurisdictional species at risk

Jurisdiction	**Species at risk (Tree species defined as ≥10 m are in bold font)**	**Threat Level**
Newfoundland	None	-
Prince Edward Island	None	-
Nova Scotia[1]	***Thuja occidentalis***[2,3]	Vulnerable[1], Red[4]
	General Status of NS species:[4]	
	Fraxinus pennsylvanica	Red
	Fraxinus nigra	Yellow
	Amelanchier nantucketensis	Red
	Toxicodendron vernix	Red
	Salix vestita	Red
	Salix uva-ursi	Red
	Salix reticulata spp. reticulata	Red
	Salix reticulata	Red
	Salix glauca ssp. callipcerpaea	Red
	Salix glauca	Red
	Salix candida	Red
	Betula nana	Yellow
	Betula pumila	Yellow
	Rhamnus alnifolia	Yellow
	Shepherdia canadensis	Yellow
	Viburnum edule	Yellow
	Crataegus flabellata	Yellow
	Salix sericea	Yellow
	Salix pedicellaris	Yellow
	Cephalanthus occidentalis	Yellow
	Crataegus succulenta	Undetermined
	Amelanchier fernaldii	Undetermined
	Crataegus jonesiae	Undetermined
	Crataegus robinsonii	Undetermined
	Crategeus submollis	Undetermined
New Brunswick	None	None
Quebec[9, 10]	***Ulmus thomasii***[5]	Threatened
	Pinus rigida[6]	Threatened
	Salix chloropolepis[7]	Threatened
	Rhus aromatica[8]	Vulnerable
	Species listed in the Quebec Biodiversity Atlas (2005):[9]	
	Acer nigrum	Likely to be designated
	Celtis occidentalis	Likely to be designated
	Quercus alba	Likely to be designated
	Quercus bicolor	Likely to be designated
	Alnus serrulata	Likely to be designated
	Amelanchier sanguinea var. *grandiflora*	Likely to be designated
	Arctous rubra	Likely to be designated

	Ceanothus americanus	Likely to be designated
	Ceanothus herbaceus	Likely to be designated
	Corylus americana	Likely to be designated
	Crataegus brainerdii	Likely to be designated
	Crataegus crus-galli	Likely to be designated
	Crataegus dilatata	Likely to be designated
	Crataegus pruinosa var. *pruinosa*	Likely to be designated
	Crataegus suborbiculata	Likely to be designated
	Elaeagnus commutata	Likely to be designated
	Juniperus virginiana var. *virginiana*	Likely to be designated
	Rhus glabra	Likely to be designated
	Salix arbusculoides	Likely to be designated
	Salix maccalliana	Likely to be designated
	Salix pseudomonticola	Likely to be designated
	Toxicodendron vernix	Likely to be designated
	Viburnum recognitum	
Ontario[11]	***Castanea dentata***	Endangered
	Juglans cinerea	Endangered
	Betula lenta	Endangered
	Magnolia acuminata	Endangered
	Cornus florida	Endangered
	Morus rubra	Endangered
	Celtis tenuifolia	Threatened
	Gymnocladus dioicus	Threatened
	Ptelea trifoliata	Threatened
	Fraxinus quadrangulata	Special Concern
	Quercus shumardii	Special Concern
Manitoba[12]	***Celtis occidentalis***	Threatened
Saskatchewan[13]	None	None
Alberta[14]	***Pinus flexilis***	Endangered
	Pinus albicaulis	Endangered
British Columbia[15]	***Juniperus maritime (new species)***	Blue
	Salix amygdaloides	Red
	Salix lemmonii	Red
	Salix raupii	Red
	Salix reticulata ssp. *glabellicarpa*	Red
	Pinus albicaulis	Blue
	Pinus flexilis	Blue
	Salix boothii	Blue
	Salix petiolaris	Blue
	Salix serissima	Blue
	Salix tweedyi	Blue
	Salix setchelliana	Blue
Yukon Territory[16]	None	None
Northwest Territories[17]	**Species listed in NT's General Status Ranking Program:** [18]	
	Prunus virginiana	May be at risk
	Salix ovalifolia var. *arctolitoralis*	May be at risk
	Salix raupii	May be at risk
	Salix sphenophylla	May be at risk
	Pinus contorta	Undetermined
	Betula pumila	Sensitive

	Salix chamissonis *Salix commutata* *Salix petiolaris*	Sensitive Sensitive Sensitive
Nunavut[19]	None	None

1. *Nova Scotia Endangered Species Act.* Government of Nova Scotia, Department of Natural Resources. Species at Risk Recovery and Conservation: Species at Risk Conservation. [online] URL: http://www.gov.ns.ca/natr/wildlife/biodiversity/species-recovery.asp Accessed June 2011.
2. Newell (2005)
3. Lemieux (2010).
4. Government of Nova Scotia, Department of Natural Resources. General Status Ranks of Wild Species of Nova Scotia. [online] URL: http://www.gov.ns.ca/natr/wildlife/genstatus/ Accessed June, 2011.
5. Translated from: Dèveloppement durable, Environnement et Parcs. *Orme liege*. [online] URL: http://www.mddep.gouv.qc.ca/biodiversite/especes/orme-liege/index.htm Accessed June, 2011.
6. Translated from: Developpement durable, Environnement et Parcs. *Pin rigide*. [online] URL: http://www.mddep.gouv.qc.ca/biodiversite/especes/pin-rigide/index.htm Accessed June, 2011.
7. Translated from: Dèveloppement durable, Environnement et Parcs. *Saule a bractee vertes.* http://www.mddep.gouv.qc.ca/biodiversite/especes/saule/saule.htm Accessed June, 2011.
8. Translated from : Dèveloppement durable, Environnement et Parcs. *Sumac aromatique variété aromatique*. http://www.mddep.gouv.qc.ca/biodiversite/especes/sumac/sumac.htm Accessed June, 2011.
9. The *Quebec Biodiversity Atlas: Threatened or Vulnerable Species* analyzed 17 years worth of CDC data on Quebec's threatened or vulnerable species. The report also lists many tree and shrub species whose occurrence in the province are few and far between, and that these species will likely be designated 'at risk' in the very near future.
10. Species listed under Quebec's R*especting Ecological Reserves Act.*
11. Species designated under Ontario's *Endangered Species Act.*
12. Species listed under Manitoba's *Endangered Species Act*.
13. Species listed under Saskatchewan's *Wildlife Act*
14. Species listed under Alberta's *Wildlife Act*
15. Species at risk are administered under British Columbia's *Wildlife Act*
16. Some wildlife (fauna) species at risk are administered under Yukon's *Wildlife Act*
17. Species at risk in Northwest Territories are designated under the NT's *Species at Risk (NT) Act*
18. NT Species 2006-2010: General Status Ranks of Wild Species in the Northwest Territories. [online] URL: http://www.enr.gov.nt.ca/_live/documents/content/NT_Species2006.pdf Accessed June, 2011.
19. Nunavut species at risk are administered under the territory's *Wildlife Act*

Table 1.12. Jurisdictional species at risk categories and definitions

Jurisdiction	Species at Risk Definition
Newfoundland and Labrador[1,2]	**Endangered:** A wildlife species facing imminent extirpation or extinction. **Threatened:** A wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction. **Vulnerable:** A wildlife species that has characteristics that make it particularly sensitive to human activities or natural events (equivalent to COSEWIC's designation of Special Concern). **General Species Ranks[3]** **Extinct/Extirpated:** Extinct species no longer exist on Earth. Extirpated native species are no longer present in Newfoundland or Labrador, but exist elsewhere. **At Risk:** Native species determined to be at risk of extirpation or extinction. COSEWIC uses the terms endangered or threatened to identify this rank. **May Be at Risk:** Native species may be at risk of extirpation or extinction and are therefore candidates for a detailed risk assessment and research priority. **Sensitive:** Native species are not immediately at risk of extirpation or extinction, but are sensitive to exploitation or habitat loss and may require special attention or protection to prevent them from becoming at risk. **Secure:** Native species are not at risk or sensitive. This category includes species that show a decline in numbers but remain relatively abundant. **Undetermined:** Species are known to occur in Newfoundland or Labrador, but information, knowledge, or data are

	insufficient to reliably evaluate their general status. **Not Assessed:** Species are known to occur in Newfoundland or Labrador, but no assessment has been carried out. **Exotic/Alien:** Species have been introduced as a result of human activity. **Accidental/Vagrant:** Species occur infrequently and unpredictably outside their usual range.
Prince Edward Island[4]	**Endangered species:** A species of wildlife is threatened with imminent extinction. **Threatened species:** A species of wildlife is likely to become endangered if the factors affecting its vulnerability are not reversed. **Species of special concern:** A species of wilidfe is of special concern due characteristics that make it particularly sensitive to human activities or natural events.
Nova Scotia[5,6]	**Endangered**: A species facing imminent extirpation or extinction. **Threatened**: A species likely to become endangered if limiting factors are not reversed. **Vulnerable:** A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events. **Extirpated:** A species that no longer exists in the wild in the province but exists in the wild outside the province. **Extinct:** A species that no longer exists. **General Status Ranks and Definitions:** **BLUE** (Extirpated/Extinct): No longer in Nova Scotia or extinct in the wild. **RED** (At Risk or Maybe at Risk): Known or thought to be at risk. **YELLOW** (Sensitive): Sensitive to human activities or natural events. **GREEN** (Secure): Not believed to be sensitive or at risk. **UNDETERMINED**: Insufficient data exist to assess status. **NOT ASSESSED**: Known or believed to be present in Nova Scotia but as yet unassessed. **EXOTIC**: Introduced as a result of human activity. **ACCIDENTAL**: Occurring infrequently and unpredictably, outside their usual range.
New Brunswick[7]	**Endangered species**: Any indigenous species of fauna or flora threatened with imminent extinction or imminent extirpation throughout all or a significant portion of its range and designated by regulation as endangered. **Regionally endangered species:** Any indigenous species of fauna or flora threatened with imminent extirpation throughout all or a significant portion of its range in the province and designated by regulation as regionally endangered. **Endangered[8]:** A wild species that is facing imminent extirpation from New Brunswick, or extinction. **Extirpated:** A wild species that no longer exists in the wild in New Brunswick, but exists elsewhere in the wild. **Threatened:** A wild species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation. **Special Concern:** A wildlife species that may become a threatened species or an endangered species because of a combination of biological characteristics and identified threats.
Province of Québec[9]	**Menacée:** Une espèce est menacée lorsque sa disparition est appréhendée. (A species is threatened when its disappearance is apprehended). **Vulnérable:** Elle est vulnérable lorsque sa survie est précaire même si sa disparition n'est pas appréhendée. (A species is vulnerable when its survival is threatened, even though its disappearance is not expected).
Ontario[10]	**Extirpated:** A species that no longer exists in the wild in Ontario but still occurs elsewhere. **Endangered:** A species facing imminent extinction or extirpation in Ontario that is a candidate for regulation under Ontario's ESA. **Threatened:** A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed.

	Special Concern (formerly vulnerable): A species with characteristics that make it sensitive to human activities or natural events.
Manitoba[11]	**Extinct:** Any species extirpated throughout its entire range. **Extirpated:** Any species once native to Manitoba that has disappeared through all of its Manitoba range. Extirpated species may still be found elsewhere in their range, or in captivity. **Endangered:** Any native Manitoba species threatened to disappear through all or most of its Manitoba range. **Threatened:** Any native Manitoba species likely to become endangered or at risk due to low or declining numbers in Manitoba if the factors affecting it do not improve. **Vulnerable:** Species not regulated under the *Endangered Species Act* but which could eventually be considered endangered or threatened if the factors affecting them do no improve.
Saskatchewan[12]	**Extirpated:** No longer exists in the wild in Saskatchewan, but exists in the wild outside of Saskatchewan. **Endangered:** Threatened with imminent extirpation or extinction. **Threatened:** Likely to become endangered if the factors leading to its endangerment are not reversed. **Vulnerable:** Species of special concern because of low or declining numbers due to human activities or natural events but that is not endangered or threatened.
Alberta[13]	**At Risk** (formerly 'Red List'): Any species known to be at risk after formal detailed status assessment and legal designation as Endangered or Threatened in Alberta. **May Be At Risk** (formerly 'Blue List'): Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment. **Sensitive:** Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk. **Undetermined:** Any species for which insufficient information, knowledge or data are available to reliably evaluate its general status. **Not Assessed:** Any species that has not been examined during this exercise. **Exotic/Alien:** Any species that has been introduced as a result of human activities. **Extirpated/Extinct:** Any species no longer thought to be present in Alberta (Extirpated) or no longer believed to be present anywhere in the world (Extinct).
British Columbia[14,15]	**Endangered species:** A species of animal that is designated as an endangered species, but does not include a controlled alien species. **Threatened species** : A species of animal that is designated as a threatened species, but does not include a controlled alien species. **General Status Ranks and Definitions**: **Extinct:** Species that no longer exist. This status is only assigned if the Global Conservation Status rank is GX. **Red:** Includes any indigenous species or subspecies that have—or are candidates for—Extirpated, Endangered, or Threatened status in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Not all Red-listed taxa will necessarily become formally designated. Placing taxa on these lists flags them as being at risk and requiring investigation. **Blue:** Includes any indigenous species or subspecies considered to be of Special Concern (formerly Vulnerable) in British Columbia. Taxa of Special Concern have characteristics that make them particularly sensitive or vulnerable to human activities or natural events. Blue-listed taxa are at risk, but are not Extirpated, Endangered or Threatened. **Yellow:** Includes species that are apparently secure and not at risk of extinction. Yellow-listed species may have Red- or Blue-listed subspecies. **Exotic:** Species that have been moved beyond their natural range as a result of human

	activity. Exotic species are also known as alien species, foreign species, introduced species, non-indigenous species, and non-native species. Exotic species are excluded from the Red, Blue, and Yellow lists as a Provincial Conservation Status Rank is not applicable (i.e., SNA) **Accidental:** Species occurring infrequently and unpredictably, outside their usual range. Accidental species are excluded from the Red, Blue, and Yellow list as a Provincial Conservation Status Rank is not applicable (i.e., SNA) **Unknown:** Includes species or subspecies for which the Provincial Conservation Status is unknown due to extreme uncertainty (e.g., S1S4). It will also be "Unknown" if it is uncertain whether the entity is native (Red, Blue, or Yellow), introduced (Exotic), or accidental in British Columbia. This designation highlights species where more inventory and/or data gathering are needed. **No Status:** Includes species that have not been ranked (i.e., Provincial Conservation Status Rank is SNR). No Status is also assigned to an animal when all subspecies or populations of a species are assigned to either the Red List or the Blue List. For example, there are two populations of Western Painted Turtle in British Columbia; one population is on the Red list, the other is on the Blue list. The species record for Western Painted Turtle is therefore not assigned to a list.
Yukon Territory[16,17]	**Endangered:** A species facing imminent extirpation or extinction. **Threatened:** A species likely to become endangered if limiting factors are not reversed. **Special Concern:** A species with characteristics that make it particularly sensitive to human activities or natural events. **Specially protected wildlife** refers to any population, species or type of wildlife prescribed by the regulations as specially protected wildlife under Yukon's Wildlife Act.
Northwest Territories[18,19]	**Species of special concern:** A species that may become threatened or endangered in the Northwest Territories (NT) because of a combination of biological characteristics and identified threats. **Threatened species:** A species that is likely to become endangered in the Northwest Territories if nothing is done to reverse the factors leading to its extirpation or extinction. **Endangered species:** A species that is facing imminent extirpation from the Northwest Territories or extinction. **Extinct species:** A species that no longer exists anywhere in the world. **Extirpated species:** A species that no longer exists in the wild in the Northwest Territories but exists in the wild outside the Northwest Territories. **From General Status of Wild Species 2006-2010 report:** **At Risk**: A species for which a detailed assessment has already been completed (e.g., by COSEWIC or jurisdictional status reports) that determined the species to be at risk of extirpation or extinction. This is a special category that may be used only for species that have been assessed as "Endangered" or "Threatened" according to COSEWIC, or according to a similar future committee in the Northwest Territories. Exceptions are noted. **May Be At Risk:** A species that may be at risk of extinction or extirpation, and are therefore candidates for detailed risk assessment. **Sensitive:** A species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk. **Secure:** A species that is not at risk or sensitive. **Undetermined:** A species for which insufficient information, knowledge, or data are available to reliably evaluate their general status. **Not Assessed:** A species that has not been examined for this report. **Alien:** Species that have been introduced as a result of human activities. **Extirpated/ Extinct:** A species no longer thought to be present in the Northwest Territories (extirpated) or are believed no longer present anywhere in the world (extinct). **Vagrant:** A species occurring infrequently and unpredictably in the Northwest Territories. These species are outside their usual range. These species may be in the Northwest Territories due to unusual weather occurrences, an accident during migration, or unusual

	behavior by a small number of individuals. If a species appears in the Northwest Territories with increasing predictability and more frequently, it may eventually be given a different rank. Changes in the number of vagrant species may be a good indicator of general ecosystem or climatic change. **Presence Expected:** A species not yet recorded in the Northwest Territories, but it is expected to be present. Such species are expected in the Northwest Territories due to their presence in adjacent jurisdiction(s), the presence of appropriate habitat in the Northwest Territories, and other evidence.
Nunavut[20]	**Endangered:** A species that it is facing imminent extirpation or extinction in Nunavut. **Extirpated:** A species that no longer exists in the wild in Nunavut but exists elsewhere in the wild. **Of special concern:** A species that: (a) may become a threatened or endangered species because of a combination of biological characteristics and identified threats, (b) is rare inside and outside Nunavut, or (c) is threatened or endangered outside Nunavut. **Threatened:** A species that it is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.

1. Newfoundland and Labrador Department of Environment and Conservation. Species at Risk. Last modified: September 16, 2011. [online] URL: http://www.env.gov.nl.ca/env/wildlife/endangeredspecies/index.html. Accessed September, 2011.
2. Newfoundland and Labrador Department of Environment and Conservation. General Status of Species. Last modified: December 9, 2010. [online] URL: http://www.env.gov.nl.ca/env/wildlife/all_species/general_status.html. Accessed September, 2011.
3. The goal of Newfoundland's General Status evaluations are to list and assess NF&L's wildlife species, to identify and categorize the level of threat to an individual species, population or its habitat and to track and monitor the status of biodiversity in the province. They have yet to do this type of study on Newfoundland's tree & shrub species.
4. Prince Edward Island Department of Environment, Energy and Forestry. Wildlife Conservation Act. [online] URL: http://www.gov.pe.ca/law/statutes/pdf/w-04_1.pdf. Accessed March, 2010.
5. Nova Scotia Department of Natural Resources. Species at Risk. Last modified: October 30, 2009. [online] URL: http://www.gov.ns.ca/natr/wildlife/biodiversity/species-list.asp. Accessed September, 2011.
6. Nova Scotia Department of Natural Resources. General Status – Background and Process. Last modified: October 6, 2009. [online] URL: http://www.gov.ns.ca/natr/wildlife/genstatus/background.asp#ranks. Accessed September, 2011.
7. Province of New Brunswick. Endangered Species Act. Act current to September 27, 2011. [online] URL: http://laws.gnb.ca/en/showdoc/cs/E-9.101. Accessed September, 2011.
8. According to New Brunswick's Department of Natural Resources website, (URL: http://www2.gnb.ca/content/gnb/en/departments/natural_resources/wildlife/content/SpeciesAtRisk.html) the province is presently developing a new Species at Risk Act to modernize existing legislation. The tentative definitions were taken from a pdf file titled *New Brunswick Species at Risk Act: Proposed Elements, March 14, 2011*, http://www.gnb.ca/0078/Publications/SAR-ProposedElements2011-e.pdf. Accessed September, 2011.
9. Dévelopment durable, environment et parcs de Québec. Plantes menacé ou vulnérables au Québec. Last modified April 2010. [online] URL: http://www.mddep.gouv.qc.ca/biodiversite/especes/index.htm Accessed September, 2011.
10. Ontario Ministry of Natural Resources. Species at Risk in Ontario (SARO) List. [online] URL: http://www.MBr.gov.on.ca/en/Business/Species/2ColuMBSubPage/276722.html. Last modified: June 14, 2011.
11. Manitoba Conservation Wildlife and Ecosystem Branch. Manitoba's Species at Risk. Last modified: 2009. [online] URL: http://www.species-at-risk.mb.ca/s-mb-at-risk.html. Accessed September, 2011.
12. Saskatchewan Ministry of Environment. Wild Species at Risk. [online] URL: http://www.environment.gov.sk.ca/wildspeciesatrisk Accessed September, 2011.
13. Alberta Fish and Wildlife Division. 2011. Definitions of General Status Categories. [online] URL: http://www.srd.alberta.ca/FishWildlife/SpeciesAtRisk/GeneralStatusOfAlbertaWildSpecies/GeneralStatusofAlbertaWildSpecies2010/documents/GeneralStatusWildSpecies-DefinitionsStatusCategories-Mar2011.pdf. Accessed September, 2011.
14. Province of British Columbia. 1996. Wildlife Act. Act current to September 21, 2011. [online] URL: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_96488_01. Accessed September, 2011.
15. British Columbia Ministry of Environment. BC List Status. [online] URL: http://www.env.gov.bc.ca/atrisk/help/list.htm. Accessed September, 2011.
16. Yukon Department of Environment. Yukon Species at Risk. [online] URL: http://www.env.gov.YT.ca/wildlifebiodiversity/speciesrisk.php. Last modified: September 20, 2011.
17. Territory of Yukon. 2002. Wildlife Act.v. http://www.gov.YT.ca/legislation/acts/wildlife.pdf. Accessed September, 2011.

18. Government of the Northwest Territories. 2010. Species at Risk (NWT) Act. [online] URL: http://www.justice.gov.nt.ca/PDF/ACTS/Species%20at%20Risk.pdf. Accessed September, 2011.
19. Working Group on General Status of NWT Species. 2006. NWT Species 2006-2010 – General Status Ranks of Wild Species in the Northwest Territories. Dept. of Environment and Natural Resources. Government of Northwest Territories.
20. Nunavut Department of Justice. 2005. Consolidation of Wildlife Act. Act current to December 17, 2007. [online] URL: http://www.justice.gov.nu.ca/apps/authoring/dspPage.aspx?page=CURRENT+CONSOLIDATIONS+OF+ACTS+AND+REGULATIONS&letter=W. Accessed September, 2011.

1.2.4 (FAO Question 1.13) Main Forest Tree Species Considered Threatened

As previously identified in section 1.2.3, there are different Canadian priority setting exercises for identifying threatened tree species. At a national level, Table 1.7 identifies species with official federal risk designation, Table 1.8 is a general federal-level species assessment, and Table 1.9 identified species 'of concern' based on the national survey conducted by CON**FOR**GEN in 2003. Table 1.13a and b amalgamates information and captures the threats identified through SARA and the CON**FOR**GEN survey (Beardmore et al. 2005) and these are approximations made using the available literature.

It should be noted that there are other reasons to conserve forest genetic resources beyond their being identified as being under threat. For example, species may be conserved that have present or potential socioeconomic values, or based on their relative importance in the ecosystem (Canadian Council of Forest Ministers 2006).

The reasons to conserve tree species may include conserving species that are important to forestry, in particular, tree improvement programs, where species and provenances are conserved for providing improved levels of goods and services (reviewed nationally by Boyle 1992). These efforts may focus on conserving genotypes that demonstrate a high value for production or, genotypes with resistance to pests and diseases. Another reason for conserving forest genetic resources may also be to maintain the variation within forest types and to maintain ecosystem services. Specific examples of these activities are identified in jurisdictional conservation plans and strategies (e.g. Government of Alberta Sustainable Resources and Development 2009; Forest Genetic Council of British Columbia 2009).

Table 1.13a. Possible threats to tree species

Types of threat:	
1. Forest cover reduction and degradation	10. Pollutant emissions
2. Forest ecosystem diversity reduction and degradation	11. Pests and diseases
3. Unsustainable logging	12. Forest fires
4. Management intensification	13. Drought and desertification
5. Competition for land use	14. Rising sea level
6. Urbanization	15. Other – Rarity
7. Habitat fragmentation	16. Other – No or an uncertain viable seed source
8. Uncontrolled introduction of alien species	17. Other – General environmental change
9 Acidification of soil and water	18. Other – Hybridization or introgression

Table 1.13b. Native tree and other woody forest species considered to be threatened in all or part of their range in Canada

Species (scientific name)	Area of species' natural distribution if known	Proportion of species' natural distribution in Canada (%)[1] [2]	Distribution in the country: widespread, rare, or local	Type of Threat (Code)[3]	Threat Category		
					H	M	L
Tree Species (≥ 10 m in height)							
Abies grandis	--	20%	Local	(15)[3]		X	
Acer negundo	--	25%		(15)[3]		X	
Acer negundo var. *negundo*	--	--		--			X
Acer negundo var. *violaceum*	--	--		--			X
Acer nigrum	--	10%	Rare	(15)[3]		X	
Aesculus glabra	--	<1%	Rare	(1,3,5,15,16)[3]	X		
Arbutus menziesii	--	1%	Rare	--		X	
Asimina triloba	--	<1%	Rare	(1,3,5,15,16)[3]	X		
Betula alleghaniensis	--	40%	Local	--	X		
Betula cordifolia	--	70%	Local	(15)[3]			X
Betula lenta	--	<1%	Rare	(5,6,15)[4] (1,3,5,15,16)[3]	X		
Betula neo-alaskana	--	80%	Widespread	(15)[3]	X		
Betula occidentalis	--	55%	Widespread	(15)[3]	X		
Betula papyrifera var. *cordifolia*	--	--	Local	--			X
Carpinus caroliniana	--	<5%	Rare	(1,5)[3]		X	
Carya glabra var. *odorata*	--	1%	Rare	(1,3,5,15,16)[3]	X		
Carya laciniosa	--	<1%	Rare	(1,3,5,15,16,17)[3]	X		
Carya ovata	--	<5%	Rare	(1,5)[3]		X	
Castanea dentata	--	1%	Local	(3,11,15)[6] (8,15,16)[3]	X		
Celtis occidentalis	--	<1%	Rare	(15)[3]		X	
Cornus nuttalii	--	--	Rare	--			X
Cornus florida	--	1%	Rare	(7,11,15)[7]	X		

Fagus grandifolia	--	20%	Local	(8)[3]	X		
Fraxinus americana	--	10%	Local	(1,3,5,8)[3]	X		
Fraxinus nigra	--	50%	Local	(1,4,8,15,16)[3]	X		
Fraxinus pennsylvanica	--	30%	Local	(8)[3]	X		
Fraxinus pennsylvanica var. *austina*	--	--	Local	--			X
Fraxinus pennsylvanica var. *subintegerrima*	--	--	Local	(15)[3]		X	
Fraxinus profunda	--	<1%	Rare	(8,15)[3]	X		
Fraxinus quadrangulata	--	1%	Rare	(5,6,15,16)[17] (8,15,16)[3]			X
Gleditsia triacanthos	--	<1%	Rare	1,3,5,15,16	X		
Gymnocladus dioicus	--	1%	Rare	(5,6,11)[11] (15,16,17)[12] (1,3,5,15,16)[3]		X	
Juglans cinerea	--	5%	rare to local	(3,5,6,11,15)[5] (1,4,5,8,18)[3]	X		
Juniperus scopulorum	--	40%	Local	(15)[3]		X	
Juniperus virginiana var. *virginiana*	--	<5%	Rare	(15)[3]		X	
Larix laricina	--	85%	Widespread	(15)[3]		X	
Larix lyallii	--	80%	Rare	(15)[3]			X
Larix occidentalis	--	35%	Rare	(5,15)[3]		X	
Liriodendron tulipifera	--	1%	Rare	(1,3,5,15,16)[3]	X		
Magnolia acuminata	--	2%	Rare	(3,5,15,16)[9] (1,3,5,8,15,16)[3]	X		
Morus rubra	--	<1%	Rare	(5,15,18)[8] (1,15,16,18)[3]	X		
Nyssa sylvatica	--	1%	Rare	(1,3,5,15,16)[3]	X		
Ostrya virginiana	--	<10%	Rare	(1,3,5,15)[3]	X		
Picea rubens	--	40%	Local	(1,3,5,15,16,18)[3]	X		
Pinus albicaulis	--	50%	Local	(1,5,8,16)[3]	X		
Pinus banksiana	--	90%	Widespread	(3,5,15,16)[3]	X		
Pinus flexilis	--	10%	Rare	(8)[3]	X		
Pinus monticola	--	50%	Local	(8)[3]	X		

Pinus resinosa	--	60%	Local	(1,3,8,15)[3]	X		
Pinus rigida	--	1%	Rare	(1,3,5,15,16)[3]		X	
Pinus strobus	--	30%	Local	(1,4,5,8,15)[3]	X		
Populus angustifolia	--	1%	Rare	(15,17,18)[3]		X	
Populus balsamifera	--	90%	Widespread	(15)[3]		X	
Populus deltoides	--	--	--	(17)[3]		X	
Populus deltoides ssp. *deltoides*	--	<5%	Rare	(1,3,5,15,16,18)[3]	X		
Populus deltoides ssp. *monilifera*	--	10%	Local	(5,17)[3]	X		
Populus grandidentata	--	30%	Local	(15)[3]	X		
Prunus serotina	--	<5%	Local	--			X
Ptelea trifoliata	--	<5%	Rare	(5,6,7,11,15)[14] (1,3,5,15,16)[3]			X
Quercus alba	--	5%	Rare	(15)[3]		X	
Quercus bicolor	--	1%	Rare	(5,15)[3]		X	
Quercus ellipsoidalis	--	--	Rare	(1,3,5,15,16)[3]	X		
Quercus garryana	--	<5%	Rare	(5,16)[3]	X		
Quercus ilicifolia	--	<1%	Rare	(15)[3]	X		
Quercus macrocarpa	--	25%	Local	(1,8,15)[3]	X		
Quercus muehlenbergii	--	<5%	Rare	(3,5,15)[3]	X		
Quercus palustris	--	1%	Rare	(1,3,5,15,16)[3]	X		
Quercus prinoides	--	1%	Rare	(1,3,5,15,16)[3]	X		
Quercus rubra	--	20%	Local	(1)[3]	X		
Quercus shumardii	--	<1%	Rare	(4)[18] (5,7,15)[19] (1,3,5,15,16,17)[3]			X
Taxis brevifolia	--	45%	Local	(15)[3]		X	
Thuja occidentalis	--	65%	Local	(1,3,4,5,15,16)[3]	X		
Thuja plicata	--	45%	Local	(15)[3]		X	
Tilia americana	--	15%	Local	--		X	
Tsuga canadensis	--	25%	Local	(1,3,5,8,15,16)[3]		X	
Tsuga heterophylla	--	65%	Local	(15)[3]		X	
Ulmus americana	--	20%	Local	(1,5,8,15,16)[3]	X		
Ulmus rubra	--	5%	Rare	(1,3,5,8,15,16,18)[3]	X		
Ulmus thomasii	--	20%	Rare	(1,3,5,8,15,16,18)[3]	X		

Total Number					44	24	11
Shrub Species (<10 m in height)							
Alnus serrulata	--	--	Rare	(5,15)[3]	X		
Amelanchier amabilis	--	--	--	(15)[3]	X		
Amelanchier bartramiana	--	--	Local	--			X
Amelanchier canadensis	--	--	--	(15)[3]			X
Amelanchier fernaldii	--	--	--	(15)[3]	X		
Amelanchier laevis	--	--	Local	--		X	
Amelanchier lucida	--	--	--	--		X	
Amelanchier nantucketensis	--	--	--	(15)[3]	X		
Amelanchier sanguinea var. *grandiflora*	--	--	Local	(15)[3]		X	
Amelanchier spicata	--	--	--	(15)[3]	X		
Amelanchier stolonifera	--	--	--	(15)[3]		X	
Arctous rubra	--	--	--	(15)[3]	X		
Atriplex canescens	--	--	--	(15)[3]		X	
Betula minor	--	--	--	(15)[3]	X		
Betula nana	--	--	--	(3,15,17)[3]	X		
Betula pumila	--	--	--	(5,8,15,17)[3]	X		
Betula pumila var. *pumila*	--	--	--	(5)[3]		X	
Ceanothus americanus	--	--	--	(15)[3]		X	
Ceanothus herbaceus	--	--	--	(15)[3]		X	
Ceanothus velutinus	--	--	--	--		X	
Celastrus scandens	--	--	--	(15)[3]		X	
Celtis tenuifolia	--	<5%	Rare	(5,11,15)1[3] (1,3,5,15,16)[3]		X	
Cephalanthus occidentalis	--	--	Local	(1,5,15,16)[3]	X		

Cornus alternifolia	--	10%	Local	(15,16)[3]	X		
Cornus obliqua	--	--	--	(5,15)[3]	X		
Cornus racemosa	--	--	--	(15)[3]		X	
Cornus rugosa	--	--	--	(15)[3]	X		
Cornus sericea (stolonifera)	--	--	--	--			X
Cornus unalaschkensis	--	--	--	(15)[3]			X
Corylus americana	--	--	Local	(15)[3]	X		
Corylus cornuta	--	--	Widespread	--			X
Crataegus apiomorpha	--	--	--	(15)[3]	X		
Crataegus ater	--	--	--	(15)[3]	X		
Crataegus brainerdii	--	--	--	(15)[3]	X		
Crataegus chrysocarpa	--	--	Widespread	(15,18)[3]			X
Crataegus chrysocarpa var. *chrysocarpa*	--	--	--	(15)[3]	X		
Crataegus compta	--	--	--	(15)[3]	X		
Crataegus conspecta	--	--	--	(15)[3]	X		
Crataegus corusca	--	--	--	(15)[3]	X		
Crataegus crus-galli	--	--	Local	(15)[3]		X	
Crataegus dilatata	--	--	--	(15)[3]	X		
Crataegus disperma	--	--	--	(15)[3]	X		
Crataegus dissona	--	--	--	(15)[3]	X		
Crataegus flabellata	--	--	Local	(15)[3]			X
Crataegus formosa	--	--	--	(15)[3]		X	
Crataegus fulleriana	--	--	--	(15)[3]	X		
Crataegus grandis	--	--	--	(15)[3]	X		
Crataegus holmesiana	--	--	--	(15,18)[3]	X		
Crataegus jonesiae	--	--	--	(15)[3]	X		
Crataegus lumaria	--	--	--	(15)[3]		X	
Crataegus macrosperma	--	--	--	--			X
Crataegus perjucunda	--	--	--	(15)[3]	X		

Crataegus persimilis	--	--	--	(15)[3]	X		
Crataegus pruinosa var. *pruinosa*	--	--	--	(15)[3]	X		
Crataegus robinsonii	--	--	--	(15,18)[3]	X		
Crataegus scabrida	--	--	--	(15)[3]	X		
Crataegus submollis	--	--	--	(15)[3]	X		
Crataegus suborbiculata	--	--	--	(15)[3]	X		
Crataegus succulenta	--	--	Local	(15,18)[3]	X		
Crateagus macrosperma var. *acutiloba*	--	--	--	(15)[3]	X		
Diervilla lonicera	--	--	--	--			X
Dirca palustris	--	--	--	(15)[3]	X		
Elaeagnus commutata	--	--	Local	(3,4)[3]			X
Hamamelis virginiana	--	<5%	Local	(15)[3]	X		
Juniperus communis	--	--	Widespread	(5)[3]		X	
Juniperus horizontalis	--	--	Widespread	(5)[3]		X	
Loise leuria procumbens	--	--	--	(15)[3]		X	
Lonicera oblongifolia	--	--	--	(15)[3]	X		
Lonicera villosa	--	--	--	--			X
Paxistima myrsinites	--	--	--	--			X
Penstemon frutico sus var. *scouleri*	--	--	--	(15)[3]		X	
Philadelphus lewisii	--	--	--	(15)[3]		X	
Physocarpus malvaceus	--	--	--	(15)[3]		X	
Prunus nigra	--	45%	Local	--			X
Prunus virginiana var. *virginiana*	--	50%	Widespread	--			X
Rhamnus alnifolia	--	--	--	(8,15)[3]	X		
Rhododendron lapponicum	--	--	--	(15)[3]		X	
Rhus aromatica var.	--	--	--	(15)[3]		X	

aromatica							
Rhus glabra	--	--	Local	(15)[3]	X		
Rhus typhina	--	20%	Local	(15)[3]		X	
Salix alaxensis	--	--	Local	(15)[3]	X		
Salix alaxensis var. *alaxensis*	--	--	--	(15)[3]	X		
Salix amygdaloides	--	10%	Local	(15)[3]	X		
Salix arctica	--	--	--	(15)[3]	X		
Salix arctophila	--	--	--	(15)[3]	X		
Salix argyrocarpa	--	--	--	(15)[3]	X		
Salix ballii	--	--	--	(15)[3]	X		
Salix boothii	--	--	--	(15)[3]	X		
Salix brachycarpa	--	--	--	(15)[3]	X		
Salix brachycarpa var. *psammophila*	--	--	Rare	(1,2,15)[22](15)[3]			X
Salix calcicola	--	--	--	(15)[3]	X		
Salix calicola var. *calicola*	--	--	--	(15)[3]		X	
Salix candida	--	--	--	(15,16,18)[3]	X		
Salix chamissonis	--	--	--	--			X
Salix chlorolepis	--	--	Rare	(1,2)[15] (11,15,18)[16] (15)[3]		X	
Salix commutata	--	--	--	(15)[3]		X	
Salix cordata	--	--	--	(15)[3]	X		
Salix cordifolia	--	--	--	(15,16)[3]	X		
Salix eriocephala	--	--	Widespread	--			X
Salix fuscescens	--	--	--	(15)[3]	X		
Salix herbacea	--	--	--	(15)[3]	X		
Salix jejuna	--	--	Rare	(1,14,15,17)[1] (15)[3]	X		
Salix lanata	--	--	--	(15)[3]	X		
Salix lanata ssp. *calicola*	--	--	--	(15)[3]		X	
Salix lemmonii	--	--	--	(15)[3]	X		
Salix lutea	--	--	--	(15)[3]	X		
Salix maccalliana	--	--	--	(15)[3]		X	

Salix myricoides	--	--	--	(5)[3]		X	
Salix myricoides var. *albovestita*	--	--	--	(15)[3]	X		
Salix myricoides var. *myricoides*	--	--	--	(15)[3]	X		
Salix myrtillifolia	--	--	--	(15)[3]	X		
Salix nigra	--	5%	Local	(15)[3]	X		
Salix ovalifolia var. *arctolitoralis*	--	--	--	--			X
Salix pedicellaris	--	--	--	(8,15)[3]	X		
Salix pedunculata	--	--	--	(15)[3]	X		
Salix petiolaris	--	--	Widespread	(15)[3]	X		
Salix planifolia	--	--	--	--		X	
Salix pseudomonticola	--	--	--	(15)[3]		X	
Salix pyrifolia	--	--	Widespread	--		X	
Salix raupii	--	--	--	(15)[3]	X		
Salix reticulata	--	--	--	(15,18)[3]	X		
Salix reticulata ssp. *glabellicarpa*	--	--	--	(15)[3]	X		
Salix sericea	--	--	--	(15)[3]	X		
Salix serissima	--	--	--	(15)[3]	X		
Salix sessilifolia	--	--	--	(15)[3]	X		
Salix setchelliana	--	--	--	(15)[3]		X	
Salix silicicola	--	--	Rare	(1,2)[20] (15)[21] (15)[3]			X
Salix sitchensis	--	--	Local	(15)[3]		X	
Salix sphenophylla	--	--	--	--			X
Salix stolonifera	--	--	--	(15)[3]		X	
Salix turnorii	--	--	Rare	(1,2,15)[23] (15)[3]			X
Salix tweedyi	--	--	--	(15)[3]	X		
Salix tyrrellii	--	--	--	(15,17)[3]		X	
Salix uva-ursi	--	--	--	(15)[3]	X		
Salix vestita	--	--	--	(15,16)[3]	X		
Shepherdia canadensis	--	--	--	(15)[3]	X		
Sorbus decora	--	95%	Local	(16,18)[3]			X
Sorbus scopulina	--	--	--	(18)[3]			X

Staphylea trifolia	--	--	--	(15)[3]		X	
Suaeda moguinii	--	--	--	(15)[3]		X	
Taxus canadensis	--	--	Local	(3,4,8,15)[3]		X	
Toxicodendron vernix	--	1%	Rare	(5,15)[3]	X		
Viburnum acerifolium	--	--	--	(15)[3]	X		
Viburnum dentatum var. *lucidum*	--	--	--	(15)[3]	X		
Viburnum edule	--	--	Widespread	(15)[3]	X		
Viburnum lantanoides	--	--	--	(1,5,15)[3]	X		
Viburnum lentago	--	5%	Local	(15)[3]	X		
Viburnum recognitum	--	--	--	(5,15)[3]	X		
Viburnum trilobum	--	--	Widespread	(15)[3]		X	
Total Number					85	41	23

-- , data not available.

H, high threat levels, where species is threatened throughout its Canadian range; **M**, medium threat level, where the species is threatened in at least 50% of its range; **L,** low threat level, where the species is threatened in <50% of its range.

1. Silvics of North America. [online] URL: http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm Accessed January 2012.
2. Farrer (1995)
3. 'Type of Threat' numbers correspond to those identified in Table 1.13a and the 'Threat catagoy' was determined by using data from Canada's *Species at Risk Act* (SARA) or from the CON**FOR**GEN survey (Beardmore et al. 2005).
4. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Cherry Birch. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=896#limits. Accessed October, 2011.
5. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Butternut. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=793#limits. Accessed October, 2011.
6. Government of Canada Species at Risk Public Registry. 2010. Species Profile: American Chestnut. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=205#limits. Accessed October, 2011.
7. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Flowering Dogwood. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=987#limits. Accessed October, 2011.
8. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Red Mulberry. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=228#limits. Accessed October, 2011.
9. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Cucumber Tree. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=176#limits. Accessed October, 2011.
10. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Barrens Willow. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=678#limits. Accessed October, 2011.
11. Threat code 11 (pests and diseases) in this case is for the increasing population of cormorants (*Phalacrocorax auritus*) threatens some of Canada's Kentucky Coffee-tree populations because their droppings kill most trees.
12. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Kentucky Coffee-tree. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=222#limits. Accessed October, 2011.
13. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Dwarf Hackberry. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=247#limits. Accessed October, 2011.
14. Government of Canada Species at Risk Public Registry. 2010. Species Profile: Common Hoptree. http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=255#limits. Accessed October, 2011.

1.2.5 (FAO Question 1.16) The State of Genetic Diversity of a Selection of Native Tree Species

The state of genetic diversity of a selection of native tree species was estimated as low, moderate, or high based on surveying the scientific literature and using the most current data available (Table 1.14). In order to categorize genetic diversity as low, moderate or high, the author's general conclusions concerning their study were used. It should be noted that this is quite subjective as typically each study used different measures, tests and analyses for evaluating genetic diversity. Furthermore, in most cases, range-wide assessments had not been conducted and that results presented include studies that have primarily evaluated genetic diversity; however, some have evaluated genetic variation. These results do present a relative comparison of the state of the genetic diversity of 32 tree species, which represent only 25% of native tree species. Fifty-nine percent of species exhibited what the authors considered to be 'high' genetic diversity. The four species identified as having 'low' genetic diversity—American chestnut (*Castenea dentata*), butternut (*Juglans cinerea*), whitebark pine *(Pinus albicus)*, and red pine (*Pinus resinosa*)—are considered species of concern (Beardmore et al. 2005); red pine is the only species that does not have an official federal risk designation (Table 1.7).

Table 1.14. State of genetic diversity of a selection of native tree species

Scientific name	Common names	Genetic Diversity	Notes
Acer saccharum	Sugar maple	High	Analyses have determined that genetic diversity was high, and most of the diversity was present within populations.[1]
Alnus crispa	Green alder	High	Analyses showed high levels of genetic variation. Western populations had more genetic differentiation than the populations in northern Quebec. This differentiation could be due to gene introgression due to hybridization with *Alnus sinuata* and partial isolation in the West.[2]
Alnus rugosa	Speckled alder	High	Levels of genetic variation were high in Quebec populations with low population differentiation. Levels of genetic diversity were similar to *Alnus crispa* although no interspecific hybridization was observed.[3]
Alnus sinuata	Sitka alder	High	Levels of genetic variation were high with low population differentiation.[4]
Arbutus menziesii	Arbutus	Low	[5]
Asimina triliba	Pawpaw	High	A relatively high level of genetic variation among populations, but moderate or no variation within populations in pawpaw tree. [6]
Castanea dentata	American chestnut	Low	The genetic diversity of American chestnut is diminishing due to the threat posed by chestnut blight; it is estimated that only 120–150 mature trees are left in Canada.[7]
Callitropsis nootkatensis	Yellow cedar	High	Common garden studies of morphological and physiological traits have shown that yellow cedar has substantial genetic diversity.[8]
Gymnocladus dioicus	Kentucky coffee tree	Low	The Kentucky Coffee tree only produces seed at two sites in Canada; most sites are single-sex clones. Given this, it is assumed that there is little genetic diversity in the Canadian populations.[9]

Juglans cinerea	Butternut	Low	Evidence to date points to low levels of genetic diversity between and within populations. The main threat is the presence of the butternut canker, which causes extremely high mortality rates of the species.[10]
Larix laricina	Tamarack	High	Results of this survey indicated that the species has levels of genetic variation comparable with those of other species of woody perennials with extensive transcontinental ranges.[11]
Larix occidentalis	Western Larch	High	The species exhibits levels of genetic variation comparable to other wide-ranging, long-lived, outcrossing, wind-pollinated species. Levels of genetic variability in the British Columbia populations were higher than their American counterparts.Two populations in this analysis were identified as genetically unique and were recommended for consideration for conservation efforts.[12]
Picea glauca	White spruce	High	[13]
Picea glauca, englemannii and crosses	Interior spruce	High	Genetic diversity for lodgepole pine, interior spruce, western red cedar, and coastal Douglas-fir are staying the same or even increasing due to the adopted practices (*in situ* and *ex situ* conservation) and minimum required standards of genetic diversity required for reforestation.[14]
Picea mariana	Black spruce	High	Genetic parameters estimated from enzyme and RAPD loci both indicated that there are important levels of genetic diversity in black spruce and that this diversity is predominantly found within populations.[15]
Picea sitchensis	Sitka spruce	High	Sitka spruce has a similar distribution to that of yellow cedar and western.[16]
Pinus albicaulis	Whitebark pine	Low	Whitebark pine generally shows a low level of variation at both the local population level and the species level (across populations). Whitebark pine populations in Canada are declining currently due to the combined effects of white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), fire exclusion, and climate change.[17]
Pinus banksiana	Jack pine	High	[18]
Pinus contorta	Lodgepole pine	High	Genetic diversity for lodgepole pine, interior spruce, western red cedar, and coastal Douglas-fir are staying the same or even increasing due to the adopted practices (*in situ* and *ex situ* conservation) and minimum required standards of genetic diversity required for reforestation.[14]
Pinus flexilis	Limber pine	unknown	Level of genetic diversity is unknown but pressures from white pine blister rust (*Cronartium ribicola*) and poor regeneration provide a poor prognosis for limber pine. [19]
Pinus monticola	Western white pine	High	Western white pine (*Pinus monticola*) has declined in prominence over the past several decades, mainly due to white pine blister rusts. Canadian populations of western white pine have lower levels of genetic diversity compared with populations below 45°N latitude.[20]

Pinus resinosa	Red pine	Low	Low levels of genetic diversity in red pine confirmed by random amplified polymorphic DNA markers.[21]
Populus balsamifera	Balsam poplar	High	Analysis from populations across Canada indicates that balsam poplar is both highly variable and capable of a broad range of adaptive physiological responses to a changing climate.[22]
Populus deltoides	Eastern cottonwood	Moderate	Compared with other North American poplars, this species, as assessed from populations in Ontario, has a moderate amount of genetic diversity with low levels of differentiation between populations.[23]
Populus tremuloides	Trembling aspen	High	Multiple analyses have determined that genetic diversity is high in tree populations across Canada.[24]
Populus trichocarpa	Black cottonwood	High	Ecotilling analysis done on multiple British Columbia populations of this species shows a high level of genetic diversity.[25]
Pseudotsuga menziesii var. *glauca*	Douglas fir	High	[26]
Pseudotsuga menziesii var. *menziesii*	Coastal Douglas fir	High	Genetic diversity for lodgepole pine, interior spruce, western red cedar, and coastal Douglas-fir are staying the same or even increasing due to the adopted practices (*in situ* and *ex situ* conservation) and minimum standards of genetic diversity required for reforestation.[14]
Quercus garryana	Garry oak	Moderate	Levels of genetic diversity were lower than what is observed in other white oak species. This might suggest that Garry oak is a closely adapted species with limited responses to threats such as climate change and sudden oak death (*Phytophthora ramorum*).[27]
Taxus brevifolia	Pacific yew	Moderate	[28]
Thuja plicata	Western red cedar	High	Genetic diversity for lodgepole pine, interior spruce, western red cedar, and coastal Douglas-fir are staying the same or even increasing due to the adopted practices (*in situ* and *ex situ* conservation) and minimum standards of genetic diversity required for reforestation.[14]
Tsuga canadensis	Eastern Hemlock	High	The short-term trend for eastern hemlock is estimated to be a decline of 50–70% due to the threat associated with the presence of the hemlock wooly adelgid (*Adelges tsugae*), which is already established in half of eastern hemlock's range. A related threat is the pre-emptive logging of the species outside of the insect's present range[29]. Within-population cpDNA diversity appears relatively high in eastern hemlock but among-population differentiation was low. It is predicted that global climate change could result in the extirpation of eastern hemlock through host–pathogen–climate interactions.[30]

1. Perry and Knowles 1989.
2. Bousquet et al. 1987c.
3. Bousquet et al. 1988.
4. Bousquet et al. 1990a.
5. Beland et al. 2005.

6. Rogstad et al. 1991b.
7. COSEWIC 2004.
8. Ritland et al. 2001.
9. Source: Species at Risk Public Registry, Species information. [online] URL: http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=222#docs. Acccessed January 2012.
10. COSEWIC 2003.
11. Cheliak et al.1988.
12. Jaquish and El-Kassaby 1998.
13. Rajora et al. 2005.
14. British Columbia Ministry of Forests, Mines, and Lands 2010.
15. Isabel et al. 1995.
16. Yeh and El-Kassaby 1980.
17. COSEWIC 2010.
18. Godbout et al. 2010.
19. Alberta Sustainable Resource Development and Alberta Conservation Association 2007.
20. Kim et al. 2011.
21. Mosseler et al. 1992.
22. Keller et al. 2011.
23. Rajora et al. 1991.
24. Mitton and Grant 1996.
25. Gilchrist et al. 2006.
26. Wei et al. 2011.
27. Ritland et al. 2005.
28. El-Kassaby and Yanchuk 1994.
29. Information was obtained from NatureServe (2011c).
30. Lemieux et al. 2011.

3. FACTORS INFLUENCING THE STATE OF FOREST GENETIC DIVERSITY

1.3.1 (FAO Question 1.18) Assessing Genetic Erosion and Vulnerability of Forest Genetic Resources

Genetic erosion is the loss of individual genes and particular combinations of genes (i.e. gene complexes) such as those maintianed in locally adapted populations (Food and Agricultural Organization 2010). Genetic erosion can occur when an already limited gene pool decreases even more when individuals from the population(s) die off, has been or is currently being assessed for a selection of threatened or endangered species including high-elevation pines (e.g., *Pinus albicus* (Natural Resources Defence Council 2008, McLane 2011); red pine (*Pinus resinosa*) (Mosseler 1992); and butternut (*Juglans cinerea*) and American chestnut (*Castenea dentata*) (McIlwrick et al. 2000).

Species vulnerability, the condition that results when a species is uniformly susceptible to pests, pathogens or environmental hazards as a result of its genetic constitution, is assessed both at the national and jurisdictional level. Nationally, vulnerability is assessed through COSEWIC species-specific assessments, the CON**FOR**GEN survey and through NatureServe priority setting processes (see section 1.2.3.1 for details). Climate change is a significant risk to Canadian forests (Johnson and Williamson 2007) and recent efforts have focused on assessing vulnerability to climate change. National-level reviews on the vulnerability of native tree species and forest-based communities have been produced that provide management options for policy makers and land practitioners (Williamson et al. 2007; Johnson et al. 2009). At the jurisdictional level species-specific vulnerabilities are assessed by multiple means and information is typically conveyed through species-specific vulnerability rankings, where species can be assigned to a threat level (e.g. threatened or endangered) (see section 1.2.3.1 for details). The inputs to the different jurisdictional assessments vary, and can include a systematic analysis of species, habitats or ecosystems and, integrate information pertaining to species sensitivity, adaptive capacity and exposure to threats.

1.3.2 (FAO Question 1.18) Main Threat for the Genetic Erosion Forest Genetic Resources

Generally, the threats to forest genetic resources in Canada vary depending on location; however, most forest genetic professionals in Canada consider impacts of climate change, forest practices, forest conversion, and invasive alien species to be the primary challenges at both the regional and national scales (Boyle 2005).

Climate change is perhaps the most serious threat to forest genetic resources in Canada. Climate change will result in local populations of forest species being no longer adapted to their local environmental conditions. Tree species distribution models predict a broad redistribution of trees in the next century. However, the migratory responses that are necessary to spatially track climates far exceed maximum post-glacial rates (Aiken et al. 2008). The observed impacts of the changing climate are already evident: increases in the frequency and severity of natural disturbances such as wildfires, pest outbreaks, and droughts (Williamson et al. 2009, Michaelian et al. 2011) and, at a more subtle level, changes in phenology (Menzel and Fabian 1999, Ahas et al. 2002) and in the ranges of certain species (Parmesan 2007, Beckage et al. 2008) are occurring and can be attributed to climate change with increasing confidence (Parmesan 2007, Rosenzweig et al. 2008). The impacts of these changes in Canada are described by Ste.-Marie et al. (2011). Climate change also impacts indigenous pest and disease populations and invasive alien species in unpredictable ways (Boyle 2005). The mountain pine beetle (*Dendroctonus ponderosae* Hopkins, Coleoptera: Curculionidae, Scolytinae) is a native insect of the pine forests of western North America, and its populations periodically erupt into large-scale outbreaks. Mountain pine beetle successfully attacks most west coast pine, however, lodgepole pine is the beetle's primary host (Kurtz et al. 2008). The beetle thrives under warm weather conditions, and the interior of British Columbia, which has an abundance of mature lodgepole pine, has experienced several consecutive mild winters and drought-like summers. These conditions have resulted in beetle populations in many parts of interior British Columbia increasing to epidemic levels. Climate change has contributed to the unprecedented extent and severity of this outbreak (Kurtz et al. 2008). The BCMFR estimates that, as of 2009, the cumulative area of provincial Crown forest affected to some degree (red-attack and gray-attack) was about 16.3 million hectares and that a cumulative total of 675 million cubic meters of timber (630 million cubic meters of red- and gray-attack, plus 45 million cubic meters of green-attack) have been affected since the current infestation began (BCMFR 2008a,b).

With regard to the impacts of forest practices, harvesting and regeneration practices can pose a potentially significant threat. In general, the more divergent harvesting practices are from natural disturbance regimes, the greater the potential for negative genetic impacts. For example, the use of clearcutting in a fire-adapted boreal ecosystem may approximate natural disturbance regimes, acknowledging that there are problems of scale and spatial variation in impact and that the physical and chemical impacts of harvesting are not identical to those associated with fire. Similar harvesting techniques when used in many Canadian temperate forest types are less appropriate. Harvesting regulations that require group retention on an appropriate spatial scale can minimize genetic erosion.

Regeneration practices also have the potential to impact genetic erosion, where, in the extreme case of monoclonal plantations, virtually all genetic diversity is lost. The use of non-selected, non-local seed sources in artificial generation can potentially result in adverse genetic impacts due to maladaptation. It should be noted that most of Canada's forest area has not been and will not be subjected to harvesting. However, forest management practices do constitute a threat in many areas; in particular, in highly productive forest types, which also tend to have higher levels of species diversity.

Forest conversion at a national and even at a regional level that results in a loss of forest cover is a relatively minor issue. However, locally, when forested areas are in close proximity to urban areas or areas to be used for industrial uses, forest conversion can be a threat to these communities. For example, certain areas within Canada are subject to agricultural expansion and, oil and gas exploration.

In 2003 a pan-Canadian survey was conducted in order to identify native tree species that may be in need of genetic conservation (Beardmore et al. 2005). Survey respondents were asked to identify whether the following threats were an issue: species rarity; no or an uncertain viable seed sources; exotic disease or insect population decline; environmental change (including climate change); harvesting practices prevent the regeneration of a species; the range or frequency of the species is substantially decreasing; the preferred habitat of the species is in high demand for other uses; there is a high demand for a special purpose; and the species is threatened due to hybridization or introgression (Beardmore et al. 2005). The main reasons cited for identifying a species as one of concern, possibly requiring conservation measures were: species rarity, followed by preferred habitat of the species in high demand for other uses, the frequency or range of a species was substantially decreasing, and a lack of a viable seed sources (Table 1.15). The survey identified that, for 52% of Canada's native tree species, *in situ* or *ex situ* conservation was recommended and, for 8% of species, more information was required before a rating could be made.

Table 1.15. Reasons for tree species being listed as of concern based on criteria values [1]

Abiotic Reasons	**Summary**
a) Rarity: *Abies grandis, Acer negundo, Acer nigrum, Aesculus glabra, Alnus serrulata, Asimina triloba, Betula cordifolia, Betula lenta, Betula occidentalis, Carya glabra* var. *odorata, Carya laciniosa, Castanea dentata, Celtis occidentalis, Cornus alternifolia, Crategus douglasii, Fagus grandifolia, Fraxinus nigra, Fraxinus pennsylvanica, Fraxinus profunda, Fraxinus quadrangulata, Gleditsia triacanthos, Gymnocladus dioicus, Hamamelis virginiana, Juniperus scopulorum, J. virginiana, Larix larcina, Larix lyalii, Larix occidentalis, Lirodendron tulipifera, Magnolia acuminata, Morus rubra, Nyssa sylvatica, Picea rubens, Pinus banksiana, Pinus resinosa, Pinus rigida, Pinus strobus, Populus augustifolia, Populus deltoides* var. *deltoides, Populus grandidentata, Ptelea trifoliata, Quercus alba, Quercus bicolor, Quercus ellipsoidalis, Quercus macrocarpa, Quercus muehlenbergii, Quercus palustris, Quercus prinoides, Quercus shumardii, Salix amygdaloides, Salix nigra, Thuja occidentalis, Thuja plicata, Tsuga canadensis, Tsuga heterophylla, Ulmus americana, Ulmus rubra, Ulmus thomasii*	Total # of species: 56 Total # of varieties: 2 # of conifers: 15 # of hardwoods: 43
b) Uncertain viable seed source: *Aesculus glabra, Asimina trilobia, Betula lenta, Carya glabra* var. *odorata, Carya laciniosa, Castanea dentata, Cornus alternifolia, Fraxinus nigra, Fraxinus quadrangula, Gleditsia tricanthos, Gymnocladus dioicus, Liriodendron tulipifera, Magnolia acuminata, Morus rubra, Nyssa sylvatica, Pinus albicaulis, Pinus banksiana, Pinus rigida, Populus deltoides* var. *deltoides, Ptelea trifoliata, Quercus ellipsoidalis, Quercus garryana, Quercus palustris, Quercus prinoides, Quercus shumardii, Sorbus decora, Thuja occidentalis, Tsuga canadensis, Ulmus americana, Ulmus rubra, Ulmus thomasii*	Total # of species: 30 Total # of varieties: 2 # of conifers: 5 # of hardwoods: 27
c) Range or frequency of species substantially decreasing: *Aesculus glabra, Asimina triloba, Betula lenta, Carpinus caroliniana, Carya glabra* var. *odorata, Carya laciniosa, Carya ovata Fraxinus americana, Fraxinus nigra, Gleditsia triacanthos, Gymnocladus dioicus, Juglans cinerea, Liriodendron tulipifera, Magnolia acuminata, Morus rubra, Nyssa sylvatica, Picea rubens, Pinus albicaulis, Pinus resinosa, Pinus rigida, Pinus strobus, Populus deltoides* var. *deltoides, Ptelea trifoliata, Quercus ellipsoidalis, Quercus macrocarpa, Quercus palustris, Quercus prinoides, Quercus rubra, Quercus shumardii, Thuja occindentalis, Tsuga canadensis, Ulmus americana, Ulmus rubra, Ulmus thomasii*	Total # of species: 32 Total # of varieties: 2 # of conifers: 7 # of hardwoods: 25
d) Hybridization or introgression: *Castanea dentata, Juglans cinerea, Morus rubra, Picea rubens, Populus augustifolia, Populus deltoides* ssp. *deltoides, Sorbus decora, Ulmus rubra, Ulmus thosmasii*	Total # of species: 8 Total # of varieties: 1 # of conifers: 1 # of hardwoods: 8

Biotic Reasons:	
e) Exotic disease or pest: *Castanea dentata, Fagus grandifolia, Fraxinus americana, Fraxinus nigra, Fraxinus pennsylvanica, Fraxinus profunda, Fraxinus quadrangulata, Juglans cinerea, Magnolia acuminata, Pinus albicaulis, Pinus flexilis, Pinus monticola, Pinus resinosa, Pinus strobus, Quercus macrocarpa, Tsuga canadensis, Ulmus americana, Ulmus rubra, Ulmus thomasii*	Total # of species: 19 Total # of varieties: 0 # of conifers: 6 # of hardwoods: 13
f) Environmental change: *Carya laciniosa, Populus angustifolia, Populus deltoides, Populus deltoides* spp. *occidentalis, Quercus shumardii*	Total # of species:3 Total # of varieties: 1 # of conifers: 0 # of hardwoods: 4
g) Harvesting practices prevent regeneration: *Aesculus glabra, Asimina triloba, Betula lenta, Carya glabra* var. *odorata, Carya laciniosa, Fraxinus americana, Gleditsia triacanthos, Gymnocladus dioicus, Larix occidentalis, Magnolia acuminata, Nyssa sylvatica, Picea rubens, Pinus banksiana, Pinus resinosa, Pinus rigida, Populus deltoides, Ptelea trifoliata, Quercus ellipsoidalis, Quercus muehlenbergii, Quercus palustris, Quercus prinoides, Quercus shumardii, Taxus brevifolia, Thuja occidentalis, Tsuga canadensis, Ulmus rubra, Ulmus thomasii*	Total # of species:26 Total # of varieties:1 # of conifers:7 # of hardwoods: 20
h) Preferred habitat of the species in high demand for other uses: *Aesculus glabra, Asimina triloba, Betula lenta, Carpinus caroliniana, Carya glabra* var. *odorata, Carya laciniosa, Carya ovata, Fraxinus americana, Gleditsia triacanthos, Juglans cinerea, Juglans nigra, Larix occidentalis, Liriodendron tulipifera, Magnolia acuminata, Nyssa sylvatica, Pinus albicaulis, Pinus rigida, Pinus strobus, Populus angustifolia, Populus deltoides* ssp. *deltoides, Ptelea trifoliata, Quercus biocolor, Quercus ellipsoidalis, Quercus garryana, Quercus muehlenbergii, Quercus prinoides, Quercus shumardii, Thuja occidentalis, Thuja plicata, Tsuga canadensis, Ulmus americana, Ulmus rubra, Ulmus thomasii*	Total # of species:32 Total # of varieties:2 # of conifers:7 # of hardwoods: 27
i) High demand for special purpose: *Fraxinus nigra, Juglans cinerea, Pinus strobus, Taxus brevifolia, Thuja occidentalis*	Total # of species:5 Total # of varieties:0 # of conifers:3 # of hardwoods: 2

[1,] Adapted from Beardmore et al. 2005.

1.3.3 (FAO Question 1.18.) Information Systems on Threatened Tree Species and Trends in Threats

Information systems on threatened tree species and trends in threats have been established at the jurisdictional level for many provinces and territories (see section 1.1.4), at the national level by NatureServe Canada, plant rarity, and CAFGRIS (discussed in section 1.1.5).

It is recognized that information management is essential in order to develop an accurate picture of the status and trends in forest genetic resources. Linking and integrating the information in the various systems is important for the development of national-level conservation strategies and to assist in reporting and decision making at the national level. CAFGRIS and NatureServe Canada are examples of information systems that are integrating information from various agencies to generate either a pan-Canadian (e.g., CAFGRIS) or a species range-wide (e.g., NatureServe Canada) perspective.

1.3.4 (FAO Question 1.18) Risk Disaster Analyses for Forest Genetic Resources

A national risk disaster analysis has not been undertaken for forest genetic resources. However, various risk analyses have been developed that are related to forest genetic resources. For example, with the mountain pine beetle epidemic in western Canada, risk analyses and strategies to decrease the spread and outbreak potential have been developed and/or put in place by the provinces of British Columbia (2010b) and Alberta (Alberta Sustainable Resource Development 2007) and also by industry and local communities (e.g., Ranger Great Slave Lake Pulp 2009). Species-specific risk analyses and responses to these risks have been conducted for invasive alien pests by the Canadian Food Inspection Agency. This federal agency develops and delivers programs and services designed to protect Canada's plant resource base, including forest plants. The federal department Natural Resources Canada has developed the *Canadian Forest Fire Danger Rating System (*Natural Resources Canada 2010a) which is a national system to facilitate the efficient and economical deployment of wildfire-fighting resources across Canada. This system allows fire and land managers (including forest land) to plan and implement fire management strategies in advance and as such can be considered a threat-specific disaster analysis that can impact forest genetic resources (Natural Resources Canada 2011b,c). Futhermore, the Canadian Forest Service integrates historical and current knowledge to assist in the risk analyses of threats such as forest insects and diseases (e.g. *Spruce Budworm Decision Support System*, MacLean et al. 2000).

General disaster plans have been developed, for example, BCMFLNRO's "catastrophic event" plan for forested areas (BCMFR 2005) and their plan for addressing the consequences of fires (BCMFR 2008b), and regional plans exist such as the BC's district of Summerland's hazard, risk and vulnerability assessment for their municipal area that contains forest land (District of Summerland 2006). Furthermore, a variety of responses to and disaster analyses of climate change have been conducted by various jurisdictions, and mitigation strategies that indirectly pertain to forest genetic resources through the reduction of emissions have been developed (e.g., BCMFR 2009b, OMNR 2010, Government of Saskatchewan 2011, Government of Alberta 2012).

4. FUTURE NEEDS AND PRIORITIES

1.4.1 (FAO Question 1.18) Canadian Needs and Priorities for Improving Forest Genetic Resources Disaster Response Mechanisms and for Improving Monitoring of Genetic Erosion and Vulnerability

The needs and priorities for improving forest genetic resources disaster-response mechanisms are, in part, related to the type of disaster (e.g., biotic vs. abiotic) and the ecological scale of the disaster (e.g., biome, ecozone, ecosite); the geographical location will also dictate which agencies have jurisdiction (e.g., municipal, provincial, or national) to respond to the disaster.

One priority identified by the jurisdictional survey is the need for rapid and informative exchange on threats to forest genetic resources and mitigation protocols associated with major national issues such as climate change, invasive alien species, and impacts of forestry across governmental levels and among agencies involved in responding to the disaster. For example, the National Forest Information System (NFIS) is a pan-Canadian information system intended to convey current and authoritative national-level data. The NFIS also integrates jurisdictional data and data acquired through other organizations such as NatureServe Canada. Another priority is continued financial support for the operation of such a system. This type of information exchange is not only important for responding to a disaster but also for avoiding a disaster.

Furthermore, the federal government acknowledges the importance of integrated decision-making; it also recognizes the importance of environmental considerations to ensure that they are on equal footing with the social and economic considerations (Environment Canada 2010). Natural Resources Canada also identifies integration of a science and technology knowledge base for meeting challenges and opportunities as a key direction (Natural Resources Canada 2010c). Additionally, the Canadian Forest Service integrates historical and current knowledge to assist in the risk analyses of threats such as forest insects and diseases (e.g. Spruce Budworm Decision Support System, MacLean et al. 2000).

The detection of the disaster necessitates having a tracking or monitoring mechanism, the appropriate decision support system to analyze the ability to predict the impact of the threat(s), and resources to respond to the disaster. For forest tree species, jurisdictions have various means of monitoring (remotely through geographic information systems, analyses, field studies, etc.). However, the extent to which this is done varies greatly. Consistent national-level monitoring is a priority (Canadian Council of Forest Ministers 2006). Another priority based on the jurisdictional survey is the sharing of information through a common platform, using common language (international data standards) to enhance accessibility of basic information necessary for detecting a change in the status of forest genetic resources. Climatic conditions are monitored to a certain extent by the federal and provincial governments, and this type of data is more readily available. It is the species-specific data across jurisdictions that are often lacking.

Priorities for improving the monitoring of genetic erosion and for assessing species' vulnerability as identified by jurisdictional survey include supporting continued research to assess and monitor species' genetic diversity, and their adaptive potential to various stressors and to identify native tree species' resistance to high-impact stressors. Continued efforts for *ex situ* and *in situ* conservation of species at risk at both national and jurisdictional levels are essential, as is continued research in Gap analysis to investigate how well each species is covered by protected areas. Gap analysis is an assessment of the extent to which a protect area or system of areas meet protection goals that can be set at a national, jurisdictional or regional levels (Convention on Biological Diversity 2012). The knowledge gained from Gap analysis would greatly enhance Canada's ability to respond to threats before they significantly impact species' adaptive capacity and ultimately their viability. Currently, Gap analysis has been conducted in British Columbia and Alberta (Andreas Hamann, University of Alberta) and has been initiated in Quebec. Research is also needed to support the development of guidelines for managing genetic diversity at stand and landscape scales, with emphasis on both commercial and non-commercial species.

Another priority identified by the jurisdictional survey is the need for research to support the assessment of species' vulnerabilities. It is recognized that vulnerability assessments are a systematic analysis of species, habitats, or ecosystem at risk and use information pertaining to species sensitivity, adaptive capacity and exposure to threats such as climate change. Species' vulnerability assessments require diverse information pertaining to species habitat, physiology, phenology, biotic interactions, and genetic parameters such as the species' ability to respond to such threats as a changing climate, where the ability of the species to adapt in place, ability to move, etc. is important knowledge for the decision-making process for mitigating the impacts of climate change and other stressors, and for assisting land managers to prioritize efforts. Therefore, it is important to continue basic research assessing species biology and ecology, as this knowledge will enhance the vulnerability assessments and will assist in decreasing uncertainty.

Overall, continued long-term investments in research are critical for improving the monitoring of genetic erosion and vulnerability and, the response to these impacts. This includes research conducted by the various levels of government, academia, and industry. Teaching undergraduates and graduate students is also important to ensure that we have the future human capacity for continued research in these areas, particularly quantitative and molecular geneticists.

1.4.2 (FAO Question 1.23) The Level of Perception of the Importance of Forest Genetic Resources

The level of perception concerning the importance of forest genetic resources of those working in the field is very good, and it is recognized that genetic diversity is the key component to survival of a species. However, generating interest among those who are not working in this area can be a challenge. In part, this is related to the nature of genes, in that they are invisible to the naked eye and require relatively complex laboratory techniques to visualize (Boyle 2005). Also, there can be a degree of complexity associated with explaining what genes are and why they are important. As such, it can be difficult to communicate the importance of managing forest genetic resources and of supporting efforts in this area. Increasing the level of perception often occurs when forest genetic resources are linked to key environmental or production challenges that have significant impacts on the forest sector. For example, with regard to climate change, the management of forest genetic resources is an essential component of a climate change and any change in the production systems that requires the use of new genes. The level of perception for forest genetic resources is usually greater when addressed in a context such as this.

1.4.3 (FAO Question 1.26) Level of intervention required (national, regional and/or global)

Continued support from the federal and jurisdictional governments for on-going research and conservation efforts is very important. Regional groups such as the North American Forest Commission are very beneficial for coordinating efforts across national borders. As well, international groups can also be important for enhancing our research capacity and can help raise the profile of the work being done in Canada or support the need for further work associated with forest genetic resources.

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Chapter 2: The State of *in situ* genetic conservation

In situ conservation is a primary strategy for the long-term conservation of forested areas in Canada. Approximately 975 816 km^2, or 6.5%, of Canada's land area lies within currently designated park or other reserves (Canadian Council on Ecological Areas 2010). There is also an estimated additional 30 000 km^2 of privately owned land under conservation-oriented management (Rubec et al. 1990). The data concerning the proportion of current protected areas that contain forests are incomplete. However, in 1992, it was estimated that approximately 225 000 km^2 of forests are within the various park or reserve systems, representing approximately 4.9% of the total forested area, and areas considered "highly protected" (in which no disturbance is permitted) represent 100 000 km^2 or 2.1% of the total forested area (Boyle 1992).

The information presented in sections 2.3–2.6 was obtained from a jurisdictional survey, with participation from the following provinces: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec, and Saskatchewan and data are current as of 2010. All other information presented in this chapter is current as of 2012.

2.1 (FAO Question 2.2) Categories of *In Situ* Conservation Areas Established

In Canada, *in situ* conservation and protection of biodiversity are not centrally planned; they encompass a wide range of protected areas, mechanisms, and approaches. The federal government states that protected areas are geographically defined areas designed and managed to achieve specific conservation objectives (Natural Resources Canada 2011). Protected areas are created to ensure representation of a natural region; to protect biodiversity, specific species, or wildlife habitat; to preserve ecological integrity; and to ensure public access to outstanding natural areas for recreation and tourism. Activities in protected areas are controlled; certain activities may be prohibited, regulated, or managed, depending on the conservation objectives of the area.

The delineation of a protected area does not ensure that *in situ* conservation occurs, as this requires a level of management and enforcement in order to provide for optimal conservation conditions. The extent of protection in protected areas also varies, from no human disturbances permitted (e.g., national parks) to areas where partial logging and other activities may be permitted with restrictions (e.g., some jurisdictional parks). The restrictions usually specify such goals as maintaining a continuous forest canopy (spatially and temporally) and ensuring that there is adequate natural regeneration.

Canada has numerous categories of protected areas established by multiple organizations at the federal and jurisdictional levels and through non-governmental organizations (Table 2.1) that either directly or indirectly have the intent to conserve tree species *in situ*. In 1992, a *Statement of Commitment to Complete Canada's Network of Protected Areas* was signed by federal and provincial governments, confirming Canada's commitment to establish a network of national protected areas representing Canada's 39 ecological regions (Natural Resources Canada 2012).

The three main federal departments with mandates for the establishment and management of various types of federal protected areas, both terrestrial and marine, are Parks Canada Agency, Environment Canada, and the Department of Fisheries and Oceans. Parks Canada Agency has a lead role in establishing and maintaining national Canadian parks. Parks Canada, established in 1912, is the world's first national park service (Parks Canada 2012). National Parks are created under the *Canadian National Parks Act* (2000), which provides a legislative framework for protecting representative examples of Canada's natural regions. Canada's first national park and the world's third national park, Banff National Park, was established in 1885 by Order in Council as a wilderness recreation park, but its original guidelines did not contain any explicit conservation function (Parks Canada 2011). Environment Canada's Canadian Wildlife Service is responsible for migratory bird sanctuaries (Environment Canada 2010a). The intent of these protected areas is to protect critical wildlife habitat and unique and productive ecosystems for wildlife protection. Many of these are associated with forest areas and indirectly result in the conservation of forest genetic resources. The First Nations, through land-claim negotiations with the Government of Canada, have established wildlife sanctuaries and protected areas.

The jurisdictions have the mandate to create their own protected areas within their jurisdiction. Each province and territory has its own system of protected areas, which range from wilderness parks to parks with high recreational use (Table 2.1). In some jurisdictions, responsibility for the establishment and management of protected areas is shared among agencies, with the division of responsibilities occurring either along lines of establishment or operations management.

Non-governmental organizations (NGOs) are active in conserving forested areas and play a key role in the stewardship and establishment of protected areas by acquiring private lands to create new protected areas or to add to existing ones, by helping secure conservation easements to protect the land, and by holding and managing lands for conservation (Table 2.1).

Transboundary cooperation and management of protected areas is increasing. Several agreements have been made between Canada and the United States for transboundary responsibilities for *in situ* conservation. For example, Waterton Lakes National Park (Alberta, Canada) is linked with Glacier National Park (Montana, United States) and forms the world's first International Peace Park (UNESCO 2012). In addition, large corridor initiatives, such as the Yellowstone to Yukon Conservation Initiative (YYCI) (YYCI 2012), conserve *in situ* large forested regions, with the goal of linking ecosystems among provinces, territories, and nations.

Table 2.1. Examples of federal, provincial, territorial, non-governmental, and industry *in situ* conservation areas

Governance	*In situ* (forested) conservation categories	Types of *in situ* conservation categories and description
A) Federal *in situ* conservation areas		
Environment Canada – Canadian Wildlife Service	Migratory Bird Sanctuaries, National Wildlife Areas	**Migratory Bird Sanctuaries**: A designated migratory bird sanctuary can be any area on private or Crown land that meets one of four criteria: (1) supports bird populations that are concentrated for any part of the year to meet the population feeding and/or breeding needs, (2) the area is vulnerable to area-specific threats, (3) supports populations that occupy habitats or restricted geographical areas that are vulnerable to human disturbance, and (4) regularly supports at least 1% of a population of a species or subspecies.[1] These lands can include forested areas. **National Wildlife Areas**: A national wildlife area is a region of relatively undisturbed land containing nationally significant aquatic and/or terrestrial ecosystems necessary for plant and animal habitat. These areas are created for conservation purposes as well as scientific and wildlife research purposes.[2]
Aboriginal Peoples	Wildlife Sanctuaries, Protected areas	**Wildlife Sanctuaries** can included land that is set aside as a protected area at the request of Aboriginal Peoples during land-claim negotiations with the Government of Canada. For example, the Ddhaw Ghro, (formerly McArthur Wildlife Sanctuary), was set aside as a habitat protection area at the request of the Northern Tutchone First Nations in the Yukon during land-claim negotiations in the Selkirk First Nations Final Agreement.[3]
Parks Canada	National Parks, National Park Reserves	**National Parks** are established to protect examples of natural landscapes and natural phenomena occurring in Canada. National parks protect the habitats, wildlife, and ecosystem diversity representative of natural regions.[4] **National Park Reserves** are areas set aside as a national park pending settlement of any outstanding aboriginal land claims. During this interim period, the National Parks Act applies, and traditional hunting, fishing, and trapping activities by Aboriginal peoples will continue. Other interim measures may also include local Aboriginal people's involvement in park reserve

		management.[5]
B) Jurisdictional *in situ* conservation areas		
British Columbia Parks	Ecological Reserves, Conservation Lands, Wildlife Management Areas, Parks	**Ecological Reserves** are areas selected to preserve representative and special natural ecosystems, plant and animal species, features, and phenomena. Scientific research and educational purposes are the principal uses of ecological reserves. Ecological reserves are established for: preservation of representative examples of British Columbia's ecosystems; protection of rare and endangered plants and animals in their natural habitat; preservation of unique, rare, or outstanding botanical, zoological, or geological phenomena; perpetuation of important genetic resources; and scientific research and educational uses associated with the natural environment.[6] **Conservation Lands** are areas to conserve and manage critical habitat for the benefit of regionally, nationally, and internationally significant fish and wildlife species. Principal objectives of the Conservation Lands Program include conserving or managing habitat with regard to: sensitive, vulnerable, or at-risk species; critical species' life-cycle phases such as spawning, rearing, nesting, or winter feeding; important species migration routes or other movement corridors; areas of very high species productivity or diversity. Conservation lands often concurrently provide for a range of wildlife-related opportunities for the public, such as day hiking, hunting and fishing, wildlife viewing, scientific research, and interpretive programs.[7] **Wildlife Management Areas** constitute conservation land requiring a special level of protection and management. Reasons for this designation include: an area's wildlife/habitat values are of regional, provincial, or national significance; special management zones or objectives for wildlife, fish, and their habitats have been identified in a local or regional strategic land-use plan; there is a need to conserve or manage important species and habitats while still allowing certain types of activities or developments to continue; a standard "protected area" designation is not an available option or is considered too restrictive; a buffer zone or link for a core protected area is desirable.[8] **Parks** are areas selected for a broad range of activities and uses many of which pertain to recreational activities.[9]
Alberta Tourism, Parks and Recreation	Ecological Reserves, Provincial Parks, Provincial Recreation Areas, Natural Areas, Heritage Rangelands, Wilderness Areas, Wildland Parks	**Ecological Reserve:** is land preserved for ecological purposes and is representative of natural ecosystems in Alberta that contain rare or endangered native plants or animals or areas with unique examples of natural biological or physical features.[10] **Provincial Park:** is land designated as a provincial park for the preservation of Alberta's natural heritage. These parks have multiple purposes, including the conservation and management of flora and fauna; the preservation of specified areas that are of geological, historical, ecological, or other scientific interest; facilitating their use and enjoyment for outdoor recreation, education, and appreciation of Alberta's natural heritage; and ensuring their lasting protection for the benefit of present and future generations. [11] **Provincial Recreation Area:** is land designated as a provincial recreation area to facilitate its use and enjoyment for outdoor recreation by present and future generations.[10] **Natural Area:** is land set aside to protect sensitive or scenic public land or natural features on public land from disturbance; to maintain that land or those features in a natural state for use by the public for conservation, nature appreciation, low-intensity outdoor recreation, education, or for any combination of these purposes.[10] **Heritage Rangeland:** are lands that contain natural landscapes, features, and ecological processes associated with Alberta's rangelands and are designated

		as such to ensure their preservation and protection using grazing to maintain the grassland ecology.[10] **Wilderness Area:** are among the most strictly protected areas in Canada; no developments of any kind are permitted. Travel in wilderness areas is by foot only. Collection, destruction and removal of plant and animal material, as well as fossils and other objects of geological, ethnological, historical and scientific interest, are prohibited. Hunting, fishing and the use of horses are not permitted in wilderness areas.[10] **Wildland Park:** Wildland parks are large, undeveloped natural landscapes. Trails and primitive backcountry campsites are provided in some wildland parks to minimize visitor impacts on natural heritage values. Designated trails for off-highway vehicle riding and snowmobiling are provided in some Wildland parks Hunting is allowed in some Wildland Parks.[10]
Saskatchewan Tourism, Parks, Culture & Sport	Ecological Reserves, Game Preserves, Protected Areas, Natural Environment Parks, Wilderness Parks, Wildlife Development Fund, Land Wildlife Habitat Protection Lands, Wildlife Refuges	**Ecological Reserves:** are lands that sustain or are associated with unique or representative parts of the natural environment including water, land, plants, wildlife, and people, with the goal to preserve natural areas to protect genetic resources and to provide areas for scientific research in a natural setting.[12] **Game Preserves:** are areas established for protecting, propagating, managing, controlling, regulating, or enhancing wildlife and its habitat with the goal of preserving and managing a wildlife population and its habitat and can included forested areas.[12] **Protected Areas:** are lands that offer maximum protection to important, rare, or fragile resources.[12] **Natural Environment Parks:** are large natural tracts of land that protect representative and unique landscapes found in Saskatchewan, with the goal of landscape protection and provision of appropriate recreational opportunities to the public.[12] **Wilderness Parks:** are large remote tracks of land preserved where low-intensity and non-mechanized wilderness recreation is permitted. A goal is to protect representative areas of Saskatchewan's major ecoregions.[12] **Wildlife Development Fund Lands:** are lands conserved to improve critical habitat for game and endangered species, with the goal to protect or restore wildlife habitat in the agricultural and forested areas.[12] **Wildlife Habitat Protection Land:** are designated multiple-use provincial Crown lands that provide seasonal or year-round habitat critical to wildlife survival, including rare and endangered species located primarily in the agricultural and forest fringe regions of Saskatchewan.[12] **Wildlife Refuges:** are areas for the protection, propagation, perpetuation, management, control, regulation, and/or enhancement of wildlife and its habitat and include forested areas.[12]
Manitoba Conservation	Ecological Reserves, Protected Areas, Provincial Parks, Public Reserves, Wildlife Management Areas	**Ecological Reserves:** are areas that contain rare or sensitive habitats that can be set aside as ecological reserves with greater restrictions on uses and activities so that the natural region features for which they are set aside endure for future generations.[13] **Protected Areas:** are areas prohibited, through legal means, for logging, mining (including aggregate extraction), and oil, petroleum, natural gas, or hydro-electric development. Protected areas with this minimum level of protection still remain open for activities such as hunting, trapping, or fishing.[13] **Provincial Parks:** can be protected areas; however, not all provincial parks are protected areas. Provincial Parks are classified into 4 categories: 1. Wilderness Park: preserves that represent areas of a natural regions (protected area); 2) Natural Park: preserves of a natural region that accommodates a diversity of recreational uses (maybe protected); 3) Recreation Park: provides recreation opportunities (not protected); 4) Heritage Park: preserves of land containing

		resources of cultural or heritage value (may be protected). **Public Reserves:** are areas that preserve unique and rare natural (biological and geological) features of the province and, examples of natural and modified ecosystems. These sites are set aside for ecosystem and biodiversity preservation, research, education and nature study. [13] **Wildlife Management Areas:** are areas designated for the better management, conservation, and enhancement of the wildlife resource of the province. Hunting and trapping are generally permitted, but these activities may be prohibited or restricted in selected areas.[14]
Ontario Parks and Protected Areas	Provincial Parks, Conservation Reserves, Natural Environment Reserves, Wilderness Areas	**Provincial Parks:** are protected areas representative of Ontario's ecosystems, biodiversity, and provincially significant natural elements. They provide opportunities for ecologically sustainable outdoor recreation and opportunities for visitors to increase their knowledge and appreciation of Ontario's natural and cultural heritage, and they facilitate scientific research and provide points of reference to support monitoring of ecological change on the broader landscape.[15] **Conservation Reserves:** are similar to Ontario's provincial parks but also provides opportunities for ecologically sustainable land uses, including traditional outdoor heritage activities and associated benefits.[15] **Wilderness Areas:** are lands set aside for the preservation of the area in its natural state, with the goal to protect flora and fauna.[16]
Faune Québec, Ministère des Ressources naturelles et de la Faune	National Parks, National Park reserves¸ Wildlife and Biodiversity Preserves, Ecological Reserves as examples	**Protected Area:** is any area that is dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means. Note, land types that fall under Quebec's Protected Areas include Exceptional Forest Ecosystem, Wildlife Habitat, threatened plant species Habitats, Quebec's National Parks and National Park reserves¸ Wildlife and Biodiversity Preserves, and Ecological Reserves.[17]
New Brunswick Department of Natural Resources	Protected Natural Areas, Provincial Parks	**Protected Natural Area (PNA):** an area of land or water permanently set-aside for the conservation of biological diversity.[18] **PNA Class I:** requires complete protection as they contain ecologically sensitive features that could be damaged by human activity. All activities are prohibited in these areas, except by permit from the Minister for educational and scientific purposes.[18] **PNA Class II:** ecosystems that are representative of the New Brunswick landscape or that are ecologically important or rare. Certain recreational uses having minimal environmental impact and traditional food-gathering activities are permitted in these areas, but industrial, commercial, and agricultural uses and development are prohibited. Educational and scientific activities require a permit.[18]
Nova Scotia Department of the Environment	Nature Reserves, Wilderness Areas	**Nature Reserve:** is an area selected to preserve and protect, in perpetuity, representative and special natural ecosystems, plant and animal species, features and natural processes. Scientific research and education are the primary uses, with recreation being restricted generally.[19] **Wilderness Areas:** are representative of NS landscapes, native biological diversity, and unique natural features, used for scientific research, education, recreation, and nature-tourism-related activities.[19]
Prince Edward Island Department of the Environment,	Conservation Zones, Wildlife Management Zones,	**Conservation Zone:** is an area established for preserving animate or inanimate objects of aesthetic, educational, or scientific interest, or for preserving unusual combinations of elements of the natural environment having educational, historical, or scientific interest.[20] **Wildlife Management Area:** is an area to be maintained for the protection,

Energy and Forestry	Natural Areas, Provincial Parks	management, and conservation of wildlife and wildlife habitat. [21, 22] **Natural Area:** is an area that contains natural ecosystems or constitutes the habitat of rare, endangered, or uncommon plant or animal species.[21, 22] **Provincial Parks:** are responsible for maintaining and restoring ecological integrity of the designated area. [21, 22]
Newfound-land & Labrador Department of Environment & Conservation	Ecological Reserves, Provincial Parks, Wildlife Reserves, Wilderness Reserves	**Ecological Reserves:** represent areas smaller than 1000 km^2 designed to protect representative ecosystems or to protect unique, rare, endangered plants, animals, or other elements of Newfound and Labrador's natural heritage.[23] **Provincial Parks:** protected areas with significant natural features that have been established to protect the representative areas of the different ecoregions within the province.[23] **Wildlife Reserves:** areas created to protect the habitat of particular wildlife species.[23] **Wilderness Reserves:** are areas greater than 1000 km^2 designed to protect significant natural features and landscapes and to provide opportunities for low-impact outdoor recreation.[23]
Yukon Department of Environment	Multiple categories	**Special Management Areas:** are protected areas that can be parks, habitat protection areas, wildlife areas, or other types.[24] **Habitat Protection Area:** an area identified as requiring special protection under Yukon's *Wildlife Act*.[25]
Northwest Territories Environment and Natural Resources	Territorial Parks, Protected Areas	**Protected Area:** is any area that is dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal or other effective means. **Territorial Parks are divided into the following categories:**[26] **1) Heritage Parks:** parks with historical significance. **2) Natural Environmental Parks:** preserve and protect unique, representative, or aesthetically significant natural areas **3) Recreational Parks:** encourage an appreciation for the natural environment or provide recreational activities (including campgrounds). **4) Wayside Parks:** provide for the enjoyment or convenience of the travelling public.
C. Non-governmental organizations *in situ* conservation areas		
Ducks Unlimited	Wetland conservation areas	**DUC Boreal Forest Conservation Program:** conserves wetland areas in Canada's boreal forest through a combination of ecosystem-based sustainable development that utilizes state-of-the-art best management practices and by promoting the establishment of an extensive network of large, interconnected wetland-rich protected areas.[27] DUC partners with multiple stakeholders, including the federal and jurisdictional governments, industry (e.g., Weyerhaeuser), Aboriginal peoples, academic institutions, foundations, and conservation organizations to help establish a national boreal conservation network of large, wetland-rich protected areas.[28]
Island Nature Trust, Prince Edward Island	Multiple categories	The Island Nature Trust is the first private, provincially based Nature Trust in Canada.[29] It is a non-governmental, not-for-profit organization dedicated to the protection and management of Prince Edward Island's Natural Areas. Lands acquired are held in trust and managed for future generations as examples of appropriate and sustained use. Their Trees in Trust program enables donors to pay for a mapped piece of forest, which will then be dedicated in their name.[30, 31]
Nature Conservancy of Canada	Multiple categories	The Nature Conservancy of Canada (NCC) protects areas of natural diversity for their intrinsic value and for the benefit of our children and those after them.[32] The NCC identifies, plans, and executes the protection of natural spaces and manages and restores them for the long term. This process ensures that our conservation actions (like buying land, removing invasive weeds, or

		mapping the location of rare species) are efficient and effective.[33] They do so through the following means: **Conservation Agreement:** a voluntary, legal agreement between a landowner and conservation organization that permanently limits uses of the land in order to protect its conservation values.[34] **Ecogift Program:** Many land and easement donations to the NCC are processed through the federal Ecogift program, which is administered by Environment Canada. The land must be certified by the Minister of the Environment as ecologically sensitive.[35] **Capital donations:** Donors receive a tax receipt for the appraised value of the land/conservation agreement.[36] **Donation of Land as Assets:** Occasionally, NCC may receive a donation of land of minimal ecological value purely as an asset to be sold, with the proceeds of the sale being invested in projects with higher priority conservation needs.[36]
New Brunswick Nature Trust	Multiple categories	Established as New Brunswick's (NB) provincial land trust in 1987, the Nature Trust of NB identifies, promotes, protects, and maintains diverse areas of ecological significance in the province.[37, 38]
Ontario Nature	Multiple categories	Ontario Nature protects wild species and wild spaces through conservation, education, and public engagement. Ontario landowners can help conserve the ecological integrity of natural spaces through a number of means, so they are included in Ontario Nature's Nature Reserves System.[39, 40]
D) Forest Industry		
J.D. Irving, Ltd.	Unique Areas Program	J.D. Irving, Ltd. (JDI) has been establishing habitat protection areas, including old-growth forests, on its freehold lands since the 1980s. To date, 715 unique areas have been set aside for protection, totalling 77 000 ha.[41] JDI is acting to ensure that areas of ecological importance remain healthy and vibrant through their habitat conservation, green initiatives, stringent policies, environmental education projects, and extensive scientific research.[42]

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2.2 (FAO Question 2.1 and Appendix 2.1, 2.2) Target Species Included in Actively Managed Areas Within *In Situ* Conservation Programs

The rationale for protecting individual species vs. ecosystems and habitats has not been proven as the best method to achieve objectives in areas managed within *in situ* programs (Boyle 1992; Yang and Yeh 1992). The most effective way to conserve biodiversity of species and genes is to conserve the variety of ecosystems that have this diversity to emerge and survive. This supports Goal 1, ecological planning and management, of the *Canadian Biodiversity Strategy* (Minister of Supply and Services Canada 1995) which was developed as part of Canada's commitments under the Convention on Biodiversity. In the event of climatic and population fluctuations, or even local extinctions, the environment would still be able to support the regeneration, return, and success of these plants and animals. Therefore, the data are not available for providing a national perspective in this area. There are numerous efforts at the jurisdictional level, where plans or protocols for assessing species conservation measures, including *in situ* conservation activities, have been developed (e.g., *Gene Conservation Plan for Native Trees of Alberta* (Alberta Sustainable Resource Development 2009; *Indigenous-Tree Genetic Conservation in British Columbia* (Forest Genetics Council of British Columbia 2007) *Genetic Guidelines for Forest Managers* (Forest Gene Conservation Association of Ontario 1997). In addition, a number of jurisdictions have evaluated provincial protected areas to determine if they are meeting the goal of conserving *in situ* indigenous tree species' genetic diversity. For example, in 2009, the province of British Columbia produced a status report on the *in situ* conservation of approximately 50 native tree species in all major biogeoclimatic ecological classification (BEC) units (zones) in which they occur (British Columbia Ministry of Forests and Range 2009). They combined data on species coverage for thousands of botanical plots in the province with the distribution of BEC units using geographic information systems and spatial analysis. This information was used to determine: (1) where additional information is needed (e.g., genetic structure and degree of population differentiation for minor angiosperm and conifer tree species not previously investigated) and (2) where additional *in situ* protection is needed. At the federal level, Parks Canada produces a *State of Parks Report* for each national park (Parks Canada 2009). These reports provide information on the status and trends of species found within the parks, many of which are tree species.

All provincial and territorial governments and the federal government assess species at risk (See Chapter 1, section 1.2.3 for details) and many of these assessments or the resulting management plans include an evaluation of *in situ* conservation capacity. These plans can be specific to species (e.g., eastern white cedar (*Thuja occidentalis*), Nova Scotia Department of Natural Resources 2010) or regions (e.g., Grand River Conservation Authority (2004) for multiple species with official risk designation in Ontario).

2.3 (FAO Question 2.5 and Appendix 2.4) Constraints to Improving *In Situ* Conservation in Canada

The below constraints are based on the results of the jurisdictional survey.

A) Regulation constraints:

- The protection of species is often addressed by different legislation. Consolidation of legislation may streamline activities.

- The development and implementation of a cross-jurisdictional landscape-scale strategic conservation framework.
- There may be a lack of enforceable provisions and regulations for the *in situ* conservation of forest species.
- Limited application and implementation of regulations on private lands make it challenging for establishing and maintaining *in situ* conservation areas on private lands.
- The listing of species under the *Species at Risk Act* (SARA) is time consuming. Additional constraints arise when species under SARA do not have recovery plans developed. Where there is a recovery plan, implementation, monitoring, and evaluation may be incomplete.
- Limitation in the ability to create new protected areas as mining or other activities related to the energy sector take priority and land reserved from special groups (Aboriginal rights) have priority.
- Creation of protected areas is a voluntary program that occurs in consultation with local and regional authorities. This can limit the government's ability to created protected areas.

B) Information, data, and monitoring constraints:
- Quality data for species may be lacking, including a lack of accurate inventory at a scale appropriate for making decisions.
- Critical habitat for tree species may not be appropriately identified.
- Lack of knowledge on the actual distribution of species requiring conservation.
- Knowledge of the genetic structure of most tree species is lacking and this would enable more effective gene capture in *in situ* conservation areas.
- Lack of monitoring for habitat and population trends.

C) Management/decision-making constraints:
- Lack of consensus over decision making.
- Lack of agreement of between parties involved in designating *in situ* conservation areas, particularly as pertains to the best use of public and private lands.
- *In situ* conservation of non-commercial species may not be a priority.
- Climate change has significant implications for the efficacy of protected areas policies and management objectives
- Management of protected areas should focus on protecting, connecting, and restoring ecosystems.
- Contemporary planning and management initiatives provide a hedge against uncertainty.
- Lack of recognition of explicit climate change impacts with respect to the values desired for conservation (redundancy, corridors, elevational gradients, etc.).
- Uncertainty with regard to the ability of many tree species to adapt under climate change; this can make it challenging to prioritize efforts.
- Financial constraints of implementation and management of *in situ* areas.
- A lack of understanding by the public, government, and industry on the role and importance of *in situ* conservation of forest genetic resources.
- Challenges in developing protected areas in jurisdictions that are predominantly privately owned; this reduces the effectiveness of a "top down" approach.
- Application of modern modeling approaches to protected areas with management options under climate change to a greater extent than is currently reflected in the scientific literature.

D) Financial constraints:
- Financial constraints with the implementation and management of *in situ* areas.

E) Public perception constraints:
- Mainstream media reporting may lack insight into complex conservation issues.
- Scientific extension is often inadequate for the public. Information on the studies and values of *in situ* conservation is often full of technical jargon, making it difficult for the public to understand the significance of *in situ* conservation. For example, "*in situ* conservation" can be a difficult concept for the public to quickly grasp and relate to.

- Protected areas should more effectively embed broader societal sustainability goals.
- Communicating climate change to the Canadian public remains a fundamental challenge for protected areas agencies.

F) General constraints:

- Many government professionals believe that as trees do not form a distinct biological group, they should not be considered separate from other vascular plants when prioritizing and funding conservation efforts. In this context, many vascular plants are recognized as being at greater risk of extinction than most tree species.
- It is challenging to locate potential *in situ* conservation areas with adequate population sizes in locations that are secure from industrial activity and buffered against anticipated climate change
- No critical evaluation of how well protected areas have worked in the past.
- Under climate change scenarios, many predict that protected areas will not protect the original ecosystems for which they were designated.
- Although climate change presents unprecedented and significant challenges, the protected area contribution to ecosystem function and human health and well-being will remain an essential and worthwhile investment in the 21st century.

2.4 (FAO Questions 2.6, 2.9 and Appendix 2.4, 2.5) Priorities for Future *In Situ* Conservation Actions

The below priorities are based on the results of the jurisdictional survey.

Priorities include:

- Protecting the most threatened or endangered at-risk species and their habitats at a landscape level (i.e., critical habitat for species at risk, restricted habitat niches containing multiple rare species or communities).
- Although a large percentage of the genetic diversity of a species (in nearly all documented cases) is within populations, large adaptive differences among populations are usually present, and identifying representative populations for conservation across the species range is key.
- When clearly unique populations are documented (e.g., a special ecotype or pest-resistant population), determining their *in situ* conservation status and the potential to adequately conserve what may be under-protected populations is an important goal.
- Continued support for the development and maintenance of park reserves and protected areas.
- To provide support for groups such as Nature Conservancy Canada.
- Conducting Gap analysis, to determine whether native species gene resources are adequately represented in existing protected areas given geographic distribution, climate variation, and population sizes. Gap analysis will also assist with developing the ability to estimate mature population size of less common or abundant species.
- Identification of species of concern on public lands. Efforts can involve assisting private landowners with information pertaining to identification and protection of these species. Also, it is of value to establish management plans for properties with species of concern.
- To continue to increase the number of *in situ* areas and to assess the adequacy of these areas through cooperative work with various jurisdictional government agencies, universities, and forest industry.
- Continue to establish *in situ* conservation areas for tree species with official federal risk designation. For example, limber and whitebark pine listed by SARA as endangered in Alberta. Several candidate *in situ* conservation areas have been identified for limber and whitebark pine, with one established for limber pine in 2011 (Panther Corners Limber Pine Tree Gene Conservation Reserve).
- Review previously established *in situ* tree gene reserves on Green Area Crown lands to determine their status and suitability for future listing.
- To promote or develop mechanisms to allow multiple stakeholders (e.g., forest companies, NGOs, public) to be involved in *in situ* conservation. British Columbia Parks and Parks Canada, as well as numerous regional and local governments have volunteer warden programs. Many NGOs from global (Wilderness International, World Wildlife Fund) to national (Nature Conservancy of Canada, The Nature

Trust) to regional (The Land Conservancy) organizations are involved in building partnerships with parks agencies and donating lands that private individuals or companies have gifted or put conservation covenants on.
- Linking carbon sequestration offset programs with conservation activities. For example, opportunities for conserving British Columbia's forests through carbon sequestration offset programs are also underway—a final draft (November 2010—for public review (British Columbia Ministry of the Environment 2010a)) of the *Forest Carbon Offset Protocol* (British Columbia Ministry of the Environment 2011). This protocol has been developed to guide the design, development, quantification, and verification of forest carbon offsets from a broad range of forestry activities on private and public land in British Columbia, including "conservation/avoided deforestation" projects.
- Continue to educate and communicate conservation management to the public, ensuring that they have the best available information methods and technology.
- To develop comprehensive conservation strategies by identifying the current state of the conservation of forest genetic resources and then determining conservation priorities.
- To organize seed collection for species or provenances identified as being at 'risk' using Gap analysis, and establish conservation plantations in a diverse range of environments that are representative of the actual climatic envelopes of the species, and in environments where this climatic envelope will be in the future.
- Develop collaborative initiatives to monitor the health of tree species over years as climate changes and to develop indictors/thresholds to the species adaptive capacity.

2.5 (FAO Question 2.8) National Forum for Stakeholders Involved in *In Situ* Conservation

Canada does not have a national forum pertaining to *in situ* conservation for forest genetic resources. The Canadian Council on Ecological Areas (CCEA) is a national, non-profit organization with a mission "to facilitate and assist Canadians with the establishment and management of a comprehensive network of protected areas representative of Canada's terrestrial and aquatic ecological natural diversity" (CCEA 2010b). CCEA membership includes representation from federal, provincial, territorial, and non-governmental agencies responsible for protected area establishment and management, and academic and private sector experts and, as such, it functions as a national forum addressing protected areas (CCEA 2010b). The CCEA is administered by an Executive Board with managing and decision-making authority. The Executive seeks advice and assistance of representatives of the jurisdictions, environmental NGOs, and academic institutions.

This group provides advice and assistance to international, national, provincial/territorial, and local agencies on matters dealing with protected areas and ecosystem conservation. National strategic priorities for this group include the design of protected areas, design of their stewardship and management, data and information management, and communications. They have developed a Conservation Areas Reporting and Tracking System (CARTS), a web-based application to standardize national reporting and mapping for all Canadian public conservation areas (commonly called protected areas) (CCEA 2010a). The CARTS web portal contains data from all federal, provincial, and territorial jurisdictions.

2.6 (FAO Question 2.9) Research Priorities to Support *In Situ* Conservation

Research priorities as identified by the jurisdictional survey include:
- Understanding genetic structure of tree species and tree populations.
- Understanding climatic amplitude of *in situ* genetic resources under unprecedented climate change.
- Understanding how genetic variation in foundation species affects biodiversity and associated plant and animal communities.
- Understanding natural selection and adaptation mechanisms for the development of genetic diversity requirements (e.g., minimum thresholds, composition, ranges, extent, and distribution) for managing and conserving forests at both the stand and landscape level.
- Increased knowledge of the geographical genetic structure of indigenous plant populations is required.
- Determining native species' ranges and populations across jurisdictional landscape-scale boundaries.

- Developing data and methods to adapt genetic conservation strategies, actions, and plans for a changing climate (e.g., genetic outposts, climate-tolerant set asides/reserves, buffered areas and spatio-temporal recruitment strategies).
- Determining preferred locations for establishing *in situ* conservation areas where they will contain sufficient populations and be buffered against projected climate change (generally warming and increased drought risk) and damaging insects and diseases.
- Research should focus on non-commercial tree species, in addition to commercial species.
- Developing GIS tools for monitoring and ground-truthing techniques.
- Developing modeling systems like GAP analysis to assess the adequacy of current tree gene protection in existing protected areas and recommendations for addressing any deficiencies.
- Developing modern modeling systems like distribution modeling, species shift, and niche modeling
- Enhancing and elaborating CON**FOR**GEN's impact with respect to *in situ* conservation within national and international capacities.

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Chapter 3: The State of *ex situ* Genetic Conservation

This chapter describes the current state of *ex situ* conservation of forest genetic resources and the needs and priorities for improving it. The information presented in this chapter represents the state of *ex situ* genetic conservation in Canada, as of 2012, based on a survey that was completed by the following provinces: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec and Saskatchewan and data is current as of 2010. A list of pertinent definitions was provided to ensure clear consistent answers to the survey questions.

The definitions were as follows:
Germplasm: A collection of genetic resources such as seed, pollen, tissue culture, clones.
***Ex situ*:** Moving germplasm from its original location and re-establishing or storing it at another location for the purposes of the conservation of components of biological diversity outside their natural habitats.
Clone bank: A collection of clonal propagules for the purpose of *ex situ* conservation.

Ex situ conservation of forest trees has probably never been as important as it is today, given climate change and the challenges for forests that it creates regarding impacts from insects and disease. In Canada, there are four main *ex situ* conservation reserves for tree species: three jurisdictional seed banks (British Columbia's Ministry of Forests, Lands and Natural Resource Operations, Alberta Ministry of Sustainable Resource Development, Manitoba Conservation (Forestry Branch)) and one national seed bank (the National Tree Seed Centre) (Beardmore and Simpson 2010). It should be noted that there are other *ex situ* reserves of tree seed in Canada that are not considered here.

In British Columbia, forest genetic conservation activities are conducted by the Genetic Conservation Technical Advisory Committee, which functions as a sub-committee of the Forest Genetics Council (Kolotelo 2010).The primary functions of the seed bank, established in the late 1950s, are the processing, testing, and storage of seed from commercial species. Leftover seed from samples from operational seedlots submitted to the lab for testing is placed in *ex situ* conservation. The minimum sample size is 1000 viable seed. Seed is also obtained from non-commercial species. *Pinus albicaulis* is the highest priority because it is threatened from a variety of sources (Kolotelo 2010). In Alberta, *ex situ* conservation activities are guided by the Gene Conservation Plan for Native Trees of Alberta (Alberta Forest Genetic Resources Council 2010). Collections stored at the seed bank are composed of samples from operational seedlots from commercial species, as well as targeted collections from non-commercial species, in particular *Pinus albicaulis* and *Pinus flexilis* because of the threats to these species posed by an introduced disease, a native insect, and climate change. The seed bank in Manitoba stores samples of seed taken from operational seedlots of reforestation species.

The Canadian Forest Service (CFS) established the National Tree Seed Centre (NTSC) in 1967 to store tree seed for the purpose of *ex situ* conservation. The NTSC has facilities, expertise, and people to coordinate, conduct work, and collaborate with national and international conservation programs. The NTSC stores seed in two categories: a seed bank (seed available for research) and genetic conservation. To move forward, a comprehensive strategy in collaboration with all jurisdictions is needed in order to collect and conserve seeds for supporting conservation and recovery of key representative populations, habitats, and ecosystems. Currently, work is underway to produce a pan-Canadian *ex situ* conservation strategy to conserve genetic diversity. Development, in collaboration with participating agencies, of an effective deployment and rejuvenation strategy for *ex situ* conservation and concomitant research with the collections and banking activities are necessary to ensure that effective *ex situ* conservation measures are being undertaken (Beardmore and Simpson 2010). To date, there has been inter-jurisdictional effort to coordinate the storage of germplasm for *ex situ* conservation at the NTSC.

3.1 (FAO Questions 3.1 – 3.4 and Appendix 3.1) Means of *Ex Situ* Conservation of Tree Species and Number of Seedlots Stored in Canada

Table 3.1 is a compilation of data from four provinces and the NTSC. Germplasm for 82 tree species (38 softwoods and 44 hardwoods) is conserved by one or more means. Seed is stored for all species, except *Betula neoalaskana* which is represented in plantations, and *Quercus macrocarpa* and *Sherpherdia argentea,* which are conserved in clone banks. *Picea glauca* has germplasm stored in all categories. The number of seedlots stored is almost equal between single tree and bulk collections (7,224 and 7,803, respectively). *Pinus contorta* var. *latifolia* has the most seedlots stored (3,157), followed by *Picea glauca* (1,872).

Table 3.1. Tree species conserved by *ex situ* conservation

	Means of *ex situ* conservation					Seedlot type		
Tree Species (≥ 10 m in height)	Seed	Pollen	Tissue culture	Clone bank	Plantations	Single tree	Bulk	TOTAL
Abies amabilis	X					0	403	403
Abies balsamea	X					0	2	2
Abies grandis	X					0	116	116
Abies lasiocarpa	X					40	240	280
Acer negundo	X					15	8	23
Acer pensylvanicum	X					17	0	17
Abies procera	X					0	63	63
Acer rubrum	X					111	0	111
Acer saccharinum					0	0	1	1
Acer saccharum	X					23	0	23
Acer spicatum	X					50	0	50
Alnus incana ssp. *Rugosa*	X					3	0	3
Alnus incana ssp. *Tenuifolia*	X					0	1	1
Alnus rubra	X					0	33	33
Betula spp.	X					1	0	1
Betula alleghaniensis	X					57	0	57
Betula cordifolia	X					5	0	5
Betula neoalaskana					X	0	0	0
Betula occidentalis	X					37	0	37
Betula papyrifera	X				X	10	32	42
Betula populifolia	X					20	0	20
Callitropsis nootkatensis	X					0	143	143
Cornus florida	X					0	4	4
Carya cordiformis	X					0	1	1
Cornus nuttalli	X					73	0	73
Crataegus douglasii	X					68	0	68
Fraxinus Americana	X					223	0	223
Fraxinus nigra	X					150	8	158
Fraxinus pennsylvanica	X			X		153	5	158
Fraxinus profunda	X					1	0	1
Fraxinus quadrangulata	X					1	0	1
Juniperus maritime	X					29	0	29
Juniperus scopularum	X					35	1	36
Larix laricina	X			X	X	254	49	303
Larix lyallii	X					34	3	37
Larix occidentalis	X			X	X	0	216	216

Malus fusca	X					34	0	34
Picea engelmannii	X			X		0	11	11
Picea glauca	X	X	X	X	X	1585	287	1872
Picea glauca var. *albertiana*	X					9	0	9
Picea glauca x *engelmannii*	X			X	X	10	1179	1189
Picea glauca var. *porsildii*	X					15	0	15
Picea luzii	X					0	60	60
Picea mariana	X			X	X	348	121	469
Picea rubens	X					217	3	220
Picea sitchensis	X					38	105	143
Pinus albicaulis	X		X		X	520	14	534
Pinus banksiana	X			X	X	85	99	184
Pinus contorta x *banksiana*	X			X	X	61	12	73
Pinus contorta var. *contorta*	X					41	76	117
Pinus contorta var. *latifolia*	X					931	2226	3157
Pinus flexilis	X		X		X	394	28	422
Pinus monticola	X					0	148	148
Pinus ponderosa	X					0	251	251
Pinus resinosa	X					15	1	16
Pinus rigida	X					0	4	4
Pinus strobus	X					31	1	32
Populus balsamifera	X			X	X	20	4	24
Poplulus deltoids	X			X		0	2	2
Populus grandidentata	X					13	0	13
Populus tremuloides	X				X	16	25	41
Populus trichorcarpa		X				0	0	0
Populus nigra				X		0	0	0
Populus maximowiczii		X				0	0	0
Prunus emarginata	X					43	0	43
Prunus pensylvanica	X					61	0	61
Prunus serotina	X						4	4
Prunus virginiana	X					69		69
Prunus virginiana var. *virginiana*	X			X		337	0	337
Pseudotsuga menziesii var. *glauca*	X			X	X	20	786	806
Pseudotsuga menziesii var. *menziesii*	X					636	259	895
Quercus macropcarpa				X		0	0	0
Rhamnus purschiana	X					22	0	22
Sherpherdia argentea				X		0	0	0
Symphoricarpus occidentalis	X			X		0	0	0
Taxus brevifolia	X					11	0	11
Thuja occidentalis	X					49	0	49
Thuja plicata	X					0	333	333
Tsuga Canadensis	X					183	0	183
Tsuga heterophylla	X					0	362	362
Tsuga mertensiana	X					0	54	54
Ulmus americana	X					9	0	9

3.2 (FAO Question 3.2) Storage Temperature used for *Ex Situ* Conservation of Seed

Three provinces and the NTSC have active *ex situ* conservation programs where seed is stored at -15°C to -20°C.

3.3 (FAO Question 3.6) Germplasm Stored in *Inter Situ* Plantations and Clone Banks in Canada

Germplasm from 23 conifer and 14 hardwood species is conserved in trials/plantations and clone banks (Table 3.2). There are 481 trials/plantations established on approximately 268 ha and 37 clone banks containing 2,326 clones and 20505 seedlings. *Picea glauca* and *Picea glauca* x *engelmannii* have the largest number of clones (772 each), followed by *Pinus contorta* var. *latifolia* and hybrids (562 each).

Table 3.2. Tree species conserved in trials/plantations and clone banks in Canada

Species	Trials or plantations		Clone banks	
	No.	Total area	No.	No. clones
Abies amabilis	16	N/A	1	80
Abies grandis	4	N/A	1	50
Abies lasiocarpa	12	N/A	0	0
Abies procera	16	N/A	0	0
Acer macrophyllum	4	N/A	0	0
Alnus rubra	2	N/A	0	0
Betula papyrifera	3	0.6	0	0
Callitropsis nootkatensis	12	N/A	0	0
Fraxinus pennsylvanica	7	7.7	9	4500*
Larix laricina	8	3.3	1	10
Larix occidentalis	2	N/A	0	0
Larix sibirica	21	6.5	0	0
Picea engelmannii	0	0	1	23
Picea glauca	50	102.9	1	772
Picea glauca x *engelmannii*	7	3.6 +[1]	1	772
Picea mariana	11	13.3	0	0
Picea sitchensis	13	N/A	0	0
Pinus albicaulis	2	0.1	0	0
Pinus banksiana	13	9.8	1	57
Pinus contorta var. *latifolia* (and hybrids with *P. banksiana*)	123	96.0 +	1	562
Pinus flexilis	4	0.7	0	0
Pinus monticola	12	N/A	0	0
Pinus ponderosa	2	N/A	0	0
Pinus resinosa	4	0.7	0	0
Pinus sibirica	2	8.1	0	0
Pinus sylvestris	25	6.9	0	0
Populus balsamifera	6	3.0	3	555*
Populus balsamifera x *trichocarpa*	3	N/A	0	0
Populus deltoïdes	0	0	1	150*
Populus tremula x *tremuloides* triploid	4	1.1	0	0
Populus tremuloides	10	1.6	0	0
Pruns virginiana var virginiana	0	0	5	4600*
Pseudotsuga menziesii var. *glauca*	11	3.0 +	0	0
Pseudotsuga menziesii var. *menziesii*	49	N/A	0	0
Quercus macrocarpa	0	0	4	2200*
Shepherdia argentea	0	0	4	1900*
Symphoricarpus occidentalis	0	0	3	6600*
Thuja plicata	18	N/A	0	0
Tsuga heterophylla	36	N/A	0	0

'+' indicates additional area was established
* indicates additions for number of seedlings

3.4 (FAO Questions 3.8 and 3.9) Transfer of Germplasm within Canada and to Agencies Outside Canada

In Canada, there is currently no specific national legislation or guidelines regarding the transfer of germplasm. Breeding materials that are developed in each province are adapted to each province's ecophysiographic conditions. Therefore, there is limited movement/transfer between provinces. British Columbia has a policy and uses material transfer agreements when germplasm (seed and breeding material) is transferred to ensure ownership/custodianship is recognized and to provide limited rights for the use of the germplasm, such as for seed production (British Columbia Ministry of Forest and Range 1998). Another province employs a material transfer agreement for material moved or exchanged outside the province. This province has standards for forest genetic resources management and conservation that recommend transfer and intellectual property agreements, but such agreements are not required.

Seed and seedlings are deployed (transferred) within provinces based on seed zones that were often developed based on results from provenance tests. Mathematical models and spatial tools are being used in at least one province to assist forest managers with seed movement Seed is generally not transferred between provinces. One province stated that requests for transfer agreements between jurisdictions are handled on a case-by-case basis.

3.5 (FAO Question 3.11) Current Actions for Promoting *Ex Situ* Conservation

Eleven actions for promoting *ex situ* conservation in Canada were identified in the jurisdictional survey (Table 3.3).

Table 3.3. Current actions for promoting *ex situ* conservation in Canada

1	The National Tree Seed Centre strategy will safeguard Canada's forest genetic resources in the face of climate change and other threats by acquiring, evaluating, preserving, and providing a national collection of forest genetic resources to assist in securing the forest biological diversity that underpins the sustainable development of Canada's forests.
2	CON**FOR**GEN (Conservation of Forest Genetic Resources) is a pan-Canadian, national coordination mechanism to: (1) promote the conservation of forest genetic resources, (2) define guidelines for conservation of native trees in a sustainable manner, (3) monitor and report on the genetic resources of native tree species, and (4) identify emerging issues and research priorities (See http://conforgen.ca/).
3	No formal legally binding actions to promote *ex situ* conservation exist.
4	Forest genetic councils or tree improvement cooperatives promote *ex situ* conservation.
5	Peer-reviewed documents have summarized the genetic conservation status of many tree species.
6	In two provinces and at the federal level, the role for genetic conservation of trees is undertaken by the respective Ministries of Environment, which have oversight for biodiversity.
7	There are many non-governmental organizations (NGOs) concerned with biodiversity and genetic conservation of trees (e.g., David Suzuki Foundation, Sierra Club, Western Canadian Wilderness Committee).
8	Collections of seed for conservation storage are made when species are identified as being at risk.
9	In two jurisdictions, provincial biodiversity and conservation strategies are under development and, it is hoped, will address genetic-level *ex situ* conservation needs for forest species.
10	In one jurisdiction, the provincial government and forest industry are conducting *ex situ* conservation activities by collecting seed from threatened species.
11	In some jurisdictions, government and forest companies are encouraged to make *ex situ* tree seed conservation collections, but there are no strategies to guide this process.

3.6 (FAO Question 3.12 and Appendix 3.2) Constraints to Improving *Ex Situ* Conservation

The jurisdictional survey identified the below constraints to the improvement of *ex situ* conservation activities and programs in Canada (Table 3.4). The constraints are not listed in any priority.

Table 3.4. Constraints to improving *ex situ* conservation in Canada

1	Personnel capacity.
2	Financial (i.e., where it fits in the list of funding priorities and budgets to perform the required activities).
3	The need for greater inter-agency communication.
4	Low priority placed on genetic conservation activities at the political level.
5	Limited knowledge about genetic variation and distribution of non-commercial and native species.
6	Scepticism about preserving tree germplasm outside of its natural environment (*ex situ*) as a valid approach to conserve species at risk and mitigate biodiversity loss.
7	Sense that trees do not form a distinct biological group (should not be considered separate from other vascular plants when prioritizing conservation efforts and allocating funding). In this context, many vascular plants are recognized to be at greater risk of extinction compared with most tree species.
8	Absence of a provincial biodiversity conservation strategy.
9	Long term conservation in terms of knowledge and stability (concerning storage banking and conditions).

3.7 (FAO Questions 3.13 and 3.14, and Appendix 3.3) Priorities and Capacity-Building Needs for Future *Ex Situ* Conservation Actions

The jurisdictional survey indentified the below priorities and capacity needs for future *ex situ* conservation activities and programs in Canada (Table 3.5). They are not listed in any priority.

Table 3.5. Priorities and capacity-building needs for future ex *situ* conservation actions in Canada

1	Climate change is increasing the priority for *ex situ* conservation.
2	To mitigate changes from climate change, *ex situ* resources may be used for assisted migration.
3	Priority for species listed as endangered or threatened.
4	Species for which we currently have an inadequate number of samples (primarily non-commercial conifers and broadleaf tree species).
5	GAP analyses to identify and optimize genetic sampling.
6	Desire to collect to conserve the native genetic base that is at risk from invasive alien species.
7	Species of concern and with official federal or jurisdictional designation, such as: *Fagus grandifolia, Fraxinus americana, Fraxinus pennsylvanica, Fraxinus profunda, Fraxinus quadrangulata, Larix lyallii, Pinus albicaulis, Pinus banksiana, Pinus flexilis, Pinus resinosa , Thuja occidentalis, Ulmus americana.*
8	The prohibitive cost of developing longterm storage protocols for recalcitrant and orthodox tree seed species.

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Chapter 4: The State of Use and Sustainable Management of Forest Genetic Resources

Sustainable forest management (SFM), as defined by Natural Resources Canada, is management that maintains and enhances the long-term health of forest ecosystems for the benefit of living things, while providing environmental, economic, social and cultural opportunities for present and future generations (Natural Resources Canada 2009). In 1992, at the United Nations Conference on Environment and Development (UNCED), Canada declared its commitment to SFM. This vision towards SFM shifts from the previous approach that focused on sustained yield timber. Canada's forest strategy for SFM deals with policies to conserve ecosystem integrity, protect representative areas and support society's sustainable use of the forest (Natural Resources Canada 2009). Canada relies on science based knowledge and innovation in adapting its policy, practices, regulations and legislation with regards to SFM. The tools, processes and science based measures that Canada has developed allow one to asses SFM results both nationally and internationally (Natural Resources Canada 2009). For example, forest planning is based on strategic decisions about land use and decisions made by the government (with consultation) to guide the operational levels of planning on Crown land. Governments in Canada support the use of third-party certification as a tool to demonstrate the rigour of Canada's forest management laws and to document the country's sustainable world class sustainable forest management record.

Canada has had a history of managing its forest starting with tree improvement programs were initiated in several Canadian provinces in the 1960s in response to expanding reforestation programs. As reforestation efforts continued to expand, tree improvement programs were initiated in the remaining provinces in the mid to late 1970s. Small quantities of orchard seed were beginning to be produced in the 1980s, and production has continued to increase with concomitant increases in the genetic quality as a result of roguing seed orchards and programs moving to advanced generations. In fact, several provinces have been producing sufficient quantities of genetically improved seed to meet reforestation needs for over 10 years. The overall objective of the tree improvement programs is to increase productivity (volume). Other traits often targeted are wood quality and pest resistance.

The information presented in this chapter represents the state of tree improvement activities and reproductive material production, storage, and dissemination in Canada as of 2010. It was obtained from a survey that was completed by the following provinces: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Quebec and Saskatchewan. Due to minor variances in survey responses, there is not always a 1:1 species match between Tables 4.1, 4.3 and 4.5. Expanded descriptions of jurisdictional tree improvement activities are included in Chapter 5 (see Table 5.5B).

4.1 GENETIC IMPROVEMENT PROGRAMS AND THEIR IMPLEMENTION

4.1.1 (FAO Questions 4.1–4.3 and Appendix 4.2, 4.3) Canadian Tree Improvement Programs: Species and Objectives

In Canada, there are 34 tree species and two genera (*Larix* and *Populus*) with hybrids (4) for which genetic improvement programs, using traditional breeding and selection methods, are conducted (Table 4.1). There are four species (*Abies amabilis*, *A. grandis*, *A. lasiocarpa,* and *A. procera*) for which there are no breeding or seed orchard programs. For these species, seed is collected from the best-adapted local seed sources. In addition, there are four species (*Juglans nigra*, *Pinus resinosa*, *Pinus sylvestris* and *Thuja occidentalis*) for which there are seed orchards but no tree improvement programs. *Acer saccharinum*, *Fraxinus pennsylvanica* and *Populus balsamifera* x *trichocarpa* have only been provenance tested. Overall, there are seven species and two genera (*Larix* and *Populus*) with hybrids (4) that are not native to Canada. Timber production, for the purpose of producing solid wood products, is the most common program objective, with pulpwood production also being important for nine of the same species. The objective for four *Populus* species/hybrids is solely pulpwood and

NWFP is an additional objective for two *Populus* species/hybrids. *Abies balsamea* is being genetically improved for the Christmas tree industry.

Table 4.1. Tree species for which there are genetic improvement programs in Canada

Species	Native (N) or Exotic (E)	Improvement program objective		
		Timber	Pulpwood	NWFP
Abies amabilis	N	X		
Abies balsamea	N			X
Abies grandis	N	X		
Abies lasiocarpa	N	X		
Abies procera	E	X		
Acer saccharinum	N	X		
Acer macrophyllum	N	X		
Alnus rubra	N	X		
Callitropsis nootkatensis	N	X		
Fraxinus americana	N	X		
Fraxinus pennsylvanica	N	X		
Juglans cinerea	N	X		
Juglans nigra	N	X		
Larix decidua	E	X		
Larix kaempferi	E	X		
Larix laricina	N	X		
Larix occidentalis	N	X		
Larix (hybrids)	E	X		
Picea abies	E	X		
Picea glauca	N	X	X	
Picea glauca x *engelmannii*	N	X		
Picea mariana	N	X	X	
Picea rubens	N	X	X	
Picea sitchensis	N	X		
Pinus banksiana	N	X	X	
Pinus contorta var. *latifolia*	N	X	X	
Pinus monticola	N	X		
Pinus ponderosa	N	X		
Pinus resinosa	N	X		
Pinus strobus	N	X		
Pinus sylvestris	E	X		
Populus balsamifera	N		X	
Populus balsamifera x *trichocarpa*	N	X		
Populus deltoides spp. *deltoides*	N	X	X	X
Populus maximowiczii	E	X	X	
Populus nigra	E	X	X	
Populus tremuloides	N		X	
Populus trichocarpa	N	X	X	
Populus (aspen hybrids)	E		X	
Populus (cottonwood hybrids)	E		X	
Populus (hybrids)	E	X	X	X
Pseudotsuga menziesii var. *glauca*	N	X		
Pseudotsuga menziesii var. *menziesii*	N	X		

Quercus rubra	N	X		
Thuja occidentalis	N	X		
Thuja plicata	N	X		
Tsuga heterophylla	N	X		

NWFP, non-wood fiber production.

4.1.2 (FAO Question 4.5) List Species for Which Provenance Tests Have Been Established

The establishment of provenance trials is important in order to evaluate patterns of genetic variation that occur within a species as well as to provide guidance for seed movement and the development of seed zones. The Canadian Forest Service (CFS) has been actively involved for over 50 years in establishing provenance tests for many native species and some exotic species. Many of these tests are planted at the CFS's two research forests: Acadia Research Forest and Petawawa Research Forest. Other tests were established by provincial jurisdictions and forest companies. Nine hundred and eighty-three provenance tests comprised of 7,493 provenances have been established for 41 species and hybrids in Canada, eight of which are exotic (Table 4.2). With regard to native species, six species have been extensively tested both nationally and provincially (*Picea glauca*, *Picea mariana*, *Pinus banksiana*, *Pinus contorta* var. *latifolia*, *Pseudotsuga menziesii* var. *menziesii,* and *Tsuga heterophylla*) because these species are the most widely used in reforestation programs. *Larix decidua*, *L. kaempferi* and *Picea abies* were the most widely tested exotic species.

Table 4.2. Summary of provenance testing in Canada

Species	Native (N) or Exotic (E)	Provenance tests	
		No. tests	No. provenances
Abies amabilis	N	16	68
Abies balsamea	N	4	45
Abies grandis	N	4	32
Abies procera	E	16	28
Abies lasiocarpa	N	12	110
Acer macrophyllum	N	4	43
Acer saccharinum	N	7	31
Alnus rubra	N	2	42
Betula alleghaniensis	N	1	45
Callitropsis nootkatensis	N	12	40
Fraxinus americana	N	2	148
Fraxinus pennsylvanica	N	5	158
Larix decidua	E	67	210
Larix kaempferi	E	53	368
Larix laricina	N	30	399
Larix occidentalis	N	2	135
Larix sibirica	E	3	64
Larix spp.	N,E	3	30
Larix hybrids	E	19	153
Picea abies	E	58	213
Picea glauca	N	109	1607
Picea glauca x *engelmannii*	N	3	100
Picea mariana	N	100	758
Picea rubens	N	35	57
Picea sitchensis	N	14	46
Pinus banksiana	N	84	432
Pinus contorta var. *latifolia*	N	100	233
Pinus monticola	N	12	20

Pinus ponderosa	N	2	75
Pinus resinosa	N	23	153
Pinus rigida	N	7	19
Pinus strobus	N	13	791
Pinus sylvestris	E	25	77
Populus balsamifera	N	6	52
Populus balsamifera x *trichocarpa*	N	3	180
Populus tremuloides	N	5	43
Pseudotsuga menziesii var. *glauca*	N	6	72
Pseudotsuga menziesii var. *menziesii*	N	62	210
Quercus rubra	N	4	16
Thuja plicata	N	18	120
Tsuga canadensis	N	2	10
Tsuga heterophylla	N	36	60

4.1.3 (FAO Questions 4.4–4.5 and Appendix 4.4) Level of Tree Improvement Programs (First-, Second-generation) and Species with Phenotypically Selected Individuals and Seedling Progenies Tested in Field Trials

There are 30 species and two genera (*Larix* and *Populus*) with hybrids (2) for which there are active tree improvement and breeding programs, as well as three species (*Abies balsamea*, *Acer macrophylum* and *Juglans nigra*) for which either only plus trees have been selected or progeny tests planted (Table 4.3). First-generation programs are composed of 55,105 plus trees selected predominantly from the natural forest. Second-generation programs are in place for 14 species, and breeding populations contain 9,456 selections made from progeny tests and other tests. Third-generation selections have been made for *Pseudotsuga menziesii* var. *menziesii*. Open-pollinated progeny testing was employed to evaluate the genetic quality of first-generation selections from 26 species, with 775 tests planted to test 41,229 families. Four hundred and seventeen control-pollinated progeny tests comprised of 6,601 familes were planted to test first-generation selections from twelve species. For second-generation testing,.314 control-pollinated progeny tests were planted in Canada to test 6,758 families.

Table 4.3. Tree species for which plus trees have been selected and progeny tests established in Canada

Species	Generation	No. plus trees	Progeny tests			
			No. tests	No. open-pollinated families	No. tests	No. control-pollinated families
Abies balsamea	1	448	0	0	0	0
Acer macrophyllum	1	0	4	400	0	0
Alnus rubra	1	60	2	200	0	0
Callitropsis nootkatensis	1	400	0	0	14	340
Fraxinus americana	1	267	16	267	0	0
Juglans cinerea	1	60	4	60	0	0
Juglans nigra	1	50	0	0	0	0
Larix decidua	1	985	19	985	0	0
Larix kaempferi	1	101	13	101	0	0
Larix laricina	1	1199	16	933	18	462
Larix occidentalis	1	637	14	607	0	0
Larix (hybrids)	1	2294	40	2294	0	0
Picea abies	1	483	17	267	14	164
Picea glauca	1	8818	91	7612	97	1888

Picea glauca	2	1530	8	74	28	708
Picea glauca x *engelmannii*	1	4000	75	2533	0	0
Picea glauca x *engelmannii*	2	224	0	0	13	799
Picea mariana	1	11302	163	10778	0	0
Picea mariana	2	2159	0	0	134	2225
Picea rubens	1	1508	4	29	31	744
Picea rubens	2	437	0	0	1	5
Picea sitchensis	1	1616	9	300	0	0
Picea sitchensis	2	127	0	0	9	150
Pinus banksiana	1	8341	72	6388	0	0
Pinus banksiana	2	1007	0	0	50	749
Pinus contorta var. *latifolia*	1	3737	87	3493	0	0
Pinus contorta var. *latifolia*	2	346	0	0	15	694
Pinus monticola	1	675	8	557	0	0
Pinus monticola	2	675	0	0	9	300
Pinus ponderosa	1	50	0	0	0	0
Pinus strobus	1	827	13	194	0	0
Pinus strobus	2	87	0	0	0	0
Populus balsamifera	1	503	0	0	1	30
Populus deltoides spp. *deltoides*	1	25	0	0	10	125
Populus maximowiczii	1	40	2	30	0	0
Populus maximowiczii	2	15	0	0	1	28
Populus nigra	1	10	0	0	1	34
Populus tremuloides	1	946	0	0	10	25
Populus trichocarpa	1	NA	1	100	0	0
Populus trichocarpa	2	20	2	20	0	0
Populus (aspen hybrids)	1	0	0	0	22	100
Pseudotsuga menziesii var. *glauca*	1	1500	33	1671	0	0
Pseudotsuga menziesii var. *glauca*	2	1800	0	0	0	0
Pseudotsuga menziesii var. *menziesii*	1	142	12	227	134	1789
Pseudotsuga menziesii var. *menziesii*	2	300	0	0	20	400
Pseudotsuga menziesii var. *menziesii*	3	50	0	0	0	0
Quercus rubra	1	478	6	478	0	0
Thuja plicata	1	2086	2	25	65	900
Thuja plicata	2	642	0	0	18	100
Tsuga heterophylla	1	1470	52	700	0	0
Tsuga heterophylla	2	176	0	0	16	600

4.1.4 (FAO Question 4.5) Tree Species for Which Clones Are Tested and Deployed

Clonal testing has been employed for species when seed production is inadequate, seed is difficult to germinate, vegetative propagation is easy and/or to maximize genetic gain. Such testing is often directed at species that produce high-value products such as saw logs. Clonal testing is being conducted for 12 conifer species, one *Larix* hybrids and five *Populus* species or hybrids (Table 4.4). A total of 298 tests have been planted containing 27,377 clones. Almost 4,000 clones have been selected but 852 clones were deployed either as stecklings or emblings.

Table 4.4. Tree species established in clonal tests and with material deployed in reforestation programs in Canada

Species	Generation	Clonal tests		Clonal deployment	
		No. tests	No. clones	No. clones selected	No. clones deployed
Callitropsis nootkatensis	1	14	4500	100	690
Larix decidua	1	13	1677	0	0
Larix kaempferi	1	13	869	0	0
Larix laricina	1	2	117	0	0
Larix (hybrids)	1	20	807	0	0
Picea abies	1	4	242	48	12
Picea glauca	1	15	1367	273	35
Picea glauca	2	10	841	0	0
Picea glauca x *engelmannii*	1	14	1400	0	0
Picea mariana	1	34	1236	0	0
Picea mariana	2	22	432	0	0
Picea rubens	1	1	798	0	0
Pinus banksiana	1	8	1371	0	0
Populus balsamifera	1	6	483	0	0
Populus nigra	1	3	50	0	0
Populus tremuloides	1	15	447	18	0
Populus (aspen hybrids)	1	10	106	0	0
Populus (hybrids)	1	90	9000	3000	115
Thuja plicata	1	0	0	560	0
Tsuga heterophylla	2	3	1100	0	0

4.1.5 (FAO Question 4.6–4.8) Seedling and Clonal Seed Orchards and Clone Banks

Seed orchards have been established for 28 tree species in Canada (Table 4.5). Seedling seed orchards were planted exclusively in the first generation primarily for species such as *Picea mariana* and *Pinus banksiana* that become reproductively mature at a young age (8−10 years old). There are a total of 97 seedling orchards, comprising 12,016 families, planted on 1,138 ha. Many of these orchards have been rogued based on data collected in the open-pollinated progeny tests. One hundred and ten first-generation clonal orchards, comprised of 8,905 clones, were planted on 412 ha. Most of these seed orchards have had some level of genetic roguing applied. One hundred and forty-one second-generation seed orchards, containing 8,119 clones have been planted on 695 ha. Some first-generation clones with high breeding values were included in second-generation orchards. Clone banks have been established to preserve genetic material and selections as well as for conducting breeding. They typically contain additional material not represented in seed orchards. There are 86 clone banks planted on 120 ha, comprising 28,608 clones.

Table 4.5. Number, area, and number of genetic entries in seedling and clonal seed orchards and clone banks in Canada

Species	Generation	Seedling seed orchards			Clonal seed orchards			Clone banks		
		No.	Area	No. families	No.	Area	No. clones	No.	Area	No. clones
Abies balsamea	1	0	0	0	5	4.6	238	5	2.1	472
Alnus rubra	1	0	0	0	1	0.5	30	1	0.3	116
Callitropsis nootkatensis	2	0	0	0	3	15.8	102	1	2.0	400
Fraxinus americana	1	0	0	0	1	0.4	16	0	0	0

Juglans nigra	1	2	1.0	45	3	1.1	50	0	0	0
Larix decidua	1	2	3.6	31	0	0	0	0	0	0
Larix kaempferi	1	1	1.8	42	2	3.6	34	0	0	0
Larix laricina	1	2	10.1	434	7	25.6	149	5	1.7	311
Larix occidentalis	1	0	0	0	1	0.2	18	1	0.1	22
Larix occidentalis	2	0	0	0	3	9.9	146	1	2.0	640
Larix (hybrids)	1	0	0	0		0	0	NA	NA	121
Picea abies	1	0	0	0	13	52.7	314	4	0.8	427
Picea abies	2	0	0	0	1	6.1	905	0	0	0
Picea glauca	1	5	24.2	111	37	178.2	5530	12	10.1	5069
Picea glauca	2	0	0	0	9	43.4	433	5	4.4	1122
Picea glauca x *engelmannii*	2	0	0	0	21	62.6	925	2	20.0	3395
Picea mariana	1	46	705.6	7208	4	15.9	145	5	3.0	1379
Picea mariana	2	0	0	0	16	125.9	928	6	1.8	881
Picea rubens	1	0	0	0	10	43.2	1046	8	2.8	635
Picea rubens	2	0	0	0	2	3.9	93	0	0	0
Picea sitchensis	2	0	0	0	4	5.0	293	1	6.5	1321
Pinus banksiana	1	31	377.3	3462	4	17.3	181	10	2.8	1403
Pinus banksiana	2	0	0	0	9	113.5	556	2	1.0	404
Pinus contorta var. *latifolia*	1	1	1	279	5	14.4	36	1	1.8	562
Pinus contorta var. *latifolia*	2	0	0	0	28	207.5	1669	3	13.0	1654
Pinus monticola	1	1	1.2	40	0	0.0	0	0	0	0
Pinus monticola	2	0	0	0	7	14.1	754	2	0.5	261
Pinus ponderosa	1	2	1.2	40	2	4.4	39	0	0	0
Pinus resinosa	1	1	2.7	86	0	0	0	0	0	0
Pinus strobus	1	0	0	0	13	50.0	786	6	3.1	919
Pinus strobus	2	0	0	0	1	10.0	87	0	0	0
Pinus sylvestris	1	1	6.1	155	0	0	0	0	0	0
Pseudotsuga menziesii var. *glauca*	1	0	0	0	1	0.3	39	1	0.3	65
Pseudotsuga menziesii var. *glauca*	2	0	0	0	8	31.0	297	1	12.0	1870
Pseudotsuga menziesii var. *menziesii*	1	1	0.6	62	0	0	0	0	0	0
Pseudotsuga menziesii var. *menziesii*	2	0	0	0	15	33.0	649	1	12.6	1685
Quercus rubra	1	0	0	0	1	0.1	20	0	0	0
Thuja occidentalis	1	1	2.0	21	0	0	0	0	0	0
Thuja plicata	2	0	0	0	6	5.1	240	1	5.0	2000
Tsuga heterophylla	2	0	0	0	8	8.3	276	1	10.0	1474

4.1.6 (FAO Question 4.10) Gene Banks and the Volume of Seed Stored

Each province in Canada manages a seed bank. Consequently, from the survey responses, there are eight seed banks storing 332,073 kg of seed for reforestation use. Storage temperatures are sub-freezing, with some banks storing seed at -20°C.

4.1.7 (FAO Question 4.11) Grade of Use of Improved Forest Reproductive Materials

In 2010, almost 452 million seedlings and vegetative propagules were planted in the eight Canadian provinces that replied to the survey. Of this number, 44% (199 million) were from unimproved sources, 26% (117 million) were from first-generation seed orchards, about 30% (134 million) were from second-generation seed orchards, and 0.26% (1.1 million) was clonal material. Clones were deployed as stecklings and emblings.

4.1.8 (FAO Questions 4.12–4.15 and Appendix 4.5) Actions Taken to Promote the Use of Improved Reproductive Material

In Canada, regulations in one province require forest companies with reforestation obligations on public land to use genetically improved seed. Another province promotes the used of improved seed through timber supply models and the Annual Allowable Cut Effect. In the other provinces, as much genetically improved seed as is available is used to reforest public land and forest industry freehold land.

There are participatory tree breeding programs in Canada. Five of the provinces have cooperative tree improvement programs involving the provincial governments, forest companies, universities, and the federal government (Canadian Forest Service). Memoranda of Understanding between forest companies and the provincial government are used in one of these provinces to facilitate cooperative tree improvement. In two provinces with no cooperative program, the provincial government takes the lead. There is no active breeding program in one province.

Information systems have been established for tree breeding programs. Data are collected for a range of purposes including parent tree registration, breeding records, test measurements, seed orchard management and seed production. Data are stored and managed using a variety of software including MS Access, SAS and ARCMAP.

4.1.9 (FAO Questions 4.16–4.17) The State of the Use and Transfer of Germplasm

Germplasm has been imported from other countries for research purposes such as provenance testing. In Canada, there is currently no specific national legislation or guidelines regarding the transfer of germplasm. Breeding materials that are developed in each province are adapted to each province's ecophysiographic conditions. Therefore, there is limited movement/transfer between provinces. One province has a policy and uses transfer agreements when germplasm (seed and breeding material) is transferred to ensure ownership/custodianship is recognized and to provide limited rights for the use of the germplasm, such as for seed production. Another province employs a material transfer agreement for material moved or exchanged outside the province. This province has standards for forest genetic resources management and conservation that recommend transfer and intellectual property agreements, but such agreements are not required.

Seed and seedlings are deployed (transferred) within provinces based on seed zones that were often developed based on results from provenance tests. Mathematical models and spatial tools are being used in at least one province to assist forest managers with seed movement. Seed is generally not transferred between provinces. One province stated that requests for transfer agreements between jurisdictions are handled on a case-by-case basis.

As well, there are no national legislation or guidelines in Canada specifically regarding access and benefit sharing (ABS). The province that uses transfer agreements also applies them to ABS and does not feel that there is a need to develop additional guidelines and regulations for ABS of commercial tree species because of existing legislation, regulations, and policies, including in particular property law and contract law. In another province, authorization is required in order to collect reproductive material from public land. Although this addresses the access issue, there are no specific sharing requirements, although this is alluded to in the Standards for Forest Genetic Resources Management and Conservation as being desirable. In the latter province, further development of a permitting system is required due to increasing collection of both reproductive and commodity materials from public lands as well as potential requirements for prior informed consent and benefit sharing under the Convention on Biological Diversity, Access and Benefit Sharing policy. Another province has created an inter-departmental committee to discuss how ABS will be addressed and to evaluate its possible implications from both the legal perspective and practical application.

4.2 DELIVERY/DEPLOYMENT SYSTEMS: AVAILBILITY OF REPRODUCTIVE MATERIALS

4.2.1 (FAO Question 4.18 and Appendix 4.1) Quantities of Seed, Pollen, Scions, and/or Other Reproductive Materials that May Be Made Available Upon Request

Seed, pollen, or vegetative material have been provided for domestic commercial purposes, tree breeding, or research from the following species: *Abies grandis*, *Betula neoalaskana*, *Callitropsis nootkatensis*, *Larix laricina*, *Larix occidentalis*, *Picea engelmanii*, *P. glauca*, *P. glauca* x *engelmanii*, *P. mariana*, *P. rubens*, *P. sitchensis*, *Pinus contorta* var. *latifolia*, *P. monticola*, *P. strobus*, *Populus balsamifera*, *P. trichocarpa*, *Pseudotsuga menziesii*, *Thuja plicata,* and *Tsuga heterophylla*. One province refers international requests for seed to the National Tree Seed Centre.

Commercial quantities of seed that are marketed internationally are certified under the OECD Scheme for the Certification of Reproductive Material Moving in International Trade. The seed is from tree species growing in British Columbia and Yukon Territory and is sold primarily to clients in Europe. All seed is certified as Source-Identified, except *Picea sitchensis* which is certified as Qualified. Over the past 5 years, an average of 432 kg of seed was marketed from seven species (Table 4.6).

Table 4.6. Quantity of OECD-certified seed marketed internationally each year (average of last 5 years)

Species	Quantity of seed (kg)
Abies grandis	63
Abies lasiocarpa	38
Picea sitchensis	3
Pinus contorta var. *contorta*	1
Pinus contorta var. *latifolia*	280
Pseudotsuga menziesii var. *glauca*	13
Pseudotsuga menziesii var. *menziesii*	34

4.2.2 (FAO Questions 4.20 – 4.22) Classification of Improved Reproductive Materials

Improved reproductive material is usually referred to by generation of production, i.e., first generation, second generation, etc. One province, in addition to classifying material by generation, uses genetic worth, which is based on the breeding values of the clones in a seed orchard and is the weighted average of the parental contributions that make up the seedlot.

The goal of most tree breeding programs is to produce reproductive material that is broadly adapted for planting on a range of sites within seed zones or seed planting areas. Therefore, no effort has been made to develop varieties for specific purposes or products.

4.2.3 (FAO Question 4.23) National Seed Improvement Programs

In Canada, there is no national improved seed program. Each province acts independently and has its own legislation and regulations regarding the production, dissemination, and use of genetically improved seed.

REFERENCES

Natural Resources Canada. 2009. *The State of Canada's Forests: Annual Report 2009*. Natural Resources Canada, Canadian Forest Service, Ottawa, ON.

Chapter 5: The State of National Programs, Research, Education, Training, and Legislation

This chapter describes the state of national capacities in research, education, training, and legislation, as well as the coordination of information mechanisms for forest genetic resources as of 2012. Specifically, the following areas that address forest genetic resources are considered: national programs and legislation, research, education and training, dissemination of information, coordination mechanisms, and an assessment of capacity-building needs.

5.1 NATIONAL PROGRAMS

5.1.1 (FAO Questions 5.1, 5.2 and Appendices 5.2, 5.7) Institutions Engaged in Field and Laboratory Work Related to Forest Genetic Resource Conservation

Canada has a number of institutions actively engaged in forest genetic resources conservation. These include universities and colleges, federal and provincial departments, industry, and non-governmental organizations (NGOs) and tree improvement councils. There are 10 universities and 25 colleges and institutes that offer courses (academic, field, laboratory, extension, and certified) in forest genetic resources conservation education and training (Table 5.1). Twenty-three national institutions pursue some activities that address forest genetic resource conservation (Table 5.2). Federal government departments and agencies involved in this work include Natural Resources Canada (NRCan), Environment Canada, Agriculture and Agri-Food Canada (AAFC), the Canadian Food Inspection Agency (CFIA), and the Canadian International Development Agency (CIDA). Natural Resources Canada is the main federal department that conducts field and laboratory studies, whereas Environmental Canada and Agriculture and Agri-Food Canada have a more limited role with regard to forest genetic resources. The CFIA addresses areas related to legislation (e.g., cross-border movement of genetic resources) and CIDA provides funding and facilitates research related to forest genetic resources in developing countries. Non-governmental agencies such as NatureServe Canada and Ducks Unlimited are engaged primarily in field work that can be associated with forest genetic resources, among other resources.

The provinces and territorial governments have departments that are responsible for managing the forests within their mandates and boundaries (Table 5.3 and 5.5) and, as such, they conduct field and laboratory work to varying degrees. Industry also conducts and supports field and laboratory work addressing forest genetic resources (e.g., biodiversity and ecosystem health-related research is supported by J.D. Irving, Ltd. (2012) (Table 5.3)). Table 5.4 provides examples of the types of NGOs conducting work in this area. Several jurisdictions have tree improvement councils or cooperatives that are directly responsible for managing and ensuring the sustainability of forest genetic resources (Table 5.5) (see Chapter 6.1.B for a detailed description of these groups), and these groups often support or are engaged in field and laboratory work.

Table 5.1. Universities and colleges with programs engaged in forest genetic resources

Name of institution	Program	Contact information
A) Universities		
Lakehead University	Degree	http://nrm.lakeheadu.ca/
Simon Fraser University	Degree	http://www.sfu.ca/archaeology/
Trent University	Degree	http/:www.trentu.ca/registrar/
University of Alberta	Degree	http://www.ales.ualberta.ca/forestry
University of British Columbia	Degree	http://www.ubc.ca/academic/
University of British Columbia Northern	Degree	http/:www.unbc.ca/forestry
University of Guelph	Degree	http://www.uoguelph.ca/ses/content/envb-program
Université Laval	Degree	http://www2.ulaval.ca/en/academic-programs/faculties/forestry-and-geomatics.html
Université de Moncton (Edmundston, NB)	Degree	http://www.umoncton.ca/etudiants/programmes

University of New Brunswick	Degree	http://www.unb.ca/fredericton/forestry/
University of Toronto	Degree	http://www.forestry.utoronto.ca/
B) Colleges		
Algonquin College	Diploma	http://www2.algonquincollege.com/pembroke/program/forestry-technician/
Aurora College	Diploma	http:/www.resolutionhost.com
Collège de l'Abitibi-Témiscamingue	Diploma	http://www.cegepat.qc.ca/accueil/programmes-et-formations/formation-technique/technologie-forestiere
CÉGEP de Baie Comeau	Diploma	http://www.cegep-baie-comeau.qc.ca/Technologie-forestière-190.B0.html
CÉGEP de la Gaspésie et des Îles	Diploma	http://www.cgaspesie.qc.ca/cegep/programmes-detudes
CÉGEP de St-Félicien	Diploma	http://www.cstfelicien.qc.ca/milieu-naturel.asp#
CÉGEP de Sainte-Foy	Diploma	
Collège Boréal (Sudbury) Fr	Diploma	http://www.collegeboreal.ca/programs-courses/full-time-studies/
College of New Caledonia (Prince George, BC)	Diploma	http://www.cnc.bc.ca/CNC_Programs/NRETech.htm
Confederation College Forestry Programs (Co-op)	Diploma	http://www.confederationc.on.ca/node/534
Grande Prairie Regional College	Diploma	http://www.gprc.ab.ca/programs/calendar/program-of-study-2011-2012/html/72.html
MacDonald College	Diploma	http://www.mcgill.ca/macdonald/prospective/degrees/bscagenvsc
Malaspina University College (BC)	Diploma	http://www.viu.ca/nrep/index.asp
Maritime College of Forest Technology	Diploma	http://www.mcft.ca/for-tec.htm
C) Institutes		
Nicola Valley Institute of Tech	Diploma	http:/www.nvit.bc.ca
Northern Alberta Institute of Technology	Diploma	http://www.nait.ca/program_home_76697.htm
Nova Scotia Agriculture College –Truro	Diploma	http://nsac.ca/prospectivestudents/programs/environmentalsciences/
Portage College	Diploma	http://www.portagec.ab.ca/programs.htm?expandArea=x158
Saskatchewan Institute Of Applied Technology	Diploma	http://www.siast.sk.ca/
Sault College	Diploma	http:/www.saulte.on.ca
Selkirk College (BC)	Diploma	http://selkirk.ca/programs/rr/academicprograms/foresttechnology/
Sir Sanford Fleming College	Diploma	http://flemingcollege.ca/school/environmental-and-natural-resource-sciences
Sir Wilfred Grenfell College (NF)	Diploma/Degree	http://www.swgc.mun.ca/resource/Pages/default.aspx
Vancouver Island University	Diploma	http://www.viu.ca/nrep/index.asp
Centre for Indigenous Environmental Resources	Certificate	http/cier.mb.ca/

Table 5.2. Federal institutions engaged in forest genetic resources

Federal Institutions	Activities or programs	Contact information
Agriculture and Agri-Food Canada	Canadian Plant Germplasm System (as it relates to non-timber forest species)	http://pgrc3.agr.gc.ca/index_e.html
Biodivcanada	Protect biodiversity	http://www.biodivcanada.ca/default.asp?lang=En&n=DABC84B3-1
Canadian Boreal Initiative	Sustain the ecological integrity of the Boreal forest	http://www.borealcanada.ca/framework-e.php
Canadian Council of Forest Ministers	Direction for sustainable forest management	http://www.ccfm.org/english/index.asp

(CCFM)		
Canadian Council on Ecological Areas (CCEA)	Protected areas	http://www.ccea.org/index.html
Canadian Food Inspection Agency	Plants with Novel Traits	http://www.inspection.gc.ca/english/plaveg/bio/pbobbve.shtml
Canadian Forest Genetics Association	Promote scientific and technical forestry practices	http://www.cfga-acgf.com/index.php?option=com_content&view=article&id=1&Itemid=1
Canadian Forestry links	Numerous links to sustainability, biodiversity in forestry	http://www.magma.ca/~evb/forest.html
Canadian National Forest Inventory (NFIS)	Sustainable Forest Management Information system	https://nfi.nfis.org/index.php
Canadian National Standards (CSA)	Sustainable Forest Management Program	http://www.csa-international.org/product_areas/forest_products_marking/Default.asp?language=english
Canadian Nature Network	Conservation	http://canadiannaturenetwork.ca/
Canadian International Development Agency (CIDA)	Ensure environmental stability	http://www.acdi-cida.gc.ca/acdi-cida/acdi-cida.nsf/eng/home
Conservation of Forest Genetic Resources (CON**FOR**GEN)	Promote conservation of forest genetics	http://conforgen.ca/
Ducks Unlimited Canada	Wetland conservation	http://www.ducks.ca/index.html
Environment Canada	Boreal forest conservation	http://www.ec.gc.ca/default.asp?lang=En&n=FD9B0E51-1
FSC- Forest Stewardship Council	Forest Management standards	http://www.fsccanada.org/
Natural Resources Canada – Canadian Forest Service	Research and policy	http://www.nrcan.gc.ca/home
Nature Canada	Protect and conserve habitat	http://www.naturecanada.ca/
Nature Conservancy of Canada	Conservation of Canada's natural heritage	http://www.natureconservancy.ca/
NatureServe Canada	Conservation Data Centres	http://www.natureserve-canada.ca/
Parks Canada	Forest and heritage conservation	http://www.pc.gc.ca/eng/index.aspx
SFI - Sustainable Forest Initiative	Forest management standards	http://www.certificationcanada.org/english/programs_used_in_canada/sfi.php
World Wildlife Fund Canada	Forest conservation	http://wwf.ca/

Table 5.3. Jurisdictional organizations, industry, and councils and working groups engaged in forest genetic resources

Organizations	Type of organization	Contact information
A. Jurisdictional		
Government of Alberta	Sustainable Resource Development	http://www.srd.alberta.ca/
Government of British Columbia	Ministry of Forest Lands and Natural Resource Operations	http://www.gov.bc.ca/for/index.html
Government of Manitoba	Conservation	http://www.gov.mb.ca/conservation/index.html
Government of	Department of Natural	http://www.nr.gov.nl.ca/nr/

Newfoundland and Labrador	Resources	
Government of Newfoundland and Labrador	Department of Environment and Conservation	http://www.env.gov.nl.ca/env/
Government of New Brunswick	Department of Natural Resources	http://www2.gnb.ca/content/gnb/en/departments/natural_resources.html
Government of Northwest Territories	Department of Environment and Natural Resources	http://www.enr.gov.nt.ca/_live/pages/wpPages/home.aspx
Government of Nova Scotia	Department of Natural Resources	http://gov.ns.ca/government/gov_index.asp
Government of Nunavut	Department of Environment	http://www.gov.nu.ca/en/Departments.aspx
Government of Ontario	Ministry of Natural Resources	http://www.mnr.gov.on.ca/en/index.html
Government of Prince Edward Island	Department of Agriculture and Forestry	http://www.gov.pe.ca/agriculture/index.php3
Government of Quebec	Ministry of Natural Resources	http://www.mrnf.gouv.qc.ca/english/home.jsp
Government of Saskatchewan	Environment	http://www.environment.gov.sk.ca/forests
Government of Yukon	Department of Energy Mines and Resources	http://www.emr.gov.yk.ca/forestry/
B. Industry		
AbitibiBowater	Research	http://www.bowater.ca/
AV Nackawic	Research	http://www.av-group.ca/
CanFor	Research	http://www.canfor.com/
Domtar	Research	http://www.domtar.com/
J.D. Irving, Ltd.	Research	http://www.jdirvinglumber.com/
Kruger	Research	http://www.kruger.com/
Tembec	Research	http://tembec.com/en
Weyerhaeuser	Research	http://www.weyerhaeuser.com/
C. Councils and Working Groups		
Alberta Forest Genetic Council	http://www.abtreegene.com/	Alberta Forest Genetic Council
British Columbia Forest Genetics Council	http://www.fgcouncil.bc.ca/	British Columbia Forest Genetics Council
British Columbia First Nations Forestry Council	http://www.fnforestrycouncil.ca/	British Columbia First Nations Forestry Council
Forest Genetics Ontario	http://www.fgo.ca/	Forest Genetics Ontario
Nova Scotia Tree Improvement Working Group	http://www.gov.ns.ca/natr/forestry/programs/renewal/	Nova Scotia Tree Improvement Working Group

Table 5.4. Examples of non-government organizations engaged in forest genetic resources

Non-governmental organizations	Activities or programs	Contact information
David Suzuki Foundation		www.davidsuzuki.org
Greenpeace Canada		http://www.greenpeace.org/canada/en/
Naturalists Society	Numerous in each province	http://www.ofnc.ca/cfn/
Sierra Club		http://www.sierraclub.ca/
Various non-governmental organizations across Canada	Canadian forest websites - Model Forests, ecology centres	http://www.canadian-forests.com/environmental_groups.html

5.1.2 (FAO Questions 5.5, 5.6, 5.8, 5.24 and Appendices 5.1, 5.9) National Programs for Forest Genetic Resources

Canada does not have a national program for forest genetic resources. However, the Canadian Council of Forest Ministers (CCFM) is an entity that provides provides leadership on national issues related to the stewardship and sustainable management of Canada's forests (CCFM 2012). The CCFM consists of 14 federal, provincial, and territorial ministers (elected officials). The objectives include: (1) promoting cooperation between governments regarding emerging forest and forestry-related issues of common interest and of intergovernmental or international significance; (2) developing and maintaining the scientific information base required to support forest management decision making; and (3) demonstrating international leadership on sustainable forest management (CCFM 2012). These activities can address forest genetic resources, such as assessing the vulnerability of tree species to climate change.

The Canadian Forest Service (CFS), which is within the department of Natural Resources Canada, has national-level projects pertaining to forest genetic resources. These activities include assessing genetic diversity of tree species and developing strategies for their conservation (e.g., National Tree Seed Centre, see Chapter 3), often at a national level (NRCan 2012).

No national legal framework has been established in Canada for forest genetic resources. There are national legislation and regulations that are relevant to forest genetic resources. These include the development of phytosanitary standards to reduce forest pest movement (as signatory to the International Plant Protection Convention; CFIA 2011a); development of a national approach to Access and Benefit Sharing in Canada (Environment Canada 2011; see Chapter 7, this report, for further detail); the Plant Breeder's Rights Act, which is a form of intellectual property rights by which plant breeders can protect their new varieties (CFIA 2011b). Treaties, agreements, and conventions endorsed by Canada that are related to forest genetic resources (FAO Question 5.25) are addressed in Chapter 6, section 6.7.

5.1.3 (FAO Questions 5.12 – 5.14) Forest Genetic Resources National Program: Challenges, Needs and Priorities

The main challenge as identified by the jurisdictional survey is the need for a national program for forest genetic resources with multi-stakeholder participation.

The two groups that specifically address forest genetic resources at a national level are the Canadian Forest Genetics Association, established in 1937, and the Canadian Program for Conservation of Forest Genetic Resources (CON**FOR**GEN), established in 2006 (Table 6.1.A). Both groups, although predominantly addressing national issues, also address issues relevant to North America either by fostering collaboration or through the exchange of knowledge (e.g., conferences, seminar series).

The Canadian Forest Genetics Association (CFGA) has approximately 90 members from such areas as academia, federal and provincial/territorial departments of natural resources, and industry with expertise in forest genetic resources including tree breeding, forest genetics, or tree improvement (CFGA 2012a). There are also approximately 30 honorary members who have had long, distinguished careers in forest genetic resources. The objectives of the Association are to promote the use of scientifically and technically sound genetic practices in Canadian forestry by: 1) fostering discussion on scientific and technical matters relating to all aspects of tree improvement in Canada; 2) promoting liaison and information exchange between people working in forest genetics and tree improvement and those concerned with seed collection and tree establishment; 3)fostering the active participation of managers, practising foresters, and representatives of forest industries in problem analysis and priority designation in the field of tree improvement; and 4) advising and assisting in the formulation of policies leading to better tree improvement practices and, where necessary, recommending changes in such policies (CFGA 2012a,b). The Association meets every two years and has published detailed proceedings, available online, since their first meeting in 1953 (CFGA 2012c). The Association is an important vehicle in Canada for enhancing communication in emerging areas, for providing opportunities for collaboration and for encouraging the participation of students.

The group CON**FOR**GEN is a federal-provincial-territorial mechanism which monitors and reports on genetic resources of native tree species in support of Canada's national and international commitments (Natural Resources Canada 2007). This group: 1) integrates jurisdictional data pertaining to forest genetic resources for national and international reporting; 2) monitors forest genetic resources through an electronic survey that assesses threats to native trees and identifies areas where these threats are most prevalent; and 3) produces conservation guidelines for these threatened tree species and identifies emerging issues for the group to focus efforts on (e.g. assisted migration). Membership includes 22 partners from federal and provincial/territorial government departments, First Nations and academia. A steering committee consists of representatives from provincial Forest Genetics Councils, provincial governments, one territorial government, First Nations, and Natural Resources Canada. As well, a standing technical committee consisting of provincial, federal, and academic experts oversees projects. The group has biennial meetings associated with CFGA and produces proceeding available online (CON**FOR**GEN 2011).

This group, although not an official national program, does function at a level similar to a national program in that it helps fulfill the significant engagement and reporting functions associated with the growing international agenda on forest genetic resources, including providing the necessary input and data for developing this report (*Canadian Report on Forest Genetic Resources*) and providing a forestry perspective for Canada's documentation for the Convention on Biological Diversity's Global Strategy for Plant Conservation (2006−2008). CON**FOR**GEN has developed and agreed to adhere to data standards that allow for the integration of their jurisdictional data and national-level data (e.g., NatureServe) for generating a national-level information system on forest genetic resources, CAFGRIS (Canadian Forest Genetic Resources Information System).

Canada has no national forest genetic resources networks; however, CON**FOR**GEN and CFGA loosely fulfill a national network-type role in this area.

Canada has numerous other national and subnational type networks, organizations and government departments that address to forest genetic resources (see Table 5.5). For example, the National Aboriginal Council on Species at Risk is a national network created under the Species at Risk Act to provide advice and recommendations to the Minister of the Environment and the Canadian Endangered Species Conservation Council on the administration of the Act (Table 5.5.A). This network has activities associated with forest genetic resources from a First Nations perspective. In addition, Canada has numerous other national thematic networks that address forest genetic resources in some capacity (e.g., NatureServe Canada and the Canadian Conservation Data Centres) (Table 5.5.A).

Six provinces (Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia and Ontario,) have established tree improvement and/or conservation of forest genetic resources councils to coordinate and promote the coordination of work related to forest gene conservation and tree improvement (Table 5.5.B). For some provinces, such as Quebec, the staff in the forest research directorate of the Ministère des Ressources naturelles et de la Faune are responsible for coordinating provincial tree improvement and gene conservation activities.

All provincial and territorial governments have departments of natural resources, environment or forestry that address forest genetic resources in some capacity (Table 5.5.B). Many of these government agencies often function as a "network" with regard to their collaborative efforts and, thus, they are listed in Table 5.5.B. Furthermore, the federal department of Natural Resources Canada - Canadian Forest Service, works with many national and international partners to address various aspects of forest genetic resources, and this is listed under national thematic networks in Table 5.5.A.

The Aboriginal peoples of Canada have a diverse range of thematic type national and subnational networks or organizations that address forest genetic resources and their conservation, among other issues (Table 5.5.A and B.). Three distinct Aboriginal peoples of Canada are recognized in the Constitution: Indians (commonly referred to as the First Nations), Métis and Inuit. Aboriginal peoples in Canada have lived within the forest environment for thousands of years and the manner in which they related to and utilize the resources of the land has formed the basis for many of their societies. In general, their approach to resource management encompasses the principle of stewardship of the earth, with attendant responsibilities and obligations and the thematic type networks reflect this.

There are numerous subnational type networks and organizations, and they are often species- or region-specific in their activities. There are also multiple Aboriginal programs that address forest genetic resources in a sub-national capacity, and a few are presented as examples in Table 5.5C Information concerning university-based thematic networks is presented in Chapter 1, section 1.1.4 and in Table 5.1.

Table 5.5. Examples of Canadian thematic groups that address forest genetic resources

A) National groups:
1) Canadian Forest Genetics Association: promotes the use of genetically sound practices in Canadian forestry by fostering discussions and information exchange related to all aspects of tree improvement between people working in forest genetics, conservation, seed collection, and seed establishment, as well as managers, foresters, forest industry, and by advising and assisting policy formation to better tree improvement practices.[1] **2) Canadian Program for Conservation of Forest Genetic Resources (**CON**FOR**GEN**)**: provides a coordinated approach that focuses on monitoring, assessing, and reporting on the state of forest tree genetic resources and developing management guidelines.[2] This group has developed a knowledge management system, the Canadian Forest Genetic Resources Information System (CAFGRIS), a geospatial information system that has data pertaining to the current status of native tree species, threats to these species, and species' conservation activities. This system integrates national and jurisdictional-level data. **3) NatureServe Canada:** is a network that provides scientific information about Canada's species and ecosystems to help guide effective conservation action and natural resource management. As part of the international NatureServe network, it is a leading source for reliable information and analysis on the distribution and conservation status of Canada's plants, animals, and ecological communities, including forest-associated species. A goal is to improve natural resources decision making and to serve the public by increasing awareness among Canadians of the nation's rich natural heritage.[3] **4) Canada's Conservation Data Centres (CDCs):** fall under NatureServe Canada's umbrella, Canada hosts eight independent CDCs covering all 10 provinces and Yukon Territory. All CDCs share the same mandate: to conduct biological inventories to find and document populations of rare species, study and classify ecological communities, analyze critical conservation issues, provide customized information products and conservation services, and make their data widely available to the public via the Internet. The CDCs collect and maintain data pertaining to forest-associated species. Each CDC serves as a clearinghouse for reliable and current scientific information about plants, animals, and ecological communities within its respective jurisdiction.[4] **5) The Canadian Botanical Conservation Network (CBCN)**: promotes the positive effects of botanic gardens, arboreta and other organizations or individuals maintaining native and exotic plants in cultivation on the conservation of endangered or rare plants (including native tree species), or plants that constitute an important cultural, historical, or economic genetic resource.[5] **6) Nature Conservancy Canada (NGOs)**: is a national conservation land organization, protecting areas of biological diversity (including forested land) for their intrinsic value and for the benefit of future generations by securing ecologically significant areas through land securement and through management plans and monitoring arrangements.[6] **7) Canadian Wildlife Federation (NGOs):** is an organization with the goal to ensure that there is an appreciation of our natural world (including forested areas) and a lasting legacy of healthy wildlife and habitat by informing and educating Canadians, advocating responsible human actions, and representing wildlife on conservation issues.[7] **8) Natural Resources Canada (NRCan), Canadian Forest Service (CFS):** NRCan is a federal department and the CFS activities related to forest genetic resources are conducted throughout the five regional centres across Canada. The benefits of these activities are that they contribute to scientific information and advice to assist with decision making pertaining to the management and conservation of forest genetic resources. [8] Furthermore, the CFS has Canada's only National Tree Seed Centre (Atlantic Forestry Centre, New Brunswick) with the mandate to conserve native tree species of concern using a variety of *ex situ* conservation means.

9) **Canadian Model Forest Network (CFMN)**: is a national network of 11 Forest-based Community Program (FCP) partnership sites and one national organization, the Canadian Model Forest Network (CMFN). The network conducts integrated forest-science research and policy development activities associated with Canada's forest health and the economic sustainability of forest-based communities. Initiatives include: bioenergy / biomass research and production, ecological goods and services, international knowledge transfer, non-timber forest products research and production (e.g. blueberries and mushrooms), and forest community capacity building in the form of youth education and training Initiatives. Regional-level and local projects may include: building Aboriginal partnerships, biodiversity, climate change, criteria and indicators of sustainable forest management and community economic wellness, forestry practices, and ecological processes.[9,10]

10) **The National Aboriginal Council on Species at Risk (NACOSAR):** was created under the *Species at Risk Act* to provide advice and recommendations to the Minister of the Environment and the Canadian Endangered Species Conservation Council on the administration of the Act. This group has multiple responsibilities including to build, develop, and maintain networks and relationships with national, regional, and community First Nations, Inuit, and Métis leaders, experts, and federal, provincial, and territorial government officials, to advance NACOSAR positions.[11]

11) **Inuit Tapiriit Kanatami, Department of Environment and Wildflife (DEW):** represents 55,000 Inuit living in 53 communities across the Inuvialuit Settlement Region (Northwest Territories), Nunavut, Nunavik (Northern Quebec), and Nunatsiavut (Northern Labrador) and land claims regions.[12] The DEW provides enhanced leadership and advocacy on a national level pertaining to the environment and wildlife policy and research issues affecting Inuit, including climate change, resource development and species at risk. Forest genetic resources are addressed as Nunacik (Canadian Council of Forest Ministers 2005) and Nunatsiavut (Memorial University of Newfoundland 2012) does contain forested land.[12]

12) **Assembly of First Nations, Environmental Stewardship Unit (ESU):** has the mandate to conduct research, develop policy, and advocate on behalf of First Nations, in a manner consistent with the recognition of Aboriginal and Treaty Rights as they relate to environmental stewardship. The ESU has specific initiatives addressing forestry, biological diversity and climate change, among other areas.[13]

13) **Centre for Indigenous Environmental Resources (CIER):** is national, First Nation-directed environmental non-profit organization with charitable status first established in 1994 by a group of First Nation Chiefs from across Canada. Their program focus is on climate change, building sustainable communities, protecting lands and waters, and conserving biodiversity.[14]

B) Subnational: jurisdictional groups and departments

1) **British Columbia's Ministry of Forests, Lands and Natural Resource Operations:** British Columbia's (BC) Tree Improvement Branch has a mandate to protect, manage, and conserve BC's forest genetic resources through excellence in cone and seed services, research, tree breeding, decision support, and client services.[15] The Forest Genetics Section of BC's Research and Knowledge Management Branch, is a model research program for Canada and attracts national and international interest due to its long history of success in four main areas: (1) tree breeding and improvement, (2) genetic conservation, (3) seed transfer and climate change, and (4) supporting research projects.[16]

2) **Forest Genetics Council (FGC) of British Columbia**: is appointed by BC's Chief Forester to guide tree improvement activities in the province. The Council provides a forum for stakeholders' representatives to set goals and objectives, and to oversee the development and delivery of business plans to fulfill them. The annual FGC Business Plan outlines the activities and budgets of the subprograms that constitute the provincial forest gene resource management program. This group is a multi-stakeholder group representing forest industry, BC's Ministry of Forests, Lands and Natural Resource Operations, universities, and the CFS. The Council's mandate is to lead provincial tree improvement and forest genetic resource management programs, which include the conservation, controlled use, and value enhancement of the genetic resources of forest tree species, and to advise the Provincial Chief Forester on forest genetic resource management policies. The FGC has technical advisory committees (TACs)(e.g., Gene Conservation TAC) that provide technical and policy information to the Council. Examples of this group's activities include inventorying and cataloguing forest tree gene resources, supporting information and policy requirements related to forest gene conservation, providing gene conservation expertise to support and integrate with other biodiversity

and forest ecosystem conservation efforts in British Columbia.[17]

3) **University of British Columbia: Centre for Forest Gene Conservation (CFGC):** has a mandate to: (1) study population genetic structure of forest trees using existing or new data; (2) assess the current degree of gene conservation both *in situ* in existing reserves and in *ex situ* collections and the need for additional protection; and (3) evaluate the current degree of maintenance of genetic diversity in breeding and deployment populations of improved varieties to meet current and future environmental challenges.[18](See Chapter 1, Section 1.4 for a detailed description of CFGC activities).
4) **Alberta Ministry of Sustainable Resource Development (SRD):** has a Tree Improvement and Seed Centre that stores seed for reforestation and conservation. In conjunction with the SRD, the centre also conducts research regarding genetics and tree improvement of Alberta's tree species.[19] In 2009, the SRD partnered with Alberta's Ministry of Tourism, Parks and Recreation to develop Alberta's "Gene Conservation Plan for Native Trees of Alberta."[19]
5) **Alberta Forest Genetic Resources Council:** has the goal to promote biodiversity, productivity, and conservation of genetic resources, specifically to make advances in genetic gain, adaptation, genetic diversity, and conservation of forest genetic resources.[20] Numerous universities, industry, and government (federal and provincial) agencies collaborate and contribute to their projects. This Council provides advice to the provincial government on policy issues and opportunities involving genetic conservation and tree improvement.[21] Furthermore, the Council makes recommendations concerning the management of gene resources of Alberta's deciduous and coniferous forests to the Minister of Alberta Sustainable Resource Development. Key interest areas of the Council include maintenance of genetic diversity throughout Alberta's forest and genetic gain for growth and yield, wood quality, and pest resistance.[20]
6) **Saskatchewan's Centre for Northern Agroforestry and Afforestation:** is based out of the University of Saskatchewan. The Centre's mission is to: (1) facilitate the coordination and collaboration of scientific research activities, both biological and socioeconomic, among the stakeholders in Saskatchewan for using woody plants in agroforestry/afforestation systems on agricultural land for farm diversification, fiber production, and other environmental purposes, (2) facilitate the incorporation of the biological and socioeconomic knowledge related to agroforestry/afforestation systems into the University of Saskatchewan's College of Agriculture curriculum and into extension programs for stakeholders on the land base, and (3) network with various agencies to develop Saskatchewan as a knowledge centre in agroforestry and afforestation.[22]
7) **Saskatchewan's Indian Head Shelterbelt Centre:** has been in operation since 1901. The Centre supplies trees and shrubs for wildlife habitat, biodiversity, and agroforestry initiatives.[23]
8) **Manitoba Conservation:** the forestry branch has numerous activities, including monitoring forest management actions, delivering woodlot management programs to private landowners, assessing the impacts of pests and pathogens (e.g., emerald ash borer), and supporting forest conservation efforts.[24]
9) **Manitoba Tree Improvement Program**: has three main objectives: (1) to provide a reliable supply of seed, 2) to provide a genetically improved seed source, and 3) to ensure the conservation of the genetic resource.[25] This program is directed through the Province of Manitoba's Forestry Branch. Their strategy focuses on four areas: (1) species diversity and breeding zones for their three main reforestation species (*Picea mariana*, *Picea glauca,* and *Pinus banksiana*); (2) genetic diversity for commercial (e.g., *Picea mariana*) and non-commercial tree species; (3) tree improvement strategies focusing on plus trees, family tests, advanced breeding, etc.; and (4) tree improvement cooperatives, specifically the planning of tree improvement programs and provision of technical direction.[25]
10) **Ontario Forest Research Institute (OFRI)**: under Ontario's Ministry of Natural Resources' umbrella, the OFRI addresses the function of Ontario forests, changes over time, and how forests respond to human activities. The Institute focuses on research areas that include: (1) climate change, looking at the adaptive capacity of selected Ontario tree species in a changing climate, (2) forest health and pathology, and (3) genetic studies that provide academic support to Ontario's gene conservation and tree improvement programs.[26]
11) **Forest Genetics Ontario (FGO)**: through a partnership with the province of Ontario, forest industry, and other stakeholders, this group promotes, advocates for, and conducts genetic conservation, genetic resource management, research, and technology transfer and information sharing of forest-associated species, with a focus on tree species. The activities of the group include selective tree breeding to produce seed and seedlings for Ontario's production forests, seed zone work to aid in ecological restoration efforts and to ensure forest health, and research on issues such as the conservation of genetic diversity, adaptation, and

recovery of endangered and threatened tree species. The FGO works through three regional associations: Superior-Woods Tree Improvement Association, Northeast Seed Management Association, and the Forest Gene Conservation Association.[27]

12) **Forest Gene Conservation Association (FGCA):** promotes the importance of the genetic resources of the forests in south-central Ontario, with emphasis on conservation, maintenance, and restoration of genetic diversity of native forest tree and shrub species.[27] They have three main programs. The first is to ensure biologically appropriate reforesations, where the FCGA runs a seed source certification program (Ontario's Natural Selections) and certifies seed collectors who have taken specific training workshops. The second program, conservation and recovery of Ontario's species at risk, is involved in preparing Committee on the Status of Wildlife in Canada (COSEWIC) reports (e.g., butternut), reviewing recovery plans, and assisting the University of Guelph Arboretum program to archive *Ulnus americana* resistant to Dutch elm disease (*Ophiostoma ulmi or Ceratocystis ulmi*). The third program comprises tree improvement and genetic studies (e.g., white pine and hybrid poplar).[28]
13) **New Brunswick's Department of Natural Resources**: has a tree improvement and reforestation program.[29] The department also conserves the seed of selected New Brunswick trees. [30]
14) **New Brunswick Tree Improvement Council:** has the goals of coordinating tree improvement efforts of the New Brunswick Department of Natural Resources and industrial agencies and facilitating the free exchange of genetic material and information. Another goal is to develop gene conservation strategies for native trees and shrubs, with two main objectives of providing an adequate supply of tree seed from locally adapted sources and genetically improved seed to meet reforestation demands.[31]
15) **Nova Scotia's Department of Natural Resources**: has a forest renewal/reforestation section responsible for their forest nursery and tree breeding centre, which produces forest tree seedlings for Nova Scotia's reforestation programs. Other activities include storing seed for research activities, gene conservation, and special interest collections.[32]
16) **Nova Scotia Forest Genetics Working Group:** working with industry and the Nova Scotia Department of Natural Resources, guides tree improvement and conservation efforts in the province. As the climate changes, tree improvement of native species will continue to increase in importance.[33]
17) **Prince Edward Island Department of Environment, Energy and Forestry:** operates seed orchards and a tree nursery that produces seedlings for watershed enhancement, wildlife management, and reforestation projects on private and public lands, as well as seedlings for the Island's Christmas tree operations. The department also provides advice in such areas as landscape management, insect and disease problems, and suitable native tree and shrub species for planting in the Acadian forest, as well as ornamentals.[34]
18) **Newfoundland & Labrador's Department of Natural Resources:** operates a tree nursery that provides genetically improved stock for reforestation efforts in the province.[35]
19) **Yukon Department of Energy, Mines and Resources:** the forestry sector undertakes such activities as forest management planning and promotes the sustainable harvesting of non-timber forest products (e.g., mushrooms).[36]
20) **Northwest Territories' Department of Environment and Natural Resources:** provides a policy, planning, and regulatory framework for the stewardship, protection, and sustainable management of forest resources.[37]
21) **Nunavut Department of the Environment:** activities include conservation, heritage appreciation, and development of programs and policies that will assist Nunavut in adapting to projected climate change impacts.[38]

C) Subnational groups focusing on specie- or region-specific issues

14) **Garry Oak Meadow Preservation Society**: is dedicated to the preservation, protection, and restoration of the Garry oak ecosystem in British Columbia. They work with the education system and all levels of government, including the BC Ministry of Environment.[39]
15) **Carolinian Canada Coalition**: is a charitable organization formed to "protect and restore the natural heritage of Ontario's Carolinian life zone for healthy, sustainable landscapes through stewardship, cooperation and research." This group has conservation-related activities associated with the Carolinian forest region. The coalition is supported through donations by many large corporations and also by provincial and federal governments.[40]
16) **Canada's First Nations organizations:** the following presents a selection of First Nation's initiatives across Canada, whose mandates may directly or indirectly be related to forest genetic resources:

a. **Nanakila Institute Society:** its mission is to conserve and restore all resources in Haisla and surrounding territory, to promote equitable economic and social development of the Haisla community, to promote Haisla culture and traditional knowledge, and to share experiences with British Columbia's coastal communities.[41]
b. **Aboriginal Boreal Conservation Leaders:** Manitoba's boreal forest is inhabited primarily by Aboriginal populations. This group has multiple conservation efforts associated with Manitoba's boreal forest, where they have the goal to maintain the ecological integrity of the large, undisturbed region of boreal forest that still exists in Manitoba.[42]
c. **Walpole Island Land Trust:** a grassroots organization aiming to conserve land in the Walpole Island First Nation/Bkejwanong Territory. In addition to conserving land, the Walpole Island Land Trust aims to maintain and reconnect the community's cultural ties to the land, thereby ensuring community investment in the natural beauty that is found within Bkejwanong.[43]
d. **Maliseet Nation Conservation Council:** is dedicated to the conservation and co-management of resources in the Saint John River Watershed in the province of New Brunswick, and in promoting Wolustwik management watersheds and ecosystems through conservation and stewardship education. In particular, a goal is to conserve traditional knowledge associated with these resources for present and future generations.[44]
e. **The Northwest Territories Protected Areas Strategy:** is a community-based group that established a network of protected areas within each of the 42 ecoregions in the Northwest Territories, recognizing the need to balance conservation and economic development, while respecting Aboriginal rights.[45]

1. Canadian Forest Genetics Association. 2012a.
2. Canada: National Report to the Ninth Session of the UNFF. November 2010.
3. NatureServe Canada. 2007b.
4. NatureServe Canada. 2007a.
5. Botanic Gardens Conservation International. 2012.
6. Nature Conservancy Canada. 2012.
7. Canadian Wildlife Federation. 2012.
8. Natural Resources Canada. 2012.
9. Canadian Model Forest Network. 2011b.
10. Canadian Model Forest Network. 2011a.
11. The National Aboriginal Council on Species at Risk. 2012.
12. Inuit Tapiriit Kanatami. 2012.
13. Assembly of First Nations. 2012.
14. Centre for Indigenous Environnemental Resources. 2011.
15. British Columbia Ministry of Forest, Lands and Natural Resource Operations. 2012b.
16. British Columbia Ministry of Forest, Lands and Natural Resource Operations. 2012a.
17. Forest Genetics Council of British Columbia. 2011.
18. University of British Columbia's Centre for Forest Conservation Genetics. 2012
19. Alberta Ministry of Sustainable Resource Development. 1995–2012.
20. Alberta Forest Genetic Resources Council. 2011b.
21. Alberta Forest Genetic Resources Council. 2011a.
22. Centre for Northern Agroforestry and Afforestation. 2012.
23. Saskatchewan's Environmental Champions. 2010.
24. Manitoba Conservation. 2012.
25. Manitoba Forestry. 2011.
26. Ontario Ministry of Natural Resources. 2011.
27. Forest Genetics Ontario. 2011.
28. Forest Gene Conservation Association. 2012.
29. Boyle 2005.
30. New Brunswick Department of Natural Resources. 2009.
31. NB Forest Products Association. 2011.
32. Nova Scotia Department of Natural Resources. 2011.
33. Forest Panel of Expertise. 2010.
34. Prince Edward Island's Environment, Energy and Forestry. 2012
35. Newfoundland's Department of Natural Resources. 2011.
36. Yukon Department of Energy, Mines and Resources. 2011.
37. The Northwest Territories Department of Environment and Natural Resources. 2012.

38. Nunavut Department of the Environment. 2012.
39. Garry Oak Meadow Preservation Society. 2009.
40. Carolinian Canada Coalition. 2004.
41. Nanakila Institute Society. 2012
42. Aboriginal Conservation Leaders. 2007–2010.
43. Walpole Island Land Trust. 2012.
44. Maliseet Nation Conservation Council. 2012.
45. The Northwest Territories Protected Areas Strategy. 1999–2009.

5.2 EDUCATION, RESEARCH, AND TRAINING

5.2.1 (FAO Question 5.18) Budget Allocation to Forest Genetic Resource Research

An estimate of budget allocation to forest genetic resource research in Canada is difficult to determine. Forest genetic research falls under a number of different departments within the federal government (e.g., NRCan, Environment Canada, CFIA, Parks Canada) as well in provincial and territorial government departments. There are also universities and colleges that have programs with individual budgets allocated to research, depending on the project or area of expertise. A large number of organizations have ongoing research in forest genetic resources. This is dependent on the funding and fiscal policies of the current government, both federal and provincial, and therefore, is not easy to determine empirically.

5.2.2 (FAO Question 5.19) Patents Pertaining to Forest Genetic Resources

A search of patents related to native tree species was conducted using the Canadian Intellectual Property Office Canadian Patent Database (Canadian Intellectual Property Office 2012), which includes over 75 years of patents and is updated on an annual basis. There were 36 Canadian tree species that had patents in 2011 (results not shown). In total, there were 185 patents (including duplicates, i.e., more than one species per patent) and 100 patents (not including duplicates). The lead patent inventors ranged from industry to university to individuals. *Taxus* sp. had the most patents of any species (24).

5.2.3 (FAO Questions 5.20, 5.21) State of Education and Training in Forest Genetic Resources

Colleges with recognized technical forestry programs are described in Table 5.2; students enrolled in these programs can obtain a diploma upon completion of a 2- to 4-year program (depending on discipline and co-operative education option). Universities offer degree programs at the undergraduate and graduate levels from faculties of Science in Forestry or Natural Resource Management and a number of these programs address forest genetic resources in their courses. Enrolment in forestry programs has decreased over the past several years (Interim National Recruitment Strategy Steering Committee 2006). Universities and colleges are examining new ways to entice students into their programs by rebranding and transforming their programs, developing new programs and partnerships, and broadening the relevance of the faculty and programs (e.g., addressing broader environmental issues) (Smallwood 2011).

In 2010, a symposium was held by the Association of University Forestry Schools of Canada to address concerns about the decline in enrolment in forestry programs at the university level (International Symposium on Forestry Education 2010). The following recommendations were proposed as an outcome of the meeting: (1) have forestry schools join forces with the broader forestry community (e.g., forest industry) to enhance the image of the forest sector and the forest profession; (2) develop an effective partnership framework among all forest research organizations in the county (e.g., CFS and FPInnovations, provinces and territories, industry, Social Development Canada, Forestry Sector Council); and (3) develop or enhance existing partnerships with funding agencies and develop an international forestry education and research program (International Symposium on Forestry Education 2010). At the symposium, it was recommended that programs need to reflect a shift from timber-oriented forestry to the “new forestry” described as sustainable forest management and resource management.

5.3 INFORMATION SYSTEMS

Refer to Chapter 1, sections 1.1.4 and 1.1.6 for information systems and challenges, needs, and priorities for these systems.

5.4 PUBLIC AWARENESS

5.4.1 (FAO Question 5.32) Level of Public Awareness for the Roles and Values of Forest Genetic Resources

Based on results from a jurisdictional survey, a perceived consensus was identified among respondents that the public and NGOs have the lowest awareness of the roles and values of forest genetic resources. Industry and government rated much higher.

In general, the values of forest genetic resources have not been widely communicated at a national level. However, public awareness concerning the value of Canadian forests and the species within these forests has been enhanced through multiple programs and activities from diverse groups, including the jurisdictions (e.g., British Columbia’s Trees for Tomorrow (2012)) and the federal government (e.g., The State of Canada’s Forests (Natural Resources Canada 2011), botanical gardens (Canadian Botanical Conservation Network 2012), small woodlot partnership programs (e.g., British Columbia Small Woodlot Partnership Outreach (2012), New Brunswick Federation of Woodlot Owners (2011), and through forest or tree-specific conservation groups (e.g., Forest Gene Conservation Association, Garry Oak Meadow Preservation Society) (see Chapter 6, Table 6.1 for further detail). The multiple types of federal and jurisdictional *in situ* conservation areas (see Chapter 2 for further detail) have also raised public awareness of the forest and its resources. Furthermore, environmental NGOs have also increased awareness of the value of Canadian forested areas and associated species (e.g., Table 5.4).

The public is engaged with regard to threats to forest genetic resources in such areas as climate change and changes in land use, in particular as this pertains to the boreal forest and other old-growth forested areas. These topics have been and continue to be prevalent in the media.

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Chapter 6: The State of Regional and International Collaboration

Information presented in this chapter is current as of 2012 and was obtained through literature searches and by consultation with the jurisdictions.

6.1 REGIONAL AND SUB-REGIONAL THEMATIC FOREST GENETIC RESOURCE NETWORKS IN CANADA

6.1.1 (FAO Question 6 and Appendix 6.3) Regional Forest Genetic Resources-based or Thematic Networks for Forest Genetic Resources

The Food and Agriculture Organization, North American Forest Commission's Forest Genetic Resource Working Group is an example of a regional network that has been beneficial for Canada (Table 6.1). The working group was formed in 1961 and has addressed multiple forest genetic resources topics collaboratively between the United States, Mexico and Canada.

6.1. Example of a regional forest genetic resource network that has been beneficial for Canada

Regional Network:
1) **Food and Agriculture Organization, North American Forest Commission (NAFC) – Forest Genetic Resource Working Group:** has the mandate to "generate, share and disseminate knowledge that is crucial for the conservation and the sustainable use of North American forest genetic resources to the benefit of present and future generations."[1] The NAFC Forest Genetics Resource Working Group has three objectives: (1) to promote the collection, exchange, and dissemination of information about forest genetic resources so that *in situ* and *ex situ* programs of conservation and sustainable use are based on sound scientific knowledge, (2) to promote cooperation and coordinate research, conservation, training, and exchange among member countries on genetic resource conservation problems, and (3) to facilitate the international exchange of forest genetic resources.[1] These activities are all beneficial to Canada.

1. North American Forest Commission. 2000

6.1.2 (FAO Question 7) Canadian Needs and Priorities to Develop or Strengthen International Networks for Forest Genetic Resources

The distribution of forest genetic resources does not correspond to political borders, and this is an important basis for cooperation and also for coordination on issues related to the management of forest genetic resources. Furthermore, environmental drivers for change, including climate change, are issues that, again, span political borders. Canada presently has numerous partnerships with the United States and Mexico, as the three countries share a number of forest genetic resources, including trees. Collaboration to amalgamate knowledge and data pertaining to forest genetic resources that are hosted by various agencies and institutions in all three countries would be very beneficial, enhancing continent-wide conservation and management strategies. The sharing of national forest resource inventories across Canada, the United States, and Mexico could include forest ecosystem maps and disturbance databases. The opportunity to further strengthen relationships and cross-border studies will become more apparent as gaps in forest genetic resource knowledge are studied further. Monitoring, which can be closely linked to information management, is also important. Monitoring can be of forest genetic resources and also of biotic stressors (e.g., invasive alien species) impacting these resources at a regional level (i.e., North America). Work of this type is highly beneficial for developing effective long-term strategies for conserving these resources and for either minimizing the impacts of the stressors or for developing scale-appropriate mitigation strategies. Concerning invasive alien pests that can impact the forest sector, the sharing of data concerning outbreaks, etc. in other regions—European and Asian forests, as examples—is also important as this can assist Canadian researchers and forest managers in developing proactive responses to future potential stresses.

Further networking to maintain the existing research capacity and to expand upon it is also useful. Continued collaborative research, such as that which is on going through the North American Forest Commission's Working Groups (WG), is important as it addresses issues that are often addressed at the level of species distribution within North America. It is also important to enhance the ability of research to inform policy at national and regional levels, and to coordinate its implementation.

6.2 INTERNATIONAL PROGRAMS

6.2.1 (FAO Question 8) International Programs for Forest Genetic Resources that Have Been Beneficial for Canada

There are numerous programs for forest genetic resources that have benefited Canada, either by promoting research efforts, enhancing collaboration, technology, and data exchange, or clarifying some of the issues pertaining to Aboriginal peoples' claims that may include forested areas. Table 6.2 highlights some of these programs and their benefits.

Table 6.2. Examples of international forest genetic resource programs, organizations and networks that have been beneficial for Canada

International programs, organizations or networks:
2) **Circumboreal Vegetation Mapping Initiative:** has the mission to develop a global map of the circumboreal forest biome with a common legend. The reason for concentrating efforts to produce a map of global boreal vegetation is to provide a common international framework for understanding the boreal region. This mapping initiative will be compatible with the Circumpolar Arctic Vegetation Map (CAVM, scale 1:7,500,000). Linking these two global-scale maps is necessary because very few issues relevant to the Arctic or the boreal regions stop at the tree line. Canada benefits from such an initiative because boreal scientists and managers will be able to use the map to conduct impact studies on flora and fauna and to help determine feedback mechanisms of greenhouse gas emissions for climate change modeling programs. This will in turn contribute to Canada's effort to improve understanding and communication with its nation's policy makers. [1]
3) **International Model Forest Network (IMFN):** Canada as the originator of the model forest approach is a committed member of the IMFN and continues to host the Network Secretariat at Natural Resources Canada. The IMFN is a global community of practice directed toward the sustainable management of forest-based landscapes through the Model Forest approach. Canada has 14 model forests across the country. These forests are used as living laboratories, where leading-edge techniques and approaches to the sustainable management of forest-based landscapes are researched, developed, applied, monitored, and then shared with others. For example, the pioneering local-level criteria and indicator work for sustainable forest management carried out in Canadian Model Forests is increasingly in demand from other areas of the Network. [2]
4) **International Union of Forestry Organizations (IUFRO):** has numerous working groups that address directly or indirectly forest genetic resources. In a general context, the benefit of these working groups for Canada is that they offer a means to exchange information, promote research, and support the conservation of forest genetic resources within Canada. [3]
5) **Millennium Seed Bank Project:** is beneficial to Canada in that: (1) seed has been made available for research; (2) there has been technology transfer, and (3) the Millennium Seed Bank is storing back-up accessions of Canadian tree species at risk (e.g., *Fraxinus* sp.).[4]
6) **Taiga Rescue Network:** supports local issues and strengthens the cooperation between individuals, NGOs, and Aboriginal peoples and nations concerned with the protection, restoration, and sustainable use of the world's boreal forests. One of the benefits to Canada is assistance with the clarification of

some of the issues surrounding Aboriginal peoples' claims. [6,7]

[1] CanopyPlanet. 2010.
[2] International Model Forest Network. 2010.
[3] International Union of Forest Research Organizations. 2012.
[4] Canadian Botanical Conservation Network. 2012.
[5] Royal Botanical Gardens, Kew. 2012.
[6] Taiga Rescue Network. 2011a.
[7] Taiga Rescue Network. 2011b.

6.2.2 (FAO Question 6.6 and Appendix 6.12) Canada's Needs and Priorities for Future International Collaboration

The needs and priorities for future international collaborations are summarized in Table 6.3 and range from medium to high. This data was obtained through consultation with various experts in forest genetic resources and forest genetic resource managers. High-priority activities include understanding the state of diversity, enhancing education, and information management and early warning systems for forest genetic resources. Medium priorities include enhancing *in situ* and *ex situ* management and conservation, enhancing the use of forest genetic resources, research, legislation, and public awareness.

Table 6.3. Needs for international collaboration and networking

Needs	Level of priority			
	Not applicable	Low	Medium	High
Understanding the state of diversity				x
Enhancing *in situ* management and conservation			x	
Enhancing *ex situ* management and conservation			x	
Enhancing use of forest genetic resources			x	
Enhancing research			x	
Enhancing education and training				x
Enhancing legislation			x	
Enhancing information management and early warning systems for forest genetic resources				x
Enhancing public awareness			x	
Any other priorities for international programs			X	

6.3 INTERNATIONAL AGREEMENTS

6.3.1 (FAO Questions 6.7, 6.8 and Appendices 6.10) International Agreements, Treaties, Conventions, or Trade Agreements that Pertain to the Sustainable Use, Development, and Conservation of Forest Genetic Resources

There are many international agreements, treaties, conventions, and trade agreements that Canada is engaged in that either directly or indirectly address the sustainable use, development, and conservation of forest genetic resources. Legally binding commitments that Canada has made by ratifying multilateral environmental agreements are an important policy driver for national coordination and action. The Convention on Biological Diversity (CBD) (United Nations 1992) is of particular relevance for forest genetic resources and their conservation. As Party to the CBD, Canada has a legally binding obligation to achieve the three objectives of the CBD: (1) the conservation of biological diversity, (2) the sustainable use its components, and (3) the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

The Convention has promoted the following activities in Canada:

1) The *Canadian Biodiversity Strategy* provides a guide to the implementation of the CBD in Canada. In 1996, federal, provincial and territorial governments committed to the conservation of biodiversity and the sustainable use of biological resources, and to use the *Strategy* as a guide to their actions.
2) Conservation genetics initiatives including the Plant Germplasm System and Plant Gene Resources of Canada[1] .
3) Federal and provincial governments have developed biodiversity indicators.
4) Federal and provincial governments have increased the number of parks/protected areas within their jurisdictions.

Canada continues to play an active role in global efforts to ensure implementation of the Convention, including revising the national biodiversity assessment guidelines, participating on key policy issues, and assisting developing countries to increase their capacity to conserve biodiversity and biological resources in a sustainable way.[1]

There are other international agreements, treaties, conventions, and trade agreements in which Canada is engaged that pertain to the sustainable use, development, and conservation of forest genetic resources, but they tend to be less comprehensive than the CBD, and may indirectly address forest genetic resources by addressing stresses to the forest (e.g., climate change under the UN Framework on Climate Change (Table 6.4).

Table 6.4. International agreements, treaties, conventions, and trade agreements in which Canada is engaged pertaining to the sustainable use, development, and conservation of forest genetic resources

Name of Agreement, Convention, Treaty, etc.	Description of activities, impacts, and benefits
Agreement between Canada and the United States on Cooperation in the a) Boreal Ecosystem–Atmosphere Study (BOREAS) and b) Boreal Ecosystem Research and Monitoring Sites (BERMS)	The agreement addresses climate change, ecosystems, forests, and trees and provides the basis for a joint Canada–United States Boreal Ecosystem–Atmosphere Study involving the Canadian federal department Natural Resources Canada and the U.S. National Aeronautics and Space Administration (NASA), an agency of the Government of the United States, in order to better understand the interactions between the boreal forest biome and the atmosphere with a view to clarifying the roles of these interactions in global change. This agreement was in force in Canada in 1999.[1] The BERMS is a joint federal government–university initiative that has expanded on BOREAS and was launched near the end of the BOREAS field project to ensure a continuous data record. Using the BOREAS study forested sites, the study's main objective is to continue to study the role that Canada's boreal forest plays in global carbon, water, and energy cycles, and their importance to climate change.[2,3]
Agreement Establishing the Inter-American Institute for Global Change Research	The Agreement resulted in the establishment of the Inter-American Institute for Global Change whose focus is on increasing our understanding of global change-related phenomena and the societal implications of such phenomena while augmenting the overall scientific capacity of the region. [4,5] Activities that can benefit forest genetic resources include studies pertaining to the impacts of climate change on biological diversity. The Agreement came into

[1] Boyle 2005.

	force in 1994. [5]
Agreement on Environmental Co-operation between Canada and Mexico	According to the commitments outlined in the agreement that came into force in 1994, Canada is to maintain and expand with Mexico, bilateral cooperation in environmental matters, including conservation and protection of the environment, on the basis of equality and mutual benefits, while considering differences in relative development and respective environmental policies, and to provide financial support mutually agreed upon by both parties in the environmental field. Forested areas would be included when considering conservation and protection of the environment. [6]
Agreement on Environmental Cooperation between Canada and Chile	The agreement came into force in 1997[7] and has multiple objectives, including to conserve, protect, and enhance the environment (e.g., wild flora, including forested areas, and fauna) in both countries.[8]
Convention on Biological Diversity (CBD)	Canada actively participates at the meetings of the Conference of the Parties and in the development of recommendations by the Convention's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). The SBSTTA oversees implementation of CBD work related to forest genetic resources, including agricultural bioiversity, forest biodiversity, sustainable use of biodiversity, the Global Taxonomy Initiative, and the Global Plant Conservation Strategy.
Convention on International Trade in Endangered Species (CITES)	The aim of the convention is to ensure that the trade in wild animals and plants does not threaten their survival.[10]The Canadian Wildlife Service in Environment Canada is responsible for managing CITES species within Canada's borders and provides a management authority that administers the convention nationally and a scientific authority, that coordinates CITES science-based activities in the country.[11] CITES addresses any forest-associated species that may be endangered or threatened by international trade.
Instrument for the Establishment of the Restructured Global Environmental Facility	This instrument addresses climate change and biological diversity issues.[12] Through contributions to the Global Environment Facility, Canada has provided new and additional funding to address global environmental concerns, including biodiversity loss in forested areas. Canada's Official Development Assistance programs provide resources and technical assistance to support sustainable development in developing countries, including projects and programs designed to help these countries reap long-term benefits from the sustainable use of their biological resources.[13]
International Plant Protection Convention (IPPC)	Canada's obligations to the IPPC are met through the International Plant Protection Organization and the North American Plant Protection Organization. [14] The Canadian Food Inspection Agency (CFIA) administers the convention through their programs. In Canada, these activities include conducting regular, on-going pest surveillance, and the CFIA is responsible for creating policy regarding the inspection of imported goods coming into the country that may have come into contact with pests that could have adverse effects on Canada's forests and forest genetic resources.[15]
International Tropical Timber Agreement	Canada, a consumer of tropical timber is listed as a "consuming member" by the International Tropical Timber Organization (ITTO). [16] In October 2011, representatives from ITTO, the Montreal Process, and Forest Europe met in Canada to review the Criteria & Indicator process for the world's temperate, boreal, and tropical forests, and to discuss possibilities for future collaboration and for streamlining global forest reporting.[17]

North American Plant Protection Agreement	See above, International Plant Protection Convention.[18]
Santiago Declaration Statement on Criteria and Indicators for the Conservation, Sustainable Management of Temperate and Boreal Forests	Criteria and indicators for the conservation and sustainable management of temperate and boreal forests made by the governments of Australia, Canada, Chile, China, Japan, Mexico, New Zealand, the Republic of Korea, the Russian Federation, and the United States in 1995. As a declaration, it is not legally binding but indicates the countries' intention to implement a set of criteria and indicators. Among the seven criteria, Criterion 1 is concerned with conservation of biodiversity and includes indicators relating to genetic diversity (number of forest-dependent species that occupy a small portion of their former range and population levels of representative species from diverse habitats monitored across their range).[19]
United Nations Framework Convention on Climate Change	Canada supports the Cancun Agreement outlined in 2010, whose main objectives are to: (1) protect the world's forests, which are a major repository of carbon, (2) build up the global capacity, especially in developing countries, to meet the overall challenge, and (3) establish effective institutions and systems required for implementing these objectives. [20,21]

1. Foreign Affairs and International Trade Canada. 2002f.
2. Government of Canada. 2011.
3. UNFCCC. 2011.
4. Foreign Affairs and International Trade Canada. 2002a.
5. Environment Canada. 2003.
6. BERMS: Boreal Ecosystem Research and Monitoring Sites. 2001.
7. Foreign Affairs and International Trade Canada. 2002i.
8. ITTO. 2011.
9. Convention on Biological Diversity. 2012.
10. Foreign Affairs and International Trade. 2002h.
11. International Plant Protection Convention. 1997.
12. Foreign Affairs and International Trade Canada. 2002j.
13. Foreign Affairs and International Trade Canada. 2002b.
14. Inter-American Institute for Global Change. 1999.
15. Foreign Affairs and International Trade Canada. 2002d
16. Environment Canada. 2011
17. Foreign Affairs and International Trade Canada. 2002c.
18. Foreign Affairs and International Trade Canada. 2002e.
19. Environment Canada. 2010.
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21. Biodivcanada.ca. 2010.

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Chapter 7: Access to Forest Genetic Resources and Sharing of Benefits Arising from their Use

The Canadian forest sector considers forest genetic resources as encompassing trees, non-timber forest species (e.g., shrubs, fungi, forest herbs), and genetic resources in forest soil (e.g., fungi, bacteria). Information presented in this chapter is current as of January 2012.

7.1 ACCESS TO FOREST GENETIC RESOURCES

7.1.1 Canadian Participation in International Agreements Relevant to Access to Forest Genetic Resources, and Transfer and Sharing of Benefits Arising from their Use over the Last 10 Years

Canada is one of the 193 Parties to the legally binding 1992 United Nations *Convention on Biological Diversity* (CBD), established to promote the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from their use. Article 15 of the CBD addresses the Access to Genetic Resouces. In 2002, the Parties agreed to negotiate an international regime addressing access and benefit sharing (ABS). Canada, as both a provider and user of genetic resources, has a clear interest in the development of a fair, practical, and transparent international regime—one that reflects the principles and core elements of our national ABS policy approach.

The *Nagoya Protocol on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out from their Utilization*, that was adopted at the Tenth Meeting of the Conference of the Parties to the CBD on 30 October 2010 would be, if it enters into force, a core element of the international regime on ABS. Canada is not a signatory, but will over the next two years work diligently with our Canadian partners and stakeholders to consider the complex issues around the Nagoya Protocol and whether, and how, it could be implemented in a way that reflects Canada's interests.

Canada signed and ratified the Food and Agriculture Organization's *International Treaty on Plant Genetic Resources for Food and Agriculture* in 2002. Through this treaty, countries agree to establish a multilateral system to facilitate access to plant genetic resources for food and agriculture and to share the benefits in a fair and equitable way in harmony with the CBD (Environment Canada 2011).

Canada is also involved in issues related to ABS through discussions in a number of other international forums, including the World Intellectual Property Organization, where Canada and other countries are negotiating an international legal instrument, or instruments, relating to intellectual property, genetic resources, traditional knowledge, and traditional cultural expressions (Environment Canada 2011). The relationship between the *Agreement on Trade-Related Aspects of Intellectual Property Rights* (TRIPS) and the CBD is also being discussed at the TRIPS Council of the World Trade Organization (WTO) (Environment Canada 2011).

7.1.2 (FAO Question 7.3. and Annex 7.1. – 7.3.) National Activities Related to Access and Benefit Sharing

Canada's federal, provincial and territorial governments are working on the development of a national approach to ABS in Canada under the auspices of the Canadian Council of Resource Ministers (CCRM) (Environment Canada 2011). This approach may involve the development of legislation, policies and/or administrative measures by federal, provincial or territorial governments. A Federal-Provincial-Territorial Task Force on ABS was also created. This group is led by Environment Canada and includes provincial and territorial representatives as well as federal departments including Natural Resources Canada, Agriculture and Agri-Food Canada, Fisheries and Oceans, Industry Canada, Heritage Canada, and Aboriginal Affairs and Northern Development Canada.

It is recognized that domestic policy on ABS should take into account the various levels of governments including, where applicable, Aboriginal governments as they are all managers of genetic resources to some degree. Furthermore, it is acknowledged that Aboriginal peoples play a unique role with regard to ABS, in that they are holders of traditional knowledge associated with genetic resources. This knowledge concerns specific properties and uses of the genetic resources and has been gained through generations of experience and practice; it is often passed down as an oral tradition (Environment Canada 2011).

Development of Domestic Access and Benefit Sharing Policy in Canada

In moving toward further development of national ABS policy, the ABS Task Force has prepared a guidance document to assist federal, provincial and territorial governments considering ABS policy: *Managing Genetic Resources in the 21st Century: Domestic Policy Guidance for Canada*. This document, approved in 2010 by Federal-Provincial and Territorial Deputy Ministers responsible for natural resources, identifies policy objectives and principles, the scope of the policy and implementation measures, and possible implementation tools. Objectives include: 1) promoting the conservation and sustainable use of Canada's biodiversity; 2) improving Canada's competitiveness in the bio-based economy; 3) supporting ethical scientific research and development; 4) fostering regional and Aboriginal development; 5) supporting Canadian foreign policy objectives; and 6) contributing to the improvement of the health of Canadians (Environment Canada 2010).

According to this document, domestic policy should be environmentally focused to ensure that it contributes to the conservation and sustainable use of biodiversity (Environment Canada 2010). This policy would need to be practical and economically supportive by ensuring that the economic benefits arising from the use of genetic resources are shared among providers and users and contribute to sustainable development. Furthermore, it needs to be simple, efficient, and adaptable, taking into account the different sectors and allowing for different approaches in the various jurisdictions. It also should be supportive of, and consistent with, current Government of Canada policies, building on and respecting Canada's existing international commitments. The policy should also be balanced with regard to the responsibilities of the users and providers of the genetic resources, and to be inclusive and involve Aboriginal groups and communities.

The scope identified in the document provides that domestic policy should address all Canadian genetic resources, including those in the wild (*in situ*) and in collections (*ex situ*), with the exception of genetic resources beyond Canada's borders, those acquired for personal use or consumption and those purchased or traded as commodities (e.g., trees used for lumber) (Environment Canada 2010). Furthermore, the document provides guidance to the effect that the development and implementation of measures to manage access to and benefit sharing of genetic resources should be founded on the following three elements: (1) prior informed consent; (2) mutually agreed terms (including benefit-sharing agreements); and (3) traditional knowledge associated with genetic resources (Environment Canada 2010). This policy guidance would allow for different governments to tailor their specific policy to their particular circumstances.

Concerning implementation of further domestic ABS policy, the intent would be to use, to the fullest extent possible, existing mechanisms such as contracts and legislation addressing access to biological resources, including for example requirements for permits, supplemented as required by regulatory and non-regulatory measures (Environment Canada 2010). It is anticipated that the jurisdictions would also elaborate on the tools for promoting effective and consistent approaches.

7.1.3 (FAO question 7.7.) Changes to Access to Forest Genetic Resources over the Last Ten Years

Access to forest genetic resources has not changed significantly over the last ten years. However, awareness of issues pertaining to access to and sharing of benefits has increased over that period. Between 2004 and 2006, the federal government held a series of workshops on ABS involving several groups in different regions of the country, including Aboriginal and local communities in the North and representatives and stakeholders from the science and technology sectors, including a workshop with forest stakeholders in 2006. A report of this workshop can be consulted at: http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=FE5C3334-8655-462B-9190-B9AE1E7D5D92.

7.2. BENEFITS ARISING OUT OF THE USE OF FOREST GENETIC RESOURCES

7.2.1. (FAO question 7.10.) Sharing Benefits and arising from the Use of Forest Genetic Resources

Domestically, there are current practices, laws, and regulations that affect access to genetic resources including: (1) access to and collection of biological resources in federal parks and other protected areas, which often are governed by permitting systems; (2) private property and trespass laws regarding access to biological resources on a private property; and (3) agreements to transfer material among academic institutions, researchers, and private business (Environment Canada 2009). Various industry sectors also have policies or practices in place addressing aspects related to ABS (Environment Canada 2009).

Examples of existing jurisdictional practices and regulations include the northern research legislation and permitting systems (e.g., the Northwest Territories Scientist Act, Government of the Northwest Territories 1988), which contain elements of ABS. Northern institutions, such as the Nunavut Research Institute, have integrated measures into their operating procedures that facilitate access to their territory for scientific purposes while ensuring the information generated is shared with Nunavut. An example of an existing federal regulation is that pertaining to the collection of biological resources (including forest genetic resources) in federal parks. The requirement for a permit is addressed under the *Canada National Parks Act*, where the user applies for a collection permit and the genetic resources collected under authority of that permit remain the property of the Crown (Government of Canada) and are considered to be on loan to the permit holder (Government of Canada 2011).

Within the forest sector, there is generally openness to implementing measures related to the access to forest genetic resources and benefit sharing. However, it is recognized that it is important to do so in an ecologically sustainable manner. This is identified as a primary principle in the development of a domestic ABS policy (Environment Canada 2009).

7.2.2 (FAO Annex question 7.3) Legislation Pertaining to Access and Movement of Forest Genetic Resources into or out of Canada

The Canadian Food Inspection Agency (CFIA) assists in the regulation of the movement of biological materials into Canada (CFIA 2011). These regulatory requirements are in place primarily to limit the introduction of invasive pests and pathogens entering the country on various biological materials. These requirements limit the movement of materials into Canada if the appropriate permits are not in place. In exporting genetic resources from Canada, Canada adheres to all foreign import permit requirements. Canada adheres to international controls pertaining to the movement of genetic resources that may be threatened or endangered as stipulated by the *Convention on International Trade in Endangered Species of Wild Fauna and Flora*.

7.2.3 (FAO Annex questions 7.4 – 7.5) Canadian Mechanism for Recognizing Intellectual Property Rights

Issues concerning the interplay between intellectual property regimes and genetic resources are being dealt within a number of international fora, including at the World Trade Organization (WTO) and at World Intellectual Property Organization's Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC). Preventing the grant of erroneous patents on genetic resources that do not meet patentability requirements and using intellectual property to monitor access to genetic resources and the equitable sharing of benefits from the use of genetic resources are being discussed without, however, there being at this time a consensus on technical and administrative solutions to reach these objectives. Canada is participating in these negotiations and has emphasized in all relevant international negotiations its commitment to working to avoid the grant of erroneous patents, to secure compliance with national agreements on benefit-sharing regimes, and to ensure patent offices have available the information needed to make proper decisions on patent grant.

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Chapter 8: Contribution of Forest Genetic Resources to Food Security, Poverty Alleviation, and Sustainable Development

Information in this chapter was obtained through literature searches and is current as of 2012.

8.1. CONTRIBUTION OF FOREST GENETIC RESOURCE MANAGEMENT TO THE MILLENNIUM DEVELOPMENT GOALS

The following information provides examples of programs related primarily to the Government of Canada. It should be noted there are other programs developed by other Canadian agencies and groups, including non-governmental organizations, that pertain to forest genetic resource management that contribute to the UN Millennium Goals.

Canadian forest genetic resource management contributes primarily to Millennium Development Goals (1) eradicate extreme poverty and hunger, and (7), ensure environmental sustainability. However, it also contributes to other Millennium Development Goals by assisting in sustainable management through to harvesting of forest genetic resources, thus providing opportunities for employment and income generation. Adoption of sustainable forestry practices can enhance food production and food security, produce wood products for sale or consumption, and improve ecosystem stability, thereby enhancing sustainability. Furthermore, providing assistance for sustainable forest management will help conserve forest genetic resources.

8.1.1 International Contributions

Sustainable Management and Production of Forest Resources Project in Honduras
($8.9 million funded from 2009–2016).
Canada is supporting this project financially with the goal of increasing the income of rural families working in the forestry sector by strengthening Honduran forestry cooperatives and establishing sustainable forestry practices in broadleaf and deciduous forests (Canadian International Development Agency 2011d). Several activities are taking place to strengthen Honduran forestry cooperatives and establish sustainable forestry projects, including (i) training forestry-sector groups and cooperatives in management accounting and planning; (ii) coordinating workshops on the production and marketing of value-added timber products; (iii) guiding groups and cooperatives through the process for obtaining Forest Stewardship Council certification and monitoring management practices of certified community forests; and (iv) developing and applying strategies for the commercialization of value-added products; and (v) providing start-up funding to establish small businesses linked to reforestation initiatives with the Honduras National Forestry Program. With regard to goal 7, the federal, provincial, and territorial governments recognize the importance of sustainable forest management for maintaining and enhancing the long-term health of forest ecosystems and the genetic resources found within these ecosystems. It is recognized that sustainable forest management provides environmental, economic, social, and cultural opportunities for both present and future generations. Specifically, genetic resources when used in a sustainable manner contribute to economic diversification and income generation and can assist with poverty alleviation in rural economies through farm forestry, fuelwood management, non-timber forest products, and commercial forestry.

Support for Local Development in Agroforestry in Nippes Project in Haiti
($6.15 million from 2005–2011, 25% of which is classified as forestry development)
The focus of this project was to help improve rural living conditions by promoting agroforestry models that will enhance the management of natural resources and assist with agricultural marketing (Canadian International Development Agency 2011c).

Forest and Environment Sector Program in Cameroon
($10.0 million from 2007–2011)
This program's goal was to assist in the sustainable management of forest and wildlife resources in Cameroon, focusing on balancing the ability to generate long-term revenue with sustainable development of these resources. The funds were targeted to provide technical assistance and training required for the implementation of this program's five components: (1) environmental management of forestry activities; (2) management of production forests and adding value to forest products; (3) conservation of biodiversity and adding value to wildlife resources; (4) community-based management of forest and wildlife resources; and (5) institution building, training, and research (Canadian International Development Agency 2011b).

Environmental Governance and Sustainable Livelihoods Program
($19.6 million from 2008–2015)
The goal of this program is to reduce rural poverty in Sulawesi by protecting and creating livelihoods based on the sustainable management of renewable natural resources and the environment (Canadian International Development Agency 2011a). This program links policy makers and regulators within the government with the multiple resource users, many of whom are small in scale and function on a subsistence or marginal level. The project has other functions, including assisting aid agencies and implementation agencies to increase their knowledge of the motivations and constraints faced by resource users and to engage them. Furthermore, the project facilitates participatory development and implementation of natural resource management solutions by stakeholders at the community and watershed levels and assists the Government of Indonesia through its National Development Planning Agency in adapting structures and processes for improved environmental and natural resource governance.

Forest without Borders
(2011 – to be determined)
This is a new project that has been initiated in Haiti with support of Canadian Institute of Forestry and Foreign Affairs and International Trade Canada. Working with local communities, this project will develop plans for regional reforestation and environmental stabilization. The focus will be on forest conservation and restoration of their forest genetic resources to assist in building and sustaining local economies (Canadian Institute of Forestry 2011).

Note, FAO Annex Table 22 is not relevant for Canada.

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