Sustainable Management in the Boreal Forest: A Real Response to Environmental Challenges

Québec

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Table of Contents

Introduction 1

Part 1 – The boreal forest in Québec 3

Part 2 – Sustainable forest management 6

2.1 Worldwide origin of the concept 6

2.2 A long-standing concern in Québec 6

Part 3 – Sustainable management of the boreal forest: the present-day challenge 9

3.1 Conservation of biological diversity 9
3.1.1 Protected areas 10
3.1.2 Threatened or vulnerable species 13
3.1.3 Old-growth forests and intact forests 16
3.1.4 Dead wood 17
3.1.5 Diversification of silviculture 18
3.1.6 Spatial distribution of cutting areas 19

3.2 Maintenance and improvement of the condition and productivity of forest ecosystems 21
3.2.1 Insects and disease 21
3.2.2 Forest fires 21

3.3 Conservation of soil and water resources 22
3.3.1 Rutting in harvested areas 22
3.3.2 Loss of productive forest area 23
3.3.3 Roadbed erosion and watercourse sedimentation 23
3.3.4 Increase in peak flows 24

3.4 Multi-purpose forest development for the benefit of society 25
3.4.1 Harmonization of forest uses 25
3.4.2 Visual quality of forest landscapes 25
3.4.3 Native communities in the boreal forest 26
3.4.4 Forest certification 26

Part 4 – A model under development 29

4.1 Better forestry practices 29
4.1.1 Ecosystemic management 29
4.1.2 New regulation respecting sustainable forest management 30
4.1.3 Management by objectives and results 31

4.2 Better use of forest resources 31
4.2.1 New wood products 31
4.2.2 Non-timber forest products 32

4.3 Knowledge acquisition 32
4.3.1 Forest inventories 33
4.3.2 Other types of inventories 34
4.3.3 Forestry research 34

Conclusion 37

Bibliography 39

Glossary 45

List of Tables

Table 1 Area of vegetation zones and sub-zones in Québec and relative area of the managed continuous boreal forest 5

Table 2 CCFM criteria for sustainable forest management included in the Forest Act 6

Table 3 Categories of protected areas defined by the International Union for Conservation of Nature 10

Table 4 Examples of protected areas of various sizes and legal designations in Québec 12

List of Figures

Figure 1 Vegetation zones and sub-zones in Québec 4

Figure 2 Protected areas in Québec 11

Figure 3 Forest management units subject to the spatial distribution of cutting areas 20

Figure 4 Rutting following regeneration cuts in public forests 23

Figure 5 Loss of productive area associated with the road network in the public forest 23

Figure 6 Indicator of compliance with standards by sectors verified 24

Figure 7 Indicator of compliance with standards by protection objectives 24

Figure 8 Territory covered by the Agreement Concerning a New Relationship between the Gouvernement du Québec and the Crees of Québec, to which an adapted forest regime applies 27

List of Boxes

The economic importance of Québec's forests 2

The Northern limit for timber allocations 4

Exceptional forest ecosystems 13

Woodland caribou 15

Long-term maintenance of forest productivity 35

Acid precipitation 35

Climate change 36

Carbon sinks 36

List of Abbreviations and Acronyms

CCFM	Canadian Council of Forest Ministers
CMO	Block cutting
CPRS	Cutting with protection of regeneration and soils
FMA	Forest management agreement
FMC	Forest management contract
FMU	Forest management unit
GDP	Gross domestic product
GFMP	General forest management plan
IRLRDP	Integrated regional land and resource development plan
MDDEP	Ministère du Développement durable, de l'Environnement et des Parcs
Mha	Million hectares
MRNF	Ministère des Ressources naturelles et de la Faune
PDO	Protection and development objective
RESEF	Réseau d'étude et de surveillance des écosystèmes forestiers
RSFM	Regulation respecting standards of forest management for forests in the domain of the State
SOPFEU	Société de protection des forêts contre le feu
TSFMA	Timber supply and forest management agreement

Introduction

The population of Québec is increasingly aware of the boreal forest. Some people see it primarily as a vast reservoir of harvestable timber, able to support the economy and viability of outlying regions, while others see it as the setting for a wide range of outdoor activities (hunting, fishing, cottage building, tourism, etc.). It is also considered one of the last great intact forests that can still be protected, and as a gigantic carbon sink, able to trap a portion of the carbon emissions driving climate change worldwide.

The management approach taken by the Ministère des Ressources naturelles et de la Faune (MNRF) with regard to the boreal forest is based on the responsible use of biological resources. The approach, known as *sustainable development*, has received widespread support around the world since the publication of the Brundtland Report, which highlighted the importance in all forms of resource use, of considering the clear link between the viability of planetary ecosystems and human survival (Wold Commission on Environment and Development, 1987).

Viability is a term that applies not only to environmental resources, but also to the people who make a living from those resources. Seen from this standpoint, the links between boreal forest management and Québec's population are clear. In Québec, over 250 municipalities are economically dependent on a strong forest industry. The forest sector includes not only logging and forestry, but also processing (wood products and pulp and paper products). In 2005, businesses in the forest sector supported 83,500 direct jobs and created forest products valued at $23.7 billion, contributing an added value of $8.4 billion to Québec's economy (Ministère des Ressources naturelles et de la Faune, 2007a), in other words 4% of GDP (see box on p. 2). In addition, the economic benefits generated by other forest uses, such as tourism, recreation, hunting, fishing and the harvesting of non-timber products, are not included in this figure. If Québec is to derive sustainable socio-economic value from the boreal forest, it must ensure that it remains a renewable resource.

The objective of maintaining the viability of the boreal forest goes beyond the question of timber harvesting. In addition to the harvesting of other resources, such as wildlife and non-timber products, the forest is used for many recreational activities. Furthermore, the Québec portion of the boreal forest is part of a major world ecosystem that helps regulate key ecological cycles, such as the water, carbon and nitrogen cycles. Québec must therefore take its share of the responsibility for maintaining a planetary balance when it sets conservation objectives within its own borders.

In short, for Québec society, managing the forest sustainably means taking advantage of the resources it contains without exhausting them. Starting from this principle, the MRNF, in its approach to managing the boreal forest, targets a balance between two fundamental objectives: protecting the forest environment, and helping to develop its resources for the benefit of society. In keeping with this approach, the MRNF permits a range of uses while continuing to consider the boreal forest as a major source of timber. It also recognizes that the Québec population is proud of its forest heritage and wants to take full advantage of all the benefits it offers.

To respond to the concerns of the Québec population and to provide a concrete illustration of Québec's achievements in the area of sustainable boreal forest management, the MRNF has produced this document describing current actions and the progress that must be made if the boreal forest is to be managed in a truly sustainable fashion.

The economic importance of Québec's forests

Following the passage of Bill 71 in 2005, the allowable annual cut was reduced by 20% for softwoods and 5% for hardwoods, as recommended by the Commission d'étude sur la gestion de la forêt publique québécoise (2004). The total allowable cut in public forests was set at 35 million cubic metres of wood (Ministère des Ressources naturelles et de la Faune, 2007a). The total volume, 69% of which was softwoods and 31% hardwoods, was allocated to 230 companies holding timber supply and forest management agreements or forest management agreements, and 89 companies holding forest management contracts. In 2005, these agreement and contract holders harvested 30 million cubic metres of timber in the public forests, or around 80% of the allowable annual cut. The harvest affected 3,212 km² of forest land, or around 1% of the productive public forest area in Québec.

In 2005, companies in the forest sector provided almost 83,500 direct jobs, in the forest or in mills. The total value of forest product shipments, in other words the total value of all goods manufactured by the timber and pulp and paper industries, was $23.7 billion. The importance of the forest sector is demonstrated by the fact that it generated an added value of $8.4 billion in 2005 for the Québec economy. Added value is the difference between the final value of a product on the market and the cost of the intermediate products required for its production, in other words the amount paid in wages (jobs) and capital (profits) to manufacture the product. The forest sector's contribution accounted for 4% of Québec's GDP (gross domestic product) in 2005; GDP is the total of all the added value generated by all activities in Québec's economy. The forest sector has a positive balance of trade; in other words, exports in this sector exceed imports. This trade surplus was $9.2 billion in 2006, thanks to exports of $11.1 billion. Forest products accounted for 15% of the value of all Québec's exports, making a major contribution to the province's overall balance of trade.

Source: Statistics Canada (2007a and 2007b)

Part 1 – The boreal forest in Québec

The boreal forest is a belt of coniferous forest stretching across Eurasia and North America and located to the south of the Arctic tundra. It is one of the most extensive vegetation zones in the world, covering 15 million km^2, or just over 10% of the world's land surface. The climate is especially suitable for coniferous species, with long, cold winters and short, cool summers. The flora in this biome is relatively restricted, with only ten tree species for an entire continent (including spruces, fir, pines, larch, birches and poplars). Most boreal species of flora are generalist, robust species that are able to support severe, recurrent disturbances such as forest fires and insect epidemics. Despite its uniform appearance across the continent, the boreal forest includes a wide range of forest types at the local level, depending on the climate, topography and soil conditions, and the effects of natural disturbances.

In Québec, the boreal zone is easily the largest of all the vegetation zones (Pothier, 2001), covering an area of around 1 million km^2, or 70% of Québec's territory (Figure 1 and Table 1). It forms a belt over 1,000 km wide between the 48th and 58th parallels, in other words between the Northern Temperate zone in the south, with its deciduous and mixed forest stands, and the Arctic zone in the north, where no trees grow. The boundary between the temperate forest and the boreal forest, and between the boreal forest and the Arctic tundra, is determined by a climatic gradient featuring warmer, more humid conditions in the south (1 °C annual average temperature and 1,000 mm rainfall at the southern limit) and colder, drier conditions in the north (-7.5 °C annual average temperature and 500 mm rainfall at the northern limit). The boundaries between the zones depend on climatic variations, and also on changes to the aspect and specific composition of the forest cover in response to various natural disturbance patterns. Locally, the boundaries

are influenced by the physiographic features of the terrain (relief and altitude). The boreal vegetation zone is divided into three sub-zones: from south to north, the continuous boreal forest (closed forest), taiga (open forest) and forest tundra (Saucier et al., 1998).

The continuous boreal forest is made up of relatively dense stands, with forest cover of 40% to 80% in mature forests. This closed forest is where commercial logging takes place. The sub-zone is divided into two bioclimatic domains: the balsam fir-white birch forest in the south, and the black spruce-moss forest in the north. The balsam fir-white birch domain covers roughly 139,000 km^2, with balsam fir as the main species. In this domain, the main natural disturbance factor is the spruce budworm, with periodic outbreaks that affect all fir stands in eastern North America. The spruce-moss domain is the largest bioclimatic domain in Québec, covering an area of 412,000 km^2, with black spruce as the main tree species. Forest fires are the most important natural disturbance factor.

Last, the taiga covers an area of 300,000 km^2. black spruce-lichen stands are the characteristic vegetation in this zone, with low-density stands of black spruce and lichens as the main ground-level species. The forest tundra is a broad strip covering 217,000 km^2 where stands of trees alternate with open ground. This sub-zone marks the transition from

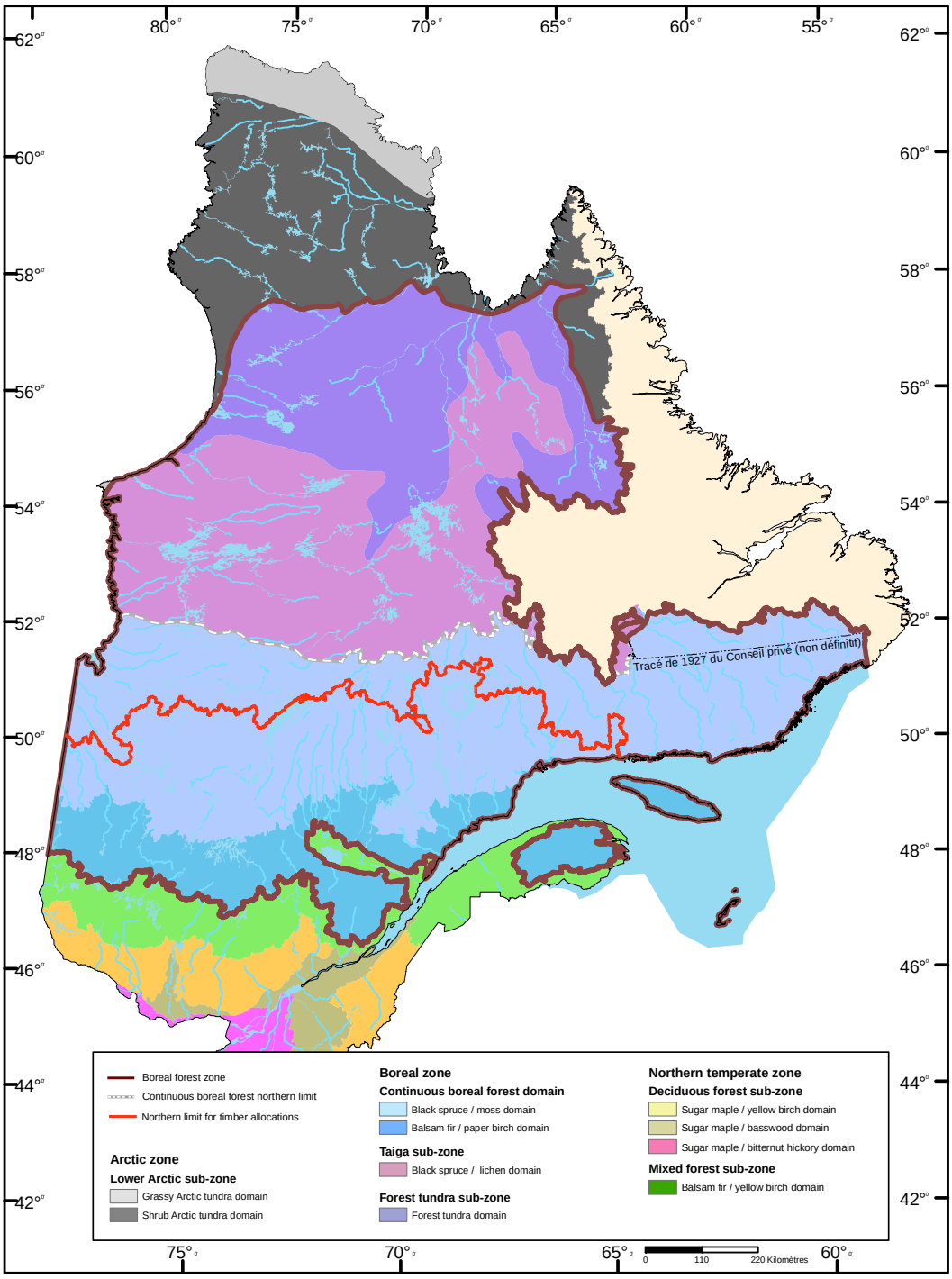

Figure 1 Vegetation zones and sub-zones in Québec

The northern limit for timber allocations

The northern limit for timber allocations divides the continuous boreal forest sub-zone into two parts. Its goal is to protect the northern black spruce stands, where growth conditions are more difficult and where the risks associated with current harvesting methods are greater. The limit is based on an analysis of management constraints, tree growth and biodiversity maintenance (Ministère des Ressources naturelles, 2000).

the boreal forest to the Arctic tundra, with the tree line marking its northern boundary.

In the immense boreal zone, logging is only carried out in so-called *managed* forests, in other words forests where commercial timber volumes may be allocated. This type of forest is generally more productive and more suitable for management because of its milder climate, better soil quality and denser stands. The area of *managed* boreal forest covers 317,000 km^2, or 57% of the continuous boreal forest (Table 1).

Table 1 Area of vegetation zones and sub-zones in Québec and relative area of the managed continuous boreal forest

Vegetation zone or sub-zone	Area (km^2)	% of Québec land mass	% of continuous boreal forest sub-zone
Québec land mass (continental)	1 514 100	**100**	
Arctic zone	236 000	16	
Boreal zone:	1 068 400	70	
• Forest tundra sub-zone	217 100	*14*	
• Taiga sub-zone	299 900	*20*	
• Continuous boreal forest sub-zone:	551 400	*36*	**100**
- Northern (unmanaged)	234 400	(15)	43
- Managed	317 000	(21)	57
Northern temperate zone:	209 700	14	
• Mixed forest sub-zone	98 600	*7*	
• Deciduous forest sub-zone	111 100	*7*	

Part 2 – Sustainable forest management

2.1 Worldwide origin of the concept

The Québec government's commitment to sustainable forest management results from a series of international, national and provincial events. At the international level, the Brundtland Report by the World Commission on Environment and Development (1987), which established the basis for the concept of sustainable development, introduced a new approach to development and the use of renewable resources. The second key international event was the Earth Summit held in Rio de Janeiro in 1992, which saw the launch of several major programs to fight climate change, along with programs to protect biodiversity and eliminate dangerous toxic products (United Nations Organization, 1993).

Following the Rio summit, Canada organized an international seminar of experts on the sustainable development of boreal and temperate forests. The Seminar was held in Montreal in 1993, and focused on criteria and indicators for sustainable forest development (Montreal Process, 2003). The work begun in Montreal was continued in greater depth by the Canadian Council of Forest Ministers (CCFM), leading to the definition of criteria and indicators for sustainable forest management in Canada (Canadian Council of Forest Ministers, 1997) and the production of two national reports on sustainable forest management in 2000 and 2005 (Canadian Council of Forest Ministers, 2006). Québec participated in these activities. Since then, sustainable forest management in Québec has been based on six internationally-recognized criteria (Table 2).

Table 2 CCFM criteria for sustainable forest management included in the Forest Act

1. Preservation of biological diversity
2. Maintenance and improvement of the condition and productivity of forest ecosystems
3. Conservation of soil and water resources
4. Maintenance of the function of forest ecosystems as a component of global ecological cycles
5. Maintenance of the multiple socioeconomic benefits society derives from forests
6. Proper consideration, in the selection of forms of development, for the values and needs expressed by the populations concerned

2.2 A long-standing concern in Québec

At the provincial level, clear management rules were introduced to support the ongoing viability of the forests as early as 1987, when the Forest Act was passed and Québec's new forest regime was implemented. Various measures were introduced, such as a requirement to establish and comply with an allowable annual cut based on the principle of sustained yields (logging must reflect the productive capacity of the ecosystem concerned) and to bring all logged areas back into production. The following year saw the adoption of the Regulation respecting standards of forest management for forests in the domain of the State, which also changed forestry practices.

In 1994, Québec released its *Forest Protection Strategy*, based on the natural regeneration of harvested areas (Ministère des Ressources naturelles, 1994). This innovation led to changes in harvesting practices and the introduction of *cutting with protection of regeneration and soil* as the main regeneration cut used in the softwood boreal forest. The new method was designed to protect natural regeneration and ensure that the forest cover was re-established quickly in harvested areas without replanting. The *Forest Protection Strategy* also banned chemical pesticides as a means of controlling competing vegetation and insects. These innovative measures represented a major step forward in the maintenance of biodiversity in Québec's forests.

In 1996, the implementation of sustainable forest management practices continued when the Regulation was substantially revised. Forestry activities were more strictly supervised to minimize impacts on the environment, lakes, rivers, wildlife and landscapes. The preamble to the Forest Act was amended to include the six criteria for sustainable forest development established by the CCFM. The purpose of the Forest Act was stated as being "to foster recognition of the forest as a common heritage and promote sustainable forest development in order to meet the economic, environmental and social needs of present and future generations". At the same time, the MRNF established a program to monitor various indicators for sustainable forest management, known as the INDI project. The indicators, based on those defined by the CCFM, monitored the progress made in sustainable management and allowed an assessment of Québec's forest regime (Ministère des Ressources naturelles et de la Faune, 2007b). The basis for sustainable forest management was firmly established.

In 2001, when the forest regime was revised, the government undertook to introduce block cutting to ensure a better spatial distribution of logged areas within the forest and to respond to the concerns of the population and forest area managers. Further amendments were made to the Regulation to allow the gradual implementation of the new cutting method, which was fully implemented by April 2003.

The 2001 revision of the forest regime gave the Minister the power to classify certain forest areas as *exceptional forest ecosystems* and to protect them from all forestry activities. The Forest Act also allows the Government to modify the *northern limit for timber allocations*, the line beyond which all forest operations aimed at supplying mills are prohibited (Ministère des Ressources naturelles, 2000*)*. Since 2001, the northern limit has protected a large part (roughly 43%) of the continuous boreal forest from logging.

Other amendments to the Forest Act gave the Minister of Natural Resources and Wildlife the power to assign *forest resource protection and development objectives* to each *forest management unit* (section 35.6). The objectives are considered to be new contractual and legal obligations and respond to various forest issues, mostly environmental and social concerns raised by the scientific community or the Québec population.

In 2003, the MRNF released its Consultation Policy on Orientations for the Management and Development of the Forest Environment (Ministère des Ressources naturelles, 2003). The policy created an opportunity for members and representatives of the general public, organizations and user groups to influence forest management approaches by making the Minister aware of their values and needs before the latter established guidelines and objectives. The Minister then had the task of reconciling, as far as possible, the various expectations expressed by the population, while targeting the general interests of all Quebecers.

To give concrete form to its consultation commitments, the MRNF launched a widespread process in 2003 to consult the general population and user groups on its protection and development objectives (Ministère des Ressources naturelles, de la Faune et des Parcs, 2003a; Ministère des Ressources naturelles, de la Faune et des Parcs, 2004). The MRNF then defined 11 objectives that will be integrated the into general forest management plans throughout Québec in 2008 (Ministère des Ressources naturelles, de la Faune et des Parcs, 2005).

Lastly, in late 2003, the Québec Government instructed the *Commission d'étude sur la gestion de la forêt publique québécoise* (commission to examine the management of Québec's public forests, also known as the Coulombe Commission) to look at ways of improving Québec's forest regime and the management of public forests by drawing inspiration from the concept of sustainable forest management. The Coulombe Commission examined various aspects of the question, including the economic, environmental, social and regional dimensions of forest management, regeneration, ongoing forest viability and biodiversity, and the protection and development of the forest environment and its resources. The Commission ended its work in December 2004

and made various recommendations to the Government to improve forest management in Québec (Commission d'étude sur la gestion de la forêt publique québécoise, 2004).

The work of the Coulombe Commission is seen today as a crucial step in the process that led the Québec Government to launch an in-depth review of Québec's forest regime. In recent years, various legislative measures (Bills 71, 94 and 39) have provided the framework for the review.

Since 2005, the MRNF has responded to the recommendations made by the Commission concerning the allowable annual cut, the appointment of a *Chief Forester*, the gradual implementation of an ecosystemic management approach, the introduction of a new *sustainable forest management regulation* and the creation of *regional boards*. New measures will also provide legal recognition for small protected areas known as *biological refuges* and permit the Minister to require *sustainable forest management certification*.

Québec's forest sector, in short, has shown that it can build on its achievements from the past, but is also facing the future with confidence. The actions taken to implement sustainable forest management during the current period (from the work of the Coulombe Commission to 2013) will clearly be of key importance for the future.

Part 3 – Sustainable management of the boreal forest: the present-day challenge

The MRNF recognizes that the sustainable management of the boreal forest raises a large number of environmental, economic and social issues. The MRNF must contribute, for the benefit of society, to the development of forest resources while protecting the forest environment, and can use various regulatory and standards-based tools for that purpose.

To guide its actions in the area of sustainable forest management, the MRNF has drawn inspiration from the six criteria proposed by the Canadian Council of Forest Ministers (Table 2). In this section, the current challenges facing the MRNF in connection with the sustainable management of the boreal forest have been grouped under four main headings:
1) the conservation of biological diversity;
2) the maintenance and improvement of the condition and productivity of forest ecosystems;
3) the conservation of soil and water resources;
4) multi-purpose forest development for the benefit of society.

The actions presented in this section are characteristic of the current period of review of Québec's forest regime (approximately from 2005 to 2013).

3.1 Conservation of biological diversity

The conservation of biological diversity in the forest environment has been a major concern worldwide for several decades. Scientists and environmental protection organizations have shown that an increase in human activities around the world has created a threat to the biological diversity of species, populations and ecosystems (World Commission on Environment and Development, 1987; United Nations Organization, 1993).

In Québec, only a small amount of data is available to show that the forests in the boreal zone are truly under threat. Only a handful of forest species in the zone are currently considered to be threatened or vulnerable in their natural habitat, and the few that are at risk are covered by protection measures under the applicable laws and regulations (Gouvernement du Québec, 1996; Cimon et al., 2005). Nevertheless, some stakeholders have recently expressed concerns about the ecosystems and wild populations that could be affected, over the long term, by ongoing habitat fragmentation, silvicultural methods and climate change.

One of Québec's main commitments to biodiversity consists in its support for the principles and objectives of the *National Forest Strategy* (Canadian Council of Forest Ministers, 1992) and the international convention signed in Rio de Janeiro (Ministère de l'Environnement et de la Faune, 1996a). Through the *Québec Biodiversity Action Plan* (Ministère de l'Environnement et de la Faune, 1996b) and the report on the state of biodiversity in the forest environment (Ministère des Ressources naturelles, 1996), the MRNF has undertaken to improve its knowledge of biological diversity in the forest by completing an inventory, conducting research and environmental monitoring, and focusing on the maintenance of biodiversity in its management of forests in Québec.

The strategy for sustainable forest management combines the creation of a network of protected areas with the introduction of forestry practices that help preserve the natural characteristics and ecological functions of the forest. This approach is currently being implemented as part of the *Québec Strategy on Protected Areas* (Gouvernement du Québec, 2002a) and through actions to protect threatened or vulnerable species, old-growth forests and wildlife habitats, diversify silvicultural practices, and improve the spatial distribution of harvesting areas.

3.1.1 Protected areas

As defined in Québec's Natural Heritage Conservation Act, a *protected area* is "a geographically defined expanse of land or water established under a legal and administrative framework designed specifically to ensure the protection and maintenance of biological diversity and of related natural and cultural resources" (Gouvernement du Québec, 2008, article 2). Industrial activities (forestry, mining and energy production) are prohibited in a protected area.

Protected areas provide evidence to help understand how ecosystems function, to measure the long-term impact of human activities on the environment, and to design changes to land and natural resource management methods. Combined with other measures, the creation of protected areas helps provide a concrete, immediate solution for the preservation of biological diversity (threatened and vulnerable species, rare forests, old-growth forests, intact forests, etc.) and a response to public demands concerning land allocation (education, recreation, tourisms, local economy diversification, etc.).

In recent years, Québec has devoted extensive resources to the development of its network of protected areas, which it considers to be an essential driving force behind sustainable forest management. In the boreal forest, and in other vegetation zones, the MRNF has worked with the Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) and key socio-economic stakeholders to develop a high-quality network of protected areas that fully represents biological diversity in Québec.

In the early 2000s, protected areas accounted for only 1% of Québec's land mass. Since 2002, the *Québec Strategy on Protected Areas* has led to significant progress throughout Québec, and especially in the continuous boreal forest (Ministère du Développement durable, de l'Environnement et des Parcs, 2007). Around one hundred protected areas have been created in the boreal forest, multiplying the total area of the network by a factor of ten (from 4,000 to 40,000 km^2), bringing it today to about 7% of the continuous boreal forest sub-zone (Figure 2).

In addition, the protected areas created during this period are Category I, II and III protected areas as defined by the International Union for Conservation of Nature (1994); in other words the areas subject to the strictest protection measures (Table 3). This makes the continuous boreal forest one of the sub-zones with the most protected areas in Québec, both in terms of quantity (percentage of protected area) and quality (high level of protection and representativeness).

Table 3 Categories of protected areas defined by the International Union for Conservation of Nature

Category	Description	Example
I	Protected area managed mainly for science and nature protection, or for the protection of wild resources	Ecological reserve
II	Protected area managed mainly for ecosystem protection and recreation	National park
III	Protected area managed mainly for conservation of specific natural features	Biodiversity reserve
IV	Protected area managed mainly for conservation through management intervention	White-tailed deer yard
V	Protected area managed mainly for landscape/seascape conservation and recreation	Currently inexistent in Québec
VI	Protected area managed mainly for the sustainable use of natural ecosystems	Water fowl gathering area

For the Québec Government, the quality of the network of protected areas is as important as the total area covered. In terms of quality, Québec has set some of the most stringent objectives in the world, since it also focuses on the ecological representativeness of its network. Using an ecological reference framework, it is able to determine the representative nature of the network and any possible gaps. Currently, there are not enough protected areas in the boreal zone, especially in the taiga (Figure 1) but to a lesser extent in the continuous boreal forest as well, and several projects are currently under examination.

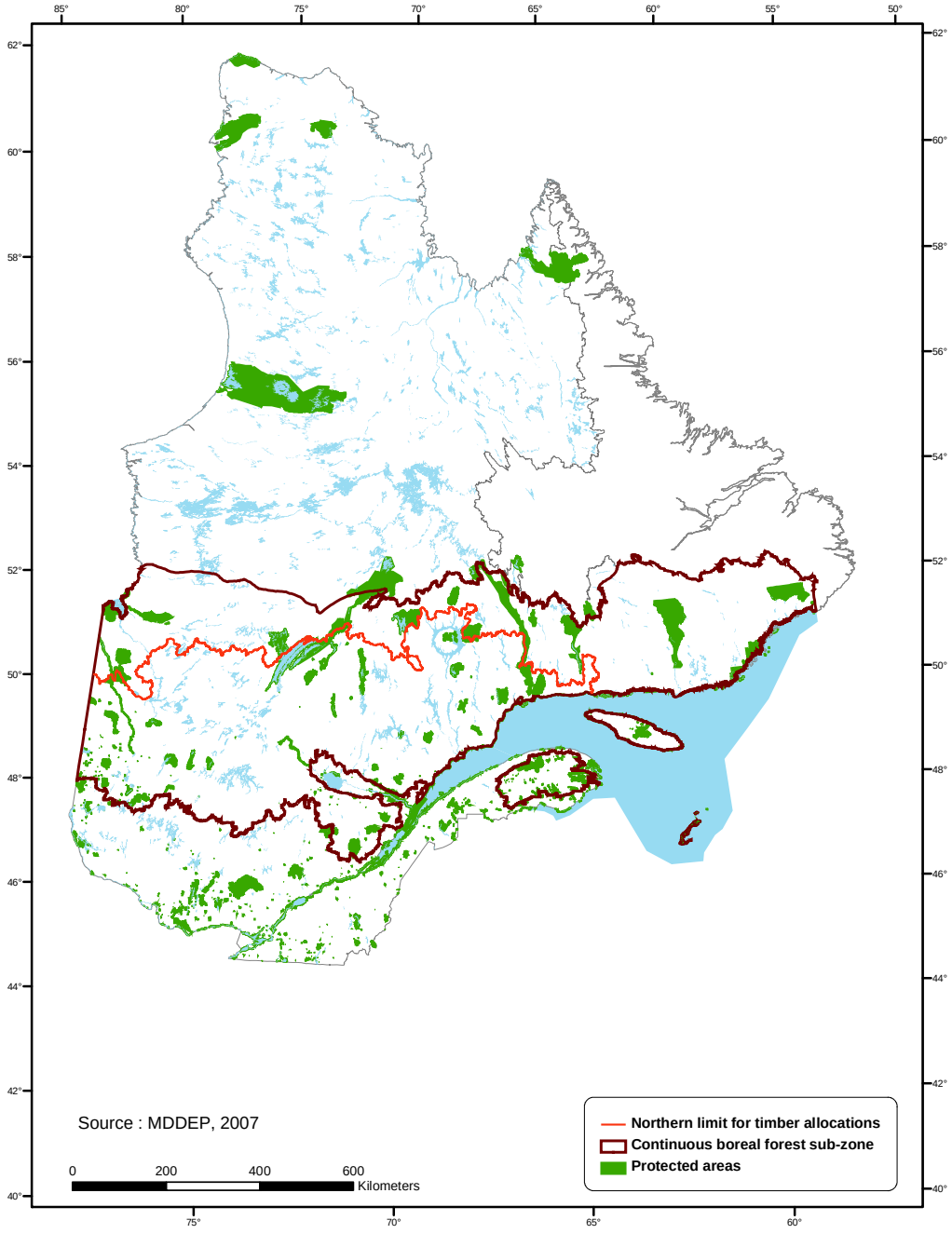

Figure 2 Protected areas in Québec

Worldwide, in 2007, protected areas covered around 12% of the terrestrial environment (including freshwater but not saltwater environments). The same year, in Québec, the comparable percentage was 5% (7% in the continuous boreal forest), and around 10% in Canada. The Québec Government recently reiterated its objective of classifying 8% of its territory as protected areas by the end of 2008.

Although the creation of large protected areas (100, 1,000 or 10,000 km^2) is a key element in its strategy, Québec also wants to ensure the creation, by the MRNF, of several thousand

small protected areas (1 to 10 km^2) in the productive forest portion of its territory (Table 4). Since 2002, Québec has been developing a network of exceptional forest ecosystems (see box, p. 13) of which over one-third (44 old-growth or rare forests, or refuges for threatened or vulnerable species of flora) is located in the boreal forest (Ministère des Ressources naturelles, 2001). In addition, the Government amended the Forest Act in 2007 (Bill 39) to provide for the establishment of a vast network of biological refuges (several thousand mature or overmature forests with an average area of 200 hectares). The refuges are protected from logging (Ministère des Ressources naturelles, de la Faune et des Parcs, 2005) and the Government intends to grant them sufficient protection for them to enter Québec's *register of protected areas* under the Natural Heritage Conservation Act. The refuges will help maintain an effective distribution of old-growth forests throughout Québec and create a level of connectedness between large protected areas. Along with the network of exceptional forest ecosystems, the biological refuges will provide protection for specific habitats and help increase the diversity and overall quality of the network of protected areas.

Table 4 Examples of protected areas of various sizes and legal designations in Québec

Designation of the protected area	Region	Area (km^2)
Projet de parc national Albanel-Témiscamie-Otish (proposed national park)	Nord-du-Québec	11 000
Réserve aquatique de la rivière Moisie (aquatic reserve)	Côte-Nord	3 900
Réserve de biodiversité des marais du lac Parent (biodiversity reserve)	Abitibi-Témiscamingue	400
Parc national d'Aiguebelle (national park)	Abitibi-Témiscamingue	270
Aire de confinement du cerf de Virginie Kiamika–Lac-du-Cerf (white-tailed deer yard)	Laurentides	110
Réserve écologique de la Pointe-Heath (ecological reserve)	Côte-Nord	20
Forêt ancienne du Lac-des-Neiges (old-growth forest)	Capitale-Nationale	2

Exceptional forest ecosystems

Since 2002, the MRNF has developed a network of small conservation areas featuring various types of exceptional forest ecosystems, as defined by the Forest Act (Ministère des Ressources naturelles, 2001). The exceptional nature of each forest site is defined by its specific attributes, which distinguish it from the surrounding stands. An exceptional forest ecosystem can be an *old-growth forest* (an old forest having suffered little disturbance), a *rare forest*, or a forest habitat providing a *refuge* for a threatened or vulnerable species. These sites in the public forest, placed under the responsibility of the MRNF, are specially targeted because of their high ecological value and their remarkable contribution to the preservation of ecosystem diversity.

The MRNF has worked hard since 1996 to gather more knowledge about the specific nature and location of exceptional forest ecosystems in Québec. Today, it has analyzed over 175 sites in the boreal forest and extended legal protection to 44 sites. Together, these exceptional forest ecosystems cover 140 km^2, an area that is in addition to 38 other exceptional forests protected under various types of protected area status (national park, ecological reserve, etc.). Lastly, 66 forest stands have been protected from all forestry work until legal conservation measures have been defined. Québec has clearly demonstrated its intention to grant effective protection to a sufficient number of exceptional forest ecosystems of various types as and when they are discovered. Over time, the network could protect up to a hundred exceptional forest ecosystems in the boreal forest.

Already, the work completed in the boreal forest has led to the discovery and protection of several remarkable old-growth stands, home, for example, to 600-year-old eastern white cedars with a diameter of 130 cm on the Gaspé Peninsula, 35-metre-high white spruce in Northern Québec, and 300-year-old black spruce on the North Shore. Ecosystems that occur rarely in the boreal forest have also been protected, including several white pine stands on the Gaspé Peninsula, red pine and American elm stands on the North Shore, cedar stands in Northern Québec and red ash stands in Abitibi-Témiscamingue. Four of the refuge forests with protection status are located in Eastern Québec; they contain key populations of two extremely rare ferns, northern holly fern and American alpine lady fern, as well as several species of orchids whose situation is precarious.

3.1.2 Threatened or vulnerable species[1]

Québec has around 1,800 native species of vascular plants and 650 species of vertebrates. Almost 20% of all plant and animal species are considered to be threatened or vulnerable within the meaning of the Act respecting threatened or vulnerable species – in other words 375 plant species and 85 animal species, sub-species or populations (Gouvernement du Québec, 2007). The threat most commonly blamed for the precarious situation of all these species is a change to or loss of their habitat. The boreal forest contains fewer threatened or vulnerable species of plant or wildlife than the southern portion of the province (132 plant species, 22 animal species). However, some of these species have attracted interest from outside Québec (for example, some endemic plants in the Gulf of St. Lawrence or on the Gaspé Peninsula, and the woodland caribou population).

1. The expression *threatened or vulnerable species* encompasses legally designated species and those likely to be so designated according to the MDDEP (Labrecque and Lavoie, 2002).

Threatened or vulnerable plant species are found in Québec in several hundred different known sites, with major concentrations in the alpine and subalpine zones of the Chic-Choc Mountains, around Percé, on the Magdalen Islands, on Anticosti Island, in the Mingan archipelago, around Blanc-Sablon, in Lac Mistassini and around James Bay (the Bell, Eastmain, Harricana and Nottaway rivers). Most of these threatened or vulnerable plant species are not associated with forested land as such, but are found on open land, river banks and rocky or sandy outcrops. Over one-third of the species, including the largest known populations, are found within Québec's network of protected areas, especially in the Gaspésie national park and the Mingan Archipelago National Park Reserve of Canada, where they enjoy a level of protection. On the other hand, several other species are found in areas where logging takes place.

Of the vertebrate species found in the boreal forest, 22 are considered to be threatened or vulnerable. Seven species have been legally designated: the wolverine, bald eagle, golden eagle, peregrine falcon, Barrow's goldeneye and woodland caribou.

François Bourgeot http://go.to/naturephoto

Forest operations may affect the habitats of some of these species, especially the bald eagle, woodland caribou and Barrow's goldeneye. Other species are less affected by operations because of the specific environment they favour, like the golden eagle and yellow rail. Unfortunately, knowledge about several of these species remains fragmentary; their habitat needs are not well known, nor are the negative or positive effects of forestry activities.

To deal with the risks that forest management may create in some cases, the MRNF has recently made protection for the habitats of threatened or vulnerable species in public forests one of its protection and development objectives (Cimon et al., 2005). This new requirement strengthens the protection provided since 1996 under an administrative agreement between the MRNF and the MDDEP to improve protection for known habitats (Gouvernement du Québec, 1996). Under the agreement, foresters are advised of the presence of a confirmed population of a threatened or vulnerable species, or of the most appropriate protection measures (for example, a ban on cutting trees in certain sectors or at certain times of the year), and are required to include the measures in their general forest management plans. For some species with a large home range, such as the caribou (see box, p. 15), protecting the habitat of known populations involves the creation of a specific management plan that is included in the general forest management plan and reviewed every five years (Courtois et al., 2003).

To assess the protection measures required and ensure that essential knowledge is transmitted to the foresters concerned, the MRNF produces situation reports and, working with the MDDEP or outside specialists, draws up recovery plans for certain threatened or vulnerable species. In addition, given the immense size of the boreal forest and the fact that not all habitats are known, the MRNF and MDDEP have prepared handbooks for the recognition of the forest habitats of threatened or vulnerable plant species to facilitate the identification of new populations and protect them during forest operations (Petitclerc et al., 2007).

Woodland caribou

Pierre Pouliot

The woodland caribou population (*mountain* ecotype*)* on the Gaspé Peninsula is the only remaining population south of the St. Lawrence. Because of its precarious situation, the MRNF began to take action to assist in its recovery in 1990. In 1999, a management plan for the caribou range was adopted for public land around the Gaspésie national park (Turcotte et al., 2007), defining the forest management activities that help maintain a high-quality habitat for the caribou and improve its survival rate. In 2001, the Québec Government demonstrated its commitment to the survival of the Gaspésie caribou by designating both the population and its habitat as *vulnerable* under the Act respecting threatened or vulnerable species. Since then, control of predators has had a clear effect on the survival rate of fawns and, as a result, on the condition of the population as a whole.

In recent years, the woodland caribou forest ecotype has also been a focus of concern. More specifically, a protection and development objective has been defined to protect the habitats of various threatened or vulnerable species, including the woodland caribou forest ecotype, beginning in 2008 (Cimon et al., 2005). Several special forest management plans have been drawn up by the MRNF (forest and wildlife sectors), in partnership with the forest industry and guided by an advisory committee established in 2003, and known as *Comité du plan de rétablissement de l'espèce*. These regional plans will be implemented gradually, beginning in 2008, in the regions of the boreal forest falling into the spruce-moss bioclimatic domain (Abitibi, Nord-du-Québec, Saguenay–Lac-Saint-Jean, Côte-Nord). Further south, in the balsam fir-white birch domain, special plans already target some isolated populations such as those in the Charlevoix (Lafleur et al., 2006) and Val d'Or (Chamberland et al., 1999) areas.

The approach proposed for the woodland caribou forest ecotype is part of a management strategy based on a better understanding of ecosystems, known as *ecosystemic management*. A central pillar in this chosen strategy is the conservation of large blocks of mature forest stands, protected from logging for a period of 20 to 60 years. In the areas around these large protected blocks, extensive sectors will be managed in a way that recreates a suitable habitat for caribou as quickly as possible (Courtois et al., 2003). In addition to this work to protect the woodland caribou forest ecotype, strict conservation measures for the species will be applied, for example within the Québec network of protected areas. Currently, 11 protected areas in Québec make a significant contribution to the conservation of habitat for the woodland caribou forest ecotype.

In plans to manage the habitat of the woodland caribou forest ecotype, drawn up under a sustainable development approach, various social values and needs must be taken into account in addition to the need to protect caribou habitat. The next few years will be crucial for saving the woodland caribou forest ecotype and maintaining its habitat, namely extensive unfragmented tracts of black spruce-moss stands, part of Québec's outstanding ecological heritage. On the basis of current knowledge, ecosystemic management is one of the best ways of achieving this.

3.1.3 Old-growth forests and intact forests

Old-growth forests and intact forests have, over the last twenty years, become a focus of attention around the world because of the essential role they play in the survival of numerous animal and plant species. Because of their specific attributes, namely coarse woody debris, large snags, trees with wildlife value and multi-story vegetation structure, old-growth forests offer unique habitats.

It is clear that this type of forest is becoming increasingly rare worldwide (Bryant et al., 1997). Human use of timber has generally led to a transformation of the forest environment, fragmenting intact forests and rejuvenating old-growth forests. Québec is no exception to this trend. According to recent data, large areas of the boreal forest remain untouched, but in the managed portion of the territory, untouched forests are decreasing rapidly (Lee et al., 2006; Stanojevic et al., 2006; Valéria et al., 2007). It has become clear that a balance must be struck between the desire to use the forest environment resource for economic and social development, and the need to maintain a significant proportion of old-growth forests and intact forests as part of the forest landscape (Hunter, 1999).

The Québec Government is particularly aware of the need to protect these forests for present and future generations, and has responded to the insistent demands of scientists and the general population. Starting in the late 1990s, it introduced new tools (for data gathering, planning and control) to ensure the preservation of wilderness areas and tracts of old-growth forest, just as new areas of the boreal forest began to be developed for logging and the extraction of other natural resources. These tools include:

- the identification, since 1996, of the most outstanding old-growth forests and their protection, since 2002, as exceptional forest ecosystems under the Forest Act;
- the 2002 review of the northern limit on timber allocations, leading to the preservation of large areas of intact boreal forest;
- increased efforts, since 2002, to develop a network of protected areas in all of Québec's natural regions, beginning in the continuous boreal forest sub-zone.

In introducing these measures, Québec has chosen to preserve its northern forests and to ensure permanent protection for the more southerly areas of the boreal forest as protected areas.

These choices also mean that a large part of the productive forest environment remains available today for sustainable forest management. The situation creates new challenges for foresters, and this is why the Québec Government has decided to implement actions to ensure the maintenance of mature and overmature forests in the areas under forest management. For example, the MRNF requires that mature and overmature forests be maintained at all times within each forest management unit (FMU). The protection and development objectives that will be implemented under general forest management plans beginning in 2008 will offer a complementary way of preserving old-growth forests. The measures introduced include:

- a protection and development objective to ensure the maintenance of mature and overmature stands in Québec's forest landscape, in particular through the creation of a network of *biological refuges* (Leblanc et Déry, 2005) and extended rotation patches (Déry et Leblanc, 2005a), and the application of *adapted silvicultural practices* (Déry et

Leblanc, 2005b) to maintain the attributes of old forests;

- a strategy for the *spatial distribution of forestry operations* (Jetté, 2007) adapted to the ecology of the boreal forest and management plans for woodland caribou habitat (Courtois et al., 2003), two elements that help maintain old forest stands.

Implementation of the strategy to maintain old-growth forests will stretch over several years, and will no doubt be modified over time to respond to other sustainable development requirements.

3.1.4 Dead wood

Many animal and plant species depend on the presence of dead wood, whether in the form of snags or coarse woody debris, to complete their life cycles. The fundamental role played by dead wood in soil fertility and the carbon cycle also supports the objective of maintaining dead wood in managed forests. By setting a protection and development objective to protect dead wood, the MRNF intends to ensure its ongoing presence in the managed forests (Déry and Labbé, 2006). The MRNF has defined various measures that forest managers must include in their general forest management plans, for riparian buffer zones, cutting areas and, eventually, forests areas affected by natural disturbances.

In riparian buffer zones, forest managers will be required to protect 20% of forested areas from all logging, indefinitely. In cutting areas, the objective will be to leave intact groups of living trees in at least 5% of areas where cutting with protection of regeneration and soils is applied.

The living trees left standing will ensure the presence of dead wood over the medium and long term. In addition, in all cutting areas, forest managers will be required to leave all snags and trees without commercial value standing, as long as they do not compromise worker safety. Last, in zones where dead trees are logged after a natural disturbance, windstorm or insect infestation, forest managers will have to leave a minimum number of dead trees standing to ensure the maintenance of the plant and animal species that depend on them for their survival.

3.1.5 Diversification of silviculture

Most harvesting operations in the boreal forest have, until now, been clearcuts (such as cutting with protection of regeneration and soils), in which mature trees are cut to release seedlings and young trees, which can then develop to form a new stand. The new forest resulting from the cut is generally made up of trees of the same age (even-aged stands). However, studies in recent years have shown that this type of cut is not suitable for all types of stand. For example, in the eastern boreal zone, the lengthening of the fire cycle means that more stands reach and exceed maturity. In this type of forest, young trees develop thanks to small openings created in the canopy by the death of one tree, or a small group of trees. Over time, these coniferous forests develop an irregular internal structure both vertically and horizontally.

To respond to the new challenges of the boreal forest, such as a trend toward uniform internal stand structures, changes in forest composition and a lack of dead wood, new cutting methods have been tested. The MRNF assists in their development and has instructed forest managers in how to apply them. For example, cutting with *protection of small merchantable stems* and *cutting with protection of regeneration and soil protection and retention of clusters*, which can be grouped under the general heading of *retention cuts,* are increasingly applied in the boreal forest. These types of cut target several objectives:

- the conservation, within the cutting area, of more *biological legacies*, in other words attributes such as dead and dying trees, which provide a habitat for a number of living organisms;
- the maintenance of uneven stand structures (vertical stratification of vegetation);
- dead wood recruitment over the medium and long term.

In some types of retention cuts, the trees left standing also ensure the creation of a closed forest canopy in less time than *cutting with protection of regeneration and soils*.

Jacques Duval

Retention cut

In addition, new types of partial cuts that ensure the maintenance of a forest canopy over time have been developed to meet the following goals:

- maintenance of the internal stand structure;
- multiple forest use (for example, the preservation of landscapes around sites suitable for cottage development);
- maintenance of the attributes of large tracts of closed forest.

Selection cutting in the boreal forest, as well as *shelterwood cutting,* are other examples of cuts that maintain the forest canopy.

These new types of cut preserve natural variation and unevenness in stands and the landscape.

3.1.6 Spatial distribution of cutting areas

Harvesting activities in the boreal forest change the composition and structure of the forest landscape immediately after the cut, and for the entire life of the resulting stands. The new spatial patterns created in the forest ecosystem may be less natural, in other words different from the landscapes generally resulting from natural disturbances alone. However, the spatial organization of ecosystems influences the population dynamics of species, the quality of their habitat and the maintenance of the ecological functions of the boreal forest. This means that spatial organization is a key factor in biodiversity maintenance. Similarly, the new spatial arrangement defines the kind of forest available for other uses (Aboriginals, cottage dwellers, hunters, fishers, tourists, etc.) and affects (positively or negatively) the quality of their activities. The social acceptability of the model chosen is also an important element to take into consideration.

In 2003, to deal with these concerns, the MRNF began to define and apply a new spatial distribution model for harvesting to a significant portion of the continuous boreal forest (Jetté, 2007), as part of a new ecosystemic management approach. To meet the requirements of biodiversity, forest managers will have to create a managed landscape that resembles the landscape resulting from natural disturbances. This basic principle relies on the assumption that all the species present in the boreal forest have adapted to the disturbances they have encountered in the past. The maintenance of a forest landscape with natural features is the best guarantee against biodiversity loss.

An analysis of the natural landscapes formed by boreal spruce stands, as well as an examination of the forest fire dynamics that shape them, have led the MRNF to propose a global management strategy for the black spruce-moss forest. It basically involves dispersing cutting areas throughout the landscape while maintaining a certain quantity of tracts of closed forest at all times. The two elements are indissociable. In addition, to reproduce the effects of the natural disturbances to which spruce stands are subjected, forest managers will have to adapt their management practices to the length of the fire cycle in the natural region. The result should be to maintain vast tracts of closed forest over longer periods of time.

The new approach is complementary to the *block cutting* prescribed by the Regulation respecting standards of forest management for forests in the domain of the State. It is important to note that under section 25.3 of the Forest Act, the Minister may permit a departure from the standards for forest management prescribed by the regulation if it is shown that proposed substitute measures offer equivalent or superior protection for forest resources and the forest environment. In the early 2000s, concerns were raised about the suitability of block cutting for maintaining large tracts of continuous forest in the boreal forest zone. The progression of cuts, combined with ongoing forest fires, gradually pushed the existence of large tracts northwards, to the point where they began to disappear. The uniform dispersal of cuts introduced by block cutting quickly led to fragmentation, leaving a multitude of small stands but no continuous forest. Because of this, there was a clear need to design a new approach allowing the concentration of cutting areas while ensuring the maintenance of a certain quantity of forest tracts.

Since 2003, departures from the Regulation's standards have been approved by the Minister in several areas. Soon, most forest management units in the black spruce zone, except the area covered by the *Agreement Concerning a New Relationship Between the Gouvernement du Québec and the Crees of Québec*, will be covered by this new approach to cut distribution (Figure 3). The change will allow for the introduction of key elements of an ecosystemic approach over vast areas of the boreal forest.

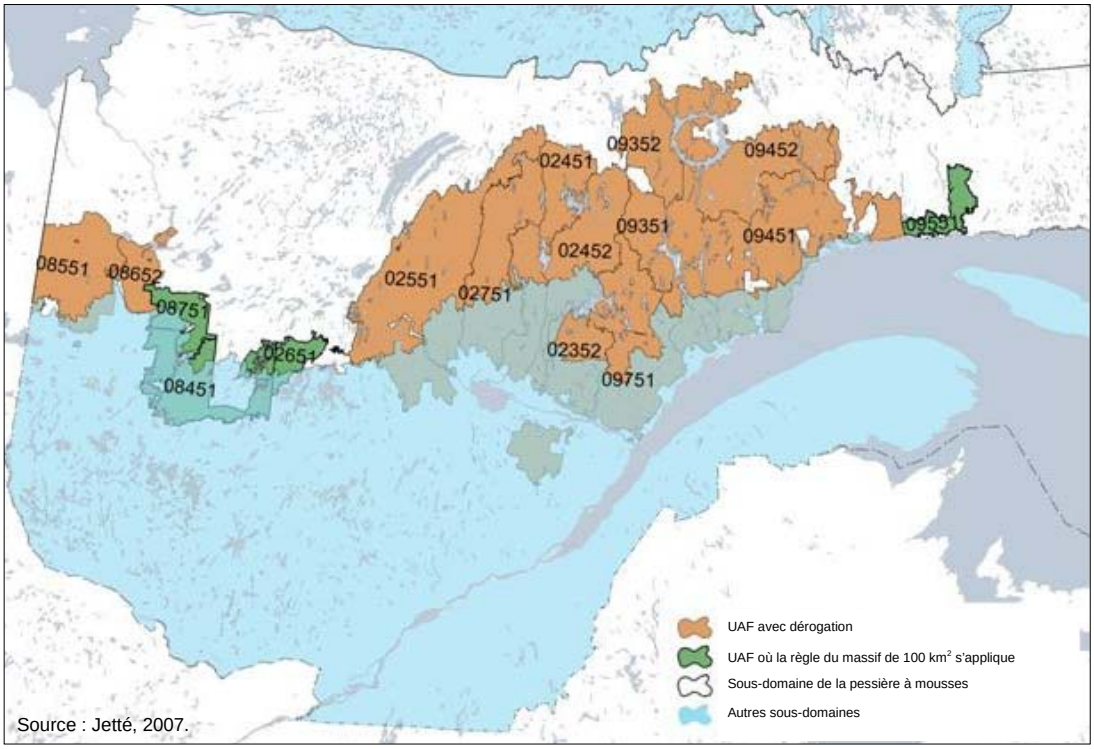

Figure 3 Forest management units subject to the spatial distribution of cutting areas

3.2 Maintenance and improvement of the condition and productivity of forest ecosystems

Maintaining and improving the condition and productivity of forest ecosystems mainly involves preserving soil fertility and the health of the vegetative cover, ensuring the integrity of the fragile links between ecosystems, and minimizing the damaging influence of humans and natural agents.

Natural ecosystems have an inherent capacity to recover from the natural disturbances to which they have been exposed over time. Some types of forest even depend on disturbances to regenerate and maintain productivity over the long term. On the other hand, managed forests, whose composition and structure have been modified by human intervention, are less resistant to disturbance. To maintain the condition and productivity of a managed forest, it is sometimes necessary to carry out further management operations to reduce their vulnerability to various disturbances of human or natural origin (insects and disease, fire, windthrow, acid rain and climate change).

To meet this challenge, Québec has developed expertise in forest protection over several decades, as well as a degree of mastery over direct and indirect methods to combat insets, disease and fires in the boreal forest. This is currently its main focus, even though it is also involved in research into the functioning of ecosystems and environmental monitoring.

3.2.1 Insects and disease

The basis for the *Forest Protection Strategy* (Ministère des Ressources naturelles, 1994) is knowledge of the physical environment and vegetation, and the influence of insects and disease on the health of the forest. It emphasizes prevention of the negative effects of natural disturbances as one of the goals of management strategies, for example by harvesting the most vulnerable stands first. Silvicultural methods to increase stand resistance or reduce vulnerability are also part of the preventive approach (for example, the thinning of managed stands to promote species with greater resistance to insect attacks).

In addition, the MRNF may use mitigation measures, such as the spraying of biological insecticides (which has been the responsibility of the *Société de protection des forêts contre les insectes et maladies* (SOPFIM) since the early 1990s), and the salvaging of damaged timber. Such measures are considered only if damage cannot be prevented by the preventive management of vulnerable stands, and are used as a last resort. In such cases, active monitoring of the main agents of disturbance and monitoring of forest health are the two key elements of the ministerial strategy, and allow for appropriate action to be taken in a timely manner.

3.2.2 Forest fires

In Québec's boreal forest, protection against forest fires is intensive in public managed forests, large and small private forests, and some forest reserves and conservation areas. The MRNF policy in these forests is to put out all fires, whether caused by human actions or lightning. Fire protection in the intensive protection zone falls under the responsibility of the Société de protection des forêts contre le feu (SOPFEU). To the north of the timber allocation limit, and to the east of the black spruce-moss zone, forest fires are not fought to protect timber, but only to protect people and the infrastructures necessary for public security. In other words, they are mostly left to burn. To pursue its mission in the intensive protection zone, the SOPFEU has set operational

Antoine Nappi

objectives for detection, intervention, control and extinction. To assist the SOPFEU in its mission, the Government may also use targeted advertising campaigns to reduce man-made fires, and preventive measures such as a ban on open-air fires, the halting of forestry operations and a ban on travelling through the forest. Since 1995, the MRNF has worked with the SOPFEU to map forest combustibles, providing a tool for use in managing firefighting operations and assessing fire behaviour.

Forest fire management includes a component to enable timber to be salvaged and burned areas to be brought back into production. As knowledge is gathered, the activities are carried out in accordance with the criteria of sustainable forest management. The MRNF supports various projects to improve forestry practices (time limit for salvage, salvage methods that promote regeneration and protect biodiversity, methods taking other resources than timber into account, etc.).

Like other provinces and countries, Québec has begun to review its forest fire policy. Various issues connected with biodiversity maintenance and ecosystem productivity in zones where fire is excluded, consideration for fire in management strategies and calculation of the allowable annual cut, the increasing cost of firefighting programs and awareness of their limitations, especially in certain parts of the boreal forest subject to timber allocations, are just some of the factors that will influence the fire management policy in coming years.

3.3 Conservation of soil and water resources

Soil and water conservation is one of the environmental criteria for sustainable forest development that has received the most attention from the MRNF over the last decade. Already, many of the provisions of the Regulation deal with soil and water conservation, and various measures for the monitoring and protection of soils in the forest have been established since the *Forest Protection Strategy* was first tabled (Ministère des Ressources naturelles, 1994).

Forest management activities alter the physical, chemical and biological properties of the forest soil, and affect lakes and streams. Since they can affect soil fertility and certain ecological functions, the MRNF has required forest managers to increase the protection they provide for soil and water in the forest environment by introducing new protection and development objectives (Ministère des Ressources naturelles, de la Faune et des Parcs, 2005). These protection and development objectives address problems such as rutting, the loss of productive forest area, roadbed erosion, and increased peak flows in streams and rivers.

3.3.1 Rutting in harvested areas

Ruts of varying depths are sometimes left by heavy machinery on wet ground or ground with a low load-bearing capacity. According to current knowledge, rutting has a negative effect on forest soil productivity over the long term. Rutting increases soil compaction, damages roots, alters drainage patterns, increases the risk of erosion and creates pools of water, and therefore leads to the loss of productive forest area.

Since 1998, the MRNF has monitored the disturbances caused by rutting in harvested areas in the boreal forest, and has developed an indicator to assess the degree of rutting (Figure 4). Using the indicator, the disturbance observed is classified into one of three intensity categories. The indicator is also used to provide a periodic status report and an assessment of the performance of each forest company. It has already led, in managed forest areas, to ongoing improvements in forestry practices.

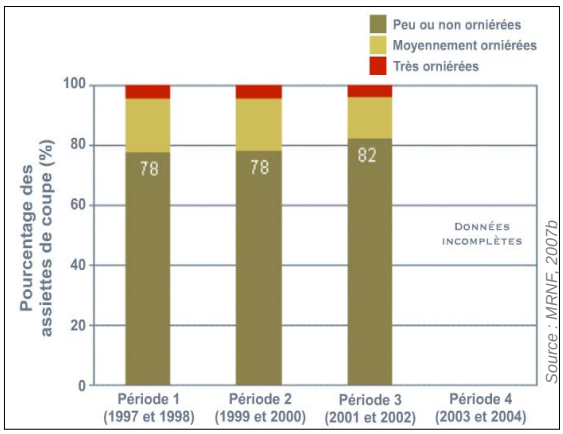

Figure 4 Rutting following regeneration cuts in public forests

Recently, the MRNF notified forest managers that it expected to see no extensively-rutted zones in harvested areas, and required 90% of harvested areas to exhibit little or no rutting (Schreiber et al., 2006). To meet this target, the MRNF has adopted a progressive approach, based on a timetable adapted to each forest management unit and the specific ecological conditions of the site.

3.3.2 Loss of productive forest area

Loss of productive forest area occur when part of a given zone become unsuitable for tree growth. Forest roads and unproductive roadside zones (mainly lopping and piling areas) are the main disturbances that lead to loss of productive forest area. The land affected is considered to be unproductive because no trees can become established or grow quickly enough to reach a merchantable diameter during a stand rotation.

Since 2002, the MRNF has made a regular assessment of the amount of forest land that has become unproductive following harvesting operations in public forests. It has developed an indicator to quantify land losses and trends over time (Figure 5). More recently, forest managers have been instructed by the Minister to introduce measures aimed at minimizing losses of productive forest area. Acceptable levels of loss have been defined, based on the biophysical and operational characteristics of each managed unit (Schreiber et al., 2006). In addition, since December 2006, the Forest Act has permitted some forest roads to be closed and the land to be brought back into production.

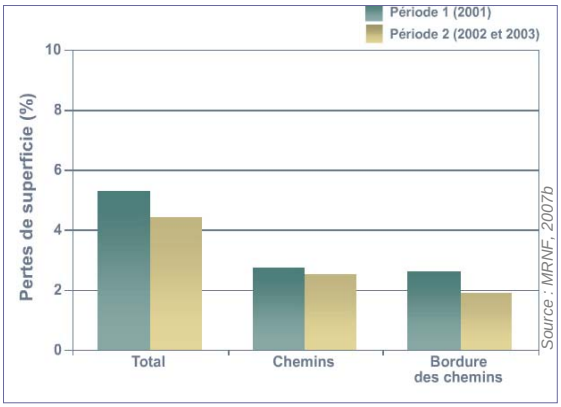

Figure 5 Loss of productive area associated with the road network in the public forest

3.3.3 Roadbed erosion and watercourse sedimentation

Roadbed erosion can increase the amount of sediment in streams and rivers. Fine sediments can, among other things, block spawning grounds and block access by fish to the invertebrates on which they feed. Increased sedimentation reduces water depth and can prevent fish movements; it also has a negative impact on the reproductive cycle of the brook trout and Atlantic salmon, two species with high social and economic value.

The Regulation already contains road construction standards designed to reduce the risk of erosion and the sedimentation of watercourses. It requires a strip of vegetation to be left along streams and around lakes, in which heavy machinery cannot operate. In addition to stabilizing the bank, the vegetation filters particles washed down from roadbeds and cutting areas. Despite the standards, however, various problems remain, especially at points where roads cross streams.

The MRNF has introduced an additional measure to preserve water quality. Since 2002, on an experimental basis, the MRNF has located and assessed areas of erosion along forest roads in the year following harvesting operations that have increased sedimentation in streams and lakes. Beginning in 2008, forest managers will have to apply suitable measures to eliminate this type of erosion, and correct erosion detected during MRNF monitoring operations (Schreiber et al., 2006). To monitor the improvement in industry practices, the MRNF has developed an indicator for compliance with existing standards (Figure 6 and Figure 7).

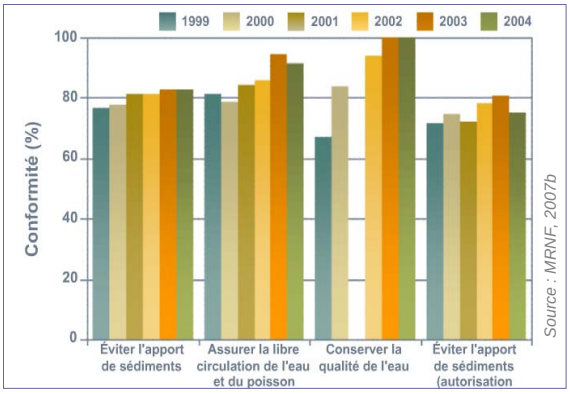

Figure 6 Indicator of compliance with standards by sector verified

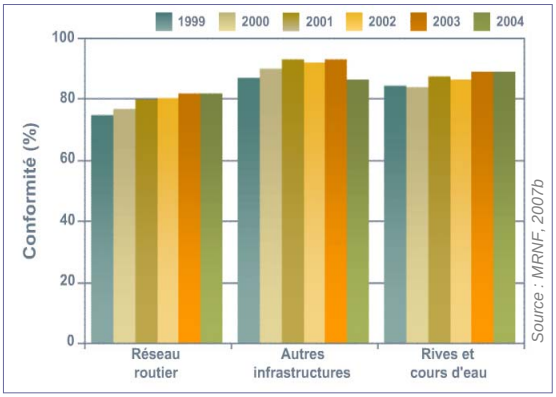

Figure 7 Indicator of compliance with standards by protection objective

3.3.4 Increase in peak flows

Peak flow is defined as the maximum flow of water in a watercourse following a storm, heavy rain or snowmelt. Harvesting operations can lead to an abnormal increase in peak flows, causing erosion and sedimentation, which can both degrade water quality and fish habitats. However, according to specialists, the situation is highly localized and has no significant effect on watercourses throughout Québec.

Nevertheless, given the social and economic importance of Atlantic salmon and landlocked salmon and their precarious situation, the MRNF has chosen to avoid any increase in peak flow caused by harvesting operations in the drainage basins of recognized salmon rivers that are equal to or exceed an area of 100 km^2. The MRNF has also instructed forest managers that, from now on, the treeless area of each drainage basin must be maintained at 50% or

less (following harvesting, fire, insect attack or windthrow) (Schreiber et al., 2006).

3.4 Multi-purpose forest development for the benefit of society

Environmental protection in the boreal forest targets the preservation of its intrinsic qualities, but the development of the boreal forest involves a transformation of those intrinsic values into values that are recognized by society. A managed forest, maintained in a good functional state, will be more likely to be productive, diversified, dynamic and able to demonstrate the expected social and economic values.

The many different values (commercial, cultural, aesthetic, etc.) that society ascribes to the boreal forest are reflected in the many different ways in which the forest is used. Harmonizing the uses is not an easy task, since the harvesting of forest resources can conflict with activities that require an unbroken forest canopy. For this reason, Québec's Forest Act includes various provisions that require forest managers to consider the needs of other users of a forest management unit.

3.4.1 Harmonization of forest uses

Section 54 of the Forest Act gives forest users a legal framework for making their needs known to forest managers during the preparation of the general forest management plan. Planning operations in a way that ensures the ongoing visual quality of the landscape, or agreeing on the placement of a forest road, are two examples of the needs that may be expressed by regional county municipalities, Aboriginal band councils and wildlife managers, among others. The forest managers responsible for preparing the general forest management plan can also ask other individuals and organizations to make their needs known.

The harmonization measures agreed on by users and forest managers are recorded in a written agreement that must be included in the general forest management plan, in accordance with the protection and development objective notified by the Minister (Pâquet and Deschênes, 2005). Users may also take advantage of the information and consultation period for general forest management plans (sections 58.1 and 58.2 of the Forest Act) to make agreements with forest managers. In the event of a dispute, the Minister may appoint a conciliator (section 58.3). The MRNF also checks annually to see whether forest managers have complied with the harmonization measures provided for in agreements signed with other forest users.

The harmonization of land uses in the forest environment is a major challenge for sustainable forest development, and work must continue to respond more effectively to the needs expressed by various forest users.

3.4.2 Visual quality of forest landscapes

The aesthetic value of the landscape for the general population cannot be ignored. Forest management activities may temporarily degrade visual landscape quality, with a negative impact for the recreation and tourism sector in particular. The MRNF has therefore set a protection and development objective to maintain visual landscape quality that complements the current standards set out in the Regulation concerning landscape protection. The general objective is to minimize the visual impact of harvested areas in certain sectors, such as areas where recreation or tourism facilities exist (Pâquet and Deschênes, 2005).

When a general forest management plan is being prepared, forest managers and other forest users must agree on the sectors of interest that must be considered, and their

relative importance. Next, they work together to determine visual landscape quality targets that must be met in the sectors concerned. Other protection and development objectives may also help meet the need to maintain visual landscape quality. These include objectives relating to the retention of mature and overmature stands, the spatial distribution of cuts and the reduction of physical disturbance to the soil.

3.4.3 Aboriginal communities in the boreal forest

Québec's boreal forest is a living environment for several Aboriginal communities, mainly from the Cree, Innu, Atikamekw and Algonquin Nations. The forest plays an essential role in their cultural, social and economic development. As a result, their rights, values, needs and concerns about the management of the boreal forest must be taken into account as a fundamental element, indissociable from the goal of sustainable ecosystem management.

In Québec, the management of the boreal forest is partly governed by a unique, nation-to-nation agreement known as the *Agreement Concerning a New Relationship Between the Gouvernement du Québec and the Crees of Québec* (Gouvernement du Québec, 2002b). Among other things, it provides for the introduction of an adapted forest regime in an area of 66,000 km^2, located entirely within the managed area of the continuous boreal forest (Figure 8). This adapted forest regime takes traditional Cree lifestyles into account, incorporates sustainable development concerns, and provides for Cree participation, via a consultation process, in the various processes used to plan and manage forestry activities.

In addition, several provisions of the Forest Act and the departmental consultation process reflect the importance In Québec, the boreal forest is a source of economic development for Aboriginal communities. It provides volumes of timber for a growing number of communities under timber supply and forest management agreements, forest management agreements and forest management contracts. Access to timber supplies leads to partnerships with other forest and municipal stakeholders, and helps develop expertise and create jobs in Aboriginal communities, for example connected with timber harvesting and transportation, road construction and maintenance, silvicultural work and replanting. In addition to these economic activities, various projects for the development of resources in the forest environment have been launched under agreements signed with Aboriginal communities, as part of dedicated departmental programs for which major funding is provided each year.

3.4.4 Forest certification

Today, the forest industry must not only focus more on social values and government responsibilities in the way it manages the public forests, but must also respond to market forces increasingly influenced by environmental, social and cultural values.

In recent years, the MRNF has recognized that certification systems can help move forestry practices towards a sustainable forest management approach. Certification can support several of the objectives of the legislation governing forest management in Québec. It is therefore in the interests of the MRNF to work with companies seeking certification. The MRNF does not promote one standard in particular, but leaves companies free to choose a certification system, based on their own needs. However, it is involved in the definition of national standards, and helps create regional standards that apply to forests in Québec, such as those governing the Canadian boreal forest.

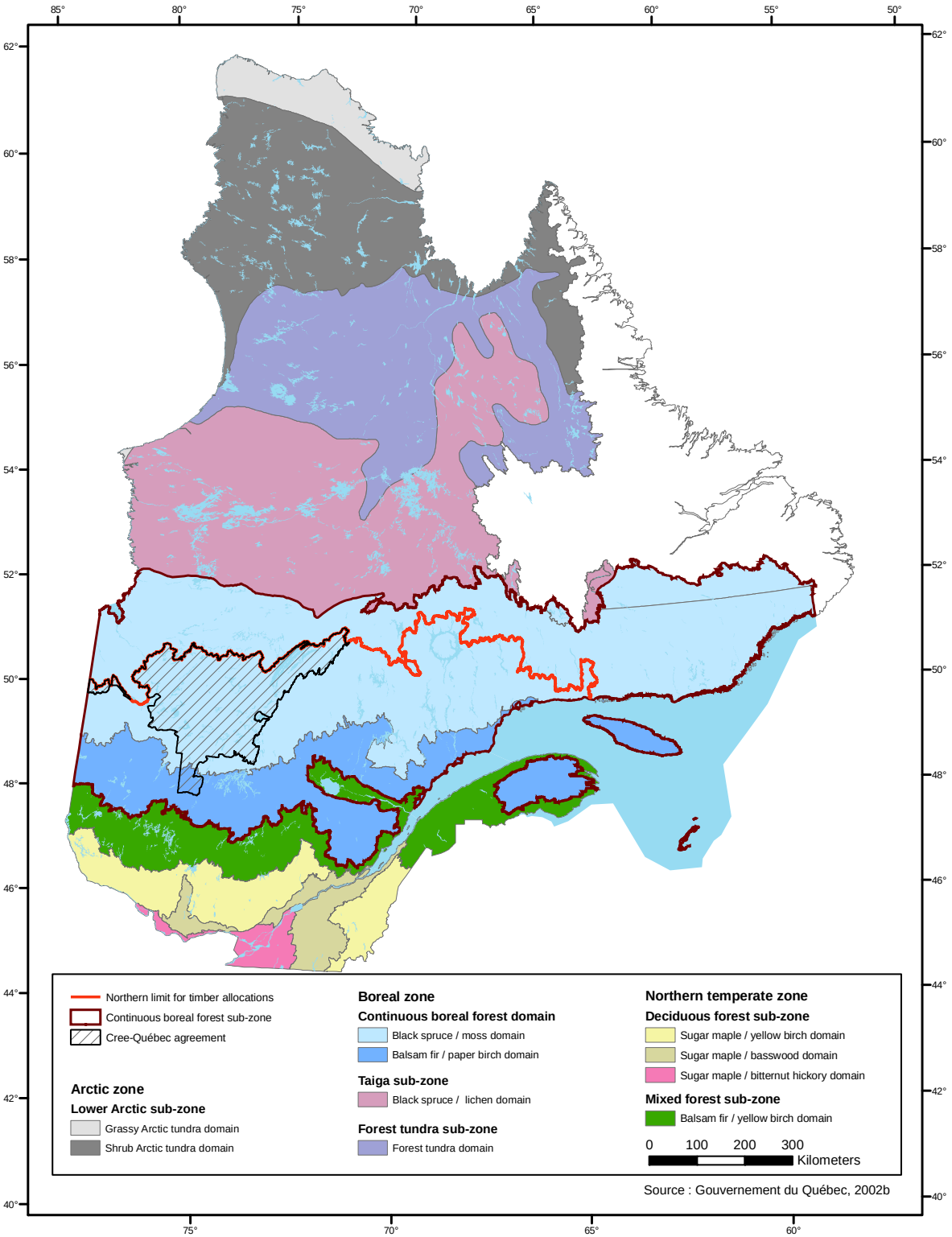

Figure 8 Territory covered by the Agreement Concerning a New Relationship between the Gouvernement du Québec and the Crees of Québec, to which an adapted forest regime applies

To date, several major forest companies have obtained certification in Québec, including Abitibi-Bowater, Domtar, Kruger, Louisiana Pacific, Norbord Industries and Tembec. In June 2007, the managed boreal forest in Québec included 0.2 million hectares (Mha) with SFI certification (Sustainable Forestry Initiative), 12.8 Mha with CSA Z809 certification (Canadian Standards Association), and 2.2 Mha with FSC certification (Forest Stewardship Council). In all, 15.2 Mha of forest land has been certified – in other words 55% of all managed boreal forest land in Québec. In addition, SFI certification has been obtained for 372,000 m^3 of timber supplies from non-certified forests (i.e. 3% of the timber allocations from those areas).

The MRNF has taken a proactive approach to forest certification, and plans to introduce the concept of ecoconditionality into public forest management, which will be binding on the entire forest sector. All forest companies wishing to work in Québec will have to show that their management of the forest environment is responsible and sustainable, in particular by obtaining certification.

Part 4 – A model under development

Sustainable forest management is a challenge for Québec's managers and planners, since it constantly requires them to reconcile all the different values (environmental, economic and social) associated with the forest and its resources. This task of reconciliation is only possible with the renewed collaboration of the various players involved in the forest management process. Ideally, a sustainable forest management model would be implemented gradually, and would be improved to reflect the positive or negative impacts of its forest management strategies and practices

One of the goals set by the MRNF, in its role as manager of Québec's public forest, is to improve forestry practices in the boreal forest. As the gains of the last 20 years have shown, improvements are being achieved. However, the process must continue and additional efforts are still required of forest managers.

In the spring of 2005, the MRNF carefully examined the recommendations made by the *Commission d'étude sur la gestion de la forêt publique québécoise* (2004) and introduced a number of measures designed to improve its management of the public forests in general, and the boreal forest in particular. For example, it significantly reduced softwood (20%) and hardwood (5%) allocations as a precautionary measure prior to a reassessment of the allowable annual cut.

At the same time, the Québec Government created the position of Chief Forester. The holder of this new position is responsible for preparing the *Forest Management Manual* (Ministère des Ressources naturelles, de la Faune et des Parcs, 2003b), identifying the forestry and ecological data required to calculate the allowable annual cut, performing the allowable annual cut calculations and publishing both the final decision and the underlying reasons. The Québec Government has also undertaken to regionalize and further decentralize the forest management process in Québec, among other things by setting up *regional land and natural resource boards* reporting to the *Regional Conferences of Elected Officials.* The boards will have a role to play in forest management by involving local and regional stakeholders in the preparation of integrated regional land and resource development plans (IRLRDPs).

Some of the measures the MRNF hopes to introduce in the coming years to continue to implement sustainable forest management beyond 2013 include an ecosystemic management approach and a new *regulation respecting sustainable forest management (*RRSFM), both of which were recommended by the Coulombe Commission. At the same time, the MRNF hopes to encourage diversification of forest products in order to stimulate economic activity in the forestry regions. This will be achieved through *integrated resource management* and the development of secondary and tertiary wood processing activities.

When implementing a sustainable development model, it is vital to have access to new knowledge generated through scientific research, in order to monitor the actions taken and assess their real benefits. The MRNF has understood this need and has been working actively over the last 30 years with several partners (including Natural Resources Canada, universities and colleges, the industry and others) to acquire new knowledge on the boreal forest through forest inventories and by carrying out or financing scientific research. The benefits of this new information are already being felt, and include the introduction of new forestry practices based on ecological approaches and tailored to specific environments and the fragile nature of the boreal forest.

4.1 Better forestry practices

4.1.1 Ecosystemic management

In 2005, the MRNF stated its intention to begin introducing an ecosystemic management approach. The Act respecting the Ministère des Ressources naturelles et de la Faune was amended to give the Minister the mission of ensuring that ecosystemic management becomes a core element of public forest

management in Québec. In 2006, after a series of consultations with Québec's scientific community, the MRNF adopted the following definition of ecosystemic management:

"Ecosystemic management consists in an ecological approach applied to forest management, with a view to maintaining the biodiversity and viability of all forest ecosystems while meeting socio-economic needs with due respect for the social values associated with the forest environment."

In the last two years, the MRNF has worked on the gradual implementation of an ecosystemic approach, with the ultimate goal of applying it to all GFMPs from 2013 onwards. The ministerial plan of action provides for three pilot projects in the Mauricie region (Triad), Abitibi (with Tembec) and the Laurentians wildlife sanctuary. These projects will help clarify the ecological, social and economic issues generated by ecosystemic management. At the same time, they will provide an opportunity to test a management process that will ultimately lead to the introduction of innovative management strategies and new methods better suited to the demands of sustainable forest management.

Alongside these projects, the MRNF and its partners have begun work to identify the principal ecological issues at both the provincial and regional level. The results of this process will fuel future discussions concerning the integrated regional land and natural resource plans. The portion of the task relating to the boreal forest has already begun, and will lead to the definition of management objectives and targets.

Lastly, a significant effort is being made to diversify silvicultural methods, and a new spatial distribution model for forestry work is currently being introduced for the boreal forest. These initiatives are also part of the gradual implementation of an ecosystemic approach.

4.1.2 New regulation respecting sustainable forest management

One of the recommendations made by the Coulombe Commission concerned the Regulation respecting standards of forest management (RSFM). The Commission recommended that the current regulation should be enhanced in order to incorporate the principles of sustainable forest management. The MRNF is currently working on the RSFM with the intention of converting it into a regulation respecting sustainable management of forests in the domain of the State (RRSFM).

As part of this task, the MRNF has set up working committees to identify the elements of sustainable forest management that need to be regulated. All components of sustainable development will be considered. The new regulation is being prepared in collaboration with the MRNF's forestry and wildlife sectors, and with the MDDEP. If necessary, other government departments will also be brought into the process. The new regulation will then be subjected to a transparent assessment process.

The aspects of sustainable management being considered are:

- riparian environments;
- wetlands;
- aquatic environments;
- wildlife habitats;
- spatial organization of forestry operations and residual forests;
- recreational and public utility uses, including landscapes;
- the specific management needs of structured wildlife territories;
- sites and sectors of interest to Aboriginal communities;
- non-timber forest products;
- logging and restoration of production;
- soil conservation and productivity.

The MRNF intends to prepare the new regulation in such a way that it fits in with preparation of the GFMPs, thereby ensuring that sustainable forest management issues and the new regulatory requirements can be applied to the early stages of the forest planning process. Management objectives and clear requirements concerning results will be included in the regulation, and will have to be considered at both the planning and operational stage. This approach is what is known as *management by objectives and results.*

4.1.3 Management by objectives and results

This particular management method is the main alternative solution to the standards-based approach used so far in Québec's forests. Management by objectives and results offers the advantage of focusing more on the results to be achieved than on the means used to achieve them (i.e. management techniques and methods), thereby allowing methods and tools to be adjusted to specific local and regional characteristics. Under this approach, planners and managers are responsible for selecting their own working techniques.

In using this approach, the MRNF is effectively giving planners the flexibility they need to meet the challenges of sustainable forest management.

4.2 Better use of forest resources

Many different resources are available from the forest, and a significant effort is currently being made to ensure that they are put to better use. Since 1995, to take advantages of the goods and services available in a given forest area and reduce under-utilisation of certain timber sources, emphasis has been placed on the development of secondary and tertiary processing activities. To do this, the forest industry has changed its structure as technologies have become available to process smaller logs, use formerly under-utilised species and salvage the by-products of sawmills (e.g. chips, sawdust, shavings and bark). Québec's mills are therefore able to process all available forms of timber into finished products such as lumber, pulp, paper, board, composite panels and electricity.

4.2.1 New wood products

Québec has become a leader in Canada in the secondary and tertiary wood processing sectors, increasing the number of jobs generated by the volumes of wood harvested. The raw material for these secondary and tertiary processing activities is lumber or composite boards, which are used to produce solid wood substitutes such as finger joints, floor joists, glulam beams, roof trusses, doors, windows, kitchen cabinets and other products. The reconstituted wood sector is able to use shorter cuts to produce items with higher structural specifications than solid wood. For example, floor joists made from shorter cuts have now replaced the traditional 2" x 12" products imported from Western Canada. These new structural products make full use of the good quality resources available in Québec, especially from the boreal forest, even though stem sizes are much smaller than those produced by market competitors.

Secondary and tertiary processing activities continue to develop in response to the needs expressed by the commercial, industrial, institutional and agricultural markets. Engineering and architectural services are required if the industry is to offer products suitable for use in concrete and steel buildings. In the case of the residential construction market, the current decline in available manpower will gradually lead to a more industrialized approach to the production of this type of building.

Research and development in the pulp and paper industry has revealed potential for new products such as technical and intelligent papers to be used for secure packaging, as well as new generations of boards, including flat boards with polymer membranes, and by-products including a range of chemical and energy-related products obtained from biorefining.

The boreal forest also offers a huge supply source that has not yet been exploited: forest biomass, which is composed of non-commercial timber such as branches, roots and silvicultural waste. Biomass is an excellent resource for energy production. Rising energy prices and

greenhouse gas reduction targets, achievable only by replacing fossil fuels, provide ample potential for development and profitability of this type of activity.

4.2.2 Non-timber forest products

The non-timber forest products industry offers excellent potential for economic development, especially in Québec's resource regions. The boreal forest contains a host of hitherto unexploited resources, many of which have not yet been fully investigated.

The United Nations Food and Agriculture Organization defines non-timber forest products as products of biological origin other than wood derived from forests, other wooded land and trees outside forests. (Langner, 1998). In other words, they are products of the forest that are not made of wood, pulp, paper or board, and that have a market value.

Non-timber forest products can be divided into four categories:

- Food products such as wild fruits and mushrooms;
- Ornamental products such as Christmas trees and wreaths;
- Pharmaceutical and nutraceutical products such as fir gum;
- Manufactured products and materials such as essential oils, resins, alcohols, etc.

The most common non-timber forest products available in the boreal forest include blueberries and softwood essential oils, which are sold in Québec and occasionally on export markets.

Other products are sold on a smaller scale but could be developed in the future. Examples would be edible forest mushrooms, fern shoots, and fruits such as Saskatoon berries and cloudberries, which are becoming increasingly popular in food markets and restaurant kitchens.

The same applies to certain medicinal plants such as the ericaceas and yew. Yew is used to produce paclitaxel (taxol), a cancer drug ingredient.

Many companies in Québec produce non-timber forest products from forest biomass, or are currently engaged in research with a view to doing so. For example, the food, forestry, pharmaceutical and cosmetics industries all use synthetic chemical products derived from the by-products of pulp and paper mills (e.g. turpentine, ethanol, resins and lignosulphates.

The economic importance of non-timber forest products in Québec is difficult to quantify. However, in 2005, blueberries generated total sales of $38 million, and essential oil exports were valued at $31,000, accounting for nearly 40% of Canada's total exports of these products (Ministère des Ressources naturelles et de la Faune, 2007a). New non-timber products are currently being developed in Québec, and some are being marketed on a small scale to pave the way for more extensive sales in the future.

4.3 Knowledge acquisition

Sustainable forest management means ensuring that renewable resource use is limited by the natural ecosystem's inherent capability to produce those resources at a sustained level. Implicit in this is the existence of ecological limitations within ecosystems, of which managers must be aware. Knowledge of ecosystem variability thresholds is therefore essential for successful sustainable forest management. Such knowledge is by no means intuitive; on the contrary, it is acquired through experience. It should therefore come as no surprise that scientific research is an important component of the MRNF's mission, and that a

great deal of time, money and energy has been invested over the decades in the acquisition of knowledge about the forests, especially in the boreal zone.

The MRNF oversees two major areas of forest ecosystem knowledge acquisition activities: (1) inventories and (2) scientific research.

4.3.1 Forest inventories

The MRNF carries out periodic forest inventories in the continuous boreal forest in order to gather information on timber volumes and the composition, development, growth and extent of the different forest types. Three forest inventory programs have been completed since 1970, based on a cycle of approximately ten years. A fourth inventory is currently underway.

The inventory of the managed boreal forest is based on data obtained from permanent and temporary sample plots and ecoforest maps to a scale of 1:20,000, produced from aerial photographs. The ecoforest maps show the boundaries and area of each stand, along with its dendrometric features, aspects of the physical environment (surface deposit, drainage, slope) and ecological types. The map is updated periodically from information presented in forest management reports and from satellite images used to locate and measure major natural disturbances. Sample plots are measured during each inventory cycle, to monitor the development and growth of the forest. In the boreal zone, data are available from approximately 5,700 permanent sample plots that have each been measured three times, at ten-yearly intervals. The volume of timber in the boreal forest under management is estimated from tens of thousands of temporary sample plots measured during each inventory cycle. In the case of the current inventory program, there are approximately 72,000 such plots. Data from the sample plots are linked to the stand areas shown on the ecoforest map in order to calculate the timber stocks available in each territorial unit.

Between 1986 and 2000, the MRNF also carried out an ecological inventory south of the 52nd parallel in order to investigate the relationship between physical environment and vegetation, and to document forest dynamics. The data collected from approximately 28,400 ecological observation points, including 15,380 in the boreal forest, were used to draw up an ecosystem typology that has been used in association with the forest inventory since the late 1990s, transforming it into a veritable *ecoforest* inventory.

The MRNF is currently working to establish station quality indicators based on stem analyses for the most common ecological types in the boreal forest. These studies of station productivity, used in conjunction with management limitations, will be the basic elements in silvicultural guides and will also serve to identify intensive timber production zones.

In the boreal forest, however, despite the inventories carried out over the last 40 years or so, the sheer size of the territory continues to present a considerable challenge for knowledge acquisition. Nevertheless, knowledge has accumulated quickly over the decades, and efforts have been intensified in recent years. For example, in 2006 the MRNF began a surveillance inventory on either side of the 52nd parallel with a view to building its knowledge of the northernmost portion of the continuous boreal forest. Stereoscopic mapping methods involving satellite images are used to map the physical environment and forests of this immense area. The data collected will fuel new studies of the boreal forest's growth and

renewal capacity in Northern areas. These studies will be used among other things to gather information on forest dynamics and growth, as well as on the regeneration problems associated with natural disturbances. The results of this inventory will be used by a multidisciplinary scientific committee between now and 2010, as a basis for revising the boundaries of the forest under management in the continuous boreal forest subzone.

The land ecological classification and the results of the MRNF's ecoforest inventories are used to guide the management of Québec's boreal forest, among other things by serving as a basis for the allowable annual cut calculation and growth modelling work. They are also used to define the criteria and indicators for sustainable forest management (Ministère des Ressources naturelles et de la Faune, 2007b), which are then used to report on the benefits and impacts of forest management, and to produce an annual statistical profile of forest resources (Ministère des Ressources naturelles et de la Faune, 2007a) as well as a five-yearly report on the state of the forest (Ministère des Ressources naturelles, 2002).

4.3.2 Other types of inventories

In addition to the ten-year inventories, the MRNF carries out a number of specialist inventories to guide its environmental, forest protection and new resource development activities. Since 1997, for example, it has carried out annual inventories of exceptional forest ecosystems (Villeneuve et al., 2001) and the habitats of threatened or vulnerable plant species (Petitclerc et al., 2003) for conservation purposes. The MRNF also maintains an inventory and network of forest fires, insect infestations and diseases (Ministère des Ressources naturelles et de la Faune, 2006), which serves as a guide for its interventions and protection initiatives. In addition, it finances and takes part in inventories of certain non-timber forest products (woodland mushrooms, yew, etc.). This work complements the large-scale wildlife inventories carried out in the forest by Faune Québec (MRNF).

4.3.3 Forestry research

Besides conducting inventories, the MRNF devotes considerable financial and human resources to forestry research, particularly in the boreal forest. In most cases the research is practical in nature and is designed to meet medium and longer term needs for forest management information. The research findings serve as a basis for the adoption of new protection measures and innovative forestry practices. The MRNF has its own team of scientific researchers, who work with specialists from an extensive network of universities and research centres. The research team works in eight different sectors:
1) Ecology;
2) Ecosystems and environment;
3) Genetic tree improvements;
4) Plant and seedling production;
5) Silviculture in natural forests;
6) Modelling and forest yields;
7) Plantations;
8) Forestry work.

In the forest ecology sector, the MRNF researches and monitors ecosystemic management. It gathers information on ecosystem structures and operations, and focuses in particular on forest productivity in the boreal zone, assessing the long-term impacts of acid precipitation on soil fertility (see the box on p.37). Other important topics include the ability of ecosystems to adapt to a changing environment (see the first box on p.38), the contribution of Québec's boreal forest to the world's carbon cycle (see the second box on p.38), and national greenhouse gas reduction targets. By constantly building knowledge on all these subjects, it should be possible to guide the future development of forestry practices.

In Québec, restoration of production after logging in softwood stands is based to a large extent on natural regeneration. Silvicultural treatments are therefore monitored in order to foster ongoing improvement and gather information on their impacts on regeneration and forest productivity. Where applicable, corrections are made to the methods themselves or to the yield assumptions set out in the *Forest Management Manual* (Ministère des Ressources naturelles, de la Faune et des

Parcs, 2003b). Other studies are also carried out to prepare the general forest growth models that are key elements in the allowable annual cut calculations. They examine aspects such as success factors for post-disturbance regeneration (e.g. interactions between ericaceas and black spruce), or are used to develop more suitable treatments for complex stands. Lastly, research is currently underway in the boreal forest's mixed stands with a view to improving silvicultural work and restoring damaged stands.

Although reforestation is not the preferred solution for post-disturbance regeneration, it has nevertheless been a major element of silvicultural practice, as a means of overcoming potential deficiencies in natural regeneration. Currently, it is estimated that between 15% and 20% of logging areas are reforested every year. The MRNF's research in Québec has been helping to address this problem for the last 30 years.

The MRNF has been researching genetic tree improvement since 1969, with support from its research partners. It bases its work on traditional selection processes, and therefore does not produce genetically modified organisms. By guiding the choice of species and provenance for planting, and by improving the main species of commercial interest (larches, jack pine, spruces and poplars), the MRNF's aim is to increase the volume, quality and hence the value of wood produced in plantations. Today, 85% of the seeds sent to nurseries every year come from selected sources. Research into seed production, cuttings and forest plants enables the development of innovative production technologies applicable to a broad variety of plants, as well as the use of high quality plants for reforestation. This work is a key element in improving forestry production, among other things because it ensures that trees are planted on highly productive stations.

Research into plantation silviculture has also produced guidelines for the use of plants in reforestation, and for mechanical release methods. The MRNF monitors its experimental plantations over the long term, in order to develop intensive silviculture models, improve knowledge of release treatments and produce yield tables for plantation species. The ultimate goal is to improve the overall yield of the managed forest, which may gradually help reduce management pressure on intact forests in the boreal zone.

Long-term maintenance of forest productivity

The productivity of a forest depends mainly on climate, soil fertility, species composition, age structure and disturbances. Its survival over time also depends on a number of factors, including changes in growing conditions (senescence, paludification, climate warming, acid precipitation and atmospheric pollution), as well as the forest's ability to recover after a disturbance (insect infestation, disease, extreme weather conditions and logging) – in other words, its resilience. Resilience may be lost in an ecosystem that has been disturbed when the vegetation does not recover immediately in the disturbed sectors, or when the pre-disturbance productivity level cannot be achieved within a reasonable time. The MRNF is particularly concerned with maintaining soil fertility, which is a key factor in resilience and forest productivity. It is currently assessing station sensitivity to forestry operational methods. This research should enable it to identify stations that are at risk, and to adopt the most appropriate measures for maintaining soil fertility.

Acid precipitation

Acid precipitation continues to affect Québec's forests, despite the reductions recorded following the 1991 introduction of the Canada-United States Air Quality Accord (Government of Canada, 2007), which aims to reduce sulphur dioxide emissions by 2010. It is estimated that approximately 20% of Québec's boreal forest land continues to receive acid precipitation at levels exceeding the critical load (i.e. the amount of acid deposits that the ecosystem is able to receive without suffering long-term effects). The outcome of this has been an increased risk, over time, that the ecosystems will become impoverished and more sensitive to other types of stress (disturbances, climate, insects, disease).

The MRNF's researchers, in collaboration with other specialists, are currently studying ways of mitigating the negative impacts of acid precipitation. Using data gathered over the last 20 years from the Forest Ecosystem Research and Monitoring Network (commonly known by its French acronym RESEF), they are continuing to assess the damage that these ecosystems may suffer in the short, medium and longer term (nutritive deficiencies for trees, loss of vigour, growth, etc.). The RESEF was set up by the MRNF (Gagnon et al., 1994), and is the principal apparatus in Québec for long-term monitoring of forest ecosystem reactions to environmental stressors (e.g. acid precipitation, climate change, etc.).

Climate change

The climate is largely responsible for the composition and distribution of the forests, and plays a highly dynamic role. Climate change is therefore likely to influence forest development, due to the long-term variations in temperature regimes and precipitation levels. In addition, these changes may well alter the frequency and scope of forest fires, insect infestations and extreme weather, all of which also have an impact on the forests.

It is impossible for the time being to assess the extent and speed of climate change, and hence its impact on the forest, with any degree of accuracy. However, thanks to RESEF, the monitoring system set up by the MRNF, it will be possible to identify the future impacts of climate change on forest ecosystems. The MRNF, through its participation in the Consortium on Regional Climatology and Adaptation to Climate Change (Ouranos) and thanks to the contributions made by its partners, is able to help profile changes in forest ecosystems over the short, medium and longer terms, using different climate change models and scenarios.

The Québec Government's 2006-2012 Plan of Action on Climate Change includes a scientific study aimed at identifying the vulnerability of Québec's forests and forest sector to climate change, and incorporating the anticipated effects of these changes into the forest management process (Ministère du Développement durable, de l'Environnement et des Parcs, 2006). The results should allow for adjustment measures to be introduced from 2013 onwards.

Carbon sinks

Québec's boreal forest is a major carbon sink that contributes to the global carbon cycle, since the trees and soil continually exchange carbon with the atmosphere. Carbon, accumulated in the trees, litter and soil, transforms the forest into a carbon sink. Its importance depends on the forest's age and productivity. Carbon levels are at their maximum when the forest reaches maturity, and decline as the forest becomes senescent or is destroyed by fire, or if growth is reduced by insect infestations or other disturbances.

The MRNF is currently acquiring information on the carbon stored in the forest. Based on its findings so far, it has already been able to identify and map the organic carbon content of mineral forest soils throughout the province, and also to quantify carbon stores following forestation of abandoned farmland. Other studies currently underway will provide information on the impacts of natural and human disturbances on carbon sink development in the boreal forest. Among other things, the MRNF is examining the soil's initial reactions to the impacts of climate warming. Its findings will be used to guide the management of carbon reservoirs in the forest.

If Québec's boreal forest is to contribute fully to the global carbon cycle, as much carbon as possible must be maintained in the "sink", while allowing the forest to fulfill society's other needs, including forest products. In fact, carbon accounts for half the mass of dry wood. Forestry products are therefore reservoirs that store carbon outside the atmosphere until they decompose or are burned. Forest products also help reduce greenhouse gas emissions when they are used instead of materials such as steel and concrete, for which the manufacturing processes consume large quantities of energy. The MRNF is currently examining the possibility of introducing measures to promote the use of wood, especially in the non-residential construction sector.

Wood can also be used to produce thermal energy or can be converted into biofuel. Wood's attraction as a replacement for fossil fuels is based on the fact that the carbon emitted when wood is burned forms part of the global carbon cycle and does not introduce new volumes of carbon into the biosphere. In contrast, the carbon emitted into the atmosphere through the use of fossil fuels is added to the cycle, because it is derived from the Earth's crust, where it had previously been imprisoned for centuries. Europe is already developing methods of converting forest biomass into energy, and this process is also of interest to Québec, which is currently working on a strategy for the use of forest biomass.

Conclusion

Québec's boreal forest is extremely important from the environmental, economic and social standpoints. It hosts commercial activity that generates thousands of jobs both in the forest and in the mills, and is the motor of social and economic development in several regions. It is also a source of many tourist, recreational and cultural activities, and delivers up its resources while playing an ecological role that is essential to life and environmental quality.

Nearly fifteen years ago, when the Québec Government undertook to introduce a new sustainable forest management approach, it implicitly acknowledged the importance of ensuring the survival of the boreal forest, so as to be able to continue to benefit from its many resources while protecting the right of future generations to do the same thing. The Québec Government has made this a legal obligation, by including provisions in the Forest Act to ensure the sustainability of its forests.

In recent years, the MRNF has reviewed its management practices, policies, orientations and programs, bringing them into line with the principles of sustainable forest management. The review has taken place within a context of ongoing improvement and adaptive management. It is not yet complete, and a number of potential improvements have yet to be explored. For example, the Commission d'étude sur la gestion de la forêt publique québécoise (2004) made more than 80 recommendations for the introduction of sustainable forest management, and the MRNF has publicly undertaken to explore all these potential avenues, and to continue its review of Québec's forest regime.

To help maintain biodiversity and ecosystem productivity during forest management activities, the MRNF has undertaken to continue or launch a number of actions, including the following:

- Work on the creation of Québec's network of protected areas, with a view to protecting 8% of the total territory in all Québec's natural regions;

- Implementing woodland caribou habitat management plans and fostering the creation of protected areas to shelter sedentary populations;
- Continuing to identify and provide legal protection for new exceptional forest ecosystem sites, with a view to protecting 100 different sites in the boreal forest;
- Giving legal conservation status to the biological refuges;
- Devising a fire management policy in line with the goals of protecting the biological diversity and productivity of forest ecosystems;
- Establishing the vulnerability of the boreal forest to climate change and proposing ways of adjusting to those changes.

On several occasions, the MRNF has expressed its wish to introduce management by objectives and by results, which would allow it to relax the normative and regulatory framework. To reflect its expectations of sustainable management in the boreal forest, and to measure achievement of its objectives, the MRNF has undertaken to:

- Establish and maintain sustainable forest management indicators that can be used to report on its progress and assess the forest regime;
- Measure its protection achievements through 11 protection and development objectives (PDOs) that will come into force in 2008;
- Foster certification of forest areas by introducing the principle of *ecoconditionality* into the allocation of rights in the forest, and by ensuring that the forest is managed in accordance with the principles of sustainable forest development;
- Prepare a *sustainable forest management strategy* setting out the Government's objectives and commitments.

However, the MRNF does not intend to abandon the regulatory approach altogether, and has also expressed its intention to improve the RSFM by adopting a new regulation (RRSFM) that incorporates the principles of sustainable forest management.

The MRNF has announced a number of new measures that will profoundly alter management methods and forestry practices in the boreal forest, including the following:

- Introduction of an ecosystemic management approach, testing of this new approach in pilot projects, and gradual implementation throughout the boreal forest;
- Introduction of new spatial distribution models for forestry activities;
- Adoption of new silvicultural practices designed to maintain the characteristics of old-growth forests.

The MRNF is aware that the introduction of sustainable forest management will foster diversification of forestry activities and provide a greater variety of better quality wood and non-timber products and services. Accordingly, in the last few years, it has focused on:

- Improving timber yields in the forest by using more intensive silvicultural practices with a view to stimulating the creation of innovative companies and high added-value products;
- Encouraging the use of a larger portion of the timber resource and the development of alternative products (new wood products and non-timber forest products);
- Preparing a strategy for the use of forest biomass;
- Promoting the use of wood as a means of reducing greenhouse gas emissions.

Lastly, given that ongoing knowledge acquisition is fundamental to adaptive management, the MRNF will continue with its inventory and research activities in the boreal forest, and will focus specifically on sustainable forest management. Among other things, it has undertaken to:

- Acquire new knowledge on the boreal forest by completing the fourth forest inventory program and the inventory of Northern forests (around the 52nd parallel);
- Increase forestry research in order to understand how forest ecosystems work and assess the real impacts of management activities on the forest;
- Continue its research effort in order to strengthen the role played by Québec's forest in maintaining a healthy world environment.

These are just some of the measures the MRNF is responsible for applying in order to ensure that the management of Québec's boreal forest continues to move towards the goal of sustainability.

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Glossary

Acid precipitation or acid rain

A phenomenon caused by air pollution, resulting in too high a level of acidity in precipitation. Acid rain is mainly the result of emissions of sulphur dioxide and certain nitrogen oxides, which are gases generated by burning coal and petroleum in the foundry and transportation sectors.

Adaptive management

An approach to forest management based on biophysical constraints, previous results and the development of new logging techniques. An adaptive management process and tools can be used to identify problems, find ways of solving them, and set targets.

Ageing forest

A forest stand in which the trees die gradually as they reach senescence. Ageing forests can be recognized by their structure, which includes a less dense canopy with scattered holes, and an understorey from which young stems are recruited for the canopy. Ageing forests may be virgin forests or forests under management. They may develop as a result of natural disturbances or a long plant succession.

Allowable annual cut

The maximum annual volume of timber that can be cut in perpetuity from a given area without reducing the forest's productive capacity.

Bearing capacity

The soil's ability to bear the loads conveyed through machine wheels.

Bioclimatic domain

An area characterized by the presence of the particular type of vegetation that, at the final stage of succession, grows on sites with average soil conditions, drainage and exposure (mesic sites). The main criterion separating the domains is the influence of the climate on plant life.

Biodiversity or biological diversity

The range and number of living organisms of all origins. Biodiversity includes genetic diversity within species, diversity of species and diversity of land-based, aquatic and marine ecosystems.

Biodiversity reserve

A protected area set up with a view to helping maintain land-based biodiversity, and especially the representative elements of Québec's various natural regions.

Biofuel or biomass fuel

A fuel produced from forest or agricultural biomass, providing energy from a renewable source. Examples include ethanol and biodiesel.

Biological legacy

An organism, the reproductive portion of an organism or a biological structure inherited from a previous ecosystem.

Biological refuge

A small area of forest in which all forest management activities are permanently prohibited, in order to preserve the biodiversity associated with ageing forests.

Biomass

The total mass of living organisms per surface or volume unit. Forest biomass is composed mainly of the above-ground and underground elements of trees (stems, branches, leaves and roots), other types of woody vegetation and mosses, lichens and grasses. Animal biomass usually accounts for only a very small portion of total forest biomass.

Biorefining

Conversion of biological matter into chemical products, materials, fuels or energy for use in other applications and sectors. Biorefining is an alternative to the oil refineries that produce fuels and derivatives from petroleum.

Carbon sink

A system that has the ability to accumulate or release carbon. Forest biomass, wood products, soils and the atmosphere are all carbon sinks.

Clear cutting

Cutting of all the merchantable stems in a forest stand. Cutting with protection of regeneration and soils and cutting with protection of tall regeneration and soils are both forms of clear cutting.

Continuous boreal forest

A sub-zone of the boreal forest where the stands are fairly dense and are composed mainly of softwood boreal species along with shade-intolerant hardwoods. The continuous boreal forest covers 36% of Québec's territory and is divided between two bioclimatic domains (balsam fir-white birch and spruce-moss domains).

Cutting with protection of regeneration and soils

Cutting of all commercially sized trees (diameter breast height of 10 cm or more) in a stand, taking the steps required to avoid damaging established regeneration and minimize the negative impact of forestry operations on soil conditions.

Cutting with protection of regeneration and soils and cluster retention

Cutting with protection of regeneration and soils, during which clusters of trees are left intact to provide a more constant provision of dead wood throughout the stand revolution period. The aim is to retain clusters measuring between 150 and 200 square metres, covering approximately 5% of the logged area, within which no trees are cut.

Cutting with protection of small merchantable stems

A form of logging that consists in cutting between 70% and 90% of the merchantable wood in a stand while preserving existing regeneration (i.e. saplings with a dbh of between 2 and 8 centimetres and small merchantable stems with a dbh of between 10 and 14 centimetres.

Designated species

See *threatened or vulnerable species.*

Ecoconditionality

A concept by which government financial assistance to an organization, company or individual is made conditional upon the achievement of environmental goals.

Ecological classification

Delimitation and division of forest sites by geology, relief, soil, vegetation, climate, wild species, water resources and anthropogenic factors.

Ecological reference framework

A system used to classify and map ecosystems. The abiotic elements of ecosystems are essential to life – energy (light, heat and food), water and soil – and constitute the support environment for the living communities that form the ecosystem's other component.

Ecological reserve

An area that is representative of a region's natural features, which is preserved in its natural state in order to provide complete and permanent protection for environments or landscapes with different soil types, surface deposits and plant or animal species.

Ecological type

A classification unit that expresses both the physical characteristics of the environment and the ecological characteristics of the vegetation (composition, structure and dynamics). The ecological type describes a given location by means of a combination of physical type and potential vegetation (i.e. the vegetation present at the end of natural forest succession).

Ecosystemic management

An ecological approach to forest management that allows the biodiversity and viability of all forest ecosystems to be maintained while meeting socio-economic needs, with due respect for the social values associated with the forest environment.

Endemic species

A species whose geographical distribution is confined to a specific region.

Equivalent cut area

The total area that has been deforested over the years by logging or through the effects of natural disturbances (fires, insect epidemics and windfall) in a watercourse drainage basin, converted (using weighting) to an area equivalent (in terms of its impact on the watercourse's peak flow) to that of a cut with protection of regeneration and soils within the last 12 months.

Even-aged stand

A forest stand in which the trees are more or less the same age.

Exceptional forest ecosystem

An exceptional forest or stand of particular interest for the conservation of biological diversity. There are three types of exceptional forest ecosystems: rare forests, old-growth forests and forests sheltering threatened or vulnerable species.

Extended rotation patch

A small area of forest where the vast majority of the stands are allowed to age beyond the felling age (mature forest), to create overmature forests.

Fire cycle

The number of years required for the burning of an area equivalent to the total area of a given territory.

Forest management agreement

An agreement by which Québec's Minister of Natural Resources and Wildlife grants the right to harvest trees from the public forests to persons who do not hold wood processing plant operating permits, provided the fact of doing so is in the interests of the population in general or a specific community in particular. Signatories of forest management agreements may harvest, from one or more management units, volumes of wood that have not already been allocated under a timber supply and forest management agreement, and may sell that wood to processing mills. They have the same obligations as timber supply and forest management agreement holders and are jointly responsible for work done in the management unit (or units) to which their agreements apply.

Forest management contract

An agreement by which Québec's Minister of Natural Resources and Wildlife entrusts the management of an entire forest to an individual or group of individuals (e.g. regional county municipality, Aboriginal community or regional development organization). The contract holder undertakes to fulfill obligations similar to those imposed on the holders of timber supply and forest management agreements or forest management agreements, for example by drawing up management plans and complying with forest protection standards. A forest management contract may be granted in a forest reserve (i.e. an area in which the Minister has not granted a timber supply and forest management agreement).

Forest management unit

The basic territorial unit used to manage the forest with a view to supplying the wood processing mills. It is also used to calculate the allowable annual cut.

Forest sheltering threatened or vulnerable species

A forest characterized by the presence of one or more plant species designated as threatened or vulnerable in Québec. This may include (1) a very rare species; (2) at least three threatened or vulnerable species; or (3) an outstanding population of one threatened or vulnerable species.

Forest station

A wooded area with uniform ecological characteristics (e.g. soil, climate, topography and plant species).

Fossil fuel

A fuel derived from organic matter accumulated in the ground over the course of geological periods, composed mainly of carbon and hydrogen. Fossil fuels exist in liquid (petroleum), solid (coal, peat, bituminous coal) and gaseous (natural gas) forms.

General forest management plan

A strategic plan revised once every five years, containing a description of the management unit, existing socio-economic conditions, areas

to be protected, the allowable annual cut calculated by the Minister, a statement of the protection and development objectives, a description of the forest management strategies chosen to achieve the yields and objectives set, the silvicultural program for the next five years, a description of the areas of particular interest to other forest users, and a review of management activities already carried out in the area.

Genetically modified organism

An organism whose genetic material has been modified by the introduction of one or more foreign genes in order to create a new characteristic or improve an existing characteristic, which will then be transmitted to the organism's descendents.

Greenhouse gas

A gas present in the atmosphere, either naturally or as a result of human activity, which absorbs and reflects infrared rays from the earth's surface. High atmospheric concentrations of greenhouse gases such as carbon dioxide, nitrous oxide and methane, are one of the causes of global warming.

Gross domestic product (GDP)

The total value of all goods and services produced within the geographical borders of a country or territory within a given period.

Insular block

An area of residual forest situated within a community of logging areas, completely surrounded by stands measuring less than 3 metres high, or by unproductive areas of forest. Insular blocks have a specific configuration, covering an area of between 50 and 200 ha, with a minimum width of 250 metres.

Intact forest

A forest covering an area of at least 500 km^2 and measuring at least 10 km in width, where there are no signs of human activity (according to Global Forest Watch Canada).

Mature forest

A forest stand whose age falls between felling age and the beginning of dominant stem mortality (senescence).

Mechanical release

A mechanical treatment, performed mainly with strippers, designed to control competing vegetation in order to allow for natural or artificial regeneration of dominant species.

Block cutting

A form of logging carried out in mature forests dominated by softwood trees, in order to obtain a mosaic of forest stands of different age classes in the medium term. Block cutting consists in spreading cuts with protection of regeneration and soils over a given area with a view to preserving a residual forest within the boundaries of the cutting area.

National park

A area within which sites representative of Québec's natural regions or sites considered to be exceptional, for example because of their biological diversity, are conserved and protected. The general public has access to these sites for educational purposes and extensive recreation (i.e. activities that make minimal use of the territory and require only very simple equipment).

Non-timber forest product

Merchandise other than wood, derived from the forest. The expression is used to refer to products such as large game, fur animals, nuts and seeds, small fruits, mushrooms, oils, foliage, medicinal plants, peat and firewood.

Northern limit for timber allocations

The northern limit beyond which allocations of timber for commercial use are prohibited.

Old-growth forest

A very old forest where the dominant trees have reached an age that is exceptional, given their growing environment and geographical location. Old growth forests are virtually undisturbed by human activity and have been minimally affected by natural disturbances, which has allowed them to develop specific characteristics. They contain living, senescent and dead trees, and large tree trunks at varying stages of decomposition are scattered over the forest floor. These forests are also characterized by an uneven-aged or irregular

age structure due to their slow maturity dynamics that results in small openings in the forest canopy and dominance of shade-tolerant species.

Overmature forest

A forest stand whose age falls between the start of senescence and the time at which a new stand becomes established (break-up time).

Paludification

A process by which a peat bog or moist forest expands as the water table gradually rises due to the fact that drainage is prevented by accumulations of turf (sphagnum).

Partial cutting

Harvesting of some of the merchantable trees in a forest stand, while maintaining a closed forest with a canopy density of 40% or more (density classes A, B and C) and trees measuring at least 7 metres in height (height classes 1, 2, 3 and 4). Selection cutting and shelterwood cutting are both forms of partial cuts.

Peninsular block

An area of residual forest situated within a community of logging areas, connected on one side to a forest mass and bordered on the other sides by stands composed of trees less than 3 metres high, or by unproductive areas of forest. Peninsular blocks have a specific configuration, covering an area of between 25 and 200 ha, with a minimum width of 500m and a height-to-base ratio of at least 1.

Productive forest area

In Québec, an area with the ability to produce at least 50 m^3/ha of merchantable wood from trees with a diameter breast height of at least 10 cm.

Protected area

A geographically delimited portion of land or sea set aside specifically for the protection and maintenance of biological diversity, along with its associated natural and cultural resources, managed through effective legal or other means, within which all industrial (forestry, mining and energy) activities are prohibited.

Rare forest

A forest notable for its mix of plant species, its structure and its unusual location, all resulting from specific environmental conditions. Its rarity may be of natural origin, but can also be due to human activity. Rare forests are limited in number and are generally small in terms of area. A forest may be rare in Québec, or rare in terms of a smaller territorial unit.

Riparian band

See *wooded riparian strip.*

Rutting

The formation of ruts due to the use of heavy forestry machines on wet ground or ground with a small load capacity in a felling location. Only ruts measuring 4 metres or more in length and at least 20 cm in depth (measured from the mineral soil) are considered when measuring rutting in felling locations. In the case of organic soil, rutting is said to occur as soon as the plant cover is torn.

Sample plot

A sampling unit of a specific shape and size, created for the purposes of stand surveys or to monitor hydric, ecological and dendrometric characteristics over time.

Selection cutting

A method used to regenerate stands and maintain an uneven-age structure by cutting trees through all age classes, either individually or in small groups or strips.

Senescence

The life stage of an organism or part of an organism preceding natural death, usually characterized by a reduced ability to repair damage and deterioration.

Shelterwood cutting

A two-phase approach to logging, where partial cover is maintained over time, and natural regeneration from residual tree seeds is encouraged. The cutting area includes partially cut strips, clear-cut strips (in trails) and intact wooded areas. The first phase consists in harvesting some of the trees (partial cutting), based on specific selection criteria, in the first

few metres on each side of the hauling trails. The second phase consists in harvesting the trees left standing during the first phase, using new trails created in the intact areas.

Silvicultural practices

The set of techniques and methods used to modify and manage a forest stand over the years, with a view to achieving the objectives and goals set, depending on the chosen silvicultural system.

Snag

A dead standing tree, most of whose leaves and branches have fallen.

Stand age structure

A description of a stand based on the age of its trees. A stand may be even-aged, uneven-aged, regular or irregular.

Stand rotation

The number of years required to establish an even-aged stand and bring it to maturity.

Station quality indicator

A measurement used to estimate the productivity (growth and production potential) of a given site in the forest (known as a forest station). The station quality indicator is based on the average height of the dominant trees at a given age (usually 50 years). The higher the station quality indicator, the greater the site's volume production potential.

Stem analysis

Examination of a tree stem carried out by counting and measuring the annual rings in a series of cross-sections at different heights, in order to determine the tree's growth rate and to establish volume and tapering equations.

Stereoscopy

A science and technique involving the use of binocular vision to obtain relief images by taking two pictures of the same object at the same time from slightly different angles (rather like two overlapping photographs).

Sustainable development

A general approach to natural resource management aimed at meeting human needs and aspirations while preserving genetic resources, maintaining biological diversity and minimizing harmful impacts on the air, water and soil, in the interests of present and future generations.

Sustainable forest management

Management focused on the maintenance and improvement of the long-term vitality of forest ecosystems while providing present and future generations with environmental, economic, social and cultural benefits.

Sustainable forest management indicator

A quantitative or qualitative variable that can be measured or described, and which, when observed periodically, reveals a trend in sustainable forest management. The MRNF has selected sustainable forest management indicators that are tailored to the context in Québec, in order to achieve three goals: (1) to draw up an accurate profile of forest development; (2) to provide forestry decision-makers with tools for analyzing and assessing the state of the forest; and (3) to inform the general public about the state of the forest and the progress made by Québec in the area of sustainable forest management.

Territorial reference unit

A subdivision of a single-block forest management unit delimited by biophysical features, covering less than 100 km^2 in the hardwood forest, less than 300 km^2 in the fir or mixed forest, and less than 500 km^2 in the spruce forest.

Threatened or vulnerable species

In Québec, a plant or wildlife species legally designated as threatened or vulnerable, or likely to be so designated, pursuant to the Act respecting threatened or vulnerable species. A species is threatened when it is considered likely to become extinct, and is vulnerable if its survival is regarded as being at risk, even though it is unlikely to become extinct in the short or medium term. A species likely to be designated as threatened or vulnerable is scientifically assessed to determine its level of vulnerability and the relevance of providing legal protection.

Timber supply and forest management agreement

An agreement between Québec's Minister of Natural Resources and Wildlife and the owner of a wood processing mill. The mill owner obtains the right to harvest, each year, from the public forest, a specific volume of predetermined species (e.g. fir and spruce). In return for this wood, the timber supply and forest management agreement holder undertakes to restore the logged areas to production. A timber supply and forest management agreement covers a period of 25 years, but is revised every five years. If the holder has met its obligations, the agreement can be extended for a further period of five years.

Unbroken forest mass

In Québec, in the black spruce-moss forest zone, a forest area covering at least 30 km² (3,000 ha) composed mostly (66 %) of stands measuring at least 7 metres in height, evenly distributed throughout the mass, with a minimum canopy density of 40% (density class A, B or C).

Variable retention harvesting

Harvesting carried out in such a way that certain structural elements of a stand, including living trees of different diameters, snags, wood residues, underbrush species and portions of intact plant litter, are maintained either separately or in clusters. Cutting with retention of small merchantable stems and cutting with protection of regeneration and soils and cluster retention are all forms of variable retention.

Vegetation subzone

A subdivision of a vegetation zone based on the profile of the dominant vegetation in the landscape at the end of plant successions. For example, the boreal zone is divided into three subzones, namely the continuous boreal forest, the taiga and the forest tundra.

Vegetation zone

A large, continental-scale territory formed according to climate and colonized by its own distinct plant life. Québec is divided into three vegetation zones: (1) the northern temperate zone, dominated by hardwood and mixed stands; (2) the boreal zone, with its characteristic conifer stands; and (3) the Arctic zone, known for its shrubs and grassy vegetation. The vegetation zones are based on global vegetation divisions.

Virgin forest

A natural forest that is virtually unaffected by human activity.

Wooded riparian strip

A 20-metre wide strip of trees left at the time of logging along the shoreline of a peat bog with a pond, a marsh, a swamp, a lake or a steady-flow watercourse), measured from the edge of the adjacent forest to the riparian ecotone in question (a transition zone between the aquatic environment and the forest).

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