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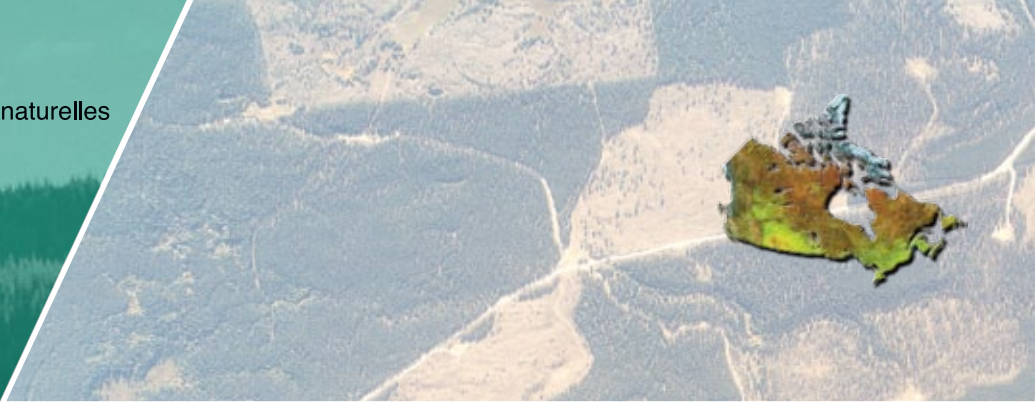

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Natural Resources Canada • Canadian Forest Service
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Executive Summary

Canada's boreal forest economy faces many challenges and opportunities. The current industry structure reflects past resource and economic conditions, government policies, and industry strategy. As economic conditions and the resource change, industry, communities and governments must also adjust.

Forest sectors vary from one region to another, but all boreal regions face similar challenges. Boreal forest industries face four main pressures: a changing resource base (reduced inventory, changed species mix); increased demands for environmental and social amenities; increased demands for non-timber values, and; increased competition in export markets. These will challenge the industries to remain competitive vis-à-vis other forest regions throughout the coming decades while also achieving other goals of sustainable forest management. To sustain competitiveness, Canadian boreal forest industries (timber and non-timber) require improved forest resource information and development of new tools to support investment and management decisions that, in turn, maintain and increase value derived from the many goods and services provided by Canada's boreal forests.

Opportunities to meet the coming challenges and ensure a competitive and sustainable boreal forest sector include:

- Organization of the land base to minimize timber costs and enhance non-timber values, while taking into account the potential impacts of climate change and forest health issues, and maximizing synergies between non-forest sectors;
- Development of new and innovative tenure arrangements and property-right regimes that support a sustainable and competitive boreal forest sector;
- Improvement of decision support tools and systems to enhance effectiveness and efficiency of forest investments in forest renewal and protection;
- Development of non-timber goods and services, including enhanced use of biomass for energy;
- Development of secondary wood and paper manufacturing;
- Development of new markets;
- Development of new technologies in harvesting, transportation and processing;
- Redesign of policies, including those that relate to transportation, energy, and environment, that support a sustainable balance between economic, environmental, and social goals.

In order to maintain competitiveness and environmental and social sustainability in the boreal forest sector, research is needed in the following areas:

1. Economics and policy in forestland management: integrated versus specialized land management;
2. Economics and policy in integrated land-use management: forestry, mining, agriculture, recreation, and oil and gas;
3. Economics of forest protection, including fire management and integrated pest management;
4. Regional and local economic impacts of traditional and non-traditional forest industries on different aspects of the boreal population—rural and urban, Aboriginal and non-Aboriginal;

5. Economics of transportation in the context of forest management and manufacturing;
6. Economic and policy research in the areas of non-timber forest products;
7. Economics of climate change mitigation and adaptation in northern forests, including impacts of climate change policy on sustainable forest management and long-term timber supply;
8. Analysis of effectiveness and efficiency of environmental, energy, transportation, and tax regulation and policies in the context of the forest sector (timber and non-timber).

Such research will need to be spatially rooted and consider the varied circumstances that exist across the boreal forest region; otherwise, the research findings risk being based on 'average' conditions, and will not help resolve resource conflicts nor achieve a sustainable balance of economic, social, and environmental values at local and regional scales. Moreover, risk-analysis methods and tools specifically tailored to issues of the boreal forest region would be invaluable for development of future forest policies.

In order to support such research and orient it to questions of greatest relevance to the boreal forest region, a more complete and detailed assessment of the state of the boreal region is recommended. An assessment similar to the report, "Criteria and Indicators of Sustainable Forest Management in Canada: National Status 2005," with particular attention to regional circumstances, would be a useful reference point from which to better focus research in the boreal forest sector. At the very least, a compilation of all socioeconomic statistics by ecoregion or ecozone would facilitate analysis. Other specific information in the following areas would support relevant economic and social research on Canada's boreal region:

1. Frequency, extent and impacts of small fires in the boreal;
2. Growth and yield of timber resources in the boreal;
3. Production and use of non-timber forest resources;
4. Inventory and location of water, wetland, carbon, wildlife, and biodiversity resources;
5. Inventory and location of non-forest resources;
6. Boreal timber inventory, timber supply, and harvest trends;
7. Location of industry, and its associated transportation and other infrastructure, within the boreal region.

Résumé

L'économie de la forêt boréale du Canada est confrontée à de nombreux défis et dispose de diverses possibilités. La structure actuelle de l'industrie reflète les ressources, les conditions économiques, les politiques gouvernementales et les stratégies antérieures de l'industrie. Les collectivités, les administrations gouvernementales et l'industrie doivent s'adapter aux conditions économiques et aux ressources changeantes.

Les secteurs forestiers varient, d'une région à l'autre, mais l'ensemble des régions boréales est confronté à des défis semblables. Quatre facteurs principaux exercent une influence sur les industries de la forêt boréale : une base de ressources changeante (un inventaire réduit et une nouvelle combinaison d'espèces); une demande accrue en commodités environnementales et sociales; une demande accrue en valeurs non ligneuses ainsi qu'une concurrence accrue dans les marchés d'exportation. Ces derniers appelleront les industries à demeurer compétitives par rapport aux autres régions forestières, au cours des prochaines décennies, tout en respectant leurs objectifs d'aménagement forestier durable. En vue d'alimenter leur compétitivité, les industries de la forêt boréale du Canada (ligneuses et non ligneuses) ont besoin de renseignements meilleurs concernant les ressources forestières et de nouveaux outils pour appuyer les décisions en matière d'investissement et de gestion qui, en retour, maintiennent et augmentent la valeur des nombreux produits et services issus des forêts boréales du Canada.

Parmi les mesures servant à relever les défis et à favoriser la compétitivité et la durabilité de l'industrie de la forêt boréale, on compte :

- l'organisation du territoire forestier en vue de minimiser les coûts du bois et d'améliorer les valeurs non ligneuses, tout en tenant compte de l'incidence potentielle des changements climatiques et des questions relatives à la santé des forêts, ainsi qu'en optimisant la synergie entre les industries non forestières;
- l'élaboration d'ententes novatrices relatives au régime foncier et de régimes des droits de propriété qui favorisent la durabilité et la compétitivité de l'industrie de la forêt boréale;
- l'amélioration des outils et des systèmes d'appui aux décisions afin de rehausser l'efficacité et l'efficience des investissements en renouvellement et en protection des forêts;
- l'élaboration de biens et de services non ligneux, y compris l'utilisation accrue de la biomasse à des fins énergétiques;
- le développement de l'industrie de la transformation secondaire du bois et du papier;
- la création de nouveaux marchés;
- la création de nouvelles technologies en matière de récolte, de transport et de traitement;
- la révision des politiques, y compris celles qui traitent du transport, de l'énergie et de l'environnement, afin qu'elles favorisent un équilibre durable entre les objectifs économiques, environnementaux et sociaux.

Dans le but de conserver la compétitivité et la durabilité environnementale et sociale de l'industrie de la forêt boréale, des recherches s'avèrent nécessaires dans les domaines suivants :

1. l'économie et les politiques en aménagement des territoires forestiers; la gestion des terres intégrée par rapport à la gestion des terres spécialisée;
2. l'économie et les politiques de la gestion intégrée de l'utilisation des terres; la foresterie, l'exploitation minière, l'agriculture, les loisirs et l'industrie pétrolière et gazière;

3. l'économie de la protection de la forêt, y compris la gestion des incendies et la lutte antiparasitaire intégrée;
4. les impacts économiques régionaux et locaux des industries forestières traditionnelles et non traditionnelles sur différents aspects de la population boréale, rurale ou urbaine, autochtone ou non autochtone;
5. l'économie du transport dans le cadre de l'aménagement forestier et de la transformation;
6. la recherche en matière d'économie et de politique dans le domaine des produits forestiers non ligneux;
7. l'économie des mesures d'atténuation des changements climatiques et d'adaptation à ces derniers, dans les forêts nordiques, y compris l'incidence des politiques en matière de changements climatiques sur l'aménagement forestier durable et l'approvisionnement en bois à long terme;
8. l'analyse de l'efficacité et de l'efficience des règlements et des politiques en matière d'environnement, d'énergie, de transport, d'impôts et de taxes dans le secteur forestier (ligneux et non ligneux).

De telles recherches devront se fonder sur le lieu physique, et tenir compte des circonstances variées propres à la région de la forêt boréale. Autrement, les résultats de la recherche risqueraient de ne tenir compte que des conditions « moyennes » et ne contribueraient ni à régler les conflits concernant les ressources, ni à atteindre un équilibre durable entre les valeurs économiques, sociales et environnementales, à l'échelle locale et régionale. De plus, les méthodes et les outils d'analyse du risque, spécialement conçus en fonction des questions relatives à la région de la forêt boréale, seraient d'une valeur inestimable pour l'élaboration des politiques forestières à venir.

On propose de réaliser une évaluation plus exhaustive et détaillée de l'état de la région boréale afin d'appuyer de telles recherches et d'orienter celles-ci vers les questions les plus pertinentes pour la région de la forêt boréale. Une évaluation semblable au rapport intitulé « Critères et indicateurs de l'aménagement durable des forêts au Canada : bilan national 2005 », accordant une attention particulière aux circonstances régionales, s'avérerait un outil de référence utile pour mieux orienter la recherche dans le secteur de la forêt boréale. À tout le moins, une compilation des statistiques socioéconomiques, classées par écorégion ou par écozone, faciliterait l'analyse. D'autres renseignements précis, dans les domaines suivants, pourraient appuyer une recherche économique et sociale pertinente sur la région boréale du Canada :

1. la fréquence, la portée et les répercussions des petits incendies dans la région boréale;
2. la croissance et le rendement des ressources ligneuses dans la région boréale;
3. la production et l'utilisation des ressources forestières non ligneuses;
4. l'inventaire et l'emplacement des ressources relatives à l'eau, au carbone, à la faune et à la biodiversité;
5. l'inventaire et l'emplacement des ressources forestières non ligneuses;
6. l'inventaire ligneux boréal, l'approvisionnement en bois et les tendances en matière de récolte;
7. l'emplacement de l'industrie, ainsi que le transport et l'infrastructure connexes, dans la région boréale.

Contents

List of Figures

List of Appendix 1 Figures

List of Tables

List of Appendix 2 Tables

List of Appendix 5 Tables

Introduction

Discussions on the state and development of Canada's boreal forests are becoming commonplace, even outside of Canada (Natural Resources Defense Council 2004; World Conservation Union 2004). Increased attention and concern is documented in the form of recent reports—the most notable being the 1999 Senate Report, *Competing Realities: The Boreal Forest at Risk* (Senate Subcommittee on the Boreal 1999)—conferences and initiatives. These include, for example, the Canadian Boreal Initiative, the Forest Stewardship Council of Canada's Boreal Standard, the Boreal Forest Network, and the boreal forest program of the National Round Table on the Environment and the Economy.

Much attention has centred on the physical state of and change within the boreal forests; less attention has focussed on the economic and social challenges that face resource industries and communities that directly depend on boreal forests as sources of monetary and non-monetary benefits. This report surveys what we know and don't know about the economic and socioeconomic issues related to Canada's boreal forest resources, identifies possible opportunities to meet these challenges to the competitiveness and sustainability of the Canadian boreal forest sector, and identifies areas of economic and socioeconomic research to support policy decisions related to the boreal forest sector. In particular, the report identifies information gaps that must be filled if understanding of the state of the boreal region is to improve.

This report draws from articles, books, academic literature in the fields of social and physical sciences, and government publications, such as *Criteria and Indicators of Sustainable Forest Management in Canada* (CCFM 2006) and *Ecological Assessment of the Boreal Shield Ecozone (*Environment Canada 2000b). In particular, *Towards Sustainable Management of the Boreal Forest* (Burton et al. 2003a), *Boreal Mixedwood Notes* (OMNR 2000) and *Canada's Forest Inventory 2001* (Power and Gillis 2006) are excellent references and provide a basis for this report. Maps of Canada's boreal region generated by Canada's Forest Inventory 2001 are supplemented with maps generated by Natural Resources Canada's Atlas of Canada (http://atlas.nrcan.gc.ca): because the inventory and the atlas

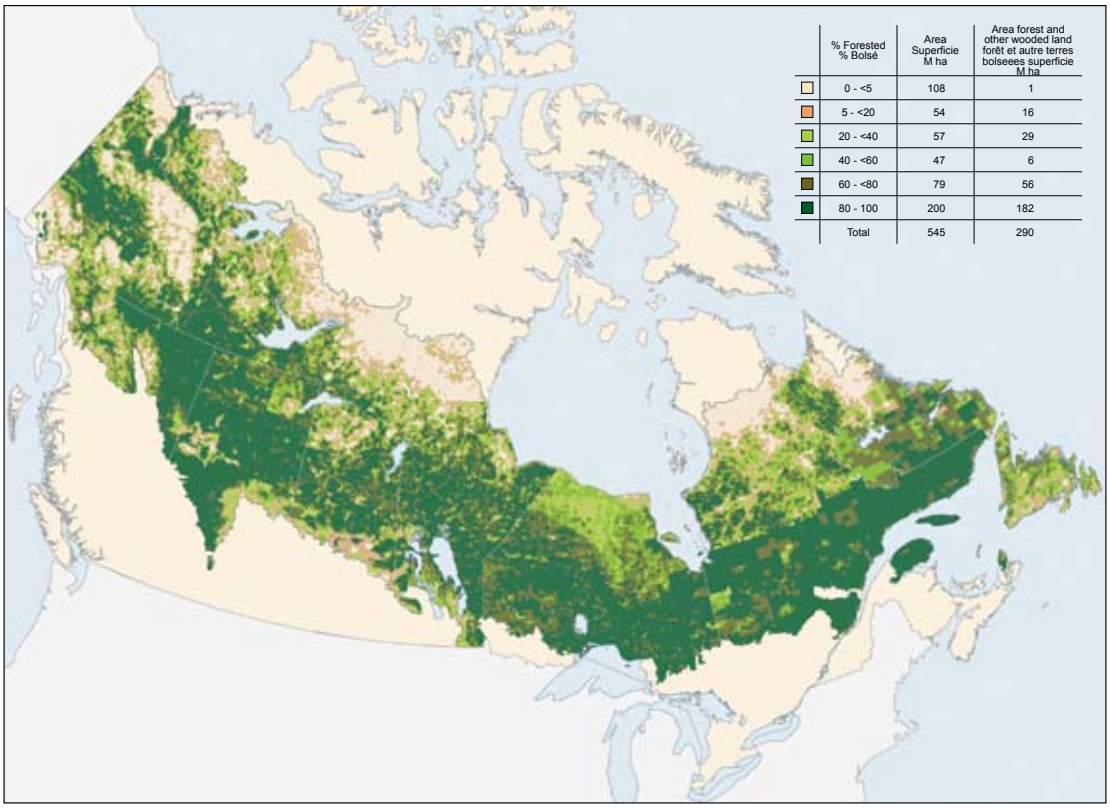

Figure 1. Map of the boreal region and boreal forests of Canada (Power and Gillis 2006)

draw on different data sources, discrepancies between the maps occasionally occur. Many of the Atlas of Canada maps included in this report present information by ecoregion (a subdivision of an ecozone) for all of Canada's terrestrial area, whereas inventory maps present info only for the country's boreal region.

Canada's boreal region

State of boreal forest resources

The circumpolar boreal forest zone is the most extensive terrestrial biome in the world, accounting for 32% of the world's forest cover. The Canadian boreal forest region encompasses as much as 30% of the world's circumpolar boreal forest zone (Burton et al. 2003b; Figure 1) and is the largest biome in Canada. There are 15 terrestrial ecozones in Canada that together can be subdivided into 194 ecoregions (Natural Resources Canada 2007c). The Canadian boreal forest region consists of seven ecozones: Taiga Cordillera, Boreal Cordillera, Taiga Plains, Boreal Plains, Taiga Shield, Boreal Shield, and Hudson Plains (Figure 2). This region covers 544.6 million ha and contains about 310 million ha of forest and other wooded land (Power and Gillis 2006). The boreal forest region includes land in Newfoundland and Labrador, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, Nunavut, and a portion of Nova Scotia.

The boreal region encompasses about 77% of Canada's forest and other wooded land, 68% of its lakes and rivers, 18% of its agriculture and cropland, and 8% of its urban areas (Statistics Canada 2000; Appendix 2: Table 2-1). Table 1 shows that Quebec has the largest portion of Canada's boreal forest, followed by Ontario and the Northwest Territories. The boreal forest accounts for 72% of Canada's total forests, ranging from 4% in Nova Scotia to 100% in Newfoundland and Labrador and in the Yukon Territory.

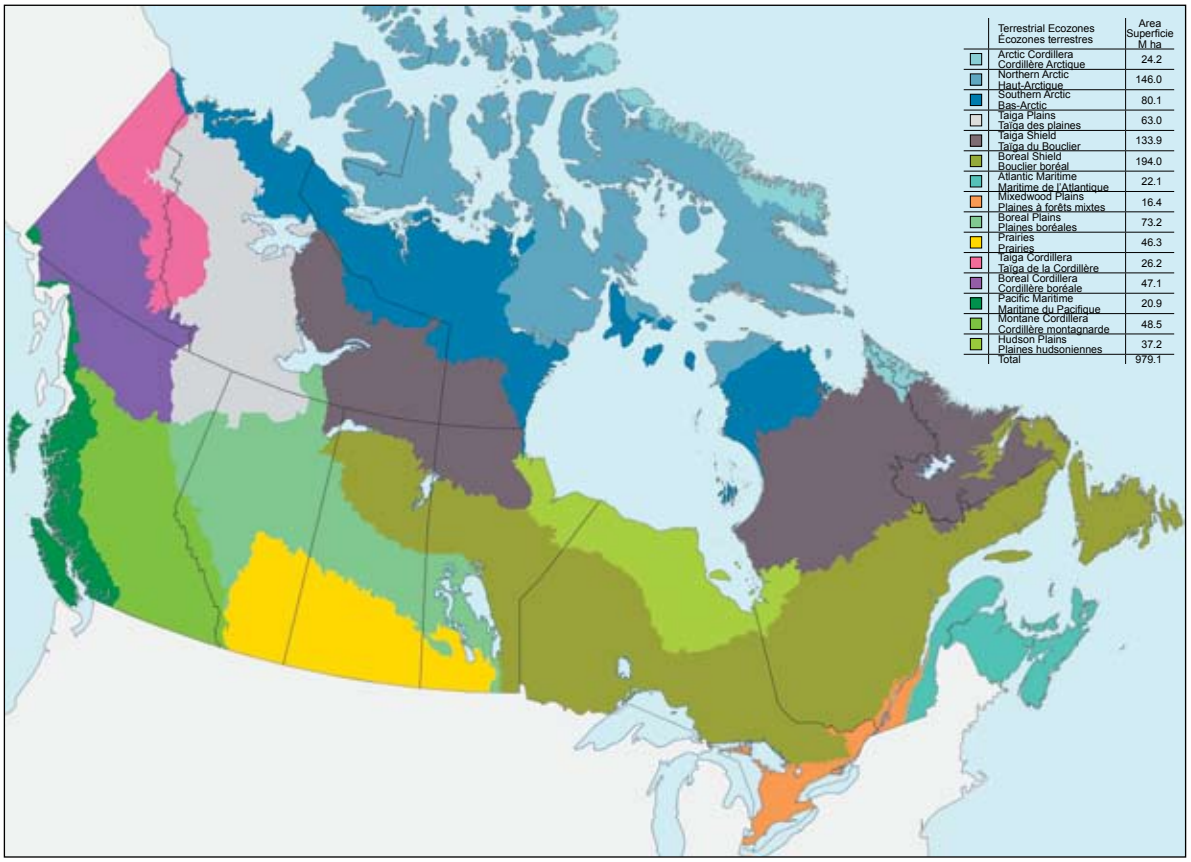

Figure 2. Ecological zones in Canada, including boreal region ecozones (Power and Gillis 2006)

Forest health

A prominent feature of the boreal forest is the occurrence of large-scale natural disturbances such as fire, insects, windthrow, ice storms and disease Bergeron et al. 1998; Bergeron et al. 2004; Burton et al. 2003a; Krcmar-Nozic et al. 2000; Natural Resources Canada 2007a; Wagner and Columbo 2001). The frequency and area affected by such events varies from year to year and across regions (Haeussler and Kneeshaw 2003). For example, volume of wood affected by fire varied annually across all of Canada's forest from 1970 to 2005 (Figure 3). Average area disturbed annually by fire and insects from 1978 to 2005 is presented in Table 2 for each province and territory with boreal forest (Canadian Council of Forest Ministers n.d.).

Table 1. Boreal forest (millions ha) by province and territory (Canada's Forest Inventory 2001, Natural Resources Canada, Canadian Forest Service, special tabulation)

	Area in Canada			Area in Boreal			Percent of total in Boreal	
Province	All land classes	Forest & other wooded land	Forest land	All land classes	Forest & other wooded land	Forest land	Forest & other wooded land	Forest land
Nfld.	40,299	20,067	10,730	38,507	20,065	10,728	100	100
N.S.	5,531	4,347	4,240	230	181	172	4	4
P.E.I.	576	272	265	-	-	-	-	-
N.B.	7,312	6,207	6,091	13	13	13	0	0
Que.	151,885	84,575	73,360	109,971	70,016	59,370	83	81
Ont.	107,482	68,294	53,758	76,421	53,865	39,963	79	74
Man.	63,623	36,354	18,968	56,407	35,321	18,076	97	95
Sask.	65,190	24,258	20,043	41,134	23,724	19,512	98	97
Alta.	65,436	36,388	27,718	45,291	33,276	24,819	91	90
B.C.	94,545	64,248	57,910	28,980	18,511	15,597	29	27
Yk.	48,486	22,789	7,884	47,537	22,779	7,880	100	100
N.W.T.	128,115	33,346	28,352	90,108	31,298	27,335	94	96
Nvt.	200,597	939	815	10,018	610	499	65	61
Canada	**979,077**	**402,085**	**310,134**	**544,617**	**309,659**	**223,963**	**77**	**72**

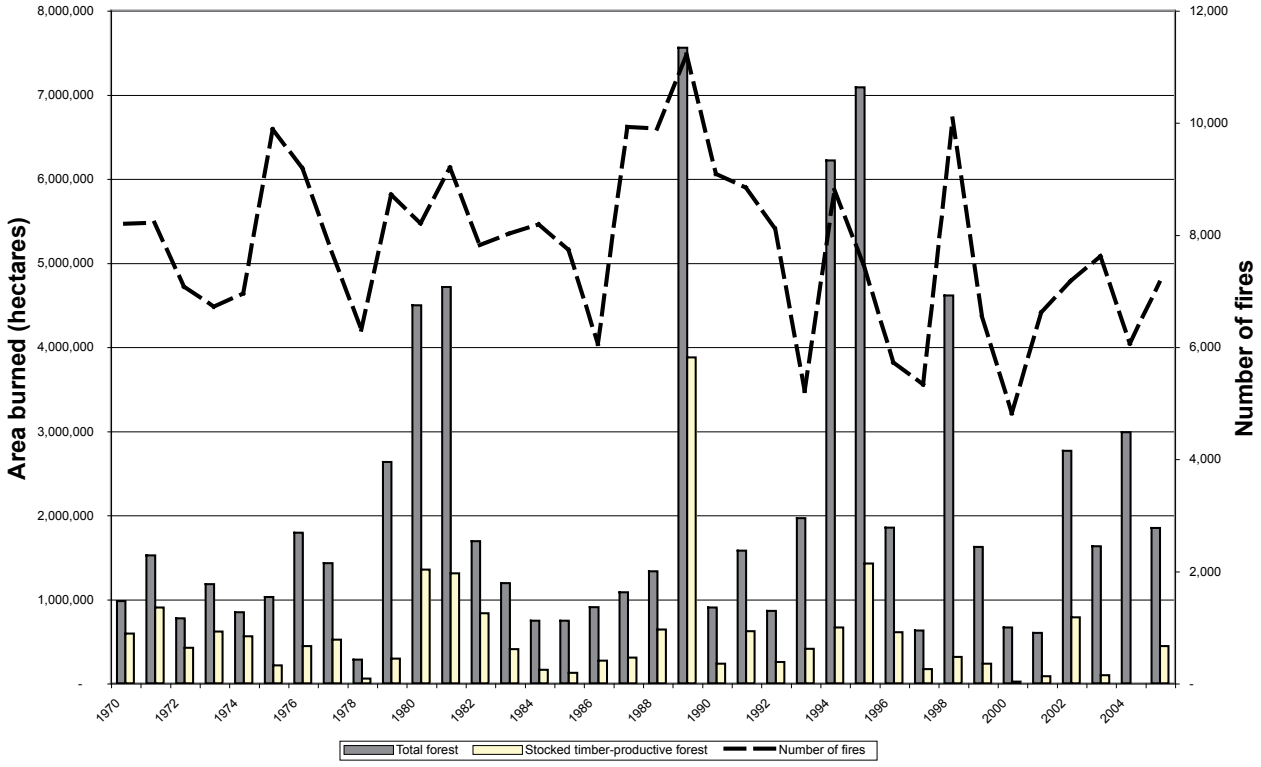

Figure 3. Area burned and number of fires in provinces and territories with boreal forests, 1970 to 2005 (Canadian Council of Forest Ministers n.d.)

No information source currently tracks all fires in Canada by ecozone or forest region; however, the Canadian Forest Service's Large Fire Database (Canadian Forest Service Wildland Fire Information System, http://cwfis.cfs.nrcan.gc.ca/) documents all large forest fires (>200 ha) by ecozone between 1959 and 1999. In Canada, 3% of fires reach a final size greater than 200 ha, but these few fires represent 97% of the total area burned (Canadian Forest Service 2004; Canadian Council of Forest Ministers 2005b); consequently, the data in the Large Fire Database describes the frequency and distribution of area burned within Canada's boreal region very well. However, although large fires account for the majority of area burned, smaller fires (<200 ha) may have economic and ecological significance that is lost if only larger fires are accounted for. Indeed, it is likely many smaller fires remain small because of effective fire mitigation to protect life and property. Small fires may also be significant agents of forest renewal and diversification.

Table 3 summarizes large fires in the boreal forest region for the period 1959 to 1999, excluding Nova Scotia. Fires in the boreal forests within each province and territory except British Columbia accounted for most, if not all, of the wildfire events and area burned. That fire is integral to the boreal region is nowhere more evident than in the Northwest Territories, where more than 20 million ha burned over the 40-year period, for an annual average of 500 000 ha burned. Fires in the Northwest Territories accounted for one-quarter of all area burned within Canada's boreal forest during this period, but account for only one-sixth of all boreal fires (Appendix 1: Figure 1-1 shows occurrence of fire in the boreal region for the period 1959 to 1997.)

According to the Canadian Council of Forest Ministers' National Forestry Database Program (http://nfdp.ccfm.org/), damage caused by insects is widespread across the boreal forest region, but is most pronounced in Quebec, Ontario and across the prairie provinces (in the Boreal Shield, Boreal Plains and Taiga Plains ecozones). Insect defoliators are the greatest contributors to tree mortality and forest

Table 2. Average area (hectares) annually disturbed by fire and insects in total forest area,1981 to 2005 (Canadian Council of Forest Ministers n.d.)

	Fire	Insects
N.L.	42,488	70,039
P.E.I.	109	21,726
N.S.	682	103,240
N.B.	3,018	541,875
Que.	318,920	2,550,436
Ont.	190,595	11,469,951
Man.	380,368	233,097
Sask.	388,728	434,282
Alta.	181,408	1,575,635
B.C.	68,323	2,133,405
Y.T.	185,480	32,931
N.W.T.	554,851	231,652
Canada	2,363,655	19,398,267

Table 3. Large-scale fires in the boreal region between 1959 and 1999 (Canadian Forest Service n.d.)

	Nfld	Que.	Ont.	Man.	Sask.	Alta.*	B.C.	Yk.	N.W.T.	Boreal region
# of fires in boreal**	345	1168	1420	1846	1412	786	505	750	1807	10,039
Cumlative area burned (000 ha)	1,639	9,052	6,853	11,464	12,710	6,699	1,854	4,703	20,591	75,565
Annual area burned (000 ha)	41	226	171	287	318	168	46	118	515	1,890
Number of fires per year	9	29	36	46	35	20	13	19	45	251
Average fire size (ha)	4,751	7,750	4,826	6,210	9,001	8,522	3,671	6,271	11,395	7,527
% of all boreal fires	3%	12%	13%	16%	13%	7%	4%	7%	16%	100%
% of all area burned in boreal	2%	12%	9%	15%	17%	9%	3%	6%	27%	100%
% of total fires that occurred in boreal	97%	95%	99%	93%	100%	97%	38%	100%	99%	89%
% of total area burned that occurred in boreal	100%	99%	100%	97%	100%	100%	62%	98%	100%	98%

*Includes fires in Wood Buffalo National Park
**Excludes fires in national parks other than Wood Buffalo

change (http://nfdp.ccfm.org/); spruce budworm, forest tent caterpillar, and jack pine budworm are the most widespread species, and are common across the western and eastern boreal. The hemlock looper is a significant defoliator in the eastern boreal.

Annual stand and forest disturbance by insects occurs over a greater area than fire (Descharnais et al. 2004). For example, the spruce budworm defoliated 54 million ha in 1975, whereas the largest fire year in the last 30 years (1989) consumed about 7 million ha (Figure 3). The areas most affected, based on tree mortality, are north–central and northwestern Ontario. Forest tent caterpillar defoliation affected 3 million ha in 1998 across the Boreal Shield ecozone. The current outbreak of mountain pine beetle in British Columbia (outside the boreal forest region) covers some 13 million ha (BC Ministry of Forests and Range, http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/); if this beetle were to spread into boreal forests, it could affect some 20 million ha (2 billion m^3; Power and Gillis 2006) of pine within the boreal region.

The lodgepole pine dwarf mistletoe (*A. americanum* Nutt. ex Engelm.) in the western boreal and root rot (*Armillaria* and *Tomentosus*) in the eastern boreal are a chronic forest parasite and disease, respectively, in Canada's boreal region. Although the full extent of damages from disease and parasites is difficult to quantify, the impacts can be significant. In mature spruce and lodgepole pine stands infected with *Inonotus tomentosus* mortality of 30% to 40% is common (Hunt and Unger 1994). Annual losses caused by the dwarf mistletoe have been estimated at 4 million m^3 of wood in western Canada (Ip 1992).

Economic and social impacts of forest insects, disease and fire are markedly different. Fire impacts occur quickly and tend to kill trees immediately. They can result in significant losses of property, life and health (human and otherwise), and reduce non-timber values, including water, recreation, carbon, biodiversity, cultural, and fisheries and wildlife (Rosenberger and Smith 1997; Hesseln et al. 2004).

The impacts of insects and disease, on the other hand, tend to occur over longer time periods; immediate damage is initially confined to timber resource values. Actual losses of commercial timber volume due to insects and disease often are difficult to estimate because of the large areas affected, the multi-year duration of the impact, and the variable decay rates of standing trees. Furthermore, large-scale insect and disease disturbances may thereafter be associated with secondary fire and insect disturbances, which compound associated economic and social costs (Descharnais et al. 2004; Stocks 1987).

Because different natural disturbances and their impacts vary to such a degree, different management practices have been developed to mitigate their damage, depending on the values being protected.

Other resources

> *Canada's boreal forests provide a host of ecosystem services for Canadians and the world: they are the largest water filters on the planet and help regulate the earth's climate by storing close to 25% of total carbon stored in vegetation and soils on Earth. They are home to roughly one third of the continent's migratory birds, as well as 40% of its waterfowl. Canada's forests are also some of the last remaining wild areas where intact natural systems function without human intervention; almost 70% of Canada's boreal region consists of intact, connected expanses of forests and wetlands.*
>
> (National Round Table on the Environment and the Economy 2003)

Some information on non-timber resources is available by ecozone or ecoregion, or can be extracted from other information sources to provide general estimates of the state of these resources in the boreal region.

Water

Canada has an abundance of renewable fresh water, much of which is contained within or travels through the boreal region. Total annual streamflow in Canada averages about 105 000 m^3 per second. This

represents about 9% of the world's renewable water supply. Approximately 60% of Canada's fresh water drains to the north (Statistics Canada 2000), through the boreal forest to the Pacific Ocean, Arctic Ocean, and Hudson Bay. (Appendix 1: Figure 1-2 shows Canada's major drainage basins.)

Wetlands

Wetlands and peatlands cover approximately one-quarter of Canada's land surface (Table 4); many lie within the boreal region (Statistics Canada 2000). Wetlands and peatlands serve numerous ecological and hydrological functions, including nutrient cycling, wildlife habitat, water-quality control (Lee 2004), and carbon sinks. Most of Canada's wetlands are located in northern Ontario, Manitoba, Alberta, and the southern reaches of the Northwest Territories.

Wildlife and biodiversity

Canada is home to more than 65 000 known species and an estimated 200 000 undiscovered or taxonomically undescribed species (Statistics Canada 2000). Many species are found in the boreal forest region; however, the exact number of species that directly depend on Canada's boreal region is unknown. The boreal is home to many of Canada's mammals, including large mammals such as caribou, moose, elk and bear, and provides important habitat for migratory and resident bird species (Statistics Canada 2000; Schmiegelow and Mönkkönen 2002; Lee 2004). According to Canada's National Environmental Indicator Series 2003 (Environment Canada 2007), the population status of the majority of resident bird species in the boreal forest region is stable; but a number of species are in decline (Table 5). bi

Biodiversity, endemic species, and species considered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be at risk of becoming endangered, extirpated or extinct occur across Canada's boreal region (Appendix 1: figures 1-3, 1-4, 1-5; visit http://www.speciesatrisk.gc.ca/map/default_e.cfm to determine range of specific species at risk). Boreal biodiversity 'hotspots' include the eastern boreal, the southern limits of the boreal across the prairie provinces, and the central Yukon Territories. Current pressures on biodiversity and on rare and endemic species in the boreal region are relatively low

Table 4. Estimated wetland and peatland area (km^2) by province and territory, 1986 (Statistics Canada 2000)

	Wetlands						Peatlands
	Proportion of Area in wetlands						
Province/Territory	0-5%	6-25%	26-50%	51-75%	76-100%	Total Area	Total Area
Nfld.	580	35,960	31,380	-	-	67,920	64,290
Que.	6,280	45,790	35,060	28,490	5,890	121,510	117,130
Ont.	1,050	6,840	47,950	86,340	150,230	292,410	225,550
Man.	380	22,250	70,890	51,840	79,340	224,700	206,640
Sask.	3,980	41,700	36,950	12,710	1,530	96,870	93,090
Alta.	1,070	10,800	32,490	68,730	23,950	137,040	126,730
B.C.	3,520	6,620	1,460	16,560	3,040	31,200	12,890
Yk	1,980	1,850	7,640	3,630	-	277,940	251,110
N.W.T.	22,410	75,200	95,480	65,210	19,640	15,100	12,980
Canada	**42,790**	**251,500**	**360,520**	**333,510**	**283,620**	**1,271,940**	**1,113,270**

Table 5. Population status of forest bird species in selected forested ecozones, 1968 to 2000 (number of species; Environment Canada 2007)

	Increasing	Little Change	Decreasing
Boreal Shield	6	42	9
Montane Cordillera	4	35	6
Atlantic Maritime	8	34	11
Pacific Maritime	3	18	9

compared to those in non-boreal areas in southern Canada; an exception is the southern extent of the boreal forest, where human activity in the boreal region is greatest (Appendix 1: figures 1-3, 1-4, 1-5).

Historically, most forestry and other types of economic development in Canada have moved from south to north. Recent research by the World Resources Institute's Global Forest Watch Canada has found that approximately 60% of the boreal forest landscape has not been greatly modified by human interaction (Lee et al. 2003). The greatest proportion of unmodified area is in the Yukon Territories and in northern British Columbia (Taiga Cordillera and Boreal Cordillera ecozones), northern Ontario and Manitoba (Hudson Plains), and east–central Northwest Territories and Nunavut (Taiga Shield). Approximately 50% of northern Ontario, Quebec, Manitoba, Saskatchewan (Boreal Shield), western Northwest Territories and eastern Yukon remain unmodified, whereas only 17% of central and northern Alberta, central Saskatchewan and Manitoba (Boreal Plains) are predominantly unmodified (Lee et al. 2003).

Non-forest resources and land uses

Canada's boreal region contains extensive non-forest resources. Many have yet to be developed; as world demand for base metals, precious metals, and energy grows, so too will pressure to exploit these resources.

Mineral resources are found across the entire boreal and are most prevalent in Ontario, Quebec and Saskatchewan (Table 6; Appendix 1: Figure 1-6). Remaining known recoverable oil and gas reserves are predominately found in the western Canada sedimentary basin, located in the boreal regions of Alberta, Saskatchewan, northeastern British Columbia, and southern Northwest Territories (Indian Affairs and Northern Development 2007c; National Energy Board 2006a); presumably oil and gas extraction will

Table 6. Estimated number of mineral deposits in the boreal forest region (Natural Resources Canada 2007b)

Region	Deposit Type						
Boreal	Iron Formations	Molybdenum	Uranium and Thorium	Lode Gold	Vanadium and Titanium	Total	Boreal share of total
Alta.[1]	1	5	23		7	36	84%
B.C.[2]		113	39	14	6	172	15%
Man.[3]	1	48	35	13	4	101	80%
N.W.T[4]		37	348	9	3	397	100%
Nfld.	6	106	85	7	15	219	100%
Nvt.[5]	14	20	165	6		205	51%
Ont.[6]	24	370	114	81	32	621	41%
Que.[7]	60	219	130	68	117	594	69%
Sask.[8]		120	376	13	2	511	98%
Yk.	5	95	74	7	3	184	100%
Total[9]	111	1133	1389	218	189	3040	54%
Non-boreal							Boreal and non-boreal total
Alta.[1]			1		6	7	43
B.C.[2]	18	732	189	26	44	1009	1181
Man.[3]	1	13	9	1	2	26	127
N.W.T[4]					1	1	398
Nfld.							219
Nvt.[5]	7	14	170	6	2	199	404
Ont.[6]	18	189	587	1	85	880	1501
Que.[7]	7	84	128	2	42	263	857
Sask.[8]			9		2	11	522
Yk.							184
Total[9]	57	1109	1208	45	207	2626	5666

1. Deposits located north of 51 degrees latitude and west of 115 degrees longitude, or north of 54 latitude.
2. Deposits located north of 57 degrees latitude.
3. Deposits located north of 51 degrees latitude.
4. Deposits located south of 68 degrees latitude.
5. Deposits located south of 64 degrees latitude.
6. Deposits located north of 49 degrees latitude and west of 85 degrees longitude, or north of 48 degrees latitude.
7. Deposits located north of 48 degrees latitude.
8. Deposits located north of 54 degrees latitude.
9. Non-boreal totals includes deposits in New Brunswick, Nova Scotia, and Prince Edward Island.

continue to occur there. Vast reserves of bitumen are located in the oil sands of the boreal region of northeastern Alberta.

The bulk of future oil and gas exploration and development activity is expected to take place in the western Canada sedimentary basin (tables 7 and 8; National Energy Board 2006a). However, there is growing interest in the potential (unproven) natural gas reserves in the northern boreal region (Indian Affairs and Northern Development 2007c).

In addition to oil and natural gas, considerable peat resources occur in the boreal; Canada's peat resources account for 40% of the global resource, and many of them are located in the boreal regions of the Northwest Territories (23%), Ontario (20%), and Manitoba (19%; International Peat Society n.d.). Peat is a potential energy source and is also used to produce horticultural products (Environment Canada 2000b). However, these lands in Canada are important environmental and ecological resources, and their economic development and management remains contentious.

Canada generates about 60% of its electricity from hydroelectric facilities. Many of the country's large hydroelectric dams are located in the boreal regions of Quebec, Newfoundland and Manitoba. Canada still has an estimated 180 000 megawatts of potential electrical energy remaining, although only 34 000 is considered economically viable; much of this is expected to also come from the northern regions of the boreal (Natural Resources Canada 2000).

The boreal region is an important source of land for agriculture (Robinson et al. 1999). As of 1996, there were approximately 15 million ha of agricultural land contained within Canada's boreal region, or less than 3% of the total boreal region (Table 9). Agricultural land, as a proportion of the total boreal land area, is a prominent land use in the boreal regions of Alberta and Saskatchewan, accounting for 14.7% and 10.4% of the provinces' land area in 1996. Most agricultural activity occurs in central Saskatchewan and central and northeastern Alberta (Appendix 1; Figure 1-7), overlapping the Boreal Plains ecozone. Most of British Columbia's grain production takes place in the boreal plains, in the northeast part of the province.

Table 7. Estimated established reserves of marketable crude oil and bitumen as of December 31, 2004. Estimates include proven reserves; they do not include potential reserves (National Energy Board 2006a)

(million m^3)	Initial	Remaining
Conventional Crude Oil (inland)		
British Columbia	126	22
Alberta	2 665	250
Saskatchewan	859	188
Manitoba	41	4
Ontario	15	2
NWT and Yukon (inland)	53	17
Total Boreal Region	3 758.6	483
Total Canada (inland and offshore)	4005	640
Crude Bitumen		
Oil Sands - Upgraded Crude	5 590	5 090
Oil Sands - Bitumen	22 802	22 570
Total Crude Bitumen in Boreal	28 392	27 660
Total Conventional and Bitumen in Boreal		
Total Conventional and Bitumen	32 397	28 300

Table 8. Estimate established reserves of marketable natural gas, as of December 31, 2004 (National Energy Board 2006a)

(Billion m^3)	Initial	Remaining
British Columbia	822	284
Alberta	4 496	1 127
Saskatchewan	225	75
Ontario	34	12
NWT and Yukon (Mainland)	32	14
Total Boreal Region	5 609	385

Human settlement

Statistics Canada, using census data, compiles and publishes information on population demographics by province and ecozone in the periodic report, *Human Activity and the Environment*. Based on this information, approximately 12% of Canada's population lives within the country's boreal forest ecozones. The percentage ranges from 100% in Newfoundland to less than 2% in British Columbia (Table 10; Statistics Canada 2005).

Total human population within the boreal has increased during the last 25 years—by about 200 000 people between 1981 and 2001—but declined recently by 50 000 due to emigration from Newfoundland and northern Ontario (Table 10; Statistics Canada 2000, 2005). Since 1981, population has increased steadily in Quebec and Alberta, declined in Newfoundland, and remained steady, but variable, in other provinces within the boreal region.

In 1996, the population in the boreal region was almost evenly split between urban and rural settlement (Table 10). The Ontario boreal region is the least rural (36%), Manitoba's is the most rural (70%). Population density varies across the boreal, but is generally low. Areas with the highest population densities are in Ontario, Quebec, Alberta and Newfoundland.

Presence and impact of human activities across the boreal region can be measured by density of transportation infrastructure—in particular, roads. Although considerable forestry, mining, oil and gas, and agricultural activities occur within the boreal forest, road access within the boreal region remains low across the region, except in parts of eastern Canada and Alberta. (Appendix 1: Figure 1-8).

Aboriginal peoples

First Nations peoples are an important segment of boreal population (Stevenson and Webb 2003). According to the 2001 Census, Canada is home to approximately 1.3 million Aboriginal people (online at: http://www12.statcan.ca/english/census01/Products/Analytic/companion/abor/canada.cfm), 734 000 of which are "Registered Indians" [see Newhouse and Peters (2003) for definitions of Aboriginals and

Table 9. Agricultural land use trends in the boreal region, 1971 to 1996 (adapted from Statisics Canada 2000)

		Agricultural land			Percent of boreal region in agricultural land	
		Area (km²)		Change		
	Total Boreal Area	1971	1996	1971-1996	1971	1996
Nfld.	388,000	254	438	72.75	0.1	0.1
Que.	1,094,800	10,125	7,348	-27.43	0.9	0.7
Ont.	749,960	8,263	6,252	-24.33	1.1	0.8
Man.	568,770	19,080	19,886	4.22	3.4	3.5
Sask.	412,700	42,084	43,017	2.22	10.2	10.4
Alta.	455,550	57,930	66,887	15.46	12.7	14.7
B.C.	252,500	6,385	7,987	25.09	2.5	3.2
Canada	5,450,000	144,120	151,816	5.34	2.6	2.8

Table 10. Boreal population, 1981 to 2001 (adapted from Statisics Canada 2000 and 2005)

	Population			Density (persons/km²)		1996 Percentage	
			Change				
	1981	2001	1981-2001	1981	2001	Urban	Rural
Nfld.	567,681	512,930	-38,862	1.70	1.54	57%	43%
Que.	1,171,540	1,305,828	7,783	1.12	1.25	60%	40%
Ont.	938,546	939,122	-42,445	1.15	1.15	63%	37%
Man.	173,409	192,411	712	0.36	0.40	30%	70%
Sask.	175,367	177,127	370	0.50	0.51	36%	64%
AB	356,047	441,403	24,918	0.81	1.00	45%	55%
BC	56,624	61,211	158	0.19	0.21	58%	42%
YK	23,152	28,674	-2,092	0.05	0.06	60%	40%
NWT	28,000	33,739	-4,113	0.03	0.04	52%	48%
NT	..	0	0	..	0.00	..	..
Boreal Region	3,490,366	3,692,445	-53,571	0.69	0.73	56%	44%

issues associated with understanding Aboriginal population changes]. Currently, the exact number and distribution of Aboriginal peoples living in the urban and rural environments within the boreal region are unknown. However, Canada's Aboriginal population is younger than the Canadian average and is expected to grow by 40% during the next 25 years (Indian Affairs and Northern Development 2007a), especially on-reserve populations in the prairie provinces: between 2004 and 2029, the working-age Aboriginal population will grow by 41% (Indian Affairs and Northern Development 2007b).

Although the exact number of Aboriginal people living within the boreal region is unknown, significant numbers are located in productive forest areas (Appendix 1: Figure 1-9) and depend on the forest for "nutritional, social, cultural, spiritual, and other needs…" and, to a lesser extent (5%), employment in forestry (Stevenson and Webb 2003). For example, more than 90% of all Aboriginal census communities in the 2001 Aboriginal Peoples Survey counted at least one adult who used non-timber forest resources (Table 11; Statistics Canada n.d.[a]). About two-fifths of all adults living in these communities hunted, fished or gathered wild plants, primarily for food. A smaller percentage of Aboriginal communities and peoples participated in trapping animals. A study by Beckley and Hirsch (1997) found that about 30% of household income and income-in-kind was generated from non-timber uses of the forest in Aboriginal forest-dependent communities in the Northwest Territories.

Table 11. Aboriginal peoples use of non-timber land resources (Statistics Canada n.d.[a], Aboriginal Peoples Survey)

	% of adults who hunted in past 12 months	% of those who hunted for food	% of adults who fished in past 12 months	% of those who fished for food	% of adults who gathered wild plants	% of those who gathered for food	% of adults who trapped in the past 12 months
Average value for all communities with responses	37	95	45	85	40	82	15
% of communities with response	92	91	94	94	96	96	41

Table 12. Total roundwood production, 1970 to 2004, for boreal provinces and territories (Canadian Council of Forest Ministers n.d.)

Year	1970	1975	1980	1985	1990	1995	2000	2004	Change 1970-2004
					1000 m³ (percentage change)				
Nfld.	2,849	2,452	2,795	2,509	2,876	2,983	2,868	2,327	- 522
		-14%	14%	-10%	15%	4%	-4%	-19%	-18%
Que.	28,897	28,407	31,686	35,400	30,148	41,438	43,485	43,269	14,372
		-2%	12%	12%	-15%	37%	5%	0%	50%
Ont.	16,795	14,216	21,322	28,225	25,420	26,260	28,118	25,147	8,352
		-15%	50%	32%	-10%	3%	7%	-11%	50%
Man.	1,260	2,022	2,335	1,717	1,563	1,987	2,188	2,106	846
		60%	15%	-26%	-9%	27%	10%	-4%	67%
Sask.	2,376	2,313	3,330	3,016	2,758	4,258	4,197	6,103	3,727
		-3%	44%	-9%	-9%	54%	-1%	45%	157%
Alta.	4,143	4,963	5,933	8,979	11,911	20,287	23,418	23,510	19,367
		20%	20%	51%	33%	70%	15%	0%	467%
B.C.	54,726	50,078	74,654	76,868	73,861	74,622	78,457	86,998	32,272
		-8%	49%	3%	-4%	1%	5%	11%	59%
Yukon	83	198	115	186	82	357	33	26	-57
		139%	-42%	62%	-56%	335%	-91%	-21%	-69%
N.W.T. and Nunavut	..	..	..	..	46	127	22	26	-20
		..	..	..	..	176%	-83%	18%	-43%
Canada	121,625	115,510	155,624	168,722	162,576	188,497	201,845	208,062	86,437
		-5%	35%	8%	-4%	16%	7%	3%	71%

State of the boreal forest sector

Considerable information is available on the state of Canada's forest industry. The National Forest Database Program of the Canadian Council of Forest Ministers compiles information on the production of roundwood, firewood and fuelwood, Christmas trees and maple syrup. Statistics Canada conducts the Annual Survey of Manufacturers, which captures most timber-related economic activities under the categories of forestry and logging services, pulp and paper products industry, and wood products industries. The information is used by Industry Canada to analyze the sector, and by the Canadian Forest Service to produce statistics for use in reports such as *The State of Canada's Forests*. The Forest Products Association of Canada and PriceWaterhouse Coopers collect and publish information on the state and direction of the Canadian forest products industries (Forest Products Association of Canada 2003; PriceWaterhouse Coopers 2006). That said, information on the sector specifically contained within the boreal forest region or specifically related to the boreal forest region is less readily available, and must be derived or compiled from other data sources.

Timber supply, timber harvest and timber land resources

Table 12 presents historical roundwood production data from 1970 to 2004 for the provinces and territories with boreal forests, and for Canada. Canada's total harvest has increased 70% over the past 35 years, from 122 million m^3 in 1970 to 208 million m^3 in 2004.

Although not all of the timber was harvested from boreal forests, the proportion of total harvest coming from the boreal region is increasing: since 1970, harvest has increased in all provinces with boreal forest, except Newfoundland. Of the provinces with boreal forests, Alberta and Quebec have had the largest absolute increases. British Columbia had large increases in harvest, but most of those have been from the non-boreal forests in the province's interior. Manitoba and Saskatchewan have seen modest increases. The timber supply in the three territories has been historically variable, with recent harvest declines.

Notable points in time in the overall increase in the Canadian annual harvest were 1975 and 1990: after 1975, significant increases in harvesting occurred in British Columbia and Ontario. Similar jumps in harvest occurred after 1990 in Alberta, Saskatchewan and Quebec. With the exception of that in British Columbia, most of the increased harvest involved development of both softwood and hardwood resources in provinces with large tracts of boreal forest. Of special note, the increased harvest has involved greater extraction of

Table 13. Hardwood harvests, 1970 to 2004, by province (Canadian Council of Forest Ministers n.d.)

Year	1970	1980	1990	2000	2004	Change 1970-2004	% of logs 1970	% of logs 2004	% of pulpwood 1970	% of pulpwood 2004	% of total harvest 1970	% of total harvest 2004
	000's cubic metres (percentage change)											
Nfld.	0	3	6	10	9	9						
		..	100%	67%	-10%	0%	..	2%	0%	0%	0%	0%
Que.	3 474	3 114	4 902	8 502	9 287	5 813						
		-10%	57%	73%	9%	-37%	22%	18%	9%	66%	13%	22%
Ont.	2 915	3 751	4 091	7 568	7 175	4 260						
		29%	9%	85%	-5%	-41%	33%	9%	11%	36%	18%	29%
Man.	146	122	70	651	687	541						
		-16%	-43%	830%	6%	-21%	31%	6%	8%	49%	14%	34%
Sask.	210	362	799	1 780	3 008	2 798						
		72%	121%	123%	69%	-7%	2%	5%	16%	75%	10%	50%
Alta.	54	108	2 373	9 179	9 247	9 193						
		100%	2097%	287%	1%	-1%	1%	23%	4%	100%	1%	39%
B.C.	129	99	620	2 478	3 019	2 890						
		-23%	526%	300%	22%	-4%	1%	5%	0%	0%	0%	4%
Canada	8 131	9 354	15 237	35 445	36 929	28 798						
		15%	63%	133%	4%	-22%	6%	10%	9%	57%	7%	18%

northern hardwood species, particularly trembling aspen (Table 13). For example, in Alberta, the annual timber supply [annual allowable cut (AAC)] in 1986 was 26 million m^3—14 million m^3 of softwood and 12 million m^3 of hardwood—but the annual harvest rate was only 6.5 million m^3, of which almost all was softwood (McDougall 1986). Today, Alberta's harvest levels are close to the total supply available for both softwoods and hardwoods, a phenomenon made possible by advances in wood technology, such as use of aspen to make oriented strand board (OSB), and improved harvesting and processing capacity.

Timber harvest and timber supply (AAC) for provinces and territories with both boreal and non-boreal forest resources are not equal. Since AAC and harvest information is not reported for the boreal forest region or by ecozone, estimating the boreal forest contribution to Canada's total timber supply is difficult. In this paper, estimates are derived from both provincial and federal information sources: timber supply information reported in the National Forest Database Program is used as an estimate of the boreal forest timber supply for the prairie provinces, Newfoundland, Yukon, and the Northwest Territories. For these boreal-dominated provinces and territories (Newfoundland: 100%; Saskatchewan: 97%; Manitoba: 95%; Yukon: 100%; and Northwest Territories: 96%), the boreal timber harvest and AAC, and the reported timber harvest and AAC are essentially equal. Ninety percent of Alberta's timber-producing forests lies within the boreal ecozone: Alberta's boreal timber supply is approximately equal to its total timber supply, even though the montane region along the east slopes of the Rockies has historically been an important source of timber (McDougall 1986). Because Ontario, Quebec, and British Columbia each have large areas of non-boreal timber-productive forest, national data for these jurisdictions are not representative of the boreal-timber supply. (See Appendix 3 for key aspects of AAC in Canada.)

Information on the forest industry specific to the boreal region of Ontario is sketchy. According to the Ontario Ministry of Natural Resources and other Ontario sources, the boreal accounts for 76% to 80% of the province's managed forest lands, and thus contributes about 80% of Ontario's timber supply and harvest (Ontario Forest Industries Association 2005; OMNR 2004a). However, future levels of timber supply and harvest from Ontario's boreal are uncertain. Although that province's timber supply is projected to decline during the next two decades (OMNR 2004a), the Ontario government plans to develop parts of the boreal that are currently undeveloped (Ross 2004), possibly causing timber supply in Ontario's boreal forests to increase. Quebec has information on AAC and harvest levels from 17

Table 14. Calculated potential and actual harvest originating from boreal forests of Canada, 2004

Province/Territory	Estimated Annual Allowable Cut for Boreal (million m^3) (2004)	% of Total AAC	Estimated Harvest From Boreal (million m^3) (2004)	% of Total Harvest	Source
Newfoundland	2.5	100	2.4	100	CCFM (2005a)
Quebec[1,2]	30.6	60	24.5	57	MRNFP (2007)
Ontario[3]	25.4	80	20.1	80	CCFM (2005a), OMNR 2004b
Manitoba[4]	8.9	100	2.1	100	CCFM (2005a)
Saskatchewan[4]	8.2	100	6.1	100	CCFM (2005a)
Alberta[5]	24.3	100	23.5	100	CCFM (2005a)
British Columbia[5,7]	6.5	8	4.6	6	BC MOFR (2007), CCFM (2005a)
Yukon[8]	0.2	70	0.03	70	CCFM (2005a)
Northwest Territories[9]	0.2	100	0.02	100	CCFM (2005a)
Total Boreal	106.8	47	83.4	40	Calculated
Total Canada	225.6	100	208.1	100	CCFM (2005a)

Notes:
1. AAC and actual harvest calculated by summing up AAC and harvest data in the boreal forest management areas
2. Includes Saguenay: Lac Saint-Jean, Abitibi-Témiscamingue, Côte-Nord, Nord du Québec, Gaspésie – Îles de la Madeleine.
3. Total AAC and harvest multiplied 0.80 - proportion of forest under planning in the boreal forest region (OMNR 2004b).
4. Assumes all harvest sourced from boreal forests. Includes allocated and unallocated AAC.
5. Assumes total harvest from boreal forests.
6. AAC calculated by summing up AAC in Cassiar, Fort Nelson, Fort St.John, Dawson Creek TSAs and all of TFL 48.
7. Actual harvest based on harvest information for the Fort Nelson and Peace Forest Districts.
8. Most recent and available data is 2003. Assumes 70 % of harvest comes from productive boreal forests.
9. Only 1996 data available.

administration units that provides a basis to estimate AAC and harvest levels in that province's boreal region. Using the administrative regions of Saguenay–Lac Saint-Jean, Abitibi–Témiscamingue, Côte-Nord, Nord-du-Québec, and Gaspésie–Îles de la Madeleine as proxies for Quebec's boreal forest region, approximately 60% and 57% of the province's timber supply and harvest (2004) are located in the boreal region. Future boreal timber supply and harvest are uncertain there, as well. In 2005, the Quebec government introduced measures to implement recommendations of the Coulombe Forest Commission, which suggested a 20% reduction in the harvest of spruce, jack pine, fir and larch (SPFL) species, and a 5% reduction in all other species (Commission d'etude… 2004). Timber supply reductions have occurred across the board, but actual impact on harvesting levels in the boreal region of Quebec may not be large because the new supply limits still exceed historical harvesting levels in the four boreal administrative districts (Ministere des Ressources Naturelles, de la Faune et des Parcs 2003, 2007).

Boreal timber supply and harvest information for British Columbia is available from the BC Ministry of Forests and Range website (www.for.gov.bc.ca). British Columbia's boreal region encompasses the forest districts of Fort Nelson, Peace and the northern portion of the Skeena–Stikine [Cassiar Timber Supply Area (TSA)]. These areas account for 8% of the province's AAC and 6% of the provincial harvest (2004).

Calculated estimates of provincial and territorial timber supply and harvests in 2004 are presented in Table 14. As a whole, Canada's boreal region accounted for 47% of the country's AAC and 40% of its total timber harvest. So, even though the boreal contains 72% of Canada's forests (Table 1), these resources provide only 40% of the country's wood supply. This reflects two aspects of the boreal region:

1. boreal forests, on average, have lower yields (m^3/ha) and are less productive (m^3/ha*yr) than non-boreal forests, due to tree species, climate, and disturbance history;
2. boreal forests are further away from markets and transportation infrastructure, and have been commercially developed at a slower rate than have southern forest resources.

By using the estimated proportions of harvest from the boreal in each province and territory in Table 14 and applying it to the area values listed in Table 15, estimates of area managed in boreal forest for timber can be derived. Estimated timber-managed boreal forest, for 1997, is about 78 million ha, or 59% of the total managed forest (Table 15). This area may increase over time as areas planned for development (forestry or otherwise) are developed (Canadian Council of Forest Ministers 2005a; OMNR 2001).

Area of boreal forest affected by timber harvesting has increased during the last three decades; however, area of forest protected within the boreal forest has also increased. About 7% of the boreal has some form of protected area status (Figure 4), more than triple the percentage of protected boreal area in 1970, but less than one-half the percentage of area protected in the Montane Cordillera ecozone, and

Table 15. Estimated area of managed boreal forest (adapted from Statistics Canada 2000)

Province/Territory	Total Managed Forest (millions of hectares)	Managed Boreal Forest (millions of hectares)
Newfoundland	2.4	2.4
Quebec	31.2	20.6
Ontario	22.9	18.3
Manitoba	5.3	5.3
Saskatchewan	5.2	5.2
Alberta	20.9	20.9
British Columbia	33.1	3.0
Yukon Territory	1.4	0.9
Northwest Territories	1.7	1.7
Canada**	133.0	78.3
Boreal as % of Total Managed Forest		59%

Calculated. 66 % of Quebec's total managed forest (MRNFP 2003), 80 % of Ontario's (OMNR 2004b). BC and Yukon are estimates.
**Excludes boreal forest on Cape Breton Island, Nova Scotia

little over one-half the area protected in the Pacific Maritime forest ecozone. The percentage of protected boreal area is larger than the percentage of protected area within the Atlantic Maritime ecozone, where a large percentage of the land is privately owned (Lowe et al. 1994). Although the percentage of protected area is less for the boreal ecozone than for other major forest ecozones, because of its immensity the absolute area of boreal forest that is protected is three times larger than the total protected area of all other ecozones. However, if protected area distribution (Appendix 1: Figure 1-10) is compared against areas of high biodiversity risk (Appendix 1: Figure 1-3, 1-4, and 1-5), the differences in areas indicate protected areas may not be located where they are most needed. (See Appendix 2: Table 2-2 for area and percentage of land protected according to province and territory.)

Boreal forest industry structure and performance

The forest sector is an important industrial sector in Canada. It contributes about 3% of Canada's gross domestic product (GDP) and employs tens of thousands of people. The boreal forest region's contribution to the Canadian forest sector is significant; but its exact contribution is unknown. In Newfoundland, the three territories, Saskatchewan, Manitoba and, to a lesser extent, Alberta, boreal forest resources more or less support the entire forest sector. No information on the exact contribution of boreal resources to the Canadian forest sector is available for the other provinces.

An estimate of the contribution of the boreal forest to the overall Canadian forest economy can be deduced from the estimated level of timber harvesting that occurs within the boreal forest in each province and territory (Table 14). If we assume a one-to-one correspondence between level of forest harvest and level of economic activity, approximately 40% of Canada's timber-based forest sector was generated from the boreal forest timber resources in 2004. This equals $41 billion in total revenue per year, directly employing approximately 127 000 people and stimulating economic activity indirectly in other sectors of the economy. However, while 40% of the total Canadian timber economy can be attributed to the boreal forest resources, not all this economic activity occurs in boreal forest areas. Many of the processing facilities are located along or outside the southern edge of the boreal, especially in Ontario and Quebec. (See Appendix 1: Figure 1-11 for location of sawmills in Canada). For example, approximately 20% of manufacturing facilities in the pulp and paper sector is located within the boreal

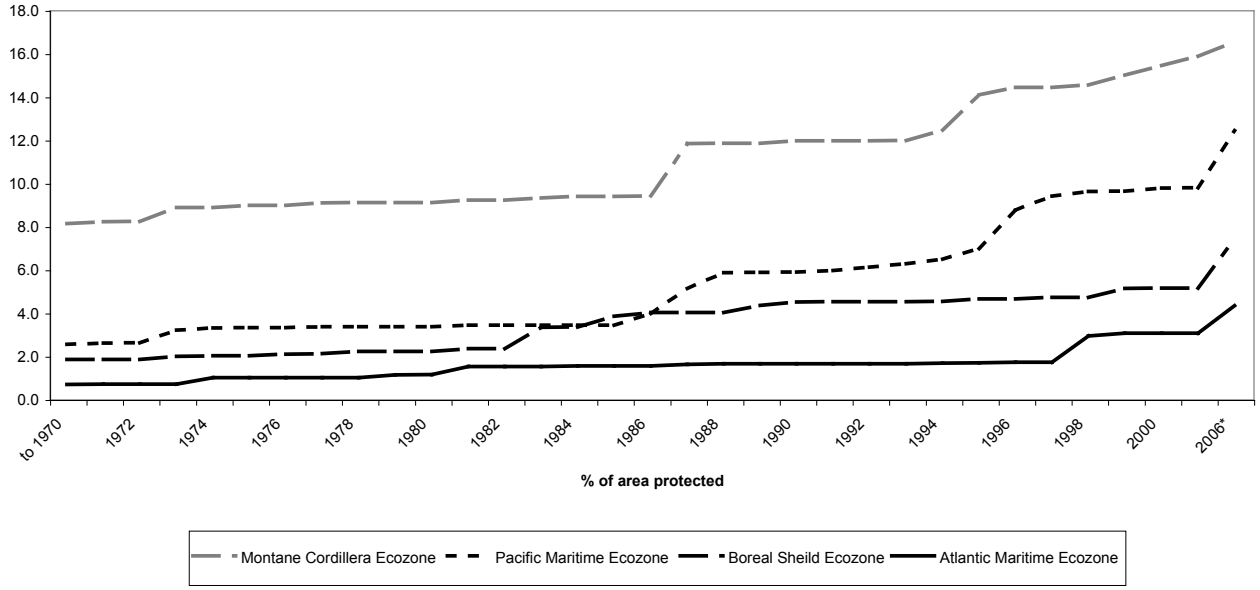

Figure 4. Strictly protected forest area in selected forested ecozones (cumulative %; Environment Canada 2007; *Environment Canada 2006)

forest region (Table 16), and 45% of Ontario's forest industry is in the boreal region (OMNR 2003). For a discussion on factors that affect location of the logging and processing industries, see Appendix 4.

The Canadian forestry sector is composed of three sub-sectors: logging, wood industries, and paper industries [see National Technical Information Service (2002) for sector definitions and codes; this paper includes categories 113b: Forestry and Logging; 1153: support activities for Forestry; 321: Wood Product Manufacturing–including engineered wood products; and 322: Paper Manufacturing]. The wood and paper industries include enterprises that produce primary commodities such as lumber, panel boards, pulp, and secondary products such as door frames and tissue paper. The boreal forest sector is a sub-sector of the total national forest sector, and includes most types of manufacturing activity found outside the boreal. However, because of abundance of some hardwood species, a greater proportion of engineered panel products are produced in some regions of the boreal.

The boreal logging industry is the smallest of the three sub-sectors in terms of revenue ($5.2 billion) and number of employees (19 000; Table 17). Because logging involves the initial transformation of trees into useable wood products, almost all of this industry occurs where the resource is located in the boreal region, although log and chip hauling occurs both within and outside the boreal region. The Quebec boreal logging industry is the largest in the country in terms of employment, whereas Ontario's is the largest in terms of revenue. Approximately 60% of the boreal logging industry, in terms of persons employed, is located in Quebec and Ontario. The next largest boreal logging regions are Alberta and British Columbia.

In absence of information that allows for exact accounting of the boreal and non-boreal wood and paper industries, the author calculated estimates by multiplying the total values for each industry by the estimated proportion of harvesting (in m^3/yr) that originates within the boreal forest region. Based on these estimates, the boreal wood products industries make up the second largest boreal forest sector in terms of value of revenue, and the largest in terms of employment. In 2004, boreal forest resources supported approximately $17 billion worth of revenue and employed about 60 000 people (Table 18). Quebec's and Ontario's boreal wood products industries are the largest, accounting for two-thirds of people employed and an equivalent proportion of value of shipments. Alberta has the next largest boreal wood products industry.

Table 16. Estimated number of pulp and paper mills within the boreal region, 2003 (Pulp and Paper Canada 2003)

	Number of mills
N&L	3
Que.	14
Ont.	11
Man.	2
Sask.	2
AB	7
BC	1
Boreal	40
% of all mills	22%

Table 17. Estimated economic impacts of the boreal forest resource to the logging industry by province, 2004 (Statistics Canada n.d. [b] Table 301-0007)

	Nfld.	Que.[1]	Ont.[1]	Man.	Sask.	Alta.	BC[1]	Canada (Boreal)[1]
Employment	606	7,266	5,358	549	643	3,825	1,031	19,279
Total Revenue (millions)	$137	$1,647	$1,659	$128	$263	$973	$374	$5,181
Wages (millions)	$23	$241	$260	$21	$29	$160	$53	$787
Cost of Energy and Water Utility (millions)	$3	$32	$40	$5	$5	$33	$7	$125
Cost of Materials and Supplies (millions)	$74	$881	$1,097	$75	$167	$502	$230	$3,025
Apparent Net Revenue (millions)	$37	$492	$261	$28	$62	$278	$85	$1,244

1. Internal Calculation

An important sub-component of the wood products industry in Canada, and in its boreal region, is the sawmilling industry. The boreal forest supports a significant sawmilling industry in Quebec, Ontario, and Alberta. Figure 5 shows the historical production of sawnwood by province. Since the early 1980s, the sawnwood industry in Quebec, Ontario and Alberta has grown considerably; much of this expansion has come from resources originating in the boreal forest.

Boreal hardwoods are an important source of fibre for wood products industries in the boreal regions of British Columbia, the prairie provinces, and Ontario. These resources have been an important supply source for engineered wood products (Adamowicz et al. 2003). Statistics Canada does not provide provincial information on wood panels, pulp chips, or pulp production, but Towill et al. (2004) provide information on the contribution of boreal mixedwood forests—hardwoods in particular—to the Ontario forest economy.

Based on the author's estimate calculations, the boreal-region pulp and paper industry is the largest boreal forest industry sector in terms of revenue and is the second largest in terms of employment. In 2004, boreal forest resources supported approximately $19 billion worth of revenue and employed about 48 000 people (Table 19). The boreal paper industries are capital- and energy-intensive; mills tend to be much larger, but employ fewer people, than do wood product industry mills in order to take advantage

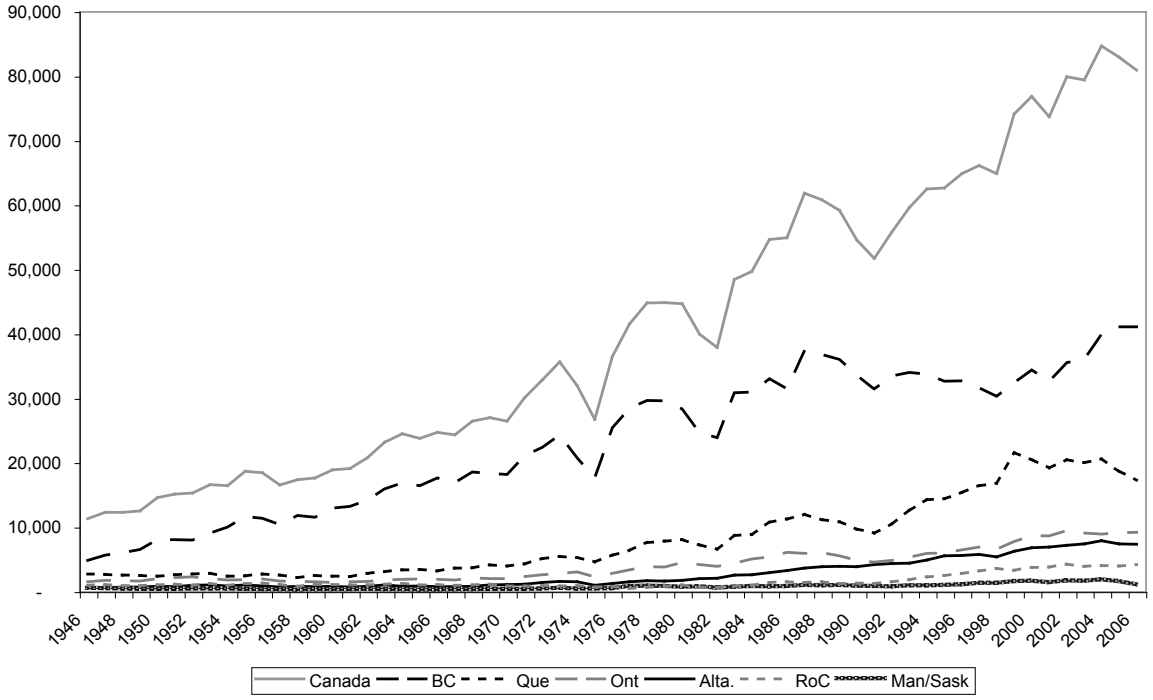

Figure 5. Lumber production from 1946 to 2006, by select provinces (000s m^3 dry; Statistics Canada n.d. [b] Table 303-0009)

Table 18. Estimated economic impacts of boreal forest timber resources to wood industries, 2004 Statistics Canada, n.d.[b]Table 301-0006)

	Nfld.	Que.[1]	Ont.[1]	Man.	Sask.	Alta.	BC[1]	Canada (Boreal)[1]
Employment	419	21,111	19,874	3,733	1,659	11,181	2,112	60,089
Total Revenue (millions)	$73	$5,617	$5,230	$754	$697	$3,788	$750	$16,909
Wages (millions)	$13	$802	$819	$126	$81	$512	$104	$2,456
Cost of Energy, Water Utility and Vehicle Fuel (millions)	$3	$144	$160	$19	$20	$116	$21	$482
Cost of Materials and Supplies (millions)	$39	$3,164	$2,685	$340	$262	$1,660	$406	$8,556
Total Expenses	$70	$5,200	$4,719	$647	$480	$3,028	$637	$14,781
Apparent Net Revenue (millions)	$3	$417	$511	$108	$217	$760	$112	$2,128

1. Internal Calculation

of economies of scale. Ontario has the largest boreal pulp industry in terms of employment and revenue. Together, Ontario and Quebec account for more than 80% of the total boreal paper sector in Canada.

Overall, in 2004, about 84 million m^3 of harvested boreal softwood and hardwood timber resources supported the employment of 108 thousand people and produced $35 billion worth in revenue from the sale of forest products (wood and paper; Table 20). The forest products industry was healthy at that time, but industry analysts report that the industry suffers from a low return on capital employed and that current industrial structure is unsustainable (PriceWaterhouse Coopers 2006; Roberts 2005). Recent mill closures (e.g., in Stephenville, Newfoundland, and Kenora, Ontario, in 2005) suggest current and future performance may not be healthy. In aggregate, the apparent net revenue (value of shipments minus wages, energy, and costs of materials) for the entire boreal forest products industries was nearly $2.8 billion in 2004. The surplus was split between industry profits, payments to capital, and payments to government in the form of stumpage charges, rents and taxes [Schwindt and Heaps 1996; Forest Products Association of Canada (2003) provides a breakdown of the entire Canadian forest products industry]. The industry may seem to be profitable, but underlying structural issues in some regions and industries, such as eastern Canada and the newsprint industry, indicate otherwise.

Information on performance of the boreal forest industries per se is unavailable, but a recent study by Hailu and Veeman (2003) found that productivity of the boreal logging industry increased at an average annual rate of 1.56% between 1977 and 1995. It is also possible to compare the general performance of the Canadian paper and wood industries to other Canadian industries to determine performance. Three measures of productivity for the wood, paper and all Canadian industries are presented in Table 21: wood and paper industries seem to be improving productivity (efficiency) more rapidly than the Canadian average; if only labor productivity (value of output per unit of labor) is considered, the Canadian wood industry is outperforming the industrial average, whereas the paper industry is lagging. Similarly, the

Table 19. Estimated economic impacts of the boreal forest timber resources to Canadian paper industries, 2004 (Statistics Canada, n.d. [b] Table 301-0006)

	Nfld.	Que.[1]	Ont.[1]	Man.	Sask.	Alta.	BC[1]	Canada (Boreal)[1]
Employment	1,541	15,668	24,642	1,814	1,006	2,967	758	48,395
Total Revenue (millions)	450	6,123	9,138	564	629	1,689	356	$18,948
Wages (millions)	75	881	1,435	91	85	206	54	$2,827
Cost of Energy, Water Utility and Vehicle Fuel (millions)	82	659	716	35	64	170	41	$1,766
Cost of Materials and Supplies (millions)	207	3,043	4,369	243	255	839	180	$9,137
Total Expenses	481	5,897	8,791	515	691	1,558	356	$18,290
Apparent Net Revenue (millions)	-31	226	346	49	-62	131	0	$658

1. Internal Calculation

Table 20. Estimated economic impacts of the boreal forest timber resources on the forest products industry, 2004 (Statistics Canada, n.d. [b] Table 301-0006)

	Employment	Total Revenue (millions)	Wages (millions)	Cost of Energy, Water Utility and Vehicle Fuel (millions)	Cost of Materials and Supplies (millions)	Total Expenses	Apparent Net Revenue (millions)
Nfld.	1,960	523	88	85	246	551	-28
Que.[1]	36,779	11,740	1,683	803	6,207	11,097	643
Ont.[1]	44,515	14,367	2,254	876	7,054	13,510	857
Man.	5,547	1,318	217	54	582	1,162	156
Sask.	2,665	1,326	166	83	517	1,171	155
Alta.	14,148	5,477	718	286	2,500	4,586	891
BC[1]	2,870	1,106	158	61	586	994	112
Canada (Boreal)[1]	108,484	$35,857	$5,283	$2,249	$17,693	$33,071	$2,786

1. Internal Calculation

wood and paper industries have decreased their capital intensity relative to other industries; in the paper industry, this is largely due to closure of high-cost mills. Considering the efficient use of all inputs other than capital and labor (i.e., energy and wood fibre for forest industries), the wood and paper industries are again performing close to average.

Table 21. Comparison of productivity trends of the Canadian logging, wood, and paper industries vis-à-vis manufacturing sector, 1994-2003 (2002=100; Statistics Canada, n.d. [b] Table 383-0022)

	Labour productivity[1]				Capital Intensity[2]				Multifactor Productivity[3]			
	All	Forestry and Logging	Wood	Paper	All	Forestry and Logging	Wood	Paper	All	Forestry and Logging	Wood	Paper
1994	79	88	69	82	99	97	96	102	96	90	91	91
1995	81	83	72	80	99	94	98	102	96	90	90	90
1996	82	95	72	83	99	98	99	103	96	91	90	91
1997	85	98	78	87	99	99	99	103	96	92	91	92
1998	88	101	84	88	100	101	100	103	97	93	93	93
1999	93	103	82	92	100	99	99	102	99	92	94	96
2000	99	103	92	98	100	100	101	102	100	96	95	98
2001	98	97	92	96	100	101	100	101	99	97	95	97
2002	100	100	100	100	100	100	100	100	100	100	100	100
2003	101	98	104	99	100	100	100	100	100	99	101	100

1. Labour productivity based on gross output is measured as real gross output per hours worked. It shows the time profile of how productively labour is used to generate gross output. Changes in gross-output-based labour productivity reflect the joint influence of capital, skill upgrading, interme and overall productive efficiency.
2. Multifactor productivity based on value-added measures the efficiency with which capital and labour inputs are used to generate value-added. It is the ratio of real Gross Domestic Product (GDP) (real value-added) to combined labour and capital inputs.
3. Contribution of capital intensity to labour productivity growth is calculated as the growth in capital services per hour times capital's share of nominal Gross Domestic Product (GDP). It reflects the effects of capital investment on labour productivity

Table 22. Comparison of the financial performance of the forestry, wood and paper industries vis-à-vis other industry aggregates, 2000-2002 and 2003-2005 averages (Statistics Canada n.d. [b] Table 180-0003)

	Forestry, logging and support activities		Paper manufacturing		Wood product manufacturing	
	2000-2002	2003-2005	2000-2002	2003-2005	2000-2002	2003-2005
Assets	$7,744	$9,060	$53,198	$48,193	$28,163	$36,394
Liabilities	$4,767	$5,609	$30,752	$27,723	$16,694	$19,516
Debt to equity (ratio)	1.02	1.05	0.88	0.94	0.92	0.70
Operating expenses	$8,997	$10,087	$37,140	$35,891	$29,250	$36,432
Operating revenue	$9,454	$10,501	$41,569	$36,901	$31,247	$39,333
Operating profit/loss	$457	$414	$4,428	$1,010	$1,997	$2,901
Profit before income tax	$366	$355	$3,716	-$169	$1,232	$2,723
Profit margin (percent)	5	4	11	3	6	7
Return on capital employed (percent)	9	7	10	3	6	9
Return on equity (percent)	13	9	13	0	7	12
Taxes to positive adjusted profit (percent)	17	15	15	32	29	21
	Finance and insurance industries		**Non-financial industries**		**All industries**	
	2000-2002	**2003-2005**	**2000-2002**	**2003-2005**	**2000-2002**	**2003-2005**
Assets	$1,957,588	$2,441,848	$2,121,306	$2,493,652	$4,078,894	$4,935,499
Liabilities	$1,713,093	$2,120,102	$1,365,221	$1,590,604	$3,078,315	$3,710,705
Debt to equity (ratio)	1.07	0.97	1.17	1.13	1.15	1.08
Operating expenses	$188,843	$190,960	$1,984,688	$2,268,681	$2,173,531	$2,459,641
Operating revenue	$233,729	$248,911	$2,120,788	$2,429,479	$2,354,517	$2,678,390
Operating profit/loss	$44,886	$57,951	$136,100	$160,798	$180,986	$218,749
Profit before income tax	$28,318	$45,762	$106,820	$140,766	$135,139	$186,528
Profit margin (percent)	19	23	6	7	8	8
Return on capital employed (percent)	7	8	7	8	7	8
Return on equity (percent)	10	12	10	12	10	12
Taxes to positive adjusted profit (percent)	33	38	25	22	27	25

Financial indicators of the Canadian forest and paper sectors suggest the forest sector has under-performed vis-à-vis the Canadian average in recent years as measured by profit margin, return on capital and return on equity. Table 22 shows the three-year average financial statistics for the periods 2000–2002 and 2003–2005 for all three sub-sectors of the forest sector and for financial industries, non-financial industries, and all industries. The percentage of profit paid in taxes by the forest sector is in line with averages in other sectors. However, the forest industry differs from other sectors of the Canadian economy in that its performance and percentage of profit paid in taxes are much more variable from period to period, a reflection of the cyclical nature of commodity markets.

Although productivity and financial indicators for forest industries are generally consistent with other sectors of the economy, these results are industry averages that include non-boreal mills and both mills that are performing poorly and those that are performing exceptionally well. Therefore, without a breakdown of the industry into boreal and non-boreal, conclusions that boreal industries have been performing to the average are speculative. Furthermore, performance within the boreal may be very different due to regional conditions (Hailu 2003).

Output and input price trends provide some insight into the general state and challenges facing the logging and forest product industries. Comparison of price trends of outputs (Appendix 2: Table 2-3) and inputs (Appendix 2: Table 2-4) indicates that wood products markets are generally favorable to the wood industries (output prices flat; input prices going down), whereas paper product markets have been less favorable (flat prices; rising costs). As mentioned previously, although the forest product industries on the whole have performed adequately well—indeed some (Ainsworth, Norbord and Canfor), extremely well (PriceWaterhouse Coopers 2006), some sub-industries in some regions are under-performing and may not be financially sustainable. High energy prices (Table 23), the Canada–U.S. exchange rate, and the softwood lumber tariffs facing Ontario, Quebec and some of the maritime provinces may be factors behind recent mill closures (Roberts 1991; Urquhart 2005; CBC 2005a, 2005b).

Costs of environmental protection are another factor that may affect future sustainability and growth of the boreal forest sector (Gray and Shadbegian 1997; Roberts 1991). No information on the costs of environmental compliance exists that is specific to the boreal region; aggregate information on the entire Canadian sector must serve as a proxy. According to Statistics Canada (2005), annual operating expenditures on environmental protection by the forestry industry were more or less unchanged between 1997 and 2002 at about $650 million, but capital expenditures associated with environmental protection, particularly for pollution control, declined by more than 30% to $284 million (Appendix 2: tables 2-5 and 2-6). In the years 1997 and 2002, the pulp and paper sector has accounted for 70% and 60% of all forest-operating environmental expenditures, and for 80% and 70% of capital expenditures, respectively. Between 1997 and 2002, operating expenditures on environmental protection by the logging industry and wood product industries increased by about 50%, whereas they declined for the pulp and paper sector. The most notable increases have been for environmental assessments and audits,

Table 23. Energy price indices, 1994 to 2006 (1997=100) (Statistics Canada n.d. [b] Table 329-0046, Table 329-0050)

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Canada	**Electricity***	98.3	98.6	99.2	100.0	99.7	100.6	100.8	102.9	111.0	116.9	115.6	125.6	120.9
N&L	**Electricity***	98.7	97.5	98.1	100.0	102.6	106.1	96.6	91.9	96.2	99.2	110.0	123.9	131.6
Quebec	**Electricity***	96.4	97.6	98.7	100.0	101.6	102.2	102.2	102.2	102.2	102.2	105.5	107.6	112.2
Ontario	**Electricity***	102.1	101.0	100.1	100.0	100.0	100.0	100.0	105.5	134.1	147.5	140.2	174.3	131.9
Manitoba	**Electricity***	99.7	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	98.9	100.4	105.2	105.8
Sask.	**Electricity***	99.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	94.6	94.6	97.2	102.5	106.9
Alberta	**Electricity***	94.9	94.4	98.7	100.0	83.0	92.7	99.5	116.9	147.6	191.0	162.0	155.3	183.1
BC	**Electricity***	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	103.6	104.8	104.8
Canada	**Motor gasoline**	85.2	90.5	98.2	100.0	82.8	101.1	140.6	134.6	126.2	135.4	158.7	191.7	208.5
Canada	**Diesel fuel**	86.3	88.7	101.4	100.0	82.0	91.5	137.0	132.9	123.6	135.6	159.7	212.8	228.7

*Electric power selling price over 5000 kw

environmental monitoring, reclamation and decommissioning, and wildlife and habitat protection. Increased expenditures on environmental compliance by the logging industry of $40 million per year between 1997 and 2002 are equivalent to 11% of the industry's aggregate operating profit. This compares to 3.5% for the wood products industry, 1.0% for the pulp and paper industry, and 0.6% for all industries. The level of expenditure by the forest industries vis-à-vis other Canadian industries is very high, albeit declining. In 2002, the forest industries' share of total environmental operating expenditures and capital expenditures was 19% and 10%, respectively; the forest sector's contribution to GDP is 3%. In the same year, the forestry industries' share of expenditures on wildlife and protection, environmental monitoring, and environmental assessments and audits were 72%, 21%, and 16%, respectively. The bulk of the forest industries' current expenditures on pollution abatement and pollution prevention are in the areas of air, water, and on-site solid and liquid waste (Appendix 2: tables 2-7 and 2-8).

Gray and Shadbegian (1997) found that expenditures on environmental protection by the pulp and paper sector crowded out investments on productivity improvement in the U.S. No similar study has occurred in Canada, but Hailu (2003) measured total factor productivity of the pulp and paper sector in four different regions of Canada (British Columbia, Ontario, Quebec, and rest of Canada) over the period of 1970 to 1993, and suggests some crowding may have occurred in Canada. Roberts (1991) found that the Canadian pulp and paper industry spent much more on environmental protection as a percentage of total investments than did pulp and paper industries in other countries.

Table 24. Exports, imports ($ million) and export intensity for the wood and paper product sub-sectors, 1996 and 2006 (Statistics Canada n.d. [b] Table 304-0014 and Table 304-0015; Industry Canada n.d.)

	Exports		Imports		Export Intensity*	
	1996	2006	1996	2006	1996	2006
Wood Products						
Nfld.	$1	$27	$0	$0	..	0.46
Que.	$3,146	$3,549	$215	$651	0.57	0.52
Ont.	$2,196	$2,450	$699	$1,280	0.63	0.43
Man.	$138	$333	$58	$114	0.49	0.53
Sask.	$130	$263	$25	$29	0.49	0.48
Alta.	$956	$1,196	$39	$163	0.48	0.36
B.C.	$9,174	$8,073	$433	$775	0.82	0.86
Yk.	$0	$1	$0	$0	..	..
N.W.T.	$1	$0	$0	$0	..	..
Nvt.	$0	$0	$0	$0	..	..
Canada	$16,334	$16,913	$1,508	$3,126	0.68	0.60
Paper Products						
Nfld.	$616	$448	$7	$9	..	..
Que.	$6,851	$7,366	$607	$993	0.68	0.69
Ont.	$4,965	$4,486	$2,675	$4,015	0.54	0.46
Man.	$230	$264	$151	$259	0.65	0.57
Sask.	$271	$230	$39	$44	0.62	..
Alta.	$975	$1,414	$89	$176	0.67	0.78
B.C.	$5,665	$4,726	$399	$664	0.97	0.83
Yk.	$0	$0	$0	$0	..	..
N.W.T.	$0	$0	$0	$0	..	..
Nvt.	$0	$0	$0	$0	..	..
Canada	$21,676	$20,633	$4,033	$6,265	0.71	0.65

*Exports divided by total shipments. Internal Calculation.

Importance of trade to the boreal forest products economy

No information exists on the level of exports specifically from mills within the boreal forest region. Statistics Canada, Industry Canada, and the Canadian Forest Service generate detailed trade information on the Canadian forest products sector as a whole and, in most cases, by province: trade data for the boreal forest industry are available for Alberta, Saskatchewan, Manitoba and Newfoundland. There are no trade data for boreal-only forest regions of British Columbia, Quebec and Ontario; limited information exists for the Yukon and Northwest Territories, as export levels are relatively insignificant in the context of the whole sector.

Table 25. Wood product export pattern trends by province, 1996, 2001 and 2006 (Industry Canada n.d.)

	Country of Destination	Percentage Share of Total Exports by Origin		
		1996	2001	2006
Canada	US	74	86	86
	Japan	19	10	7
NFLD	Netherlands	1	0	75
	United States	90	100	24
Quebec	United States	88	93	93
Ontario	United States	91	96	96
Manitoba	United States	93	98	98
Saskatchewan	United States	95	99	98
Alberta	United States	82	94	96
	Japan	17	6	2
British Columbia	United States	62	76	78
	Japan	31	19	14
Nunavut	United States		..	62
	Ireland		..	36
NWT	Japan	0	0	61
	United States	100	100	39
YK	United States	100	100	100

Table 26. Paper product exports pattern trends by province, 1996, 2001 and 2006 (Industry Canada n.d.)

	Country of Destination	Percentage Share of Total Exports by Origin		
		1996	2001	2006
Canada	US	69	75	72
	China	2	2	5
	Japan	6	4	3
NFLD	United States	37	50	47
	United Kingdom	17	8	12
	Venezuela	4	5	9
Quebec	United States	79	85	80
	Brazil	1	1	2
	China	1	1	2
Ontario	United States	96	97	96
Manitoba	United States	88	100	93
Saskatchewan	United States	64	74	35
	China	0	2	16
	Netherlands	2	1	8
	Mexico	3	2	7
Alberta	United States	40	52	61
	Japan	23	13	11
	South Korea	8	11	9
	China	1	5	8
British Columbia	United States	45	43	44
	China	6	8	16
	Japan	13	10	7
	Italy	5	7	5

The Canadian forest sector is heavily focused on foreign trade, especially with the U.S. In 2006, approximately 60% of Canada's wood products and about 65% of Canada's paper products were exports (Table 24). These percentages are lower than they were a decade ago, largely because of an expanding domestic market that is absorbing more domestic production and imports.

The most export-oriented paper regions are Saskatchewan and Alberta; British Columbia is the most export-oriented wood-products region. Ontario imports the greatest share of foreign paper and wood products.

Most Canadian wood and paper products are exported to the U.S. In 2006, the U.S. purchased 86% and 72% of Canada's exported wood and paper products, up from 74% and 69% in 1996 (tables 25 and 26). Much of the increased emphasis on the U.S. market has been due to decreased demand in Japan and Europe, and strong economic growth in the U.S. The Chinese market is increasing in importance for pulp and paper exports from Saskatchewan, Alberta and British Columbia. Generally, provinces in the interior have less diverse markets than do coastal provinces.

These facts provide little insight into the current importance of trade to the boreal forest sector, other than that it is likely important. However, they do indicate opportunities for and challenges to expansion of production within the boreal forest region:

- Expanded production from the boreal forest region will face intense competition in export markets, because expanded production from global suppliers will chase the same growth markets (China and India) in the face of continued market-access issues in the U.S. and declining market opportunities in Europe;
- Domestic forest product markets—Canada's second largest market—continue to expand and are obvious targets for expanded production from the boreal region.

Taking both these points into account with the looming possibility of reduced timber supply in the developed areas of the boreal and non-boreal of Canada, policies designed to encourage expanded forest industry development in the boreal (e.g. northern Saskatchewan and Ontario) need to consider the scale, composition and pace of expansion if competitive and sustainable industries are to be established.

Global trends

Global production and consumption of industrial roundwood remained flat during the last decade (Table 27); however, the level of trade in forest products has grown significantly. Approximately one-third of this growth is due to increased demand for forest products in the U.S., the largest forest products producer and consumer country in the world. Since 1985, Canada has supplied much of this increased demand.

Despite flat global production and consumption, Canadian forest product prices have risen somewhat during the same period (Table 27; Appendix 2: Table 2-3). Increases reflect strong growth in demand for Canadian structural panels, engineered wood products, and converted paper products. Prices for structural lumber and pulp generally remained low or declined during the last decade—particularly prices for sawn lumber. (Appendix 2: Table 2-3 presents price indices for a range of forest products.)

Table 27. World, U.S. and Canadian industrial roundwood production and forest product exports and imports (millions; FAO n.d.)

	Industrial roundwood production (cubic metres)				Forest product exports (Current US Dollars)				Forest product Imports (Current US Dollars)			
	1985	1995	2005	1985-2005	1985	1995	2005	1985-2005	1985	1995	2005	1985-2005
World	1,521	1,516	1,711	12%	$50,765	$147,383	$185,725	266%	$56,423	$153,028	$193,402	243%
United States	358	409	428	20%	$5,770	$18,252	$16,965	194%	$10,804	$22,493	$31,998	196%
Canada	162	183	196	21%	$11,227	$27,815	$29,501	163%	$1,044	$2,997	$4,921	371%
Rest of world	1,002	924	1,086	8%	$33,768	$101,316	$139,258	312%	$44,575	$127,539	$156,483	251%

Several global industry trends will affect the Canadian boreal forest industries (International Labor Organization 2001; Roberts 2005; Cohen 2005; Sande 2002; Canadian Forest Service 2005b; Gan 2004):

- The growing importance of timber (hardwood and softwood) from timber plantations (especially southern hemisphere) and decreased supply from old-growth natural forests (except in Russia);
- Increased concentration of ownership of manufacturing establishments;
- Increased separation of ownership of manufacturing assets and timber resources;
- Relocation of manufacturing to low-wage countries (e.g., China);
- Increased certification of management of northern hemisphere forests—both natural and plantation forests;
- Increased use of new technologies to process smaller-diameter logs and poorer-quality wood fibre.

Some trends will reduce competitiveness of the boreal forest industry. Actual increases in global wood supply will, all other things remaining constant, weaken world prices for many of the basic commodities in which Canada currently specializes, including lumber, newsprint, and pulp. Furthermore, a shift away from old-growth wood supply to plantation-wood supply will likely challenge any price premiums currently enjoyed by old-growth wood, as technology, product innovation, and marketing of plantation fibre will reduce differences in real and perceived quality between the two supply sources. Increased competition in foreign markets could limit expansion or erode Canada's market share in existing markets. Together, lower product prices and reduced external market opportunities may lower profitability of the boreal forest industry and reduce opportunities for industry expansion. Furthermore, relocation of value-added wood product industries to low-wage countries reduces opportunities to sustain or enhance forest-industry employment in the boreal region.

On the other hand, some trends present opportunities for boreal forest industries. Trends to increase industry concentration (Sande 2002) may allow greater access to capital needed to continue improving efficiency of boreal logging and processing industries, and may lead to increased economies of scale in manufacturing and marketing. Profit improvements may be realized more quickly if separation of forestry and wood-processing operations leads to improved productivity. If Canada wished to follow this trend, changes to existing forest policy, tenure arrangements, and forest management financing arrangements would likely be required. Further opportunities to improve the economic prospects of the boreal forest industries could be gained through adoption and innovation of new technologies to use smaller-diameter trees and tree species currently considered of lesser value. Finally, increased competition in secondary manufacturing industries from low-wage countries might be offset by taking advantage of labor market trends in final markets through innovative products, marketing, further integration downstream, and innovation in service sectors related to wood products (Schuler 2004).

Other forest resource industries

Environment Canada, the Canadian Forest Service, Statistics Canada and provincial authorities compile and publish information on the nature and scope of the non-timber forest-related economy. This information is usually less comprehensive and less up-to-date than information about the timber-related economy. Information on some goods and services—commercial production of Christmas trees and maple syrup (both of which are mainly in Quebec and outside the boreal region; Canadian Council of Forest

Ministers n.d.), forest-related tourism, and trapping and hunting (Senate Subcommittee on the Boreal 1999) is available; there is much less information on non-timber products such as mushrooms and other non-market or non-regulated goods and services, although their value may be significant (Duchesne 2003; Canadian Forest Service 2005a).

The largest non-forest sector is the nature–recreation sector, which includes expenditures for nature-related recreational activities that consist of, in some form, either direct or indirect contact with nature (e.g., outdoor activity in natural areas, residential wildlife-related activity, wildlife viewing, recreational fishing, hunting, and indirect nature-related activities; Environment Canada 2000a). One estimate of the size of this sector in Canada puts the sector's gross domestic product at $12 billion per year (1996), including approximately $1 billion in exports to the U.S. It employs about 214 800 people (Environment Canada 2000a). Table 28 presents these estimates by province and territory with boreal ecozones, based on estimated expenditures by Canadians and U.S. visitors on nature-related activities (Table 29).

It is unclear how much of these estimates pertains to boreal forest; for example, a large proportion of British Columbia's nature-related recreation sector takes place in the southern half of the province, outside the boreal region. Moreover, the estimates' accuracy is questionable; for example, the Quebec government estimated 3.6 million Quebecois directly participated in nature activities, spending more than $3 billion and supporting approximately 30 000 jobs in 1999 (Ministère des Ressources Naturelles, de la Faune et des Parcs 2003); Ontario has pegged its resource-based tourism industry—including resorts, lodges and fishing/hunting villages—in northern Ontario at $1.26 billion and supporting 18 000 jobs (Ontario Ministry of Tourism and Recreation 2003). These numbers differ significantly from Environment Canada's figures of 45 000 and 77 000 jobs, respectively. Such inconsistencies compound the difficulty of estimating the importance of this sector compared to other sectors dependent on boreal resources.

Table 28. Nature-related recreation sectors in provinces and territories of the boreal region (Environment Canada 2000a)

	GDP (millions)	Taxes (millions)	Personal Income (millions)	Jobs
Nfld.	$157	$77	$65	2,570
Que.	$2,318	$724	$1,254	45,240
Ont.	$4,522	$1,462	$2,446	77,890
Man.	$406	$142	$206	8,680
Sask.	$374	$112	$168	7,790
Alta.	$1,587	$360	$708	23,590
BC	$1,828	$618	$985	34,100
Yk.	$12	$4	$6	230
NWT	..	..	..	..
Total	$11,204	$3,499	$5,837	200,090

Table 29. Expenditures on nature-related activities by province and territory of residence, 1996 (adapted from Environment Canada 1999)

	Total $million	Per participant dollars
Nfld.	194	519
Que.	2,061	418
Ont.	4,283	566
Man.	428	569
Sask.	388	598
Alta.	1,171	616
BC	1,938	767
Yk.	16	1,052
Canada	10,956	549

Statistics Canada (2000) has compiled information on hunting and trapping from provincial and other sources. The number of big-game animals harvested between 1990 and 1996, the number of big-game licenses sold in 1995, and the value of fur pelts from non-farmed animals are presented in Table 30. Most big-game hunting occurs in provinces within the boreal region; however, once again, there is insufficient information to attribute exact numbers and values to the boreal region.

There is a small fur industry in Canada, much of which is based in the boreal forest. The value of fur pelts harvested in Canada in 1995–1996 was more than $32 million, approximately 50% of which was generated in Ontario and Quebec. Although the absolute value of trapping and hunting is greatest in the eastern and prairie boreal regions, the relative importance of trapping and hunting is probably greatest in northern regions of the boreal forest (Teitelbaum et al. 2003; Canadian Council of Forest Ministers n.d.). Furthermore, significant numbers of Aboriginal people engage in trapping and hunting (Table 11); presumably the value of these activities are captured in official statistics such as those in Table 30. However, it is unclear if the full value of trapping and hunting, market and non-market, is captured in the available data.

Other boreal resource industries

The boreal region includes more than forest resources and produces more value than that derived in the form of timber and non-timber forest values. The resources of the boreal region support significant mining, oil and gas, and agricultural sectors; however, complete information on the extent of these industries in Canada's boreal region is currently unavailable.

In 2005, the mining industry employed 35 000 people and contributed $17.9 billion to the Canadian economy (Appendix 2: Table 2-9). The mineral manufacturing sector employed an additional 234 000 people and contributed $47.3 billion to the Canadian economy (Appendix 2: Table 2-10). Oil and gas extraction, coal mining, metal, and non-metal mining accounted for 3.7% of Canada's GDP in 2004 (Statistics Canada 2005).

The metal and non-metal mining industry is biggest in Ontario. Metal mining is concentrated in Ontario, Quebec, British Columbia, Newfoundland and Manitoba. Non-metal mining is concentrated in Ontario, Quebec, Northwest Territories, Alberta and British Columbia. No information source currently breaks the industries into boreal and non-boreal economies.

As of 1996 (the most recent information), agriculture occupied 2.8% of the boreal region: some 152 thousand km^2 or 15.2 million ha of land, and proportionately more in the provinces of Alberta and Saskatchewan (Table 9). The agricultural sector within the boreal region has not been studied, but is likely to be significant. According to Statistics Canada's 2001 Census of Agriculture (online at: http://www.statcan.ca/english/agcensus2001/first/farmop/toc.htm), 246 000 farms in Canada generated $38 billion in sales. Furthermore, some 13 000 farms reported $117 million in sales of forest products, indicating that many farmers are actively involved in forestry and are dependent on forest resources to supplement farm income. In 1996, approximately 20% of all agricultural land and cultivated agricultural land were in the boreal region (Statistics Canada 2000). Based on this figure, the size of the boreal agricultural sector is estimated to be 49 000 farms generating $8 billion in sales, including an estimated $23 million in forest product sales.

Table 30. Big game harvested by boreal province and territory, 1990 to 1996 (adapted from Statistics Canada 2000)

	Big Game Harvest (# of Animals)	Big Game Licenses Sold	Value of Pelts ($)
Nfld.	21,609	32,879	425,678
Que.	69,743	284,763	6,468,184
Ont.	82,341	317,620	10,626,955
Man.	41,655	67,700	3,715,834
Sask.	72,506	105,889	2,990,893
Alta.	67,613	184,553	4,175,071
BC	49,972	208,232	1,849,596
Yk.	1,285	…	524,245
NWT	…	…	1,526,259
Canada	406,724	1,201,636	32,224,614

Emerging economic and socioeconomic challenges

Numerous social, economic and environmental pressures are directed at boreal forest-based sectors, including increasing influence of Aboriginal peoples, mounting competition and protectionism in global trade, market actions that affect the logging industry, changes to forest management policies, advances in sustainable development, regional energy developments and alternative economic generators such as tourism (Lee 2004). These pressures are external and internal, and are not unique to the boreal forest or even to Canada (Duinker et al. 1998; Pearse 2001; International Labor Organization 2001). However, some of the issues are gaining in significance in boreal regions, as evidenced by numerous boreal-related reports and research activities, and creation of boreal-related organizations and initiatives in recent years.

Perspectives on the economics of boreal forest management: integrated versus specialized forestland management

Adamowicz et al. (2003) synthesize the economics of boreal forest management and consequent issues. Key points from that study are:

- From a financial point of view, the economics of planting new forests in Canada's boreal forest are on average very poor because of the slow growth of these forests (Adamowicz et al. 2003) and the high cost of planting;
- Generally, the most economical type of forest management is natural regeneration; however, this may not always the case (Ghebremichael et al. 1996; Lieffers et al. 2003; Nautiyal et al. 2001; Willcocks et al. 1990);
- Standing harvestable timber has high value, but harvested land has low value—a reflection of low productivity and few alternative uses of the land;
- Boreal forests provide other values, most being non-market goods; current institutional arrangements focus only on timber values. Demand for non-timber goods and services may increase as population and income levels rise;
- The presence of non-use values of the forest often means the economic value of standing forest may be greater than the economic value of the flow of products harvested from the forest;
- Monetization of non-timber goods and services such as carbon sequestration or watershed services will improve the economics of intensive forest management;
- Due to the long time required to grow trees to full maturity, harvest and inventory levels will decline as older, high-volume forest stands are converted to new stands that will be harvested at younger ages;
- Volume-based constraints on harvesting increase the incentive to over-invest in silviculture (annual allowable cut effect);
- Employment per cubic metre of output will decrease over time as technical advances in harvesting and management allow capital to substitute for labor (Vincent and Binkley 1991);
- Institutions (tenures) often are inflexible and rigid, and don't provide incentives to optimize the full value of forest resources—timber and non-timber—or rationalize forest management expenses and investments (Adamowicz et al. 2003; Nelson et al. 2003).

Adamowicz et al. (2003) state that the economics of boreal forest management are challenging because of the low average productivity of the forests and increasing demands for non-market goods. Low productivity means that, in general, forest management investments in future forests are uneconomical from a financial and timber-only standpoint: in particular, immediate timber management investments such as site preparation or stand establishment (planting or seeding) are uneconomical. Investments later in the development of the stand, including fertilization, infill or understorey planting or thinning, may be more economical. [See Schroeder (2003) for an analysis of Ontario's boreal mixedwood forests].

The average productivity across the boreal forest, especially within the managed boreal forest, is generally close to the low-productivity scenarios (1.5 m^3 and 2.5 m^3 per year; Lowe et al. 1996), but in many cases productivity may be greater (5 m^3 to 10 m^3 per year; Benson 1988). Clearly for low average levels of productivity, even low timber management expenses require significant timber prices because of the time required between establishment and harvesting. Even for modest expenditures ($250/ha over the life of the stand), the economics are unfavorable if the harvesting does not happen for many decades. This suggests that even small recurring costs such as fire and pest protection, periodic surveys of the environment and timber, or small up-front costs on site preparation may be uneconomical. Therefore, from a timber point of view, the only way such unproductive timber investments can be justified is if the other forest values are great enough to offset costs. Add in the uncertainty of future revenues, and the general economics of boreal forest management—extensive or intensive—is unclear. (See Appendix 5 for discussion of the economics of timber production.)

Adamowicz et al. (2003) also state that increasing demand for non-market goods and services from boreal forests means that timber production is often incompatible with other uses of the forest and, even when compatible, forest management becomes increasingly more complex and potentially costly. Many non-timber goods have uncertain or unknown value; because of this, one of the key challenges to sustainable boreal forest management is the incorporation of timber and non-timber values into forest management planning (Adamowicz et al 2003).

An extensive land model has been advocated as the best management strategy to balance timber and non-timber values in Canada's slow-growing forests (Benson 1988; Benson 1990; Booth et al. 1993). Supporters argue that emulating natural disturbances will lead to healthier ecosystems and decreased timber management costs. However, others, such as Binkley (1999), question the economics of this management model. Binkley points out four concerns with ecosystem-based forest management:

1. The approach mixes market and non-market products that are difficult to measure (Adamowicz et al. 2003) and thus manage (Alverson et al. 1994);
2. Imposition of standards and regulations required to achieve production of non-timber products generally increase forest management costs, with uncertain benefits to the parties bearing those costs;
3. Application of forest certification standards, such as those advocated by the Canadian Sustainable Forestry Certification Coalition (www.sfms.com) or the Forestry Stewardship Council (www.fsccananda.org/boreal/index), increases the complexity of practicing forest management and reduces the quantity of industrial roundwood supplied per hectare, meaning more land must be used to generate a given level of output per year (Spence 2001);
4. As forest management costs increase, public revenues will fall and thereby reduce the resources available for financing the provision of public goods.

Binkley (1997) instead argues for a separation of management objectives across the forest landscape—in particular, areas dedicated to timber production. Concentrated timber production frees up land for other uses and minimizes management and development costs. This seems at odds to the

economics of stand-level boreal timber management illustrated in Appendix 5: tables 1 to 4; however, in the context of a landscape that produces a suite of goods and services, it may make sense as the opportunity costs of land, management and development costs, and environmental costs are taken into account. Furthermore, with sufficient areas of productive timberland and management effort, the costs of timber production may actually be lower (at the stand level) than under a land management strategy that is based on low expenditures and low timber yield. (See comparison of costs of producing timber at 2.5 m^3/year with very low management costs to the cost of producing timber at 10 m^3/year with very high management costs in Appendix 5.) If it is technically feasible to increase timber yields in shorter time, the most cost-effective means of producing timber may be under a high-expenditure, high-yield strategy. Empirical analysis using reliable growth and yield information will help determine optimal strategy.

Economic theories of multiple-use forests support the notion of stratifying the forest according to management type (Albers 1996; Bogdanski unpublished; Bowes and Krutilla 1989; Swallow et al. 1997; Vincent and Binkley 1993; Wu and Boggess 1999; Akoena and Gray unpublished). Much of this research supports separating highly competitive uses of forestland—timber and wilderness (preservation)—from other uses; however, the literature does not support separation of all uses across the landscape in all cases. Therefore, to answer questions about which management approaches are optimal, applied modeling and empirical investigation techniques are usually required (Bowes and Krutilla 1989; Bogdanski unpublished; Adamowicz et al. 2003). Which management model is optimal for meeting challenges facing forest management in the boreal forest remains to be seen, but will probably require a combination of strategies (Sedjo 1990; Senate Subcommittee on the Boreal 1999).

Lieffers et al. (2003) illustrate a broad forestland management strategy for the boreal forest: they allocate the boreal forest to four forestland management models—protected areas, semi-natural forest management, plantation management, and intensive plantation management. In this illustration, they demonstrate that long-run timber yield could exceed current harvest levels. Although the allocations are hypothetical, are not scientifically derived, nor do they account for regional economic, ecological or social circumstances, the study emphasizes the need to explore alternative land and forest management strategies across the boreal forest.

Hyde and Newman (1991) outline practical considerations in determining a broad spatial forestland management strategy. Natural forest management (extensive forest management) is usually limited by the following factors:

1. Transport costs, which are high for timber, but less so for other uses such as recreation;
2. Biodiversity, which exists where it is found;
3. Old-growth volume is greater than volume from second-growth natural forests, as extensive lands tend to be of poorer quality (shallow soils, steeper and drier sites). Therefore new natural forest stands tend be slower growing and less dense;
4. Many extensive lands tend to be environmentally more risky and more attractive for recreational uses;
5. Most joint forest goods and services are competitive, so in many cases it is most efficient to separate competing uses spatially or temporally.

Some studies have compared integrated forestland management versus specialized forestland management in other forest jurisdictions. Kutay (1977) and Walker (1974) looked at this question in U.S. national forests in Oregon. Each study concluded that separating uses spatially results in greater timber and non-timber values and more government revenues. Sahajananthan (unpublished data) conducted a case study in a timber supply area in southern British Columbia and found support for land-use separation on economic and environmental grounds. However, these studies involved temperate forests that are more productive and less prone to large-scale natural disturbances than boreal forests are. Messier et al. (2003)

summarize landscape-modeling studies of Canada's boreal forest that assess the sustainability of forest management scenarios from ecological and economic perspectives. Two questions regarding to boreal forestland management for multiple uses (and users) need to be answered, both of which consider the context of the social and physical states across the boreal region:

1. If the land is to be managed separately for different uses, what is the minimum amount of land required for each form of forest management that is both sustainable and socially desirable?
2. How economically resilient are these land management strategies to current (and changing) natural disturbance regimes?

Challenges to boreal forest management

Climatic change and invasive alien forest species are two issues that will challenge management of the boreal forest in coming years.

Hauer et al. (2001) summarize the potential socioeconomic impacts and adaptive responses to climate change. The basic challenge for boreal forest management is to understand how changed climate will effect not only the potential range and growth of tree species but of agricultural crops and, therefore, optimal land-use patterns and land management practices. A similar challenge is to understand how climate change-mitigation policies and measures (e.g., price on greenhouse gas emissions and carbon removals) will impact land management decisions.

Climate change is expected to alter the suitability of land for different uses, the potential growth and yield of trees, and the scope and frequency of natural disturbances such as fire and insect outbreaks (Volney and Flemming 2000; Hogg et al. 2002; Li et al. 2000; Elmqvist et al. 2004; Bergeron et al. 2004; Chapin et al. 2004). As climate change is expected to be greater closer to the poles and in the interior of the continent (see Atlas of Canada on-line: http://atlas.gc.ca/site/english/maps/climatechange), boreal forests may be greatly effected by increases in temperature and changes in precipitation patterns (Bhatti et al. 2003; Chapin et al. 2004). However, the timing of these changes is uncertain (Masek 2001; Chapin et al. 2004). These potential impacts will affect the economically optimal allocation of land, forest management, and mix of forest goods and services in complex ways.

Invasive alien species also pose a threat to boreal forests, as they do to other forests. Krcmar-Nozic et al. (2000) review potential socioeconomic impacts from exotic forest pests. Introduced pest species can cause:

- Timber losses, due to growth loss, quality loss and tree mortality;
- Revenue (and related jobs) loss from foregone trade, recreation and tourism;
- Property value losses;
- Reduced aesthetic values;
- Regulatory, control and mitigation expenses;
- Reduced access and increased cost to export markets.

Introduced forest pests may also affect the following social elements:

- Human health;
- Public perception of and support for forestry;
- International relations;

- Credibility of governments;
- Federal and provincial relations;
- Forest-related jobs;
- Community stability and well-being.

Krcmar-Nozic et al. (2000) conclude that the potential impacts from invasive alien forest pests are great and may be exacerbated by changing climate.

Challenges and opportunities for boreal forest-based industries and forest communities

The boreal forest sector faces several external and internal challenges. Some of the most pronounced are external trends regarding:

- Changing global wood supply: more wood from plantations and less from old-growth natural forests (except in Russia, where an increase is expected);
- Technological change that increases use of smaller-diameter logs and poorer-quality fibre;
- Increased concentration of ownership of manufacturing establishments and increased separation of manufacturing and timberland assets;
- Relocation of manufacturing to low-wage countries (globalization of capital);
- Increased demand for forest certification (a reflection of downstream market pressure for certified forestry products).

These trends challenge the boreal forest sector to maintain its competitiveness vis-à-vis other regions by increasing productivity (Hailu and Veeman 2003; Bernstein 1994), reducing costs at all levels of production (Wagner and Hansen 2004; Lantz 2005), and further developing manufacturing to produce higher-valued products (Wilson et al. 2001; Lantz 2005).

The Canadian industry also faces internal challenges—none of which apply to all regions, because each region has its own unique environmental, social and economic circumstances:

- Reductions in regional timber supplies—immediately in Ontario and Quebec and perhaps later in Alberta;
- Reductions in timber quality (smaller logs and reduced fibre quality, increased salvage logging) as forest development moves into marginal natural forests;
- Increased transportation costs (increased distances; increased fuel costs);
- Increased management costs (increased information requirements to fulfill sustainable forest management; i.e., criteria and indicators, certification);
- Uncertain resource rights (e.g., unclear Aboriginal title);
- Conflicting and uncertain demands on land resources (e.g., biodiversity) and increased demand for non-consumptive uses (Cartwright 1999);
- Infrastructure constraints, development and costs, and conflicts with competing sectors such as mining, agriculture, and oil and gas;
- Increased energy costs;

- Market access issues, including internationally applied forest health measures and other non-tariff barriers (Cohen et al. 2003);
- Development of forestry practices that balance economic costs and maintenance of the ecological integrity of ecosystems;
- Forest practices and policies that account for Aboriginal rights and culture;
- Establishment of a protected areas network that is representative and sustainable over time in face of natural and human disturbances and potential shifts in regional climates and ecosystems.

In the face of the combined internal and external challenges, the boreal-based forest sector may be hard pressed to maintain its competitive advantage as a source of low-cost wood products. Meeting these challenges may mean industry restructuring; this, in turn, may endanger stability (employment and income) of forest-dependent communities and regions (Nelson et al. 2003).

Ensuring competitive and sustainable boreal industries (timber and non-timber) will require reducing costs and enhancing value of goods and services produced, with increased focus on adding value at each stage of production.

Opportunities to meet the challenges and ensure a competitive and sustainable boreal forest sector include:

- Organization of the land base in ways that minimize timber production costs, maximize value derived from other forest goods and services, take into account potential impacts of climate change and forest health issues, and increase synergies between non-forest–based sectors;
- Development of new and innovative tenure arrangements and property-rights regimes that support a sustainable and competitive boreal forest sector;
- Improvements to decision support tools and systems to increase effectiveness and efficiency of forest investments in forest renewal and protection;
- Development of non-timber goods and services, including enhanced use of biomass for energy;
- Development of secondary wood and paper manufacturing;
- Development of new markets;
- Development of new technologies in harvesting, transportation, and processing;
- Redesign of policies dealing with transportation, energy, taxation, environmental, etc., to support a sustainable balance between economic, environmental, and social goals.

Summary and areas of economic and socioeconomic research

As economic conditions and the resource change, boreal-based industries, forest-dependent communities, and governments will need to adapt.

In order to help the boreal forest sector maintain competitiveness and sustainability, economic research in the areas of forest management for multiple uses, timber and non-timber forest products, climate change and forest health, industrial organization, regional economics, and forest policy is required. Many of these areas are identified by Phillips et al. (1986) in their assessment of economic

research needs for west-central Canada in 1986 and remain relevant today. The need for research in the areas of non-timber forest products and innovative marketing is underscored in *A Discussion Paper: Towards a Forest Policy Framework for the Yukon* (Yukon Energy, Mines and Resources 2004).

Research undertaken needs to be spatially explicit and consider the varied circumstances that exist across the boreal forest in order to address different, explicit needs across the region. Moreover, risk analysis methods and tools specifically tailored to issues of the boreal forest region would be invaluable in the development of forest policies.

Based on gaps in knowledge identified in the previous pages, areas for research include:

1. Economic and policy research in forestland management: integrated versus specialized land management. This research would increase understanding of the economics of intensive and extensive timber management strategies within the boreal context, and the policies and institutions required to support such strategies. It would support land-planning aims to allocate land efficiently, while accounting for equity and sustainability; it could also reduce land-use conflicts, and guide forestry, forest industry and infrastructure investments.

   Possible topics include:

   - Policy research into the implications of tenures and forest policies that purposely separate forest resource management responsibility from forest resource processing;
   - Economic and financial research into forestry investments that incorporates current growth-and-yield information;
   - Exploration of alternative land and forest management strategies to potentially maximize the flow of total net benefits from Canada's boreal forests.

   This research should incorporate risks of climatic change and natural disturbances, as well as their impacts on timber supply.

2. Economic and policy research in integrated land-use management: forestry, mining, agriculture, recreation, and oil and gas. This research complements research on forestland management by addressing land-use conflicts and improving synergies between various sectors of boreal-region economies. A focus on shared infrastructure and consideration of climate change would help support land-use planning for sustainable development. This research will improve understanding of the economic value of all boreal resources to the boreal regional and Canadian economies. Accurate and detailed information on the contribution of boreal resources to other sectors of the boreal economy will support policy developments with regard to boreal land-use planning, forest resource tenures, and management of boreal resources.

   Possible topics include:

   - An examination of how the boreal forest sector is impacted (negatively and positively) by the other boreal sectors;
   - Research into the role of forestry in the larger context of regional development in the boreal region. Specifically, an examination of the cumulative impacts of boreal forest management policies and practices in the context of other land-use trends such as those associated with transportation and utility infrastructure, oil and gas development, and agricultural expansion or abandonment (Schneider et al. 2003).

3. Economic research into forest protection. Economic and policy research on forest protection from fire and insects would support development of future forest protection policies and improve the budget allocations of public and private operations and investment funds directed at boreal forest resources. This research should be comprehensive and expand values beyond timber, and should address the issues of invasive alien species and climate change.

   Possible topics include:

   - Cost–benefit analysis of mitigation strategies of pests that pose the greatest potential risks to North American forests, as well as to Canada's boreal forest.
   - Assessment of current forest protection policies. Specifically, assessment of forest protection policies and practices in light of changes in technology, knowledge and societal values.

4. Regional and local economy research. Socioeconomic studies of the timber and non-timber industries could compare relative importance of different forest industries to different segments of the boreal population, including rural and urban, and Aboriginal and non-Aboriginal. This research will inform regional development policies and planning by improving understanding of the contribution, links and trade-offs between different boreal forest-based industries; it will also highlight the relative importance of boreal forest resources to different segments of the Canadian society.

   Possible topics include:

   - Research that aims to understand and predict community vulnerability and resilience to shocks to the forest sector. This research could aim to identify communities at greatest risk (Raettig and Christensen 1999; Robertson 2003), and devise strategies to diversify the forest sector to mitigate job losses (Tsournos and Haynes 2004);
   - The economic and social relationship of Aboriginal peoples to forest resources, forest industries, and other primary sectors of the boreal region.

5. Economic research in areas of transportation. Research into the importance of transportation to the competitiveness of boreal-based industry and the values of the boreal forest would support infrastructure investment decisions, improve land-use resource planning and integrated resource management, and reduce conflicts and improve synergies between sectors of the boreal economy. Such research could complement research into links between boreal economies and other economies; e.g., the role of infrastructure and the development of interprovincial and international trade of forest products.
6. Economic and policy research in the areas of non-timber forest products. Economic research into non-timber forest products and industries, including bioenergy, would improve our understanding of the relative value of these products vis-à-vis timber forest products and support improved use and development of these resources through land-use planning and management decisions and policies.

   Specific topics include:

   - Economics of intensive non-timber forest management;

- The importance of non-timber forest product research and development, and innovative marketing such as branding and certification. This research would also benefit traditional wood product industries. [See Monserud et al. (2004) for a recent wood-use–research needs assessment for the western U.S., much of which applies to regions within the Canadian forest sector.]

7. Economic and policy research related to climate change. Research involving climate mitigation and adaptation applies to many aspects of boreal forestry and the boreal forest sector, and is highly uncertain due to the inherent uncertainties associated with long-range modeling and forecasting global and regional climate.

   Areas for focused research include:

   - Economic impacts of climate change policy on sustainable forest management and long-term timber supply;
   - Economic and social robustness of forest management strategies in light of potential changes in climate and natural disturbance regimes;
   - Economic impacts of climate change policy on energy and wood demand.

8. Policy research in the areas of environmental regulation, taxation, energy, and transportation, and such policy effects on forest industry structure and performance. Many government policies in these areas are accompanied by blunt instruments for regulation that may significantly burden particular segments and regions of the Canadian economy. A review of the government policies outside the forest sector, relevant to the boreal region, might include consideration of the boreal forest sector implications of:

   - Policies to protect the environment, with special emphasis on logging and wood industries. Specifically, this research should assess the costs and benefits, fairness and effectiveness of policies;
   - Energy policy that impacts development of bioenergy and forest resources;
   - Policies that impact transportation of wood and paper products;
   - Taxation policy regarding industries with highly variable earnings due to cyclical commodity markets.

Other information gaps identified in this report include:

- Analysis of the impacts on competitiveness and performance of forest industries across the boreal region compared to the non-boreal region arising from changes in market and regulatory conditions;
- Analysis of spending on environmental protection by the Canadian wood and logging industries vis-à-vis other countries.

In order to support such research and orient it to questions of greatest relevance to the boreal forest region, a more complete and detailed assessment of the state of the boreal region is recommended. An assessment similar to the report, *Criteria and Indicators of Sustainable Forest Management in Canada: National Status 2005* (Canadian Council of Forest Ministers 2006), with particular attention to regional

circumstances, would better focus research on the boreal forest sector. Information on the following would support future economic and social research:

- The importance of small fires within the boreal;
- Potential growth and yield of boreal timber resources, in a geographically explicit context;
- Production and use of non-timber forest resources;
- Inventory and location of water, wetland, carbon, wildlife, and biodiversity resources;
- Inventory and location non-forest resources (minerals and potential agricultural land);
- Boreal timber inventory, timber supply, and harvest trends;
- Geographical location of industry within the boreal region;
- Transportation and other infrastructure within the boreal region.

Conclusion

Canada's forest economy is heavily dependent on boreal forest resources. Conservative estimates put the contribution of the boreal forest resources to the Canadian forest economy at about $40 billion in revenue and 128 000 jobs, or about 40% of the total forest economy. The boreal region is also home to significant agriculture and mining economies, as well as tourism industries. This region also provides immense environmental and social goods and services, as well as being home to a significant population of Aboriginal and non-Aboriginal peoples.

In the coming years, new challenges and opportunities face the boreal forest-based economies. These challenges originate internally, such as increased demand for environmental and social values, and externally, such as increased competition in international markets.

Unfortunately, there are considerable information and knowledge gaps regarding many aspects of the boreal forest economy and society. Economic research in the areas of forest land management, integrated resource land management, forest protection, boreal regional economies, transportation, non-timber forest values, climate change impacts and adaptation, and public policy will help fill some of the information and knowledge gaps. This will enable development of effective public policies and industrial strategies in the areas of resource development, social development and environmental protection to ensure that the boreal forest region continues along a sustainable path.

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Appendix 1

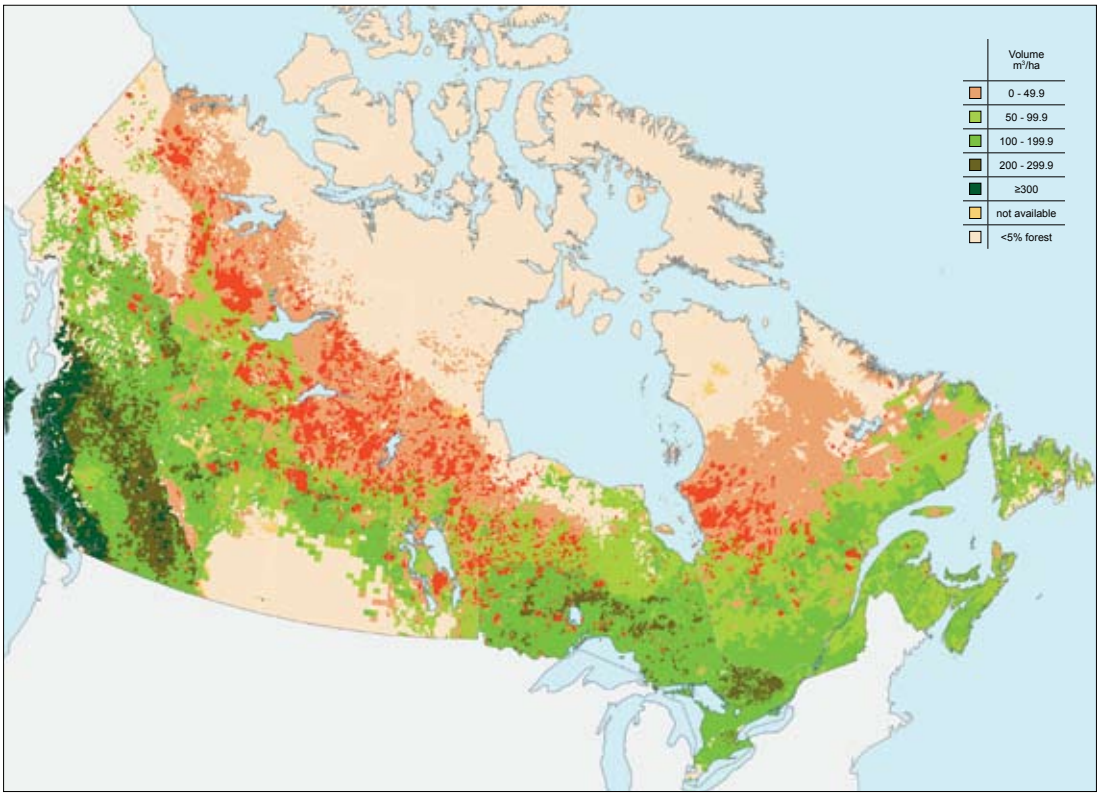

Figure 1-1. Distribution of fires greater than 200 hectares (red polygons), 1980–2001, as recorded in the Canadian Large Fire Database (Stocks et al. 2002) with respect to mature forest volume in Canada's National Forest Inventory (Power and Gillis 2006). Source: Taylor et al. 2006

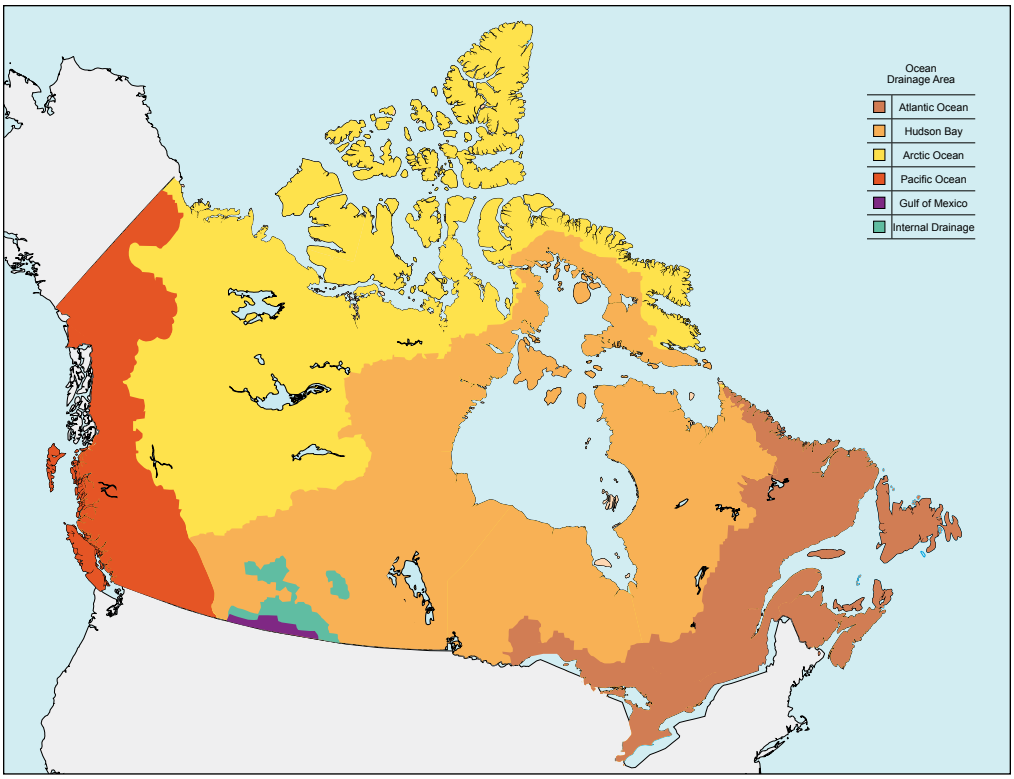

Figure 1-2. Major freshwater drainage basins of Canada (from Natural Resources Canada 2007c)

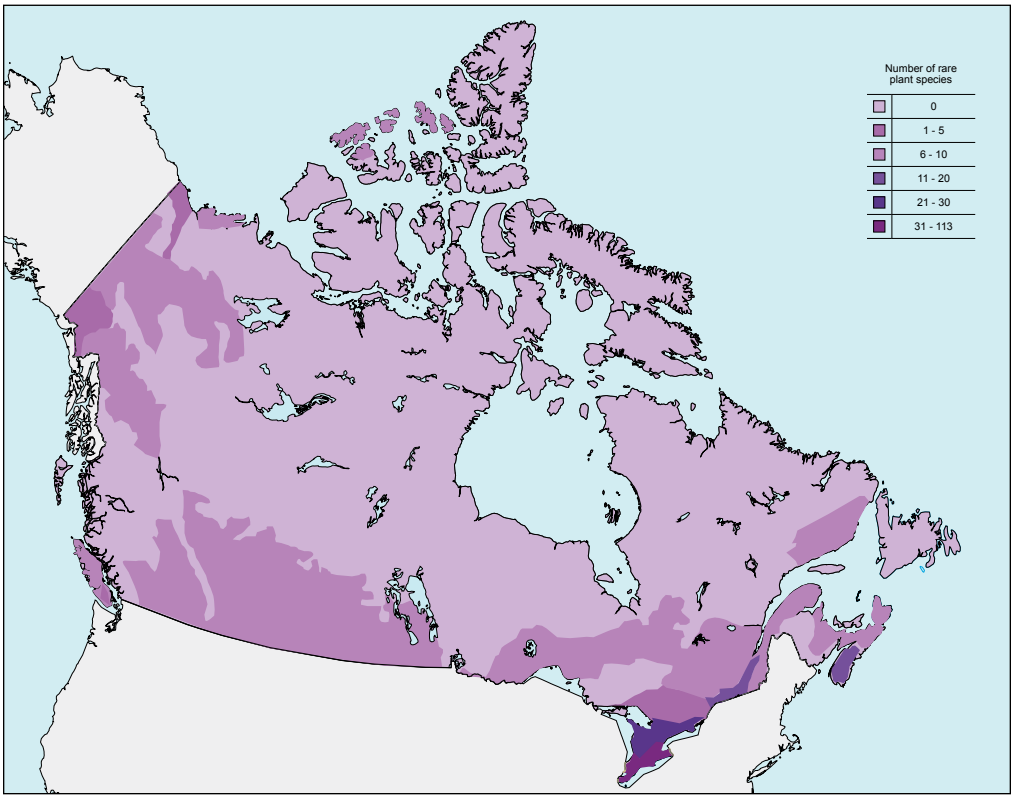

Figure 1-3. Distribution of rare plants across ecoregions in Canada (from Natural Resources Canada 2007c). Ecoregions form a subset of an ecozone; there are 194 ecoregions across Canada's 15 terrestrial ecozones.

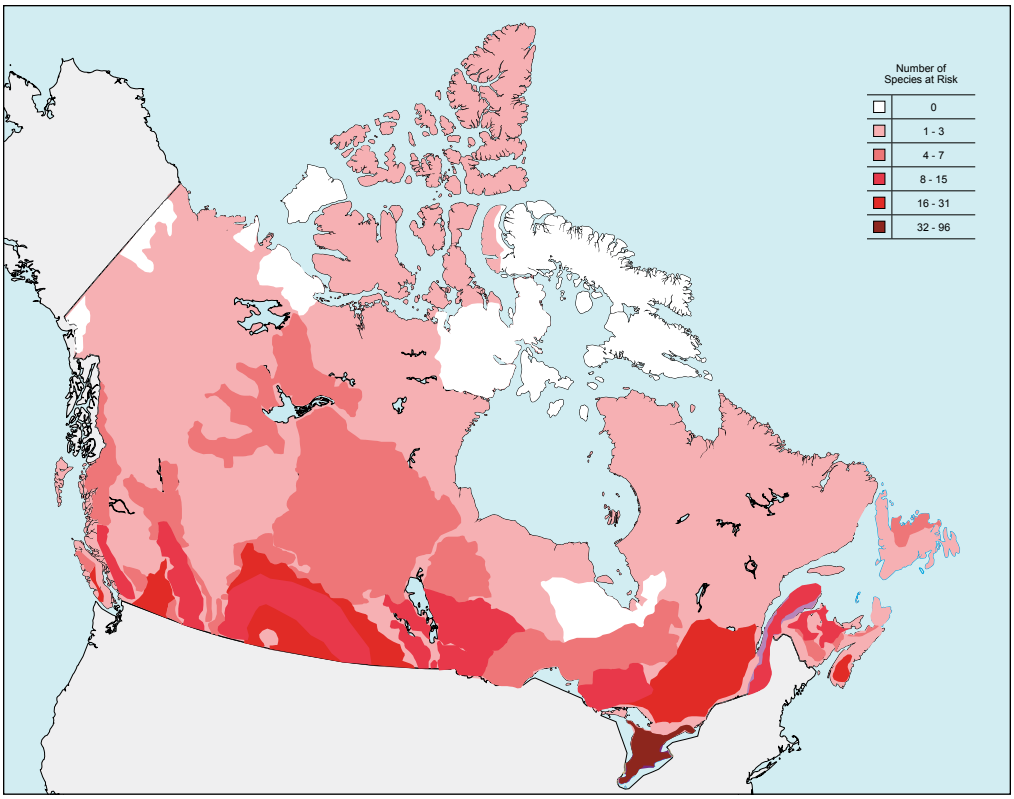

Figure 1-4. Distribution of species at risk across ecoregions in Canada. Species at risk include plants and animals assessed as being at risk of extinction at a national level (from Natural Resources Canada 2007c).

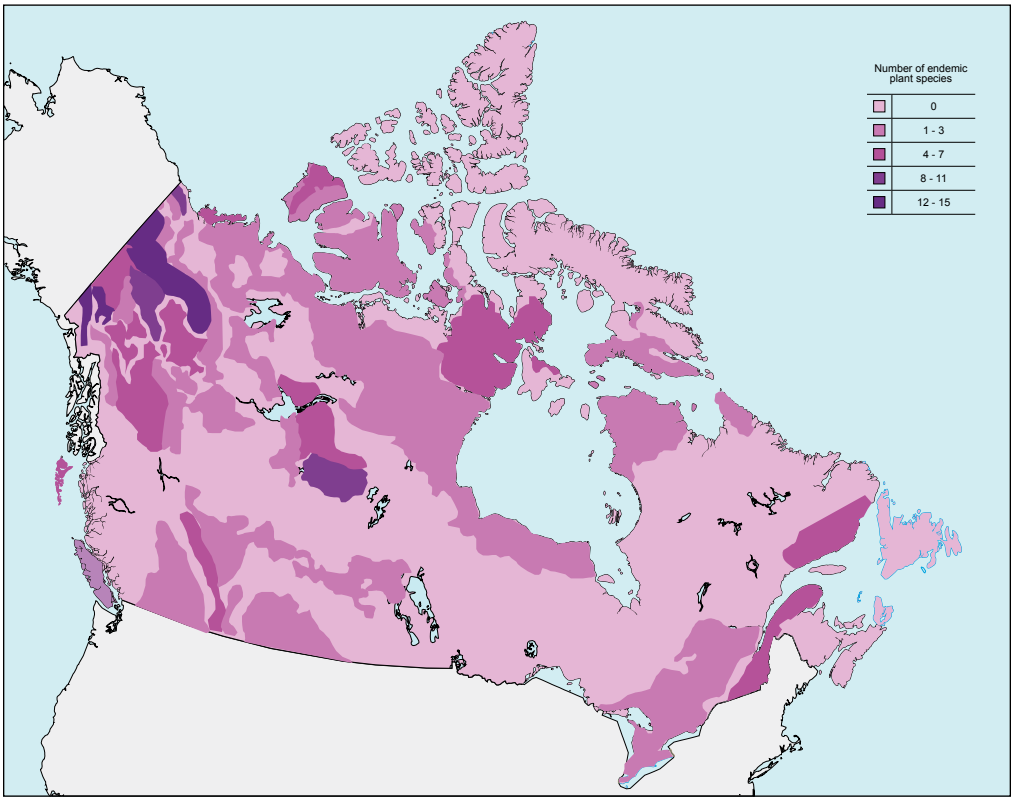

Figure 1-5. Distribution of endemic plants across ecoregions in Canada (from Natural Resources Canada 2007c)

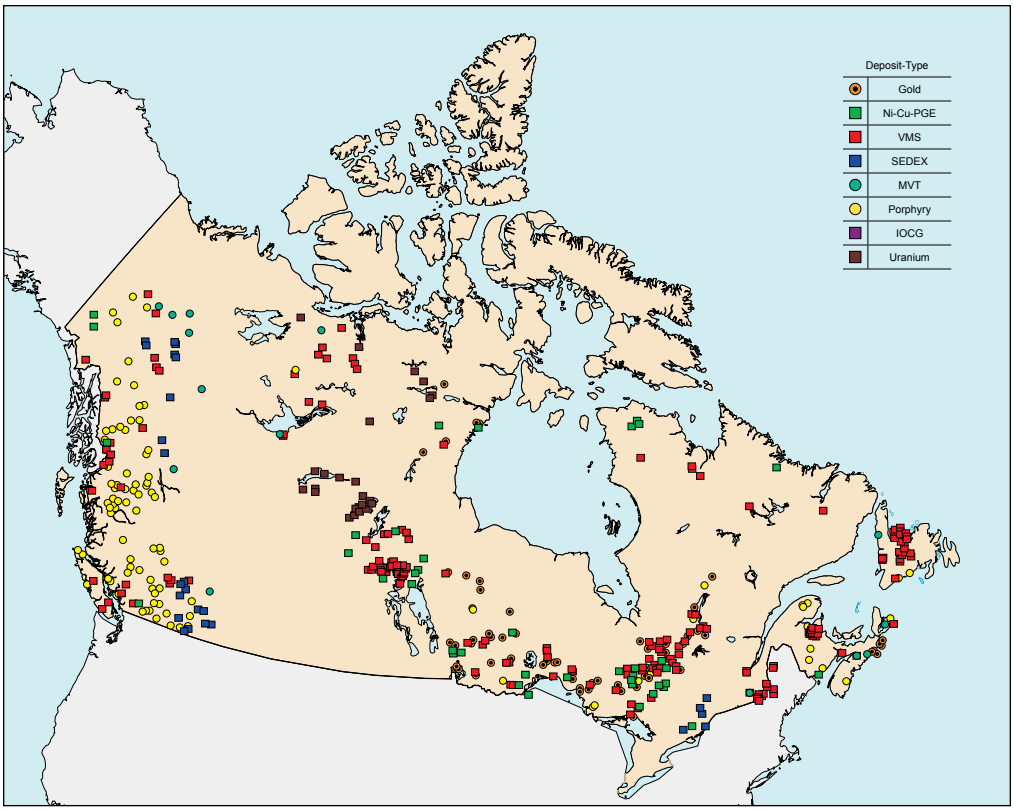

Figure 1-6. Distribution of major mineral deposits across Canada (from Goodfellow 2006); Ni-Cu-PGD = nickel, copper, platinum-group-elements deposits; VMS = volcanogenic massive sulfide deposits; SEDEX = sedmentary exhalative deposits; MVT = Mississippi Valley-type deposits; IOCG = Iron oxide, copper, gold deposits

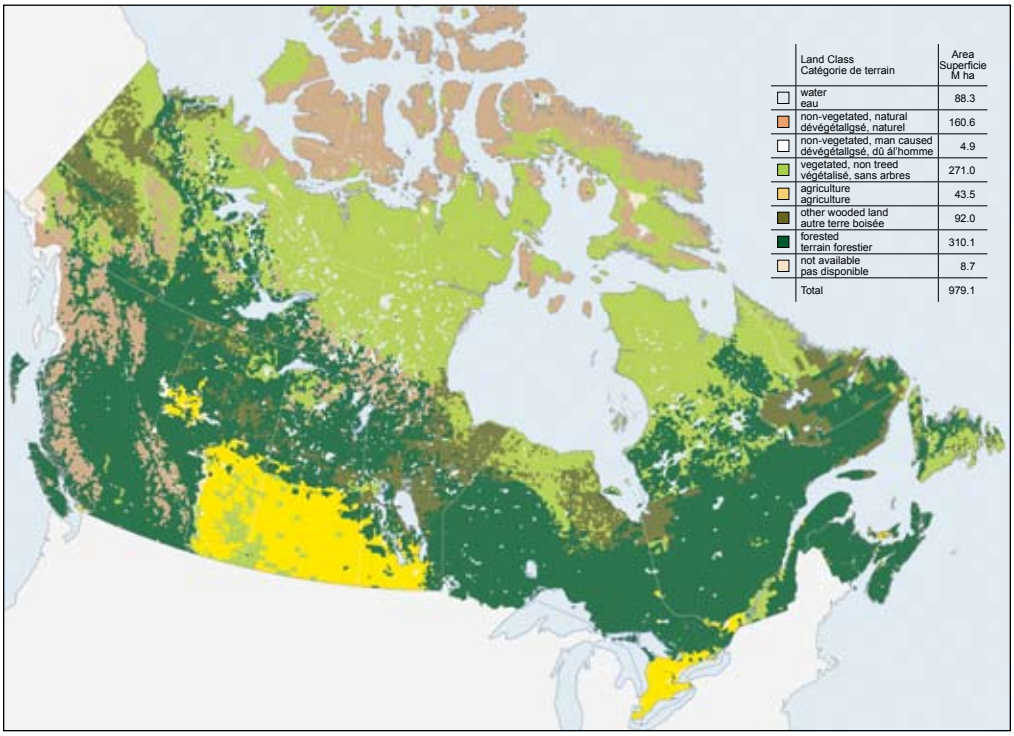

Figure 1-7. Land Classes, including agriculture, across Canada, with area (Power and Gillis 2006)

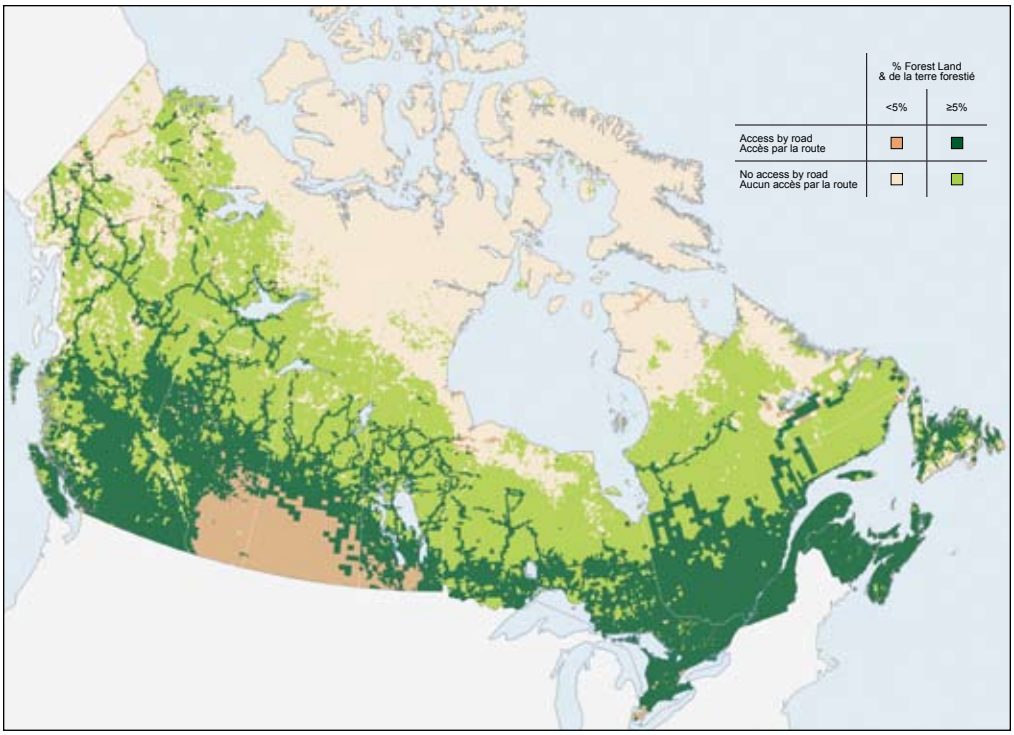

Figure 1-8. Access by road in Canada's forested lands, and percent forest land (Power and Gillis 2006)

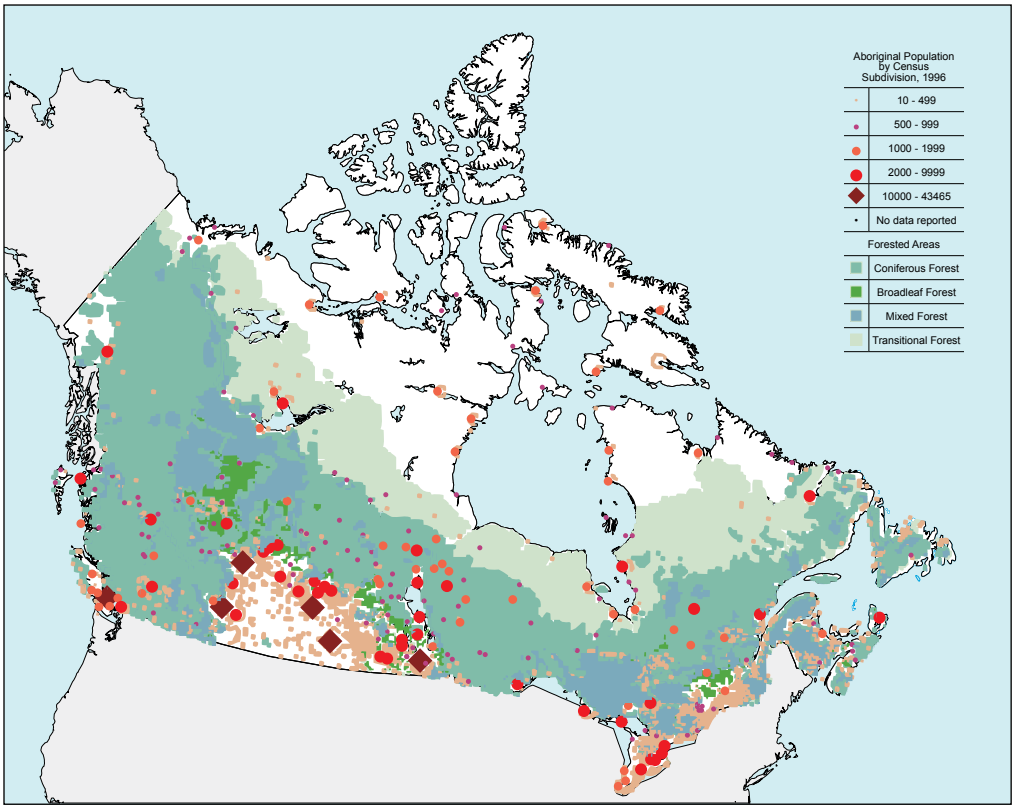

Figure 1-9. Distribution of total Aboriginal-identity population across forested areas in Canada (from Natural Resources Canada 2007c)

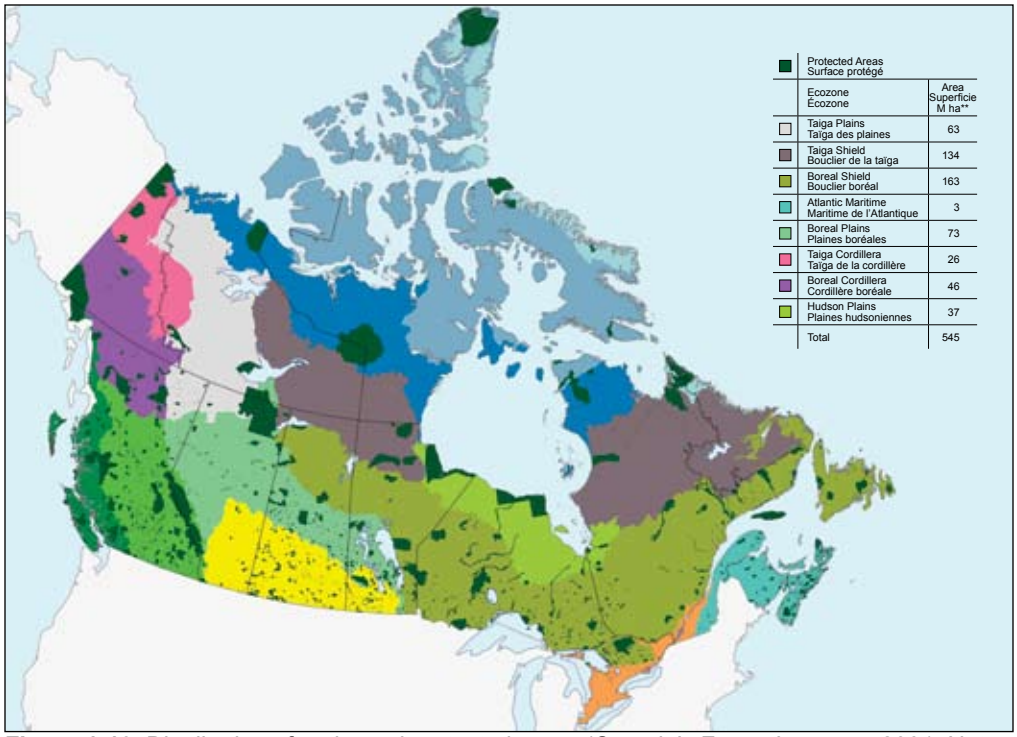

Figure 1-10. Distribution of parks and protected areas (Canada's Forest Inventory 2001, Natural Resources Canada, Canadian Forest Service – unpublished map)

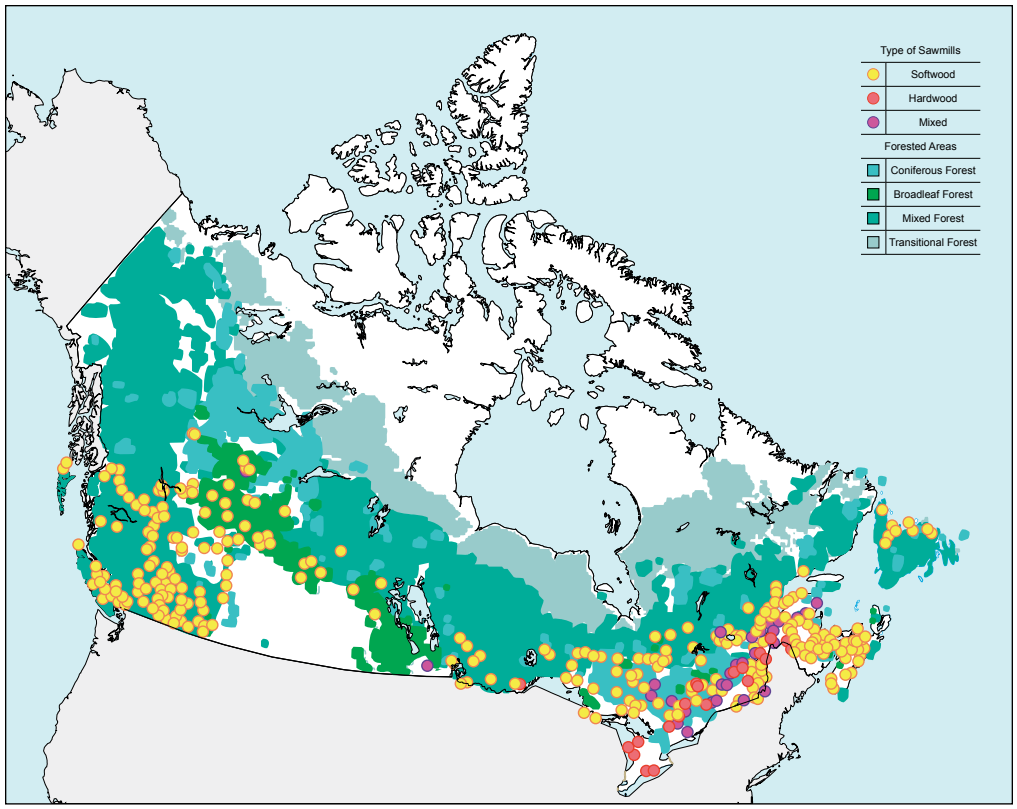

Figure 1-11. Location and types of sawmills in operation in 2002 (from Natural Resources Canada 2007c)

Appendix 2

Table 2-1. Land cover in the boreal region by province/territory (Canada's Forest Inventory 2001, Natural Resources Canada, Canadian Forest Service – special tabulation)

Province	Coniferous forest	Broadleaf forest	Mixed forest	Unclassified forest	Total forest	Other wooded land	Agriculture/ crops
Nfld.	7,255,853	458,426	70,974	2,942,423	10,727,677	9,336,820	14,449
N.S.	69,364	35,284	19,601	47,350	171,599	9,835	507
P.E.I.	-	-	-	-	-	-	-
N.B.	6,507	4,962	1,562	14	13,045	3	10
Que.	44,845,508	5,305,817	2,150,766	7,068,076	59,370,167	10,646,266	175,887
Ont.	24,637,182	7,106,873	2,741,819	5,476,620	39,962,494	13,902,942	38,247
Man.	11,952,619	1,790,006	1,736,260	2,597,492	18,076,377	17,244,314	1,383,492
Sask.	9,087,102	7,071,513	2,640,836	712,695	19,512,147	4,211,539	2,986,520
Alta.	9,889,417	4,183,172	7,567,288	3,179,542	24,819,420	8,456,159	3,403,238
B.C.	6,716,976	2,944,856	1,759,254	4,175,569	15,596,655	2,914,610	-
Yk.	3,720,418	908,406	101,265	3,149,547	7,879,635	14,899,196	3,463
N.W.T.	14,377,050	12,499,507	400	458,346	27,335,304	3,962,642	-
Nvt.	186,801	311,709	-	-	498,510	111,190	-
Boreal	132,744,798	42,620,533	18,790,025	29,807,674	223,963,030	85,695,515	8,005,811
Boreal Region as % of Total	..	..	..	..	72%	93%	18%

	Vegetated non-treed	Naturally nonvegetated	Nonvegetated due to human activity	Land not otherwise classified	Water	Unclassified	Total
Nfld.	12,759,665	732,020	65,989	-	4,785,028	85,466	38,507,113
N.S.	26,088	15,949	748	-	4,865	-	229,591
P.E.I.	-	-	-	-	-	-	-
N.B.	192	0	68	-	107	-	13,426
Que.	27,225,103	134,452	25,313	-	12,393,419	-	109,970,607
Ont.	12,288,543	152,534	205,408	-	9,812,423	58,536	76,421,126
Man.	7,283,636	3,022,180	260,296	-	9,111,977	24,796	56,407,066
Sask.	4,524,496	3,971,151	95,698	-	5,716,482	115,843	41,133,875
Alta.	4,147,726	462,307	530,491	-	1,901,537	1,570,013	45,290,891
B.C.	1,113,498	8,249,846	526,509	-	578,453	-	28,979,570
Yk.	18,812,892	4,411,965	11,654	48,874	595,148	874,167	47,536,994
N.W.T.	31,879,990	12,494,979	-	-	13,770,211	665,240	90,108,365
Nvt.	7,386,383	450,550	-	-	1,458,706	112,845	10,018,183
Boreal	127,448,211	34,097,931	1,722,173	48,874	60,128,355	3,506,906	544,616,806
Boreal Region as % of Total	47%	21%	35%	98%	68%	40%	56%

Table 2-2. Total area protected by province and territory, 1989 and 2003 (adapted from Statistics Canada 2005)

Province/ Territory	1989		2003		Change in protected area as a share of total land 1989 to 2003
	Total area protected[1] (ha)	Protected area as a share of total land (%)	Total area protected[1] (ha)	Protected area as a share of total land (%)	
N&L	367,500	0.9	1,701,412	4.3	3.4
Quebec	622,800	0.4	5,217,586	3.5	3.1
Ontario	5,152,900	5.2	9,142,039	9.2	4.0
Manitoba	315,400	0.5	5,402,416	8.5	8.0
Sask.	1,936,000	3.0	2,243,230	3.5	0.5
Alberta	5,642,000	8.7	8,009,229	12.3	3.6
BC	4,958,300	5.4	12,017,617	13.0	7.6
Yukon	3,218,300	6.8	5,678,119	12.0	5.2
NWT & NT	6,978,550	2.0	31,752,615	9.3	7.2
Canada	**29,425,250**	**3.0**	**81,877,849**	**8.4**	**5.4**

1. Defined by World Wildlife Fund Canada as those areas that are permanently protected through legislation and that prohibit industrial uses such as logging, mining, hydro-electric development, oil and gas and other large scale developments.

Table 2-3. Select price wood and paper product price indices. Prices are producer prices at mill gate after taxes (Index, 1997=100, Statistics Canada. n.d.[b] *Table 329-0042*)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Wood Products										
Lumber and other wood products	**100**	**96**	**105**	**96**	**95**	**94**	**90**	**101**	**93**	**87**
Lumber and ties, hardwood	**100**	**107**	**105**	**117**	**116**	**115**	**108**	**106**	**101**	**97**
Lumber, hardwood, birch	**..**	**..**	**106**	**107**	**107**	**111**	**121**	**119**	**112**	**110**
Lumber and ties, softwood	**100**	**88**	**99**	**83**	**83**	**83**	**73**	**87**	**78**	**71**
Lumber, softwood, domestic	**100**	**90**	**99**	**82**	**83**	**83**	**72**	**89**	**83**	**74**
Lumber, softwood, export	**100**	**87**	**99**	**83**	**83**	**83**	**74**	**88**	**77**	**72**
Veneer and plywood, hardwood	**100**	**103**	**113**	**118**	**113**	**110**	**103**	**99**	**97**	**94**
Veneer, hardwood, domestic	**100**	**107**	**129**	**134**	**111**	**104**	**102**	**100**	**99**	**98**
Veneer, hardwood, export	**100**	**100**	**93**	**105**	**124**	**118**	**102**	**93**	**88**	**79**
Plywood, birch	**100**	**107**	**113**	**115**	**119**	**120**	**108**	**102**	**95**	**90**
Veneer and plywood, softwood	**100**	**95**	**112**	**97**	**95**	**105**	**113**	**134**	**101**	**96**
Veneer, softwood	**100**	**97**	**104**	**98**	**97**	**97**	**99**	**100**	**92**	**91**
Plywood, softwood excluding Douglas fir	**100**	**95**	**116**	**98**	**95**	**108**	**118**	**146**	**105**	**99**
Pulpwood chips	**100**	**102**	**103**	**115**	**108**	**98**	**100**	**105**	**102**	**102**
Particle board and waferboard	**100**	**135**	**161**	**139**	**116**	**117**	**139**	**167**	**132**	**101**
Paper Products										
Pulp and paper products	**100**	**104**	**102**	**115**	**115**	**106**	**103**	**104**	**104**	**105**
Wood pulp, sulphate	**100**	**98**	**99**	**128**	**106**	**97**	**98**	**105**	**98**	**99**
Wood pulp, sulphite	**100**	**107**	**105**	**110**	**114**	**114**	**103**	**98**	**96**	**92**
Wood pulp, other	**100**	**96**	**100**	**123**	**107**	**106**	**115**	**106**	**100**	**101**
Newsprint and other paper for printing	**100**	**108**	**99**	**108**	**118**	**99**	**90**	**90**	**91**	**93**
Paperboard and building board	**100**	**103**	**105**	**119**	**118**	**119**	**118**	**119**	**121**	**125**
Other converted paper products	**100**	**102**	**103**	**107**	**108**	**108**	**105**	**102**	**100**	**100**
Paper products	**100**	**102**	**106**	**115**	**118**	**117**	**117**	**118**	**119**	**121**

Table 2-4. Select raw material input price indices. Prices reflect the total costs buyers pay for raw materials for use in further wood and paper manufacturing (Index, 1997=100, Statistics Canada. n.d.[b] *Table 330-0006* and *Table 329-0042**)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Wood	100	85	88	92	85	84	82	83	75	78
Logs and bolts	100	82	86	91	82	81	78	79	69	73
Pulpwood	100	101	99	99	102	100	104	108	108	108
Pulpwood, hardwood	100	98	99	102	115	105	110	118	126	121
Pulpwood, softwood	100	102	98	98	100	99	103	107	105	106
Recycled paper	100	100	116	180	138	157	150	169	155	142
Pulpwood chips*	100	102	103	115	108	98	100	105	102	102

Table 2-5. Capital expenditures on environmental protection by industry and type of activity, 1995 to 2002, selected years (adapted from Statistics Canada 2005)

Year/Industry	Environmental monitoring	Environmental assessments and audits	Reclamation and decommissioning	Wildlife and habitat protection	Pollution abatement and control processes (end-of-pipe)	Pollution prevention processes	Total
	$ million						
1997							
Logging	0.0	0.6	0.8	0.8	0.9	4.6	7.6
Wood products	3.4	1.0	x	x	49.3	21.6	77.4
Pulp and paper	6.2	1.9	3.5	3.0	180.0	136.8	331.5
Forest Industries	9.6	3.5	4.3	3.8	230.2	163.0	416.6
All Industries	**60.9**	**52.3**	**113.8**	**32.3**	**690.3**	**716.0**	**1,665.7**
2002							
Logging	0.0	0.0	0.1	x	x	0.6	5.8
Wood products	x	0.4	0.2	0.6	x	29.0	62.7
Pulp and paper	3.8	0.1	0.8	0.3	57.4	152.9	215.3
Forest Industries	3.8	0.5	1.1	0.9	57.4	182.5	283.8
All Industries	**192.3**	**75.1**	**207.4**	**40.0**	**907.7**	**1,427.2**	**2,849.7**
	percentage share of total						
1997							
Logging	0.0	1.1	0.7	2.5	0.1	0.6	0.5
Wood products	5.6	1.9	..	..	7.1	3.0	4.6
Pulp and paper	10.2	3.6	3.1	9.3	26.1	19.1	19.9
Forest Industries	15.8	6.7	3.8	11.8	33.3	22.8	25.0
All Industries	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
2002							
Logging	0.0	0.0	0.0	..	..	0.0	0.2
Wood products	..	0.5	0.1	1.5	..	2.0	2.2
Pulp and paper	2.0	0.1	0.4	0.8	6.3	10.7	7.6
Forest Industries	2.0	0.7	0.5	2.3	6.3	12.8	10.0
All Industries	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 2-6. Operating expenditures on environmental protection by industry and type of activity, 1995 to 2002, selected years (adapted from Statistics Canada 2005)

Year/Industry	Environmental monitoring	Environmental assessments and audits	Reclamation and decommissioning	Wildlife and habitat protection	Pollution abatement and control processes (end-of-pipe), waste management and sewerage services	Pollution prevention processes	Fees, fines and licences	Other	Total
	$ million								
1997									
Logging	1.6	3.1	10.5	68.8	7.9	1.7	0.5	2.0	96.1
Wood products	5.9	2.2	5.9	10.4	28.9	8.9	6.6	2.8	71.7
Pulp and paper	52.6	11.9	6.4	25.4	251.1	95.7	9.2	26.1	478.3
Forest Industries	60.1	17.2	22.8	104.6	287.9	106.3	16.3	30.9	646.2
All Industries	**206.1**	**81.0**	**298.2**	**147.4**	**1,293.2**	**421.8**	**80.9**	**177.2**	**2,705.9**
2002									
Logging	3.6	8.9	21.5	82.2	5.3	6.4	2.8	5.0	135.6
Wood products	8.9	4.0	21.0	27.4	42.2	10.1	3.8	8.3	125.9
Pulp and paper	41.6	6.5	12.9	1.8	265.1	69.2	8.2	16.5	421.8
Forest Industries	54.1	19.4	55.4	111.4	312.6	85.7	14.8	29.8	683.3
All Industries	**262.8**	**121.7**	**489.8**	**153.8**	**1,558.0**	**542.3**	**88.6**	**312.4**	**3,558.4**
	percentage share of total								
1997									
Logging	0.8	3.8	3.5	46.7	0.6	0.4	0.6	1.1	3.6
Wood products	2.9	2.7	2.0	7.1	2.2	2.1	8.2	1.6	2.7
Pulp and paper	25.5	14.7	2.1	17.2	19.4	22.7	11.4	14.7	17.7
Forest Industries	29.2	21.2	7.6	71.0	22.3	25.2	20.1	17.4	23.9
All Industries	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
2002									
Logging	1.4	7.3	4.4	53.4	0.3	1.2	3.2	1.6	3.8
Wood products	3.4	3.3	4.3	17.8	2.7	1.9	4.3	2.7	3.5
Pulp and paper	15.8	5.3	2.6	1.2	17.0	12.8	9.3	5.3	11.9
Forest Industries	20.6	15.9	11.3	72.4	20.1	15.8	16.7	9.5	19.2
All Industries	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 2-7. Distribution of capital expenditures on pollution abatement and control (end-of-pipe), by medium and by industry, 2000 (adapted from Statistics Canada 2005)

Industry	Air	Surface water	On-site contained solid and liquid waste	Noise, radiation and vibration	Total
	$ million				
Logging	0.1	0.0	0.0	0.0	0.1
Wood products	43.7	0.5	6.8	0.3	51.2
Pulp, paper and paperboard mills	24.0	47.0	14.7	0.2	85.8
Forest Industries	67.7	47.5	21.4	0.5	137.1
All Industries	**560.4**	**194.8**	**98.2**	**27.9**	**881.4**
	percentage share of total				
Logging	0.0	0.0	0.0	0.0	0.0
Wood products	7.8	0.2	6.9	1.1	5.8
Pulp, paper and paperboard mills	4.3	24.1	14.9	0.8	9.7
Forest Industries	12.1	24.4	21.8	1.9	15.6
All Industries	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 2-8. Distribution of capital expenditures on pollution prevention by medium and by industry, 2000 (adapted from Statistics Canada 2005)

Industry	Air	Surface water	On-site contained solid and liquid waste	Noise, radiation and vibration	Other	Total
	$ million					
Logging	x	0.5	0.4	0.0	x	1.2
Wood products	16.4	3.2	40.4	0.2	2.9	63.1
Pulp, paper and paperboard mills	65.7	42.5	21.0	0.0	11.3	140.4
Forest Industries	82.0	46.2	61.8	0.2	14.1	204.7
All Industries	**482.8**	**248.6**	**164.8**	**8.4**	**39.1**	**943.7**
	percentage share of total					
Logging	..	0.2	0.2	0.0	..	0.1
Wood products	3.4	1.3	24.5	2.6	7.3	6.7
Pulp, paper and paperboard mills	13.6	17.1	12.7	0.0	28.8	14.9
Forest Industries	17.0	18.6	37.5	2.6	36.1	21.7
All Industries	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 2-9. Principal statistics on Canada's mineral industry, 2005 (Statistics Canada n.d.[b] *Table 152-0003*)

		Production Related Workers			Total employees		
	Establishments	Employees	Wages ($000)	Value of Production ($000)	Employees	Wages ($000)	Value added ($000)
Nfld.	16	1,981	183,056	1,562,185	2,532	222,536	1,232,873
Que.	185	5,855	391,179	3,242,914	8,681	583,117	2,082,525
Ont.	288	10,232	649,133	6,334,335	13,348	938,358	4,522,816
Man.	31	1,729	106,647	1,202,411	2,253	141,541	848,936
Sask.	50	4,671	347,433	3,812,131	5,753	441,557	3,139,898
Alta.	89	2,186	124,844	847,660	2,683	156,435	662,316
B.C.	72	5,402	407,958	4,703,055	6,292	483,177	3,510,553
Canada	813	35,342	2,412,895	24,635,545	46,038	3,257,677	17,874,839

Table 2-10. Principle statistics on the Canada's mineral manufacturing industries, 2005 (Statistics Canada n.d.[b] *Table 301-0006,* includes primary metal, non-metallic mineral product, fabricated metal product, and petroleum and coal product manufacturing industries)

		Production Related Workers			Total employees		
	Establishments	Employees	Wages ($000)	Revenue ($000)	Employees	Wages ($000)	Value added ($000)
Nfld.	61	701	31,908	111,968	841	39,880	60,916
Que.	1,634	60,320	2,731,408	43,591,842	80,063	3,948,938	13,894,779
Ont.	3,181	114,693	5,664,682	63,332,976	151,870	8,163,074	21,589,425
Man.	220	6,452	272,178	2,574,010	8,106	370,886	1,147,248
Sask.	171	2,399	91,638	620,881	3,029	128,846	320,336
Alta.	783	21,606	975,181	19,234,038	28,055	1,400,254	3,938,482
B.C.	840	17,247	769,985	5,790,274	22,167	1,114,448	2,519,146
Canada	7,178	234,115	11,060,023	155,841,853	307,822	15,882,041	47,312,945

Appendix 3

Key aspects of annual allowable cut (AAC) in Canada

(adapted from Canadian Council of Forest Ministers 2005a)

1. AAC regulation is governed by provincial legislation, and applies specifically to publicly owned provincial lands (with the exception of some British Columbia tenures).
2. AAC regulation applies to both area-based and volume-based tenures.
3. AAC levels are reviewed and revised to reflect changes in information and practices. Major unforeseen changes can trigger more frequent revision.
4. AAC levels are enforced through periodic comparison of AAC and harvest levels.
5. Most provinces establish AAC levels based on a policy of non-declining future wood supply. However, short- and mid-term deviations from this policy can occur with transition from old-growth to second-growth sources of supply, and to accommodate short-term timber salvage requirements.
6. Definitions of current forest conditions are derived from provincial inventory sources, which are updated to reflect past harvests and natural disturbances, as well as the natural aging of unharvested stands.
7. Wood supply forecasts and AAC determinations reflect consideration of landbase withdrawals for non-timber values, as well as impacts that multiple value management strategies may have on harvesting practices within the net harvestable landbase.
8. Wood supply and AAC determinations are net of the non-harvest depletions associated with both endemic and catastrophic events.
9. Wood supply and AAC determinations are based on operational practices that can be currently implemented.

Appendix 4

Transport costs and location of processing facilities in and around Canada's boreal region

Transportation costs are an important factor in the spatial development of the forest industry (Nautiyal et al. 1995; Ledyard and Moses 1976; Pearse 1990; Nautiyal et al. 2001). As the cost of transporting timber from the stand to the mill increases as the distance increases, the profitability of harvesting declines and so to does the profitability of silviculture. Tsournos and Haynes (2004) summarize the challenges facing forest economic development and sustainability in remote forest regions and identify high transportation costs as a key barrier to sustainable development.

As transportation costs become prohibitive to long-distance movement of unprocessed logs and chips the economics support establishment of primary and some secondary processing farther from final market demands and closer to the raw resource, until the point that costs are so prohibitive that any timber-based activity is uneconomical, except for purely local consumption. This is especially true in remote locations where cost of imported inputs is high due to high transportation costs. Transportation costs will both limit and create opportunities to expand industrial forestry into unexploited areas of the boreal in northern Ontario, Saskatchewan, Manitoba, Quebec and British Columbia and expansion in the Yukon and Northwest Territories. As timber supply decreases in the south and costs of transporting raw materials

increases, the economics of establishing processing further into the heartland of the boreal will improve. However, while transport costs are important, they are not the only factor in determining the location of processing facilities. Other factors of production such as water, energy and labor and proximity to other related industry are also important, as are environmental factors such as climate, e.g. seasonal working conditions, and of course the quality of the resource stocks. Closeness to customers is important also. Another important factor in determining location of processing plants is the tenure arrangement. Many tenures (contractual agreements between the Crown and user of timber and forestland resources) tie processing plants to geographically specified timber resources. [See Ross (1995) for an overview of tenures in Canada.]

Appendix 5

Economics of timber production

The economics of timber production (establishing and developing a stand of trees for timber production) involves determining whether benefits from silviculture expenditures are worth more than their costs. The benefit is the value of the standing timber for wood or paper products. The cost of growing timber from stands of different productivity and different levels of management effort illustrates much of the economics of timber production. Timber production involves the preparation, establishment and tending of a stand of trees. It also involves the effort to harvest the trees. The art and science of silviculture for timber involves increasing the commercial volume and/or value of stand of trees in a given time frame. The practice of timber management is inexact; it is complex due to natural variability, changing market conditions, and lack of precise information. The inclusion of other forest management objectives increases the complexity and uncertainty of the practice and outcomes of forest management.

The tables illustrate the basic economics from a cost perspective. The present value of a dollar invested today is presented in Table 5-1 for different rates of interest and lengths of time. A range of possible cost scenarios of establishing and maintaining a stand of trees is presented in Table 5-2. The hypothetical costs of producing 1 m^3 for five different hectares of land of varying productivity and time are presented in Table 5-3. The minimum economic value per hectare of forest required to justify the original investment (Table 5-3 values multiplied by Table 5-1 values) is presented in tables 5-4 and 5-5, for a 3% and 5% real return on alternative investments, respectively.

The results show the economics of growing timber become increasingly unfavorable on sites of low productivity and longer cutting rotations. Conversely, larger expected benefits (value of timber) are required to justify investments on sites of low yields and long rotations. The art and science of timber management involves discovering cost-effective silviculture and harvesting systems that increase yields, decrease time of production, and decrease harvesting costs while maintaining or enhancing the value of the timber. First, if forest management involves higher costs but does little to change timber productivity (note the significant increase in costs per cubic meter for low productivity scenarios in tables 5-4 and 5-5), this means that higher and higher stumpage values are required to cover the investment. Conversely, if management costs are kept low then yields will be kept low on a per hectare basis and necessitate harvesting larger areas of land to achieve a given harvest level. This is fine if there is zero opportunity cost associated with using land for timber, however it is likely there will be some cost, typically in the form of road construction, planning and environmental management. Therefore, from a timber point of view, the only way such unproductive timber investments can be justified is if the other forest values are great enough to offset costs.

Regarding intensive timber management, a sufficiently high yield of timber within a relatively short period of time is necessary, but not sufficient, to justify high management expenditures. From Table 5-4, annual growth rates above 5 m^3/year may justify intensive-timber management. That said, given

uncertainties regarding future yields and values and competing uses of land, much higher expected growth rates are likely required.

Obviously the value of the timber is critical to understanding the economics of timber management. The value of the timber is the price offered for the use of the timber for use in producing wood and paper products. This price depends on the value of the products made from the timber and the cost of converting the timber into the final products. As part of the cost of conversion involves harvesting and transporting timber to mills, the geographic and physical characteristics of the stand and how the existing stand of trees factor into the next crop of timber will impact the value of the stand. Due to the various factors involved in determining the value of standing timber, it is difficult to generalize the current value of forests in the boreal: prices can range from zero to tens of dollars per cubic meter depending on location and site characteristics. However, for example, the average price charged for public timber across all tenure types in British Columbia for the years 1998 to 2004 was $\$17/m^3$. Average values over the seven years for across British Columbia's 29 forest districts ranged from $\$2/m^3$ to $\$37/m^3$. Therefore, the key challenge to boreal timber management is to produce a crop of timber as quickly and cheaply as possible.

Table 5-1. The present value of a dollar invested today

	Years	20	40	60	80	100
Real rate of return	3%	$1.81	$3.26	$5.89	$10.64	$19.22
	5%	$2.65	$7.04	$18.68	$49.56	$131.50

Table 5-2. Silvicultural costs per hectare ($ per hectare)

Silviculture Cost Scenario	Very Low	Low	Medium	High	Very High
	$250	$500	$1,000	$1,500	$1,750

Table 5-3 Hypothetical costs of timber ($ per m^3)

Growth (m^3/yr)	Rotation age (yrs)	Merchantable Volume (m^3)	Very Low	Low	Medium	High	Very High
20	25	500	$0.50	$1.00	$2.00	$3.00	$3.50
10	40	400	$0.63	$1.25	$2.50	$3.75	$4.38
5	60	300	$0.83	$1.67	$3.33	$5.00	$5.83
2.5	80	200	$1.25	$2.50	$5.00	$7.50	$8.75
1.5	100	150	$1.67	$3.33	$6.67	$10.00	$11.67

Table 5-4. Required break even stumpage – 3 % interest ($ per m^3)

Growth (m^3/yr)	Rotation age (yrs)	Merchantable Volume (m^3)	Very Low	Low	Medium	High	Very High
20	25	500	$1.05	$2.09	$4.19	$6.28	$7.33
10	40	400	$2.04	$4.08	$8.16	$12.23	$14.27
5	60	300	$4.91	$9.82	$19.64	$29.46	$34.37
2.5	80	200	$13.30	$26.60	$53.20	$79.81	$93.11
1.5	100	150	$32.03	$64.06	$128.12	$192.19	$224.22

Table 5-5. Required break even stumpage – 5 % interest ($ per m^3)

Growth (m^3/yr)	Rotation age (yrs)	Merchantable Volume (m^3)	Very Low	Low	Medium	High	Very High
20	25	500	$1.69	$3.39	$6.77	$10.16	$11.85
10	40	400	$4.40	$8.80	$17.60	$26.40	$30.80
5	60	300	$15.57	$31.13	$62.26	$93.40	$108.96
2.5	80	200	$61.95	$123.90	$247.81	$371.71	$433.66
1.5	100	150	$219.17	$438.34	$876.68	$1,315.01	$1,534.18

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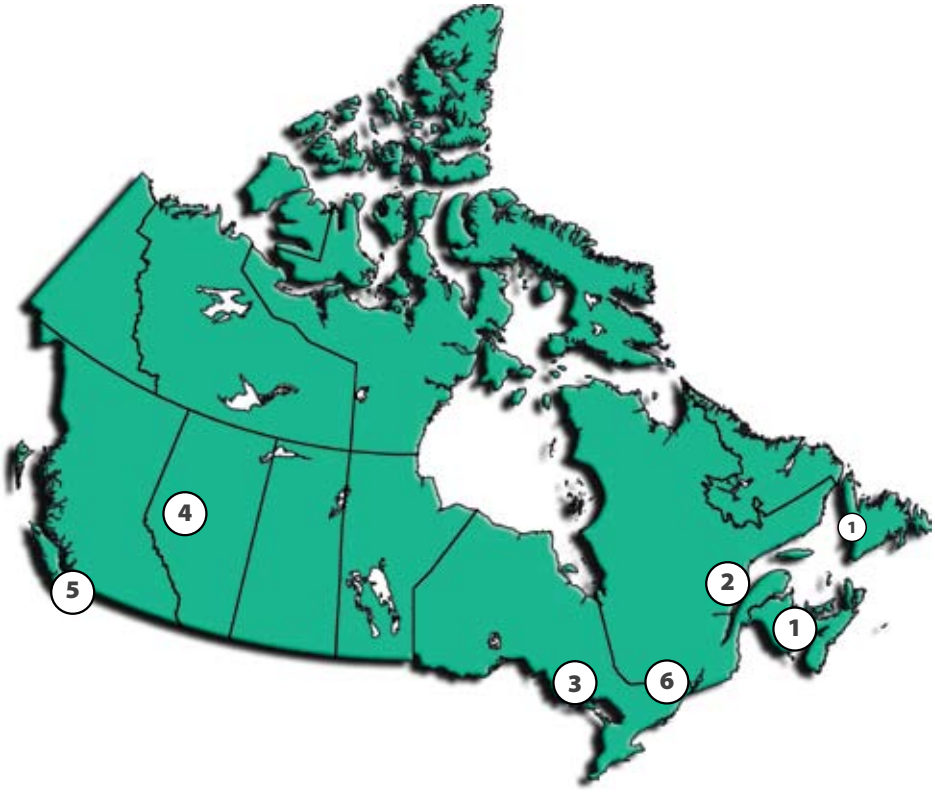

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