Competing Natural-Resource Demands Associated with Canada's Forests

Kimberly A. Lisgo, Fiona K.A. Schmiegelow, Robert G. D'Eon, and Peter N. Duinker

Report #10 in the series "Drivers of change in Canada's forests and forest sector", prepared for the Forest Futures Project of the SFM Network, University of Alberta.

January 2009

1. Introduction

Canada is blessed with immense natural resources. Along with this resource abundance come immense demands on, and competition for, these natural resources. Such resource competition covers a wide spectrum of consumptive and non-consumptive resource use, often overlaps in space and time, and involves a wide variety of stakeholders, from commercial resource-extraction industries to recreational users to wilderness preservationists. The cumulative effects of these demands have profound effects on the abundance and quality of forest ecosystems in Canada. Thus, how we manage competing demands on the forest land base strongly influences the future of Canada's forests.

The purpose of this paper is to examine the spectrum of demands competing for the land base of Canada's forests, the drivers that shape these demands, and how this may affect the future of our forests and the forest sector. We review how the demands and their management have evolved and present possible scenarios for the future of Canada's forests to 2050.

2. Competing demands in the context of Canada's forests and forest sector

Resource competition is a major driver shaping Canada's forests. Timber extraction is but one activity represented within a large spectrum of stakeholders competing for use of Canada's forest land base. As resource markets shift within a global marketplace, in conjunction with the evolution of societal needs and desires, the importance of timber products and other outputs of forest management has shifted, and will continue to shift accordingly. In such an environment, the benefits of forests managed for timber products must be weighed against the benefits accrued from other competing uses of forest land. The influence of resource competition in shaping Canada's forests is therefore profound. Indeed, industrial development in Canada touches the majority of Canada's forest lands, 62% of which shows some kind of human footprint (Smith and Lee 2000; Figure 1). At a minimum, in areas that are or were in recent history forested, there are 182 active mines (our calculations based on the Active Mineral Mine Database of GFWC 2007), 15,467 inactive mines (Smith and Lee 2000), 1,509 dams (our calculations based on the National Topographic Database of NRCan 2008a), and 4,045 settlements (Smith and Lee 2000). Undeveloped areas are almost exclusively in northern boreal and taiga forest regions.

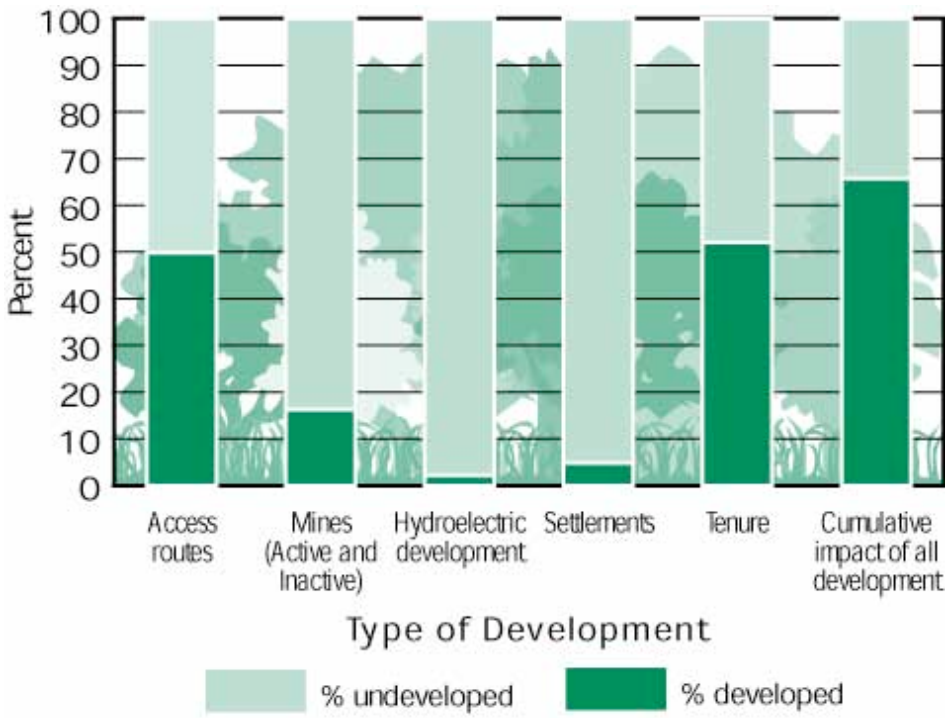

Figure 1. Percent forest area in Canada disturbed by development (Smith and Lee 2000). Tenure represents area- and volume-based timber tenures and other areas managed for commercial timber production.

Demands on Canada's forests often occur at the same times and places, and may be incompatible. Some uses of forest land, including agriculture, urban and industrial infrastructure, transportation, oil and gas development, mines, and hydro-electric developments are prominent examples of forest conversion or deforestation where forests are converted to non-forest cover types. Other uses of Canada's forests, including timber management, nature protection, and recreation, are equally prominent examples of competing uses for forest land. The cumulative effects of such demands can have profound effects on the abundance and quality of forest ecosystems (Figure 2).

Here, we describe some of the major competing demands on Canada's forests. Many other uses of, and competition for, the forest land base occur, but are not described in detail here; examples include peat extraction, ecotourism, urbanization, rural residential development, cottaging, trapping, fishing, hunting, livestock grazing, biofuel extraction, carbon storage, and water extraction.

Of all industrial activities, timber production affects the largest portion of Canada's forest lands. A total of 294.8 million ha (or 73%) of the forest land base[1] are available for commercial timber harvest, and of this area, about half is under management for timber production with an annual harvest of less than 1% (or 0.9 million ha) (NRCan 2007a). Private woodlots account for 18 million ha (or 6%) of the commercial productive forest (NFSC 2003a). Not all woodlots are managed for timber, but those that are produce 21% of the national timber harvest (NFSC 1998). Overharvesting and conversion of woodlots to agriculture and crop production are concerns (NFSC 1998).

[1]Here, forested land base is the combined area of forest (310.1 million ha) and other wooded lands (92 million ha) as defined by Canada's National Forest Inventory.

Figure 2. Multiple uses of the forest land base along the southern fringe of the Boreal Plains ecozone in Alberta: town site of Edson, agriculture, timber management, and oil and gas development (well sites and roads). Seismic lines are also present, but are too small to see at this resolution.

Extraction of non-timber forest products (NTFPs) is growing in Canada's forests. These are defined as plant-based products used for food, medicinal, ornamental, or industrial purposes and include blueberries, wild rice, wild ginseng, maple sap products, fiddleheads, edible mushrooms, paclitaxel from ground hemlock (active cancer-fighting drug ingredient), conifer boughs, balsam fir wreaths, and cedar leaf oil, to name a few of potentially hundreds across Canada (Smith et al. 2007, NRCan 2005a). In recent years, extraction of NTFPs has an estimated economic output of $725 million to $1.33 billion, with additional potential earnings of $2 billion to $7.4 billion per year (Wetzel et al. 2006).

Recreationalists include hikers, skiers, horse-back riders, mountain bikers, ATV and snowmobile users, canoeists and others. Tracking the number of people recreating in Canada's forests is difficult. However, in 2006, national parks had 12.2 million person-visits (NRCan 2007b), and each year, Canadians spend billions of dollars on nature-related activities (Wetzel et al. 2006).

Forest protected areas currently account for approximately 8% of Canada's forest area (CCFM 2006, Table 1). Of all the terrestrial ecosystems protected in Canada, industrial activities such as mining, hydro-electric development, and commercial timber production are prohibited on 95% of their area (Government of Canada 2006).

Table 1. Area and percent area of protected forest and other woodland in all of Canada's ecozones (after CCFM 2006).

Ecozone	Area (000 ha) of forest and other wooded land	% of total forest and other wooded land protected
Arctic Cordillera	11	27.3
Northern Arctic	152	25.7
Southern Arctic	2,444	2.0
Taiga Plains	35,785	12.2
Taiga Shield	48,421	2.9
Boreal Shield	144,457	7.1
Atlantic Maritime	16,530	6.0
Mixedwood Plains	3,319	1.4
Boreal Plains	47,914	8.7
Prairies	1,947	5.6
Taiga Cordillera	7,687	12.0
Boreal Cordillera	24,124	7.8
Pacific Maritime	12,058	9.5
Montane Cordillera	35,610	12.2
Hudson Plains	21,626	6.4
Canada	402,085	7.8

Initiatives to increase the area of Canada's legally protected forests continue. In 2002, the Government of Canada made a commitment to expand the national parks system. As of 2005, the expansion was 60% complete (NRCan 2005a). In 2006, the federal government announced a 10 million ha land withdrawal from industrial activity in the Northwest Territories (EC 2007a) and expansion of the Nahanni National Park Reserve (Office of the Prime Minister 2007). The Senate Subcommittee on the Boreal Forest (SSBF 1999) recommended 20% protection of Canada's boreal regions "to meet the competing realities of preserving the resource, maintaining the lifestyle and values of boreal communities, extracting economic wealth, and preserving ecological values." The Boreal Framework, with signatories including First Nations, environmental non-government organizations, and forest and oil-and-gas companies, calls for a minimum of 50% of the boreal to be protected (The Boreal Leadership Council 2003). Partly in response to this call for 50% protection, the Government of Ontario announced a commitment to protect 225,000 km^2 of the boreal in northern Ontario (Government of Ontario 2008).

Canada is the world's third-largest and seventh-largest producer of natural gas and crude oil respectively, with onshore oil and gas development in 11 of the 13 provinces and territories (CAPP 2008). Oil and gas development is located primarily in the boreal region, with an industrial footprint of approximately 46 million ha or 8% of the boreal region (Anielski and Wilson 2005). Alberta has the greatest concentration of oil and gas development, with more than 377,000 km of energy-related pipelines (AEUB 2007), thousands of kilometres of seismic lines (Anielski and Wilson 2005), 40,500 abandoned well sites,

213,000 active well sites, and approximately 15,000 new wells each year (Alberta Environment 2008a)[2]. Other infrastructure associated with conventional oil and gas development includes oil and gas batteries, compressor stations, and oilfield injection and treating facilities. In Alberta, there are more than 14,000 oilfield and more than 5,600 gas-battery facilities (Alberta Environment 2008b). In addition to traditional oil extraction, Alberta has leased more than 3.6 million hectares of land to oil-sands development, and if fully developed, this would translate to 296,000 ha of forest cleared and more than 30,000 km of access roads (Schneider and Dyer 2006).

Canada is the world's largest producer of hydroelectric power (NRCan 2006). Hydroelectric developments occur in all provinces and territories (EC 2003), with primary producers in Quebec, Manitoba, Ontario, and Newfoundland and Labrador (NRCan 2006). There are 6.5 million hectares of surface area impoundments associated with these activities.[3] As of 2000, there were 1100 hydroelectric facilities located on the forest land base (Smith and Lee 2000). The James Bay Project in Quebec is the largest hydroelectric facility in Canada, consisting of eight dams, 198 dikes, and five reservoirs covering 11,900 km^2 (EC 2007b).

Canada is one of the world's largest mineral producers with a production of $40.4 billion in 2007 (NRCan 2008b). As of early 2003, "there were some 190 principal metal, non-metal and coal mines, more than 3,000 stone quarries and sand and gravel pits, and about 50 non-ferrous smelters, refineries and steel mills operating in Canada" (Lee 2004) with more than 40 million hectares used for mining purposes (Mining Watch Canada 2001). Mining in Canada's forest is heavily concentrated in the Mixedwood Plains, Boreal Shield, and Montane Cordillera ecozones (NRCan 2003) with approximately 80% of mining located in the boreal forest (Mining Watch Canada 2001). In the boreal forest regions, there is a minimum of 105 mineral mines, 583,000 km^2 of mineral claims (IBCC and CBI 2008), and more than 7000 abandoned mines (Mining Watch Canada 2001).

Roads are associated with most human activity in the forest. In Canada, there are 1,326,531 km of pubic road (Statistics Canada 2008a), the majority of which fall within the forest ecozones (Figure 3, Table 2). There are more than 945,832 km of roads in the forest ecozones of Canada (Figure 3, Table 2**,** Statistics Canada 2008). This number is conservative and does not take into account many of the secondary roads, such as those used by the oil and gas industry to access well sites.

[2]Pipelines are typically 15-18 m wide, up to 45 m, and well sites are approximately 1 ha in extent (Alberta Environment, http://www.environment.alberta.ca/1175.html).

[3]Source cited as IPCC (International Panel on Climate Change: Greenhouse Gas Inventory Programme) http://www.plugintogreencanada.com/content/Renewable_Energy/167/43/0

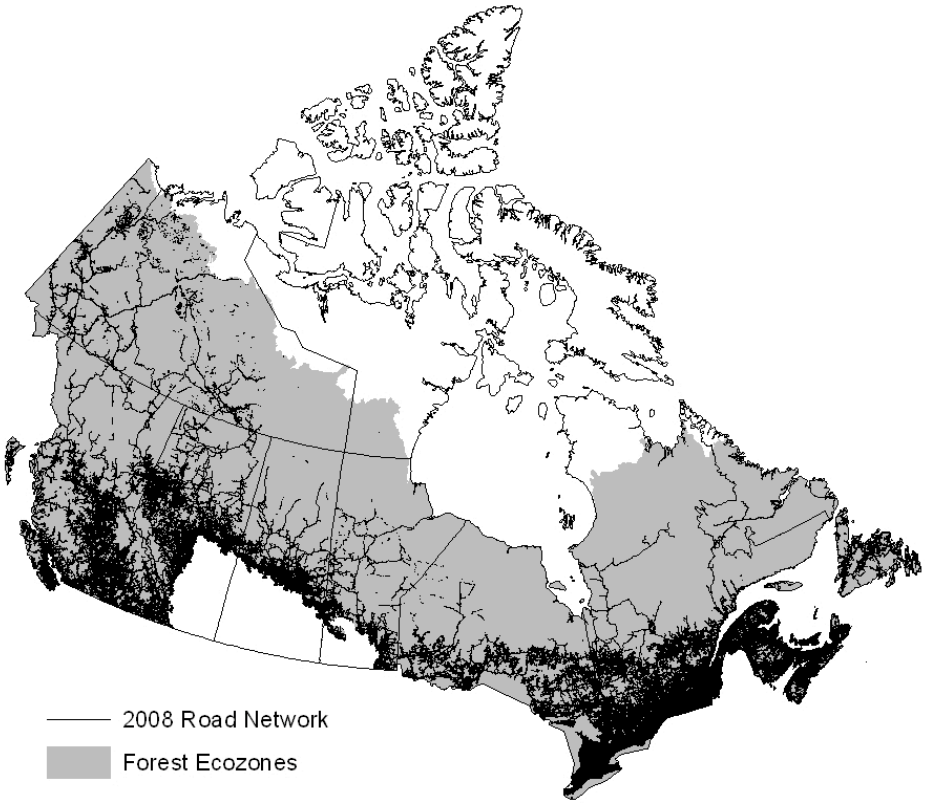

Figure 3. The road network in the forest ecozones of Canada based on the 2008 Road Network File (RNF). The RNF is a digital representation of Canada's national road network (Statistics Canada 2008).

Table 2. The length of road in each forest ecozone based on the 2008 Road Network File (Statistics Canada 2008).

Forest Ecozones	**Length of Road (km)**
Atlantic Maritime	155,397
Mixedwood Plains	183,679
Montane Cordillera	114,167
Pacific Maritime	48,582
Boreal Shield	238,099
Boreal Plains	168,054
Boreal Cordillera	13,919
Hudson Plains	1,220
Taiga Shield	3,596
Taiga Plains	14,427
Taiga Cordillera	4,692
Total	**945,832**

3. Competing Demands and Other Drivers of Forest Change

Many drivers of forest change influence resource competition in Canada's forests (see other driver papers of the Forest Futures Project). The interplay of these drivers defines the nature and composition of competing demands. At present, global population growth is one of the most influential drivers of forest change on competing demands. By its nature, population growth is accompanied by increased consumption of natural resources (Fyles et al. 2008), which magnifies competition and conflict on forest lands. How this unfolds depends to some degree on regional drivers such as available work force (Fyles et al. 2008), rising energy costs for production (McFarlane et al. 2008a), the development of cost-effective technologies (McFarlane et al. 2008b), increased aboriginal empowerment (Trosper 2008) and the needs and desires of the Aboriginal community, and the influence of society's values (Duinker 2008a) and governance (Hoberg 2008a) on forest management, amongst other things.

Global drivers are also influential and include geopolitics (Hoberg 2008b), global markets for forest products (Adamowicz et al. 2008), and global energy demands (McFarlane et al. 2008a). As global markets shift in response to shifting market demands, competition among resources will follow suit (Adamowicz et al. 2008). Canada, particularly the province of Alberta, has recently become a supplier of oil and gas on a global scale. Much of the current and future oil and gas development overlaps spatially and temporally with other forest land uses. As a result, competition and conflict within areas of overlap occur, and will increase as energy demands increase on a global scale. A similar scenario applies to agricultural biofuels (McFarlane et al. 2008a).

Climate change is a wildcard that may increase conflict between competing demands by disrupting historical patterns in land use and changing freshwater patterns (Duinker 2008b). For example, forest areas presently unsuitable for agricultural development, due to climatic limitations (e.g., too cold, too dry), may become more suitable, increasing competition for these lands. Along a similar vein, changes in freshwater patterns may shift potential land uses.

4. A Look Back: Effects of Resource Competition on Canada's Forests Since 1970

How society values forests and how forests are managed has evolved considerably over the last 35 years. Now, there is greater emphasis on the role of ecosystem services and dramatic shifts from sustained yield and species-specific management to maintenance of biodiversity and management at the landscape scale. The impetus for this change largely lay within the forest sector itself. According to Drushka (2003), in the 1970s there was growing recognition that the sustained-yield policies applied in Canada were not working, with anticipated timber shortages by the year 2000. In part, this resulted from the lack of reliable forest inventories and thus unreliable sustained-yield calculations. The primary response of forest companies was to move into more remote areas with roads pushed north. As a result, the industry increasingly came into conflict with other forest users (e.g., fisheries with concerns for salmon habitat, Aboriginal peoples dependent on forests for food supplies and furs, and recreationists). These forest users, in combination with the increasingly science-based environmental movement, formed a powerful lobby. Protests erupted over specific tracts of land, calling for bans on industrial activity and designation of parks (e.g., Carmanah Valley BC mid-late 1980s, Temagami ON 1989, Clayquot Sound BC 1993). Through the 1980s to present, the percent area protected in Canada increased substantially from roughly 4.3% to 12% (CCFM 2006, Figure 4).

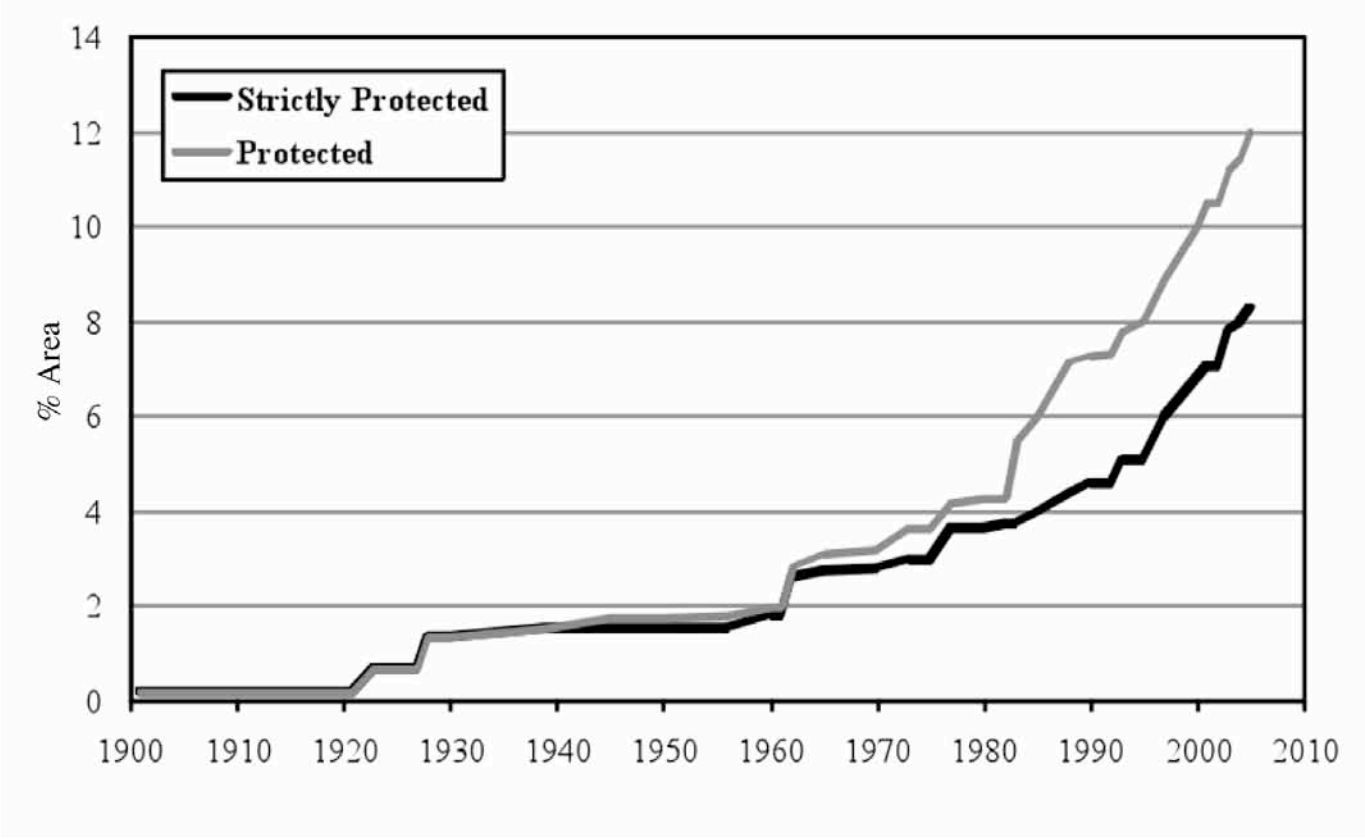

Figure 4. Percent area protected in Canada (after CCFM 2006).

Canada's new direction for forest management is reflected in a national forest strategy first released in the 1980s (NFSC 2003b). This was followed and complemented by the Canada Forest Accord (CFA 1992). With new releases every five or so years, both documents capture a growing vision for Canada's forests which includes commitments to sustainable forest management and ecosystem-based management from a broad spectrum of signatories such as governments, forest companies, academic institutions, and other forest stakeholders.

In the early 1990s, forest certification emerged as a tool to mitigate conflict between the competing demands for forest protection by environmental groups (e.g., Forest Ethics) and timber harvest by the forest industry. The number of forest companies certified in Canada has grown rapidly (Figure 5). As of January 2008, 138 million ha of forest have been certified in Canada, accounting for 40% of the world's certified forests (CSFCC 2008).

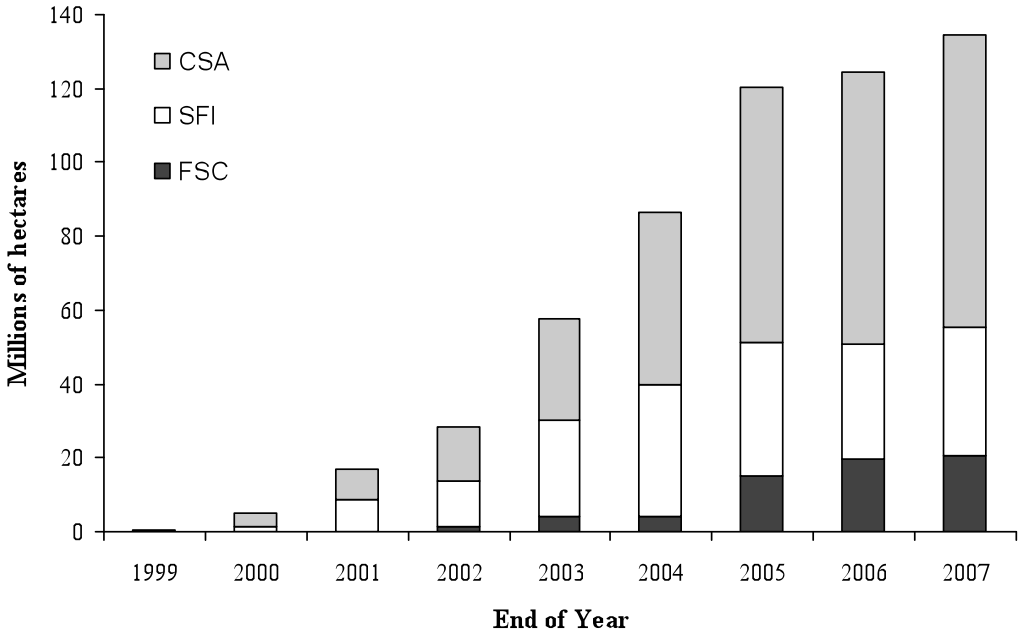

Figure 5. The area of forest certified in Canada from 1999 to 2005. There are three programs of certification: Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), and Canadian Standards Association (CSA). Source: Canadian Sustainable Forestry Certification Coalition (2008).

The most visible effect of resource use on forest landscapes has been an increase in the industrial footprint (area disturbed), fragmentation, and deforestation. Between 1975 and 2001, the total area annually subjected to timber harvests by the forest industry increased 50% (Lee 2004). The average yearly disturbance rate (natural and anthropogenic combined) in the boreal alone increased from 1.7 million ha (1920-69) to 3.9 million ha (1979-89) (Lee 2004). Anielski and Wilson (2005) reported that 92.9 million hectares of the boreal forest has been fragmented due to linear disturbances (e.g., roads, seismic lines, pipelines, etc.) from multiple forest users. All forest ecozones have experienced disturbance with estimates of up to 99% area disturbed in eastern Canada (Table 3). The most northern ecozones are the least disturbed (Figure 6).

At present, no national long-term monitoring system exists to estimate changes in forest area within Canada (Fitzsimmons 2002). Estimates of 56,000 ha/yr and 92,500 ha/yr of deforestation have been presented by NRCan (2007b) and NRCan (2005b), respectively. However, a recent analysis in the boreal forest indicated that these values did not account for afforestation (non-forest land converted to forest land), and concluded that given the enormous size of Canada's boreal forest (400 million hectares), Canada's boreal forest is neither shrinking nor expanding (NRCan 2005b). Despite this general trend, site-specific areas, such as the southern boreal, temperate mixedwood and hardwood regions of Canada, have experienced significant deforestation in recent decades. For example, Lee (2004) estimated that the southern boreal region (Boreal Plains and Boreal Shield) has lost approximately 3% of the forest area (7.7 million ha) to clearing and cover conversion in the last century. Along the southern fringe of the boreal parkland, over half of the aspen parklands have been cleared since European settlement, mostly for agriculture (NRCan 2005b). In eastern boreal Canada, about 900,000 ha of peatland and other lowland ecosystems have been flooded for hydro-electric reservoirs, with proposals to affect an additional million

Table 3. Estimate of area disturbed in forest ecozones based on GFWC forest landscape fragments analysis (Lee et al. 2006). The analysis is based on forest landscape fragments of 5,000 ha and buffered anthropogenic disturbances.

Forest	Ecozone	Total Area (km^2)	Area Disturbed (km^2)	% Area Disturbed
Temperate	Atlantic Maritime	206,197	195,263	95
	Mixedwood Plains	118,127	117,452	99
	Montane Cordillera	477,976	236,472	49
	Pacific Maritime	203,306	71,576	35
Boreal/Taiga	Boreal Cordillera	444,537	31,609	7
	Boreal Plains	679,014	432,714	64
	Boreal Shield	1,842,172	660,070	36
	Hudson Plains	361,133	7,154	2
	Taiga Cordillera	251,380	7,288	3
	Taiga Plains	572,016	126,770	22
	Taiga Shield	1,290,930	23,364	2
	Total	**6,446,788**	**1,909,734**	**30**

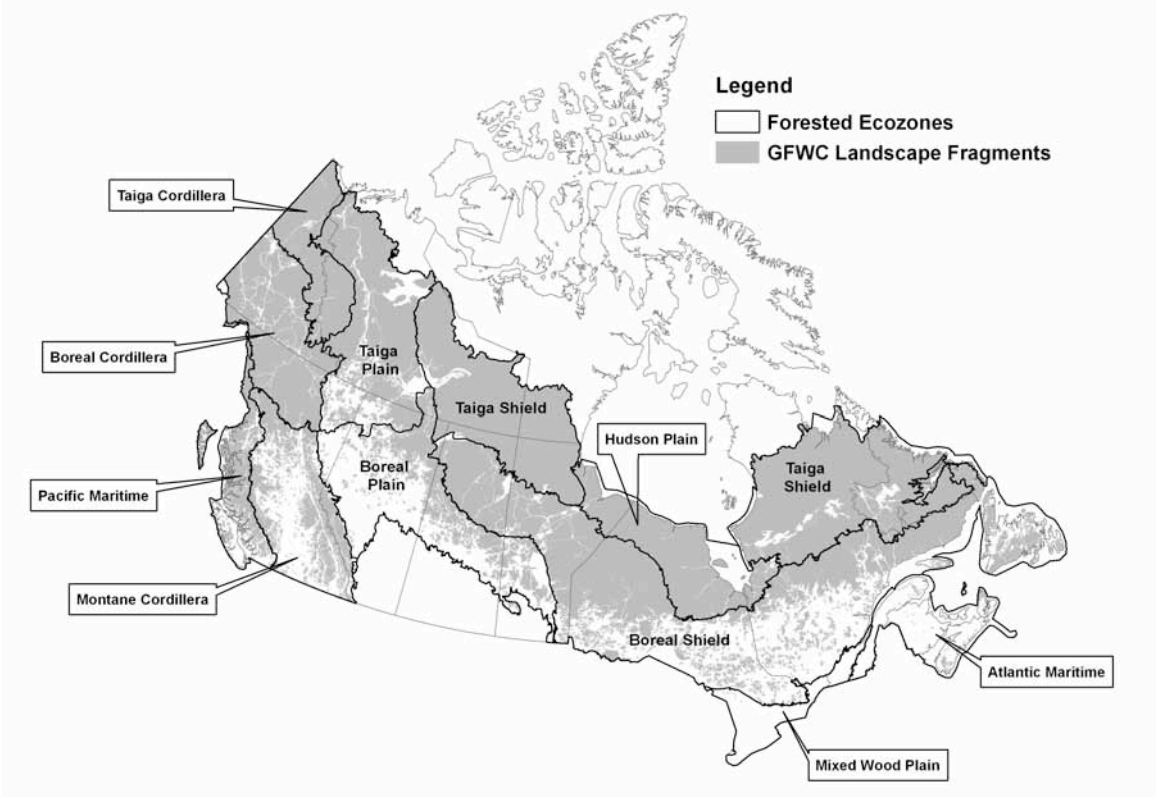

Figure 6. Forest ecozones of Canada and intact landscape fragments greater than 10,000 ha and 5,000 ha in the boreal and temperate forest regions, respectively (Lee et al. 2006).

hectares expected by 2010 (NRCan 2005b). In Alberta, recent decades have seen the exponential growth of the oil and gas industry (Figure 7). Across Alberta, more trees are removed from the boreal forest every year due to agricultural expansion and oil and gas exploration than due to the forest-products industry (NRCan 2005b). Areas deforested for oil and gas exploration in recent decades have poorly regenerated to a forest state, with 65% of seismic lines after 35 years remaining in a cleared state (Lee and Boutin 2006). Urbanization has also contributed to deforestation. Urban development and urbanization within Canada increased rapidly within the century between 1870 and 1970, but appears to have levelled off in recent decades (SRP 2004).

Historically, and still across much of the forest land base, competing demands are managed poorly to the detriment of forest health. At present, 60% of Canada's species at risk (N=323) are associated with forests, and of these species, 3% are extirpated, 42% endangered, 25% threatened, and 30% of special concern (NRCan 2007c). Between 1999 and 2007, the number of COSEWIC-listed forest-associated plants, mammals, birds, reptiles and amphibians, fish, lepidopterans and arthropods, and molluscs, increased with fewer than 4% removed from the list or moved to a lower risk category (NRCan 2007c). These data strongly suggest that in some regions of Canada's forests, the health of forest ecosystems has been and continues to be compromised and that effective broad-scale sustainable forest management has yet to be applied.

A persistent problem, in the face of multiple competing demands on our forests, is an often chronic trend of managing single resources in isolation without consideration of cumulative effects on the land base from multiple demands. Current concern over the fate of British Columbia’s endangered mountain caribou populations is a glaring example of a valued ecosystem component under severe pressure from a wide array of competing resource uses. While habitat loss and fragmentation of old forests is identified as the ultimate cause of their decline, the proximate causes include a variety of factors including logging, road construction, human settlement and agriculture, hydro-electric power development, backcountry recreation, heli-skiing, snowmobiling, and increased human access (Apps and McLellan 2006). Clearly, effective management of competing resource demands surrounding this issue is central to any potential solution (MCTAC 2002).

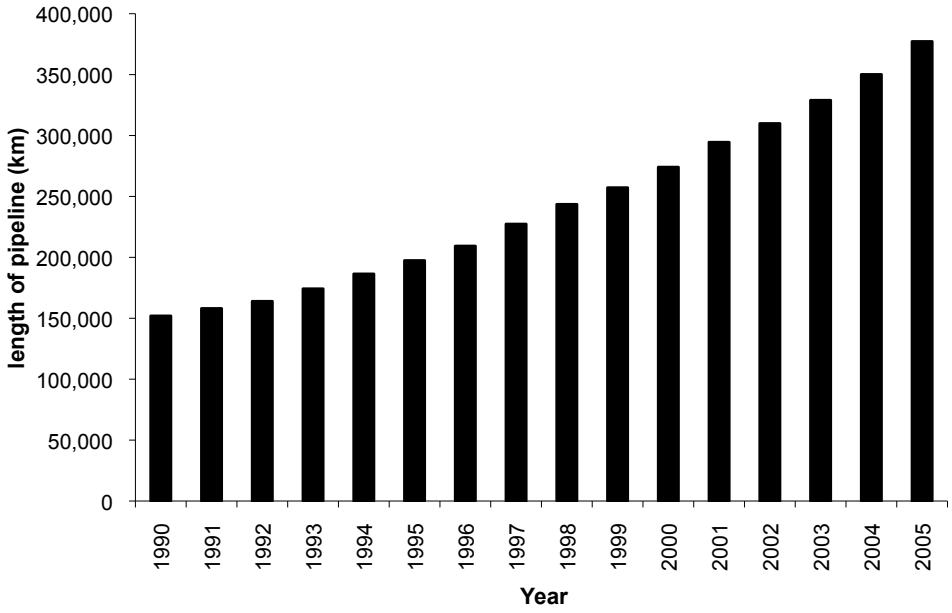

Figure 7. EUB-licensed pipeline in Alberta from 1990-2005 (AEUB 2007).

5. A Look Ahead: Resource Competition Issues Facing Canada's Forests To 2050

As the human population increases, both in Canada and worldwide, demands on the forest land base are expected to increase (Fyles et al. 2008). Global annual wood consumption has increased from 1 billion m^3 in 1961 (Bryant et al. 1997) to today's consumption of 3.5 billion m^3 (FAO 2007). By 2050, global consumption is projected to reach 6 billion m^3 (NRCan 2000). In concert with rising wood demands, global energy demands are projected to increase substantially in coming decades and present additional competing demands on Canada's forests (McFarlane et al. 2008a). Within Canada, oil and gas development in western provinces will remain high in coming decades and create significant competition for forest lands. For example, development of the oil sands has the potential to expand an additional 350%, thus affecting an estimated 13.8 million hectares of boreal forest (Schneider and Dyer 2006). As well, hydro-electric power development is predicted to place increasing pressure on forest lands with significant potential for additional hydroelectric production in Canada (NRCan 2006). Mining activity is also likely to increase (Mining Watch Canada 2001). Many areas of Canada have yet to be explored for minerals, and Canada is expected to have a promising future as a major producer (Cranstone 2002). The harvest of non-timber products is predicted to rise (NRCan 2005a). Increased road building and industrial infrastructure will inevitably accompany the expansion of industrial activities. By 2050, Canada's population is projected to grow by roughly 10 million (UNPD 2006). This will likely place further pressure on forests with conversion to residential spaces and increased draw on natural resources. In response to calls for greater protection (e.g., SSBF 1999, CBI 2005), the federal government's commitment to expand the national park system, and planning initiatives already under way (e.g. NWT Protected Areas Strategy – NWT PASAC 1999), there will likely be more protected areas established. Climate change, and its influence on natural disturbances (e.g., insects and fire) and the forest environment, will likely intensify these demands (Duinker 2008b). The total amount of forest area within Canada is likely to remain high in coming decades. However, if we continue to employ our current

models for forest management, the consequences for the forest ecosystem would include further deforestation, habitat loss, fragmentation, declines in populations of sensitive species such as woodland caribou and old-growth-dependent migratory birds such as the black-throated green warbler (Carlson et al. 2007), and possible extinctions of some boreal species (Cardillo et al. 2006).

To a large extent, how we manage people's demands on forests will determine the state of Canada's forests in 2050. Canada is fortunate in that 94% of non-urban forests are publicly owned (NRTEE 2003) and remain relatively intact with large tracts of undisturbed forest (Lee et al. 2006). For the vast majority of Canada's forests, particularly the boreal, we are in a position to plan proactively rather than reactively. There is a foundation for strong forest stewardship with commitments from federal, provincial and territorial governments, First Nations, industry, and environmental organizations to manage forests sustainably, both economically and ecologically, as well as for cultural values (e.g. National Forest Strategy, National Forest Accord, Boreal Framework – CBI 2005), growing recognition of the natural capital of Canada's forests (e.g. NRTEE 2003, Anielski and Wilson 2005) and advancements in conservation science and forest management such as systematic conservation planning (Margules and Pressey 2000) and integrated land management. Given these considerations, the future of Canada's forests looks promising. The challenge will be to overcome barriers to progress with the key barrier being lack of political will and accountability by governments (NRTEE 2003).

If commitments are met and innovations in conservation science and forest management are applied, the future of Canada's forests would be impressive. Cooperative planning (e.g., integrated land management) by multiple stakeholders would minimize cumulative impacts on the landscape. We would embrace the uncertainty of resource management and treat human activities in the forest as experiments applying true adaptive management (Walters 1986). A system of ecological benchmarks would be established to provide an anchor for a comprehensive reserve system for learning, monitoring, and maintaining functional ecological processes and cultural values. Planning would occur across large landscapes with recognition of the ecological value of lands outside of management zones.

Given these two extremes, ultimately, the state of Canada's forests in 2050 will be shaped by the economic, environmental and societal values of Canadians.

6. Conclusions

Competition for resources is a key driver shaping the future of Canada's forests. There is little doubt that multiple competing demands within the forest land base has shaped the existing structure of Canada's forests and will continue to do so into the foreseeable future. Historical clearing of forest land for agriculture and urban development has largely governed where forest land boundaries exist today. In recent decades, forest management for the development and production of timber products has strongly influenced the nature of forests within Canada. With the increased pressures of globalization and human population growth, competition for resources within the forest land base surely presents the major challenge to forest ecosystem integrity in coming decades. How we approach, manage, and accommodate these increasing, and often conflicting, pressures will determine the future state of Canada's forests.

7. Literature Cited

Adamowicz, V., Boyda, A., and McFarlane P. 2008. Global Forest-Products Markets and Canadian Wood Supply (Report #2 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the SFM Network, University of Alberta). Available from http://www.sfmnetwork.ca/docs/e/FF_GlobalMarkets_Adamowicz.pdf.

AEUB (Alberta Energy and Utilities Board). 2007. Report 2007-A: Pipeline Performance in Alberta, 1990-2005. Alberta Energy and Utilities Board, Calgary, AB. Available from www.ercb.ca/docs/documents/reports/r2007-a.pdf [accessed 23 July 2008].

Alberta Environment. 2008a. Program overview. Alberta Environment, Edmonton, AB. Available from www.environment.alberta.ca/1298.html [accessed 23 July 2008].

Alberta Environment 2008b. Upstream oil and gas facilities. Alberta Environment, Edmonton, AB. Available from www.environment.alberta.ca/1193.html [accessed 23 July 2008].

Apps, C., and McLellan, B.N. 2006. Factors influencing the dispersion and fragmentation of endangered mountain caribou populations. Biol. Cons. 130: 84-97.

Anielski, M., and Wilson, S. 2005. Counting Canada's Natural Capital: Assessing the real value of Canada's boreal ecosystems. Canadian Boreal Initiative and Pembina Institute, Ottawa, ON. Available from www.pembina.org/pub/204 [accessed 23 July 2008].

Bryant, D., Nielsen, D., and Tangley, L. 1997. The last frontier forests: ecosystems and economies on the edge. World Resources Institute, Washington, DC. Available from http://archive.wri.org/publication_detail.cfm?pubid=2619 [accessed 23 July 2008].

CBI (Canadian Boreal Initiative). 2005. The boreal in the balance: securing the future of Canada's boreal region, a status report. The Canadian Boreal Initiative, Ottawa, ON. Available from www.borealcanada.ca/reports/boreal_in_the_balance/index-e.php [accessed 23 July 2008].

CAPP (Canadian Association of Petroleum Producers). 2008. Canada. Canadian Association of Petroleum Producers, Alberta, AB. Available online: Available from www.capp.ca/default.asp?V_DOC_ID=603 [accessed 23 July 2008].

CFA (Canada Forest Accord). 1992. Canada forest accord. National Forest Strategy Coalition, Ottawa, ON. Available from http://nfsc.forest.ca/accords/accord1.html [accessed 23 July 2008].

CSFCC (Canadian Sustainable Forestry Certification Coalition). 2008. Certification status & intentions: status, i.e. statistics. Available from www.certificationcanada.org/english/status_intentions/status.php [accessed 23 July 2008].

CCFM (Canadian Council of Forest Ministers). 2006. Criteria and indicators of sustainable forest management in Canada: national status 2005. Natural Resources Canada and Canadian Forest Service, Ottawa, ON. Available from www.ccfm.org/current/ccitf_e.php [accessed 23 July 2008].

Carlson, M., Bayne, E. and Stelfox, B. 2007. Seeking a Balance: assessing the future impacts of conservation and development in the Mackenzie watershed. Canadian Boreal Initiative, Ottawa, ON. Available from www.borealcanada.ca/research-cbi-reports-e.php [accessed 23 July 2008].

Cardillo, M., Mace, G.M., Gittleman, J.L. and Purvis, A. 2006. Latent extinction risk and the future battlegrounds of mammal conservation. Proc. Nat. Acad. Sci. U.S.A. 103: 4157-4161.

Cranstone, D.A. 2002. A history of mining and mineral exploration in Canada and outlook for the future. Natural Resources Canada, Ottawa, ON. Available from www.nrcan.gc.ca/mms/topi-suje/hist_e.htm [accessed 23 July 2008].

Drushka, K. 2003. Canada's Forests: A History. McGill-Queen's University Press, Kingston, ON.

Duinker, P.N. 2008a. Society's Forest Values (Report #11 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_SocValues_Duinker.pdf.

Duinker, P.N. 2008b. Global climate change (Report #1 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_Climate_Change_Duinker.pdf.

EC (Environment Canada). 2007. News release: Government of Canada takes landmark action to conserve Canada's north. Available from www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=73BDC06C-DA04-4E53-9FE2-A42C7D887EF1 [accessed 23 July 2008].

EC (Environment Canada). 2007b. How do we use it? Hydroelectric power generation. Available from www.ec.gc.ca/water/en/info/facts/e_hydro.htm [accessed 23 July 2008].

FAO (Food and Agriculture Organization of the United Nations). 2007. Global wood and wood products: trends and perspectives. Advisory Committee on Paper and Wood Products, Shanghai, China. Available from www.fao.org/forestry/webview/media?mediaId=12711&langId=1 [accessed 23 July 2008].

Fitzsimmons, M. 2002. Estimated rates of deforestation in two boreal landscapes in central Saskatchewan, Canada. Can. J. For. Res. 32: 843-851.

Fyles, J.W., Williams, R., Corbett, B.A., and Creed, I. 2008. Demographics as a driver of the future Canadian forest (Report #12 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_Demographics_Fyles_etal41708.pdf.

GFWC (Global Forest Watch Canada). 2007. Active metal mines database. GFWC Data Warehouse, Edmonton, AB. Available from www.globalforestwatch.ca/datawarehouse/datawarehouse.htm [accessed 23 July 2008].

Government of Canada. 2006. Canadian Protected Areas Status Report 2000-2005. Government of Canada, Ottawa, ON. Available from www.cws-scf.ec.gc.ca/publications/habitat/cpa-apc/index_e.cfm [accessed 23 July 2008].

Government of Ontario. 2008. Backgrounder: Protecting a northern boreal region one-and-a-half times the size of the Maritimes: Ontario fights climate change by protecting carbon-absorbing forests. Government of Ontario, Toronto, ON. Available from www.premier.gov.on.ca/news/Product.asp?ProductID=2358 [accessed 23 July 2008].

Hoberg, G. 2008a. Governance. (Report #7 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_Governance_Hoberg41708.pdf.

Hoberg, G. 2008b. Geopolitics. (Report #4 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_Geopolitics_Hoberg41708.pdf.

IBCC (International Boreal Conservation Campaign) and CBI (Canadian Boreal Institute). 2008. Mineral exploration conflicts in Canada's boreal forest. International Boreal Conservation Campaign and Canadian Boreal Initiative, Ottawa, ON. Available from www.interboreal.org/index.php?option=com_content&task=view&id=98&Itemid=197 [accessed 23 July 2008].

Lee, P. 2004. Boreal Canada: state of the ecosystem, state of the industry, emerging issues and projections. Report to the National Round Table on the Environment and the Economy. Global Forest Watch Canada, Edmonton, AB.

Lee, P., Gysbers, J.D. and Stanojevic, Z. 2006. Canada's landscape forest fragments: a first approximation. Global Forest Watch Canada. Edmonton, AB. Available from www.globalforestwatch.ca/FLFs/download.htm [accessed 23 July 2008].

Lee, P., and Boutin, S. 2006. Persistence and developmental transition of wide seismic lines in the western Boreal Plains of Canada. J. Env. Man. 78: 240-250.

McFarlane, P., Ackom, E., Alteyrac, J., and Adamowicz, V. 2008a. Global energy (Report #5 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_Energy_McFarlane_Sept_08.pdf.

McFarlane, P. Ackom, E., Alteyrac, J., and Adamowicz, V. 2008b. Technology (Report #6 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_Technology_McFarlane41708.pdf.

Margules, C.R., and Pressey, R.L. 2000. Systematic conservation planning. Nature 405: 243-253.

MCTAC (Mountain Caribou Technical Advisory Committee). 2002. A strategy for the recovery of mountain caribou in British Columbia. British Columbia Ministry of Water, Land and Air Protection, Victoria, BC.

Mining Watch Canada. 2001. The Boreal Below: Mining Issues and Activities in Canada's Boreal Forest Region. Mining Watch Canada. Mining Watch Canada, Available from www.miningwatch.ca/index.php?/MMER/Boreal_Below_report [accessed 23 July 2008].

NFSC (National Forest Strategy Coalition). 1998. National Forest Strategy 1998-2003. National Forest Strategy Coalition, Ottawa, ON. Available from www.nfsc.forest.ca/strategy_e.htm [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2000. Canada's forests topics of interest, global trends: growing demands. Updated 2007-09-01. Natural Resources Canada, Ottawa, ON. Available from www.foretscanada.rncan.gc.ca/articletopic/65 [accessed 23 July 2008].

NFSC (National Forest Strategy Coalition). 2003a. National Forest Strategy 2003-2008. National Forest Strategy Coalition, Ottawa, ON. Available online: http://nfsc.forest.ca/strategy_e.htm [accessed 23 July 2008].

NFSC (National Forest Strategy Coalition). 2003b. People and forests in harmony – evolution of Canada's national forest strategy. Original, unedited version submitted to the XII World Forestry Congress, 2003, Quebec City, QC. www.fao.org/DOCREP/ARTICLE/WFC/XII/0560-C2.HTM [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2003. The Atlas of Canada: Mining Sites. Available from www.atlas.nrcan.gc.ca/site/english/maps/environment/ecology/humanactivities/miningsites/1 [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2005a. Benefits of the boreal forest, Part 1. Natural Resources Canada, Ottawa, ON. Available from www.canadaforests.nrcan.gc.ca/articletopic/15 [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2005b. Is Canada's boreal forest shrinking or expanding? Topics of Interest – Canada's Forest. Canadian Forest Service, Ottawa, ON. Available from www.canadaforests.nrcan.gc.ca/articletopic/23 [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2006. Technologies and applications: about hydroelectric energy. Available online: www.canren.gc.ca/tech_appl/index.asp?CaId=4&PgId=26 [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2007a. Canada's forests, land classification. Natural Resources Canada, Ottawa, ON. Available from www.canadaforests.nrcan.gc.ca/landclassification [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2007b. The state of Canada's forests 2007. Natural Resources Canada. Canadian Forest Service. Ottawa, ON. Available from www.foretscanada.rncan.gc.ca/rpt [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2007c. Canada's forests trend analysis: forest associated species at risk. Natural Resources Canada, Ottawa, ON. Available from www.canadaforests.nrcan.gc.ca/articletrend/top_suj/27 [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2008a. National Topographic Database. Natural Resources Canada, Ottawa, ON. Available from www.geogratis.ca/geogratis/en/product/search.do?id=8147 [accessed 23 July 2008].

NRCan (Natural Resources Canada). 2008b. Mineral production: 2007 Canadian mineral production exceeds $40 billion. Information Bulletin March 2008, Natural Resources Canada, Ottawa, ON. Available from www.mmsd1.mms.nrcan.gc.ca/mmsd/wndetail_e.asp?wnId=43 [accessed 23 July 2008].

NRTEE (National Round Table on the Environment and the Economy). 2003. The state of the debate on the environment and the economy : securing Canada's natural capital: a vision for nature conservation in the 21st century. National Round Table on the Environment and the Economy, Ottawa, ON. Available from www.nrtee-trnee.ca/eng/publications/securing-canadas-natural-capital/index-securing-canadas-natural-capital-eng.htm [accessed 23 July 2008].

NWT PASAC (NWT Protected Areas Advisory Committee). 1999. NWT Protected Areas Strategy: A Balanced Approach to Establishing Protected Areas in the Northwest Territories. Government of the Northwest Territories, Yellowknife, NT. Available from www.nwtwildlife.com/pas/ [accessed 23 July 2008].

Office of the Prime Minister. 2007. Backgrounder – protecting Canada's ecological treasures: Nahanni Naitonal Park Reserve Expansion. Available from www.pm.gc.ca/eng/media.asp?id=1780 [accessed 23 July 2008].

Schneider, R. and Dyer, S. 2006. Death by a thousand cuts: impacts of in situ oil sands development of Alberta's boreal forest. The Pembina Institute and Canadian Parks and Wilderness Society, Edmonton, AB. Available from www.pembina.org/pub/1263 [accessed 23 July 2008].

SSBF (Senate Subcommittee on the Boreal Forest). 1999. Competing realities: the boreal forest at risk. Report of the subcommittee on boreal forest of the standing senate committee on agriculture and forestry, Senate Subcommitee on the Boreal Forest, Ottawa, ON. Available from www.parl.gc.ca/36/1/parlbus/commbus/senate/Com-e/bore-e/rep-e/rep09jun99-e.htm [accessed 23 July 2008].

Smith, W. and Lee, P. (editors). 2000. Canada's Forests at a Crossroads: An Assessment in the Year 2000. World Resources Institute and Global Forest Watch Canada, Edmonton, AB. Available from www.globalforestwatch.ca/xrds/download.htm [accessed 23 July 2008].

Smith, R., Cameron, S. and Beckley, T. 2007. Non-timber forest products. Natural Resources Canada, Ottawa, ON. Available from www.cfs.nrcan.gc.ca/subsite/nontimber [accessed 23 July 2008].

Statistics Canada. 2008. 2008 Road Network File. Statistics Canada, Ottawa, ON. Available from http://geodepot.statcan.ca/Diss2006/DataProducts/RNF2006_e.jsp [accessed 23 July 2008].

SRP (Sustainability Reporting Program). 2004. The sustainability report. Institute for research and innovation in sustainability. York University. Toronto, ON.

The Boreal Leadership Council. 2003. Canadian Boreal Forest Conservation Framework, Canadian Boreal Initiative, Ottawa, ON. Available from www.borealcanada.ca/framework-full-e.php [accessed 23 July 2008].

Trosper, R. 2008. Aboriginal empowerment (Report #8 in the Series on "Drivers of Change in Canada's Forests and Forest Sector", prepared for the Forest Futures Project of the Sustainable Forest Management Network). Available from http://www.sfmnetwork.ca/docs/e/FF_Aboriginal_Empowerment_Trosper.pdf.

UNPD (United Nations Population Division). 2006. World population prospects: the 2006 revision and world urbanization prospects: the 2005 revision. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, New York, NY. Available from www.esa.un.org/unpp [accessed 23 July 2008].

Walters, C. 1986. Adaptive Management of Renewable Resources. MacMillan Publishing Company, New York, NY.

Wetzel, S., Duchesne, L.C., and Laporte, M.F. 2006. Recreation and other forest values. *In* Bioproducts from Canada's forests: new partnerships in the bioeconomy. Springer, the Netherlands. pp. 163-171.