5 Natural Resources

Fresh water

Fresh water is the most important resource for sustaining life. It is used for drinking, cooking, washing, and irrigation. Our fresh water resources support recreation, tourism, art, transportation, and fish and wildlife. Water is critical to industry, facilitating manufacturing, mineral extraction, and the generation of thermal power. Water also has aesthetic value.

Canada is fortunate to be a nation rich in water. Including water captured in glaciers and the polar ice-cap, Canada's watersheds contain about 9% of the world's renewable water resources (Foreign Affairs and International Trade 1999: 2). Sixty percent of Canada's water resources drain north to the Arctic Ocean, leaving roughly 40% readily available to most of Canada's population, about 84% of whom live within 300 km of the southern border (Environment Canada 2001b).

Despite the abundance of fresh water in Canada, there are concerns about its availability because of a number of regional shortages, mostly in areas such as Prince Edward Island, the southern parts of Ontario and the Prairies, and the interior of British Columbia, which are dependent upon groundwater for their daily needs. Between 1994 and 1999, approximately 26% of municipalities with water distribution systems reported water shortages. Reasons for these shortages ranged from drought to inadequate storage capacity and distribution systems (Environment Canada 2001d: 13).

Concern about water management is also rising because of the increase in interest in proposals for water diversions and bulk removals.[32] These proposals include both the transfer of water within Canada, and its export to the United States. Bulk transfers of water is a contentious issue in this country. Some people view water resources as a viable commodity to be bought and sold, much like oil. They feel that our abundance of water could produce wealth in Canada much like oil reserves have produced wealth for the OPEC nations. Other people worry about potential environmental impacts including the introduction of non-native species, the alteration of natural ecosystems, and changes in water levels and groundwater tables. Currently, the provinces have the primary responsibility for management of water resources within their borders, while the federal government has jurisdiction for international boundary waters. However, in 1999, when the Canadian Council of Ministers of the Environment (CCME) generally agreed to the prohibition of bulk water removals from major drainage basins in Canada, a few jurisdictions felt that more discussion and clarification of points were necessary before they would sign onto the proposed Canada-wide accord on bulk water removals. In response to the hesitance of some jurisdictions, and to Newfoundland's attempt to take advantage of the market for bulk water in the United States, in 2001 the federal government made amendments to the *International Boundary Waters Treaty Act* to prohibit bulk removal from Canadian portions of boundary waters, particularly from the Great Lakes (Environment Canada 2001).

There is also concern in Canada about the perceived waste of water. Canada's per-capita demands on municipal water resources are the second highest in the world, about 638 litres per person per day (Environment Canada 2001d: 19). Less than 3% of municipally treated water used in households is used for drinking (Environment Canada 1999a), 65% is used in bathrooms and, during the summer, approximately three-quarters of the treated water used domestically is sprayed onto lawns (Environment Canada 1996c: record 16441). Outside of households, rates of recirculation of industrial water used are low, and low investment into municipal delivery and treatment systems has led to 14% of municipal water being lost through leaks in pipes (Environment Canada 1999a).

Changing water prices to reflect the true cost of water would finance the repairs needed to restore neglected and deteriorating municipal water and sewage systems. Environment Canada has estimated the cost of rebuilding the infrastructure at between $40 and $70 billion over the next 10 years (Environment Canada 2001d: 20). Considering that between 14% to 30% of treated water is lost through leaky pipes, these repairs would address some of the regional shortages (Environment Canada 1996c: record 16431).

To promote water conservation, Environment Canada recommends in its *State of the Environment Report* that "we should pay a fair price that will recover the full cost of water delivered to the tap, one that is based on actual quantity used" (Environment Canada 1996c: record 16430). Not only do Canadians use more water than most people in the world, we also pay less (figure 5.1). In Canada, the government subsidizes much of the cost of water use; charges for irrigation water only recover about 10% of the actual cost of the services and municipalities charge a flat rate for the use of water. As a result, consumers make decisions on how much water to use without considering the true cost. This may start to change, however, as the use of water meters increases. The percentage of Canada's municipal population using metred water increased by about 8% between 1991 and 1999 (Environment Canada 2001d: 4).

Not surprisingly, people are more inclined to conserve water when they are required to pay the full cost of the water they use. In a study conducted in Denton, Texas between 1981 and 1985, economists found that holding all other factors constant, every 10% increase in price resulted in a 16% decrease in demand (Palda 1998: 63). Similarly, in 1999, Canadian households paying for water by volume used 33% less than households paying a flat rate (Environment Canada 2001d: 4).

Canadians do value quality water. In recent years, Canadian production and consumption of bottled water has grown. Bottled water is a $35 million industry worldwide, with Canada ranking fifth worldwide in consumption of bottled water (CBWA 2002). The number of bottlers in Canada grew from 38 in 1988 to 71 in 1997 and production is concentrated in Quebec, Ontario, and British Columbia (figure 5.2). The Canadian market grew by 174% between 1988 and 1997 and our exports increased from $4.6 million in 1988 to $256.6 million in 1999 (StatsCan 2001; Coote and Gregorich 2000). While many Canadians expect inexpensive access to water resources, a growing segment pays on average $1.19 per litre of bottled water (Coote and Gregorich 2000). If we were willing to pay cost for the water delivered to our homes, the repairs necessary to increase the efficiency of municipal water delivery systems could be paid.

To evaluate trends in the use of fresh water, the *Environmental Indicators* considers the use of water by sector from 1972 to 1991, the latest year for which data is available. Water use can be measured by two different indicators: (1) total water withdrawals, which are the total amount of water extracted and (2) total water consumption, which is the amount of water withdrawn that is not returned to a body of water after use. This section examines data for both indicators.

Trends for fresh water

Between 1972 and 1991, total water withdrawals in Canada increased by 87.4% (figure 5.3). The greatest increase during this period was in thermal power generation, where water withdrawals increased by 204.2%, from 9.8 billion cubic metres to 28.4 billion cubic metres. The second highest increase during this period was in municipal water withdrawals, which increased from 3.2 billion cubic metres to 5.1 billion cubic metres, a 61.6% increase. Agricultural use increased by 39.8% to 4.0 billion cubic metres.

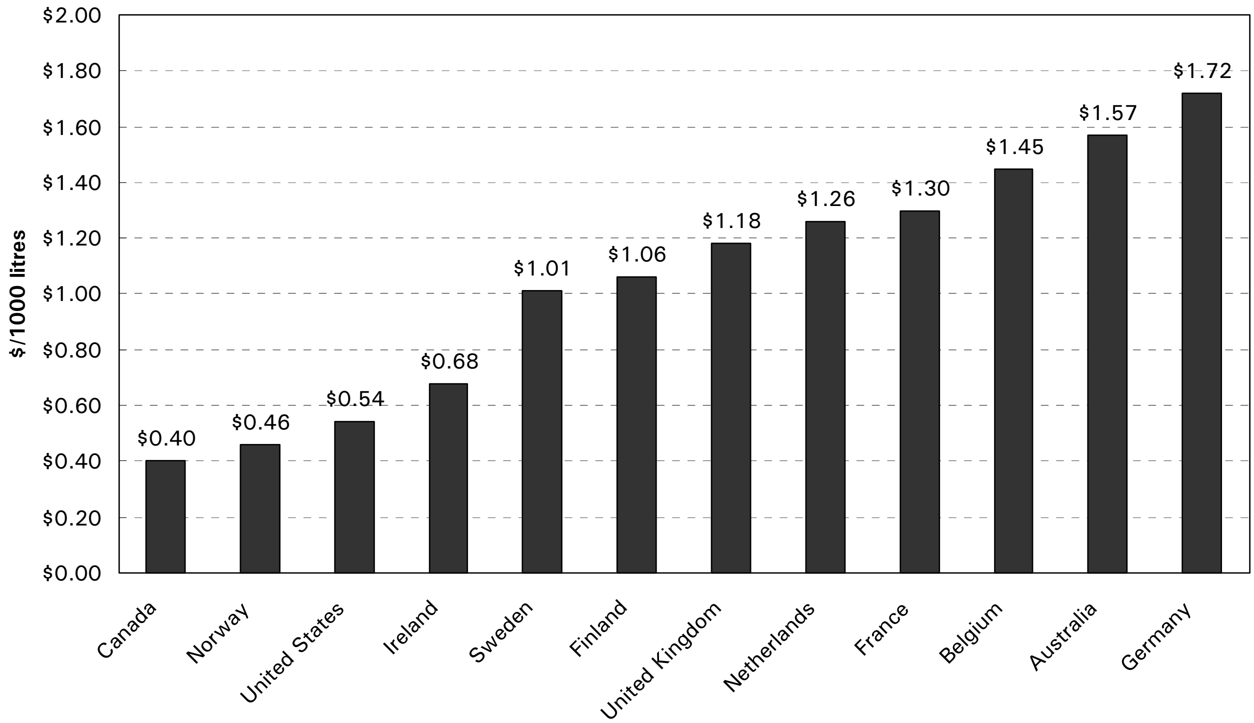
Figure 5.3 also shows that thermal power generation withdraws the most freshwater resources in Canada, accounting for 63% of total withdrawals in 1991. Other industrial sources, such as manufacturing, agriculture, and mining accounted for 16%, 8.9%, and 0.8% of withdrawals, respectively. The remaining 11% of total water withdrawals were for municipal water use.

It is important to note that in some sectors water withdrawals decreased during the same period. Water withdrawals in manufacturing decreased by 12.8%. This decrease is due, in part, to the more efficient use of water through technical advancement and recycling efforts. An example of such initiatives is a steel plant located in Quebec that was able to reduce total volume of water used by 36% through water recirculation (Environment Canada 1998d). This conservation of water not only benefits the environment but also lowers operating costs because of the energy saved by pumping less water.

Even though water withdrawals are increasing, figure 5.4 shows that Canadians withdraw less than 2% of their renewable fresh water annually. Of this water withdrawn, only a small portion of water is actually consumed. In 1991, Canadians withdrew 45,095 million cubic metres of water but only 1.9% of the water used was not returned after use (Statistics Canada 1998d: 62).

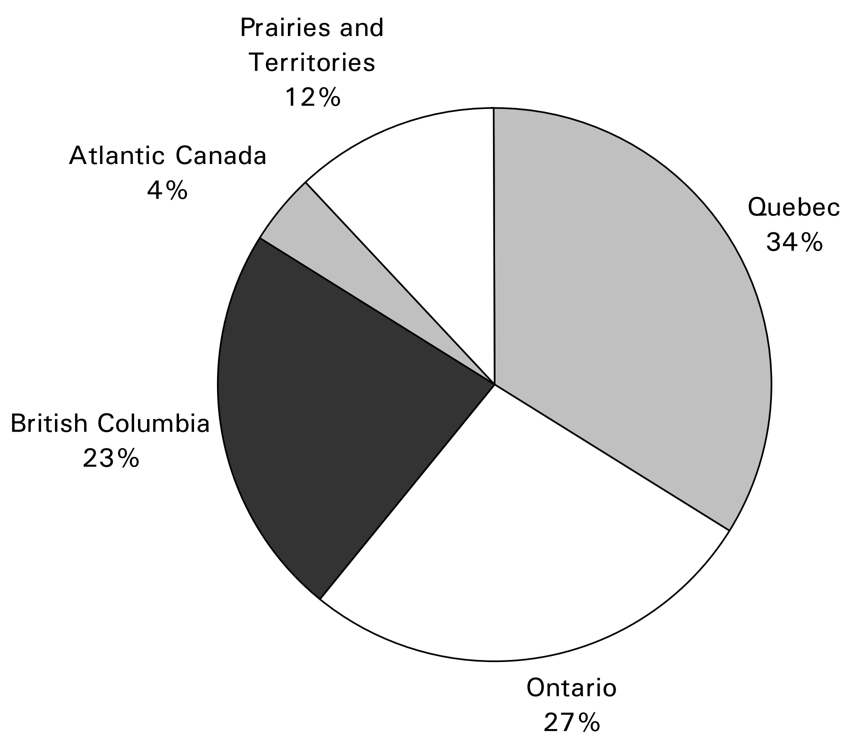
Figure 5.5 shows total water withdrawals in 1991 by region. Ontario is the major user, accounting for 63.2% of withdrawals. This high usage is a result of the large population, the heavy reliance on thermal power generation and the proximity to the Great Lakes, Canada's largest source of surface fresh water. Total water consumption, however, is greatest in the Prairie provinces at 67.6%, largely because agricultural withdrawals account for 48.4% of the regional total (figure 5.6). Whereas only as little as 23% of water withdrawn can be recycled in agricultural uses, thermal generation returns more than 99% of the water withdrawn to the source (Statistics Canada 1989: 1–7).

Figure 5.1: International water prices (CDN$1992)



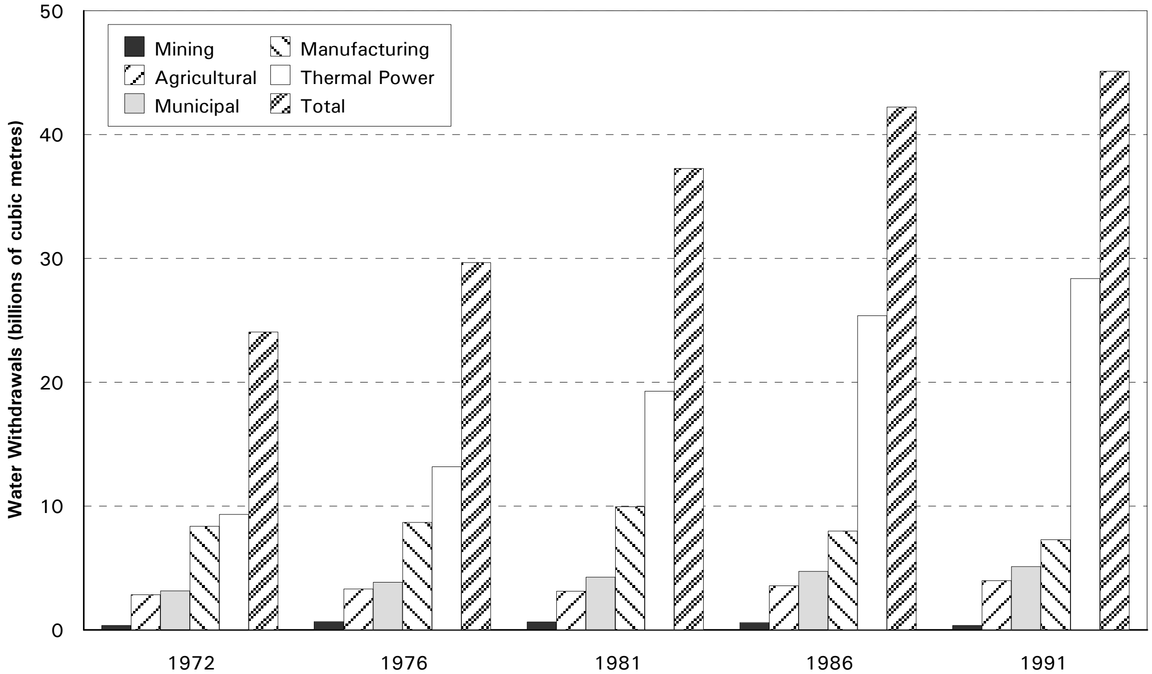
Source: Environment Canada 2001b.

Figure 5.2: Production of bottled water in Canada, 1998



Source: Agriculture and Agrifood Canada 2000.

Figure 5.3: Total fresh water withdrawals in Canada, 1972–1991

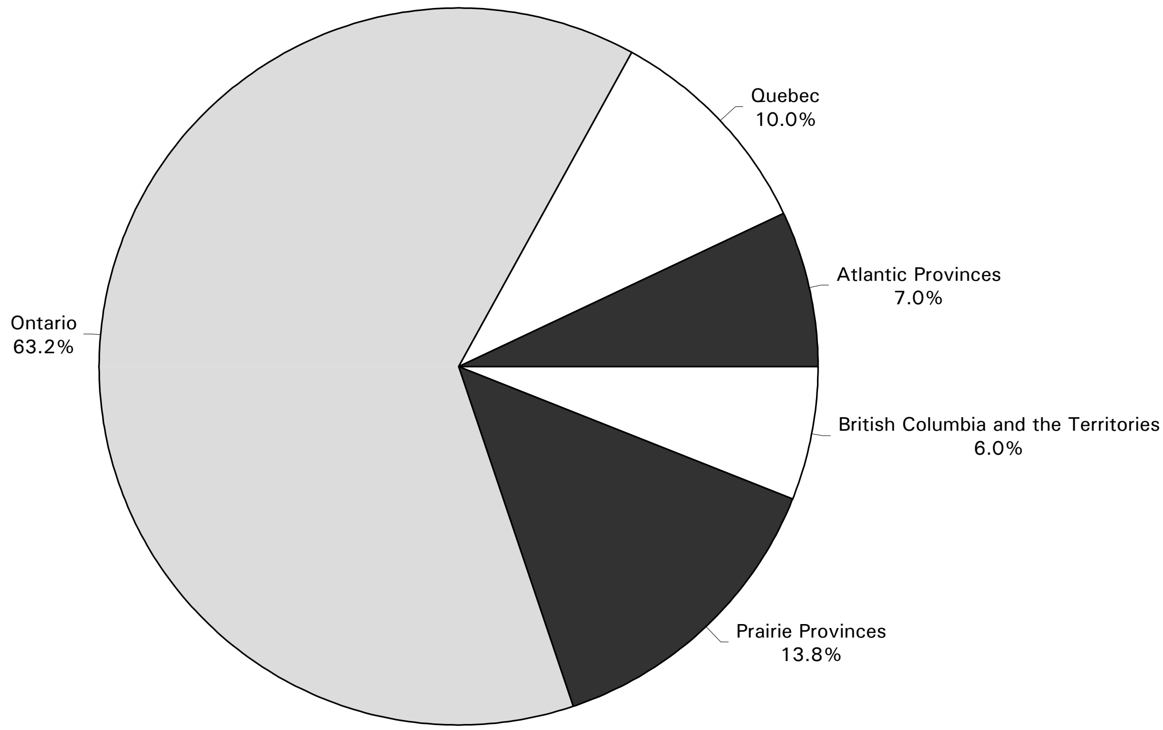


Source: Statistics Canada 1998a: 62; Supply & Services Canada 1985: 16–18.

Figure 5.4: Withdrawals as a percentage of renewable fresh water resources

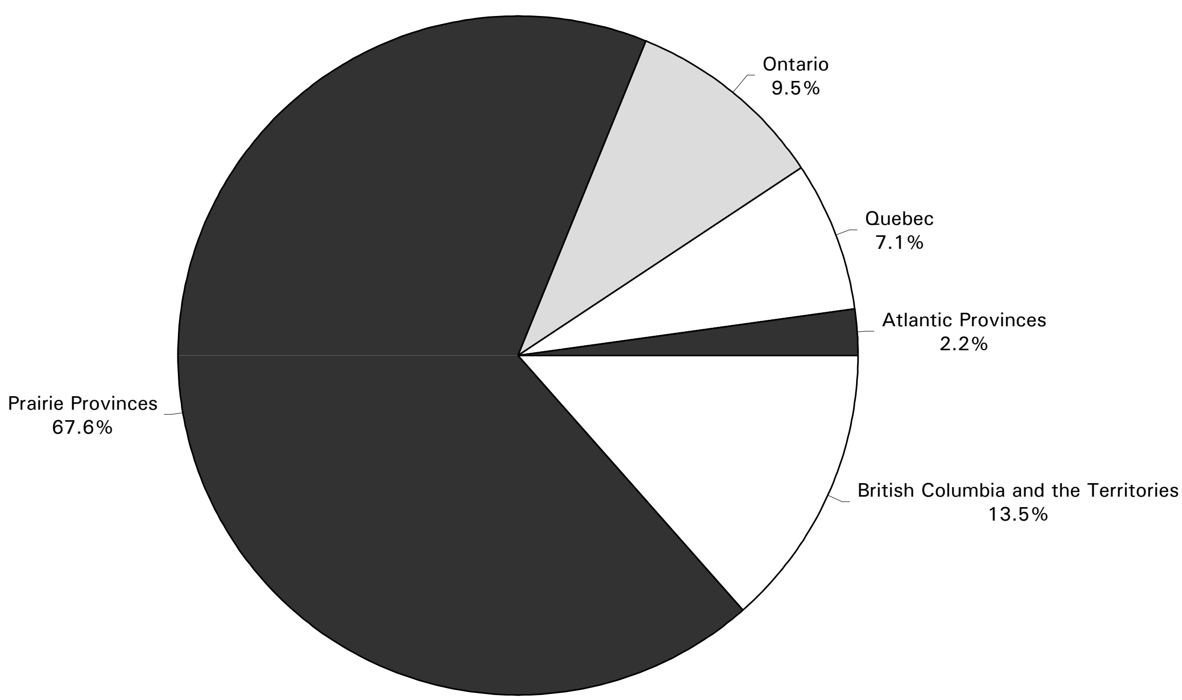
Sources: estimate of renewable fresh water resources from OECD 1999: 72; total withdrawal data from Statistics Canada 1998a: 62; OECD 1999: 72; Supply & Services Canada 1985: 16–18.

Figure 5.5: Total water withdrawals by region, 1991



Source: Statistics Canada 1998a: 62.

Figure 5.6: Total water consumption by region, 1991



Source: Statistics Canada 1998a: 62.

Forests

Canadian forests cover 45% of the nation's land mass and account for 10% of the world's forested area (CFS 2001: 6). To put this into perspective, if superimposed on a map of Europe, the area of Canada's 234.5 million hectares of forestland would cover a large proportion of the continent including, Germany, Great Britain, France, Scandinavia.

There are eight forest regions in Canada, ranging from the Boreal Forest Region, which stretches from British Columbia to New Brunswick, to the small deciduous forest region located just north of Lake Erie and Lake Ontario. Of Canada's forests, 67% are softwoods, 15% are hardwoods, and 18% are mixedwoods (CFS 2001: 7). Canadian forests contain a vast amount of biodiversity, including an estimated 180 species of trees (CCFM 1997: 1).

Canada's forests have many important ecological functions. They preserve soil quality by preventing or slowing erosion and sheltering non-forested land; they preserve water quality by protecting streams and rivers from diversion and siltation. Approximately two-thirds of the species of plants, animals, birds, and microorganisms are either found in forests or dependent upon forest habitat (Smith and Lee 2000: 13). Forests also serve as carbon sinks. Through photosynthesis, trees absorb carbon dioxide from the atmosphere, convert it into carbohydrates, and store it in their roots, leaves, branches, and trunks. Healthy, growing forests continue to store carbon as they mature. When trees become diseased, decay, or burn, the stored carbon is released back into the environment. Recent models developed by Kurz and Apps indicate that younger trees store carbon more actively than older ones (see table 5.1). The amount of carbon stored peaks for forests with trees of 140 to 159 years of age, and then decreases (CCFM 2000: 45–48).

In addition to their ecological value, forests lay an important role in Canada's economy. Canada's forest industry is the world's largest exporter of wood and paper products, contributing 37.5 billion to the country's net balance of trade in 2000 (CFS 2001: 16). The forest industry also provided 257,000 direct jobs and 772,500 indirect jobs in Canada in 2000 (PriceWaterhouseCoopers 2001: 2). The ecological and economic uses of the forests often come into conflict with special-interest groups, leading to environmental protests and industry lawsuits. In a recent survey, when British Columbians were asked to consider the importance of provincial priorities on a scale of one (not important) to 10 (extremely important), they gave the top-rated priorities "protecting the environment" and "encouraging a healthy forest industry" average ratings of 8.2 and 8.0, respectively, thus demonstrating that people value both uses strongly (MarkTrend Research 2000: 2).

In Canada, the government owns the majority of the forested land: 71% of forests are owned by the provincial governments, 23% are under federal jurisdiction, and 6% are managed privately by an estimated 425,000 landowners. As illustrated in table 5.2, there is variance amongst provinces in the percentage of forests that are privately owned: 80% are located east of Manitoba (CFS 2001: 7). There is a higher percentage of privately owned forests in the Maritime provinces, largely because of patterns of colonization. Whereas early settlers coming to the east coast were given large areas of land as an incentive to come to Canada, the Crown retained ownership of most forested land in areas settled later (CFS 1998: 41).

The provinces not only own most of Canada's forested land, under the Canadian constitution they are also responsible for forest management. This responsibility includes determining and monitoring harvesting levels and practices in Canada as well as ensuring regeneration. To fulfill this responsibility, each province allocates to business operators permits or specific rights to harvest timber on Crown land. These licenses are typically for periods of 15 to 25 years and carry with them the responsibility of ensuring successful regeneration. In addition to meeting standards set out in the licence, licensees are encouraged to meet the national standards for Sustainable Forest Management that were developed in 1996 by the Canada Standards Association. Compliance with these standards is voluntary (Armson 1999: 25–26).

To allocate harvesting permits the government determines acceptable harvesting levels for specified areas by the Annual Allowable Cut (AAC). The AAC calculation is not a measure of total new growth but rather a measure of growth available for commercial harvesting. It is calculated by considering the quantity and quality of species, the accessibility of the trees, growth rates, sensitivity of the site, and potential or existing competing uses.

To evaluate trends in forests, this section examines trends in harvesting, replanting, and regeneration. The importance and preservation of old-growth stands and the practice of clear-cutting are addressed separately, since they remain topical environmental concerns.

Harvesting, replanting, regeneration

The area of forest harvested in Canada increased by 50.8% between 1975 and 1999 (figure 5.7). The largest increase was in Quebec at 184.4%. This increase is substantially higher than the other two main roundwood-producing provinces, British Columbia and Ontario, where the area harvested increased by 12.3% and 2.4%, respectively.[33] In the Prairie provinces, the area harvested increased by 54.9% (Alberta 97.1%; Saskatchewan 21.0%; and Manitoba 29.2%). In the Atlantic provinces, the area harvested increased by 32.3% (New Brunswick 17.7%; Nova Scotia 82.2%; Prince Edward Island 261.2%; and Newfoundland 10.9%). Unlike the rest of Canada, the area harvested in the North decreased by 25.0% between 1975 and 1998 (the Northwest Territories 22.5%, and in the Yukon 27.8%).

Figure 5.7 also shows the location of the areas harvested. In 1999, 38.5% of the total area harvested in Canada was located in Quebec; 19.7% was in Ontario; 17.9% was in the Atlantic provinces; 17.2% in British Columbia; 7.6% in the Prairie provinces, and less than 1% in the North.

Although total area harvested is increasing, only a small portion of Canada's forest resources is harvested each year (figure 5.8). Of Canada's 418 million hectares of forestland, 56% (234.5 million hectares) are classified as commercially viable forests. However, of these 234.5 million hectares only 28% (119 million hectares) are being managed for timber purposes. Only 1.025 million hectares were actually harvested in 1999. This is 0.4% of commercial forests and 0.25% of total forests—less than the amount of forest lost annually to natural events: approximately 0.5% of Canada's total forests are lost to outbreaks of fire or infestation by insects each year (CFS 1998: 5; NFDP 2001).

Harvest levels have also remained within the defined sustainable limits. Figure 5.9 shows that the national harvest level has remained below the Annual Allowable Cut (AAC) throughout the period from 1970 to 1998. Data for both hardwood and softwood up to 1993 similarly shows that, with the exception of 1989, harvest levels of hardwood and softwood have remained below their respective AACs (COFI 2001: 71; Environment Canada 1996c: record 5731).

Most provincial harvest levels are below the AAC as well (table 5.3). The percentage of the AAC that is actually harvested is especially low in Manitoba (22.7%). New Brunswick is the only province where the harvest level exceeds the AAC, although Prince Edward Island exactly meets it. Although it appears that British Columbia has also harvested above its AAC level, the AAC for this province does not include all private lands, whereas the harvest level does. Harvest levels in British Columbia have been below the AAC in the past few years.

While harvest levels have been increasing, there has also been an increase in the amount of harvested land that is replanted. Table 5.4 displays the area that is replanted annually as a percentage of the area harvested from 1975 to 1999. During this period, the percentage of harvested land replanted in Canada more than doubled from 18.7% to 43.6%. In 1999, the percentage of harvested area replanted in British Columbia was 92.5%, in Ontario, 52.6%, and in Quebec, 22.4%. Since 1975, these values have increased by 130%, 244%, and 90%, respectively. Nationally, the area replanted increased rapidly through the 1980s, and has stabilized in the 1990s at about 43%. Some years indicate that British Columbia and Alberta replanted a greater area that they harvested: these years are indicated by a percentage greater than 100%.

Modeling also illustrates that Canadian forests that are harvested are being successfully regenerated. Figure 5.10 shows the forest-regeneration status of harvested land from 1975 to 1995. The information is based on data supplied by provincial and territorial governments that is compiled into a model. Stands with trees of uneven ages are not included. The data is presented cumulatively so that each year displays the status of the area harvested that year as well as all previous years back to 1975. For example, the area displayed for 1975 represents the regeneration status of the area harvested during 1975. The area displayed for 1976 shows the regeneration status of the area harvested in both 1975 and 1976 and so on (CCFM 2000: 32; Haddon 2002).

The four classes in figure 5.10 are defined by the National Forestry Database Program as follow:

> ***Non-production***: Areas such as roads, landings, and non-forestry developments that have no timber-production objective. These areas also include land where erosion, a rising water table, or other forms of site degradation make a site unsuitable for forestry purposes.
>
> ***Understocked***: Disturbed forest land that will require silvicultural treatment to meet stocking standards.
>
> ***Stocked***: Disturbed forest land that has regenerated naturally or through planting and seeding. This class includes some recently disturbed areas that are expected to regenerate within an acceptable time without further silvicultural treatment.
>
> ***Enhanced***: Stocked areas that meet density control standards. These are areas in which the required

number of trees per hectare is distributed evenly over the regenerated area for optimal growth. (CCFM 1996: 5-6)

With the exception of the non-production class, these categories are progressive. An understocked area that is replanted properly should eventually reach stocked status. A stocked area will become enhanced as the trees grow and density-control objectives are met. Although data on fully regenerated areas are not displayed on the graph, it is expected that all areas classified as stocked or enhanced will fully regenerate naturally.

As illustrated in figure 5.10, the area of harvested land that is understocked is no longer increasing. Instead, it peaked at the 1992 level of 2.4 million hectares and has leveled off since. This illustrates that even though harvesting levels are increasing, more land is being properly regenerated. The Canadian Council of Forest Ministers attributes this decrease in understocked land in proportion to the total amount harvested to expanding silviculture programs (CCFM 1996: 13). It is important to note that, although 20% of the cumulative area harvested was classified as understocked in 1995, most of this land is reported as understocked because of a time lag between treatment and observable results.

Old-growth forests

Although the technical definition of an old-growth forest varies, it can be defined broadly as a forest "dominated by mature or over-mature trees that has not been significantly influenced by human activity. The stand can contain various ages and species of vegetation" (CCFM 1997: 124). Definitions can range from those based strictly on age, to those encompassing ecological features, or requiring the presence of specific species. British Columbia has at least three definitions that apply different age measures to forests in different regions of the province:

- older than 250 years for forests on the coast;
- older than 140 years for forests in the interior; and,
- older than 120 years for lodgepole pine and deciduous species. (MacKinnon and Vold 1998)

Canada's old-growth forest is spread across the country in every province (McKinnon 2002). Because of varying definitions and incomplete forest inventories, however, there is insufficient data to make comprehensive provincial comparisons. The largest stand of old-growth red and white pine in North America is located in Temagami, Ontario (Cundiff 1992), and 20% of Ontario's inventoried forests are considered old-growth (Miller 2002). Old-growth stands in Alberta and Nova Scotia have recently received mention in the media as a result of clashes between environmental protestors and loggers. However, the coastal temperate rainforests of British Columbia are the largest, oldest, and most breathtaking in Canada. The reasons for this dramatic growth include the natural longevity of the coastal species such as the Western red cedar; abundant rainfall; temperate climate; and the rarity of fires in the rainforest. Whereas forests in the eastern parts of the country are exposed to fire on a regular basis, studies have shown that millennia can pass without an outbreak in the coastal temperate rainforest, due to abundant rainfall, the shielding of the earth from direct sunlight by the dense overhanging canopy, and proximity to the ocean, which maintains high humidity (Cundiff 1992). Public interest in the conservation of old-growth forests both nationally and internationally often focuses on this unique area.

Old-growth forests have considerable environmental and commercial value. Public interest in the conservation of old-growth forests focuses on the ecosystem as a whole: these forests contain a reservoir of gene diversity, provide habitat for diverse wildlife, and have recreational and aesthetic value. Foresters appreciate old-growth forests as a source of high-value timber. Approximately 90% of all territory logged in Canada is virgin forest, which usually has a higher volume of wood than the younger forests that will replace them (Environment Canada 1995a). Not all these virgin forests are old-growth forests, however, as natural disturbances such as fire and insects will alter forests untouched by humans.

The controversy over old-growth forests arises because these environmental and commercial uses are mutually exclusive. Even though rapid tree growth can produce large trees in some climates in 100 to 150 years (Kimmins 1997: 148), today's commercial cutting cycle of 50 to 80 years means that once harvested, old-growth ecosystems will not be re-established. As a result, while only 25% of professional foresters agreed with the statement that "most old growth forests should be protected," 86% of the public supported the view (CFS 1992: 41).

It is difficult to measure trends in old-growth forests since there is no comprehensive national inventory of Canada's old-growth forests and the definition for such forests remains vague. Data from the national forest inventory, however, do provide an inventory for commercial forests. These data suggest that there has been a decrease in the amount of old-growth forest. It reports that between 1981 and 1995 the total amount of mature, old, or mixed-age forest fell from 103.87 million hectares to 102.23 million hectares, a difference of 1.64 million hectares. This decrease is quite small, however, as in 1981 44.29% of commercial forests were in the category of mature, old, or mixed-aged forests whereas the 1995 level was only slightly lower at 43.59% (CFS 1998: 37).

A recent inventory of old-growth forests in British Columbia found that there is still a large amount of old-growth forest in the province.[34] Old growth forest covers 26.8% of the province, younger forest covers 36.1%, and 37.1% is unforested. Over 7% of British Columbia is covered with forests older than 250 years. Many of these forests are over 400 years old, especially in the wetter areas along the coast and interior wet-belt. Old-growth forests represent 50% of spruce stands, 62% of hemlock stands, 87% of coastal stands of red cedar, and 63% of interior stands or red cedar. Of these old-growth forests, 13%, or 3.2 million hectares, is estimated to be in protected areas (MacKinnon & Void 1998: 310–314).[35]

Although these data provide a glimpse of the condition of old-growth forests, more complete data are needed to examine the state of old-growth forests in Canada. Discussions on the total amount of old-growth forest are often meaningless since some of the ecological values attributed to old-growth forests are dependent upon not only the amount of old-growth forest but also the size and shape of the remaining patches (MacKinnon & Vold 1998: 310). Data on the location of old-growth forests are necessary as well. MacKinnon & Vold predict that, even if the total amount of old-growth forest remains constant, there will be a redistribution of these forests; there will be more old-growth forests at higher elevations because of fire suppression and fewer in lower elevations due to harvesting. For a national overview, data on old-growth forests in other jurisdictions is also necessary.

Clear-cutting

Clear-cutting is the silvicultural practice of completely clearing an area of all trees other than seedlings and occasional saplings. It is the most popular method of harvesting since it has many benefits. First, in converting an unmanaged forest to a managed forest, clear-cutting is safer for forest workers than other harvesting methods since there is a lower risk of injury or death from dead branches, often referred to in the industry as “widow makers.” Second, clear-cutting is sometimes a better environmental practice since it is more compatible with cable systems that reduce the number of roads used to gain access to the area. In Oregon and Washington as well as Sweden, clear-cutting has been used to restore forests degraded by partial cutting. Partial cutting can also prevent certain light-loving species like Douglas fir from regenerating properly. Finally, it is often more economically viable. Not only is clear-cutting less expensive than more selective harvesting practices, it also reduces the cost of reforestation since it facilitates site preparation and weed control (Kimmins 1997: 79–82).

Despite these benefits, clear-cutting remains a contentious issue when applied to sensitive ecosystems. Clear-cutting, by definition, involves the removal of the forest in a particular area. This means that as new vegetation replaces the harvested trees there is a change in the plant species growing in the area. This, in turn, could negatively affect the level of nutrients and micro-organisms in the soil and the wildlife that lives in the areas. When clear-cutting is not performed properly, it can also damage watersheds and the ecosystems of rivers since the exposed land has a higher risk of soil erosion. Many people also oppose clear-cuts for aesthetic reasons.

In Canada, almost 90% of trees logged over the past two decades have been harvested by clear-cutting. The size of these clear-cut blocks, however, has decreased over the past decade. A study conducted by the Canadian Pulp and Paper Association (CPPA) in 1990 found that the average clear cut sizes in Ontario, Quebec, and British Columbia were 110 ha, 69 ha, and 49 ha, respectively, with 8% of Quebec’s clear-cuts larger than 200 ha. In contrast, recent provincial legislation in Quebec reduced the limit for clear-cut sizes from 250 ha throughout the province to 150 ha within boreal forests, 100 ha in mixed-wood forests, and 50 ha in southern deciduous forest. Similarly, in British Columbia clear-cuts have been limited to 60 ha in the northern part of the province and 40 ha in the southern part. Recent data, in fact, has shown that the average size of clear-cuts in British Columbia has dropped to about 28 hectares (table 5.5) (CCFM 1998). Provided that these smaller sizes do not increase fragmentation of the forests, the smaller size should assist in minimizing some of the negative effects of clear-cutting (Environment Canada 1996c: record 6734).

Fragmentation

Fragmentation refers to the state of existing forests through which roads, pipelines, railways, and hydropower lines pass. This is a concern because it can lead to loss of biodiversity. Large stretches of contiguous forest are often necessary or desirable for maintaining viable populations of species. The fragmentation of forests can affect species in a number of ways. It leads to habitat degradation, creates barriers, such as roads that some species will not cross, and increases the dangers posed by hunters and vehicles by improving access. Because the impact of human influence diminishes rapidly with distance, access is defined as any one-kilometre-square area that includes a point of access (Smith and Lee 2000: 26).

Table 5.6 shows the amount of forest, by province, converted for other uses, mostly agricultural and urban, and of the remaining forest land, the percent of the forest that has been fragmented. Prince Edward Island has converted the largest amount of its original forest land, 46%, as a result of its small area. Alberta and Saskatchewan are next (21%, 19%), for agricultural purposes. Nunavut, the Yukon, the Northwest Territories, and Newfoundland have converted less than 1% of their forest land, mostly because of the unsuitability of their land for agriculture and, in the north, extremely low population. Over 80% of the forests in Alberta and New Brunswick, and over 60% of the forests in British Columbia, Nova Scotia, and Prince Edward Island, have been fragmented. The Maritimes are high because of their small geographic area and the date of settlement, and northeastern British Columbia and Alberta because of the extensive exploration for fossil fuels. However, it should be noted that figures for the western provinces have been overestimated through the inclusion of oil and gas seismic exploration lines in the data.

Table 5.1: Biomass carbon content of Canada's forests by age class in 1994

Age class	Area of forest		Biomass	
(years)	(millions of ha)	percent	(Megatonnes of carbon)	Average (tonnes of carbon/ha)
0–19	89.43	22.1	178.9	2.0
20–39	47.74	11.8	381.9	8.0
40–59	44.01	10.9	1320.2	30.0
60–79	49.82	12.3	2740.0	55.0
80–99	51.31	12.7	2924.9	57.0
100–119	34.66	8.6	2046.2	59.0
120–139	37.46	9.3	2322.3	62.0
140–159	16.17	4.0	1115.6	69.0
160+	33.63	8.3	1352.5	40.2
Total	404.23	100.0	14381.4	35.6

Source: Kurz and Apps 1999 in CCFM 2000: 48.

Table 5.2: Ownership of Canada's forests (millions of hectares)

	Total Forest Area	Federal (%)	Provincial (%)	Private (%)
Newfoundland	22.5	0	99	1
Prince Edward Island	0.29	1	7	92
Nova Scotia	3.9	3	28	69
New Brunswick	6.1	1	48	51
Quebec	83.9	0	89	11
Ontario	58	1	88	11
Manitoba	26.3	1	94	5
Saskatchewan	28.8	2	97	1
Alberta	38.2	9	87	4
British Columbia	60.6	1	95	4
Yukon	27.5	100	0	0
Northwest Territories	61.4	100	0	0
Nunavut	n/a	n/a	n/a	n/a
Canada	417.6	23	71	6

Source: CFS 2001: 24–30.

Table 5.3: Provincial and territorial harvest levels and Annual Allowable Cut (AAC), 1999

	Harvest level (million cubic metres)	Annual allowable cut (million cubic metres)	Percent of AAC harvested
Newfoundland *	2.4	2.7	88.9%
Prince Edward Island	0.5	0.5	100.0%
Nova Scotia *	5.9	6.7	88.1%
New Brunswick *	11.5	11	104.5%
Quebec	45.5	58	78.4%
Ontario **	0.202	0.4	50.5%
Manitoba	2.2	9.7	22.7%
Saskatchewan *	3.3	7.6	43.4%
Alberta	19.4	24.8	78.2%
British Columbia	75	70.6	106.2%
Yukon	0.25	0.35	71.4%
Northwest Territories	0.07	0.236	29.7%
Nunavut	n/a	n/a	n/a

Source: CFS 2001: 24–30.
Notes: * indicates that data are from 1998; ** Ontario in millions of hectares.

Table 5.4: Percentage of area harvested annually that is replanted

	Canada	NF	PE	NS	NB	QC	ON	MB	SK	AB	BC	YT	NT
1975	18.7	0.0	5.5	5.2	7.1	11.8	15.3	12.6	20.9	23.4	40.2	0.0	0.0
1976	17.1	0.0	7.5	4.7	8.7	8.4	16.7	6.2	20.7	25.2	34.2	0.0	0.0
1977	16.5	0.0	7.5	8.2	11.1	8.6	14.1	4.6	27.8	25.6	33.6	0.0	0.0
1978	15.6	0.0	5.9	10.2	12.0	6.2	14.1	6.1	27.0	32.3	29.6	0.0	0.0
1979	16.3	1.0	4.7	7.9	15.7	5.8	14.1	2.3	27.9	33.5	34.0	0.0	0.0
1980	16.8	2.4	22.7	10.2	25.7	5.6	13.3	4.9	34.2	14.7	33.9	0.0	0.0
1981	20.3	13.8	17.3	13.9	33.8	6.4	16.8	15.6	22.0	26.9	45.0	0.0	0.0
1982	23.8	10.0	13.8	12.1	31.0	8.8	17.1	21.1	38.2	19.4	51.1	0.0	0.0
Change in percentage of area harvested that is replanted, 1975–1982: 27.2%													
1983	25.6	13.2	23.2	19.4	24.5	9.5	26.6	18.2	32.4	21.6	50.3	0.0	0.0
1984	26.9	13.8	18.9	16.1	23.4	10.4	29.1	16.3	22.2	47.1	50.4	0.0	0.0
1985	29.1	16.8	16.6	22.1	22.3	14.7	33.3	37.0	26.8	26.7	48.2	0.0	0.0
1986	31.8	4.6	36.7	26.8	23.6	21.7	33.0	37.3	23.2	37.9	48.2	0.0	0.0
1987	37.4	25.3	40.1	23.4	21.3	28.0	32.9	46.1	12.1	33.0	65.0	0.0	0.0
1988	38.9	22.8	39.4	28.1	19.3	29.6	35.3	56.8	31.8	43.9	62.7	0.0	0.0
1989	42.6	17.4	30.7	26.6	22.5	30.1	37.0	54.8	26.9	58.2	79.8	0.0	0.0
1990	53.2	16.1	33.2	28.2	27.6	43.4	33.9	60.7	32.4	54.3	115.2	NA	24.6
Change in percentage of area harvested that is replanted, 1983–1990: 108.2%													
1991	54.6	15.2	45.5	21.5	21.2	45.2	42.0	94.4	37.4	61.3	103.0	NA	8.8
1992	47.6	18.4	42.8	21.5	16.6	37.9	37.7	62.6	34.7	66.6	83.4	NA	13.6
1993	43.9	13.2	39.0	12.0	13.4	29.5	35.8	51.4	34.0	61.3	91.5	27.4	11.6
1994	46.5	15.5	22.7	13.1	16.6	24.4	35.1	53.5	29.2	68.3	114.0	20.3	15.9
1995	43.1	17.5	26.7	14.4	16.5	21.2	30.6	40.2	34.5	107.6	108.9	74.3	16.2
1996	42.9	15.1	28.3	10.9	14.8	25.1	42.4	38.7	42.8	66.0	95.1	29.5	14.8
1997	43.4	17.1	25.1	11.6	17.8	19.9	46.5	40.0	89.5	83.5	108.5	45.4	43.6
1998	43.1	19.5	21.8	14.2	19.2	24.2	47.6	39.6	55.8	63.7	96.0	21.4	24.7
1999	43.6	19.5	19.0	19.3	19.3	22.4	52.6	55.3	56.0	84.6	92.5	n/a	24.7
Change in percentage of area harvested that is replanted, 1991–1999: –20.1%													

Source: Natural Resources Canada Compendium of Canadian Forestry Statistics, 2001.

Table 5.5: Average size of clearcuts on Crown land, by province

	Average size (hectares)	
Newfoundland	30–120	
Prince Edward Island	3.5	
Nova Scotia	<50	
New Brunswick	30	
Quebec	n/a	
Ontario	n/a	
Manitoba	10–49	
Saskatchewan	60–70 (hardwood)	30–40 (softwood)
Alberta	23.5 (hardwoods)	17.3 (spruce and pine)
British Columbia	28.2	
Yukon Territory	8.3	
Northwest Territories	15–25	

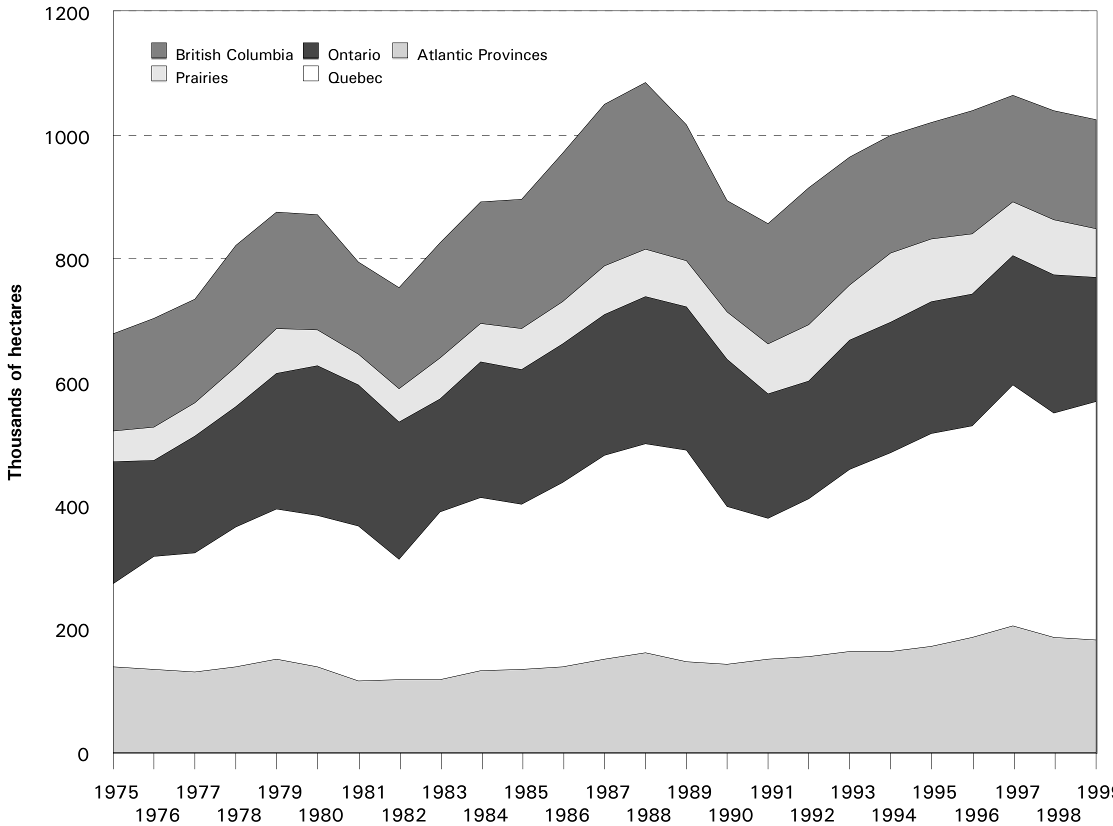
Source: BC Ministry of Forests 1998.

Table 5.6: Forest conversion and fragmentation, by province or territory

	Converted Land (000 hectares)	Percent Converted (%)	Total Remaining (000 hectares)	Fragmented Forest (000 hectares)	Percent Fragmented (%)
Newfoundland	15	0	16,813	668	4
Prince Edward Island	211	46	250	153	61
Nova Scotia	203	4	4,879	3,035	62
New Brunswick	239	3	6,612	5,797	88
Quebec	1,468	2	80,948	16,898	21
Ontario	3,858	5	78,721	21,849	28
Manitoba	3,304	8	40,289	5,074	13
Saskatchewan	7,270	19	31,558	5,841	19
Alberta	9,035	21	33,259	27,518	83
British Columbia	849	2	48,184	30,137	63
Yukon Territory	1	0	12,929	1,252	10
Northwest Territories	1	0	46,517	1,217	3
Nunavut	0	0	1,977	0	0
Total	26,454	6	402,936	119,439	30

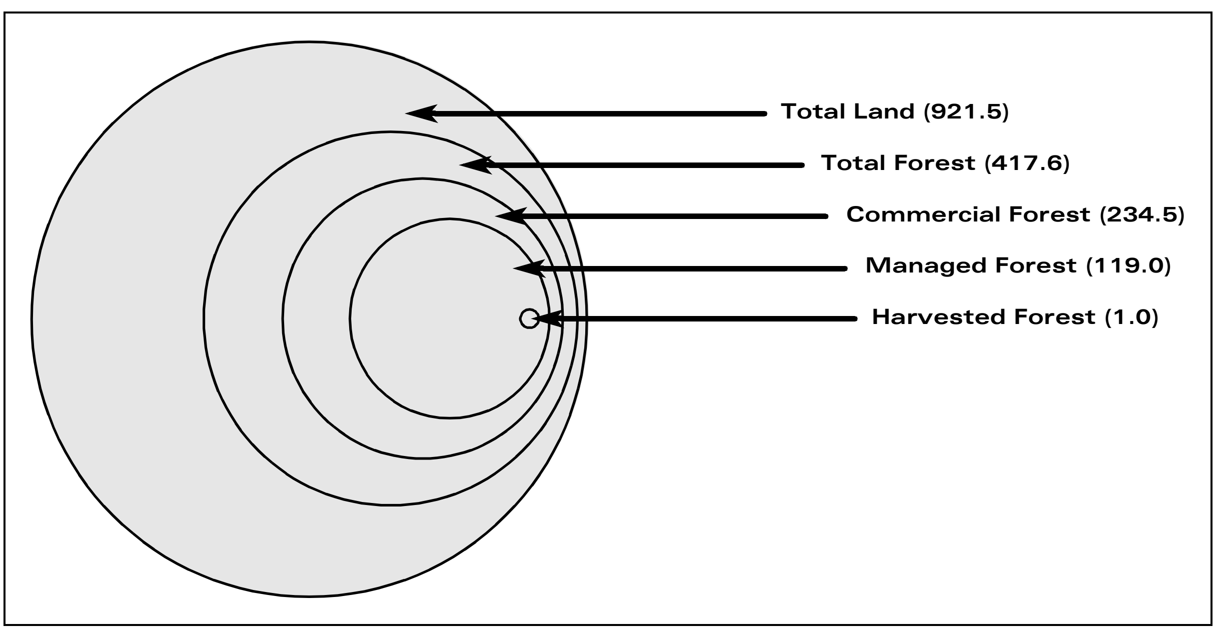
Source: WRI 2000: 29.
Note: Access data for Alberta and northeastern British Columbia has been overestimated through the inclusion of oil and gas seismic exploration lines. Access data for Newfoundland and Quebec has been underestimated due to limited availability of data.

Figure 5.7:Total area harvested, 1975–1999



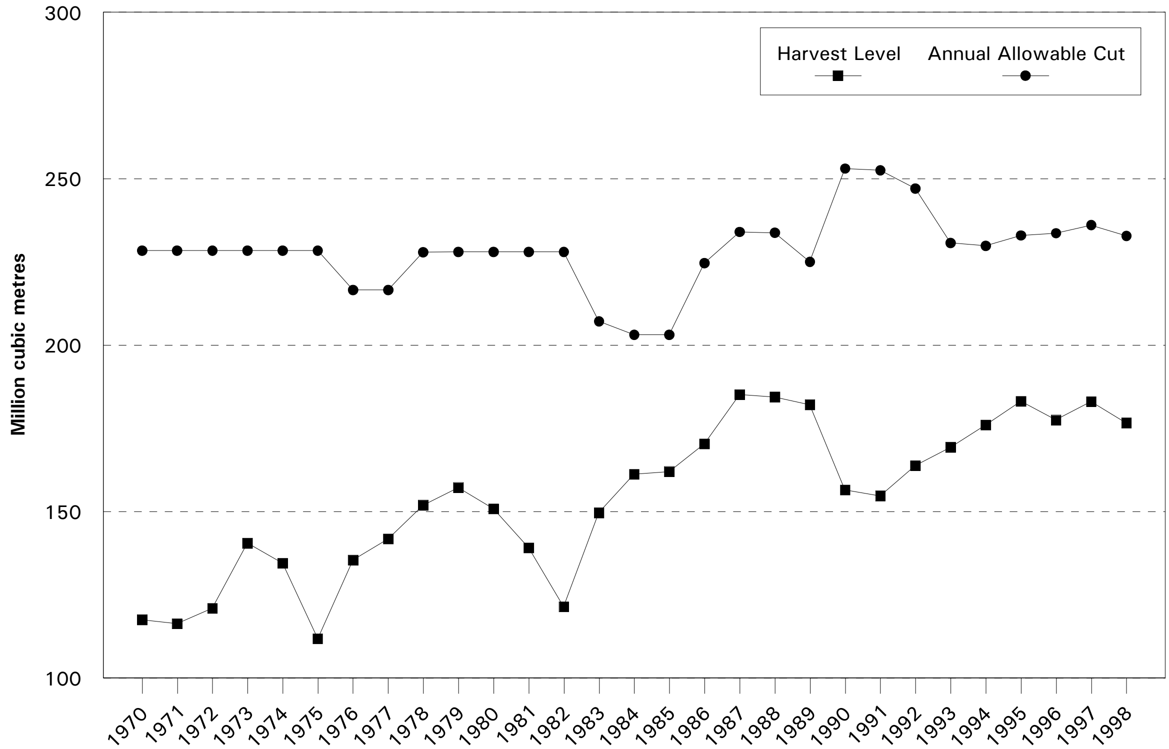
Source: National Forestry Database 2002.
Note: Harvest levels in the North are too small to show on this graph; in 1999, 547 hectares were harvested.

Figure 5.8: Canada's forests (millions of hectares)



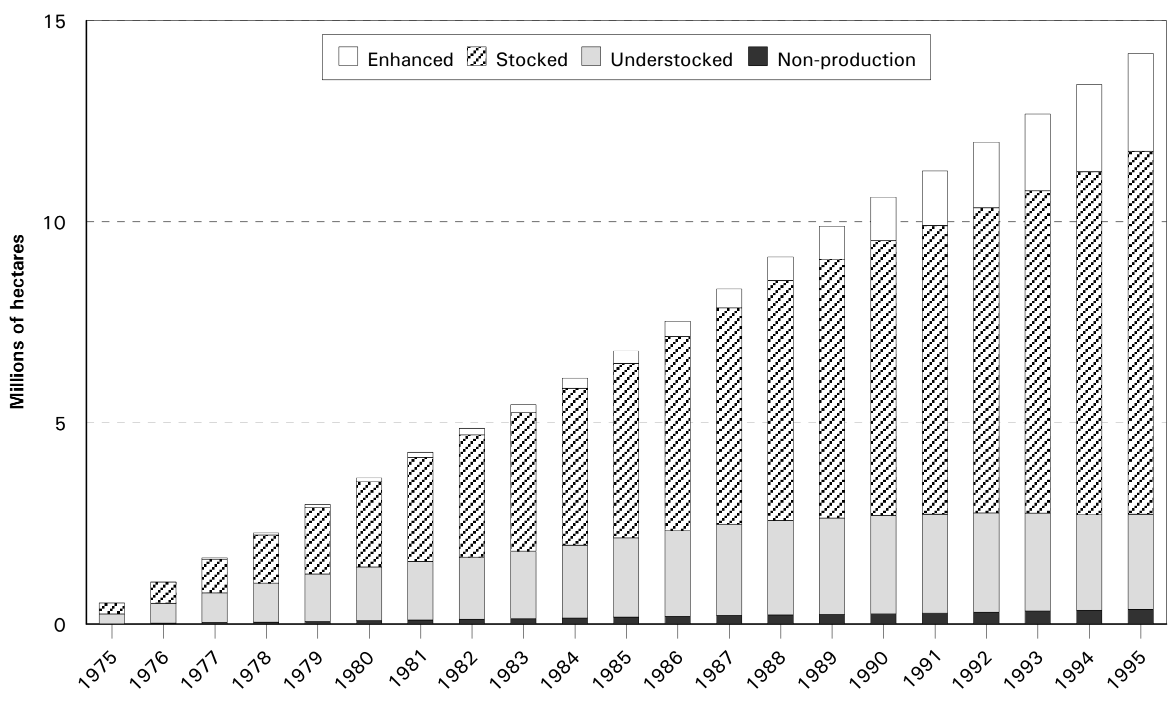
Source: Adapted from CFS 1998: 6.

Figure 5.9: Canadian annual harvest and Annual Allowable Cut (AAC)



Sources: data from 1970 to 1995 from Environment Canada 1997d; data for 1996 and later from National Forest Service Database Program 2002. Notes 1: Ontario measures its AAC in hectares, whereas all other provinces and territories measure AAC in cubic metres. Note 2: British Columbia does not include all private lands in its AAC. Saskatchewan, Alberta and Ontario do not include any private lands. Note 3: Harvesting data only considers data for industrial roundwood even though the harvest level for fuel-wood or firewood for a single province may range as high as 2.2 million cubic metres. Note 4: Harvesting levels on federal lands are not included.

Figure 5.10: Cumulative forest regeneration status at one-year intervals, 1975–1995



Source: Haddon 1999; calculations by authors. Note: national data was obtained by summing up provincial data. With the exception of Alberta and British Columbia, these numbers are based on estimates; only Alberta and British Columbia complete a comprehensive survey of cutblocks. Data for the Northwest Territories is not included; however, the total harvested area since 1975 for the Northwest Territories is less than 5000 hectares.

Energy

Canada is fortunate to have large reserves of important and diverse energy resources such as petroleum, natural gas, coal, and hydroelectric potential. By drawing on these resources, Canada's energy sector plays an important role in the global energy market. Canada is the world's second largest producer of hydro-electric power (NRC 2000a: 1), third largest producer of natural gas and the eleventh largest producer of crude oil (CAPP 1999). Canada is also a leader in the nuclear sector, producing about one-third of the world's uranium, operating 22 CANDU reactors domestically, and exporting technology around the world (NRC 2000a: 1, 13). Canada's energy sector contributes substantially to our domestic economy. In 1998, approximately 7% of the gross domestic product and 8% of total merchandise exports were attributed to the energy industry, which employed about 280,000 Canadians (NEB 1999a: 2).

Jurisdiction over the valuable energy sector is divided between the federal and provincial governments. Provincial governments have jurisdiction over resource management within their borders, and the federal government maintains ownership of resources on frontier lands (north and offshore), and control of nuclear power and uranium, international and transboundary environmental impacts. Because some provinces have disputed federal ownership of offshore oil resources, in Nova Scotia and Newfoundland the oil and gas industry is jointly managed (NRC 2000a: 8). On the west coast, federal and provincial moratoria on off-shore drilling are in place but, because of the extensive reserves believed to exist in the Hecate Strait, British Columbia is currently studying the impacts of lifting its moratorium.

Canadians not only produce a great deal of energy; they are amongst the world's most intensive users of energy. As a result of a high standard of living, cold climate, energy-intensive industrial base, large geographic area, and widely dispersed population, Canada ranks as the world's sixth largest user of primary energy (Environment Canada 1997b: 1; 1996c: records 6039-40).[36] There is, however, a great deal of regional variance in Canadian energy production and consumption. Alberta is the largest producer of energy in Canada due to its vast wealth of oil and gas. It also consumes a large amount of energy in producing energy for both domestic use and export. Ontario is the largest energy consumer in Canada due to its large population and extensive industrial base (NRC 2000: 18).

In this section, trends for both energy consumption and production are examined. Consumption trends are interesting since they illustrate changes in energy use and efficiency over time. Production trends address concerns about Canada running out of energy reserves.

Trends in energy consumption

Figure 5.11 illustrates total domestic energy consumption by end use.[37] Between 1971 and 2000, energy consumption increased by 55.5%; commercial use of energy showed the most significant increase at 73.3%. Generation of electricity increased by 33.4%, and industrial use by 27.4%. Energy consumption per capita has also increased by 31.5% over the past two decades (figure 5.12).

In 2000, industrial uses accounted for 21.9% of primary energy use in Canada. Transportation accounted for 21.3%, 14.8% was used for the generation of electricity, 12.0% was used residentially, and 10.7% was used by the commercial sector. The remaining 19% was used for non-energy purposes[38] or was lost or consumed by energy producers during extraction or refinement.

Although both total and per-capita energy consumption have increased in the past two decades, Canadians have become more efficient users of energy. Between 1971 and 1997 energy consumption per dollar or real gross domestic product (GDP) fell steadily (figure 5.13); GDP increased by 119.2% whereas energy consumption increased by only 89.3%. This decline in energy consumption per dollar of GDP is likely due to a combination of factors including improvements in energy efficiency and structural changes in the economy away from activities that require the use of more energy.

Canada's Office of Energy Efficiency (OEE) was established in 1998 to "renew, strengthen and expand Canada's commitment to energy efficiency" (OEE 2001: 4). The OEE collects and analyses data on energy efficiency looking for trends and compiling an Index depicting annual changes in energy efficiency in the Canadian economy (OEE 2001). The OEE Index is considered to be a better estimation of changes in energy efficiency than the ratio of gross domestic product to energy use because it can take into account changes in economic activity, structure, and weather. The OEE follows trends in energy efficiency and energy use for five key end-use sectors: residential, commercial, industrial, transportation, and agriculture. To evaluate improvements in energy efficiency during this period, it calculates changes in energy intensity, adjusting for weather and the structure of the economy. Change in energy intensity measures the change in the amount of energy needed to produce a fixed amount of output. An increase in energy intensity is a decrease in efficiency. The findings of the report are displayed in table 5.7.

Overall, while secondary energy use increased by 12.2% between 1990 and 1999, energy efficiency improved by 8.0%. This improvement translates into a savings to Canadians of about $5 billion in saved energy costs (OEE 2001: 4). The greatest improvements in energy intensity were in transportation with freight, which improved 15.4%. This change is due primarily to increases in activity, energy efficiency, and structure. More freight was moved by trucks, and trucking companies, in turn, improved efficiency through measures such as consolidating loads and reducing the number of kilometers traveled without freight. Residential energy intensity decreased 13.0% as a result of the introduction of more efficient space heaters and appliances. Industrial energy intensity increased 9.1% over this period. Commercial energy intensity was flat, largely due to a slowdown in new building starts.

Trends in energy production

During the period from 1971 to 2000, total production of primary energy increased by 120% with the largest increases in coal (273%) and natural gas (223%) (figure 5.14). The production of hydroelectricity and nuclear energy (combined due to data availability this year) rose by 156.6%. Petroleum increased by 63.9%.

The sources used to produce energy have changed greatly over the past few decades. Whereas crude oil accounted for 46.0% of total energy produced in 1971, it accounted for only 36% in 2000. During this same period, production of natural gas expanded from 30.6% to 44.8% of total production. Nuclear power increased as a source from 1971 to 1997, although its operations have contracted to less than 2% of total energy production during the past few years. Alternative energy sources such as solar and wind power have increased in the past decade but remain small scale, producing only about 1/10,000th of the energy consumed in Canada (Environment Canada 1996c: record 6048).

A large portion of the energy produced is exported. In 2000, exports of crude oil were estimated at 221,700 cubic metres per day, a 41% increase from 1994 (NEB 2001: 1). Exports of natural gas totaled 99.5 billion cubic metres in 2000, an increase of 38% from 1994, and approximately 57% of Canada's total production of natural gas (NEB 2001: 2). These high rates of production and export, coupled with the fact that oil and natural gas are non-renewable resources, have led some to predict that Canada will run out of oil and natural gas in the near future. Contrary to these predictions, the total amount of crude oil and natural gas discovered has increased throughout the past two decades (figures 5.15 and 5.16) and additions to established reserves continue to replace a percentage of the amount produced.

Yet, concerns about production levels remain since additions to reserves are not fully replacing the amount of natural gas and oil produced. With the exception of 1983 and 1997, annual net production has exceeded annual gross additions to reserves of crude oil (Rodrigues 2002). Similarly, additions to reserves of natural gas have generally been below production levels since 1985 (Rodrigues 2002). For oil, this negative net change in reserves can be partially attributed to decreasing oil prices that have encouraged producers to switch from drilling oil wells to drilling for natural gas (NEB 1999c: 1).

While examining figures 5.15 and 5.16, it is important to remember that they display only data on established reserves. For crude oil, it has been estimated that an additional 4,615 million cubic metres of crude oil are undiscovered and another 1,031 cubic metres can be extracted from existing reserves because of technological advances (NEB 1999b). As a result, at the end of 1997 Canadians had extracted only 7.2% of their total estimated recoverable crude oil and bitumen resources. Similarly, there is a large amount of undiscovered natural gas: it is estimated that Canadians have extracted between 14% and 17% of their economically recoverable natural gas resources (NEB 1999c).[39]

In making a decision on the optimal level of energy production, many factors beyond current production levels need to be considered. For example, Canada's oil sands, spread across northern Alberta and British Columbia, are estimated to contain as much as 397 billion m^3 of bitumen, 48 billion m^3 of which is recoverable with today's technology. This makes Canada's oil sands a larger hydrocarbon deposit than Saudi Arabia's proven oil reserves and, if fully recovered, could meet the world's oil demand for the next 100 years (Natural Resources Canada 2000a: 42). However, oil-sands projects not only tend to disturb more land per unit of oil produced than conventional projects but also to produce large amounts of contaminated sludge. There will be greater ecological and economic costs as more oil is extracted from oil sands. The process of extracting oil from the sands is also more energy intensive, requiring approximately 9 to 12 cubic metres of oil sands to produce 1 cubic metre of bitumen (Environment Canada 1999c: record 6128). To be upgraded, this bitumen then needs to be processed.

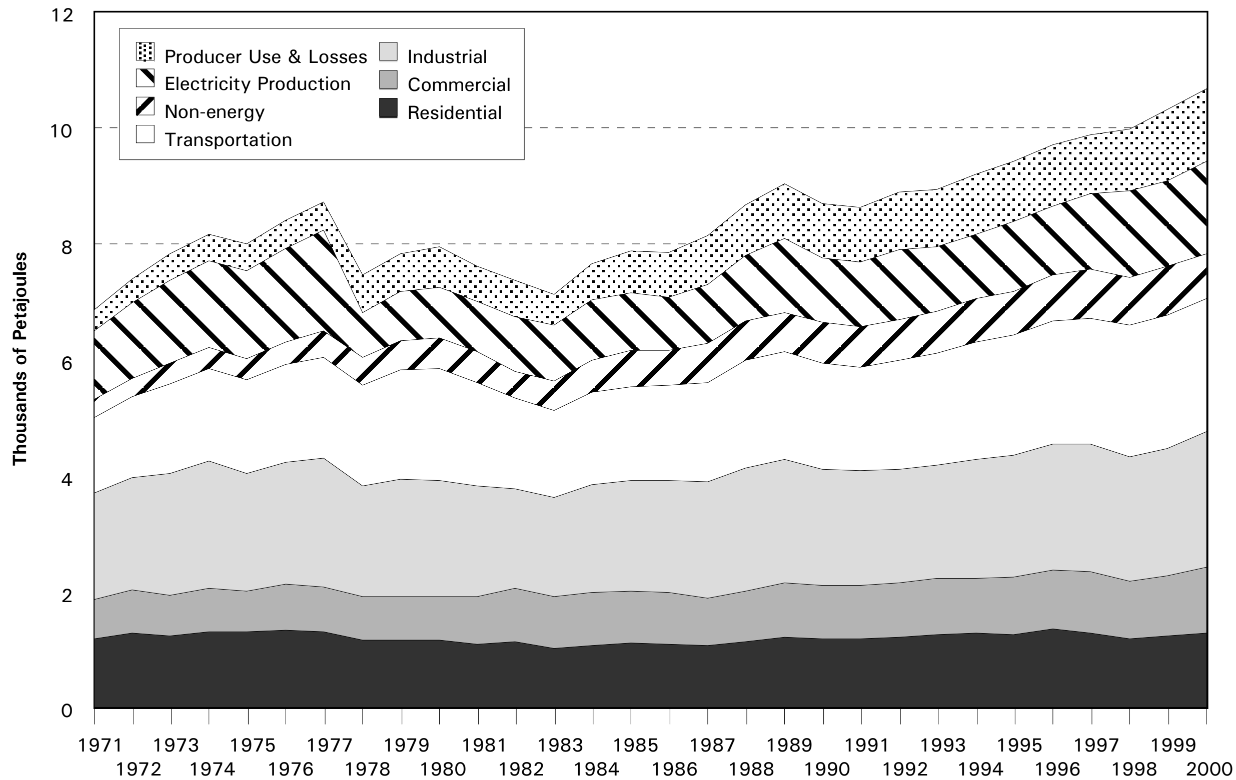
The economic benefits of current production levels must also be considered. In 2000, the "upstream"[40] crude oil and natural gas industry employed 89,000 people directly and 153,000 indirectly. With the addition of the "downstream" sector, the industry employed 525,000 Canadians (CAPP 2002a). This industry also provides much revenue to the government: in 2000, payments to government for royalties, income taxes, and bonus payments totaled $15 billion (CAPP 2002b). If production levels are reduced, these jobs and revenue may be lost.

Table 5.7: Change in energy use and intensity by sector, 1990 to 1999

	% of secondary use	Change in energy use (%)	Change in energy intensity
Residential	17.0	1.3	−13.0
Commercial	12.5	13.4	−1.6
Industrial	39.0	11.4	−9.1
Transportation	28.7	20.3	
Passenger	17.8	13.5	−3.9
Freight	10.9	30.6	−15.4
Agriculture	2.9	15.4	−7.0
Total		12.2	−8.0

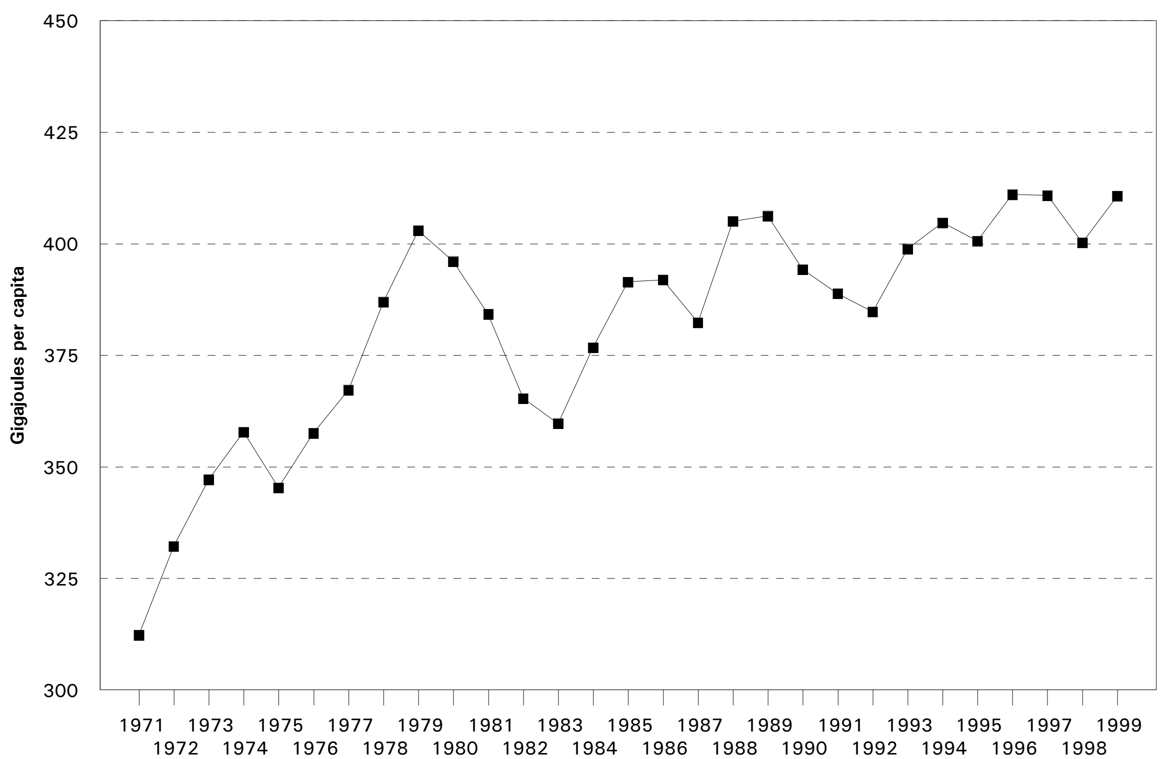
Source: Office of Energy Efficiency 2001.

Figure 5.11: Energy consumption by end-use sector, 1971–2000



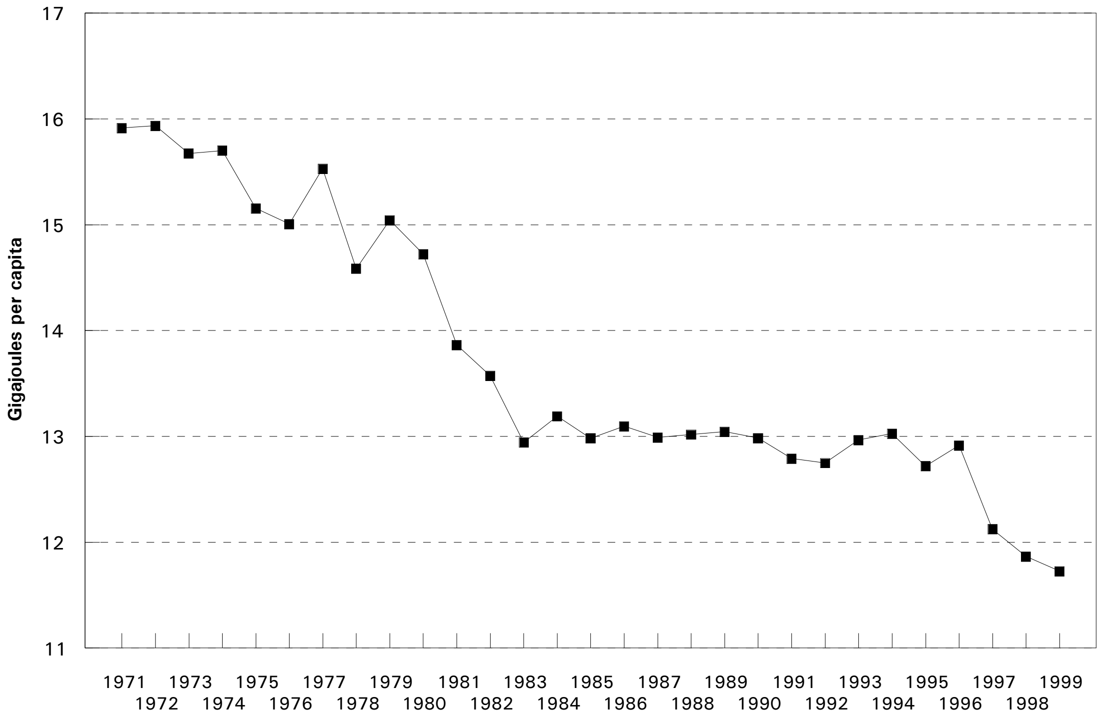
Sources: data for 1971–1977: NEB 1999a; data for 1978–2000: Statistics Canada 2002b.

Figure 5.12: Energy consumption per capita



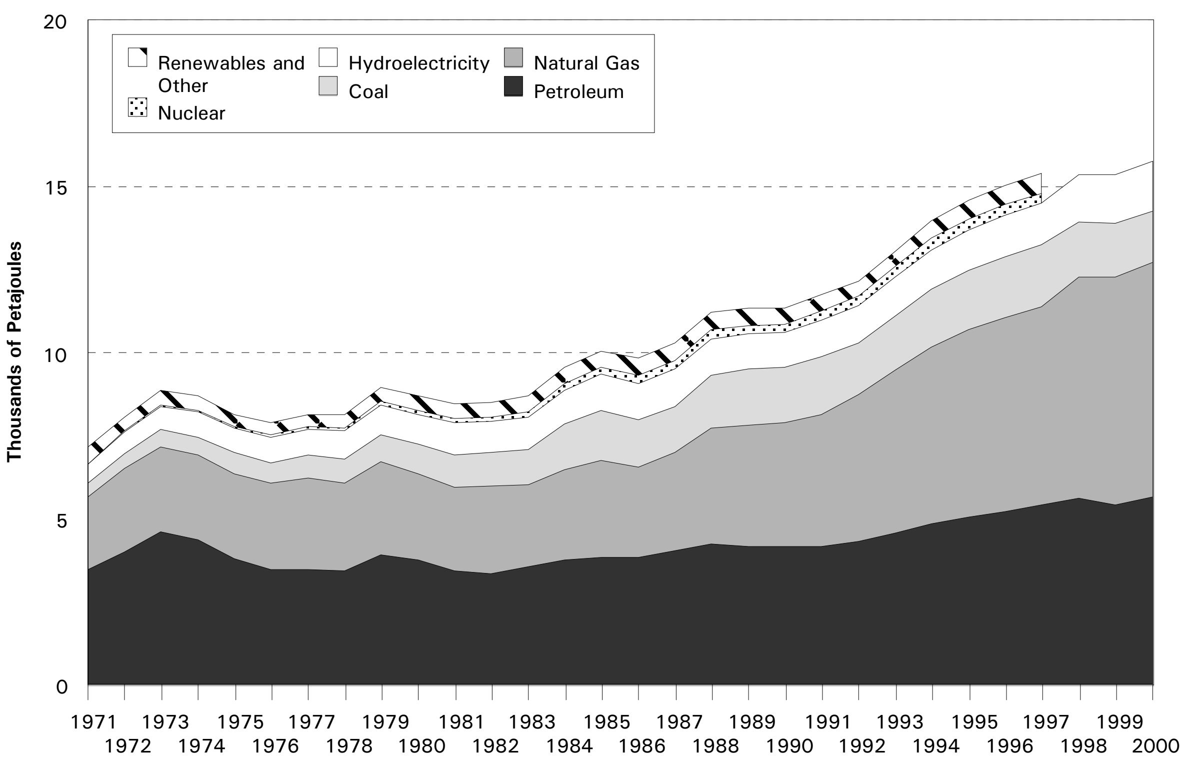
Source: data for 1971–1979: NEB 1999a; data for 1980–1999: Energy Information Administration 2001.

Figure 5.13: Energy consumption per dollar of real GDP



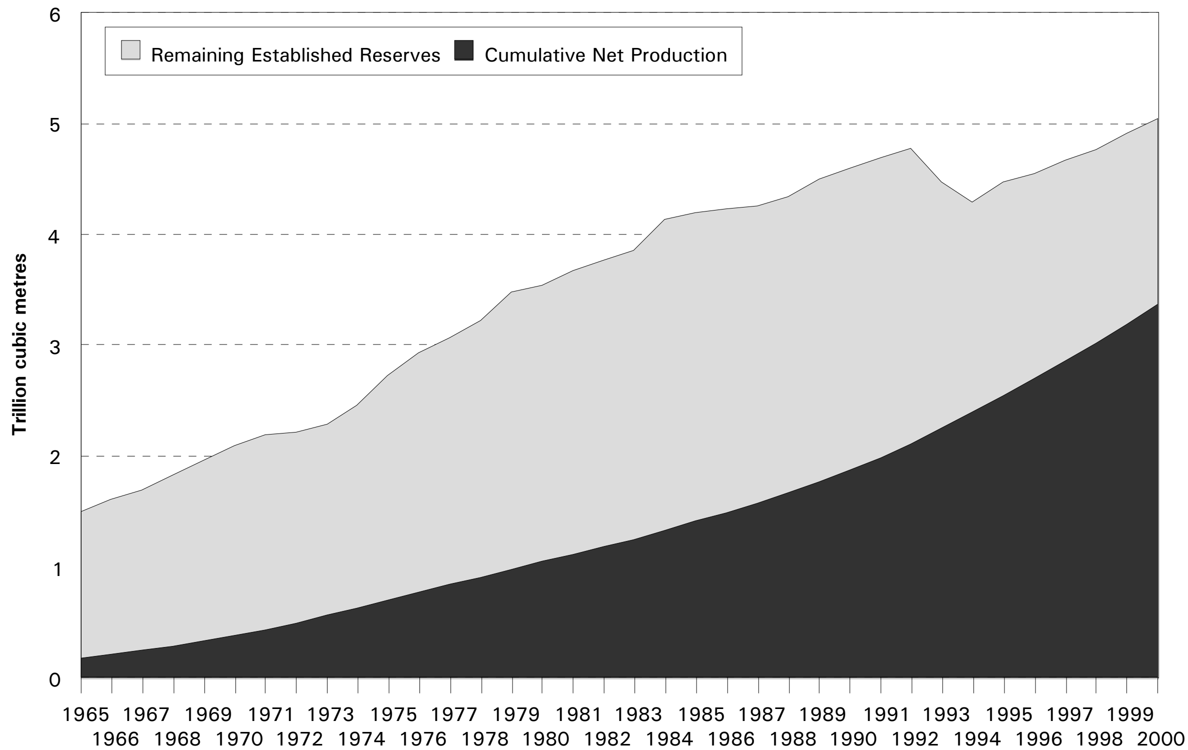
Sources: total consumption: NEB 1999a; Energy Information administration 2001; GDP: Statistics Canada 1999d, 2001.
Note: Total energy consumption is defined here as the sum of total residential, commercial, industrial, transportation and non-energy uses, as well as the energy needed to produce electricity and consumption and losses by producers.

Figure 5.14: Primary energy production by type, 1971–2000



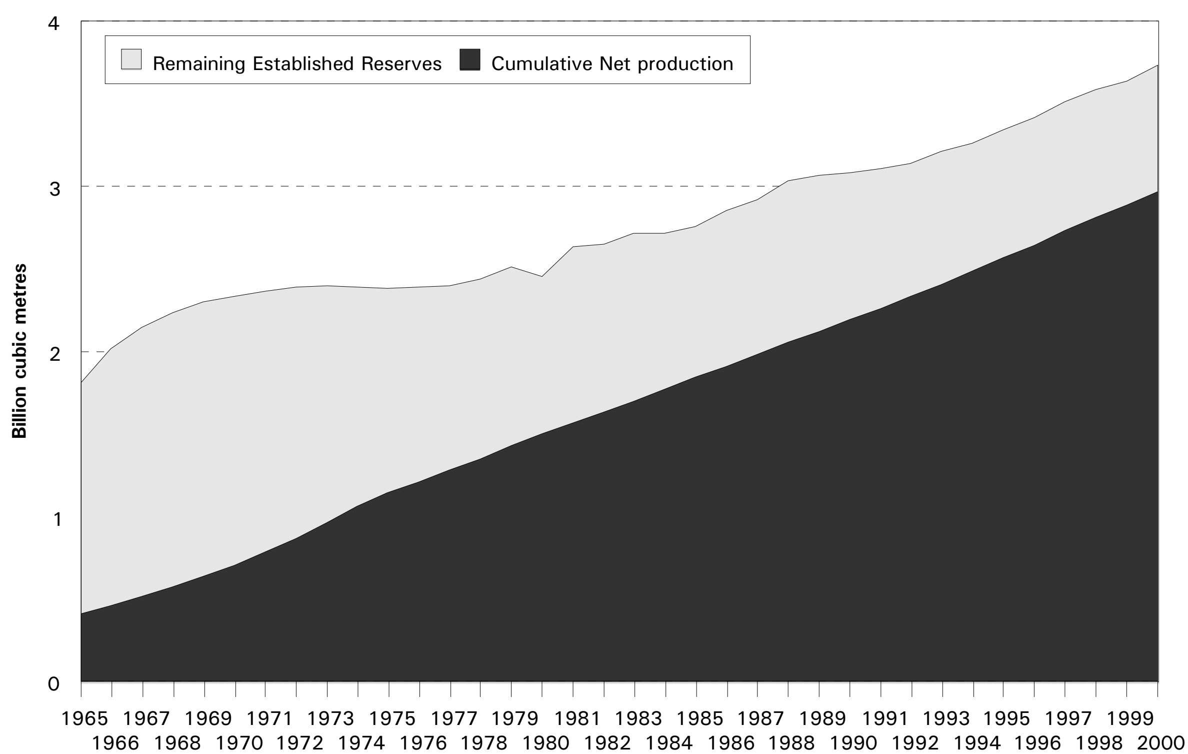
Source: Statistics Canada 2002a. Nuclear energy and hydroelectricity are combined in 1998–2000 data. Data for Renewables and Nuclear are unavailable after 1997.

Figure 5.15: Natural gas production and remaining established reserves, 1965–2000



Source: Rodrigues 2002; data from Canadian Association of Petroleum Producers (CAPP).

Figure 5.16: Crude oil production and remaining established reserves, 1965–2000



Source: Rodrigues 2002; data from Canadian Association of Petroleum Producers (CAPP).