Catalogue 11- 509E

Human Activity and the Environment 1994

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Errata

Human Activity and the Environment 1994
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Page 3, column 2, paragraph 3, line 5 - "In contrast, the United States and China are of similar size but support more evenly distributed populations of 10 and 41 times, respectively, the size of Canada's."

Page 3, column 2, paragraph 4, line 2 - "China, which has the world's largest total population, was home to over 1.1 billion persons — over 41 times Canada's population (Figure 1.1.1)."

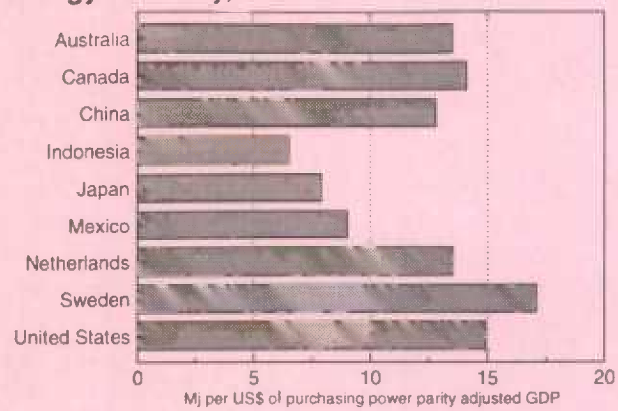
Page 5, column 2, paragraph 2, line 7 - "Canada, Australia and the United States generate between 360 and 826 kilograms of urban solid waste per person per year. This ranks them within the top seven per capita waste producers in the world together with France and New Zealand.[1]"

Page 5, column 2, paragraph 3 - "Statistics on hazardous wastes are highly variable because of differing definitions between countries. The figure of 3.2 million tonnes of hazardous wastes generated each year in Canada in Table 1.1.1 refers to waste known to contain hazardous substances. Much of this waste is treated and is not released into the environment. Hazardous wastes per unit of production (as measured by purchasing power parity adjusted GDP) provide an indicator of the waste intensity of industrial activities. In 1991, according to World Resources Institute estimates, Canada generated approximately 5 953 kilograms of hazardous waste for each million US$ of purchasing power parity adjusted GDP. Japan generated only 317 kilograms per million US$. This remarkable difference can be attributed not only to higher efficiency and recycling in Japan but also to structural differences in economies: Canada has a higher proportion of resource intensive primary and secondary industries than Japan does. The United States and China have higher waste intensities than Canada, 44 143 kilograms and 21 106 kilograms per million US$ of purchasing power parity adjusted GDP, respectively."

Page 7, column 2, paragraphs 3 and 4, and **Figure 1.1.12** - "The energy intensity of a country's economy is an important indicator of both the resource requirements and the potential for pollution. For each US$ of purchasing power parity adjusted GDP in Canada, 14.1 megajoules (Mj) of energy were consumed in 1991 (Figure 1.1.12). This energy is the equivalent of about 0.41 litres of gasoline.

Although the energy intensity of Canadian industry is decreasing,[1] it is currently almost twice that of Japan. The energy production to consumption ratio shown in Table 1.1.1 indicates whether the country is a net exporter or a net importer of energy. Ratios above 1 (Australia, Canada, Indonesia and Mexico) indicate net exporters."

Figure 1.1.12
Energy Intensity, 1991



Pages 58 and 59, Figure 2.2.1 and Figure 2.3.1 - In September of 1993, Statistics Canada introduced a new series of population estimates for Canada. These estimates now include people not counted by the Census and non-permanent residents. Historical revisions are available back to 1971. Figures 2.2.1 and 2.3.1 have large spikes occurring between 1970 and 1971, caused by the addition of individuals that were previously not counted.

Page 67, Figure 2.6.1 - Constant dollars are indicated by the dashed line and current dollars are represented by the solid line.

Page 99, Table 3.3.6 - The unit of measure for the second column under *Freight movement* is millions of tonne-kilometres. The unit of measure for the second column under *Passenger movement* is millions of passenger-kilometres.

Page 165, Table 3.12.6, column 5 - *Net coal production* should be labelled *Total coal supply.*

Page 241, Table 4.10.1, for 1987, row 65 - "Edmonton, Alta., Tornado, Yes, 27, Tornado hits July 31, over 200 injured, extensive property damage."

Page 253, Figure 4.13.2 - Unit of measure is thousand tonnes.

Page 254, Figure 4.13.5 - Unit of measure is million cubic metres.

Page 272, Table 4.14.19 - Total for 1990 -1991, last column, N.W.T, total = 35 577.

Page 273, Table 4.14.20 - Totals for 1991-1992, column 3, Nfld., total = 372 534; column 4, P.E.I., total = 57 874; column 6, N.B., total = 342 673; column 12, B.C., total = 2 697 829.

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Note of Appreciation

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Symbols

The following standard symbols are used in Statistics Canada publications:

- .. figures not available
- ... figures not appropriate or not applicable
- \- nil or zero
- -- amount too small to be expressed
- p preliminary figures
- r revised figures
- x confidential to meet secrecy requirements of the Statistics Act

Prefixes of the International System of Units

Prefix	Multiplication factor	
peta	10^{15}	1 000 000 000 000 000
tera	10^{12}	1 000 000 000 000
giga	10^{9}	1 000 000 000
mega	10^{6}	1 000 000
kilo	10^{3}	1 000
hecto	10^{2}	100
deca	10^{1}	10
deci	10^{-1}	0.1
centi	10^{-2}	0.01
milli	10^{-3}	0.001
micro	10^{-6}	0.000001
nano	10^{-9}	0.000000001
pico	10^{-12}	0.000000000001

Abbreviations

1986$	1986 dollars
°C	degrees Celsius
BCm	billion cubic metres
cm	centimetre
ha	hectare
hr	hour
kg	kilogram
km	kilometre
km^2	square kilometre
kPa	kilopascal
kt	kilotonne
l	litre
m	metre
m^2	square metre
m^3	cubic metre
MCm	million cubic metres
mg	milligram
mm	millimetre
Mt	megatonne
ng	nanogram
nec	not elsewhere classified
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
SIC	Standard Industrial Classification
t	metric tonne
tC	metric tonne of carbon
mg	microgram
US$	United States dollars

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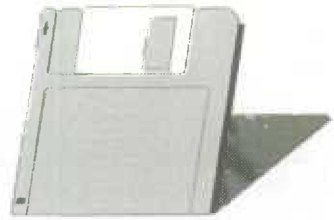

Human Activity and the Environment 1994 is also available on diskette, for micro computer users. Tables and charts from this publication are stored on DOS formatted diskettes in LOTUS 1-2-3 spreadsheets. These files can be used by most DOS compatible spreadsheet software. There is a fee of $15.00 to cover shipping and handling costs. To order a diskette mail in the order form at the back of the book. If you have questions phone 613-951-3640.

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Introduction

All life on earth depends on the environment for air, water, food and other resources. As people, we are part of the environment and co-exist with all other life in an amazingly complex biological web. As a species, we are unique because we are able to use materials and energy to modify the surrounding environment. We have diverted rivers and harnessed mighty waterfalls, we have found and extracted scarce resources and we have cleared and cultivated millions of hectares of land. In short, human activity has had profound impacts on all of the world's natural systems. Many of these impacts cannot be reversed. Unique habitats, plants and animal species cannot be replaced once they are gone.

Canadians recognize how vital a clean and healthy environment is. To be effective at reducing our collective impact on the environment we need information. Without systematic, accessible information we are unable to understand, assess, predict and respond to potential environmental changes and impacts. Statistics Canada's answer to this need is today's environment statistics handbook - *Human Activity and the Environment 1994*. This edition provides up-to-date, comprehensive and authoritative data on population, economic activities, the environment and the links between these. It systematically reviews current data from Statistics Canada and other sources, in a logical, descriptive format. The statistical facts are further illuminated by analysis and interpretation in order to unravel a multitude of complex interactions.

New for 1994 is a chapter on environmental accounting which details Statistics Canada's new initiatives in this important area. Also new are sections on waste contaminants and environmental profiles.

Much of the information in *Human Activity and the Environment 1994* is presented by *drainage basin* and *ecozone*.[1] These geographies provide the reader with a unique opportunity to examine information on a spatial frame which is not only environmentally relevant but consistent over time.

Although this volume uses the latest, most comprehensive data, Canada-wide coverage for some subject matter areas is incomplete. Other areas require further research, evaluation and data development. Some examples include: improved water quality measures, bio-diversity and other indicators of habitat change, assessment of environmental impacts on human health, detailed natural resource and pollution accounts and analyses of environmental stresses from manufacturing industries.

The information in *Human Activity and the Environment 1994 is* organized under three broad and closely interrelated headings: population, the economy and the environment.

In the last 50 years Canada's population has increased by a factor of 2.3 and this growth has been a key driving force behind our economic expansion. The economy, in turn, is reliant on the environment to supply energy and materials, and to absorb waste products. In general, the larger our population becomes the larger our demand for resources. The implications on the environment are clear. As population and the economy grow, so does the level of stress imposed on the environment. *Human Activity and the Environment 1994* integrates data on these issues.

Today Canada's economy is 6.5 times larger than it was 50 years ago. Economic growth on this order of magnitude implies much larger demands on the environment. Growing transportation networks, energy consumption and industrial processes all have significant impact. *Human Activity and the Environment 1994* uses text, tables, maps and charts to interpret each one of these important issues.

Much of Canada's economy is sustained by its natural resource wealth. Renewable resource harvests from agriculture and forests are enormous. For example, if all of the 1993 grain crop were loaded on a single train its length would be 4 times the width of Canada, and a train holding our entire forest harvest would be 10 times as long as the country is wide. Today more than ever before questions arise about the sustainability of our resource use rates. How can we maintain air, water and soil quality? Can we continue to extract non-renewable resources at current rates? Are current renewable resource harvesting activities sustainable? Are we taking steps to implement conservation and recycling measures?

The previous edition of *Human Activity and the Environment* was released in the same year, 1991, that Environment Canada's *The State of Canada's Environment* was issued. In the three years since then much has happened on the world stage and this new edition, the fourth by Statistics Canada, has been influenced by several important developments. In particular, the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, in 1992, set out an ambitious plan of action on environment and development issues, known as Agenda 21. The Government of Canada is now participating in a multi-stakeholder consultation process, facilitated by the National Roundtable on the Environment and the Economy (NRTEE), to develop a sustainable development plan for Canada. Also resulting from UNCED are The Statement of Principles on Forests, The Convention on Biological Diversity, and The United Nations Framework Convention on Climate Change.

These agreements have initiated processes in Canada which will fundamentally change the way we relate to the environment and supporting resource base. The most notable outcome of these discussions will be plans and strategies to guide Canadians in this new relationship. Statistics Canada hopes that the information compiled in this volume will be useful for the purpose of monitoring progress toward achieving these goals.

1. A *drainage basin* is an area of land which drains into a common river or ocean. An *ecozone* is a natural region delineated by landform, soil, water, vegetation, climate, wildlife and human factors.

1 Overview

1.1 International Summary Statistics

Background

This section will present comparative statistics between Canada and eight other countries. The statistics cover not only direct environmental measures but demographic, social and economic conditions as well. Many chapters within this book emphasize the interrelation between population growth, social conditions, economic growth, resource availability and environmental quality. Comparing Canadian statistics with those of other nations not only provides an assessment of our progress towards environmental goals but also highlights Canada's contribution to global environmental problems and solutions.

International statistical comparisons, while extremely informative, are also quite difficult to compile and interpret. Although many countries adhere to United Nations guidelines for economic, demographic and social data collection, most have adapted these definitions and methods to better suit local conditions. Furthermore, environmental data collection has not reached the level of standardization found in these other fields, making it difficult to obtain and compare consistent statistics.

This chapter draws upon the efforts of the international organizations such as the United Nations (UN), the World Resources Institute and the Organisation for Economic Co-operation and Development (OECD), which are mandated to reconcile information from different countries and present it in a comparable form.

The goal of this chapter is to situate Canada in a global context by comparing its characteristics with those of eight other selected countries.

- **Australia** is a large country with an unevenly distributed population, its economy is similar in size and level of industrialization as Canada's. Major environmental issues in Australia include land degradation, especially erosion and salinization. As well, it is home to many unique species of plants and animals, many of which are at risk of extinction due to the spread of agriculture and introduced species such as the rabbit and fox.
- **China** is also a large country with a very large, mostly non-industrial population. Over the past 10 years, China's manufacturing capacity has grown immensely. This industrial growth has resulted in high levels of air pollution in the large cities and a decrease in the quality and quantity of water available for irrigation, industry and human consumption. Land degradation resulting from deforestation and the destruction of its grasslands are also prominent issues.
- **Indonesia** is a nation with diverse natural and human assets. Like China it is densely populated and in the process of industrialising. The desire to increase agricultural production has led to intensification (for example, through the application of fertilizers to obtain higher yields per hectare) and extensification (increased area under cultivation). These practices are resulting in deforestation and degradation of large areas of upper watersheds. As in Canada, the resource industries (agriculture, mining and petroleum, fishing, and forestry) are an important component of the economy.
- **Japan**, also densely populated, is a smaller country with a highly-industrialized economy. Because of its lack of natural resources, Japan's economy is highly dependent on resources from foreign sources. Its size and level of industrialization require that a high priority be given to economic efficiency and pollution controls. Current environmental problems in Japan include air pollution in the major population centres and the pollution of the marine environment by coastal industrial activities.
- **Mexico** has a newly-industrialising economy. Recently, resource management and pollution control have been given a higher priority. Pollution of the air, water and land in and near large population centres, deforestation and water scarcity are the most pressing environmental issues.
- **Netherlands** is a small, very densely populated country. Since it is highly dependent on its land to provide food, it has developed very effective means of controlling environmental degradation. However, the rivers which flow from the rest of Europe into the Netherlands are still quite polluted. High rates of fertilizer and manure application have also led to an increasing contamination of groundwater.
- **Sweden** has managed to sustain a growing, industrialized economy with one of the highest standards of living in the world. The management of the environment has always been given a high priority. Acid precipitation, largely from other countries, continues to take its toll on Sweden's forests and lakes. Runoffs from fertilizer application are suspected as major causes of high pollutant levels in the North and Baltic Seas.
- **United States** is Canada's nearest neighbour and largest trading partner. Its economy and population are approximately 10 times greater than those of Canada. The two countries share many economic, social and environmental similarities. Air pollution is still a major concern despite strict standards. Fertilizer and pesticide runoff from agricultural lands is a major factor in the degradation of river and lake water quality.

Many of the indicators discussed in this chapter are illustrative rather than definitive. For example, the air and water quality indicators were chosen as ones which were available for all countries rather than the best indicators of environmental quality.

Detailed country statistics are provided in the tables at the end of this chapter:

- Table 1.1.1 International Summary Statistics
- Table 1.1.2 Water Quality Indicators
- Table 1.1.3 Air Quality Indicators

The statistical sources for the tables are provided at the end of the section.

Global Issues

Many environmental issues can be associated directly with demographic and social change. Despite a reduction in the rate of growth in world population since the predictions of the 1970s, the world population of 5.3 billion is still growing at an estimated 1.8 percent per year. In addition to population growth the world has experienced economic growth of about 2.7 percent annually over the past 15 years. This growing output depends on the intake of resources and, with current technology, results in the generation of pollution.

Goodland[1] describes the equation as:

$$I = PxAxT$$

where I=Impact, P=Population, A=Affluence (consumption per capita) and T=Technology. The net impact must be below the world's limited carrying capacity.

Whether or not the rate of growth in population and economic output (or affluence) is sustainable depends heavily upon the technology factor—can industry reduce its material and energy throughput at the same rate as population and affluence is increasing?

Global environmental change is most obvious in the depletion or degradation of the natural capital that sustains human activities. Throughout the world, whether in developed or in developing countries, there is evidence of the loss of topsoil, groundwater, forest, fish stocks and biodiversity. In all but a few locations, the quality of the air, water and land is also decreasing.

These are no longer local issues; air pollution generated in one country may affect forests and lakes in another. Economic processes also form international linkages, for example, the demand for tropical hardwoods in a developed country which protects its forests may accelerate deforestation in developing countries.

1. Goodland, R., H. Daly and S. El Serafy, *The Urgent Need for a Rapid Transition to Global Environmental Sustainability*, Environment Canada - Environmental Sustainability Seminar Series, Ottawa, 1992.

In some cases, problems are not evident at the local level but require a global view to be understood and solved. The effects of increased global carbon dioxide (CO_2) concentrations, loss of biodiversity, and marine water pollution, for example, do not respect national boundaries and ultimately affect the whole world.

There have been several positive developments in awareness of environmental problems and in co-operation towards understanding and solving these problems. Many countries, including the developing ones, are concerned with the quality of their environments and the sustainability of their activities. Many have instituted environmental reporting as a part of informing the public and decision makers about environmental issues.

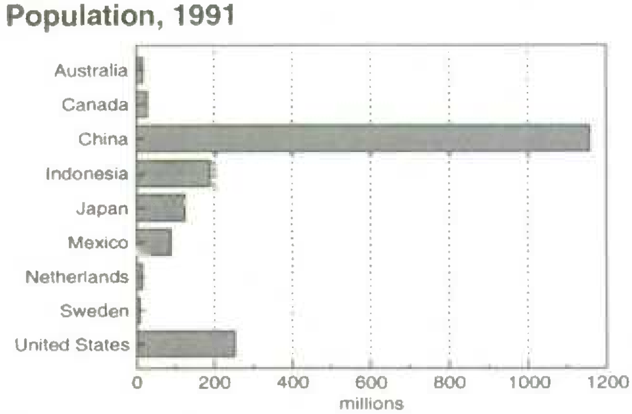
Land Area

Canada is the second largest country in the world, with a land area of 9.2 million square kilometres. Another 700 thousand square kilometres are covered by bodies of fresh water. As with Australia, only a small portion of the land area is densely inhabited. In contrast, the United States and China are of similar size but support a more evenly distributed population of 10 and 50 times the size, respectively, of Canada's.

Population

Canada with 28 million people in 1991 ranked 32nd in the world in total population. China, which has the world's largest total population, was home to over 1.1 billion persons—almost 50 times that of Canada (Figure 1.1.1).

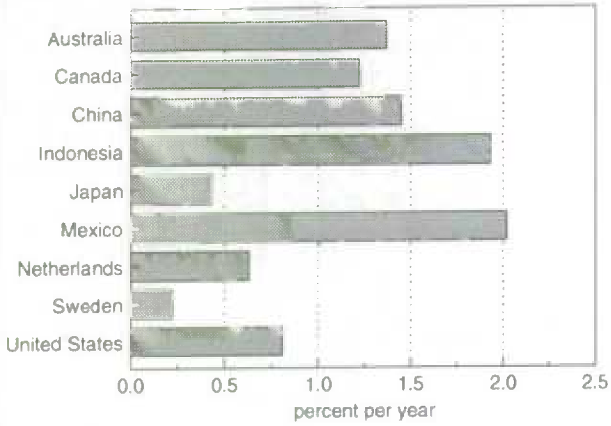
Figure 1.1.1
Population, 1991



Source:
See Table 1.1.1 for sources.

Populations in the developed countries are typically increasing by less than one percent per year (Figure 1.1.2). Between 1981 and 1991, the population of Canada grew, on average, 1.2 percent per year. The populations of Japan, the Netherlands, Sweden and the United States are growing even more slowly. The high growth rates of the developing country populations have slowed from the extremely high rates of the 1970s (typically 3-5 percent per year) to around 2 percent per year, largely due to the success of family planning programs.

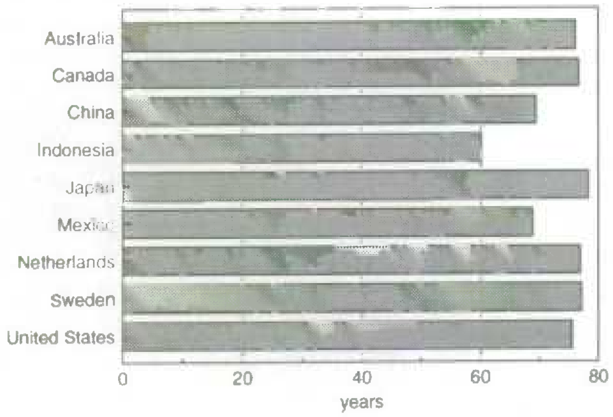
Figure 1.1.2
Population Growth Rate, 1991



Source:
See Table 1.1.1 for sources.

Canada and Australia are both sparsely populated, with 30 and 22 persons per thousand hectares on average respectively. In Canada, 76 percent of the population live in urban areas. Australian's urban areas house 86 percent of its population. This level of urbanization is in sharp contrast to developing countries such as China and Indonesia. Only 22 and 29 percent of their populations, respectively, live in urban areas. Both of these countries are experiencing a general migration from rural areas to the cities. This recent urbanization is resulting in unprecedented pressures on the cities to provide land, services and employment. One result of uncontrolled urban growth can be seen in Mexico City which houses almost one-quarter of the country's population. Its 20 million inhabitants are exposed to extremely high levels of air and water pollution.

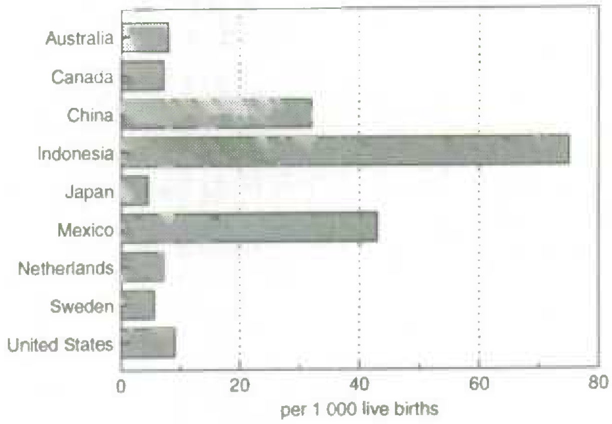
Figure 1.1.3
Life Expectancy, 1991



Source:
See Table 1.1.1 for sources.

As shown in figures 1.1.3 and 1.1.4., Canada's population has one of the highest life expectancies in the world (76.7 years) and one of the lowest levels of infant mortality (7 per 1000 live births). These levels are similar to those in Australia, Japan, the Netherlands, Sweden and the United States. Populations in the developing countries, China, Indonesia and Mexico, exhibit shorter life expectancies (60 to 69 years) and higher levels of infant mortality (32 to 75 per 1000 live births).

Figure 1.1.4
Infant Mortality Rate, 1991



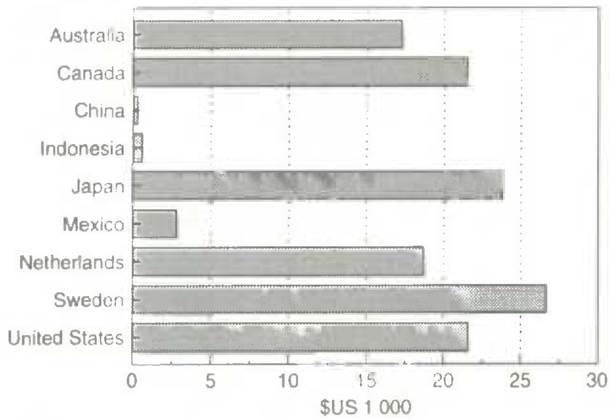
Source:
See Table 1.1.1 for sources.

Economy

Gross Domestic Product (GDP) is one measure of economic activity. It measures the value of goods and services produced by the domestic economy. GDP per capita is often taken as a measure of social welfare. However, it does not take into account the distribution of income within the population or to persons, businesses and governments in other countries. Better information on average income and income distribution is not available for most developing countries.

Figure 1.1.5 illustrates the wide differences in GDP per capita between the two groups of countries. GDP per capita, when converted to a common currency using market exchange rates, does not reflect the very different buying power of a dollar in various countries. In Indonesia, for example, US$10 000 per year provides a family with more goods and services than it would in Canada. The United Nations International Comparison Program (ICP) provides an adjusted GDP per capita figure which takes the purchasing power parity for each country into account. This adjustment tends to raise the estimates for poorer countries and slightly lower them for developed countries, except the United States, as shown in Figure 1.1.6.

Figure 1.1.5
GDP per capita, 1990



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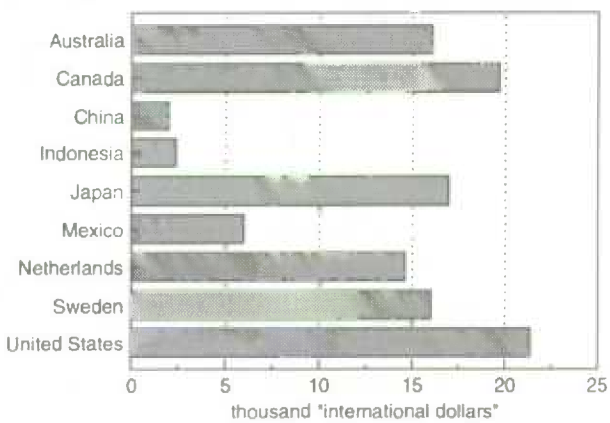
See Table 1.1.1 for sources.

Figure 1.1.6
GDP per capita, Adjusted for Purchasing Power, 1990

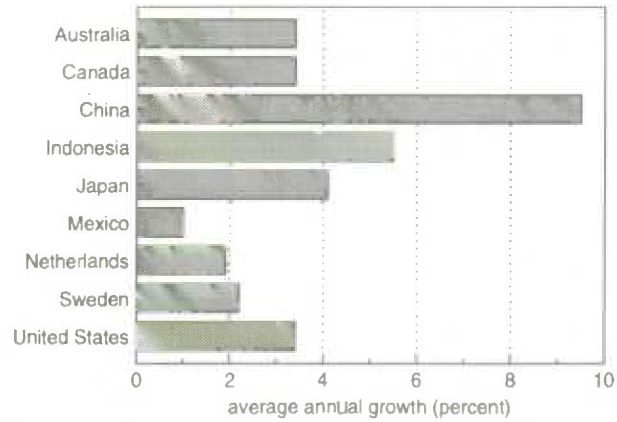


Source:
See Table 1.1.1 for sources.

Despite the global recession of 1990-92, the economies of developing countries such as China and Indonesia were growing at rates of 5 to 8 percent during this time.(Figure 1.1.7). The growth and change in structures of these economies can be seen in the differences in growth rates between the primary (agriculture, mining, forestry and fisheries), secondary (industry) and tertiary (commerce and services) sectors shown in Table 1.1.1. These reveal that the economies of the developing countries are not only growing but also changing dramatically from agricultural and resource-based towards more industrial economies.

The high rates of economic growth, especially in manufacturing, in the developing countries imply a rapid increase in the need for natural as well as human resources and a rise in the potential for pollution. The technology required to support this growth is often less efficient (in terms of labour, energy and waste generation) than the machines and processes used in developed countries.

Figure 1.1.7
GDP Growth, 1980-1990



Source:
See Table 1.1.1 for sources.

Wastes

The term wastes refers to residuals generated by industrial and household activities. This section focuses on available statistics on urban solid wastes, hazardous wastes and greenhouse gas emissions.

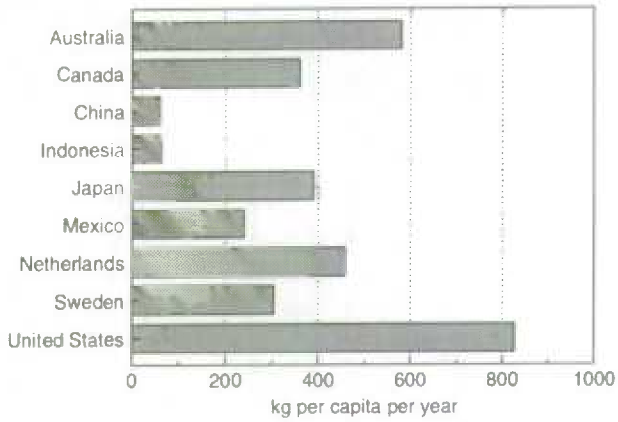
In Canada, about 360 kilograms of residential urban solid waste is generated per person per year (Figure 1.1.8). This is waste that must be collected and disposed of at municipal facilities. Much of the waste is made up of plastics, packaging and newspapers. In the developing countries, the amounts discarded are a fraction of this since, in general, less packaging is used and more items are recycled. Canada, Australia and the United States generate between 360 and 828 kilograms of urban solid waste per person per year. This ranks them within the top five per capita waste producers in the world together with France and New Zealand.[1]

Statistics on hazardous wastes are highly variable because of differing definitions between countries. The figure of 3.2 million tonnes of hazardous wastes generated each year in Canada in Table 1.1.1 refers to waste known to contain hazardous substances. Much of this waste is treated and is not released into the environment. Hazardous wastes per unit of production (as measured by GDP) provide a comparative measure of the waste intensity of industrial activities. In 1991, according to World Resources Institute estimates, Canada generated approximately 5 770 kilograms of hazardous waste for each million US$ of GDP. Japan generated only 226 kilograms per million US$. This remarkable difference can be attributed not only to higher efficiency and recycling in Japan but also to the differences in their economies: Canada has a much higher proportion of primary and secondary industries than does Japan. The United States and China showed even higher waste intensities

1. World Resources Institute, *The 1993 Information Please Environmental Almanac*, Houghton Mifflin Company, Boston and New York, 1993.

than Canada, 44 186 kilograms and 158 026 kilograms per million US$, respectively.

Figure 1.1.8
Urban Solid Waste Generation, 1991



Source:
See Table 1.1.1 for sources.

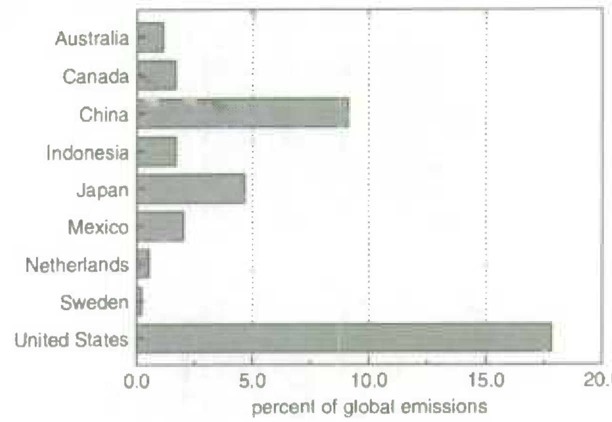
In 1991, Canada's generated less hazardous waste per unit of production than the United States, its generation of sulphur dioxide (SO_2) was twice as high on the same basis. Intensities of nitrogen oxides (NO_x) generation were similar between the two countries (Table 1.1.1).

It is suspected that the increasing concentration of greenhouse gases, in the atmosphere will contribute to an eventual warming of global temperatures. These gases include not only naturally occurring substances such as carbon dioxide and methane but also manufactured substances such as the industrial chemicals known as chlorofluorocarbons (CFCs). Major contributors to increasing greenhouse gas concentrations are fossil fuel combustion; the manufacture of cement; the decomposition of solid waste; animal emissions; wet rice agriculture; leakages from natural gas pipelines and emissions of CFCs.

Greenhouse gases have different capacities to absorb infrared radiation. Their combined effect can be expressed in CO_2 equivalents.[1]

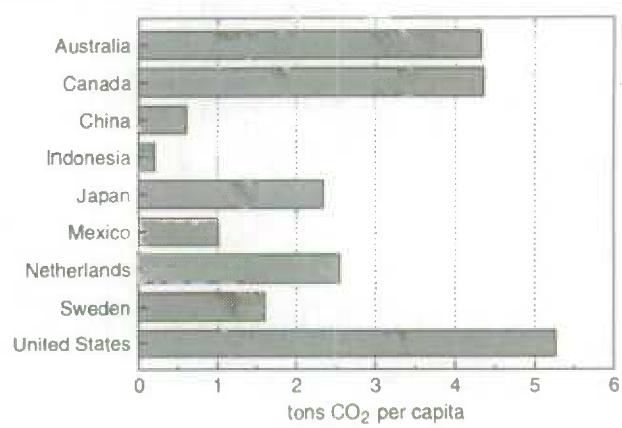
When greenhouse gases are shown in terms of absolute quantities emitted (Figure 1.1.9), the statistics largely reflect the size of the population and the economy. Emissions per capita (Figure 1.1.10), are a more useful indicator to compare greenhouse gas intensities for countries with different economic structures and populations. The World Resources Institute[2] has performed estimates of these emissions and has ranked the countries from worst to best. As shown in Table 1.1.1, the United States, Australia and Canada are among the worlds highest per capita greenhouse gas producers, ranking sixth, seventh, and eighth on this index due to high per capita fuel consumption and industrial activity. Countries with a higher level of emissions per capita (ranking first through fourth on the index) are generally the less-populated, oil-producing nations of the Middle East, where the major source is gas pipeline leakage.

Figure 1.1.9
Greenhouse Gas Emissions Global Share, 1991



Source:
See Table 1.1.1 for sources.

Figure 1.1.10
Greenhouse Gas Emissions, 1991



Source:
See Table 1.1.1 for sources.

Resources

Water

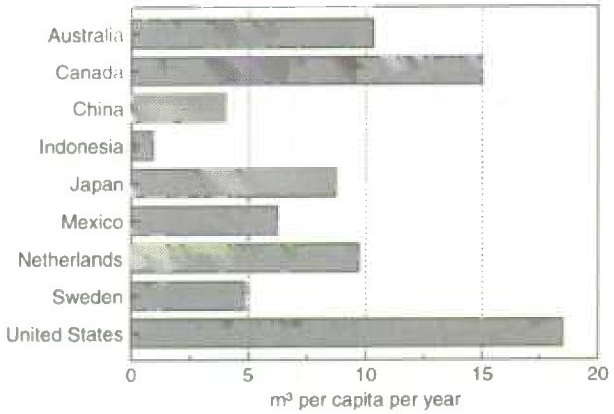
Although the supply of water seems inexhaustible, having this resource when and where it is required often imposes formidable challenges. In Canada, receding groundwater tables in some areas contribute to drought at some times of the year. After a winter of heavy snowfall, there is often a

1. The contributions of carbon dioxide (CO_2), chlorofluorocarbons (CFCs), and methane are combined according to their relative global warming potentials. The heating coefficient of one ton of methane is equivalent to 68.6 tons of CO_2. One ton of CFCs is equivalent to 6 414 tons of CO_2.
2. World Resources Institute, *The 1993 Information Please Environmental Almanac*, Houghton Mifflin Company, Boston and New York, 1993.

flooding problem. Drought and flooding are often magnified by the ways in which we use and control water and the land. Rainwater can be contained for use in times of drought by improved agricultural practices, watershed management and the construction of reservoirs and dams. These measures also reduce the risk of flooding.

Total water use includes all water withdrawn from the surface or groundwater for agricultural, industrial and municipal purposes. Per capita water consumption provides an indication of water use intensity for these activities.

Figure 1.1.11
Water Consumption, 1991



Source:
See Table 1.1.1 for sources.

Canada is using only a fraction of its renewable supply of fresh water but, relative to other countries, the use per capita (15 cubic metres per year) is among the highest in the world. Countries such as Japan and Sweden, as shown in Table 1.1.1 and Figure 1.1.11 are much less intensive in their consumption of water.

Developing countries such as China and Indonesia, have much less control over their water supplies than does Canada. Although reservoirs and dams have been built, their effectiveness is offset by extensive agriculture in upper watersheds. Natural water-retaining vegetation on steeply sloped mountain areas is often replaced with agricultural crops, leading to erosion and flooding.

The statistics on the proportion of land area irrigated in Table 1.1.1 provide an indication of the reliance on this water supply. In Canada, only 1.1 percent of agricultural area is irrigated. In Japan, 54.3 percent requires irrigation.

Metals

Metals are a finite resource which are essential to many industrial processes. The process of extracting metals from the earth often disturbs the natural land cover and creates waste. Although comparable figures on the absolute quantities of essential metals and their rates of production are not available, statistics on the relative proportion of the world's metals held in the countries considered in this section are available.

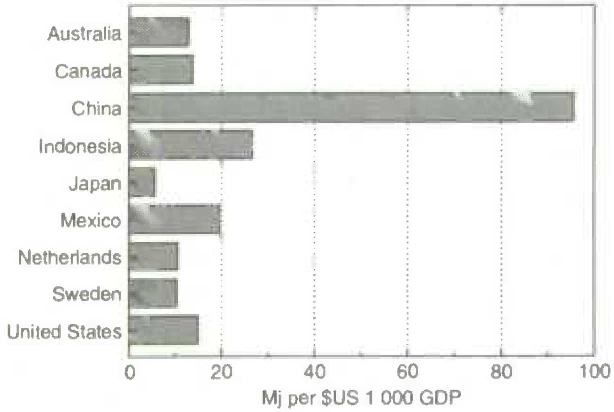
The Metal Reserve Index (Table 1.1.1) is the mean of a country's share of each of 15 of the globally important metals. The countries listed here hold about one-third of the world's important metals, with the United States (8.7 percent) and China (8.4 percent) having the largest share. Canada's share is 6.1 percent.

Energy

The energy intensity of a country's economy is an important indicator of both the resource requirements and the potential for pollution. For each thousand US$ of GDP in Canada, 20.9 megajoules (Mj) of energy were consumed in 1991 (Figure 1.1.12). This is equivalent to about 0.58 litres of gasoline.

Although the energy intensity of Canadian industry is decreasing,[1] it is currently almost four times that of Japan and double that of the Netherlands and Sweden. The energy production to consumption ratio shown in Table 1.1.1 indicates whether the country is a net exporter or a net importer of energy. Ratios above 1 (Australia, Canada, Indonesia and Mexico) indicate net exporters. The low ratios for Sweden and Japan show the dependence of these countries on foreign sources of energy. The ratio for China is close to 1 indicating that it is neutral in terms of net energy imports and exports.

Figure 1.1.12
Energy Intensity, 1991



Source:
See Table 1.1.1 for sources.

Land

The World Conservation Union has recommended that 10 percent of the area of each nation's land be given some de-

1. Statistics Canada, *Environmental Perspectives, 1993*, Catalogue No. 11-528E, Ottawa, 1993.

gree of protection from the impacts of human activities. Many countries have acknowledged the need to protect natural habitats and have set aside areas for scientific reserves, nature reserves, national and provincial parks, natural monuments, nature reserves, wildlife sanctuaries and protected landscapes. Limited protection status may still allow some degree of disturbance such as logging or residential development. The protection of designated areas, especially in developing countries, is limited by difficulties in enforcing the legislation.

About 9.8 percent of Canada's land area, or 90 million hectares, is protected by legislation. In the United States, legislation protects over 10 percent of the land area. Globally, the proportion of protected lands ranged from over 35 percent in Ecuador to under one percent in 50 countries.

Statistics on distribution and changes in land use shown in Table 1.1.1 provide an indication of the pressures on forests, cropland and pasture. **Cropland** refers to the area of temporary and permanent crops, gardens, temporary meadows and temporary fallow. **Permanent pasture** is the land used for five years or more for forage, including natural and cultivated crops. **Forest and woodland** includes natural or planted stands of trees as well as logged area that will be reforested in the near future. **Other lands** is the residual category, which may contain urban and residential areas, roads, uncultivated land, wetlands, mountains, deserts, tundra and glaciers.

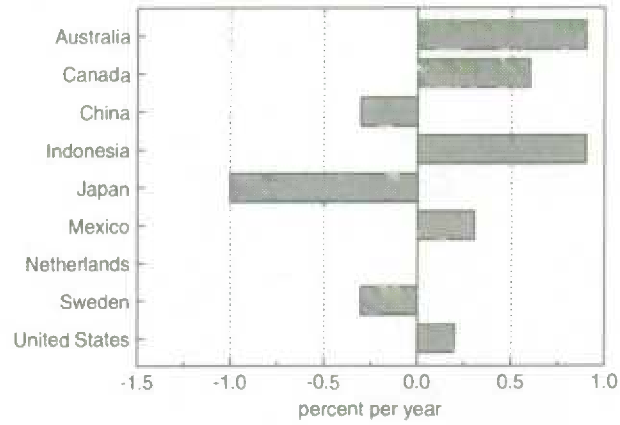
A **wilderness area** is defined by the World Resources Institute [1] as an area of at least 4 000 square kilometres showing no evidence of human development. This figure includes mountains, deserts, tundra, forests and glaciers. In Canada, this accounts for almost 70 percent of the total land area, much of it in tundra and permafrost.

Five percent of Canada's land area is used as cropland and the extent of this area has been increasing at an average rate of 0.6 percent per year over the past 15 years (Figure 1.1.13). The area of cropland is also increasing in Australia, Indonesia, Mexico and the United States. For Canada, this has been due to the conversion of pastures and other cultivated land. Other countries, such as Indonesia, increase their cropland by converting forests and growing crops on less fertile, hilly terrain. China, Japan and Sweden have experienced a net loss in cropland as a result of conversion to urban and residential uses.

Soils have a limited quantity of nutrients to support the growth of vegetation. When the vegetation is returned to the soil, as in a natural ecosystem, the nutrients are recycled. If the vegetation is removed, as in agriculture, the nutrients are also taken away. The intensity of fertilizer application shows the degree to which the natural nutrients in the soil need to be supplemented by chemical fertilizers to support the growth of crops. Nitrogen fertilizers are often washed from the soil and end up in the water systems, contributing to eutrophication. According to the World Resources Institute,[2] runoff of nutrients from fertilizers is a major contributor to water quality problems in the Netherlands and Japan.

Figure 1.1.13

Cropland Area Change, 1965-1989

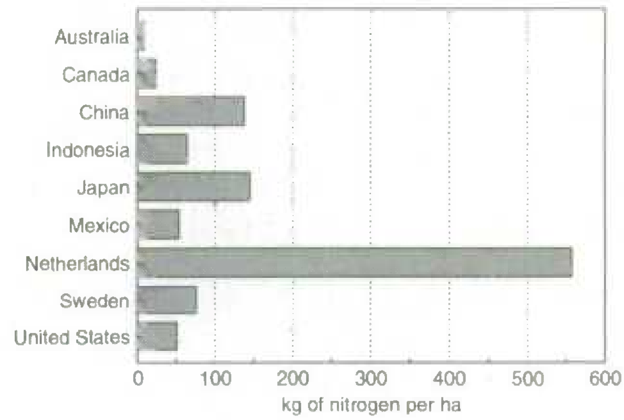


Source:
See Table 1.1.1 for sources.

Canada applies, on average, 24 kilograms of nitrogen to each hectare of arable land.[3] Although this is high when compared with Australia, it is relatively low in comparison to other countries (Figure 1.1.14).

Figure 1.1.14

Fertilizer Application, 1991

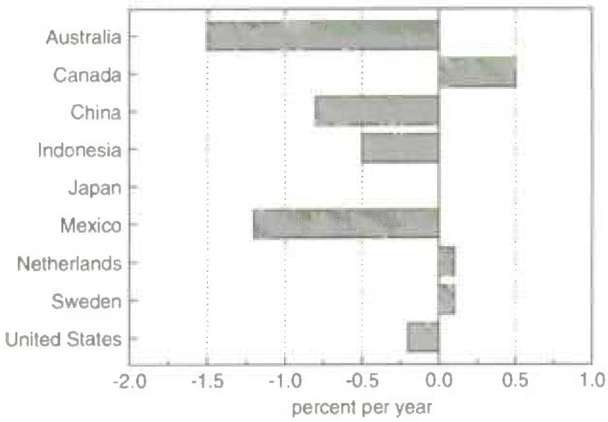


Source:
See Table 1.1.1 for sources.

Developed countries have been reducing the intensity with which they use fertilizer.[4] In developing countries, though, "annual consumption of nitrogen fertilizer has tripled since 1975, and between 1989 and 1994 is expected to grow by a further 25 percent."[5]

1. World Resources Institute, *The 1993 Information Please Environmental Almanac*, Houghton Mifflin Company, Boston and New York, 1993.
2. Ibid.
3. Statistics Canada, National Accounts and Environment Division - Estimate.
4. Conway, Gordon R. and Jules N. Pretty, *Unwelcome Harvest*, Earthscan Publications Limited, London, England, 1991.
5. Ibid.

Figure 1.1.15
Forest Area Change, 1965-1989



Source:
See Table 1.1.1 for sources.

The decreases in forest area in Australia (1.5 percent per year), China (0.8 percent per year), Indonesia (0.5 percent per year) and Mexico (1.2 percent per year) indicate a high degree of deforestation occurring in these countries (Figure 1.1.15). The losses of these forest areas can be attributed to both forestry activities and the expansion of agricultural lands. Note that the forest area of Canada, the Netherlands and Sweden has increased marginally over the period 1965-89 due to reforestation.

Wildlife

Species protection status (vulnerable, threatened, endangered, extirpated) is assigned to a species after appropriate research and reporting has been completed. As such, figures on numbers of threatened species are, at best, only indirect measures of the condition of wildlife. In Canada 4 species of mammals, 8 bird species and 22 plant species are classified as threatened. The low number of plant species in this category is likely due to the fact that only 12 percent of candidate plant species have been assessed. Most other countries show a higher number of threatened species (Table 1.1.1). As many as 50 species of mammals and 135 species of birds in Indonesia are classified as threatened. Australia and the United States report over 2 000 species of threatened plants.

Environmental Quality

Economic growth and structural changes from resource-based to industrial economies afford developing countries a unique opportunity to benefit from the experience of the more developed countries. Indonesia, for example, has passed environmental legislation and regulations that are comparable with standards set in Canada or the United States. However, in a developing country, these standards are difficult to implement and enforce. Many industries have neither the technology nor the knowledge to reduce their levels of pollution and governments rarely have the human and financial resources to monitor compliance with the regulations.

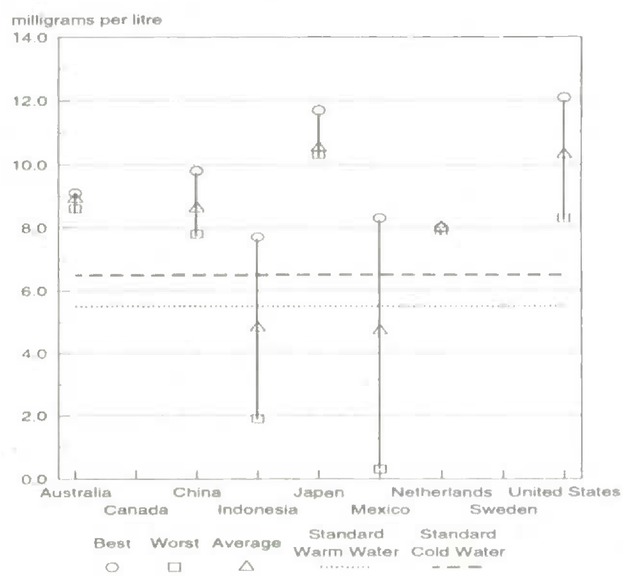
Water Quality

The figures in this section provide the results of long-term monitoring of the water quality of several rivers in each country. The two indicators chosen provide an overview of the quality of these rivers.

The concentration of dissolved oxygen (Figure 1.1.16 and Table 1.1.2) is the amount of oxygen available to plants and animals living in the water. High concentrations indicate that more oxygen is available and therefore, the water will support a greater variety and population of plant and animal species. Micro flora and fauna, organic materials and chemicals require oxygen for decomposition and reduce concentrations of dissolved oxygen. Values should exceed 5.5 milligrams per litre for life, growth and reproduction in warm-water habitats, and 6.5 milligrams per litre in cold-water habitats.

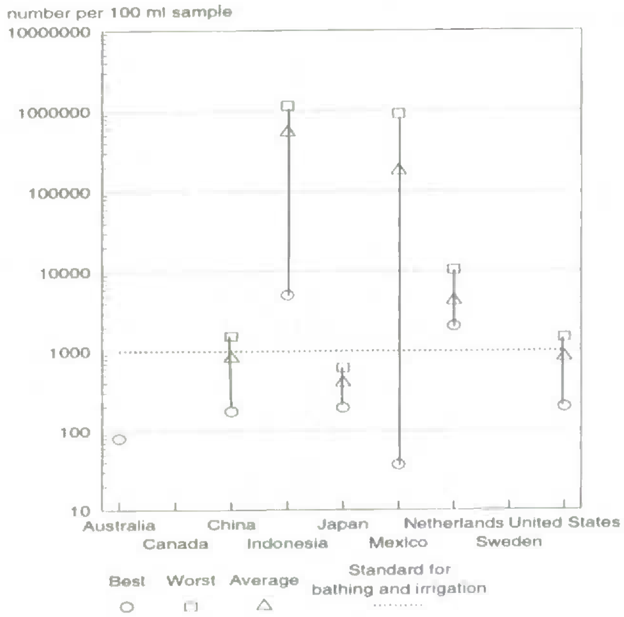
Some of the lowest concentrations of dissolved oxygen in these examples are for rivers in Mexico and Indonesia, some of which have almost no oxygen remaining such as the Citarum in Indonesia with 1.9 mg/l and the Lerma in Mexico with only 0.5 mg/l. Statistics on the average annual growth rate for the series on dissolved oxygen shown in Table 1.1.2 indicate the rate and direction of change.

Figure 1.1.16
Water Quality: Dissolved Oxygen, Annual Mean Concentrations, 1987-1990



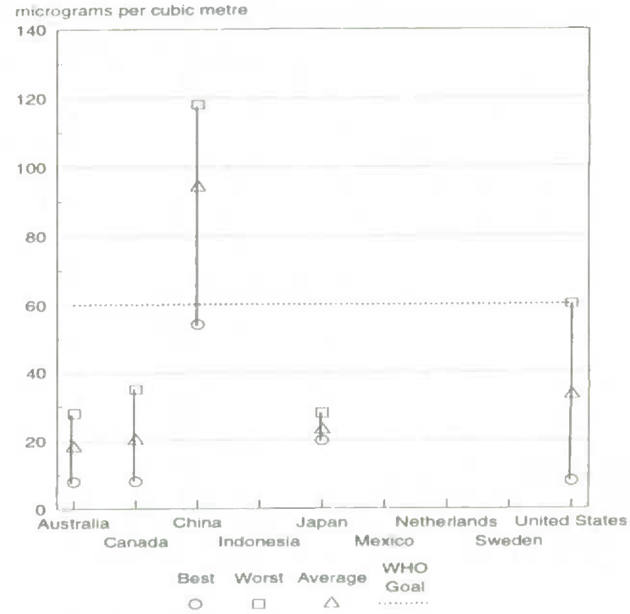
Source:
See Table 1.1.2 for sources.

Figure 1.1.17
Water Quality: Fecal Coliform, Annual Mean Concentrations, 1987-1990



Source:
See Table 1.1.2 for sources.

Figure 1.1.18
Air Quality: Sulphur Dioxide, Annual Mean Concentrations, 1987-1990



Source:
See Table 1.1.3 for sources.

The concentration of dissolved oxygen is generally increasing for many rivers in the developed countries, rivers in Indonesia, Mexico and the Netherlands show a consistent decrease over the four years reported here.

Fecal coliform is a bacterium that exists in high concentrations in human and animal feces. When untreated sewage is released into open water, the coliform reproduce. Although usually harmless to humans, fecal coliform indicate the presence of sewage and therefore other microorganisms that may be harmful. Water for human consumption should contain no fecal coliform. Bathing water and water for irrigation should contain less than 1 000 per 100 millilitre sample.

The detailed statistics in table 1.1.2 are summarized in figure 1.1.17. None of the rivers monitored would be a suitable source of drinking water although the Murray River in Australia and Colorado River in Mexico appear to be quite healthy in relation to the others. On the other hand, some of the rivers in Indonesia and Mexico show coliform counts of over 100 000 due to large quantities of raw sewage.

Air Quality

The statistics in this section (Table 1.1.3) present an overview of urban and national air quality in terms of two indicators: concentrations of SO_2 and suspended particulate matter (SPM). These indicators are not exhaustive assessment of the air quality in the cities represented but are useful as indicators of typical urban air quality problems.

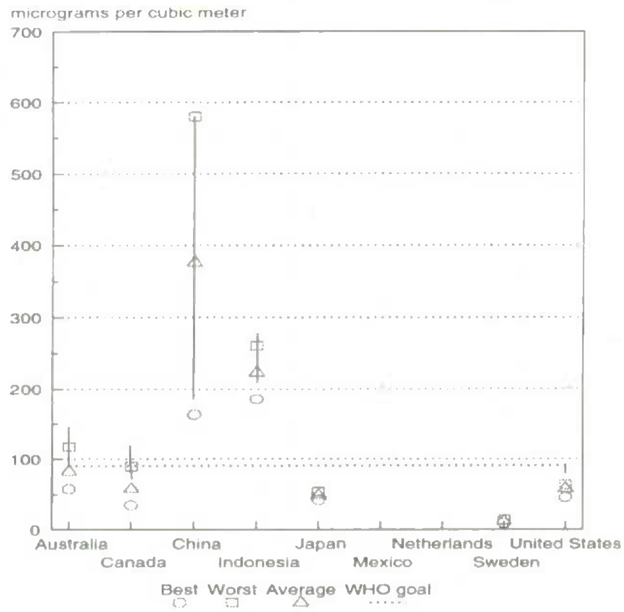
According to the World Health Organisation (WHO) guidelines, the annual average concentrations of SO_2 should not exceed 60 micrograms per cubic metre and annual averages of SPM should not exceed 90 micrograms per cubic metre.

The statistics for SO_2 (Figure 1.1.18) show marked differences between cities in China and those in the more industrialized Japan. Air pollution control is a major concern in Japan and its effectiveness is demonstrated by the relatively low levels of pollutants and the general downward trend of the concentrations.

Similarly, for SPM, cities in China and Indonesia show concentrations much higher than the WHO standard whereas cities in Canada, Japan, Sweden and the United States are generally lower than the guidelines and concentrations are decreasing. Figure 1.1.19 provides a summary of annual averages for selected cities in these countries.

Figure 1.1.19

Air Quality: Suspended Particulate Matter, Annual Mean Concentrations, 1987-1990



Source:
See Table 1.1.3 for sources.

Summary

Environmental problems vary greatly between countries, most evidently between developed and developing nations. In Canada, Australia, Europe and the United States, many aspects of the environment are improving as we find more efficient technologies. In many developing countries, the imposition of environmental constraints is seen as a hindrance to economic development and, therefore, their ability to improve their quality of life. The level of international co-operation in the solution of environmental problems is increasing and our level of understanding of these issues is also improving. What remains is the implementation of the strategies which can improve or sustain the quality of life for humans without degrading the quality of the environment for future generations.

Statistical Issues

Compiling comparative statistics between countries is never a straightforward process. Definitions, assumptions, time frames and methods of data collection vary immensely between countries and over time. Most countries adhere to the same overall standards for economic, social and demographic data as provided in UN guidelines.[1] Beyond these broad guidelines, though, most statistical activities have been adapted to local conditions so that, although two measures may have the same name, they may have different interpretations. For example, Total Labour Force may in one case be measured using a household sample survey and be defined as "persons working or looking for work within the past week". In another case Total Labour Force may be measured using administrative statistics such as employees plus those applying at the employment office.

Environmental statistics such as water quality and wildlife conditions are even less standardized between countries. Although the OECD, the United Nations Environment Programme (UNEP), the World Bank and the World Resources Institute strive to harmonize the data they compile for their comparative publications, most of the statistics are still not fully comparable.

1. United Nations, *Concepts and Methods of Environment Statistics: Statistics of the Environment, A Technical Report*, United Nations, New York, 1991.

Table 1.1.1

International Summary Statistics, Selected Countries, 1991

		Selected Countries								
Characteristics	Source	Australia	Canada	China	Indonesia	Japan	Mexico	Netherlands	Sweden	United States
Total Area (thousand km²)	n	7 687	9 971	9 561	1 905	378	1 958	37	450	9 373
Land Area (thousand km²)	n	7 618	9 216	9 326	1 812	377	1 909	34	412	9 167
Population (thousands)	n	17 340	28 118	1 158 230	187 760	123 920	87 840	15 060	8 640	252 690
Population growth rate 1981-1991 (%)	r,s	1.37	1.22	1.45	1.93	0.43	2.02	0.63	0.22	0.81
Population density (persons per km²)		2.3	3.1	124.2	103.6	329.1	46.0	444.0	21.0	27.6
Percent urban	q	85.5	76.2	21.4	28.8	76.9	72.6	88.5	83.9	74.1
Life expectancy (years)	r	76.1	76.7	69.4	60.2	78.3	68.9	76.9	77.1	75.5
Infant mortality (per 1000 live births)	m	8.0	7.2	32.0	75.0	4.5	43.0	7.1	5.6	9.1
Literacy rate[1] (%)	m,s	99.0	99.0	73.3	77.0	99.0	87.3	99.0	99.0	99.0
Expenditures on education (% of GNP)	m	5.0	6.5	2.2	0.8	4.7	2.7	6.2	6.7	6.2
Economy										
GDP 1990 (million $US)	m	294 639	570 137	301 660	107 294	2 940 360	241 386	279 153	228 110	5 392 200
Average annual GDP growth 1980-90[2,3] (% per year)	p	3.4	3.4	9.5	5.5	4.1	1.0	1.9	2.2	3.4
Agriculture (%)	p	3.2	0.2	6.1	3.2	1.3	0.4	3.6	1.1	3.7
Industry (%)	p	3.2	3.2	12.5	5.6	4.5	1.0	2.0	2.8	2.5
Services, etc. (%)	p	3.7	3.5	9.1	6.7	3.8	1.1	1.8	1.4	3.2
GDP per capita 1990 ($US)	m	17 244	21 497	265	598	23 801	2 802	18 681	26 651	21 571
ICP[4] estimates of GDP per capita, 1990	p	16 050	19 650	1 950	2 350	16 950	5 980	14 600	16 000	21 360
GDP distribution by sector[2,3,5]										
Agriculture (%)	p	4	3	27	22	3	9	4	3	2
Industry (%)	p	31	31	42	40	42	30	31	35	29
Services, etc. (%)	p	65	66	31	38	55	61	65	62	69
Exports 1990 (million $US)	m	39 628	127 419	62 091	25 675	286 949	26 524	131 839	57 415	393 592
as a proportion of GDP	m	13.4	22.3	20.6	23.9	9.8	11.0	47.2	25.2	7.3
Motor vehicles per 1000 persons	i,r	500	457	5	6	265	71	362	421	573
Wastes										
Urban solid waste (kg per capita)	j,r,s	581	360	60	62	389	240	458	304	826
Hazardous wastes[6] (kg per US$ million GDP)	f,r	1 018	5 769	158 026	42 276	226	..	5 372	2 191	44 186
SO_x emissions[6] (tons per US$ million GDP)	f,r	506	6 495	49 659	14 950	429	..	1 039	964	3 838
NO_x emissions[6] (tons per US$ million GDP)	f,r	1 469	3 407	..	6 804	476	..	2 023	1 319	3 671
CO_2 Emissions[7] (tC/capita)	m	4.32	4.35	0.61	0.21	2.34	1.01	2.54	1.60	5.26
Greenhouse gas emissions (global per capita rank[8])	r	7	8	111	105	29	62	35	55	6
Global share (%)	r	1.13	1.68	9.12	1.69	4.66	2.01	0.52	0.22	17.81
Resources										
Water										
Renewable supply (km³)	r	347.2	2 905.0	2 803.6	2 533.6	548.0	358.1	10.0	176.1	2 481.4
per capita (m³)	r	200.2	1 033.2	24.2	134.9	44.2	40.8	6.7	203.8	98.2
Total use (km³)	r	17.9	42.2	460.7	16.7	108.1	54.3	14.6	4.2	467.8
per capita (m³)	r	10.3	15.0	4.0	0.9	8.7	6.2	9.7	4.8	18.5
Irrigation, share of agricultural area (percent)	o	0.4	1.1	10.8	22.8	54.3	5.2	27.5	3.3	4.2
Water withdrawal (% of supply used)	m	5.2	1.5	16.4	0.7	19.7	15.2	145.8	2.4	18.9
Minerals										
Metal reserve index (world=100%)	r	7.6	6.1	8.4	1.5	0.4	1.0	..	0.3	8.7
Forest Products										
Roundwood production (million m³)[9]	m	20.3	155.5	277.0	171.5	29.8	22.2	1.4	55.9	501.0
Fish										
Fish Catches - all areas (thousand tonnes)	m	210.4	1 624.3	12 095.4	3 080.5	10 353.6	1 401.0	438.3	260.1	5 856.0
Energy										
Energy production: total (Pj)	r	5 601.4	11 789.0	28 483.0	4 063.4	1 375.5	7 335.1	2 440.2	496.8	60 188.4
Energy production: per capita (Mj)	r	323.0	419.3	24.6	21.6	11.1	83.5	162.0	57.5	238.2
Energy consumption: total (Pj)	r	3 769.7	7 764.3	28 805.2	2 851.8	16 571.8	4 720.3	2 957.3	2 363.3	80 559.1
Energy consumption: per capita (Mj)	r	217.4	276.1	24.9	15.2	133.7	53.7	196.4	273.5	318.8
Energy consumption: per $US GDP (Mj)	r	12.8	13.6	95.5	26.6	5.6	19.6	10.6	10.4	14.9
Energy production/consumption (ratio)	r	1.5	1.5	1.0	1.4	0.1	1.6	0.8	0.2	0.7
Land										
Protected areas (percent of total)	m	6.1	9.8	3.0	10.0	12.7	5.1	8.6	6.5	10.5
Land use										
Cropland (thousand km²)	r	490	460	962	213	46	247	9	29	1 901
Permanent pasture (thousand km²)	r	4 183	330	3 193	118	6	746	11	6	2 417
Forest and woodland (thousand km²)	m	1 060	3 590	1 265	1 134	251	425	3	280	2 936
Other (thousand km²)	r	1 885	4 836	3 906	346	73	491	11	97	1 913
Wilderness[10] (thousand km²)	r	2 296	6 411	2 109	118	-	31	-	23	441
Land use										
Cropland (% of land area)	r	6.4	5.0	10.3	11.7	12.3	13.0	27.6	6.9	20.7
Permanent pasture (% of land area)	r	54.9	3.6	34.2	6.5	1.7	-39.1	31.6	1.4	26.4
Forest and woodland (% of land area)	r	13.9	39.0	13.6	62.6	66.7	22.2	8.8	68.1	32.0
Other (% of land area)	r	24.7	52.5	41.9	19.1	19.3	25.7	32.0	23.6	20.9
Wilderness[10] (% of land area)	r	30.1	69.6	22.6	6.5	-	1.6	-	5.6	4.8
Average annual change 1965-1989										
Cropland (%)	o	0.9	0.6	-0.3	0.9	-1.0	0.3	--	-0.3	0.2
Permanent pasture (%)	o	-0.2	2.1	--	-0.3	6.0	--	-0.9	-0.8	-0.2
Forest and woodland (%)	o	-1.5	0.5	-0.8	-0.5	--	-1.2	0.1	0.1	-0.2

Table 1.1.1

International Summary Statistics, Selected Countries, 1991 (Continued)

Characteristics	Source	Australia	Canada	China	Indonesia	Japan	Mexico	Nether-lands	Sweden	United States
		Selected Countries								
Other (%)	o	1.4	-0.5	0.4	1.3	0.5	1.2	1.4	..	0.5
Nitrogen fertilizers (kg N/ha arable land)	d,k,o	8	24	138	64	145	54	557	76	51
Wildlife	0									
Threatened species: Mammals	c,r	35	4	30	50	5	26	2	1	21
Birds	c,r	39	8	83	135	31	35	13	14	43
Plants	c,r	2 133	22	841	..	687	111	7	9	2 476

Notes:

1. Adult literacy is only regularly monitored in developing countries. For industrial countries where the adult literacy rate is near 100%, values of 99% are substituted.
2. Agriculture refers to agriculture, forestry, fishing and hunting. Industry includes mining, manufacturing, construction, and electricity, water and gas. Services includes all other unallocated items including imputed bank service charges, import duties and any statistical discrepancies.
3. Figures for the US are based on 1987 data. Figures for Canada from Statistics Canada, Input-Output Division.
4. The International Comparisons Program of the United Nations calculates GDP per capita in terms of the "international dollar" which reflects the differing purchasing power of currencies in the respective countries.
5. Figures for Australia refer to 1988. Figures for Mexico are for 1990.
6. Figures for Australia estimated from Australian Bureau of Statistics, 1992.
7. Figures refer to 1989 unless otherwise noted. US - 1985, Indonesia - 1988, Japan - 1988, Netherlands - 1988, Australia - 1987.
8. Where number one is the highest per capita producer of greenhouse gases.
9. Figures refer to 1990.
10. Wilderness is not mutually exclusive from the other land use categories and therefore the land area should not be compared with the other categories.

Sources:

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n. United Nations, *Monthly Bulletin of Statistics*, UN Statistical Division, New York, 1992. and Statistics Canada.
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q. World Resources Institute, *World Resources 1990-91*, Basic Books Inc., New York, 1991.
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Table 1.1.2

Water Quality Indicators, Selected Countries, 1991

Selected countries	Source	River/City	Dissolved oxygen: Annual mean concentration (1987-90)	Dissolved oxygen: Average annual growth rate	Fecal coliform: Annual mean concentration (1987-90)	Fecal coliform: Average annual growth rate
			milligrams per litre	percent	number per 100 ml sample	percent
Australia	o	Murray	9.1	1.0	..	..
	o	Murray, Mannum	8.6	2.4	80	15.8
Canada	t	St. Lawrence (Richelieu)	3.2	..	158	..
	t	St. Lawrence (Etchemin)	5.8	..	220	..
	t	St. Lawrence (Des Praries)	5.7	..	490	..
	t	St. Lawrence (Saint Charles)	3.8	..	4 000	..
China	o	Pearl, Hong Kong	7.8	0.4	174	-14.4
	o	Yangtze, Shanghai	8.2	-0.1	731	10.6
	o	Yellow, Beijing	9.8	-0.1	1 539	9.8
Indonesia	f	Sunter, Jakarta	..	..	865 789	..
	f	Surabaya	..	..	637 567	..
	f	Barito, South Kalimantan	..	..	5 130	..
	b[2]	Citarum, Nanjung	1.9	-45.8	1 160 000	-45.3
	b[2]	Citarum, W. Saguling	7.7	-27.0	22 000	-53.3
Japan	o	Kiso, Asahi	11.7	1.7	216	-4.1
	o	Kiso, Inuyama	10.8	-0.2	600	-2.0
	o	Kiso, Shimo-Ochiai	11.4	0.3	353	-6.0
	o	Shinano, Zuiun Bridge	10.3	0.2	193	-3.0
	o	Tone, Tone-Ozeki	10.4	0.5	618	3.7
	o	Yodo, Hirakata Bridge	6.4	-0.4	..	9.3
Mexico	o	Atoyac	0.3	-47.5	916 667	23.9
	o	Balsas	6.8	-1.9	130 000	95.4
	o	Blanco	4.1	-3.7	12 150	1.8
	o	Colorado	8.2	1.4	37	-28.7
	o	Lerma	0.5	-18.6	67	5.7
	o[1]	Panuco	8.3	0.7	201	-27.8
Netherlands	o[1]	Ijssel	7.9	-3.3	2 050	-43.0
	o[1]	Rhine (German frontier)	8.0	-2.6	10 500	-11.8

Table 1.1.2

Water Quality Indicators, Selected Countries, 1991 (Continued)

Selected countries	Source	River/City	Dissolved oxygen: Annual mean concentration (1987-90)	Dissolved oxygen: Average annual growth rate	Fecal coliform: Annual mean concentration (1987-90)	Fecal coliform: Average annual growth rate
			milligrams per litre	percent	number per 100 ml sample	percent
Sweden			..	..	..	..
			..	..	..	..
United States	o[1]	Delaware, Trenton, N.J.	10.6	-2.5	197	-4.0
	o[1]	Hudson, Green Island, N.Y.	12.1	4.2	792	-7.4
	o[1]	Mississippi, Vicksburg, Miss.	8.3	-0.2	1 473	40.2

Notes:
The World Health Organization (WHO) standards for dissolved oxygen are 5.5 milligrams per litre or better in warm-water habitats and 6.5 milligrams per liter or better in cold-water habitats. Water for human consumption should contain zero fecal coliform per 100 millilitre sample, and bathing water and water used for irrigation should contain less than 1 000 per 100 millilitre sample.
1. Figures are for 1983-86.
2. Figures are for 1989-90.
Sources:
See Table 1.1.1 for sources.

Table 1.1.3

Air Quality Indicators, Selected Countries, 1991

Selected countries	Source	City	Site code[1]	Sulfur dioxide: Annual mean concentration (1987-90)	Sulfur dioxide: Average annual growth rate	Suspended particulate matter: Annual mean concentration (1987-90)	Suspended particulate matter: Average annual growth rate
				micrograms per cubic meter	percent	micrograms per cubic meter	percent
Australia	m,o	Melbourne	CCC	8	-14.3	58	-4.5
	a,m,o[2]	Sydney	CCC	28	-10.9	118	2.2
	a,m,o[2]	Sydney	SI	17	-7.3	69	-8.5
Canada	g,h		National	15	..	49	-4.5
	h,l,o	Hamilton	CCC	27	..	89	-2.8
	m,o	Hamilton	SR	35	-4.4	..	-1.9
	m	Montreal	CCC	24	-11.0	61	-1.8
	m,o	Montreal	SR	18	0.7	35	-8.3
	m	Toronto	CCC	14	4.0	61	-0.5
	m,l	Toronto	SR	8	-16.1	57	-2.2
	m,h	Vancouver	CCC	15	-7.0	42	-4.5
	m	Vancouver	CCR	..	-2.7	..	-5.2
China	m	Beijing	CCC	107	3.5	413	-2.7
	m	Beijing	CCR	115	-1.3	370	-1.6
	m	Guangzhou	CCC	54	-9.0	163	-6.1
	m	Guangzhou	CCR	95	7.7	234	7.4
	m	Shanghai	CCC	69	2.5	253	2.5
	m	Shanghai	CCR	104	9.2	290	3.8
	m	Shenyang	CCC	118	2.5	435	0.3
	m	Shenyang	CCR	88	1.8	465	-0.4
	m	Xian	CCC	95	-4.7	555	5.7
	m	Xian	CCR	100	-1.4	580	6.7
Indonesia	m,f	Jakarta	CCC	..	37.5	260	2.2
	m	Jakarta	SI	..	..	185	3.5
Japan	m	Osaka	CCC	28	-8.4	42	-6.3
	m	Osaka	SR	24	-8.0	54	-4.1
	m[2]	Tokyo	CCC	20	-8.9	50	-4.9
	m[2]	Tokyo	SR	20	-5.7	51	-4.5
Mexico				..	..	..	..
Netherlands	m[2]	Amsterdam	CCC	24	-6.7	..	..
	m[2]	Amsterdam	SR	29	-1.8	..	..
Sweden	g[3]	Goteborg		..	..	9	-1.6
	g[3]	Stockholm		..	..	14	4.5
United States	g		National	..	..	53	-2.9
	o[2]	Houston	CCC	..	..	62	-7.3
	o[2]	Houston	SR	8	-32.0	64	-6.3
	o[2]	New York City	CCR	60	-5.8	61	-2.2
	o[2]	New York City	SR	31	-5.9	46	-2.7

Notes:
The WHO goal for SO_2 is 60 micrograms per m^3.
The USEPA Standard for particulates is 260 micrograms per m^3; World Health Organization standard is 90 microgram/m^3.
1. Type of site codes: CCC (city centre commercial), CCI (City Centre Industrial), CCR (City Centre Residential), SI (Suburban Industrial), SC (Suburban Commercial), SR (Suburban Residential).
2. Figures refer to 1983-86.
3. Figures refer to 1980-88.
Sources:
See Table 1.1.1 for sources.

1.2 Provincial Summary Statistics

This section provides a broad overview of the economic, social and environmental conditions of Canada's provinces and territories. Although the focus of much of this book is on environmental geographies (such as drainage basins and ecozones), policy decisions are often made on a provincial basis. Furthermore, statistics are more generally available by province than for other geographic aggregations.

Much of the information presented in this section appears in more detail in the rest of the book.

Table 1.2.2 at the end of this section, shows a picture of the conditions in 1991. In some cases data for 1991 are not available due to collection constraints (for example, the Statistics Canada Pollution Abatement and Control Expenditure Survey referred to expenditures for the year 1989).

Background[1]

Canada is a confederation of ten provinces and two territories which range in land area from Prince Edward Island's 5 660 square kilometres to the Northwest Territories' 3.4 million square kilometres—a factor of over 600. This fact is typical of the diversity of the populations, economies and biophysical environments of Canada's provinces and territories. Due to this broad diversity environmental issues vary greatly between regions.

Only about 10 percent of Canada is permanently settled, and only Prince Edward Island is completely occupied. Large parts of the interior of Nova Scotia, New Brunswick and the Gaspé Peninsula are unpopulated. Around the Newfoundland coast and on the shores of the St. Lawrence River below Québec City, settlement occurs only in narrow bands.

Sixty eight percent of the country's population live within 100 kilometres of the Canada-United States border.[2] Nearly 40 percent of the population lives in the 9 metropolitan areas of the Québec-Windsor corridor: Québec, Montréal, Ottawa-Hull, Toronto, Hamilton, London, St. Catharines-Niagara, Windsor and Kitchener.

Canada's largest tract of continuous settlement winds through Manitoba, Saskatchewan and Alberta, occupying over 6 percent of Canada's area and boasting five major cities: Edmonton, Calgary, Winnipeg, Saskatoon and Regina. North of this mainly agricultural block, astride the Alberta-British Columbia border, is the Peace River district, an agricultural area stretching to the 57th parallel.

The southern half of British Columbia is settled in interconnecting strips in valleys between the mountain ranges. Population is dense in the lower mainland around Vancouver.

A number of remote settlements lie in the North, the largest of which are in Ontario and Quebec between the 47th and 50th parallels in the Clay Belt-Abitibi area. Outside these urban-rural blocks are smaller settlements based on mining, forest industries, transportation, administration, defence, hunting and fishing.

Newfoundland- Canada's newest and most easterly province joined Confederation in 1949. The island of Newfoundland is covered by forested hills and low mountains typical of the Boreal Shield ecozone,[3] and the land is dotted with innumerable ponds and swamps. Its rugged, rocky coastline is sprinkled with coves and isolated fishing villages.

Labrador is part of the mainland and extends 750 kilometres inland from the North Atlantic coast. The south of Labrador, in the Boreal Shield ecozone as well, is thickly forested. Towards the north, the land rises to barren mountain peaks of over 1 600 meters through the Taiga Shield, Southern Arctic and Northern Arctic ecozones.

Newfoundland's economy, once dependent upon fishing, now focuses on extracting and processing natural resources. Iron ore is the dominant commodity, followed by zinc and asbestos. Food processing and the paper industries are the main manufacturing sectors. The main economic and environmental issue is the decline of the fisheries over the past three years. This has led to substantial unemployment in the fishery and food processing sectors. For details on the state of the fisheries, see Section 4.14 - **Fish and Wildlife Harvests**.

Prince Edward Island- Canada's smallest province has a gently rolling landscape of the Atlantic Maritime ecozone, peaking at only 140 metres above sea level. The island is largely farmland with sandy beaches. The availability and quality of groundwater and soil erosion are prominent areas of concern.

Agriculture is the economic mainstay of the island: potato and mixed grain fields cover 45 percent of its area. Dairy farming and livestock are also important activities.

Nova Scotia- Nova Scotia is a peninsula connected to the rest of the country by the Isthmus of Chignecto, a strip of land only 20 kilometres wide. No part of the province is more than 50 kilometres from the sea. Its northern area is a wooded upland while the mainland is mostly flat. The entire province is part of the Atlantic Maritime ecozone.

Nova Scotia's fishery is the largest in the North Atlantic. The principal species are lobster, cod, scallop and haddock.

1. Summarized from - Statistics Canada, *Canada Yearbook 1994*, Catalogue No. 11-402, Ottawa, 1994.
2. Statistics Canada, National Accounts and Environment Division.

3. See Section 1.4 - **Geographic Units for Environmental Analysis** for maps of Canada's ecozones and political boundaries, as well as a description of the biophysical characteristics of Canada's ecozones.

About 8 percent of the land is agricultural, mostly in the Annapolis Valley and northern Nova Scotia. These areas are important for fruit, particularly apples, and for dairy farming. Coal is the province's principal mineral, but gypsum and salt mining also take place. Nova Scotia has a larger and more diverse manufacturing sector than the other Maritime provinces. It includes food processing, rubber and plastics, paper and wood products and transportation equipment.

Due to the province's concentrations of population and manufacturing activities, water pollution has become a major environmental concern near urban areas.

New Brunswick- New Brunswick, also entirely within the Atlantic Maritime ecozone, rises from the sea to a plateau several hundred metres high. Prolific forest growth covers a large portion of the province. While much of New Brunswick's soil is rocky and unsuitable for agriculture, the Saint John River Valley is very fertile. The upper sections of this valley produce potatoes while the lower areas are important for dairy and beef cattle, poultry, pork and vegetables. Food processing, and the paper and wood industries are the major manufacturing activities. Zinc, potash and lead are the principal minerals. The province's fisheries are dependent on lobster and crab.

A majority of the population is reliant on groundwater and the supply and quality of this source of water is one of the major environmental concerns.

Quebec- Quebec is Canada's largest province, covering over 1.5 million square kilometres. It ranges from the Boreal Shield ecozone in the central region through the Taiga Shield, Southern Arctic and Northern Arctic ecozones in the north. Quebec is dotted with hundreds of lakes, woods and tumbling plateaus. The low mountains of the Appalachian region lie south of the St. Lawrence River. A slim strip along the southeastern boundary of Quebec, forming part of the Mixed Woods Plains ecozone, contains the fertile soils of the Great-Lakes-St. Lawrence region.

About one-quarter of Canadian manufacturing takes place in Quebec. Paper, primary metals and food processing dominate this sector. Quebec is one of the world's leading producers of asbestos and is also a major producer of gold, iron ore and copper.

Manufacturing and agricultural activities are concentrated on the shores of the St. Lawrence River and, as such, the generation of water-borne contaminants is one of the major environmental issues.

Hydroelectric power contributes substantially to the province's economy and the water diversions required to produce this power are another major source of environmental concern.

Ontario- Canada's most populous province is located along the freshwater shores of the Great Lakes and the saltwater shores of Hudson Bay. The Southern Lowland-Great Lakes area, part of the Mixed Woods Plain ecozone, supports both intensive agricultural and manufacturing activities. The loss of some of Canada's most fertile agricultural land, due to the growth of urban areas such as Toronto is one of Ontario's prime environmental issues. Towards the north, Ontario extends through the Boreal Shield and Hudson Plains ecozones.

Ontario is the heart of Canada's manufacturing sector, accounting for about half of the country's total. The manufacture of transportation equipment such as cars and trucks is the largest single industry. Other important industries include chemicals and chemical products, electrical and electronic products, food, primary metals and fabricated metal products. Although Ontario ranks second among the provinces in the value of its total mineral production, it leads in production of nickel, copper, gold, uranium and zinc.

The concentration of heavy industry and population centres around the western shores of Lake Ontario, known as "The Golden Horseshoe", have resulted in air quality problems in this area.

Ontario has the largest farming sector in Canada. Livestock and dairy farming predominate, but small grains, fruit and vegetables are important cash crops. The freshwater fishery, conducted primarily in the Great Lakes, has declined because of pollution and overfishing.

Manitoba- Manitoba is Canada's geographic heartland and forms the eastern boundary of the Prairie ecozone. The northern region, like most of the Prairie provinces, extends through the Boreal Plains, Taiga Plains and Boreal Shield ecozones. Its southern flat plain is covered by deep, fertile clay soils left by glacial lakes. The region is separated from the Saskatchewan Plain along its western boundary by the Manitoba Escarpment, a narrow belt of hilly terrain.

Manitoba's economy is built on agriculture. Wheat and other grain crops are the most important, followed by livestock. There is also a small commercial fishery based in Lake Winnipeg. The province's manufacturing is led by food processing and transportation equipment. Mineral production is mainly metals, especially nickel, copper and zinc.

Groundwater contamination and agricultural chemical residues are cited as prominent environmental concerns.[1]

Saskatchewan- Southern Saskatchewan falls into the Prairie ecozone, sections of which are covered in deep, fertile soil. Cutting across the lowland are the branches of the Saskatchewan River that flow to Lake Winnipeg.

Known as the "bread basket of the nation", Saskatchewan's leading industry is agriculture, dominated by wheat and other grains. Saskatchewan is a major world producer of pot-

1. Manitoba Environment, *State of the Environment Report for Manitoba 1993*, Winnipeg, 1993.

ash, used in chemical fertilizers. Other important minerals include fuels such as crude oil and natural gas and metals, most notably uranium. The manufacturing sector is relatively small and mostly related to the resource industries.

Maintaining the soils and water to support continued agricultural production are major environmental issues.[1]

Alberta- Although the spectacular peaks, lakes and glaciers of the Rocky Mountains rise on its western border, Alberta lies mainly in the interior plains. The Prairie ecozone covers the southern half of the province and the north is in the Boreal Plains ecozone.

Alberta accounts for about half the value of mineral production in Canada. Almost all of this comes from fuels—petroleum, natural gas and its by-products, and coal. The province's grain and livestock production is also important. Chemicals, chemical products and food are the leading commodities in Alberta's diverse manufacturing sector.

British Columbia- British Columbia is set apart from the rest of the country by the Rocky Mountains. The provincial interior is in the Montane Cordillera ecozone, containing the headwaters of the Kootenay, Columbia, Fraser, Peace and Liard rivers. Westward, in the Pacific Maritime ecozone, the landscape is lower and broader and the effects of glaciation are not as evident. The Coastal Mountains extend southward through the Boreal Cordillera ecozone from the St. Elias Mountain Range which contain the loftiest peaks on the continent.

British Columbia's economy thrives on its natural resources. The forest industry is particularly important both as a primary activity and as the largest component of the province's manufacturing sector. Lumber is the main forest product, but pulp and paper production is also substantial. Food processing and primary metals are other important manufacturing activities. The province's extensive mineral sector is dominated by fuels such as coal, natural gas and petroleum, and metals in the form of copper and gold.

Livestock, specialty crops and fruit are the province's major agricultural products. Its extensive fishery is built on the abundant stocks of salmon and herring.

Due to its mild climate and diverse physiography, British Columbia is home to the most diverse wildlife in Canada. The trade-offs between exploiting the natural resources for economic purposes and conserving this diversity have become the main environmental issues in the province. Also cited as a major concern is the generation of wastes from households and industry.[2]

1. Saskatchewan Environment and Public Safety, *State of the Environment Report 1991*, Regina, 1991.
2. Province of British Columbia and Environment Canada, *State of the Environment Report for British Columbia*, Victoria, 1993.

Yukon- Yukon is a triangle of plateaus and mountains extending from the Boreal Cordillera ecozone in the south, through the Tundra Cordillera and Taiga Plains ecozones to the north and east. Its only coast extends along the Arctic Ocean, west of the Mackenzie River Delta. Between the Coast Mountains on the west and the Mackenzie Mountains on the east lies a plateau of rough, irregularly rolling upland. Numerous river valleys cut through the territory. In the southwest, many peaks of the St. Elias Mountains rise to heights of over 4 000 metres. The highest point in Canada, Mount Logan (5 959 metres) is located in this mountain range.

Mining is the chief economic activity in Yukon, with zinc, lead and gold as the dominant commodities. During summer periods, tourism is a major source of revenue.

Northwest Territories- The Northwest Territories include all Canadian territory north of the 60th parallel except for Yukon and the northwestern tip of Quebec and Labrador. All islands south of the 60th parallel in Hudson Bay and James Bay are also part of the Territories. This vast area, almost one-third of Canada, is characterized by extremes in topography, flora and fauna, and climate.

The Northwest Territories occupy six distinct ecozones: the Hudson Plains in the islands of Hudson Bay and James Bay, the Taiga Shield and Taiga Plains ecozones in the central region, and the Southern Arctic, Northern Arctic and Arctic Cordillera in the north.

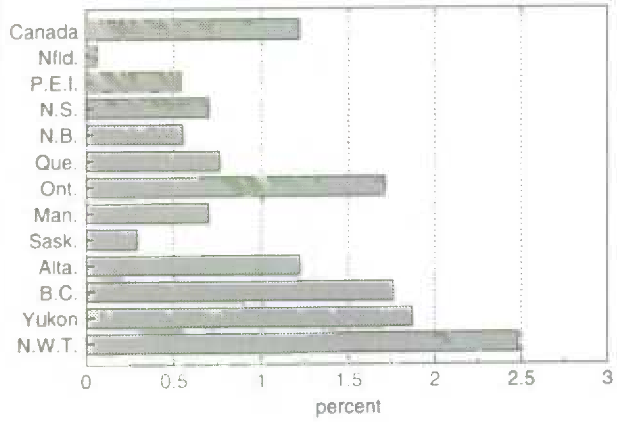
The north is home to many fur-bearing animals, crystal clear lakes stocked with many species of fish and plant life which blooms for a short period in the North's abbreviated summer season. The tundra is almost treeless although occasional dwarf tree species persist. The northeast of the mainland is covered mainly by muskeg, lakes and swamps. The islands are characterized by high mountain ranges across Baffin, Devon and Ellesmere islands.

The economy is dominated by the mining industry, especially zinc, gold and petroleum. Fur and fisheries, mainstays for the native population, are exploited commercially on a small scale.

Population

Provincial populations in 1991 ranged from 130.2 thousand in Prince Edward Island to 10.5 million in Ontario (Table 1.2.2). As shown in Figure 1.2.1, there has been a differential growth in population between the provinces over the past decade. Between 1981 and 1991, Ontario, Alberta, British Columbia, Yukon and the Northwest Territories experienced a population growth that was higher than the national average. Provinces with the lower growth rates generally experienced high levels of emigration and low fertility rates.

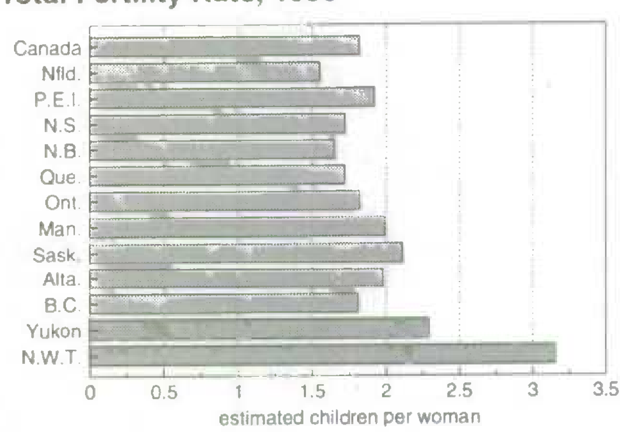
Figure 1.2.1
Population Annual Average Growth, 1981-1991



Source:
Statistics Canada, Census of Population.

Total fertility is an estimate of the number of children each woman would bear in her lifetime, based on the age-specific birth rates for a particular year. A generation would be replaced if the number of children born was 2.1 children per woman. As Figure 1.2.2 illustrates, total fertility rates in 1990 ranged from a low of 1.55 children per woman in Newfoundland to a high of 3.15 in the Northwest Territories. See Section 2 - **Population Conditions and Processes** for a more detailed discussion of provincial population dynamics.

Figure 1.2.2
Total Fertility Rate, 1990



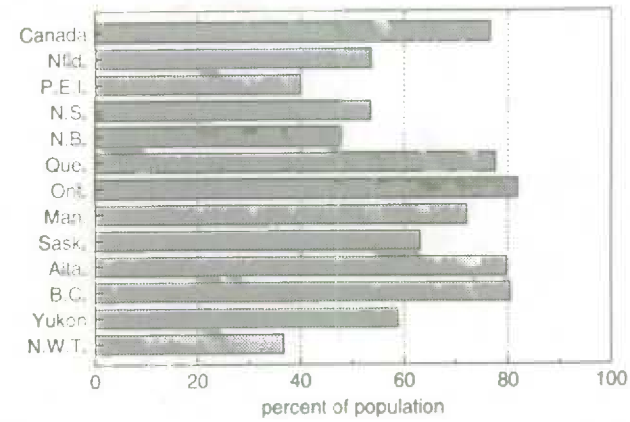
Source:
Statistics Canada, *Canada Year Book 1994*, Catalogue No.11-402, Ottawa, 1994.

Canada's population is mainly an urban one with 76.6 percent of the population living in urban areas.[1] Ontario, British Columbia and Quebec, the most populous provinces, exceed the national average as shown in Figure 1.2.3.

1. An urban area is defined in the 1991 Census of Population as an area of 1 000 or more persons having a density of at least 400 persons per square kilometres.

The differences in the standard health indicators (life expectancy, infant mortality and age-standardized death rate) as shown in Table 1.2.2 are relatively small between provinces. Life expectancy for females, for example, ranges from a high of 81.8 years in Prince Edward Island to a low of 76.5 years in the Territories. Similarly, infant mortality rates for the provinces range from a low of 5.7 in Nova Scotia to 11.6 in the Northwest Territories. The age-standardized crude death rate for males is lowest in Saskatchewan (590 deaths per 100 000 population) and highest in the Northwest Territories (837 per 100 000 population).

Figure 1.2.3
Urban Population, 1991



Source:
Statistics Canada, Census of Population.

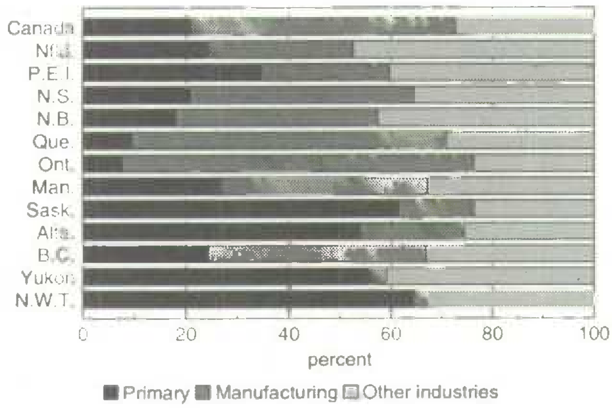
Economy

The economies of the provinces are extremely varied in structure and size. Some provinces, such as Prince Edward Island and Saskatchewan rely mainly on agriculture. In Alberta, mining predominates. Most of the provinces have a substantial manufacturing and commercial sector. An overview of the structure of the economies of the provinces is provided in Figure 1.2.4. This shows the contribution to Gross Domestic Product (GDP) of each of the goods producing sectors: primary industries (agriculture, forestry, fishing and mining), manufacturing, and other goods producing industries including construction and utilities.

Ontario alone accounts for about 40 percent of Canada's GDP. Yukon, the Northwest Territories, and Prince Edward Island at the other extreme, contribute less than one percent to Canada's GDP.

GDP per capita in 1991 (Table 1.2.2 and Figure 1.2.5) ranged from a low of $15 887 in Prince Edward Island to a high of $34 706 in the Northwest Territories. The high numbers in the Northwest Territories are largely due to the high output of the mining industries compared to the relatively small population. In addition, many workers in the Northwest Territories are not resident there and a high proportion of the wages they earn are spent in other provinces.

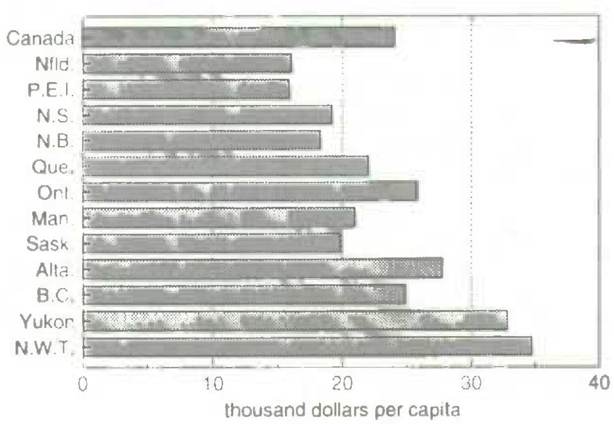
Figure 1.2.4
GDP Distribution by Sector: Goods Producing Industries, 1991



Source:
Statistics Canada, Input-Output Division.

Figures representing the economic slow-down of 1990-92 are not presented in this section, since provincial GDP by industry figures for 1992 are not yet available. In an overview section such as this it is more useful to show the changes over a longer time frame. Table 1.2.2 provides figures on the real growth rates of the goods producing industries of the economy over the years 1984 to 1991. This shows the consistent decline of the primary industries in Newfoundland, Ontario and the Northwest Territories. Overall, the economies of the provinces grew at an average of between -3.4 percent per year in the Northwest territories to 14.5 percent per year in Yukon. Figure 1.2.6 provides a summary of GDP growth for the goods producing industries in Canada, the provinces and territories.

Figure 1.2.5
GDP per capita, 1991

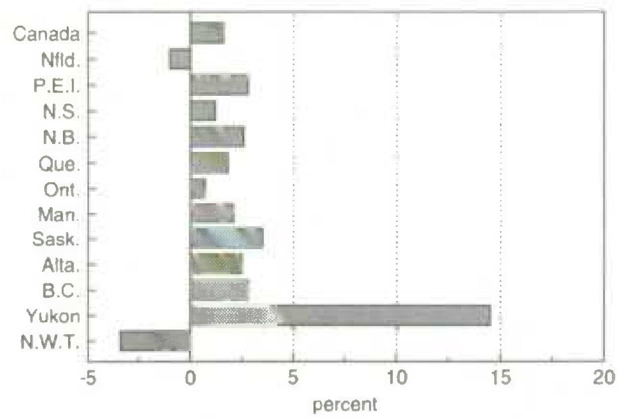


Source:
Statistics Canada, *National Income and Expenditure Accounts, Annual Estimates*, Catalogue No.13-201, Ottawa, 1993.

Personal use passenger cars are major consumers of resources and represent major sources of air emissions in urban areas. The ownership rates for personal use passenger cars nationwide averaged 465 vehicles per 1 000 persons in 1991 (Figure 1.2.7). This ranged from lows of 349 in Newfoundland and 332 in the Northwest Territories to highs of 548 in Alberta and 673 in Yukon. British Columbia (535 vehicles per 1 000 persons) also substantially exceeded the national average.

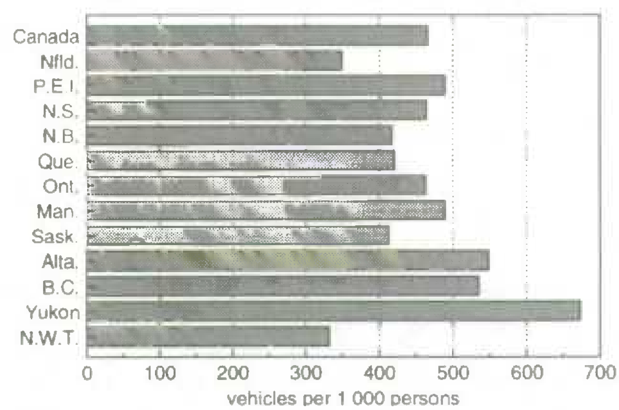
Comparing the number of automobiles with the length of the road network provides an indication of the vehicle density (Table 1.2.2). For all of Canada, there are 15 passenger automobiles for each kilometre of road. Manitoba, Saskatchewan, Alberta, Yukon and the Northwest Territories average between 2 and 8 cars per kilometre of road. In the east and in British Columbia, there are from 13 to 29 cars per kilometre.

Figure 1.2.6
GDP Average Annual Real Growth: Goods Producing Industries, 1984-91



Source:
Statistics Canada, Industry Measures and Analysis Division.

Figure 1.2.7
Passenger Automobile Registrations, 1991



Source:
Statistics Canada, *Road Motor Vehicles, Registrations*, Catalogue No. 53-219, Ottawa, 1992.

Gasoline sales for automotive purposes averaged 1 223 litres per person in 1991 (Table 1.2.2). Per capita purchases were lowest in Quebec (1 023 litres), Newfoundland (1 038 litres) and the Northwest Territories (1 068 litres). High per capita gasoline purchases were recorded in Yukon (2 364 litres), Alberta (1 646 litres) and Saskatchewan (1 623 litres).

Wastes

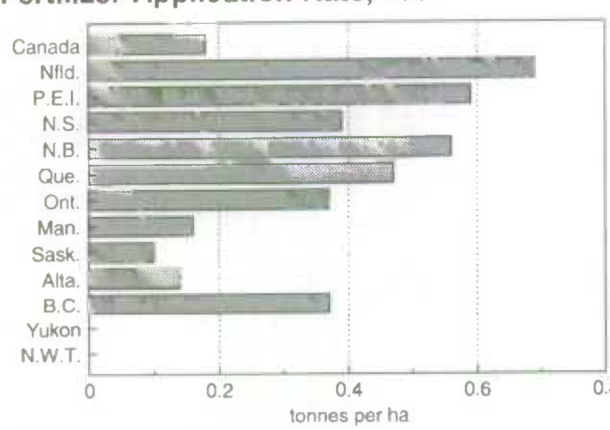
Many industrial, commercial and household activities generate wastes as solids, gases, liquids or energy. Not all aspects of waste generation are well understood or regularly measured. This section provides a selection of available statistics.

Agriculture

Agricultural fertilizers are often carried by run-off from the land and leach into groundwater, streams, rivers, lakes and coastal waters. The intensity of the application of fertilizer is one indication of the potential for causing water pollution problems. Section 3.8 - **Agricultural Chemicals** provides a more detailed discussion of these issues.

Fertilizer is applied at an average rate of 0.18 tonnes per hectare of agricultural land (Figure 1.2.8). The eastern provinces, together with British Columbia, exceed this average by a factor of two to four. While the intensity of fertilizer application is lower in the Prairie provinces, the land area to which it is applied there is much greater.

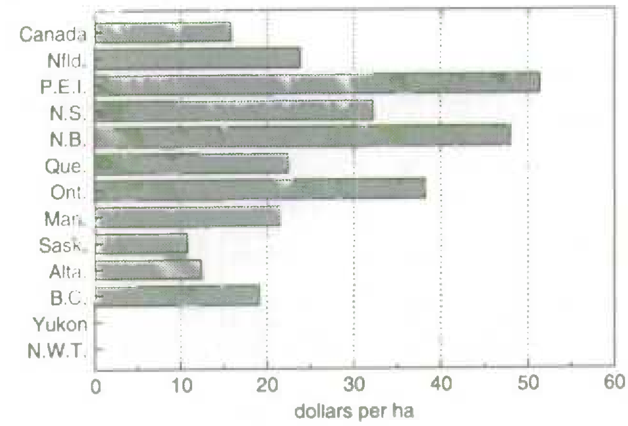
Figure 1.2.8
Fertilizer Application Rate, 1991



Sources:
Statistics Canada, Census of Agriculture and National Accounts and Environment Division.

Pesticide application rates (Figure 1.2.9) are calculated as the value of the pesticide applied per hectare of cultivated land. Cultivated land includes cropland, permanent pasture and summerfallow areas. The national average was $15.80 per hectare in 1991. The national average was exceeded in all provinces except Saskatchewan and Alberta, the provinces with the greatest amount of cropland. Prince Edward Island, New Brunswick and Ontario showed the most intensive rates of pesticide application at $51.40, $48.00 and $38.20 respectively.

Figure 1.2.9
Pesticide Application Rate, 1991

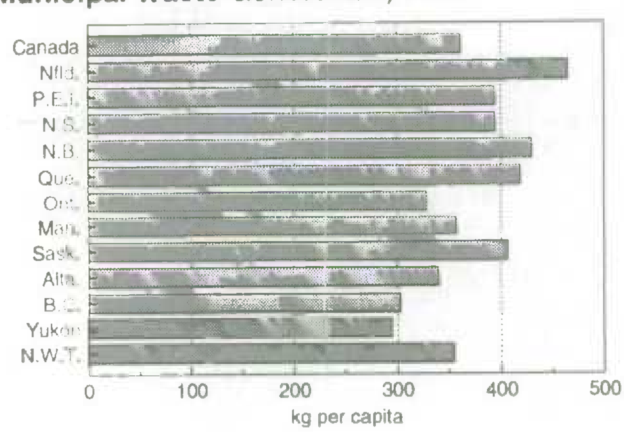


Sources:
Statistics Canada, Census of Agriculture and National Accounts and Environment Division.

Municipalities

Statistics Canada's *Survey of Local Government Waste Management Practices 1991*[1] provides information on the generation and collection of residential wastes. According to this survey, 10.2 million tonnes of residential wastes were generated in Canada in 1991. This amounted to about 361 kg per person. Figure 1.2.10 illustrates the range shown in the provincial statistics, from a low of 295 kg per person in Yukon to a high of 465 kg in Newfoundland. These figures do not include quantities of wastes diverted to recycling programs.

Figure 1.2.10
Municipal Waste Generation, 1991



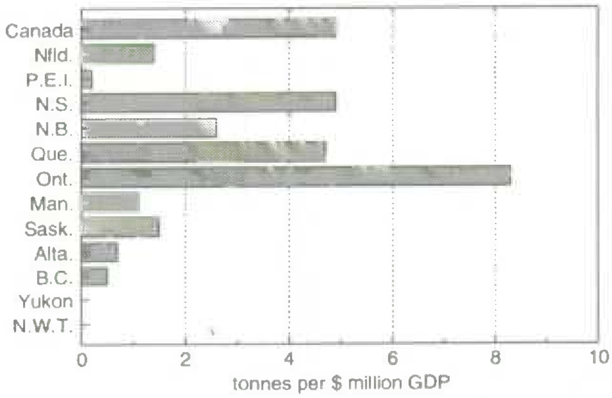
Source:
Statistics Canada, National Accounts and Environment Division.

1. Statistics Canada, "Local Government Waste Management Practices Survey", *Environmental Perspectives 1993*, Catalogue No. 11-528, 1991, p. 69-73.

Hazardous wastes

Hazardous wastes are substances which pose a risk to human health or the environment and require special disposal techniques to make them harmless or less dangerous.[1] The estimates in Table 1.2.2 are based on (a) a national estimate of 3 289 thousand tonnes for 1991 by the World Resources Institute[2] and (b) an estimated distribution by province.[3] According to these estimates, Ontario generated over 68 percent of the nation's hazardous wastes. This amounted to about 8.3 tonnes per million dollars of Ontario's GDP. As shown in Figure 1.2.11, industries in other provinces were less than half as intensive in their generation of hazardous wastes.

Figure 1.2.11
Hazardous Waste Production Rate, 1991



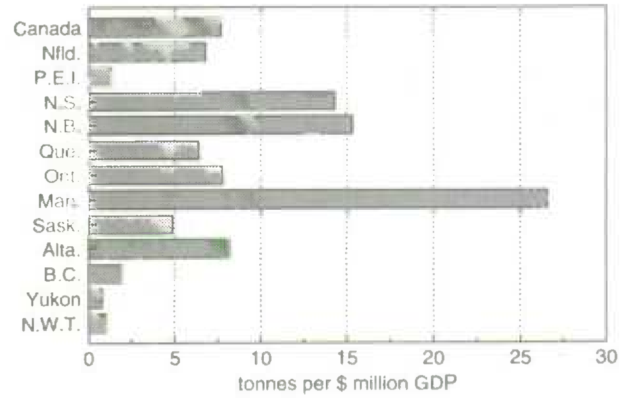
Sources:
World Resources Institute, *The 1993 Information Please Almanac*, Houghton Mifflin Company, New York, 1992.
Fenco Newfoundland Lavalin, *Report on the Economic Profile of the Hazardous Waste Management Service Subsector in Canada*, 1988. Unpublished report quoted in Government of Canada, *The State of Canada's Environment*, Ottawa, 1991, p. 21-22.

Air emissions

Emissions of major air pollutants are occasionally estimated by Environment Canada. The most recent estimates available are for 1985. These figures do not reflect the major improvements in industrial processes and pollution control technologies which have been implemented in the past nine years.

Industrial processes, fuel combustion in power generation and transportation and the incineration of wastes are the main sources of the common air pollutants: particulates, sulphur dioxide, nitrogen oxides, carbon monoxide, hydrocarbons and volatile organic compounds. Carbon dioxide emissions have been measured more recently since they have been linked to the greenhouse effect and global warming. The quantities of emissions vary between provinces not only because of the differences in the population and level of industrial activity but also because these activities are quite different. Manitoba and Saskatchewan, for example, have similar populations and GDP, but Manitoba generates less than half the particulates and five times the sulphur dioxide of Saskatchewan. These differences are largely due to the differences in fuels used for power generation and the mixture of industries.

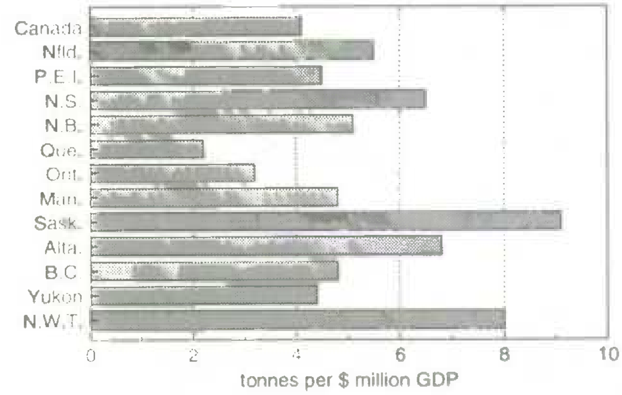
Figure 1.2.12
Sulphur Dioxide Emissions, 1985



Source:
Environment Canada, Regulatory Affairs and Program Integration Branch, *Canadian Emissions Inventory of Common Air Contaminants (1985)*, Ottawa, 1990.

In 1985, Ontario led all provinces in the total emissions of sulphur dioxide (39.1 percent of national emissions), nitrogen oxides (30 percent), carbon monoxide (30 percent), hydrocarbons (29 percent) and volatile organic compounds (34 percent). British Columbia led the country in emissions of particulates (24 percent). Figures available for carbon dioxide emissions in 1990 also indicate that Ontario was the single largest source (32 percent).

Figure 1.2.13
Nitrogen Oxides Emissions, 1985



Source:
Environment Canada, Regulatory Affairs and Program Integration Branch, *Canadian Emissions Inventory of Common Air Contaminants (1985)*, Ottawa, 1990.

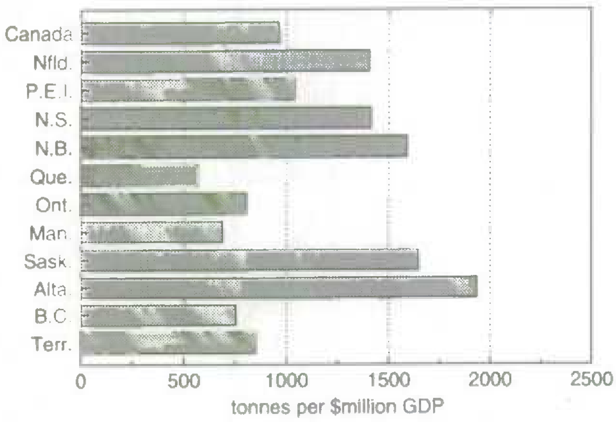
1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
2. World Resources Institute, *The 1993 Information Please Almanac*, Houghton Mifflin Company, New York, 1992.
3. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991, p. 21-22.

When viewed relative to the level of economic activity (Figure 1.2.12), Manitoba and New Brunswick were most intensive in the generation of sulphur dioxide (26.6 and 15.3 tonnes per million dollars of GDP respectively). In New Brunswick this can be attributed to the power generation sector which depends heavily on fossil fuels. In Manitoba, 97 percent of all sulphur dioxide emissions are attributed to two metallurgical smelters in the north.[1] Largely due to their readily available fossil fuels and high levels of transportation activity, Saskatchewan, the Northwest Territories and Alberta had the highest intensities of generation of nitrogen oxides (9.1, 8.0 and 6.8 tonnes per million dollars of GDP, respectively).

In 1990, carbon dioxide emissions (Figure 1.2.14) were most intense in Alberta (1 935 tonnes per million dollars of GDP) and Saskatchewan (1 646 tonnes per million dollars of GDP), largely due to the combustion of fossil fuels.

Figure 1.2.14

Carbon Dioxide Emissions, 1990



Source:
Environment Canada, *Canada's Greenhouse Gas Emissions: Estimates for 1990*, Ottawa, 1992.

Mitigation

Governments, non-governmental organizations, industries and individuals have changed their behaviour in response to a growing need to reduce pollution, to protect the natural environment and to manage natural resources. The mitigation efforts of governments and industries can be measured through their expenditures on pollution control and waste management.

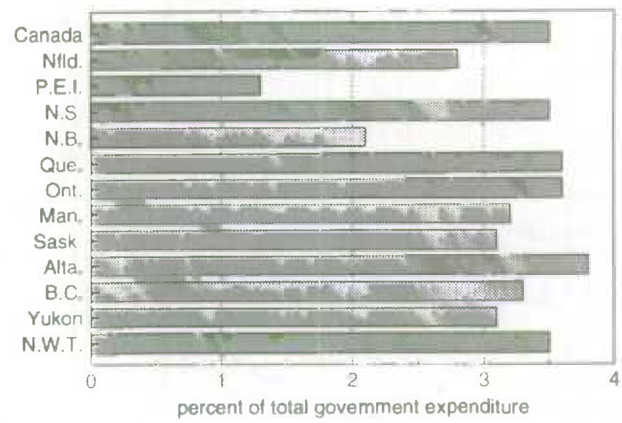
Provincial and local government expenditures on the environment (including water purification and supply, sewage treatment and disposal, pollution control, and garbage and waste collection) amounted to 3.5 percent of total expenditures for 1990-91. As shown in Table 1.2.2 and illustrated in Figure 1.2.15, the proportion of the budget spent on the environment ranged from a low of 1.3 percent in Prince Edward Island to 3.8 percent in Alberta.

On a per capita basis, Prince Edward Island was also lowest ($76.30 per person) and the Northwest Territories and Yukon were highest ($673.40 and $392.90 per person, respectively). These figures generally reflect the differences in costs of maintaining a given standard of environmental quality in the different regions of Canada and not necessarily the degree of effort in reducing impacts.

The 1990 Statistics Canada's *Pollution Abatement and Control Survey*[2] provided data on private industry capital expenditures aimed at reducing pollution. Survey results (Figure 1.2.16) show that of capital expenditures totalling $89.7 billion in 1989, 1.3 percent were spent on pollution abatement and control. This proportion ranged from a high of 3.3 percent in New Brunswick to a low of 0.1 percent in Newfoundland and zero in Yukon. For reasons of confidentiality, figures are not available for Prince Edward Island, Saskatchewan and the Northwest Territories.

Figure 1.2.15

Provincial and Local Government Expenditures on Environment, 1990-91



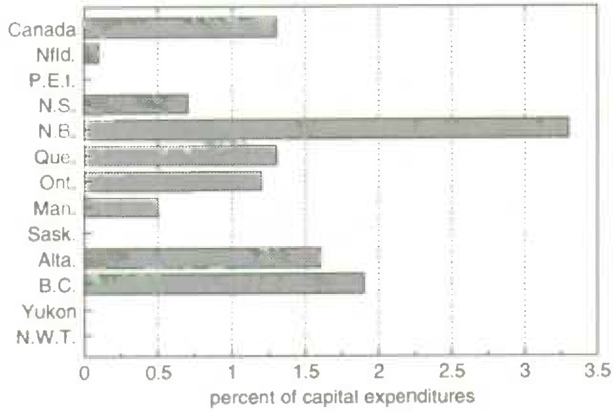
Source:
Statistics Canada, *Public Finance Historical Data 1965/66 - 1991/92*, Catalogue No. 68-572, Ottawa, 1993.

Private waste management in Canada is a growing and dynamic industry, especially in Ontario and Quebec. These firms collect and dispose of much of Canada's commercial and institutional waste as well as a substantial portion of household waste. Statistics Canada's *Survey of Waste Management Industries* represents the first specific collection of data on the economic characteristics of this sector. The survey shows that the revenues of the waste management industry totalled over $1.1 billion in 1989. Ontario and Quebec accounted for three-quarters of this total.

1. Manitoba Environment, *State of the Environment Report for Manitoba 1993*, Winnipeg, 1993.

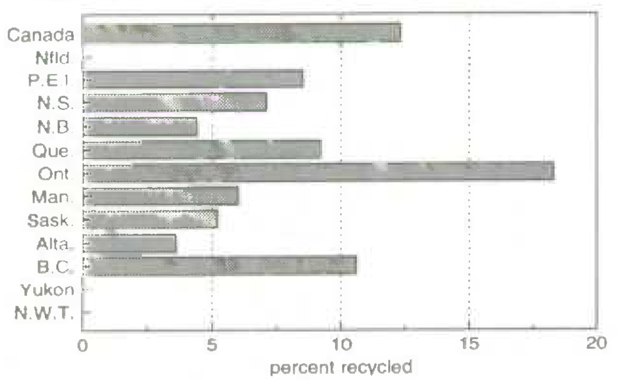
2. Statistics Canada, "Pollution Abatement and Control Expenditures", *Environmental Perspectives 1993*, Catalogue No. 11-528, 1993, p. 59-62.

Figure 1.2.16
Pollution Abatement and Control Expenditures by Industry, 1989



Note:
Values for Prince Edward Island, Saskatchewan and the Northwest Territories are confidential. Values for Yukon are too small to be expressed.
Source:
Statistics Canada, National Accounts and Environment Division.

Figure 1.2.17
Industrial Recycling of Packaging, 1990



Note:
Values for the Northwest Territories and Yukon are too small to be expressed.
Source:
National Task Force on Packaging, *National Packaging Protocol: Results of the 1990 National Packaging Survey*, Report prepared for the Canadian Council of Ministers of the Environment, Office of Waste Management, Environment Canada, 1992.

The reduction of packaging wastes has been identified as a priority by the federal government.[1] The national goal is to reduce the amount of packaging sent to disposal sites to 50 percent of the 1988 benchmark level of 5.3 million tonnes. In response, Environment Canada and Statistics Canada conducted the *National Packaging Survey*[2] in 1991. Results from this survey show that, in 1990, of the 13.5 million tonnes of packaging consumed by industry, about 8.9 million tonnes were reused or recycled, leaving 4.6 million tonnes for disposal. As shown in Figure 1.2.17, Ontario and British Columbia led the provinces in the proportion of wastes recycled at 18.3 percent and 10.6 percent respectively.

Resources

This section provides an economic and environmental perspective of the availability, use and value of natural resources: water, minerals, fish, forests, energy, land and wildlife. In many instances, it is not possible to provide a full accounting for all resources. Statistics on the total fresh water supply, for example, were estimated on a provincial basis.

Water

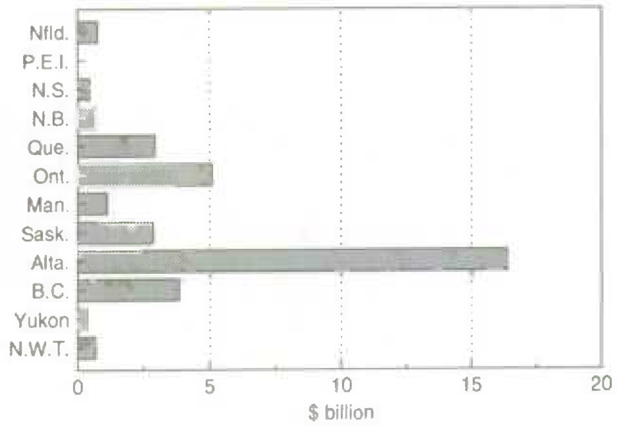
It has been estimated[3] that Canada's renewable fresh water supply exceeds 2.9 thousand cubic kilometres. This, the average annual flow of rivers and aquifers generated by rainfall during a given year, is among the highest in the world and amounts to about 1.1 thousand cubic metres per person. Only about 42 cubic kilometres, or 1.6 percent of this fresh water is withdrawn and used by agriculture, mining, manufacturing, power generation and municipalities. Only approximately 10 percent of the amount withdrawn is consumed, that is, converted to steam or incorporated into manufactured products. Statistics are not yet available to provide a complete accounting of water withdrawal and consumption by sector.

Minerals

Canada's mineral resources amount to approximately 6 percent of the Earth's important mineral reserves.[4] The value of Canadian mineral production, including metallic minerals, non-metallic minerals, structural materials and fuels, amounted to over $35 billion in 1991. Alberta accounted for almost half of this production, a majority of this derived from petroleum and natural gas. Figure 1.2.18 shows the relative values of mineral production. Table 1.2.2 provides details on the values and quantities of minerals produced in each province.

1. National Task Force on Packaging, *National Packaging Protocol: Results of the 1990 National Packaging Survey*, Report prepared for the Canadian Council of Ministers of the Environment, Office of Waste Management, Environment Canada, Hull, 1992.
2. Ibid.
3. J. Forkasiewicz and J. Margat, *Tableau mondial de données nationales d'économie et de l'eau, ressources et utilisation*, Département Hydrogéologique, Orléans, France, 1980.
4. World Resources Institute, *World Resources 1990-91*, Oxford University Press, Toronto, 1991.

Figure 1.2.18
Value of Mineral Production, 1991



Source:
Statistics Canada, *General Review of the Mineral Industries 1991*, Catalogue No. 26-201, Ottawa, 1993.

Forestry

Exploiting forest resources is also an important industry in Canada. The 162 million cubic metres roundwood produced in 1991 accounted for approximately $7.7 billion in revenues and was derived from the harvesting of over 8 500 square kilometres of forest. According to the Canadian Council of Forest Ministers,[1] Canada's forest covers over 4.5 million square kilometres. In 1991 approximately 16.9 thousand square kilometres of this forest land were lost to forest fires, the majority of losses being in Quebec (4.4 thousand square kilometres) and Ontario (2.2 thousand square kilometres).

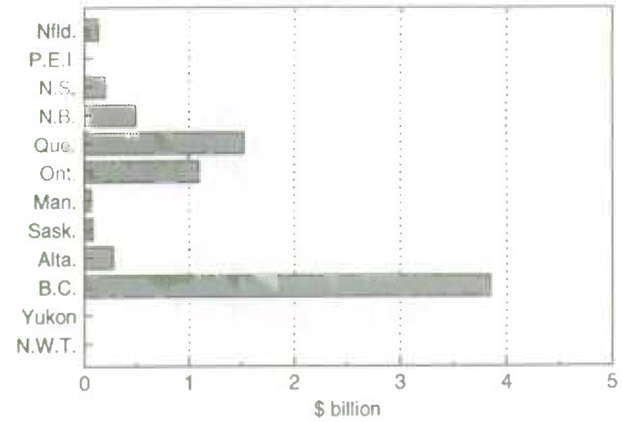
Provincial revenues from forestry activities (Figure 1.2.19) ranged from less than $3.3 million Prince Edward Island, Yukon and the Northwest Territories to $3.8 billion in British Columbia.

Fisheries

In 1989, the most recent year for which provincial fishery statistics are available, Canadian fisheries produced over 1.6 million tonnes valued at over $1.4 billion. Fisheries were important sources of income in Newfoundland and Prince Edward Island. See Section 4.14 - **Fish and Wildlife Harvests** for more recent information on fisheries production and values.

1. Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics, 1992*, Ottawa, 1993.

Figure 1.2.19
Forestry Revenues, 1991



Note:
Values for Prince Edward Island, the Northwest Territories and Yukon are too small to be expressed.
Source:
Statistics Canada, *Canadian Forestry Statistics*, Catalogue No. 25-202, Ottawa, 1992.

Energy

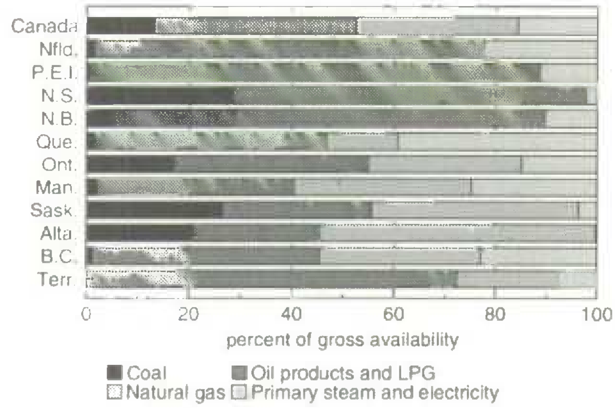
Canada is a major producer of fossil fuels and hydroelectric power. The energy situation in the provinces ranges from Prince Edward Island, which is wholly dependent on energy from outside the province, to Alberta, which exports most of its energy to the other provinces and the rest of the world. The varying levels of availability and requirements for energy in the provinces have led to vastly different energy balances and consumption patterns.

Alberta accounts for over two-thirds of the primary energy production in Canada. Only Alberta, Saskatchewan and British Columbia produce more energy than they consume. The other provinces are dependent on imports. Ontario, Quebec and Newfoundland are well endowed with hydroelectric potential which reduces the need for imports somewhat.

Figure 1.2.20 provides an illustration of the importance of various forms of energy to each of the provinces. Coal is a major source of energy in Nova Scotia, Saskatchewan and Alberta accounting for over 20 percent of gross availability[2] in each province. Oil products and LPGs dominate in most provinces ranging in importance from 25 percent in Alberta to 88.2 percent in Prince Edward Island. Natural gas is the primary source of energy in Alberta (54.2 percent).

2. Gross availability shows the original form of energy before it is converted to other forms which can be directly consumed. It includes all forms of primary and secondary energy produced except for crude oil less the production of coke, the production of coke oven gas, the production of thermal electricity and LPGs used for the production of refinery products. The difference between totals of gross availability and the availability of primary energy is due to losses in the production process.

Figure 1.2.20
Gross Availability of Energy by Type, 1991

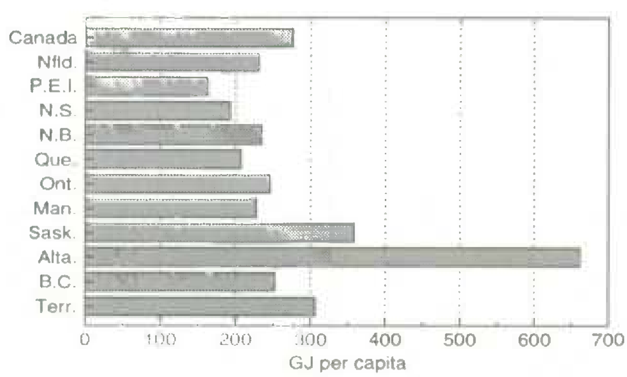


Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, 1993.

About 9.3 percent of Canada's energy production is from renewable sources. Almost all of the renewable energy is derived from hydroelectric power and Quebec accounts for over 45 percent of the national total. Renewable energy production accounts for most of the energy produced in Newfoundland, Quebec and Manitoba. Small quantities of wind and tidal power are generated in Nova Scotia.

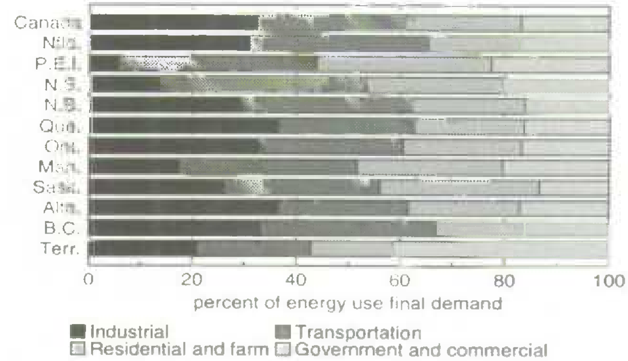
Provinces with abundant energy supplies are less conservative with their consumption. The "energy poor" provinces tend to consume less than the national average (276 GJ per person per year, the energy equivalent to about 8 000 litres of gasoline), as demonstrated in Figure 1.2.21.

Figure 1.2.21
Net Domestic Energy Consumption, 1991



Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, 1993.

Figure 1.2.22
Energy Consumption by Sector, 1991



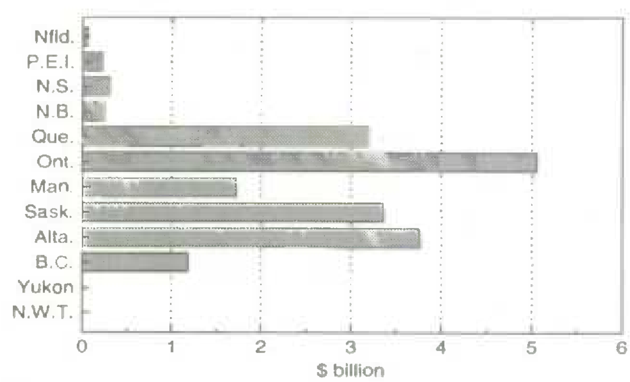
Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, 1993.

When viewed from a perspective of energy consumption by sector, industry accounts for 32.5 percent of national consumption. As illustrated in Figure 1.2.22, industrial consumption was lowest in Prince Edward Island (5.5 percent) and highest in Quebec and Alberta (36.5 percent for both).

Agriculture

In 1991, agriculture accounted for approximately 3 percent of Canada's GDP. Besides Yukon and Northwest Territories, where there is little commercial agriculture, agricultural revenues range from $58.1 million in Newfoundland to over $5 billion in Ontario (Figure 1.2.23). Ontario's agricultural sector is the largest in Canada, accounting for over one-quarter of Canada's production of crops and livestock.

Figure 1.2.23
Value of Agricultural Production, 1991

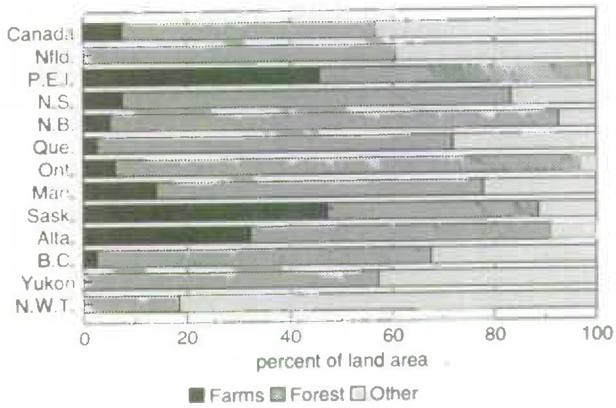


Source:
Statistics Canada, *Agriculture Economic Statistics*, Catalogue No. 21-603, Ottawa, 1993.

Land

Canada's provinces and territories range in land area from Prince Edward Island, covering 5 660 square kilometres, to the Northwest Territories which cover almost one-third of the country (3.4 million square kilometres). The diversity of their topography and physiography were described in the introduction to this section. Figure 1.2.24 shows the distribution of land cover by three major categories: farms, forest and other. The "other" category includes taiga, tundra, wetland, ice/snow and built-up areas. Whereas farms cover 7.4 percent of Canada's land area, farmland is the dominant cover in Saskatchewan (47.1 percent) but is negligible in Newfoundland (0.1 percent). A majority of Ontario is forested (90.6 percent) while forests cover only 41.5 percent of Saskatchewan and 18.6 percent of the Northwest Territories.

Figure 1.2.24
Distribution of Land Cover, 1991



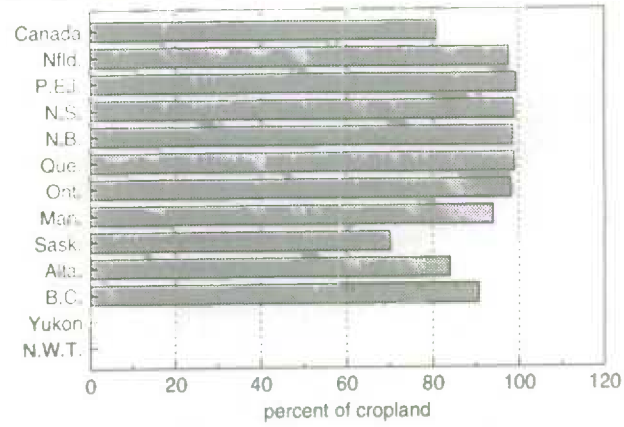
Sources:
Statistics Canada, *Canada Year Book 1994*, Catalogue No. 11-402, Ottawa, 1993.
Statistics Canada, *Canadian Forestry Statistics*, Catalogue No. 25-202, Ottawa, 1992.

The proportion of cropland which is cultivated in any given year is one indication of agricultural intensity. Figure 1.2.25 shows that, except for the Prairie provinces, little cropland is left fallow.

Loss of soil due to erosion is a major problem in many provinces. On average, one hectare of cropland loses 3.8 tonnes of topsoil per year. Provincial erosion rates range from a minimum of 1.8 tonnes per hectare in British Columbia to 5.7 tonnes per hectare in New Brunswick (Figure 1.2.26).

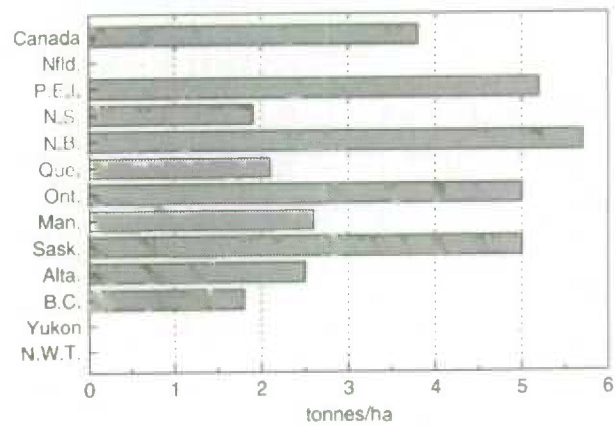
Approximately 9.8 percent of Canada's land area is protected from disturbance to some degree by designation as a national park, provincial park, wildlife management area or wilderness area. Manitoba and Quebec lead the provinces in the proportion of land area protected with 30.5 percent and 12.2 percent protected (Figure 1.2.27).

Figure 1.2.25
Cropland Tilled, 1991



Sources:
Statistics Canada, Agriculture Division and National Accounts and Environment Division.

Figure 1.2.26
Estimated Soil Erosion Rates, 1991

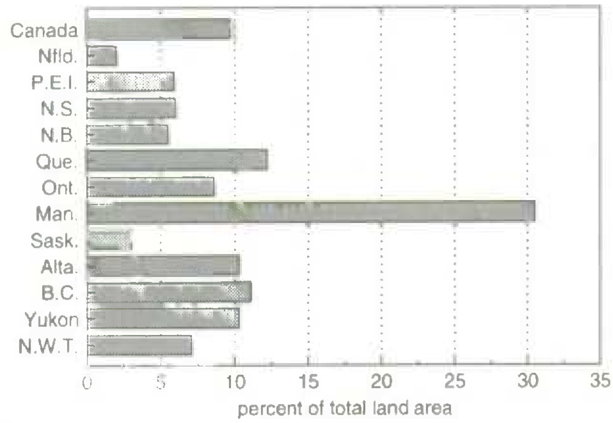


Sources:
Statistics Canada, Agriculture Division and National Accounts and Environment Division.

Road networks are often associated with environmental impacts because of the disruption of ecosystem integrity and pollutants generated from transportation activities. Saskatchewan, Alberta and Ontario account for over 60 percent of Canada's 874 thousand kilometres[1] of roads. One indication of the density of the road network and, therefore, the potential for disturbance, is the length of road per unit area of the province. Figure 1.2.28 shows that the highest road densities occur in Prince Edward Island (872 kilometres per thousand square kilometre), Nova Scotia (488 kilometres per thousand square kilometre) and Saskatchewan (340 kilometres per thousand square kilometres).

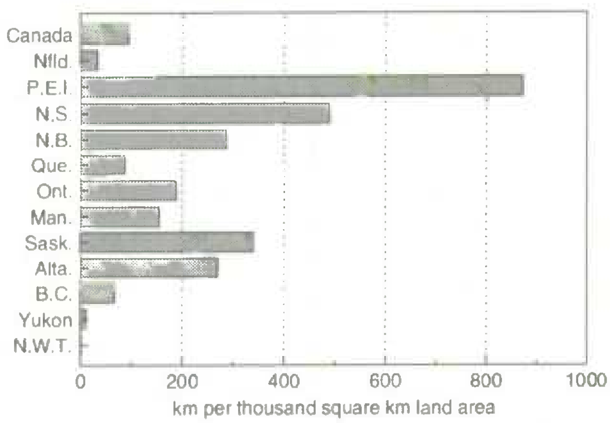
1. The road network is represented in terms of two-lane equivalents, that is, one kilometre of four-lane highway would be counted as two kilometres of two-lane equivalent.

Figure 1.2.27
Land Area Protected, 1991



Source:
Environment Canada, State of the Environment Reporting Directorate, National Conservation Areas Database, 1993.

Figure 1.2.28
Road Network Density, 1991



Note:
Figures for the Northwest Territories are too small to be expressed.
Source:
Transportation Association of Canada

Wildlife

Statistics on wildlife status are not available for each province. A recent study[1] does provide a useful overview of the status of vascular plants. This shows that of the 3 269 known vascular plant species in Canada, 1 009 are considered rare. Of these rare species, a majority occur in British Columbia (426 species) and Ontario (355 species). Of the total number of species in British Columbia 21.3 percent are considered rare.

1. Argus, George W. and Kathleen M. Pryer, *Rare Vascular Plants in Canada*, Canadian Museum of Nature, 1990

Air quality

Table 1.2.1 shows the composite air quality measures for 12 cities. The figures show the number of hours for which the air quality index in these cities exceeded the acceptable and poor levels. In Hamilton, Ontario, the air quality was unacceptable or poor for 30 percent of the hours measured.

Table 1.2.1
Air Quality Index, 1991

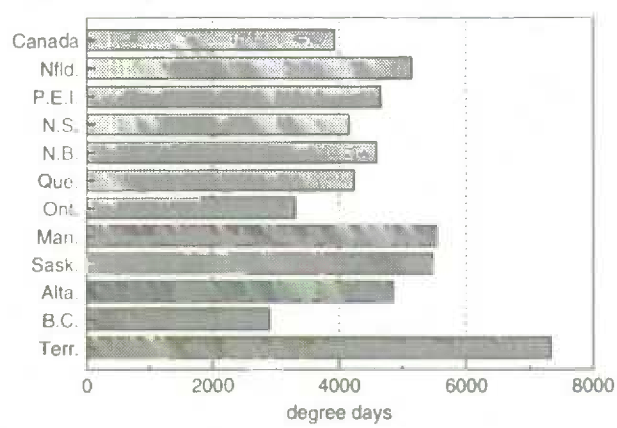
Province	City	Air quality			
		Acceptable	Unacceptable	Poor	Total measured
		hours			
Newfoundland	St. John's	8 685	75	-	8 760
Nova Scotia	Halifax	8 059	25	-	8 084
Quebec	Montréal	7 505	752	76	8 334
	Québec	8 538	112	-	8 650
Ontario	Ottawa	7 678	967	34	8 679
	Toronto	7 960	731	48	8 739
	Hamilton	6 118	2 318	300	8 736
Manitoba	Winnipeg	8 577	166	-	8 743
Saskatchewan	Regina	8 701	23	-	8 724
Alberta	Edmonton	7 678	967	34	8 679
	Calgary	8 186	552	22	8 760
British Columbia	Vancouver	7 641	961	93	8 695

Source:
Environment Canada, Regulatory Affairs and Program Integration, Environmental Protection Branch.

Climate

The climate of Canada's provinces is as diverse as their economy and physiography. One measure of overall climate is the number of degree days below 18° Celsius, also known as heating degree days. This is the sum of average daily temperatures below 18° Celsius and is often used as an indication of the requirement for home heating fuel. The number of degree days below 18° Celsius (Figure 1.2.29) ranges from 2 904 in British Columbia to 7 335 in Yukon and Northwest Territories.

Figure 1.2.29
Degree-days Below 18° Celsius, 1991



Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, 1993.

Table 1.2.2

National and Provincial Summary Statistics, 1991

Characteristics	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
POPULATION														
Total														
1991 (thousands)	a	28 117.6	579.9	130.8	918.1	748.5	7 081.2	10 471.2	1 113.3	1 007.0	2 600.3	3 376.9	29.0	61.2
Estimated 1993 (thousands)	d	28 753.0	581.1	131.6	923.0	750.9	7 208.8	10 746.3	1 116.0	1 003.1	2 662.3	3 535.1	32.0	62.9
Projected 2016[1] (thousands)	b	39 372.0	606.3	159.4	1 061.9	846.8	8 849.9	15 803.6	1 248.0	979.1	3 955.0	5 704.3	51.6	106.1
Average annual growth 1981-91 (percent)	c	1.22	0.06	0.54	0.70	0.55	0.76	1.71	0.70	0.29	1.22	1.76	1.87	2.48
Urban (percent)	ah	76.6	53.6	39.9	53.5	47.7	77.6	81.8	72.1	63.0	79.8	80.4	58.8	36.7
Density (persons / km^2)	c	3.1	1.6	23.1	17.4	10.4	5.2	11.7	2.0	1.8	4.0	3.6	0.1	0.0
Total fertility rate[2] 1990	d	1.82	1.55	1.92	1.72	1.65	1.72	1.82	1.99	2.11	1.98	1.81	2.29	3.15
Households (thousands)	ah	10 079.4	175.7	44.8	326.5	255.0	2 650.1	3 661.7	407.1	366.1	914.7	1 251.4	10.1	16.3
Life Expectancy (years)														
Male	b	73.7	73.5	74.1	72.9	73.0	73.0	74.0	74.1	74.4	74.1	74.4	70.1	70.1
Female	b	80.8	80.2	81.8	80.3	80.9	80.6	80.7	80.7	81.6	81.2	81.4	76.5	76.5
Infant Mortality (deaths / 1000 live births)	e	6.4	7.8	6.9	5.7	6.1	5.9	6.3	6.5	8.2	6.7	6.5	10.6	11.6
Age-standardized mortality rate 1990 (deaths / 100 000 population)														
Male - all causes	m	641.4	709.8	704.0	689.1	652.7	694.7	627.9	622.7	590.0	611.8	593.8	721.9	837.0
Female - all causes	m	454.0	515.1	477.7	487.7	454.6	455.2	457.4	456.6	430.5	429.9	441.4	729.2	594.0
Expenditures on education 1989-90														
Total ($ million)	d	46 184	1 029	196	1 474	1 199	11 869	18 147	1 958	1 789	4 562	5 200	286	474
percent of GDP (1990)	c	7.2	11.7	9.8	8.7	9.0	7.7	6.5	8.3	8.8	6.5	6.4	30.8	22.4
ECONOMY														
Gross Domestic Product[3] ($ million)	f,i	675 928	9 312	2 078	17 605	13 689	155 864	270 463	23 340	19 985	72 168	84 088	952	2 124
Average annual real GDP growth 1984-91:														
Goods producing industries (percent)	u	1.6	-1.0	2.8	1.2	2.6	1.8	0.7	2.1	3.5	2.5	2.8	14.5	-3.4
Primary	u	1.9	-4.0	-1.8	1.9	2.0	2.2	-1.0	2.2	4.6	2.0	2.7	28.4	-3.3
Manufacturing	u	1.1	-0.3	5.0	-0.1	2.2	1.5	0.5	1.1	3.1	3.3	1.7	21.0	7.7
Other goods producing industries	u	2.6	0.3	6.7	2.7	3.4	2.3	2.2	3.1	1.1	3.1	4.6	5.4	-4.0
GDP per capita ($)	c	24 039	16 058	15 887	19 175	18 289	22 011	25 829	20 965	19 846	27 754	24 901	32 828	34 706
Provincial GDP per capita relative to the national average (percent)	d	100.0	66.8	66.1	79.8	76.1	91.6	107.4	87.2	82.6	115.5	103.6	136.6	144.4
GDP distribution by sector: goods producing industries (percent)														
Primary	u	20.7	24.2	34.6	20.7	17.9	9.6	7.7	26.9	61.5	53.9	24.3	55.9	64.3
Manufacturing	u	51.9	28.4	25.1	43.7	39.4	61.2	68.6	40.4	14.9	20.6	42.7	3.2	2.8
Other goods producing industries	u	27.4	47.4	40.3	35.6	42.7	29.2	23.6	32.7	23.6	25.5	33.1	40.9	32.9
Personal income per person ($)	i	22 580	16 553	16 847	18 573	17 778	20 988	25 386	19 276	17 941	22 477	22 955	25 815	26 327
Passenger automobiles[4] (thousands)	j	13 061	202	64	426	312	2 978	4 847	544	416	1 424	1 807	20	20
Vehicles per thousand persons	c	465	349	489	464	417	421	463	489	413	548	535	673	332
Vehicles per km road network	c	15	16	13	17	15	25	29	6	2	8	29	4	5
Gasoline sales for automotive purposes														
Litres per person	o	1 223	1 038	1 314	1 202	1 254	1 023	1 242	1 268	1 623	1 646	1 143	2 364	1 068
GENERATION OF RESIDUALS														
Chemicals applied to agricultural land														
Commercial fertilizer (tonnes / ha)	g	0.18	0.69	0.59	0.39	0.56	0.47	0.37	0.16	0.10	0.14	0.37	--	--
Pesticides ($ / ha)	g	15.80	23.80	51.40	32.20	48.00	22.40	38.20	21.47	10.80	12.40	19.10	--	--
Urban solid waste														
Total (thousand tonnes)	g	10 151	270	52	362	322	2 965	3 439	397	409	883	1 023	9	22
Collected by municipality	g	8 749	196	24	293	195	2 673	3 115	354	357	780	743	4	16
Not collected by municipality[5]	g	1 402	74	28	69	126	292	324	44	52	102	280	4	6
Percent collected by municipality (percent)	c	86.2	72.5	46.0	81.0	60.7	90.1	90.6	89.0	87.2	68.4	72.6	49.4	72.7
Per capita (kg)	c	361.0	465.2	393.9	394.2	430.0	418.7	328.4	356.7	406.3	339.5	303.1	294.7	354.5
Hazardous wastes (thousand tonnes)	y	3 289.1	13.2	0.3	85.5	36.2	730.2	2 239.9	26.3	29.6	52.6	46.0	-	-
Per unit GDP (tonnes / $ million GDP)	c	4.9	1.4	0.2	4.9	2.6	4.7	8.3	1.1	1.5	0.7	0.5	-	-
Percent of national total (percent)	y	100.0	0.4	0.0	2.6	1.1	22.2	68.1	0.8	0.9	1.8	1.4	-	-
Emissions 1985														
Particulates (thousand tonnes)	s	1 709.5	123.2	8.2	72.1	90.4	309.8	282.7	54.0	126.0	218.7	413.6	7.0	3.8
Per unit GDP (tonnes / $ million GDP)	c	3.6	19.3	6.2	6.0	10.0	2.9	1.5	3.1	7.2	3.3	7.6	14.7	2.2
SO_2 (thousand tonnes)	s	3 686.6	43.4	1.7	170.4	137.7	692.7	1 440.0	469.2	85.6	538.7	105.1	0.4	1.7
Per unit GDP (tonnes / $ million GDP)	c	7.7	6.8	1.3	14.3	15.3	6.4	7.8	26.6	4.9	8.2	1.9	0.8	1.0
NO_x (thousand tonnes)	s	1 959.4	35.1	6.0	77.7	46.3	239.9	585.1	84.7	158.3	447.2	263.0	2.1	14.0
Per unit GDP (tonnes / $ million GDP)	c	4.1	5.5	4.5	6.5	5.1	2.2	3.2	4.8	9.1	6.8	4.8	4.4	8.0
CO (thousand tonnes)	s	10 780.7	197.9	64.2	298.8	287.8	1 914.5	3 242.7	431.0	644.1	1 276.6	2 376.8	13.3	33.0
Per unit GDP (tonnes / $ million GDP)	c	22.6	31.1	48.7	25.0	32.0	17.7	17.7	24.4	36.9	19.5	43.6	28.1	18.8
Hydrocarbons (thousand tonnes)	s	2 315.9	38.0	11.6	73.9	53.3	398.0	675.7	73.4	124.5	392.2	467.5	2.2	5.6
Per unit GDP (tonnes / $ million GDP)	c	4.8	6.0	8.8	6.2	5.9	3.7	3.7	4.2	7.1	6.0	8.6	4.6	3.2
VOCs (thousand tonnes)	s	1 798.0	35.5	11.0	53.7	46.1	359.2	621.3	67.6	79.9	227.7	289.0	1.9	5.1
Per unit GDP (tonnes / $ million GDP)	c	3.8	5.6	8.4	4.5	5.1	3.3	3.4	3.8	4.6	3.5	5.3	3.9	2.9

Table 1.2.2

National and Provincial Summary Statistics, 1991 (Continued)

Characteristics	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
CO_2 emissions 1990 (million tonnes)	ae	460.4	8.9	1.4	16.9	14.3	61.2	147.4	12.2	28.7	126.5	41.1	1.9	.. [6]
Per unit GDP (tonnes / $ million GDP)	c	963.2	1 405.5	1 037.9	1 413.9	1 592.4	566.6	802.7	689.9	1 645.8	1 935.2	754.2	849.9	.. [6]
Groundwater contamination 1986 (sites)	p	175	18	9	1	5	70	21	14	20	9	7	1	.. [6]
MITIGATION														
Government expenditures[7] 1990/91														
Total ($ million)	r	177 378	3 582	752	5 311	4 252	46 340	63 527	7 496	6 765	18 480	19 390	350	1 133
On environment 1990 ($ million)	r	6 187	100	10	187	88	1 683	2 279	237	209	705	638	11	40
Budget spent on environment (percent)	c	3.5	2.8	1.3	3.5	2.1	3.6	3.6	3.2	3.1	3.8	3.3	3.1	3.5
Per capita ($)	c	222.6	172.7	76.3	204.9	118.4	239.7	220.4	213.8	206.8	275.8	193.3	392.9	673.4
Private industry														
Capital expenditures 1989 ($ million)	g	89 723	1 355	237	2 469	2 010	19 512	35 755	2 548	2 820	11 702	10 310	145	860
PAC[8] expenditures ($ million)	g	1 186.0	1.3	x	16.1	67.3	255.4	434.7	12.9	x	182.2	200.2	-	x
Percent of capital expenditures (percent)	c	1.3	0.1	x	0.7	3.3	1.3	1.2	0.5	x	1.6	1.9	-	x
Waste management industry														
Revenues 1989 ($ million)	ac	1 119.1	0.9	x	13.2	4.8	339.6	517.7	14.4	4.6	91.0	127.8	x	x
Commercial use of packaging 1990														
Total consumed (thousand tonnes)	ab	13 526	166	47	338	295	3 516	5 820	514	328	1 130	1 356	5	11
Recycled (thousand tonnes)	ab	1 664	--	4	24	13	325	1 065	31	17	41	144	--	--
Percent recycled (percent)	c	12.3	--	8.5	7.1	4.4	9.2	18.3	6.0	5.2	3.6	10.6	--	--
RESOURCES														
Water														
Estimated renewable supply (km^3)	ag	2 905	207	4	33	65	774	491	174	142	153	403	120	338
Total withdrawals (million m^3)														
Municipal 1989 (million m^3 / year)	x	5 088	100	7	110	138	1 688	1 661	146	128	412	686	13	.. [6]
Per capita (m^3 / year)	c	186	173	57	122	187	243	164	132	125	165	214	152	.. [6]
Agricultural														
Industrial														
Thermal power														
Withdrawals 1989 (percent)	x													
Domestic	x	51.5	62.0	45.4	44.4	50.4	50.8	47.7	47.2	51.6	49.0	64.3	76.6	.. [6]
Commercial/institutional	x	19.1	14.3	24.7	21.5	20.2	12.6	23.1	19.7	25.8	26.0	19.8	19.3	.. [6]
Industrial	x	17.6	15.1	20.8	31.2	16.2	16.9	21.1	18.4	15.7	13.9	12.0	1.6	.. [6]
Other/unaccounted loss	x	11.8	8.5	9.1	2.9	13.2	19.6	8.1	14.7	6.9	11.1	3.9	2.5	.. [6]
Population reliant on groundwater 1981 (percent)	q	25	29	100	45	64	17	23	24	54	27	22	63	1
Minerals														
Value of mineral production														
Total value ($ million)	w	35 201.5	772.2	3.3	459.4	671.4	2 930.0	5 101.5	1 124.8	2 863.0	16 372.9	3 851.2	348.6	703.2
Metallics	w	10 473.0	734.4	-	32.4	375.4	1 888.0	3 783.9	947.6	373.0	3.0	1 522.2	335.5	477.6
Non-metallics	w	2 381.6	7.4	-	94.1	220.2	553.5	233.7	12.6	811.2	337.2	111.7	-	-
Structural materials	w	2 401.5	30.4	3.3	87.7	41.6	488.5	1 002.9	73.7	55.3	264.1	337.3	5.2	11.5
Coal	w	1 916.8	-	-	245.2	34.2	-	-	-	93.9	554.0	989.5	-	-
Natural gas	w	5 394.1	-	-	-	-	-	45.3	-	332.3	4 435.4	564.4	7.9	8.7
Natural gas by-products	w	2 178.1	-	-	-	-	-	-	0.5	10.8	2 103.8	59.8	-	3.1
Petroleum	w	10 456.4	-	-	-	-	-	35.7	90.3	1 186.5	8 675.4	266.2	-	202.3
Percentage of GDP (percent)	c	5.2	8.3	0.2	2.6	4.9	1.9	1.9	4.8	14.3	22.7	4.6	36.6	33.1
Mineral production quantities														
Metallics														
Copper (thousand tonnes)	w	780.4	-	-	x	10.5	113.9	261.9	54.9	x	-	338.6	-	-
Gold (kg)	w	175.3	x	-	-	x	51.9	77.2	2.9	2.9	0.0	18.3	3.9	16.8
Iron Ore (thousand tonnes)	w	35 421.0	19 799.0	-	-	-	14 905.0	650.0	-	-	-	67.0	-	-
Lead (thousand tonnes)	w	248.1	-	-	x	52.0	-	x	2.3	-	-	63.4	93.9	35.4
Nickel (thousand tonnes)	w	188.1	-	-	-	-	-	125.8	62.3	-	-	-	-	-
Silver (tonnes)	w	1 261.4	x	-	x	158.4	164.0	293.9	43.0	x	-	497.4	86.6	17.0
Uranium (U) (tonnes)	w	8 162.0	-	-	-	-	-	1 251.0	-	6 911.0	-	-	-	-
Zinc (thousand tonnes)	w	1 083.0	-	-	x	209.8	117.4	213.6	88.5	x	-	126.0	149.5	173.2
Non-metallics														
Salt (thousand tonnes)	w	11 871.0	-	-	x	x	x	7 182.0	-	566.0	1 245.0	-	-	-
Fuels														
Coal (thousand tonnes)	w	71 133.0	-	-	4 138.0	498.0	-	-	-	8 981.0	32 554.0	24 962.0	-	-
Natural gas (million m^3)	w	105 243.0	-	-	-	-	-	428.0	-	6 042.0	85 477.0	12 934.0	173.0	189.0
Natural gas by-products (million m^3)	w	24 919.0	-	-	-	-	-	-	6.0	122.0	24 108.0	654.0	-	29.0
Petroleum (thousand m^3)	w	89 789.0	-	-	-	-	-	235.0	713.0	12 390.0	72 478.0	2 046.0	-	1 927.0
Average price of electricity to residents ($)	c	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Forest products														
Value of production ($ million)	v	7 702.0	132.6	3.3	198.2	492.2	1 520.6	1 092.6	61.7	78.3	273.4	3 848.5	0.6	.. [6]
Percent of GDP (percent)	c	1.1	1.4	0.2	1.1	3.6	1.0	0.4	0.3	0.4	0.4	4.6	0.1	.. [6]
Production (million m^3)	c	161.8	2.7	0.4	4.3	8.6	29.6	23.9	1.2	3.0	14.3	73.7	0.1	.. [6]
Softwood (million m^3)	v	144.2	2.5	0.2	3.5	7.1	23.3	18.6	1.1	1.8	12.3	73.7	0.1	.. [6]
Hardwood (million m^3)	v	17.6	0.2	0.2	0.8	1.5	6.3	5.3	0.1	1.2	2.0	[9]	[9]	[9]
Inventoried stock (million m^3)	c	23 156	525	26	244	571	4 224	3 530	680	906	2 656	8 868	480	446
Softwood (million m^3)	v	17 835	487	16	150	362	3 020	2 205	444	536	1 684	8 180	436	315
Hardwood (million m^3)	v	5 321	38	10	94	209	1 204	1 325	236	370	972	688	44	131

Table 1.2.2

National and Provincial Summary Statistics, 1991 (Continued)

Characteristics	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Trees harvested (km^2)	d	8 599	206	21	376	925	2 368	1 997	85	175	502	1 936	4	5
Clearcut	d	7 329	206	11	369	527	1 929	1 779	85	172	500	1 743	4	5
Selective	c	1 270	-	10	6	398	440	218	-	3	2	194	-	-
Forest fire losses[10] (km^2 burned)	v	16 881	654	1	18	33	4 383	3 189	1 066	2 394	62	309	1 294	2 255
Tree replenishment														
Seeded (km^2)	d	437.09	-	-	-	0.32	0.40	367.10	0.02	-	69.25	-	-	-
Planted with seedlings (km^2)	d	4 614.05	28.91	10.32	81.98	193.30	995.50	839.17	80.36	59.15	331.80	1 993.15	-	0.39
Fish harvesting 1989														
Quantity[11] (thousand tonnes)	d	1 642.40	522.00	56.90	491.50	168.40	82.50	26.80	14.70	3.90	1.60	272.30	2.00	..[6]
Landed value ($ million)	d	1 458.80	266.40	69.80	436.20	104.90	84.70	48.10	21.50	4.20	1.90	416.30	2.70	..[6]
percent of GDP	c	0.22	3.14	3.68	2.73	0.83	0.06	0.02	0.09	0.02	--	0.54	0.31	..[6]
Energy														
Production of primary energy (PJ)	k	11 789.00	127.50	0.00	121.80	43.80	512.90	436.60	108.80	887.30	7 869.00	1 588.60	92.60	..[6]
Availability of primary energy (PJ)	k	8 632.80	33.50	3.30	73.30	38.60	1 424.00	2 731.70	161.00	x	2 350.30	757.10	x	..[6]
Net domestic consumption (PJ)	k	7 764.30	133.80	21.20	176.90	175.80	1 469.10	2 575.20	253.00	360.30	1 719.50	851.90	27.60	..[6]
per capita (GJ / cap)	k	276.10	230.70	162.20	192.70	234.90	207.50	245.90	227.30	357.80	661.30	252.30	306.40	..[6]
Energy use final demand by sector														
Industrial (percent)	k	32.5	31.0	5.5	13.5	29.2	36.5	32.8	17.4	26.0	36.5	33.1	20.9	..[6]
Transportation (percent)	k	28.7	34.4	38.5	40.1	33.0	26.3	27.7	34.3	30.1	25.1	33.7	22.0	..[6]
Residential and farms (percent)	k	21.9	17.3	33.5	25.8	21.6	20.8	22.6	27.8	30.5	21.2	17.1	15.7	..[6]
Government and commercial (percent)	k	16.9	17.4	22.5	20.6	16.2	16.4	17.0	20.5	13.4	17.2	16.0	41.4	..[6]
Gross availability by type (PJ)	k	8 515.5	145.7	22.1	236.1	221.6	1 473.5	2 788.0	255.8	443.9	2 042.2	855.6	31.0	..[6]
Coal (percent)	k	13.2	1.6	0.6	28.4	5.5	1.4	16.8	2.1	26.4	20.5	1.2	-	..[6]
Oil products and LPGs (percent)	k	39.3	76.0	88.2	69.4	84.2	45.3	36.1	38.3	29.1	25.0	44.2	72.6	..[6]
Natural gas (percent)	k	31.8	-	-	-	-	14.0	30.2	34.8	40.9	54.2	31.7	19.8	..[6]
Primary steam and electricity (percent)	k	15.8	22.3	11.2	2.2	10.3	39.3	14.9	24.9	3.6	0.3	22.9	7.5	..[6]
Generation of electricity														
Total (GWh)	aa	493 025.6	36 942.7	71.4	9 393.5	15 807.5	142 992.0	142 442.7	22 891.4	13 598.3	44 479.2	63 373.9	1 033.2	..[6]
Hydro (GWh)	aa	305 289.1	35 409.3	-	1 038.4	3 002.8	138 550.1	37 646.1	22 554.4	4 213.7	2 029.6	60 197.0	647.5	..[6]
Wind and tidal (GWh)	aa	32.0	-	-	32.0	-	-	-	-	-	-	-	-	..[6]
Steam (GWh)	aa	103 109.6	1 457.3	68.1	8 312.2	7 297.5	291.1	32 756.8	308.9	9 325.0	40 313.2	2 979.5	-	..[6]
Nuclear (GWh)	aa	80 122.2	-	-	-	5 439.9	3 909.8	70 772.6	-	-	-	-	-	..[6]
Internal combustion (GWh)	aa	810.5	72.6	0.3	-	--	237.7	1.9	28.0	2.9	30.1	143.6	293.3	..[6]
Combustion turbine (GWh)	aa	3 662.2	3.4	3.0	10.9	67.3	3.3	1 265.3	-	56.6	2 106.2	53.8	92.3	..[6]
Total renewable (GWh)	c	305 321.1	35 409.3	-	1 070.4	3 002.8	138 550.1	37 646.1	22 554.4	4 213.7	2 029.6	60 197.0	647.5	..[6]
Total renewable (PJ)	c	1 099.2	127.5	-	3.9	10.8	498.8	135.5	81.2	15.2	7.3	216.7	2.3	..[6]
Percentage of electrical production	c	61.9	95.8	-	11.4	19.0	96.9	26.4	98.5	31.0	4.6	95.0	62.7	..[6]
Percentage of energy production	c	9.3	100.0	-	3.2	24.7	97.3	31.0	74.6	1.7	0.1	13.6	2.5	..[6]
Agriculture														
Value of agricultural production ($ million)	c	19 086.3	58.1	218.8	305.1	241.2	3 191.3	5 049.4	1 725.0	3 355.4	3 757.2	1 184.7	--	--
Crops	af	8 324.4	9.7	120.8	80.9	95.4	674.3	1 886.7	989.3	2 500.5	1 514.1	452.7	--	--
Livestock	af	10 761.9	48.4	98.0	224.1	145.8	2 517.0	3 162.7	735.7	854.9	2 243.1	732.0	--	--
Percent of GDP (percent)	c	2.8	0.6	10.5	1.7	1.8	2.0	1.9	7.4	16.8	5.2	1.4	--	--
Land														
Total area (km^2)	d	9 970 610	405 720	5 660	55 490	73 440	1 540 680	1 068 580	649 950	652 330	661 190	947 800	483 450	3 426 320
Water area (km^2)	d	755 180	34 030	--	2 650	1 350	183 890	177 390	101 590	81 630	16 800	18 070	4 480	133 300
Land area (km^2)	d	9 215 430	371 690	5 660	52 840	72 090	1 356 790	891 190	548 360	570 700	644 390	929 730	478 970	3 293 020
Farms	d	677 537	473	2 589	3 970	3 756	34 296	54 514	77 250	268 655	208 110	23 923	-	-
Forest	v	4 532 000	225 000	3 000	40 000	63 000	940 000	807 000	349 000	237 000	377 000	603 000	274 000	614 000
Other	c	4 005 893	146 217	71	8 870	5 334	382 494	29 676	122 110	65 045	59 280	302 807	204 970	2 679 020
Land use distribution (percent of land area)														
Farms	c	7.4	0.1	45.7	7.5	5.2	2.5	6.1	14.1	47.1	32.3	2.6	-	-
Forest	c	49.2	60.5	53.0	75.7	87.4	69.3	90.6	63.6	41.5	58.5	64.9	57.2	18.6
Other	c	43.5	39.3	1.3	16.8	7.4	28.2	3.3	22.3	11.4	9.2	32.6	42.8	81.4
Use of farm land														
Improved land total (km^2)	g	455 699	110	1 744	1 381	1 488	19 241	38 655	53 993	202 474	128 059	8 553	-	-
Under crops (km^2)	g	335 078	63	1 541	1 062	1 222	16 385	34 117	47 610	134 589	92 920	5 568	-	-
Improved pasture (km^2)	g	41 412	46	193	307	250	2 709	3 902	3 413	10 757	17 425	2 410	-	-
Summerfallow (km^2)	g	79 209	1	10	12	16	147	637	2 970	57 128	17 714	575	-	-
All other land (km^2)	g	221 838	363	845	2 589	2 268	15 055	15 858	23 256	66 181	80 051	15 371	-	-
Total area of farms (km^2)	g	677 537	473	2 589	3 970	3 756	34 296	54 514	77 250	268 655	208 110	23 923	-	-
Soil erosion by water (million tonnes)	g	125.8	-	0.8	0.2	0.7	3.4	17.0	12.6	67.2	22.9	1.0	-	-
Rate (tonnes / ha)	g	3.8	-	5.2	1.9	5.7	2.1	5.0	2.6	5.0	2.5	1.8	-	-
Cropland cultivated (percent)	g	80.9	97.7	99.4	98.9	98.7	99.1	98.2	94.1	70.2	84.0	90.6	-	-

Table 1.2.2

National and Provincial Summary Statistics, 1991 (Continued)

Characteristics	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Protected area: Total (km²)	c	892 749	7 617	333	3 187	3 935	164 909	77 008	167 256	17 030	66 519	103 140	49 452	232 364
Percent of land area (percent)	c	9.7	2.0	5.9	6.0	5.5	12.2	8.6	30.5	3.0	10.3	11.1	10.3	7.1
Highly protected: IUCN I (km²)	t	23 114	3 992	-	14	1	447	4 346	569	4 174	1 279	5 667	-	2 624
Medium-highly protected: IUCN II (km²)	t	366 169	2 705	45	1 433	626	9 367	53 592	13 174	11 190	63 903	97 003	14 568	98 561
Moderately protected: IUCN III-V (km²)	t	503 466	919	288	1 740	3 308	155 095	19 069	153 513	1 666	1 337	469	34 883	131 178
Road network 1990-91														
Two-lane equivalent[12] (km)	n	874 155	12 290	4 935	25 779	20 670	119 321	167 500	84 965	193 923	173 473	62 158	5 238	3 903
Density (km / thousand km² land area)	c	95	33	872	488	287	88	188	155	340	269	67	11	1
Wildlife														
Vascular plants														
Species known	ad	3 269	1 548	1 040	1 500	1 987	2 543	2 888	1 417	1 536	1 692	2 000	1 150	1 113
Species rare	ad	1 009	40	6	45	25	106	355	52	77	125	426	91	62
Percent of known (percent)	c	30.9	2.6	0.6	3.0	1.3	4.2	12.3	3.7	5.0	7.4	21.3	7.9	5.6
CLIMATE														
Degree days below 18° Celsius	k	3 933	5 152	4 665	4 163	4 597	4 243	3 306	5 536	5 472	4 854	2 904	7 335	[6]

Notes:

Figures may not add due to rounding.

1. Projection 3 - medium growth.
2. Total fertility rate is the number of children each woman would bear in her lifetime, based on the age-specific rates for a particular year. A generation would be replaced if the number of children born was 2.1 children per woman.
3. The sum of the GDPs of the 12 provinces and territories is not equal to the Canada-level GDP because the latter also includes wages and salaries of public servants working in embassies abroad.
4. Includes taxis and for-hire cars.
5. Estimated quantities generated by households but not collected by municipal employees or agents under their contract. This includes private waste collection and individual use of disposal facilities.
6. Figures for the Northwest Territories are included with Yukon.
7. By provincial and local administrations.
8. Pollution abatement and control expenditures by private industry.
9. Figures for hardwoods are included in values for softwoods.
10. Includes 1 224 hectares burned in national parks not allocated to any province.
11. Quantity refers to live weight equivalent of landings.
12. Canada figure includes 14 743 km under federal jurisdiction.

Sources:

a. Statistics Canada, intercensal estimates adjusted for net undercount and non-permanent residents.
b. Statistics Canada, Demography Division.
c. Calculated.
d. Statistics Canada, *Canada Year Book, 1994*, Catalogue No. 11-402, Ottawa, 1994.
e. Statistics Canada, *Mortality: Summary List of Causes*, Catalogue No. 84-209, Ottawa, 1993.
f. Statistics Canada, *National Income and Expenditure Accounts, Annual Estimates*, Catalogue No. 13-201, Ottawa, 1993.
g. Statistics Canada, National Accounts and Environment Division.
h. Statistics Canada, *Census Overview of Canadian Agriculture: 1971-91*, Catalogue No. 93-348, Ottawa, 1993.
i. Statistics Canada, *Provincial Economic Accounts*, Catalogue No. 13-213, Ottawa, 1993.
j. Statistics Canada, *Road Motor Vehicles, Registrations*, Catalogue No. 53-219, Ottawa, 1992.
k. Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, 1993.
l. Statistics Canada, *Electric Power Statistics*, Catalogue No. 57-202, Ottawa, 1993.
m. Statistics Canada, Canadian Centre for Health Information.
n. Transportation Association of Canada.
o. Statistics Canada, *Road Motor Vehicles Fuel Sales*, Catalogue No. 53-218, Ottawa, 1993.
p. Beak Consultants Limited, *Groundwater Contamination in Canada: Selected Cases, Potential Sources and Protection Strategy*, Prepared for Environment Canada, 1986.
q. Environment Canada, Conservation and Protection.
r. Statistics Canada, *Public Finance Historical Data 1965/66 - 1991/92*, Catalogue No. 68-572, Ottawa, 1993.
s. Environment Canada, Regulatory Affairs and Program Integration Branch, *Canadian Emissions Inventory of Common Air Contaminants (1985)*, Ottawa, 1990.
t. Environment Canada, State of the Environment Reporting Directorate, National Conservation Areas Database, 1993.
u. Statistics Canada, Industry Measures and Analysis Division.
v. Statistics Canada, *Canadian Forestry Statistics*, Catalogue No. 25-202, Ottawa, 1992.
w. Statistics Canada, *General Review of the Mineral Industries 1991*, Catalogue No. 26-201, Ottawa, 1993.
x. Environment Canada, *Municipal Water Use in Canada*, Ottawa, 1991.
y. Fenco Newfoundland Lavalin, *Report on the Economic Profile of the Hazardous Waste Management Service Subsector in Canada, 1988*. Unpublished report quoted in Government of Canada, *The State of Canada's Environment*, 1991, p. 21-22.
z. Energy, Mines and Resources Canada, *The National Atlas of Canada, Fifth Edition*, Ottawa, 1990.
aa. Statistics Canada, *Electric Power Statistics: Volume II Annual Statistics 1991*, Catalogue No. 57-202, Ottawa, 1993.
ab. National Task Force on Packaging, *National Packaging Protocol: Results of the 1990 National Packaging Survey*. Report prepared for the Canadian Council of Ministers of the Environment, Office of Waste Management, Environment Canada, Hull, 1992.
ac. Statistics Canada, Industry Division and National Accounts and Environment Division.
ad. George W. Argus and Kathleen M. Pryer, *Rare Vascular Plants in Canada*, Canadian Museum of Nature, Ottawa, 1990.
ae. Environment Canada, *Canada's Greenhouse Gas Emissions: Estimates for 1990*, Ottawa, 1992.
af. Statistics Canada, *Agriculture Economic Statistics*, Catalogue No. 21-603, Ottawa, 1993.
ag. Statistics Canada, National Accounts and Environment Division and J. Forkasiewicz and J. Margat, *Tableau Mondial de données nationales d'économie et de l'eau, ressources et utilisations*, Département Hydrogéologique, Orléans, France, 1980.
ah. Statistics Canada, Census of Population.

1.3 The Population-Environment Process Framework

The organizational structure of *Human Activity and the Environment 1994* is based on the Population-Environment Process framework (PEP). It is important to understand what PEP represents and why it is useful before interpreting the data in this publication.

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PEP is a conceptual representation of how modern society interacts with the natural environment. It simplifies many complex relationships and interactions while enhancing the reader's understanding of how human activities affect the environment. The development of any statistical data requires a set of supporting principles or guidelines to serve as the foundation for data collection and organization. This foundation, or framework, is primarily used to organize complex statistical relationships into their principal elements. PEP plays this role in *Human Activity and the Environment 1994*.

Linking human activities to environmental impacts requires a framework that links the production and consumption activities of the economy to the population and to the supporting natural environment. This framework should be sufficiently comprehensive to include population dynamics, natural resource utilization and measures of natural environmental quality. It must also provide links to existing statistical frameworks at Statistics Canada, such as the national accounts, population census and business surveys.

Existing economic and social frameworks provide only a partial perspective of human-environment interactions. A more appropriate framework would allow an assessment of the sustainability of human activities and their impact on the environment which supports them. Past environmental reports have used many different approaches to data organization and each of these has strengths and weaknesses. The following is a list of the main organizing frameworks used in past reports:[1]

- **Issues approach** - Many publications are organized according to current policy issues. For example, acid precipitation, global warming and soil loss might provide a skeleton for the report with the other environmental data ordered according to these issues. This approach has the advantages of timeliness and topicality. However, it lacks comprehensiveness and it may overlook important cross-cutting problems. Issues can also change very quickly.
- **Resource sector approach** - This approach classifies data according to resource activities: agriculture, forestry, fisheries, mineral extraction and energy production. This provides information that is readily related to the benefits we take from the environment as well as many of the economic implications of environmental change (decline in productive forests and fish stocks, for instance). This approach does not integrate multiple impact issues.
- **Environmental media** - The most traditional organizational framework for environmental data divides the world into the categories of biota, land, air and water. This has the advantage of familiarity - we can all relate to air that is unbreathable or water that is polluted - but it is weak in categorizing cross-media and biological effects. It is also weak in linking socio-economic activity to environmental impact.
- **Environmental process approach** - This approach is based on the measurement of the physical and biological processes fundamental to natural ecosystems and the human activities that have impacts upon them. Concentrating on environmental processes is both systematic and integrative, in the sense that all human and natural agents of change will eventually produce alterations in ecosystem operation.
- **Combination frameworks approach** - This approach applies aspects of several other organizing principles. This can be seen quite clearly in the 1986 *State of Environment Report for Canada*[2] which combined resource sector and environmental process approaches.
- **System of National Account satellite accounting approach** - A new and increasingly popular framework for environmental analysis views the natural environment as a complex set of assets (timber, mineral deposits, wildlife, clean air and water, etc.) which can in principle be measured and valued much like conventional economic assets (housing, capital equipment, consumer durable goods, etc.). Several countries, including Canada, are presently developing comprehensive "environmental satellite accounts" that include time series quantity and value estimates of environmental stocks and flows including pollution flows, all linked to the traditional System of National Accounts.

The PEP framework is an extension of the combination framework. It divides the world into three sub-sets: **population**, **economy** and the **natural environment**. Each one is characterized by its **stocks** (or states), **processes** (or activities) and interactions represented by **flows** (or restructuring).

1. Sheehy, G., *Organizational and Spatial Frameworks for State of the Environment Reporting*, Environment Canada, Ottawa, 1989.

2. Environment Canada, *State of the Environment Report for Canada*, Ottawa, 1986.

From the diagram in Figure 1.3.1, three major components of PEP can be seen: stocks (represented by barrels), processes (represented by boxes) and interactions (represented by arrows). Examples are provided in Table 1.3.1.

Impacts on the natural environment resulting from human activities are referred to collectively in the PEP framework as environmental **restructuring**. The PEP framework describes a loop of interactions and processes between people, the economy and the environment. Population, the driving force in PEP, appears as a stock affected by a set of population processes (birth, death and migration). This population draws goods and services from a set of economic stocks (capital stock of durable items). The economic processes (production and consumption) give rise to activities that restructure the natural environment (i.e. road building, air pollution, water pollution, soil erosion). At the same time economic processes depend on flows of resources (both living and non-living) and services from the stocks of natural assets. The population also interacts directly with stocks of natural assets by breathing air, drinking water, engaging in activities such as fishing, hunting, canoeing, camping and hiking, and enjoying the aesthetics and amenities provided by the natural world. Direct use of the environment by the population inevitably leads to some restructuring, either physically or chemically through the release of wastes.

There are four basic types of restructuring:[1] (i) **physical** restructuring results from the construction of dams, roads, power lines, mines, dump sites and other large scale changes to the natural landscape; (ii) **chemical** restructuring results from the release of wastes into the environment; (iii) **thermal** restructuring results from the release of waste heat or chemically induced heating from pollutants; (iv) **biological** restructuring is the result of habitat destruction, harvesting or the introduction of exotic species.

Wastes are treated as a separate output of economic processes. The generation of wastes does not necessarily have a direct environmental impact. These by-products of production may be treated, stored or recycled to minimize their impact.

The stocks of natural assets change as a result of interactions with the population, economic processes and natural processes. The latter includes growth and decline of living populations, other biological processes, and geochemical processes.

The interaction of natural processes and human-induced restructuring is the least understood portion of human-environment interactions. Measurement of environmental quality is a necessary input to policy decisions on health, sustainability and aesthetic value. The systematic measurement of restructuring activities increases our scientific understanding of environmental change. For instance, enforcing environmental quality legislation requires measurement of restructuring activities such as emissions to air and water.

The strengths of the PEP framework come from the linkages it provides between disparate data sets. For example:

- there is a direct link between the framework and measures of economic processes that are the subject matter of existing Statistics Canada surveys;
- population state and population processes are measured in current health and demographic statistical systems;
- the natural asset component of the framework builds on existing natural resource data and biophysical statistics;
- linkages to the System of National Accounts are quite explicit: the flows associated with the economic process component of the framework make up a substantial portion of Gross Domestic Product; the capital stock constitutes a portion of tangible assets in the National Balance Sheet. PEP suggests the desirability of measuring natural assets as another type of tangible asset within the National Balance Sheet Accounts.[2]

The purpose of including components that are not strictly "environmental" such as industrial production or population growth, is to show how traditional environmental data (emissions, loadings in media and biota, measures of physical and biotic state) can integrate with economic data to provide a more complete picture of how environmental quality may be related to economic activities and how economic activities may be influenced by changing environmental quality.

Human Activity and the Environment 1994 is organized around the principal components in PEP. Chapter 1 introduces key concepts and compares Canada's environmental performance to a group of other countries. Chapter 1 also uses provincial environmental profiles to compare the relative environmental impacts of human activity in each of Canada's 10 provinces and 2 territories. Chapter 2 describes the population and population processes by looking at Canada's population characteristics and distributional changes over time. Chapter 3 describes capital stock and economic processes and their relationship to the natural environment. Chapter 4 describes natural processes and assets by profiling Canada's wealth of land, forests, minerals, climate and the processes controlling them.

1. The real world is much more complex than these relationships might indicate. For example, all four types of restructuring and others un-accounted for here, could occur simultaneously in varying degrees in one restructuring event.

2. Statistics Canada, *Financial Flows and National Balance Sheet Accounts*, Catalogue No. 13-214, Ottawa, 1987.

Figure 1.3.1
Population-Environment Process Framework

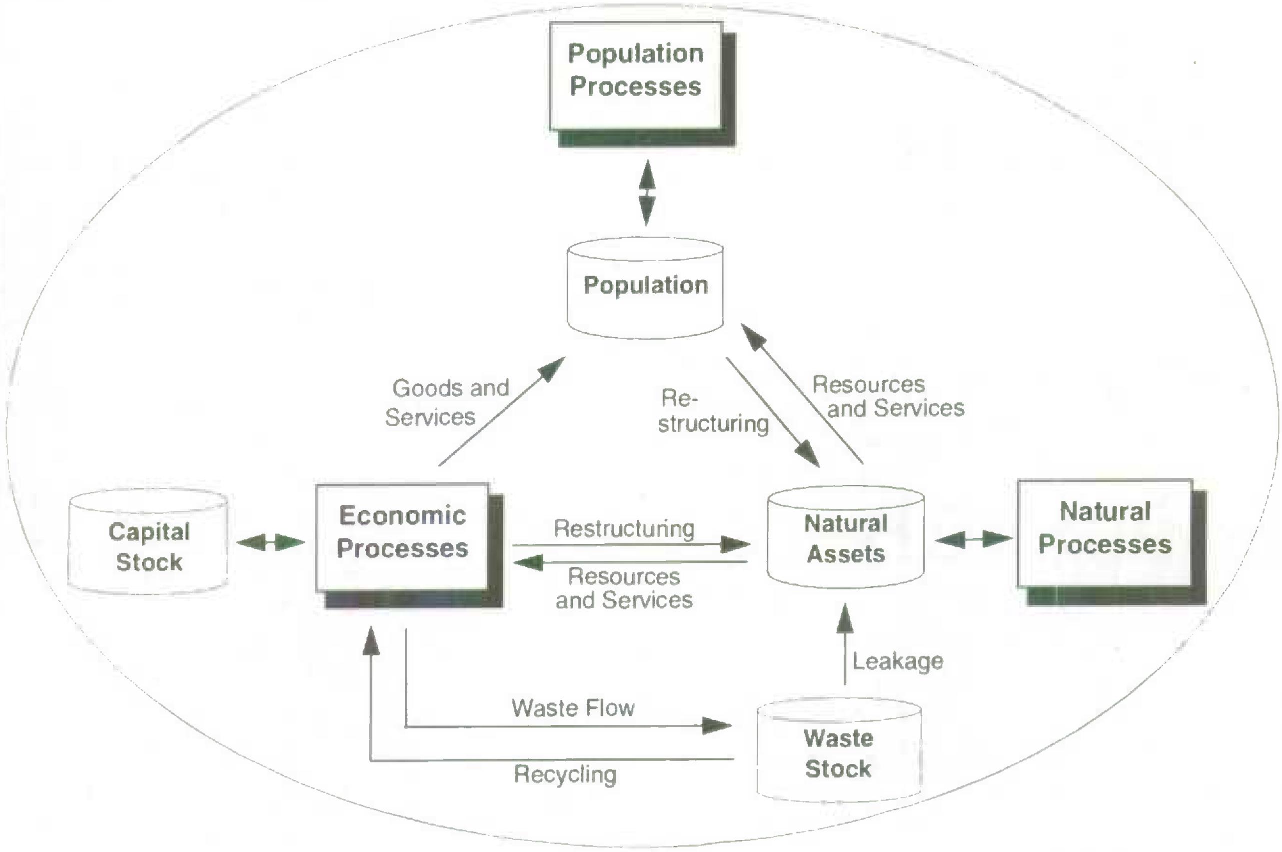

Table 1.3.1
The PEP Framework Components

Component	Variable type	Examples
Stocks		
Population	State	Number and location of people; number of households; health status; employment; income.
Capital	State	Stocks of capital for pollution abatement and control; built-up area; transportation infrastructure.
Natural assets	State	Quantity and quality of minerals and energy; quantity and quality of living resources; air quality; water quantity and quality; amount and quality of wilderness; land cover.
Wastes	State	Quantity and location of wastes; number of landfill sites.
Processes		
Population	Activity	Growth, migration, birth, death.
Economic	Activity	Outputs by sector; production and consumption of environmentally dangerous substances; energy consumption; operation of transportation stock.
Natural	Activity	Rates of geochemical cycles; natural events (storms, earthquakes, fires, pest infestations).
Interactions		
Economic processes with Population	Flow	Consumption; employment; contaminants in food and other goods.
Natural assets with Population	Flow	Air quality in populated areas; sport fishing and hunting; ground water withdrawals; water quality.
Natural assets with Economic Processes	Flow	Extraction of minerals and energy; water use; harvest of forests, fish and wildlife; agricultural production.
Population with Natural assets	Restructuring	Impacts of visits to wilderness and protected areas; impacts of extracting local environmental resources (e.g. firewood).
Economic processes with Natural assets	Restructuring	Physical restructuring through development of agriculture, mines, dams, and transport infrastructure; biological restructuring through harvesting activities.
Wastes with Natural assets	Flow	Release of pollutant emissions and wastes, breakdown of wastes.
Economic processes with Wastes	Flow	Generation of waste materials.
Wastes with Economic processes	Flow	Recycling.

1.4 Geographic Units for Environmental Analysis

Today's society is placing increasing demands on the environment to supply raw materials, energy and food to meet the demands of a growing human population. While resource consumption increases, the environment must continue to absorb expanding volumes of waste and other toxic products. Careful management will be required to ensure that environmental sustainability is achieved and that human induced stresses do not permanently disrupt essential natural systems. *Human Activity and the Environment 1994* presents detailed socio-economic information describing the relationships between people and the environment. The information is presented using a spatial framework that enhances conventional information for environmental analysis. A clear understanding of the environmental geographies employed in this publication is required at the outset to assist the reader in interpreting the data in the subject matter chapters.

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Historically, statistics have been gathered and presented most often using political or administrative boundaries, such as municipalities, counties or provinces. This publication combines typical administrative units with environmental geographies to enhance socio-economic data for environmental analysis. Both drainage basins and ecozones are used as a consistent spatial frame to analyse information in *Human Activity and the Environment 1994*. These environmental geographies are based on fixed physical properties that make them useful for spatial analysis.

Much of the statistical information in this publication is socio-economic and is presented in time series. In order to isolate and examine actual temporal changes in spatial information, it is essential that the geographic frame remain constant to allow comparison over time. Political boundaries below the provincial level change frequently because they are delineated on the basis of a changing population. For example, Toronto's population increased from 2.9 million to 3.9 million between 1981 and 1991. To accommodate this growth, Toronto's city boundaries expanded from 3 743 to 5 584 km^2. This increase in city area creates an apparent decline in population density, from 801 persons per km^2 in 1981 to 697 persons per km^2 in 1991. In contrast, when the Toronto area drainage basin is used as the spatial reference, population density actually increased from 717 to 868 persons per km^2 during the same time period. The drainage basin figures provide a more realistic picture of actual population density change and indicate increasing population pressure and associated environmental stresses in the Toronto area. This is not apparent using the changing city boundary as the spatial reference.

Drainage Basins

Drainage basins, watersheds, river basins or river valleys are all examples of terms used to describe a surface drainage catchment area. The boundaries that delineate a drainage basin usually follow heights of land. For example, the peak of a mountain range can form a drainage basin boundary separating two drainage catchment areas.

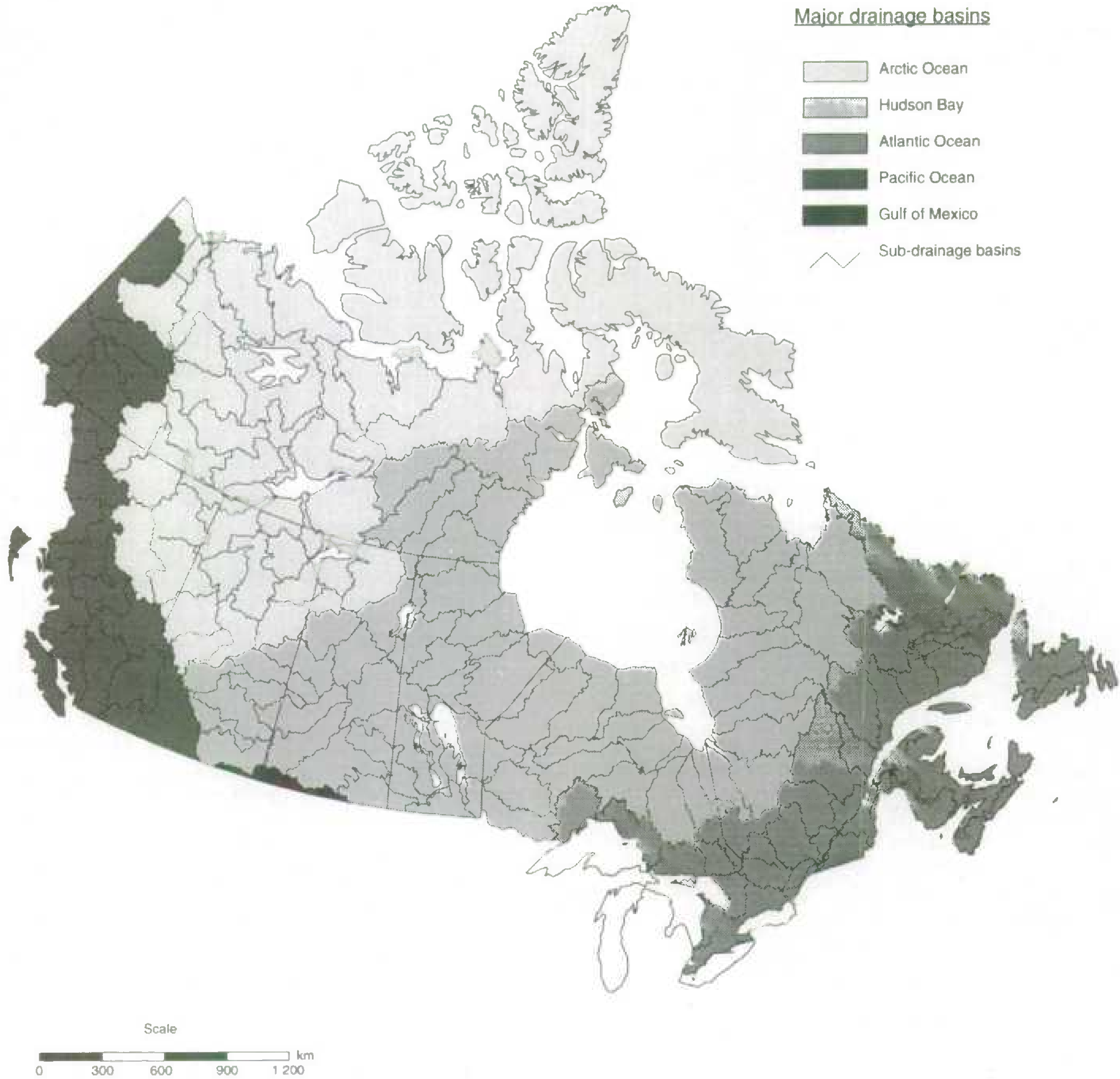
Drainage basins are useful geographic boundaries for the analysis of many different types of socio-economic information. For example, human settlements and industries can have many impacts on water systems, affecting water use, water discharge and water quality. Analysing activities by drainage basin links the impact activity directly to the system being stressed. Another example of an impact on drainage basins is the effect of thermal loading from power generating stations. Thermal pollution has significant impacts on water chemistry and physical properties primarily by raising water temperature, resulting in changes to natural plant or animal species mixes. Indigenous plant and animal species can also be affected by excess nutrient loading in streams and lakes from both agricultural and residential run-off. Measuring increased fertilizer use in a drainage basin can indicate potential nutrient loading problems, such as excessive algae growth within a water body. Problems occur as the excess algae decomposes, consuming free oxygen (a process known as *eutrophication*). This reduction in free oxygen has adverse effects on fish and wildlife.

The drainage basin classification used in this publication is consistent with the system used by the Water Survey of Canada[1]. Drainage basins are differentiated by the natural hierarchy of stream branching. Canada is part of the North American continental hydrological system of which five basins are found at the apex of the hierarchy. These are: (i) Atlantic Ocean Basin, (ii) Hudson Bay Basin, (iii) Arctic Ocean Basin, (iv) Pacific Ocean Basin and (v) Gulf of Mexico Basin. In Canada, the Gulf of Mexico Basin extends over a small area of southern Alberta and Saskatchewan. Map 1.4.1 provides an outline of Canada's five major basins which are sub-divided into 218 sub-drainage basins. Table 1.4.1 describes sub-drainage basin names and areas. These sub-drainage basins can be further sub-divided into 917 sub-sub-drainage basins.

Many tables in this report present statistics by major drainage areas and sub-drainage basins.

1. Environment Canada, *Hydrometric Map Supplement*, Water Survey of Canada, Ottawa, 1986.

Map 1.4.1
Major Drainage Basins of Canada



Source:
Environment Canada, Water Surveys Branch.

Table 1.4.1
Sub-drainage Basin Names and Areas

Province code	Sub-basin code	Province/sub-basin	Area (km²)
		Newfoundland	
10	2V	Romaine	2 709
10	2W	Natashquan	6 438
10	2X	Little Mecatina and Strait of Belle Isle	25 731
10	2Y	North Newfoundland	66 367
10	2Z	South Newfoundland	46 058
10	3N	North Labrador	86 701
10	3O	Churchill	83 035
10	3P	Naskaupi and Central Labrador	35 135
10	3Q	Eagle and South Labrador	47 022
10		Lakes	6 527
		Total	**405 720**
		Prince Edward Island	
11	1C	Prince Edward Island	5 660
		Total	**5 660**
		Nova Scotia	
12	1D	Bay of Fundy	20 860
12	1E	Southeast Atlantic Ocean	23 062
12	1F	Cape Breton Island	11 568
		Total	**55 490**
		New Brunswick	
13	1A	Saint John and South Bay of Fundy	34 627
13	1B	Gulf of St. Lawrence and North Bay of Fundy	38 736
13	2Q	North Gaspé Peninsula	77
		Total	**73 440**
		Quebec	
24	1A	Saint John	7 011
24	1B	Cascapédia and Gulf of St. Lawrence	21 809
24	2J	Upper Ottawa	33 256
24	2K	Coulonge and Central Ottawa	17 320
24	2L	Gatineau and Lower Ottawa	45 401
24	2M	Upper St. Lawrence	955
24	2N	St-Maurice	44 296
24	2O	Central St. Lawrence	34 539
24	2P	Lower St. Lawrence	37 577
24	2Q	North Gaspé Peninsula	13 795
24	2R	Saguenay	87 489
24	2S	Betsiamites	27 280
24	2T	Manicouagan and Aux Outardes	67 763
24	2U	Moisie and St. Lawrence Estuary	39 456
24	2V	Romaine and Gulf of St. Lawrence	34 260
24	2W	Natashquan and Gulf of St. Lawrence	47 282
24	2X	Little Mecatina	24 753
24	3A	Nottaway	65 559
24	3B	Broadback and Rupert	72 353
24	3C	Eastmain	53 040
24	3D	Fort George and Sakami	111 606
24	3E	Great Whale and Southeast Hudson Bay	63 541
24	3F	Little Whale and East Hudson Bay	37 691
24	3G	Northeast Hudson Bay	103 382
24	3H	West Ungava Bay	84 552
24	3J	Aux Feuilles	53 761
24	3K	Koksoak	46 222
24	3L	Caniapiskau	92 910
24	3M	East Ungava Bay	104 595
24	4M	Abitibi and North French	4 297
24	4N	Harricanaw	28 598
		Total	**1 506 350**

Province code	Sub-basin code	Sub-basin	Area (km²)
		Ontario	
35	2A	Nipigon and Northwest Lake Superior	43 038
35	2B	Northeast Lake Superior	40 068
35	2C	North Lake Huron	34 378
35	2D	Wanipitai and French	19 109
35	2E	East Georgian Bay	22 254
35	2F	East Lake Huron	14 810
35	2G	North Lake Erie	22 944
35	2H	Lake Ontario	28 709
35	2J	Montréal and Upper Ottawa	17 624
35	2K	Madawaska, Petawawa and Central Ottawa	22 903
35	2L	Rideau and Lower Ottawa	9 009
35	2M	Upper St. Lawrence	4 454
35	4A	Hayes	16 750
35	4B	Nisksibi and Central Hudson Bay	16 975
35	4C	Severn	89 407
35	4D	Winisk	78 477
35	4E	Ekwan	51 525
35	4F	Attawapiskat	56 098
35	4G	Upper Albany	63 815
35	4H	Lower Albany	39 259
35	4J	Kenogami	51 194
35	4K	Kwataboahegaa	9 047
35	4L	Moose	63 296
35	4M	Abitibi	32 707
35	4N	Harricanaw	15 894
35	5P	Upper Winnipeg	43 435
35	5Q	English	51 416
35	5R	East Lake Winnipeg	21 720
		Total	**980 315**
		Manitoba	
46	4A	Hayes	92 288
46	4B	Nisksibi and Central Hudson Bay	17 562
46	4C	Severn	3 227
46	5J	Qu'Appelle	59
46	5K	Saskatchewan	18 815
46	5L	Lake Winnipegosis and Lake Manitoba	54 912
46	5M	Assiniboine	24 874
46	5N	Souris	9 040
46	5O	Red	25 547
46	5P	Winnipeg	12 973
46	5R	East Lake Winnipeg	34 248
46	5S	West Lake Winnipeg	23 910
46	5T	Rat and Grass	42 413
46	5U	Nelson	49 164
46	6D	Reindeer Lake	10 744
46	6E	Central Churchill	43 360
46	6F	Lower Churchill and West Hudson Bay	55 298
46	6G	Seal and West Hudson Bay	75 813
46	6H	Nueltin Lake	19 159
46	6L	Kazan	807
46		Lakes	35 738
		Total	**649 950**

Table 1.4.1
Sub-drainage Basin Names and Areas (Continued)

Province code	Sub-basin code	Province/sub-basin	Area (km^2)
		Saskatchewan	
47	5A	Upper South Saskatchewan	920
47	5C	Red Deer	199
47	5E	Central North Saskatchewan	13 562
47	5F	Battle	4 431
47	5G	Lower North Saskatchewan	41 103
47	5H	Lower South Saskatchewan	55 013
47	5J	Qu'Appelle	70 192
47	5K	Saskatchewan	58 186
47	5L	Lake Winnipegosis and Lake Manitoba	18 789
47	5M	Assiniboine	26 964
47	5N	Souris	29 449
47	6A	Beaver	32 379
47	6B	Upper Churchill	43 331
47	6C	Upper Central Churchill	45 496
47	6D	Reindeer Lake	48 425
47	6E	Central Churchill	8 124
47	6H	Nueltin Lake	147
47	6L	Kazan	7 849
47	7C	Lower Central Athabasca	14 382
47	7D	Lower Athabasca	2 446
47	7L	Fond du Lac	63 808
47	7M	Athabasca Lake	27 677
47	7Q	Taltson and Southeast Great Slave Lake	4 366
47	11A	Missouri	20 506
47		Lakes	14 585
		Total	**652 330**
		Alberta	
48	5A	Upper South Saskatchewan	45 921
48	5B	Bow	25 442
48	5C	Red Deer	49 135
48	5D	Upper North Saskatchewan	27 964
48	5E	Central North Saskatchewan	28 759
48	5F	Battle	25 703
48	5G	Lower North Saskatchewan	10 764
48	5H	Lower South Saskatchewan	129
48	6A	Beaver	16 973
48	6B	Upper Churchill	668
48	7A	Upper Athabasca	34 896
48	7B	Pembina and Central Athabasca	41 135
48	7C	Lower Central Athabasca	42 244
48	7D	Lower Athabasca	26 719
48	7F	Upper Peace	17 550
48	7G	Smoky	46 148
48	7H	Central Peace	35 731
48	7J	Lower Central Peace	58 730
48	7K	Lower Peace and Lake Claire	36 452
48	7M	Athabasca Lake	4 630
48	7N	Slave	11 584
48	7O	Upper Hay	39 721
48	7P	Buffalo	16 395
48	7Q	Taltson and Southeast Great Slave Lake	1 392
48	7U	West Great Slave Lake	521
48	10C	Fort Nelson	1 206
48	10D	Petitot	7 698
48	11A	Missouri	6 982
		Total	**661 190**
		Yukon	
60	8A	Alsek	25 931
60	9A	Upper Yukon	67 084
60	9B	Pelly	50 282
60	9C	Upper Central Yukon	44 091
60	9D	Stewart	51 882
60	9E	Central Yukon	29 927
60	9F	Porcupine	62 246
60	9G	Tanana	1 993
60	10A	Upper Liard	38 634
60	10B	Central Liard	19 284
60	10D	Petitot	2 366
60	10M	Peel and Northwest Arctic Ocean	89 730
		Total	**483 450**

Province code	Sub-basin code	Sub-basin	Area (km^2)
		British Columbia	
59	7E	Williston Lake	72 865
59	7F	Upper Peace	49 133
59	7G	Smoky	4 975
59	7O	Upper Hay	8 379
59	7U	West Great Slave Lake	124
59	8A	Alsek	8 478
59	8B	Taku and North Pacific Ocean	22 600
59	8C	Stikine	50 728
59	8D	Nass and North Central Pacific Ocean	30 022
59	8E	Skeena	56 521
59	8F	Gardner Canal and Central Pacific Ocean	52 379
59	8G	Knight Inlet and South Pacific Ocean	43 196
59	8H	Vancouver Island	34 786
59	8J	Nechako	46 939
59	8K	Upper Fraser	65 949
59	8L	Thompson	55 991
59	8M	Fraser	63 094
59	8N	Columbia	102 684
59	8O	Queen Charlotte Islands	9 644
59	8P	Skagit	1 019
59	9A	Upper Yukon	25 321
59	10A	Upper Liard	20 450
59	10B	Central Liard	53 988
59	10C	Fort Nelson	53 979
59	10D	Petitot	14 554
		Total	**947 800**
		Northwest Territories	
61	6G	Seal and West Hudson Bay	491
61	6H	Nueltin Lake	54 274
61	6J	Upper Thelon	71 481
61	6K	Dubawnt Lake	70 303
61	6L	Kazan	64 530
61	6M	Lower Thelon	80 171
61	6N	Northwest Central Hudson Bay	58 882
61	6O	Northwest Hudson Bay	92 210
61	6P	Southampton Island	61 218
61	7L	Fond du Lac	5 116
61	7N	Slave	4 896
61	7O	Hay	3 095
61	7P	Buffalo	18 028
61	7Q	Taltson and Southeast Great Slave Lake	89 349
61	7R	Aylmer Lake and MacKay Lake	27 446
61	7S	Yellowknife and Northeast Great Slave Lake	67 306
61	7T	Marian	26 306
61	7U	West Great Slave Lake	28 509
61	10D	Petitot	5 627
61	10E	Lower Liard	52 777
61	10F	Upper Mackenzie	51 276
61	10G	Upper Central Mackenzie	57 714
61	10H	Central Mackenzie	68 340
61	10J	Great Bear	126 946
81	10K	Lower Central Mackenzie	47 658
61	10L	Lower Mackenzie	73 459
61	10M	Peel and Northwest Arctic Ocean	18 633
61	10N	Anderson and West Arctic Ocean	98 328
61	10O	Amundsen Gulf	93 204
61	10P	Coppermine	54 708
61	10Q	Coronation Gulf and Dease Strait	131 595
61	10R	Back and Queen Maud Gulf	160 281
61	10S	Gulf of Boothia	164 767
61	10T	Arctic Islands	1 337 502
61		Lakes	59 894
		Total	**3 426 320**
		Canada Total	**9 848 015**

Note:
These area figures do not include the area of a number of large freshwater bodies located at the outflow of some basins. The total area of Canada including these is 9 970 610 km^2.

Ecozones

Ecological land classification is the process of identifying areas with common landform, water, soil, vegetation, climate, wildlife and human factors. These can be developed into a hierarchical system ranging from site-specific ecosystems (e.g. ecoelements such as ponds, woodlots and meadows) to ecological zones encompassing large portions of the earth's surface (e.g. ecozones such as tundra, boreal forests, grasslands and deserts).

Ecozones are large natural units delineated by distinctive sets of non-living (abiotic) and living (biotic) resources that are ecologically related. Since ecozones represent common biophysical characteristics, they are valuable for monitoring the impact of natural and man-made stress on the environment.

Like drainage basins, ecozones are also useful geographic boundaries for the analysis of socio-economic information. Ecological systems are inherently stable, but can be altered rapidly by large-scale human activity. A reduction in ecological biodiversity relating to a change in physiographic or biological conditions can indicate potential instability. Levels of socio-economic activity within each ecozone provide an indication of the risk level or substantiate known impacts. The most dramatically altered natural ecozone in Canada, the Prairie Ecozone, is now more than 87 percent farmland, of which 75 percent is cultivated. Very little natural Prairie grassland remains unaltered, and the small portion that remains is isolated to a few sites. Monitoring human activity within Canada's ecozones will assist planning and subsequent protection of threatened ecological areas.

The Canada Committee on Ecological Land Classification has proposed a seven-level ecological hierarchy. This seven-level hierarchy ranges from the ecoelement, to ecoprovinces and ultimately to broad ecozones (Technical Box 1.4.1). Ecological areas have been mapped at a detailed level in various parts of Canada including Alberta, Quebec, Saskatchewan, Yukon and the Northwest Territories. This process provided valuable information in the development of 15 separate terrestrial ecozones for Canada and was a first attempt at classifying the entire country into separate ecological units.

Technical Box 1.4.1 describes four of the seven levels in the Canadian Ecological Land Classification. Map 1.4.2 uses the Prairie Ecozone as an example of the ecoregion hierarchy. The Prairie Ecozone spans three provinces in western Canada. Within this ecozone, there are eight sub-component ecoregions; two are labelled as examples in Map 1.4.2. The 15 ecozones in Canada can be broken down into 177 different ecoregions that can be further sub-divided into 5 395 ecodistricts. The 15 broad ecozones presented in *Human Activity and the Environment 1994* are combined with provincial and territorial boundaries[1]. Map 1.4.3 depicts Canada's 15 broad ecozones and Table 1.4.2 provides a brief description of ecozone biophysical characteristics.

Technical Box 1.4.1

Ecological Land Classification Hierarchy

Generalized ↓ Detailed

Ecozone- highest level, Canada is divided into 15 ecozones

↓

Ecoprovince- part of an ecozone consisting of major structural or surface forms, fauna realms, vegetation, soil, hydrology and climate (47 ecoprovinces)

↓

Ecoregion- part of an ecoprovince, distinguished by unique ecological areas influenced by climate regimes (177 ecoregions)

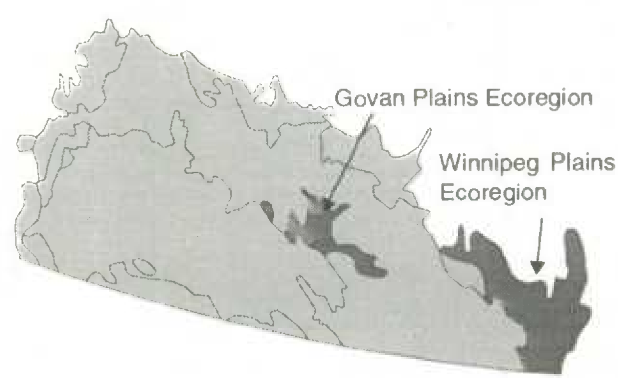
↓

Ecodistrict- part of an ecoregion, with distinctive assemblages of relief, vegetation, fauna, water, soils, landforms and geology (5 395 ecodistricts)

Source:
Wilken, E., *Terrestrial Ecozones of Canada*, Ecological Land Classification Series, No. 19, Environment Canada, Ottawa, 1986.

Map 1.4.2

The Prairie Ecozone and Ecoregion Subcomponents



Source:
Environment Canada, State of the Environment Reporting Branch, 1993.

Major Census Metropolitan Areas and Selected Weather Stations

Major census metropolitan areas (CMAs) and selected weather stations referred to in this publication are displayed on Map 1.4.4. (see also Sections 2.1 - **Population Distribution and Density** and 4.11 - **Climate**).

1. More detailed data or user-specified geographic aggregations are available on request, from our GIS based - Environmental Information System (EIS). Much of Statistics Canada's data can be obtained for ecozones, ecoregions, ecodistricts and for all drainage basin levels. For more information telephone our information officer at (613) 951-5638.

Map 1.4.3
Terrestrial Ecozones of Canada

Source:
Environment Canada, State of the Environment Reporting Branch, 1993.

Table 1.4.2
Ecozone Biophysical Characteristics

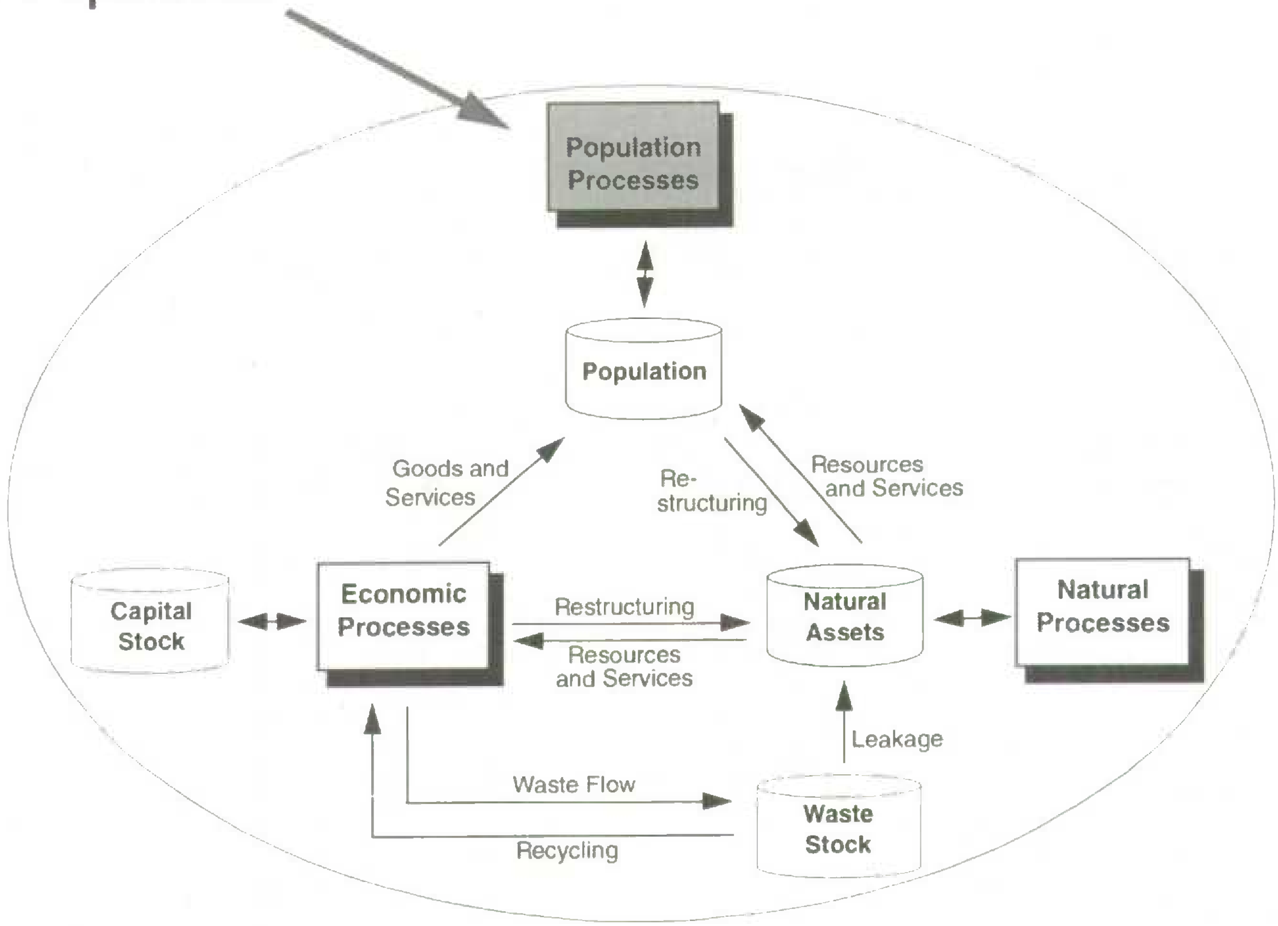
Ecozone	Physiography	Vegetation	Soils and surface materials	Climate
Atlantic Maritime	Hills and coastal plains	Mixed broadleaf and conifer stands	Acid and well weathered soils (podzols) and soils with clay-rich sublayers (luvisols), moraine, marine bottom soils, and rock debris	Cool to cold winters, mild summers, moderate to heavy precipitation
Mixed Wood Plains	Plains, some interior hills	Mixed broadleaf and conifer stands	Temperate region soils with clay-rich sublayers (luvisols), marine bottom soils, moraine, rock	Cool to cold winters, warm to hot summers, moderate precipitation
Boreal Shield	Plains, uplands, interior hills, many lakes and streams	Conifer and broadleaf boreal stands	Acid and well weathered soils (podzols), lake bottom soils, moraine, rock	Cold winters, warm to hot summers, moderate precipitation
Prairie	Plains, some foothills	Short and mixed grasslands, aspen parkland	Organically rich, relatively fertile grasslands soil (chernozems), moraine and lake bottom materials	Cold winters, warm to hot summers, moderate to minimal precipitation
Boreal Plains	Plains, some foothills	Conifer and broadleaf boreal stands	Temperate region soils with clay-rich sublayers (luvisols), moraine and lake bottom materials	Cold winters, warm summers, moderate precipitation
Montane Cordillera	Mountainous highlands, interior plains	Mixed vegetation, conifer stands to sage brush, alpine vegetation	Temperate region soils with clay-rich sublayers (luvisols), soils with minimal weathering (brunisols), moraine, rock, rock debris	Cool to cold winters, warm to hot summers, arid in lee areas, moist in montane areas
Pacific Maritime	Mountainous highlands, some coastal plains	Coastal western and mountain hemlock	Acid and well weathered soils (podzols), moraine, rock, rock debris	Mild winters, mild summers, heavy precipitation especially in fall and winter
Boreal Cordillera	Mountainous highlands, some hills and plains	Boreal, some alpine tundra and open woodland	Soil with minimal weathering (brunisols), moraine, rock	Cold winters, mild summers, minimal precipitation in lee areas, moist in montane areas
Tundra Cordillera	Mountainous highlands	Alpine and arctic tundra	Soils with minimal weathering (brunisols), frozen soils (cryosols), moraine, rock	Very cold winters, cool summers, minimal precipitation
Taiga Plains	Plains, some foothills	Open mixed-woodland, shrublands and wetlands	Soils with minimal weathering (brunisols), some frozen soils (cryosols), organic materials, moraine	Cold winters, mild to warm summers, moderate precipitation
Taiga Shield	Plains, uplands, some interior hills, many lakes and streams	Open woodlands, some arctic tundra and lichen heath	Soils with minimal weathering (brunisols), acid and well weathered soils (podzols), some frozen soils (cryosols), organic materials, moraine, rock	Cold winters, warm summers, minimal precipitation
Hudson Plains	Plains	Wetlands, arctic tundra and some conifer stands	Organic soils, sea bottom and beach materials	Cold winters, mild summers, minimal precipitation
Southern Arctic	Plains, some interior hills	Shrub/herb/heath arctic tundra, some wetlands	Frozen soils (cryosols), moraine, rock, marine bottom sediments	Cold winters, cool summers, minimal precipitation
Northern Arctic	Plains and hills	Herb-lichen arctic tundra	Frozen soils (cryosols), moraine, rock, marine bottom sediments	Very cold winters, cool summers, minimal precipitation
Arctic Cordillera	Mountainous highlands	Largely non-vegetated, some shrub/herb arctic tundra	Frozen soils (cryosols), rock, rock debris, ice	Very cold winters, cool to cold summers minimal precipitation

Source:
Wilken, E., *Terrestrial Ecozones of Canada*, Ecological Land Classification Series, No. 19, Environment Canada, Ottawa, 1986.

Map 1.4.4
Major Census Metropolitan Areas and Selected Weather Stations

Note:
All Census Metropolitan Areas displayed on the map also represent weather station locations.
Source:
Environment Canada, Atmospheric Environment Service.

2 Population



Population size, distribution and density are major factors in determining the impacts that human activities have on the environment. While the impact of an individual may be minimal, the combined impact of large numbers of people in highly populated areas places substantial stress on the physical environment. When analysing environmental issues, it is crucial to take population factors into account.

❑❑❑

Over the years, the distribution of the Canadian population has radically changed. In the last century most of the population was heavily concentrated in southern Ontario and southern Quebec. After the completion of the Trans-Canada Railway in 1887, the west and central provinces developed from a collection of isolated farm towns to diverse economic regions with large urban centres.

Population growth has resulted in massive changes to the natural environment. Millions of hectares of native grassland and forests have been transformed into cultivated agricultural land. Wetlands have been drained or filled and river systems were modified to meet immediate human needs. The greatest impacts have taken place in urban centres as buildings, pavement and parks replaced existing natural areas.

Since the time of Confederation, Canada's population has increased almost nine fold. Fertility has dropped by four-fifths and life expectancy has nearly doubled. Increased life expectancy and the continued growth of the Canadian population, largely through immigration, have contributed to the increasing impact that Canadians are having on their environment.

Population Conditions and Processes

Since the first post-Confederation census in 1871, the Canadian population has grown from 3.7 million persons to 28.1 million in 1991. This section presents statistics on population, its distribution and density, by both administrative and natural geographic regions. The natural areas, which include drainage basins and ecozones,[1] provide an environmental link in the analysis of socio-economic data.

2.1 Population Distribution and Density

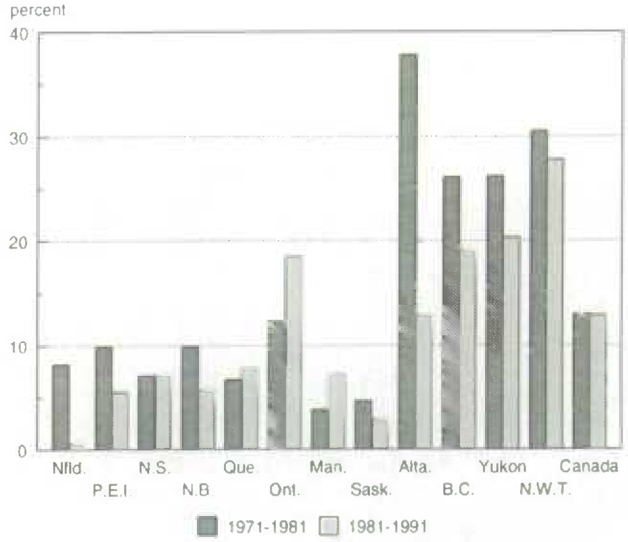
From 1971 to 1991, Canada's population increased from 22.0 million people to 28.1 million, an increase of 27.7 percent. As shown in Table 2.1.1, this growth was most pronounced in Alberta, British Columbia, the Yukon and Northwest Territories. In terms of absolute numbers, the province that experienced the most growth was Ontario.

Three of the 10 provinces and both territories exceeded the national population growth rate from 1971 to 1991. As illustrated in Figure 2.1.1, Canada's total population grew by 13.0 percent between 1971 and 1981 and 12.9 percent between 1981 and 1991. The Atlantic provinces, in general, experienced declines in population growth rates from 1971 to 1991, while Quebec's population increased at a steady rate over the two decades.

In 1971 and 1981 there were five provinces with over one million people, while in 1991 this had increased to six.

1. See Section 1.4 - **Geographic Units for Environmental Analysis** for a detailed description of drainage basins and ecozones.

Figure 2.1.1
Population Growth Rate, 1971-1991



Source:
Statistics Canada, Census of Population.

Ecozones and Drainage Basins

The east-west population trends are also evident by ecozone (Table 2.1.2 and Figure 2.1.2). From 1971 to 1991, the share of total population by ecozone decreased in both the Boreal Shield and Atlantic Maritime ecozones of eastern Canada, while the Pacific Maritime ecozone of the west coast increased its share of total population.

Figure 2.1.3 illustrates population change by major drainage basin. From 1971 to 1991 population in the Arctic Ocean Basin and the Pacific Ocean Basin increased by 49 and 50 percent respectively. The Gulf of Mexico Basin experienced a 21 percent decline while there was a 22 percent

Table 2.1.1
Total Population by Province and Territory, 1971, 1981 and 1991

Province/Territory	Total population			Change		
	1971	1981	1991	1971-1981	1981-1991	1971-1991
	thousands			percent		
Newfoundland	533	576	580	8.2	0.6	8.8
Prince Edward Island	113	124	131	9.9	5.5	16.0
Nova Scotia	799	856	918	7.1	7.2	14.9
New Brunswick	644	708	748	9.9	5.7	16.2
Quebec	6 156	6 568	7 081	6.7	7.8	15.0
Ontario	7 868	8 838	10 471	12.3	18.5	33.1
Manitoba	1 001	1 038	1 113	3.8	7.2	11.2
Saskatchewan	934	978	1 007	4.7	2.9	7.8
Alberta	1 672	2 304	2 600	37.8	12.9	55.5
British Columbia	2 250	2 836	3 377	26.1	19.1	50.1
Yukon	19	24	29	26.2	20.3	51.8
Northwest Territories	37	48	61	30.5	27.8	66.8
Canada	**22 026**	**24 900**	**28 118**	**13.0**	**12.9**	**27.7**

Note:
Intercensal estimates adjusted for net undercoverage and non-permanent residents.
Source:
Statistics Canada, Demography Division.

Table 2.1.2
Population by Ecozone, 1971, 1981 and 1991

Provincial/Territorial ecozone	Area	Population 1971	Population 1981	Population 1991	Population Change 1971-1991	Population Change 1981-1991	Density 1971	Density 1981	Density 1991	Density Change 1971-1991	Density Change 1981-1991
	km²	persons					persons / km²			percent	
Newfoundland											
Taiga Shield	207 441	24 187	26 056	24 431	244	-1 625	0.117	0.126	0.118	1.0	-6.2
Boreal Shield	130 317	496 228	539 153	541 393	45 165	2 240	3.808	4.137	4.154	9.1	0.4
Southern Arctic	51 311	1 689	2 472	2 650	961	178	0.033	0.048	0.052	56.9	7.2
Arctic Cordillera	10 124	-	-	-	-	-	-	-	-	-	-
Total	**399 193**	**522 104**	**567 681**	**568 474**	**46 370**	**793**	**1.308**	**1.422**	**1.424**	**8.9**	**0.1**
Prince Edward Island											
Atlantic Maritime	5 660	111 641	122 506	129 765	18 124	7 259	19.725	21.644	22.927	16.2	5.9
Total	**5 660**	**111 641**	**122 506**	**129 765**	**18 124**	**7 259**	**19.725**	**21.644**	**22.927**	**16.2**	**5.9**
Nova Scotia											
Atlantic Maritime	55 490	788 960	847 442	899 942	110 982	52 500	14.218	15.272	16.218	14.1	6.2
Total	**55 490**	**788 960**	**847 442**	**899 942**	**110 982**	**52 500**	**14.218**	**15.272**	**16.218**	**14.1**	**6.2**
New Brunswick											
Atlantic Maritime	73 440	634 557	696 403	723 900	89 343	27 497	8.640	9.483	9.857	14.1	4.0
Total	**73 440**	**634 557**	**696 403**	**723 900**	**89 343**	**27 497**	**8.640**	**9.483**	**9.857**	**14.1**	**4.0**
Quebec											
Taiga Shield	539 794	11 212	17 394	9 570	-1 642	-7 824	0.021	0.032	0.018	-14.7	-45.0
Boreal Shield	643 159	991 165	1 135 263	1 165 525	174 360	30 262	1.541	1.765	1.812	17.6	2.7
Hudson Plains	26 311	1 594	2 018	2 707	1 113	689	0.061	0.077	0.103	69.8	34.1
Mixed Wood Plains	55 385	4 756 823	5 019 225	5 455 656	698 833	436 431	85.886	90.623	98.503	14.7	8.7
Atlantic Maritime	28 838	264 907	261 189	255 701	-9 206	-5 488	9.186	9.057	8.867	-3.5	-2.1
Southern Arctic	138 223	186	1 883	4 588	4 402	2 705	0.001	0.014	0.033	2 366.7	143.7
Northern Arctic	67 105	1 646	1 431	2 216	570	785	0.025	0.021	0.033	34.6	54.9
Arctic Cordillera	7 535	231	-	-	-231	-	0.031	-	-	-100.0	-
Total	**1 506 350**	**6 027 764**	**6 438 403**	**6 895 963**	**868 199**	**457 560**	**4.002**	**4.274**	**4.578**	**14.4**	**7.1**
Ontario											
Boreal Shield	614 964	865 737	888 282	904 441	38 704	16 159	1.408	1.444	1.471	4.5	1.8
Hudson Bay Plains	268 924	5 822	5 447	5 789	-33	342	0.022	0.020	0.022	-0.6	6.3
Mixed Wood Plains	96 427	6 831 547	7 731 378	9 174 655	2 343 108	1 443 277	70.847	80.179	95.146	34.3	18.7
Total	**980 315**	**7 703 106**	**8 625 107**	**10 084 885**	**2 381 779**	**1 459 778**	**7.858**	**8.798**	**10.287**	**30.9**	**16.9**
Manitoba											
Boreal Plains	96 559	56 591	56 664	53 349	-3 242	-3 315	0.586	0.587	0.553	-5.7	-5.8
Prairie	74 005	843 944	885 093	944 552	100 608	59 459	11.404	11.960	12.763	11.9	6.7
Taiga Shield	103 672	900	952	1 162	262	210	0.009	0.009	0.011	29.1	22.1
Boreal Shield	244 367	83 388	81 624	90 518	7 130	8 894	0.341	0.334	0.370	8.6	10.9
Hudson Plains	93 726	3 424	1 908	2 361	-1 063	453	0.037	0.020	0.025	-31.1	23.7
Southern Arctic	1 884	-	-	-	-	-	-	-	-	-	-
Total	**614 212**	**988 247**	**1 026 241**	**1 091 942**	**103 695**	**65 701**	**1.609**	**1.671**	**1.778**	**10.5**	**6.4**
Saskatchewan											
Boreal Plains	211 330	41 827	47 113	47 379	5 552	266	0.198	0.223	0.224	13.3	0.6
Prairie	285 333	875 926	910 229	930 615	54 689	20 386	3.070	3.190	3.262	6.2	2.2
Taiga Shield	55 605	2 876	3 723	1 738	-1 138	-1 985	0.052	0.067	0.031	-39.6	-53.3
Boreal Shield	85 478	5 613	7 248	9 196	3 583	1 948	0.066	0.085	0.108	63.8	26.9
Total	**637 746**	**926 242**	**968 313**	**988 928**	**62 686**	**20 615**	**1.452**	**1.518**	**1.551**	**6.8**	**2.1**
Alberta											
Montane Cordillera	43 504	24 990	32 893	38 436	13 446	5 543	0.574	0.756	0.884	53.8	16.9
Boreal Plains	363 280	253 688	354 512	387 119	133 431	32 607	0.698	0.976	1.066	52.6	9.2
Taiga Plains	83 683	385	923	755	370	-168	0.005	0.011	0.009	96.1	-18.2
Prairie	162 542	1 347 687	1 848 452	2 118 239	770 552	269 787	8.291	11.372	13.032	57.2	14.6
Taiga Shield	8 182	1 124	944	1 004	-120	60	0.137	0.115	0.123	-10.7	6.4
Total	**661 191**	**1 627 874**	**2 237 724**	**2 545 553**	**917 679**	**307 829**	**2.462**	**3.384**	**3.850**	**56.4**	**13.8**
British Columbia											
Boreal Cordillera	120 607	1 600	2 288	2 177	577	-111	0.013	0.019	0.018	36.1	-4.8
Pacific Maritime	282 594	1 657 811	2 023 365	2 508 317	850 506	484 952	5.866	7.160	8.876	51.3	24.0
Montane Cordillera	389 734	481 479	664 345	713 464	231 985	49 119	1.235	1.705	1.831	48.2	7.4
Boreal Plains	115 320	43 237	53 988	57 844	14 607	3 856	0.375	0.468	0.502	33.8	7.1
Taiga Plains	39 545	494	481	259	-235	-222	0.012	0.012	0.007	-47.6	-46.1
Total	**947 800**	**2 184 621**	**2 744 467**	**3 282 061**	**1 097 440**	**537 594**	**2.305**	**2.896**	**3.463**	**50.2**	**19.6**
Yukon											
Tundra Cordillera	174 893	216	243	264	48	21	0.001	0.001	0.002	22.2	8.6
Boreal Cordillera	259 506	17 619	21 686	26 199	8 580	4 513	0.068	0.084	0.101	48.7	20.8
Boreal Plains	32 518	553	1 224	1 334	781	110	0.017	0.038	0.041	141.2	9.0
Taiga Plains	16 534	-	-	-	-	-	-	-	-	-	-
Total	**483 450**	**18 388**	**23 153**	**27 797**	**9 409**	**4 644**	**0.038**	**0.048**	**0.057**	**51.2**	**20.1**
Northwest Territories											
Tundra Cordillera	107 453	130	320	-	-130	-320	0.001	0.003	-	-100.0	-100.0
Boreal Plains	1 826	-	-	-	-	-	-	-	-	-	-
Taiga Plains	444 446	14 376	16 766	16 994	2 618	228	0.032	0.038	0.038	18.2	1.4
Taiga Shield	470 308	7 904	12 049	18 238	10 334	6 189	0.017	0.026	0.039	130.7	51.4

Table 2.1.2

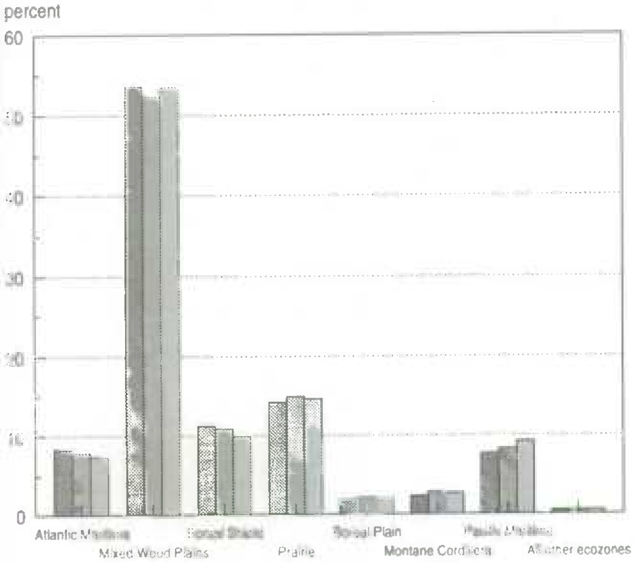
Population by Ecozone, 1971, 1981 and 1991 (Continued)

Provincial/Territorial ecozone	Area	Population 1971	Population 1981	Population 1991	Population Change 1971-1991	Population Change 1981-1991	Density 1971	Density 1981	Density 1991	Density Change 1971-1991	Density Change 1981-1991
	km^2	persons					persons / km^2			percent	
Hudson Plains	3 121	-	-	-	-	-	-	-	-	-	-
Southern Arctic	737 058	5 271	7 369	9 731	4 460	2 362	0.007	0.010	0.013	84.6	32.0
Northern Arctic	1 359 619	6 102	7 711	10 665	4 563	2 954	0.004	0.006	0.008	74.8	38.3
Arctic Cordillera	242 597	1 024	1 526	2 021	997	495	0.004	0.006	0.008	97.4	32.4
Total	**3 366 429**	**34 807**	**45 741**	**57 649**	**22 842**	**11 908**	**0.010**	**0.014**	**0.017**	**65.6**	**26.0**
Canada total	**9 731 276**	**21 568 311**	**24 343 181**	**27 296 859**	**5 728 548**	**2 953 678**	**2.216**	**2.502**	**2.805**	**26.6**	**12.1**
Ecozone											
Atlantic Maritime	163 428	1 800 065	1 927 540	2 009 308	209 243	81 768	11.014	11.794	12.295	11.6	4.2
Mixed Wood Plains	151 812	11 588 370	12 750 603	14 630 311	3 041 941	1 879 708	76.334	83.989	96.371	26.2	14.7
Boreal Shield	1 718 285	2 442 131	2 651 570	2 711 073	268 942	59 503	1.421	1.543	1.578	11.0	2.2
Prairie	521 880	3 067 557	3 643 774	3 993 406	925 849	349 632	5.878	6.982	7.652	30.2	9.6
Boreal Plains	820 833	395 896	513 501	547 025	151 129	33 524	0.482	0.626	0.666	38.2	6.5
Montane Cordillera	433 238	506 469	697 238	751 900	245 431	54 662	1.169	1.609	1.736	48.5	7.8
Pacific Maritime	282 594	1 657 811	2 023 365	2 508 317	850 506	484 952	5.866	7.160	8.876	51.3	24.0
Boreal Cordillera	380 113	19 219	23 974	28 376	9 157	4 402	0.051	0.063	0.075	47.6	18.4
Tundra Cordillera	282 346	346	563	264	-82	-299	0.001	0.002	0.001	-23.7	-53.1
Taiga Plains	584 208	15 255	18 170	18 008	2 753	-162	0.026	0.031	0.031	18.1	-0.9
Taiga Shield	1 385 003	48 203	61 118	56 143	7 940	-4 975	0.035	0.044	0.041	16.5	-8.1
Hudson Plains	392 082	10 840	9 373	10 857	17	1 484	0.028	0.024	0.028	0.2	15.8
Southern Arctic	928 475	7 146	11 724	16 969	9 823	5 245	0.008	0.013	0.018	137.5	44.7
Northern Arctic	1 426 724	7 748	9 142	12 881	5 133	3 739	0.005	0.006	0.009	66.2	40.9
Arctic Cordillera	260 256	1 255	1 526	2 021	766	495	0.005	0.006	0.008	61.0	32.4
Canada total	**9 731 276**	**21 568 311**	**24 343 181**	**27 296 859**	**5 728 548**	**2 953 678**	**2.216**	**2.502**	**2.805**	**26.6**	**12.1**

Notes:
The area figures for ecozones and the Canada total do not include the areas of a number of large freshwater bodies located on ecosystem boundaries. The total area of Canada including these is 9 970 610.
The population figures presented here are not adjusted for net undercoverage and non-permanent residents.
Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Figure 2.1.2

Population by Ecozone, 1971, 1981 and 1991



Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

increase in the Atlantic Ocean Basin. The Hudson Bay Basin population increase of 27 percent was comparable to the total Canadian increase of 26.6 percent for the same period.

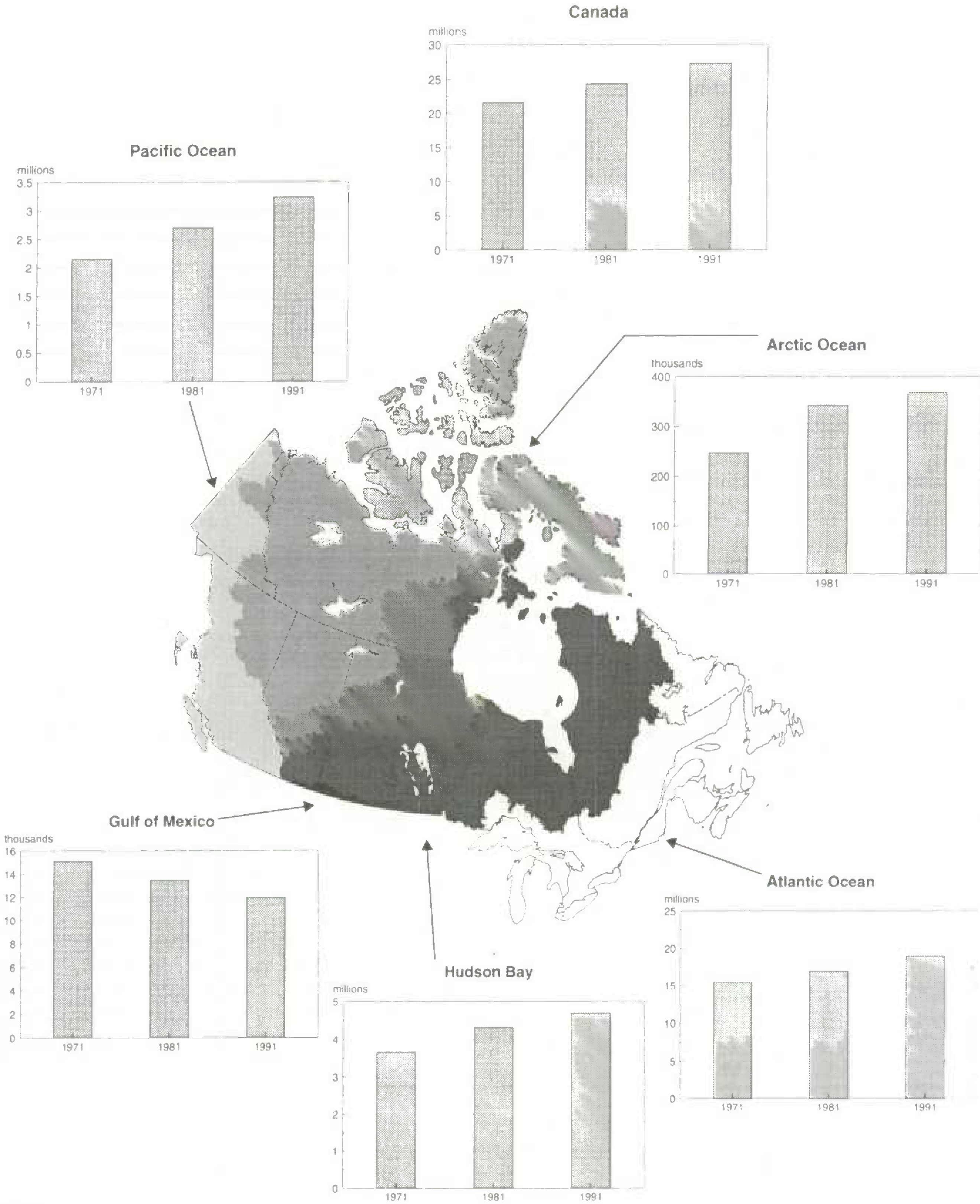
The 1991 population density by drainage sub-sub-basin is shown in Map 2.1.1.[1] Densities over 200 persons per square kilometre are found in the basins containing the following cities: Toronto (1 193 persons per square kilometre), Montréal (666), Hamilton (464), Québec (278), Vancouver (259), Halifax (246), Niagara Falls (213) and Calgary (201).

Table 2.1.3 presents population aggregated by drainage sub-basin. Thirty drainage sub-basins were unpopulated in 1991. Between 1971 and 1991, 152 sub-basins decreased in population while 136 increased in population.

Population densities at the ecozone level (Table 2.1.2 and Map 2.1.2) are highest in the Mixed Wood Plains of Ontario and Quebec largely because of its favourable location along the St. Lawrence River and eastern Great Lakes. This ecozone has a large agricultural industry which, together with the urban and industrial pressures of Canada's highest population densities, place it under more environmental stress than any other ecozone.

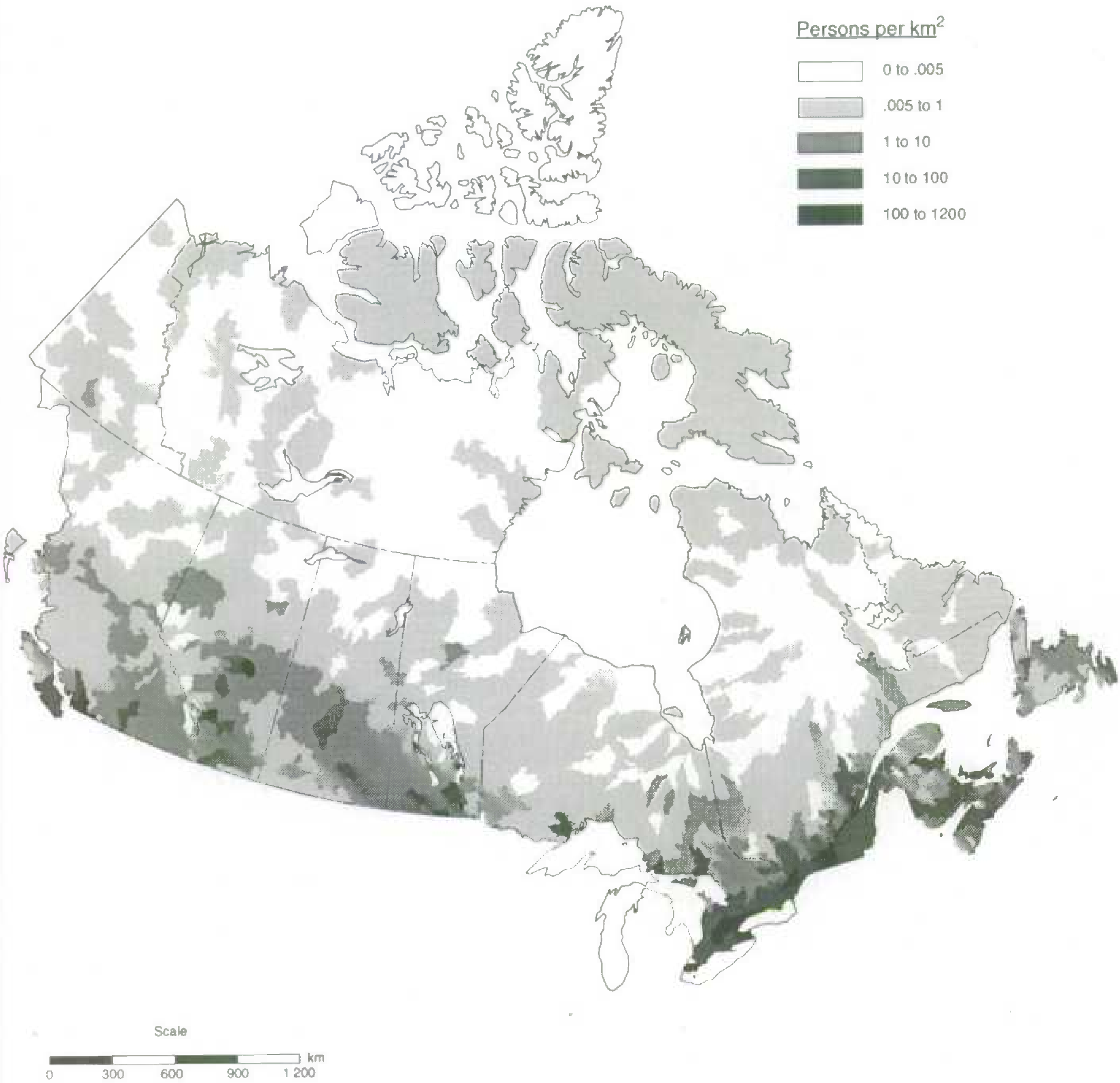
1. Canada is comprised of 1 033 sub-sub drainage basins. See Section 1.4 - **Geographic Units for Environmental Analysis** for a detailed description of drainage basins.

Figure 2.1.3
Population by Major Drainage Basin, 1971, 1981 and 1991



Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Map 2.1.1
Population Density by Sub-sub-basin, 1991



Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Table 2.1.3
Rural-Urban Population by Drainage Sub-basin, 1971, 1981 and 1991

	Total population			Rural population			Urban population			Urban population as a percentage of total		
Provincial/Territorial Sub-basin	1971	1981	1991	1971	1981	1991	1971	1981	1991	1971	1981	1991
	persons									percent		
Canada	**21 568 311**	**24 343 181**	**27 296 859**	**5 157 527**	**5 907 254**	**6 389 985**	**16 410 784**	**18 435 927**	**20 906 874**	**76.1**	**75.7**	**76.6**
Newfoundland												
Romaine	-	-	-	-	-	-	-	-	-	-	-	-
Natashquan	-	-	-	-	-	-	-	-	-	-	-	-
Little Mecatina and Strait of Belle Isle	1 977	2 315	2 181	1 977	2 315	2 181	-	-	-	-	-	-
North Newfoundland	196 774	207 192	198 177	94 599	102 380	108 427	102 175	104 812	89 750	51.9	50.6	45.3
South Newfoundland	297 164	329 171	339 918	120 433	121 124	142 196	176 731	208 047	197 722	59.5	83.2	58.2
North Labrador	1 689	2 173	2 650	1 689	2 173	2 650	-	-	-	-	-	-
Churchill	20 736	22 732	20 885	842	2 693	3 906	19 894	20 039	16 979	95.9	88.2	81.3
Naskaupi and Central Labrador	1 111	1 289	1 701	1 111	1 289	1 701	-	-	-	-	-	-
Eagle and South Labrador	2 653	2 809	2 962	2 653	2 809	2 962	-	-	-	-	-	-
Total	**522 104**	**567 681**	**568 474**	**223 304**	**234 783**	**264 023**	**298 800**	**332 898**	**304 451**	**57.2**	**58.6**	**53.6**
Prince Edward Island												
Prince Edward Island	111 641	122 506	129 765	68 860	77 991	77 952	42 781	44 515	51 813	38.3	36.3	39.9
Total	**111 641**	**122 506**	**129 765**	**68 860**	**77 991**	**77 952**	**42 781**	**44 515**	**51 813**	**38.3**	**36.3**	**39.9**
Nova Scotia												
Bay of Fundy	254 012	286 601	315 009	148 465	173 077	193 305	105 547	113 524	121 704	41.6	39.6	38.6
Southeast Atlantic Ocean	364 941	390 753	423 247	130 597	140 304	156 105	234 344	250 449	267 142	64.2	64.1	63.1
Cape Breton Island	170 007	170 088	161 686	62 495	67 219	69 024	107 512	102 869	92 662	63.2	80.5	57.3
Total	**788 960**	**847 442**	**899 942**	**341 557**	**380 600**	**418 434**	**447 403**	**466 842**	**481 508**	**56.7**	**55.1**	**53.5**
New Brunswick												
Saint John and South Bay of Fundy	323 187	345 581	363 107	120 050	149 479	174 257	203 137	196 102	188 850	62.9	56.7	52.0
Gulf of St. Lawrence and North Bay of Fundy	311 370	350 822	360 793	153 360	193 704	204 429	158 010	157 118	156 364	50.7	44.8	43.3
North Gaspé Peninsula	-	-	-	-	-	-	-	-	-	-	-	-
Total	**634 557**	**696 403**	**723 900**	**273 410**	**343 183**	**378 686**	**361 147**	**353 220**	**345 214**	**56.9**	**50.7**	**47.7**
Quebec												
Saint John	42 138	39 373	35 850	27 666	31 762	29 034	14 272	7 611	6 816	33.9	19.3	19.0
Cascapedia and Gulf of St. Lawrence	97 195	94 907	87 283	57 693	62 690	83 970	39 502	32 217	23 313	40.6	33.9	26.7
Upper Ottawa	61 658	59 183	61 494	27 571	29 430	30 394	34 087	29 753	31 100	55.3	50.3	50.6
Coulonge and Central Ottawa	35 289	43 263	49 196	15 006	15 950	17 126	20 283	27 313	32 070	57.5	63.1	65.2
Gatineau and Lower Ottawa	326 248	367 300	420 185	98 320	136 520	158 534	227 928	230 780	261 651	69.9	62.8	62.3
Upper St. Lawrence	66 905	73 382	76 847	19 570	23 147	24 250	47 335	50 235	52 597	70.7	68.5	68.4
St-Maurice	177 993	170 335	176 191	13 774	24 958	31 761	164 219	145 377	144 430	92.3	85.3	82.0
Central St. Lawrence	3 640 244	3 864 703	4 226 742	405 734	531 816	587 641	3 234 510	3 332 887	3 639 101	88.9	86.2	86.1
Lower St Lawrence	942 631	1 040 099	1 094 277	272 389	322 801	337 216	670 242	717 298	757 061	71.1	69.0	69.2
North Gaspé Peninsula	142 939	143 450	137 504	63 417	69 224	67 406	79 522	74 226	70 098	55.6	51.7	51.0
Saguenay	269 211	288 423	289 214	75 285	90 791	92 654	193 926	197 632	196 580	72.0	68.5	68.0
Betsiamites	15 703	15 052	12 563	10 402	9 487	7 455	5 301	5 565	5 108	33.8	37.0	40.7
Manicouagan and Outardes	23 511	23 659	21 835	4 613	4 349	4 681	18 898	19 310	17 154	80.4	81.6	78.6
Moisie and St. Lawrence Estuary	45 871	61 199	52 060	5 712	11 994	7 939	40 159	49 205	44 121	87.5	80.4	84.8
Romaine and Gulf of St. Lawrence	4 977	5 265	5 262	1 979	2 065	2 148	2 998	3 200	3 114	60.2	60.8	59.2
Natashquan and Gulf of St. Lawrence	16 768	17 557	16 851	15 669	16 050	15 234	1 099	1 507	1 617	6.6	8.6	9.6
Petit Mecatina	4 109	4 110	4 723	4 109	4 110	4 723	-	-	-	-	-	-
Nottaway	29 493	32 318	27 009	5 940	6 784	5 870	23 553	25 534	21 139	79.9	79.0	78.3
Broadback and Rupert	2 399	2 958	3 381	2 399	2 958	3 381	-	-	-	-	-	-
Eastmain	303	329	444	303	329	444	-	-	-	-	-	-
Fort George and Sakami	1 778	5 410	4 213	1 778	5 410	4 213	-	-	-	-	-	-
Great Whale and Southeast Hudson Bay	986	1 067	1 113	986	1 067	1 113	-	-	-	-	-	-
Little Whale and East Hudson Bay	-	-	284	-	-	284	-	-	-	-	-	-
Northeast Hudson Bay	797	1 858	2 773	797	1 858	2 773	-	-	-	-	-	-
West Ungava Bay	956	1 128	1 814	956	1 128	1 814	-	-	-	-	-	-
Leaf	600	179	283	600	179	283	-	-	-	-	-	-
Koksoak	677	805	1 405	677	805	1 405	-	-	-	-	-	-
Caniapiskau	3 977	3 170	1 144	706	1 173	1 144	3 271	1 997	-	82.2	63.0	0.0
East Ungava Bay	231	149	529	231	149	529	-	-	-	-	-	-
Abitibi and North French	26 400	24 628	24 526	17 630	15 680	15 569	8 770	8 948	8 957	33.2	36.3	36.5
Harricanaw	45 777	53 144	58 968	14 408	19 900	24 021	31 369	33 244	34 947	68.5	62.6	59.3
Total	**6 027 764**	**6 438 403**	**6 895 963**	**1 166 520**	**1 444 564**	**1 545 009**	**4 861 244**	**4 993 839**	**5 350 954**	**80.6**	**77.6**	**77.6**
Ontario												
Nipigon and Northwest Lake Superior	126 641	133 522	136 742	14 689	20 674	26 334	111 952	112 848	110 408	88.4	84.5	80.7
Northeast Lake Superior	44 444	44 009	44 831	8 611	13 496	14 194	35 833	30 513	30 637	80.6	69.3	68.3
North Lake Huron	266 239	270 488	266 165	55 370	49 719	49 083	210 869	220 769	217 082	79.2	81.6	81.6
Wanipitai and French	93 509	90 067	93 805	33 679	31 736	33 071	59 830	58 331	80 734	64.0	64.8	64.7
East Georgian Bay	323 831	410 367	542 365	144 101	178 580	222 661	179 530	231 787	319 704	55.5	56.5	58.9
East Lake Huron	220 048	252 455	289 132	127 964	142 084	154 292	92 084	110 371	134 840	41.8	43.7	46.6
North Lake Erie	1 523 839	1 664 639	1 858 171	386 788	383 207	394 627	1 137 051	1 281 432	1 463 544	74.6	77.0	78.8
Lake Ontario	3 976 860	4 537 196	5 446 611	281 042	402 559	529 898	3 695 818	4 134 637	4 916 713	92.9	91.1	90.3
Montréal and Upper Ottawa	62 189	60 941	62 887	21 266	20 452	24 023	40 923	40 489	38 864	65.8	66.4	61.8
Madawaska, Petawawa and Central Ottawa	208 690	233 202	262 739	59 507	73 092	91 991	149 183	160 110	170 748	71.5	68.7	65.0

Table 2.1.3

Rural-Urban Population by Drainage Sub-basin, 1971, 1981 and 1991 (Continued)

Provincial/Territorial Sub-basin	Total population 1971	Total population 1981	Total population 1991	Rural population 1971	Rural population 1981	Rural population 1991	Urban population 1971	Urban population 1981	Urban population 1991	Urban population as a percentage of total 1971	Urban population as a percentage of total 1981	Urban population as a percentage of total 1991
	persons									percent		
Rideau and Lower Ottawa	492 999	558 903	697 967	102 946	123 267	139 419	390 053	435 636	558 548	79.1	77.9	80.0
Upper St. Lawrence	173 126	173 537	193 920	57 273	61 690	69 916	115 853	111 847	124 004	66.9	64.5	63.9
Hayes	-	-	-	-	-	-	-	-	-	-	-	-
Nisksibi and Central Hudson Bay	151	264	335	151	264	335	-	-	-	-	-	-
Severn	2 509	4 027	3 255	2 509	4 027	3 255	-	-	-	-	-	-
Winisk	861	1 572	1 946	861	1 572	1 946	-	-	-	-	-	-
Ekwan	-	-	-	-	-	-	-	-	-	-	-	-
Attawapiskat	1 138	1 403	1 949	1 138	1 403	1 949	-	-	-	-	-	-
Upper Albany	1 630	2 774	1 606	1 630	2 774	1 606	-	-	-	-	-	-
Lower Albany	1 106	1 202	1 199	1 106	1 202	1 199	-	-	-	-	-	-
Kenogami	9 757	10 777	8 891	3 342	3 542	2 582	6 415	7 235	6 309	65.7	67.1	71.0
Kwataboahegaa	2 545	2 013	1 702	1 220	781	699	1 325	1 232	1 003	52.1	61.2	58.9
Moose	67 732	67 369	64 800	14 170	17 496	19 594	53 562	49 873	45 206	79.1	74.0	69.8
Abitibi	29 473	30 472	29 298	9 667	11 480	10 656	19 806	18 992	18 642	67.2	62.3	63.6
Harricanaw	864	895	1 130	864	895	1 130	-	-	-	-	-	-
Upper Winnipeg	46 155	43 674	43 564	15 963	17 688	18 923	30 192	25 986	24 641	65.4	59.5	56.6
English	26 158	28 360	28 301	12 808	13 416	16 090	13 350	14 944	12 211	51.0	52.7	43.1
East Lake Winnipeg	812	979	1 574	812	979	1 574	-	-	-	-	-	-
Total	**7 703 106**	**8 625 107**	**10 084 885**	**1 359 477**	**1 578 075**	**1 831 047**	**6 343 629**	**7 047 032**	**8 253 838**	**82.4**	**81.7**	**81.8**
Manitoba												
Hayes	4 580	5 142	7 366	4 580	5 142	7 366	-	-	-	-	-	-
Nisksibi and Central Hudson Bay	-	-	5	-	-	5	-	-	-	-	-	-
Severn	-	-	-	-	-	-	-	-	-	-	-	-
Qu'Appelle	-	-	338	-	-	338	-	-	-	-	-	-
Saskatchewan	21 980	22 511	21 032	7 045	7 987	7 499	14 935	14 524	13 533	67.9	64.5	64.3
Lake Winnipegosis and Lake Manitoba	82 480	78 004	73 025	65 547	58 597	55 276	16 933	19 407	17 749	20.5	24.9	24.3
Assiniboine	245 633	248 995	236 510	54 850	51 602	50 808	190 783	197 393	185 702	77.7	79.3	78.5
Souris	18 268	16 780	14 789	15 462	12 757	10 948	2 806	4 023	3 841	15.4	24.0	26.0
Red	534 802	581 659	661 005	105 491	110 579	121 262	429 311	471 080	539 743	80.3	81.0	81.7
Winnipeg	13 591	12 219	12 673	10 274	10 213	9 794	3 317	2 006	2 879	24.4	16.4	22.7
East Lake Winnipeg	3 095	3 853	3 779	3 095	3 853	3 779	-	-	-	-	-	-
West Lake Winnipeg	25 249	23 407	26 180	20 972	19 395	20 929	4 277	4 012	5 251	16.9	17.1	18.2
Rat and Grass	23 317	18 559	19 028	3 300	2 432	2 525	20 017	16 127	16 503	85.8	86.9	86.9
Nelson	6 937	7 140	9 856	6 937	7 140	8 716	-	-	1 140	-	-	11.6
Reindeer Lake	702	573	929	702	573	929	-	-	-	-	-	-
Central Churchill	4 688	5 716	4 015	1 794	3 629	3 181	2 894	2 087	834	61.7	36.5	20.8
Lower Churchill and West Hudson Bay	2 925	1 441	1 179	1 753	1 441	1 179	1 172	-	-	40.1	-	-
Seal and West Hudson Bay	-	242	233	-	242	233	-	-	-	-	-	-
Nueltin Lake	-	-	-	-	-	-	-	-	-	-	-	-
Kazan	-	-	-	-	-	-	-	-	-	-	-	-
Total	**988 247**	**1 026 241**	**1 091 942**	**301 802**	**295 582**	**304 767**	**686 445**	**730 659**	**787 175**	**69.5**	**71.2**	**72.1**
Saskatchewan												
Upper South Saskatchewan	834	652	451	834	652	451	-	-	-	-	-	-
Red Deer	-	-	4	-	-	4	-	-	-	-	-	-
Central North Saskatchewan	36 845	40 761	42 598	19 547	20 697	18 239	17 298	20 064	24 359	46.9	49.2	57.2
Battle	7 097	8 631	7 619	5 294	5 066	5 992	1 803	3 565	1 627	25.4	41.3	21.4
Lower North Saskatchewan	97 981	97 467	96 199	54 681	50 744	44 333	43 300	46 723	51 866	44.2	47.9	53.9
Lower South Saskatchewan	222 236	250 596	277 313	68 357	66 750	58 122	153 879	183 846	219 191	69.2	73.4	79.0
Qu'Appelle	297 567	314 416	324 327	101 957	93 531	85 156	195 610	220 885	239 171	65.7	70.3	73.7
Saskatchewan	49 594	49 822	47 680	34 866	30 721	30 543	14 728	19 101	17 137	29.7	38.3	35.9
Lake Winnipegosis and Lake Manitoba	21 375	20 830	16 644	18 351	17 445	13 685	3 024	3 385	2 959	14.1	16.3	17.8
Assiniboine	83 376	78 160	70 766	51 360	43 576	36 785	32 016	34 584	33 981	38.4	44.2	48.0
Souris	65 887	58 574	56 959	43 342	35 557	32 666	22 545	23 017	24 293	34.2	39.3	42.6
Beaver	18 120	18 811	19 904	14 685	14 954	14 613	3 435	3 857	5 291	19.0	20.5	26.6
Upper Churchill	5 024	6 794	7 072	3 895	5 162	7 072	1 129	1 632	-	22.5	24.0	0.0
Upper Central Churchill	4 204	6 627	8 010	4 204	6 627	5 432	-	-	2 578	-	-	32.2
Reindeer Lake	598	881	1 567	598	881	1 567	-	-	-	-	-	-
Central Churchill	497	758	770	497	758	770	-	-	-	-	-	-
Nueltin Lake	-	-	-	-	-	-	-	-	-	-	-	-
Kazan	-	-	-	-	-	-	-	-	-	-	-	-
Lower Central Athabasca	-	17	41	-	17	41	-	-	-	-	-	-
Lower Athabasca	-	-	-	-	-	-	-	-	-	-	-	-
Fond du Lac	769	856	1 701	769	856	1 701	-	-	-	-	-	-
Athabasca Lake	2 632	3 290	242	768	783	242	1 864	2 507	-	70.8	76.2	0.0
Taltson and Southeast Great Slave Lake	-	-	-	-	-	-	-	-	-	-	-	-
Missouri	11 606	10 370	9 061	11 606	10 370	8 117	-	-	944	-	-	10.4
Total	**926 242**	**968 313**	**988 928**	**435 611**	**405 147**	**365 531**	**490 631**	**563 166**	**623 397**	**53.0**	**58.2**	**63.0**

Table 2.1.3

Rural-Urban Population by Drainage Sub-basin, 1971, 1981 and 1991 (Continued)

Provincial/Territorial Sub-basin	Total population			Rural population			Urban population			Urban population as a percentage of total		
	1971	1981	1991	1971	1981	1991	1971	1981	1991	1971	1981	1991
	persons									percent		
Alberta												
Upper South Saskatchewan	151 781	192 056	206 062	51 299	56 271	56 968	100 482	135 785	149 094	66.2	70.7	72.4
Bow	452 226	676 342	812 008	31 549	38 682	42 697	420 677	637 660	769 311	93.0	94.3	94.7
Red Deer	123 383	162 089	183 689	75 646	81 159	84 123	47 737	80 930	99 566	38.7	49.9	54.2
Upper North Saskatchewan	209 260	270 229	307 859	26 882	37 874	38 544	182 378	232 355	269 315	87.2	86.0	87.5
Central North Saskatchewan	404 113	558 901	637 019	78 812	109 121	106 647	325 301	449 780	530 372	80.5	80.5	83.3
Battle	82 596	99 040	98 307	49 422	52 995	46 665	33 174	46 045	51 642	40.2	46.5	52.5
Lower North Saskatchewan	8 763	8 359	8 645	7 274	6 714	6 869	1 489	1 645	1 776	17.0	19.7	20.5
Lower South Saskatchewan	259	245	210	259	245	210	-	-	-	-	-	-
Beaver	24 898	28 680	32 557	12 609	14 797	15 667	12 289	13 883	16 890	49.4	48.4	51.9
Upper Churchill	-	-	-	-	-	-	-	-	-	-	-	-
Upper Athabasca	22 948	34 185	37 479	6 718	8 660	8 463	16 230	25 525	29 016	70.7	74.7	77.4
Pembina and Central Athabasca	43 617	52 137	52 686	30 361	33 759	33 576	13 256	18 378	19 110	30.4	35.2	36.3
Lower Central Athabasca	16 210	40 773	42 891	7 572	7 771	8 213	8 638	33 002	34 678	53.3	80.9	80.9
Lower Athabasca	-	109	3 090	-	104	513	-	5	2 577	-	-	83.4
Upper Peace	17 425	19 022	18 962	12 511	12 733	12 111	4 914	6 289	6 851	28.2	33.1	36.1
Smoky	40 937	60 853	64 882	21 187	24 989	23 016	19 750	35 864	41 866	48.2	58.9	64.5
Central Peace	15 420	19 869	18 879	8 220	11 664	12 899	7 200	8 205	5 980	46.7	41.3	31.7
Lower Central Peace	7 402	8 044	12 569	5 788	5 850	9 720	1 614	2 194	2 849	21.8	27.3	22.7
Lower Peace and Lake Claire	567	822	1 233	567	822	1 233	-	-	-	-	-	-
Athabasca Lake	1 178	944	1 008	54	944	1 008	1 124	-	-	95.4	-	-
Slave	27	27	30	27	27	30	-	-	-	-	-	-
Upper Hay	1 366	1 874	2 559	1 366	1 874	2 559	-	-	-	-	-	-
Buffalo	1	-	-	1	-	-	-	-	-	-	-	-
Taltson and Southeast Great Slave Lake	-	-	-	-	-	-	-	-	-	-	-	-
West Great Slave Lake	-	-	-	-	-	-	-	-	-	-	-	-
Fort Nelson	-	-	-	-	-	-	-	-	-	-	-	-
Petitot	-	-	-	-	-	-	-	-	-	-	-	-
Missouri	3 497	3 124	2 929	3 497	3 124	2 929	-	-	-	-	-	-
Total	**1 627 874**	**2 237 724**	**2 545 553**	**431 621**	**510 179**	**514 660**	**1 196 253**	**1 727 545**	**2 030 893**	**73.5**	**77.2**	**79.8**
British Columbia												
Williston Lake	4 863	8 619	7 104	2 048	2 822	1 540	2 815	5 797	5 564	57.9	67.3	78.3
Upper Peace	38 767	48 364	52 459	17 041	20 547	19 866	21 726	27 817	32 593	56.0	57.5	62.1
Smoky	-	-	290	-	-	290	-	-	-	-	-	-
Upper Hay	494	473	251	494	473	251	-	-	-	-	-	-
West Great Slave Lake	-	-	-	-	-	-	-	-	-	-	-	-
Alsek	-	-	-	-	-	-	-	-	-	-	-	-
Taku and North Pacific Ocean	30	155	38	30	155	38	-	-	-	-	-	-
Stikine	555	610	875	555	610	875	-	-	-	-	-	-
Nass and North Central Pacific Ocean	3 314	3 628	2 950	3 314	3 628	2 950	-	-	-	-	-	-
Skeena	49 236	59 786	61 812	16 254	24 525	21 745	32 982	35 261	40 067	67.0	59.0	64.8
Gardner Canal and Central Pacific Ocean	17 872	17 720	16 914	4 705	5 258	6 121	13 167	12 462	10 793	73.7	70.3	63.8
Knight Inlet and South Pacific Ocean	164 313	186 815	216 652	29 296	28 796	29 227	135 017	158 019	187 425	82.2	84.6	86.5
Vancouver Island	381 796	496 692	590 909	112 382	128 239	146 756	269 414	368 453	444 153	70.6	74.2	75.2
Nechako	59 009	75 454	73 802	15 003	18 478	18 310	44 006	56 976	55 492	74.6	75.5	75.2
Upper Fraser	35 892	53 450	55 575	25 554	31 745	30 383	10 338	21 705	25 192	28.8	40.6	45.3
Thompson	99 843	140 685	146 984	44 675	62 819	58 725	55 168	77 866	88 259	55.3	55.3	60.0
Fraser	1 065 999	1 294 148	1 662 105	150 433	130 535	148 785	915 566	1 163 613	1 513 320	85.9	89.9	91.0
Columbia	252 972	344 692	381 231	102 134	136 973	147 754	150 838	207 719	233 477	59.6	60.3	61.2
Queen Charlotte Islands	4 352	5 621	5 316	4 352	5 621	5 316	-	-	-	-	-	-
Skagit	520	992	83	520	992	83	-	-	-	-	-	-
Upper Yukon	309	247	479	309	247	479	-	-	-	-	-	-
Upper Liard	1 242	1 634	1 435	162	1 634	1 435	1 080	-	-	87.0	-	-
Central Liard	153	97	137	153	97	137	-	-	-	-	-	-
Fort Nelson	3 090	4 585	4 860	801	861	856	2 289	3 724	3 804	74.1	81.2	81.6
Petitot	-	-	-	-	-	-	-	-	-	-	-	-
Total	**2 164 621**	**2 744 467**	**3 282 061**	**530 215**	**605 055**	**641 922**	**1 654 406**	**2 139 412**	**2 640 139**	**75.7**	**78.0**	**80.4**

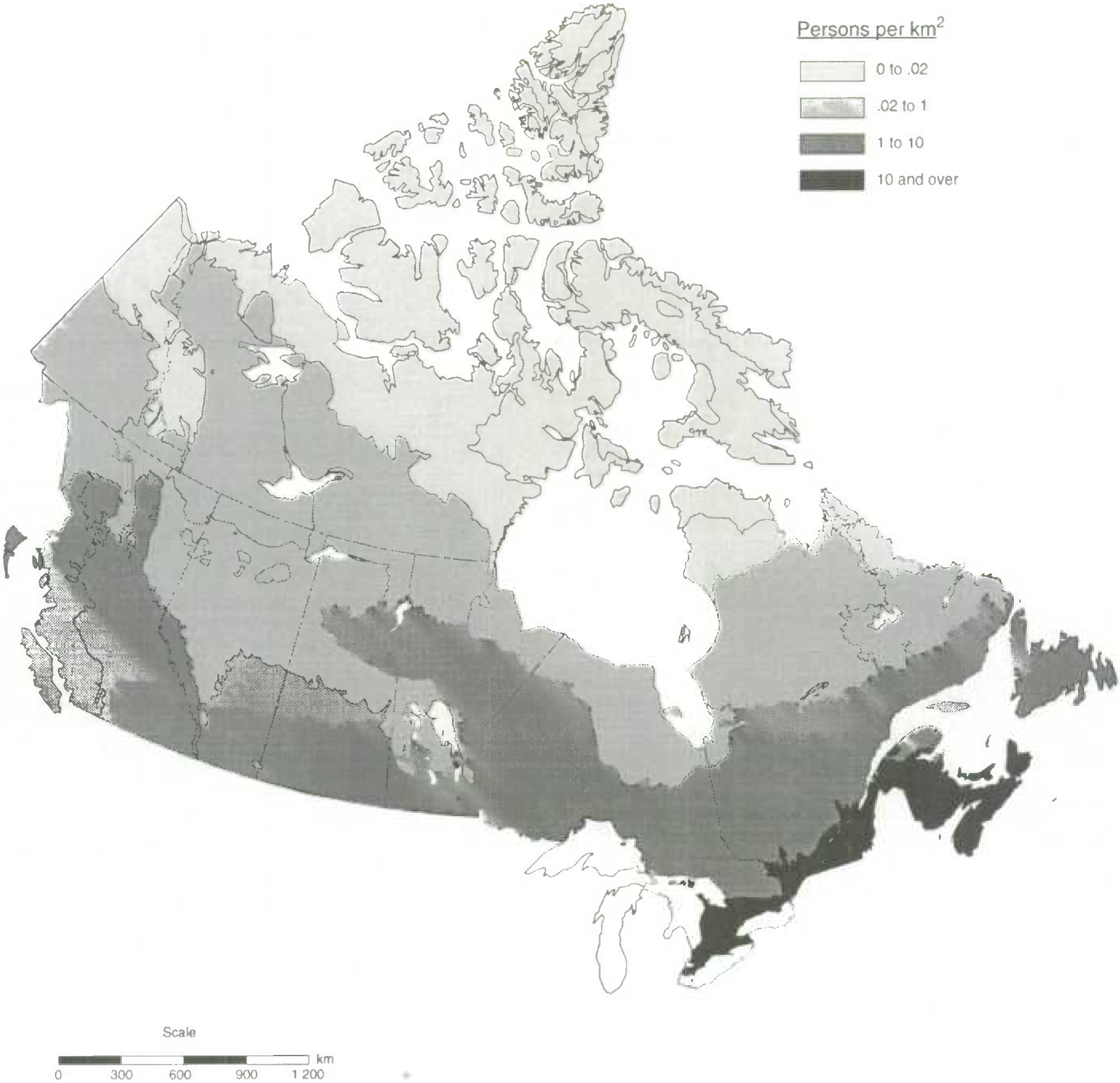
Table 2.1.3

Rural-Urban Population by Drainage Sub-basin, 1971, 1981 and 1991 (Continued)

Provincial/Territorial Sub-basin	Total population 1971	Total population 1981	Total population 1991	Rural population 1971	Rural population 1981	Rural population 1991	Urban population 1971	Urban population 1981	Urban population 1991	Urban population as a percentage of total 1971	Urban population as a percentage of total 1981	Urban population as a percentage of total 1991
	persons									percent		
Yukon												
Alsek	373	366	651	373	366	651	-	-	-	-	-	-
Upper Yukon	12 936	16 898	21 429	1 719	2 084	5 094	11 217	14 814	16 335	86.7	87.7	76.2
Pelly	1 091	2 152	1 805	1 091	2 152	1 805	-	-	-	-	-	-
Upper Central Yukon	376	306	188	376	306	188	-	-	-	-	-	-
Stewart	974	934	535	974	934	535	-	-	-	-	-	-
Central Yukon	1 302	916	1 487	1 302	916	1 487	-	-	-	-	-	-
Porcupine	216	243	256	216	243	256	-	-	-	-	-	-
Tanana	-	90	104	-	90	104	-	-	-	-	-	-
Upper Liard	1 120	1 247	1 334	1 120	1 247	1 334	-	-	-	-	-	-
Central Liard	-	1	8	-	1	8	-	-	-	-	-	-
Petitot	-	-	-	-	-	-	-	-	-	-	-	-
Peel and Northwest Arctic Ocean	-	-	-	-	-	-	-	-	-	-	-	-
Total	**18 388**	**23 153**	**27 797**	**7 171**	**8 339**	**11 462**	**11 217**	**14 814**	**16 335**	**61.0**	**64.0**	**58.8**
Northwest Territories												
Seal and West Hudson Bay	-	-	-	-	-	-	-	-	-	-	-	-
Nueltin Lake	-	-	-	-	-	-	-	-	-	-	-	-
Upper Thelon	-	-	-	-	-	-	-	-	-	-	-	-
Dubawnt Lake	-	-	2	-	-	2	-	-	-	-	-	-
Kazan	-	-	-	-	-	-	-	-	-	-	-	-
Lower Thelon	1 014	1 203	1 502	1 014	1 203	1 502	-	-	-	-	-	-
Northwest Central Hudson Bay	1 377	2 319	3 264	1 377	2 319	3 264	-	-	-	-	-	-
Northwest Hudson Bay	243	376	488	243	376	488	-	-	-	-	-	-
Southampton Island	593	812	1 104	593	812	1 104	-	-	-	-	-	-
Fond du Lac	-	-	-	-	-	-	-	-	-	-	-	-
Slave	2 998	2 778	2 484	634	480	2 484	2 364	2 298	-	78.9	82.7	0.0
Hay	1 120	2 380	3 042	-	94	373	1 120	2 286	2 669	100.0	96.1	87.7
Buffalo	2 159	2 011	656	283	-	656	1 876	2 011	-	86.9	100.0	0.0
Taltson and Southeast Great Slave Lake	219	253	286	219	253	286	-	-	-	-	-	-
Aylmer Lake and MacKay Lake	-	-	-	-	-	-	-	-	-	-	-	-
Yellowknife and Northeast Slave Lake	7 286	11 088	17 172	1 164	1 605	5 312	6 122	9 483	11 860	84.0	85.5	69.1
Marian	189	302	392	189	302	392	-	-	-	-	-	-
West Great Slave Lake	627	567	576	-	140	576	627	427	-	100.0	75.3	0.0
Petitot	-	-	-	-	-	-	-	-	-	-	-	-
Lower Liard	611	810	570	611	810	570	-	-	-	-	-	-
Upper Mackenzie	591	767	760	591	767	760	-	-	-	-	-	-
Upper Central Mackenzie	747	980	1 189	747	980	1 189	-	-	-	-	-	-
Central Mackenzie	152	152	174	152	152	174	-	-	-	-	-	-
Great Bear	675	1 104	1 178	675	1 104	1 178	-	-	-	-	-	-
Lower Central Mackenzie	300	420	627	300	420	627	-	-	-	-	-	-
Lower Mackenzie	3 098	3 730	3 969	429	583	791	2 669	3 147	3 178	86.2	84.4	80.1
Peel and Northwest Arctic Ocean	1 338	1 353	1 560	1 338	1 353	1 560	-	-	-	-	-	-
Anderson and West Arctic Ocean	662	829	1 029	662	829	1 029	-	-	-	-	-	-
Amundsen Gulf	95	186	255	95	186	255	-	-	-	-	-	-
Coppermine	637	809	1 130	637	809	1 130	-	-	-	-	-	-
Coronation Gulf and Dease Strait	-	-	-	-	-	-	-	-	-	-	-	-
Back and Queen Maud Gulf	153	86	-	153	88	-	-	-	-	-	-	-
Gulf of Boothia	1 250	1 783	2 451	1 250	1 783	2 451	-	-	-	-	-	-
Arctic Islands	6 673	8 643	11 789	4 623	6 310	8 339	2 050	2 333	3 450	30.7	27.0	29.3
Total	**34 807**	**45 741**	**57 649**	**17 979**	**23 756**	**36 492**	**16 828**	**21 985**	**21 157**	**48.3**	**48.1**	**36.7**
Canada	**21 568 311**	**24 343 181**	**27 296 859**	**5 157 527**	**5 907 254**	**6 389 985**	**16 410 784**	**18 435 927**	**20 906 874**	**76.1**	**75.7**	**76.8**

Notes:
See Section 1.4 - **Geographic Units for Environmental Analysis** for hydrological classification codes and area figures for these sub-basins.
The population figures presented here are not adjusted for net undercoverage and non-permanent residents.
Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Map 2.1.2
Population Density by Ecozone, 1991



Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Table 2.1.4
Rural-Urban Population by Province and Territory, 1971, 1981 and 1991

Province/Territory	Rural population			Urban population			Rural Change			Urban Change		
	1971	1981	1991	1971	1981	1991	1971-1981	1981-1991	1971-1991	1971-1981	1981-1991	1971-1991
	persons						percent					
Newfoundland	223 304	234 783	284 023	298 800	332 898	304 451	5.1	12.4	18.2	11.4	-8.6	1.9
Prince Edward Island	68 860	77 991	77 952	42 781	44 515	51 813	13.3	-0.1	13.2	4.0	16.4	21.1
Nova Scotia	341 557	380 600	418 434	447 403	466 842	481 508	11.4	9.9	22.5	4.3	3.1	7.6
New Brunswick	273 410	343 183	378 686	361 147	353 220	345 214	25.5	10.3	38.5	-2.2	-2.3	-4.4
Quebec	1 166 520	1 444 564	1 545 009	4 861 244	4 993 839	5 350 954	23.8	7.0	32.5	2.7	7.2	10.1
Ontario	1 359 477	1 578 075	1 831 047	6 343 629	7 047 032	8 253 838	16.1	16.0	34.7	11.1	17.1	30.1
Manitoba	301 802	295 582	304 767	686 445	730 659	787 175	-2.1	3.1	1.0	6.4	7.7	14.7
Saskatchewan	435 611	405 147	365 531	490 631	563 166	623 397	-7.0	-9.8	-16.1	14.8	10.7	27.1
Alberta	431 621	510 179	514 660	1 196 253	1 727 545	2 030 893	18.2	0.9	19.2	44.4	17.6	69.8
British Columbia	530 215	605 055	641 922	1 654 406	2 139 412	2 640 139	14.1	6.1	21.1	29.3	23.4	59.6
Yukon	7 171	8 339	11 462	11 217	14 814	16 335	16.3	37.5	59.8	32.1	10.3	45.6
Northwest Territories	17 979	23 756	36 492	16 828	21 985	21 157	32.1	53.6	103.0	30.6	-3.8	25.7
Canada	**5 157 527**	**5 907 254**	**6 389 985**	**16 410 784**	**18 435 927**	**20 906 874**	**14.5**	**8.2**	**23.9**	**12.3**	**13.4**	**27.4**

Note:
The population figures presented here are not adjusted for net undercoverage and non-permanent residents.
Source:
Statistics Canada, Census of Population.

Table 2.1.5
Population of Major Census Metropolitan Areas, 1971, 1981 and 1991

Census Metropolitan Area (1991 Rank)	Area[1]			Population			Density			Change
	1971	1981	1991	1971	1981	1991	1971	1981	1991	1971-1991
	km^2			persons			person/km^2			percent
1 Toronto, Ontario	3 628	3 743	5 584	2 628 043	2 998 947	3 893 046	724.4	801.2	697.2	48.1
2 Montréal, Quebec	2 674	2 814	3 509	2 743 208	2 828 349	3 127 242	1 025.9	1 004.9	891.2	14.0
3 Vancouver, British Columbia	2 785	2 786	2 786	1 082 352	1 268 183	1 602 502	388.6	455.2	575.1	48.1
4 Ottawa-Hull, Ont.-Que.	1 898	3 998	5 138	602 510	717 978	920 857	317.4	179.6	179.2	52.8
5 Edmonton, Alberta	3 838	4 143	9 532	495 702	657 057	839 924	129.2	158.6	88.1	69.4
6 Calgary, Alberta	404	505	5 086	403 319	592 743	754 033	999.4	1 173.8	148.3	87.0
7 Winnipeg, Manitoba	697	2 310	3 295	540 262	584 842	652 354	775.2	253.2	198.0	20.7
8 Québec, Quebec	907	2 818	3 150	480 502	576 075	645 550	529.9	204.4	204.9	34.3
9 Hamilton, Ontario	1 137	1 358	1 358	498 523	542 095	599 760	438.6	399.0	441.5	20.3
10 London, Ontario	1 805	1 602	2 105	286 011	283 668	381 522	158.4	177.1	161.2	33.4
11 St. Catharines-Niagara, Ontario	1 019	1 068	1 400	303 429	304 353	364 552	297.8	285.0	260.4	20.1
12 Kitchener, Ontario	568	824	824	226 846	287 801	356 421	399.7	349.4	432.7	57.1
13 Halifax, Nova Scotia	693	2 508	2 503	222 637	277 727	320 501	321.4	110.7	128.0	44.0
14 Victoria, British Columbia	489	489	633	195 800	233 481	287 897	400.8	477.9	454.5	47.0
15 Windsor, Ontario	821	769	862	258 643	246 110	262 075	315.1	320.1	304.2	1.3
16 Oshawa, Ontario	286	286	894	120 318	154 217	240 104	420.1	538.5	268.5	99.6
17 Saskatoon, Saskatchewan	95	122	4 749	126 449	154 210	210 023	1 335.8	1 263.6	44.2	66.1
18 Regina, Saskatchewan	835	835	3 422	140 734	164 313	191 692	168.5	196.7	56.0	36.2
19 St. John's, Newfoundland	838	1 127	1 130	131 814	154 820	171 859	157.3	137.3	152.1	30.4
20 Chicoutimi-Jonquière, Quebec	422	1 133	1 723	133 703	135 172	160 928	317.1	119.4	93.4	20.4
21 Sudbury, Ontario	1 531	2 380	2 612	155 424	149 923	157 613	101.5	63.0	60.3	1.4
22 Sherbrooke, Quebec	...	916	916	...	125 180	139 194	...	136.7	152.0	...
23 Trois-Rivières, Quebec	...	289	872	...	111 453	136 303	...	386.3	156.3	...
24 Saint John, New Brunswick	1 476	1 476	2 905	106 744	114 048	124 981	72.3	77.3	43.0	17.1
25 Thunder Bay, Ontario	672	2 032	2 203	112 093	121 379	124 427	166.7	59.7	56.5	11.0
Total Major CMAs	29 516	42 331	69 191	11 995 066	13 764 124	16 665 360	406.4	325.6	240.9	38.9
Canada	**9 215 430**	**9 215 430**	**9 215 430**	**21 568 311**	**24 343 181**	**27 296 860**	**2.3**	**2.6**	**3.0**	**21.0**
Major CMAs as a percentage of Canada	**0.3**	**0.5**	**0.8**	**55.6**	**56.6**	**61.1**	...	...	...	...

Notes:
The population figures presented here are not adjusted for net undercoverage and non-permanent residents.
1. Based on the 1981 area.
Sources:
Statistics Canada, *Canada's Population From Ocean to Ocean*, Catalogue No. 98-120, Ottawa, 1988.
Statistics Canada, *Census Metropolitan Areas and Census Agglomerations with Components*, Catalogue No. 95-903, Ottawa, 1981.
Statistics Canada, *Census Metropolitan Areas and Census Agglomerations*, Catalogue No. 93-303, Ottawa, 1991.

The highest percentage increases in population density between 1971 and 1991 occurred in less populated ecozones such as the Southern Arctic, the Northern Arctic and the Arctic Cordillera.

Because of their remote locations, the Arctic ecozones should represent pristine environments. However, pollutants originating from European and North American sources are present in the Arctic air and water. Arctic populations also tend to gather in specific locations for resource extraction activities. Increased population, coupled with problems associated with waste disposal in the Arctic, contribute to the stress placed on the Arctic ecosystems.

Urbanization and Census Metropolitan Areas

Between 1871 and 1971, the proportion of the Canadian population living in urban areas increased from 19 percent to 76 percent. From 1971 to 1991 this proportion increased only slightly from 76.1 percent to 76.6 percent (Table 2.1.3).

Urban population varies greatly by province, with Quebec (77.6 percent), Ontario (81.8 percent), Alberta (79.8 percent) and British Columbia (80.4 percent) having urban populations above the 1991 national figure (76.6 percent). Only Prince Edward Island (39.9 percent), New Brunswick (47.7 percent) and the Northwest Territories (36.7 percent) have fewer people in urban than in rural areas. From 1971 to 1991 the only province to experience a decrease in urban population was New Brunswick at -4.4 percent (Table 2.1.4). Saskatchewan was the only province to experience a decrease in rural population over the same period at -16.1 percent.

One of the units of measure for census data is the Census Metropolitan Area (CMA).[1] In 1991, 61 percent of Canada's population lived in one of the 25 largest CMAs (Table 2.1.5). However the total land area of all these 25 CMAs accounted for only 69.1 thousand square kilometres, or 0.7 percent of Canada's 9.7 million square kilometres.

CMA boundaries have expanded from 1971 to 1991 with most CMAs occupying more and more of their surrounding rural areas. Of the 25 largest CMA's in 1991, both Sherbrooke and Trois-Rivières did not qualify as CMAs in 1971. The largest increase in any one CMA land area occurred in Saskatoon, which increased from 95 square kilometres in 1971 to 4 749 square kilometres in 1991. Only Vancouver, whose CMA is bounded by both water and mountains, retained the same land area from 1971 to 1991 (2 786 square kilometres).

In 1991, Canada's most populous CMA was Toronto (3 893 045 people), while its least populous was Thunder Bay (124 425). Together, the top five CMA's accounted for 38 percent of Canada's population. In absolute numbers the greatest CMA population increase from 1971 to 1991 was Toronto (1 265 000); while the lowest increase was in Sudbury (2 190). The CMA experiencing the largest relative population increase was Oshawa (99.6 percent), while Windsor had the lowest (1.3 percent).

One impact of the expansion of CMA boundaries is reduced population density, as CMAs have expanded into lower density rural areas. Not surprisingly, the most dramatic decreases in population density are associated with the largest increase in CMA area (Saskatoon and Calgary). Overall, population density in Canada's 25 CMAs decreased significantly from 1971 to 1991.

1. The general concept of a census metropolitan area (CMA) is one of a very large urban area, together with adjacent urban and rural areas which have a high degree of economic and social integration with that urban area. A CMA is delineated around an urbanized core having a population of at least 100 000 (based on the previous census).

2.2 Components of Population Growth

Over the past 125 years, natural increase (the excess of births over deaths) has accounted for 80 percent of Canada's population growth. Canada experienced high-growth periods from 1900 to 1914 and from 1945 to the mid 1960s. Accompanying these high-growth periods were three low-growth periods from Confederation to 1900, 1930 to 1945 (Great Depression to end of World War II) and from the mid 1960s to the present.

While the growth rate of Canada's population has been declining over the last 30 years, this rate has varied widely for different segments of the population. The recent decline in growth can be attributed to both lower immigration levels and a declining birth rate (Figure 2.2.1).

Current population projections show that by 2041, population growth will slow further, with immigration becoming a larger component of population growth.[1] The average age of the population will increase substantially

Fertility and Mortality

The fertility rate in Canada has declined steadily since Confederation with two exceptions. The first was a sharp decrease in fertility during the depression years followed by a sharp increase during the baby-boom period of 1946-1960. Following the baby-boom, the fertility rate resumed its decrease; it has stabilized since 1980 (Table 2.2.1). Recently there has been a turnaround in births. In 1990 the number of births surpassed 400 thousand for the first time since 1965.

1. Statistics Canada, *Population Projections for Canada, Provinces and Territories, 1989-2011*, Catalogue No. 91-520, Ottawa, 1990.

Table 2.2.1

Components of Population Growth, 1960-1993

Year	Total population	Annual total growth: Number	Annual total growth: Rate	Immigration	Emigration	Net migration	Births: Number	Births: Rate	Deaths	Life expectancy: Male	Life expectancy: Female	Population aged 65 and over
	thousands	thousands	percent	thousands	thousands	thousands	thousands	births per woman	thousands	years	years	percent of population
1960	17 710.0	382.0	2.2	104.1	75.6	43.1	478.6	3.90	139.7	..	..	7.6
1961	18 092.0	350.0	1.9	71.7	72.3	15.3	475.7	3.85	141.0	68.3	74.2	7.6
1962	18 442.0	345.0	1.9	74.6	76.7	19.0	469.7	3.77	143.7	..	..	7.6
1963	18 787.0	355.0	1.9	93.2	83.6	36.6	465.8	3.68	147.4	..	..	7.6
1964	19 142.0	359.0	1.9	112.6	92.4	52.0	452.9	3.52	145.9	..	..	7.7
1965	19 501.0	356.0	1.8	146.8	105.3	86.3	418.6	3.16	148.9	..	..	7.7
1966	19 857.0	371.0	1.9	194.7	91.5	133.2	387.7	2.82	149.9	68.8	75.2	7.7
1967	20 228.0	353.0	1.7	222.9	108.5	132.4	370.9	2.60	150.3	..	..	7.7
1968	20 581.0	307.0	1.5	184.0	100.0	95.9	364.3	2.46	153.2	..	..	7.8
1969	20 888.0	294.0	1.4	161.5	90.1	78.9	369.7	2.41	154.5	..	..	7.9
1970	21 182.0	844.4	4.0	147.7	81.0	67.0	372.0	2.34	156.0	..	..	8.0
1971	22 026.4	258.1	1.2	121.9	70.1	39.7	362.2	2.19	157.3	69.3	76.4	8.0
1972	22 284.5	275.0	1.2	122.0	63.2	47.9	347.3	2.02	162.4	69.4	76.5	8.1
1973	22 559.5	315.2	1.4	184.2	78.5	112.5	344.3	1.94	164.0	69.5	76.7	8.2
1974	22 874.7	334.5	1.5	218.5	78.1	149.5	350.7	1.89	166.8	69.7	77.0	8.3
1975	23 209.2	308.3	1.3	187.9	70.7	122.3	359.3	1.87	166.4	69.9	77.3	8.4
1976	23 517.5	278.9	1.2	149.4	64.4	81.7	360.0	1.82	167.2	70.2	77.5	8.6
1977	23 796.4	239.9	1.0	114.9	61.4	65.1	361.4	1.80	167.5	70.5	78.0	8.8
1978	24 036.3	240.6	1.0	86.3	63.5	36.4	358.9	1.75	168.2	70.9	78.3	9.0
1979	24 276.9	316.4	1.3	112.1	54.7	69.5	366.1	1.76	168.2	71.1	78.6	9.2
1980	24 593.3	306.7	1.2	143.1	45.2	110.2	370.7	1.74	171.5	71.5	78.8	9.4
1981	24 900.0	301.9	1.2	128.6	43.7	61.7	371.4	1.70	171.0	71.9	79.0	9.6
1982	25 201.9	254.4	1.0	121.1	49.4	23.6	373.1	1.69	174.4	72.2	79.3	9.7
1983	25 456.3	245.5	1.0	89.2	50.1	-8.6	373.7	1.68	175.0	72.6	79.5	9.8
1984	25 701.8	239.8	0.9	88.2	46.8	-6.7	377.0	1.68	175.7	72.7	79.7	10.0
1985	25 941.6	262.2	1.0	84.3	46.9	-10.8	375.7	1.67	181.3	73.0	79.8	10.2
1986	26 203.8	345.9	1.3	99.2	49.0	30.2	372.9	1.66	184.2	73.0	79.7	10.5
1987	26 549.7	345.1	1.3	152.1	43.9	109.5	369.7	1.65	185.0	..	..	10.7
1988	26 894.8	484.5	1.8	161.9	37.2	124.7	376.8	1.68	190.0	73.4	80.2	10.9
1989	27 379.3	411.3	1.5	192.0	38.3	153.7	391.9	..	191.0	73.7	80.3	11.0
1990[1]	27 790.6	327.0	1.2	214.3	39.2	174.9	405.5	..	191.7	74.0	80.6	11.2
1991[1]	28 117.6	318.0	1.1	230.8	43.1	187.7	402.5	..	195.5	74.2	80.8	11.2
1992[2]	28 435.6	317.4	1.1	248.7	44.3	204.4	404.3	..	199.0	..	..	11.6
1993[2]	28 753.0	..	..	..	..	..	..	..	..	..	..	11.8

Notes:

1. Data may be subject to minor revision.
2. Preliminary data.

Sources:

Statistics Canada. *Report on the Demographic Situation in Canada 1992*, Catalogue No. 91-209, Ottawa, 1992.
Statistics Canada, *Quarterly Estimates*, Catalogue No. 91-002, Ottawa, various issues.
Statistics Canada, Census of Population and Demography Division.

Table 2.2.2

Net Internal Migration for Provinces and Territories, 1970-1991

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon and N.W.T.
						thousands					
1970	-5 950	-29	-3 967	-2 373	-41 156	54 590	-7 707	-28 358	9 898	22 579	2 473
1971	733	-129	-755	1 798	-25 005	18 580	-7 251	-17 986	2 408	25 034	2 573
1972	-189	858	2 845	241	-19 891	8 227	-7 735	-17 296	6 538	24 927	1 475
1973	-2 510	478	2 107	2 841	-14 730	-5 275	-2 200	-13 261	2 698	30 537	-685
1974	-618	1 386	1 576	4 192	-11 852	-22 163	-5 400	-4 835	14 810	22 655	249
1975	915	814	4 454	7 572	-12 340	-25 057	-4 134	6 555	23 463	-2 864	622
1976	-2 732	309	361	1 640	-20 801	-10 508	-3 655	3 819	34 215	-1 490	-1 158
1977	-4 009	614	-1 277	-886	-46 536	8 596	-3 789	384	32 344	15 507	-948
1978	-3 540	25	-109	-1 644	-33 424	415	-9 557	-3 701	31 987	20 698	-1 150
1979	-4 217	-225	-1 840	-2 219	-30 025	-15 317	-13 806	-3 510	39 212	33 241	-1 294
1980	-3 082	-1 082	-2 494	-4 165	-24 283	-34 919	-11 342	-4 382	46 933	40 165	-1 349
1981	-6 238	-783	-2 465	-4 766	-22 549	-19 665	-3 621	-520	40 243	21 565	-1 201
1982	261	-6	1 591	2 183	-28 169	19 614	1 498	1 743	3 961	-2 019	-657
1983	-1 092	799	3 861	2 296	-19 080	32 825	950	2 501	-26 246	4 029	-843
1984	-3 585	524	2 963	812	-10 943	36 691	-49	733	-30 591	3 505	-60
1985	-5 019	-13	-234	-1 559	-6 023	33 414	-1 755	-5 014	-9 568	-3 199	-1 030
1986	-4 682	-493	-739	-2 897	-3 020	42 916	-3 039	-7 020	-20 293	910	-1 643
1987	-4 374	301	-2 183	-1 762	-7 410	40 278	-4 751	-9 043	-27 595	17 618	-1 079
1988	-2 154	424	71	-1 215	-7 003	14 898	-8 584	-16 338	-5 535	25 865	-429
1989	-2 606	-102	572	-21	-8 379	-1 205	-10 004	-18 589	3 366	37 367	-399
1990	-3 315	-886	-150	67	-10 014	-12 329	-9 479	-16 163	8 481	44 007	-219
1991	-1 961	-1 553	987	-2 377	-12 259	-6 604	-7 663	-9 829	7 264	33 447	548

Source:
Statistics Canada, *Report on the Demographic Situation in Canada 1992*, Catalogue No. 91-209, Ottawa, 1992.

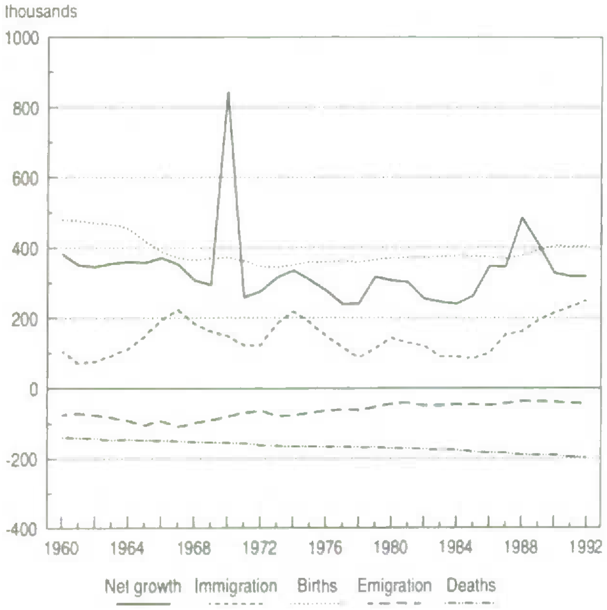
Table 2.2.3

Interprovincial Migrants, January-December 1991

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.	Out Migration
							persons						
Nfld.	-	228	2 175	766	393	6 026	284	117	1 413	1 112	39	175	12 728
P.E.I.	182	-	1 469	627	159	1 107	116	73	575	393	-	21	4 722
N.S.	1 546	681	-	2 959	1 170	8 971	688	413	1 951	2 461	47	256	21 143
N.B.	617	551	3 818	-	2 588	5 658	560	201	1 358	1 349	58	96	16 854
Que.	376	153	1 348	2 473	-	26 723	761	314	3 138	5 021	21	222	40 550
Ont.	6 333	980	8 602	5 297	18 223	-	6 044	2 654	16 921	23 636	183	726	89 599
Man.	109	82	584	363	876	7 412	-	2 994	6 392	7 290	34	285	26 421
Sask.	124	46	356	215	519	2 793	2 991	-	15 250	6 539	171	478	29 482
Alta.	910	268	1 735	1 030	1 882	12 136	3 778	9 167	-	30 654	512	1 360	63 432
B.C.	411	130	1 857	693	2 228	11 489	3 279	3 534	21 509	-	1 097	628	46 855
Yukon	43	-	30	7	31	178	54	25	401	1 029	-	94	1 892
N.W.T.	98	50	174	47	222	502	203	161	1 788	818	219	-	4 282
In Migration	10 767	3 169	22 148	14 477	28 291	82 995	18 758	19 653	70 696	80 302	2 381	4 341	357 978
Out Migration	12 728	4 722	21 161	16 854	40 550	89 599	26 421	29 482	63 432	46 855	1 892	4 282	357 978
Net Migration	**-1 961**	**-1 553**	**987**	**-2 377**	**-12 259**	**-6 604**	**-7 663**	**-9 829**	**7 264**	**33 447**	**489**	**59**	**0**

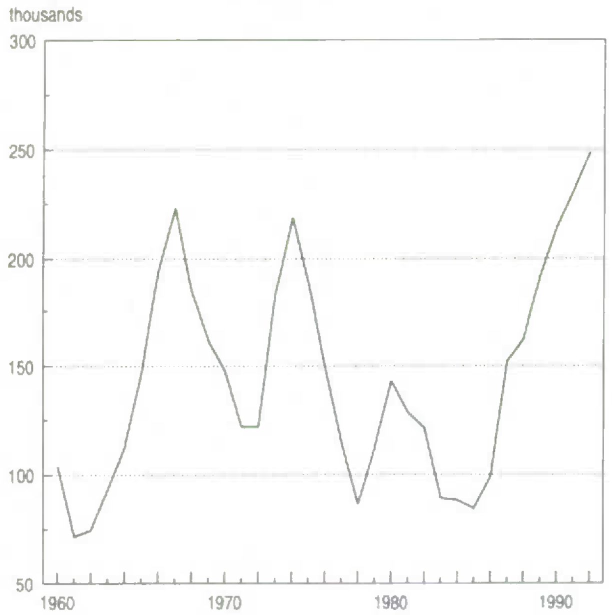
Source:
Statistics Canada, *Report on the Demographic Situation in Canada 1992*, Catalogue No. 91-209, Ottawa, 1992.

Figure 2.2.1
Components of Population Growth, 1960-1992



Source:
Statistics Canada, Demography Division.

Figure 2.2.2
Immigrant Arrivals,1960-1992



Source:
Statistics Canada, *Report on the Demographic Situation in Canada*, Catalogue No. 91-209, Ottawa, 1992.

Although life expectancy has, in general, gradually increased, a larger increase occurred between 1976 and 1981. At this time male life expectancy increased more than that of women (an increase of 1.7 years for males versus 1.5 years for females). This increasing trend for males over females has continued over the following 5 year periods (1981 to 1986 and 1986 to 1991). As a result, the difference between male and female life expectancies had narrowed slightly by 1991.

Immigration

Immigration has added to Canada's population and given Canada a richer cultural diversity. The highest influx of immigrants occurred from 1910 to 1914 when 3 million settlers entered Canada in response to the government's promotion of agriculture in the western provinces.

Over the last century, the focus of Canada's immigration policy has switched from farmers (early 1900s) to skilled factory workers (1950s) to a selection process based on merit (1960s). As illustrated in Figure 2.2.2, during the 1960s and 1970s immigration has averaged about 135 000 persons annually. Since 1987, immigration levels have gradually increased to a high of 248 700 in 1992 (Table 2.2.1).

Internal Migration

Regional populations and economies both influence and are influenced by population movements within a country. These internal migration streams include inter-provincial movements as well as rural/urban movements. It is of no surprise that regions with mild climates and/or strong economies tend to attract people from other regions. Table 2.2.2 shows that for the period 1970 to 1991, the Atlantic provinces, Quebec, Manitoba, and Saskatchewan attracted the fewest internal migrants, while Ontario, Alberta and British Columbia attracted the most. Table 2.2.3 presents detailed inter-provincial migration figures for 1991. British Columbia recorded the highest positive net migration (over 33 thousand).

2.3 Population Trends

Population Growth Rate

The rate of growth of the Canadian population reached its lowest level (0.9 percent per year) in 1984 (see section 2.2 - **Components of Population Growth**). After 1985, the growth rate slowly increased and stabilized at 1.2 percent in 1990 (Figure 2.3.1).

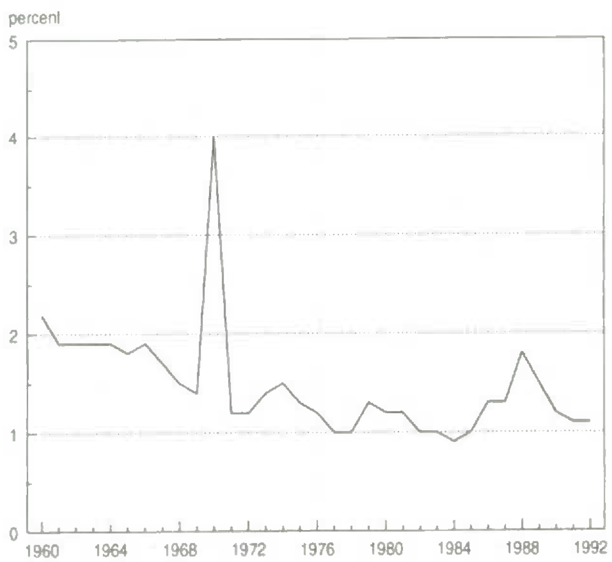
Immigration

Immigration, in the past, has accounted for one-quarter to one-half of Canada's population growth. In the years between 1987 and 1992, increasing immigration and decreasing emigration resulted in a net immigration of over 100 thousand persons per year (see section 2.2 - **Components of Population Growth**).

Aging Population

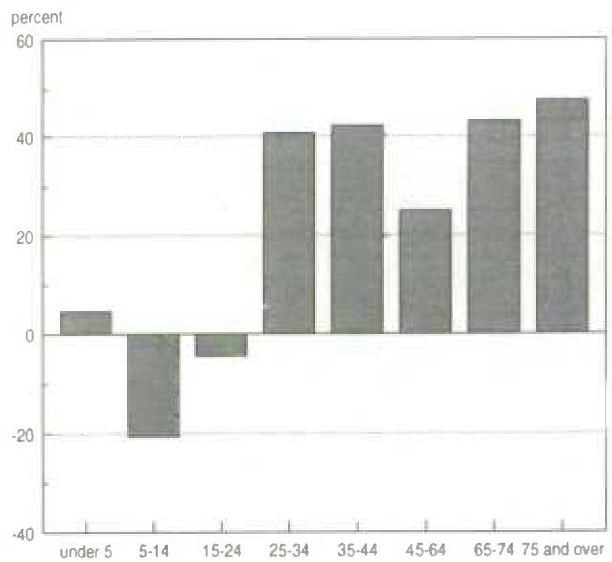
As shown in Figure 2.3.2 and Table 2.3.1, over the period 1971-1991 there has been considerable growth in both the elderly segment of the population (65 and over) and in the adult working population (20 to 64). There has also been a dramatic reduction in the number of youths in the Canadian population. From 1971 to 1991, the population aged 14 and under decreased from 6.4 million (29.1 percent of total) to 5.8 million (20.7 percent of total). The number of persons over 65 years grew from 1.8 million (8.0 percent of total) to 3.2 million (11.4 percent of total). In 1971, eight people in every 100 were over 65 and this had increased to nearly 12 in 100 by 1991. The main causes for these changes are declining fertility rates and increased life expectancy.

Figure 2.3.1
Population Growth Rate, 1960-1992



Source:
Statistics Canada, Demography Division.

Figure 2.3.2
Percent Change by Age Group, 1971-1991



Source:
Statistics Canada, Census of Population.

Table 2.3.1
Population by Age Group, 1971, 1981 and 1991

Age groups	Total population			Age group population as a percentage of total			Change		
	1971	1981	1991	1971	1981	1991	1971-1981	1981-1991	1971-1991
	thousands			percent					
Under age 5	1 840.3	1 807.3	1 953.2	8.4	7.3	6.9	-1.8	7.5	5.8
5-14	4 603.9	3 735.5	3 865.9	20.9	15.0	13.7	-23.2	3.4	-19.1
15-24	4 163.3	4 879.3	4 034.9	18.9	19.6	14.3	14.7	-20.9	-3.2
25-34	2 999.2	4 352.5	5 126.7	13.6	17.5	18.2	31.1	15.1	41.5
35-44	2 578.4	3 050.3	4 483.5	11.7	12.3	15.9	15.5	32.0	42.5
45-64	4 075.9	4 695.5	5 442.6	18.5	18.9	19.4	13.2	13.7	25.1
65-74	1 090.2	1 488.4	1 918.6	4.9	6.0	6.8	26.8	22.4	43.2
75 and over	675.2	891.2	1 292.4	3.1	3.6	4.6	24.2	31.0	47.8
Total	**22 026.4**	**24 900.0**	**28 117.8**	**100.0**	**100.0**	**100.0**	**11.5**	**11.4**	**21.7**

Source:
Statistics Canada, Census of Population.

2.4 Population Projections

Statistics Canada produces population projections for Canada, the provinces and the territories using the regional cohort component approach. After the analysis of previous trends in each component of population growth (fertility, mortality and internal and international migration) these parameters are applied to their corresponding base year values to obtain an estimate of the future population.[1] Four series of projections are presented here (Figure 2.4.1 and Table 2.4.1) and suggest that the demographic pattern for Canada by the year 2000 could be marked by:

- a slow down in population growth;
- a gradual aging of the population at first, followed by substantial acceleration by 2015 as the baby-boom cohorts reach retirement age;
- an increasing role of immigration in the dynamics of Canada's population growth;
- more internal migration leading to changes in provincial population distributions.

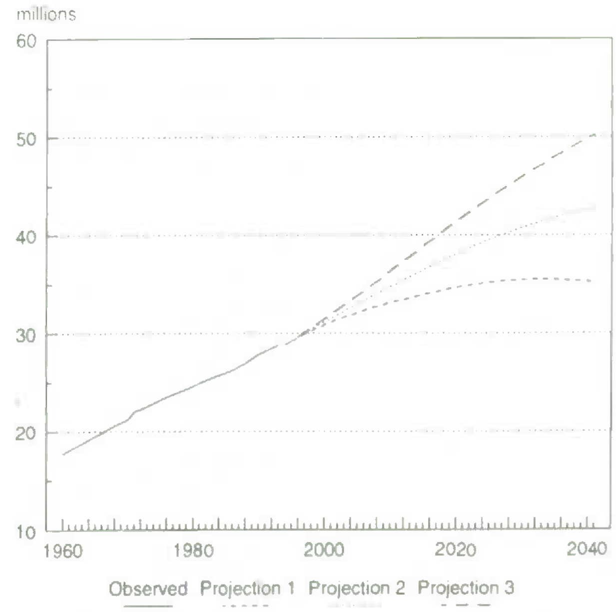
Projection Results

A total of 18 projections were developed using all possible combinations of the three fertility, the two international migration, and the three internal migration scenarios. From these, one projection represents the continuation of current trends (Projection 3). The other scenarios are intended to reflect possible deviations from these trends.

At the national level, Projection 1 is a low-growth scenario. Projections 2 and 3 are medium-growth scenarios, whereas Projection 4 yields higher growth. All four projected population totals for Canada are found in Table 2.4.2.

Whichever projection is considered, Canada's population will likely grow at a slower pace than in the past, and the increase in the average age of the population will accelerate. Considering the internal migration assumptions, only minor changes in the distribution of population among the provinces and territories are expected by 2011.

Figure 2.4.1
Population Projections, 1960-2041



Note:
Projection 4 not included in chart.
Source:
Statistics Canada, Demography Division

1. The rationale of these assumptions and details on methodology can be obtained from Statistics Canada, *Population Projections for Canada, Provinces and Territories 1989-2011*, Catalogue No. 91-520, Ottawa, 1990.

Table 2.4.1
Total Population Projections for Canada, 1994-2041

Year	Projection 1	Projection 2	Projection 3	Projection 4
	thousands			
1994	28 798.1	28 798.1	28 798.1	28 798.1
1995	29 176.6	29 183.3	29 191.8	29 191.8
1996	29 539.4	29 562.5	29 589.8	29 589.9
1997	29 876.3	29 963.7	30 048.3	30 048.6
1998	30 200.3	30 358.4	30 507.4	30 507.9
1999	30 512.8	30 747.0	30 966.1	30 967.0
2000	30 814.8	31 129.3	31 423.4	31 424.8
2001	31 107.6	31 505.9	31 879.2	31 881.1
2002	31 361.9	31 877.3	32 363.8	32 336.3
2003	31 608.7	32 244.3	32 847.5	32 850.7
2004	31 848.9	32 607.2	33 330.7	33 334.7
2005	32 083.2	32 966.7	33 813.6	33 818.4
2006	32 312.4	33 323.4	34 296.5	34 302.1
2007	32 506.7	33 677.5	34 799.9	34 806.4
2008	32 696.6	34 029.5	35 304.2	35 311.6
2009	32 882.4	34 379.7	35 809.4	35 817.8
2010	33 064.3	34 728.1	36 315.7	36 325.0
2011	33 242.7	35 075.0	36 823.0	36 833.2
2012	33 417.6	35 420.3	37 331.2	37 342.5
2013	33 589.0	35 764.0	37 840.4	37 852.7
2014	33 756.9	36 106.0	38 350.3	38 363.6
2015	33 921.2	36 446.2	38 860.9	38 875.3
2016	34 081.5	36 784.2	39 372.0	39 387.5
2017	34 237.6	37 119.8	39 883.4	39 900.0
2018	34 386.9	37 449.4	40 390.0	40 407.7
2019	34 529.0	37 772.6	40 891.5	40 910.5
2020	34 663.2	38 089.0	41 387.7	41 408.0
2021	34 789.0	38 398.0	41 878.4	41 900.0
2022	34 905.7	38 699.3	42 363.3	42 386.3
2023	35 012.7	38 992.2	42 842.0	42 866.5
2024	35 109.6	39 276.6	43 314.5	43 340.5
2025	35 196.0	39 552.0	43 780.4	43 808.0
2026	35 271.5	39 818.3	44 239.6	44 268.8
2027	35 336.0	40 075.1	44 691.8	44 722.6
2028	35 389.4	40 322.3	45 136.8	45 169.3
2029	35 431.7	40 560.0	45 574.5	45 608.8
2030	35 463.1	40 788.1	46 004.7	46 040.7
2031	35 483.8	41 006.8	46 427.2	46 465.1
2032	35 494.2	41 216.1	46 842.0	46 881.7
2033	35 494.6	41 416.2	47 249.1	47 290.6
2034	35 485.6	41 607.3	47 648.4	47 691.8
2035	35 467.4	41 789.8	48 040.0	48 085.3
2036	35 440.7	41 964.0	48 424.0	48 471.2
2037	35 405.9	42 130.1	48 800.6	48 849.6
2038	35 363.6	42 288.4	49 169.8	49 220.6
2039	35 314.2	42 439.4	49 531.8	49 584.5
2040	35 258.3	42 583.5	49 887.0	49 941.5
2041	35 196.5	42 721.1	50 235.6	50 291.9

Source:
Statistics Canada, Demography Division.

Table 2.4.2

Population Projections for Canada, Provinces and Territories, 1994-2016

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
							thousands						
Projection 1													
1994	28 798.1	581.3	131.7	923.8	751.8	7 215.0	10 765.6	1 118.1	1 004.0	2 670.0	3 541.6	32.0	62.9
1996	29 539.4	581.6	133.2	931.7	756.4	7 340.7	11 111.5	1 126.1	1 002.3	2 747.3	3 709.3	33.9	65.2
2001	31 107.6	574.9	136.3	942.5	761.5	7 582.4	11 899.3	1 140.8	996.7	2 905.6	4 060.4	36.6	70.6
2006	32 312.4	559.6	138.1	944.5	756.6	7 736.9	12 558.0	1 149.9	987.9	3 039.7	4 325.1	37.8	76.2
2011	33 242.7	538.7	138.9	939.6	750.2	7 824.5	13 107.7	1 153.9	978.7	3 155.2	4 535.1	38.5	81.6
2016	34 081.5	514.9	138.9	930.0	739.3	7 883.0	13 633.9	1 156.5	969.6	3 261.0	4 728.8	38.6	87.0
Percent change	**15.4**	**-7.3**	**5.5**	**1.7**	**-0.2**	**8.4**	**21.8**	**3.2**	**-2.5**	**18.2**	**28.0**	**20.3**	**29.7**
Projection 2													
1994	28 798.1	581.3	131.7	923.8	751.8	7 215.0	10 765.6	1 118.1	1 004.0	2 670.0	3 541.8	32.0	62.9
1996	29 562.5	582.0	133.3	932.4	757.0	7 346.1	11 120.3	1 127.1	1 003.2	2 749.6	3 712.1	34.0	65.3
2001	31 505.9	578.9	137.3	949.9	766.8	7 667.6	12 083.1	1 153.3	1 005.7	2 940.3	4 114.5	36.9	71.4
2006	33 323.4	568.8	140.6	962.1	770.9	7 950.9	13 031.7	1 180.2	1 009.4	3 126.8	4 465.0	38.7	78.2
2011	35 075.0	554.2	143.3	970.3	771.3	6 208.5	13 976.2	1 207.1	1 015.8	3 311.9	4 791.3	40.1	85.2
2016	36 784.2	536.9	145.3	975.1	770.4	8 445.9	14 919.0	1 233.6	1 023.2	3 492.6	5 108.7	40.9	92.5
Percent change	**21.8**	**-4.7**	**8.8**	**5.0**	**2.6**	**13.8**	**29.8**	**8.0**	**1.2**	**24.0**	**35.3**	**25.3**	**35.5**
Projection 3													
1994	28 798.1	581.3	131.7	923.8	751.8	7 215.0	10 765.6	1 118.1	1 004.0	2 670.0	3 541.8	32.0	62.9
1996	29 589.6	586.4	135.4	936.3	761.0	7 342.6	11 114.2	1 124.9	998.2	2 762.0	3 727.7	34.7	66.4
2001	31 679.2	598.2	140.0	969.7	785.4	7 710.9	12 173.3	1 148.6	984.9	3 029.5	4 223.2	40.0	75.5
2006	34 296.5	604.6	146.5	1 002.1	807.3	8 086.5	13 326.6	1 177.0	975.8	3 320.1	4 720.7	44.4	85.1
2011	36 823.0	606.6	152.9	1 033.2	827.4	8 471.7	14 553.8	1 211.1	974.8	3 633.1	5 214.9	48.4	95.2
2016	39 372.0	606.3	159.4	1 061.9	846.8	8 849.9	15 803.6	1 248.0	979.1	3 955.0	5 704.3	51.6	106.1
Percent change	**27.9**	**4.4**	**16.1**	**11.8**	**10.1**	**17.4**	**35.2**	**8.3**	**-2.9**	**36.1**	**47.2**	**51.2**	**51.4**
Projection 4													
1994	28 798.1	581.3	131.7	923.8	751.8	7 215.0	10 765.6	1 118.1	1 004.0	2 670.0	3 541.8	32.0	62.9
1996	29 589.9	578.7	132.8	930.5	754.2	7 362.5	11 147.2	1 131.5	1 010.4	2 742.6	3 702.0	33.3	64.2
2001	31 881.1	569.2	136.0	947.9	760.4	7 786.7	12 326.5	1 181.5	1 045.4	2 919.4	4 104.9	34.4	68.8
2006	34 302.1	554.8	139.0	964.1	762.9	8 231.9	13 624.5	1 241.8	1 087.7	3 108.1	4 477.1	34.8	75.4
2011	36 833.2	537.8	141.9	979.1	763.2	8 686.3	15 011.9	1 305.2	1 133.6	3 302.3	4 854.3	35.3	82.5
2016	39 387.5	518.9	144.4	992.3	764.1	9 131.8	16 432.0	1 368.2	1 178.8	3 493.5	5 237.5	35.7	90.2
Percent change	**27.9**	**-7.5**	**7.7**	**6.0**	**1.5**	**20.4**	**39.4**	**16.7**	**12.9**	**23.7**	**37.1**	**10.3**	**31.2**

Source:
Statistics Canada, Demography Division.

2.5 Perceptions and Attitudes

Our motivation to protect the environment arises, first and foremost, from our perception of its impact on our daily lives. This includes concerns about the effects on our health from the water we drink, the air we breathe and the food we eat. We may also have concerns about the way we use natural resources and whether we will be able to sustain these resources for our future well-being. The pleasure we derive from hiking through natural areas with diverse populations of animals, plants and birds, or even from simply knowing that such areas still exist for our enjoyment, also elevates our environmental awareness. Our actions may also be motivated by a sense of moral responsibility to prevent the extinction of species and other changes in natural systems.

The environment is important to Canadians. In opinion surveys conducted for Environment Canada in 1992, over 90 percent of respondents said they were somewhat or very concerned about the environment.[1] Furthermore, a 1991 study found that 67 percent of Canadians agreed to at least some degree that, from an environmental perspective, we are in serious danger of destroying the world; 83 percent felt environmental problems were already causing health problems.[2]

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Although Canadians are concerned about the environment, Table 2.5.1 illustrates that few people, when surveyed in 1993, ranked it as the most important and pressing issue requiring political attention. Other issues, including the need for jobs, the government budgetary deficit and the state of the economy were seen to need more immediate attention.

Table 2.5.1

Canadians Ranking the Environment as the Number One Issue, 1993

Issue	Fall 1993
	percent
Jobs	44
Deficit	20
Free trade/economy	10
Environment	1

Note:
A selection of issues are presented, therefore column does not total to 100 percent.
Source:
Angus Reid Group as reported in the Ottawa Citizen, October 1993.

Does this mean that environmental concerns are less important than economic ones and that short term priorities take precedence over long term ones for most Canadians? Alternatively, do Canadians see more progress with environmental problems than with the economy and, despite fears of environmental destruction, trust that these problems can be successfully dealt with?

Many Canadians, in fact, are optimistic about the future state of the environment. In 1991, 45 percent of the people questioned expected an improved environment in ten years, compared to the 33 percent who thought it would be in worse shape than today. The remainder of those asked expected little change.[3] It seems that many Canadians are convinced that the actions of today by government, industry, and the public will successfully address many of the current environmental concerns.

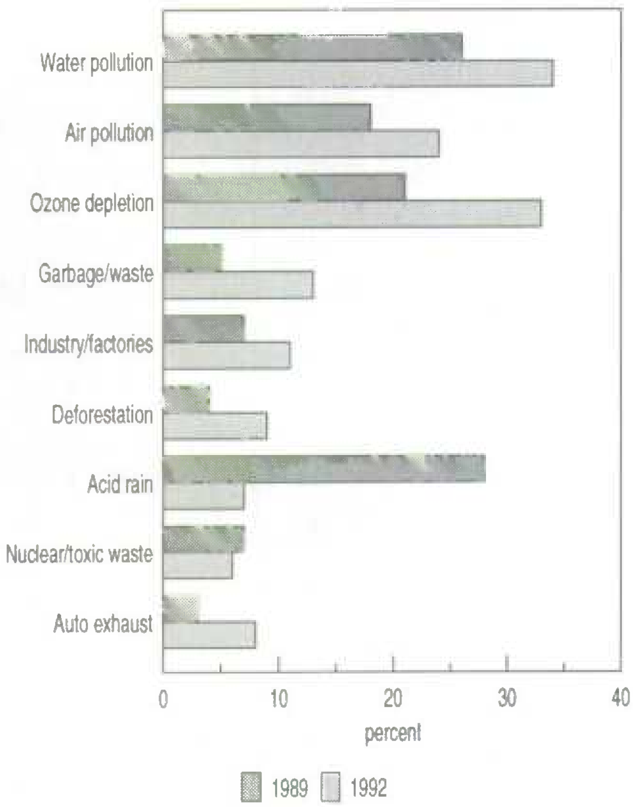
In general, the degree of attention paid to protecting the environment is much greater than it was fifty years ago. Part of the reason for this is the recognition of the consequences of our past actions; in some cases we have had to take major steps to rehabilitate and protect the resources we need to survive and prosper. The scale of our influence on the environment has generally grown over time. However, we continue to learn new lessons about the need to keep environment and resource policies in touch with our long-term environmental objectives.

Since Canada's economy has a strong natural resource dimension, economic concerns reflect, at least to some degree, problems in the environment. While an east coast fisherman or a west coast logger may voice concerns about the economic state of their industry and the lack of jobs, these problems originated largely as a result of problems in the environment.

Popular perceptions of the most important environmental problems have changed from year to year, reflecting the flow of information from government and scientists, as well as the reporting of specific incidents reported by the media. When asked to name their two greatest environmental concerns, 33 percent of Canadians mentioned ozone depletion in the atmosphere in 1992 compared to 21 percent in 1989. Thirty-four percent mentioned water pollution in 1992, about 6 percentage points higher than in 1989. Meanwhile, Canadians have become less concerned about acid rain. In 1989, 28 percent cited this as one of the most important problems, in contrast with the 7 percent who did in 1992 (Figure 2.5.1).

1. Environment Canada, Communications Division.
2. Angus Reid Group, *Canadians and the Environment*, 1991.
3. Ibid.

Figure 2.5.1
Major Global Environmental Concerns, 1989 and 1992



Source:
Angus Reid Group, Canadians and the Environment Survey as reported in the *Toronto Star*, September 1, 1992.

Tables 2.5.2 and 2.5.3 present the environmental priorities of Canadians by region for 1991. As a global concern, water pollution was the highest priority for residents in all regions except Alberta, where air pollution was at the top of the list. Water pollution was mentioned more frequently in Quebec and Ontario than in other provinces and environmental problems associated with industries and factories were also a higher priority in Quebec than elsewhere. Perhaps surprisingly, given the warmer-than-normal weather of the late 1980s, climate change (the greenhouse effect) was well down on the list of major global environmental concerns.

At the community level, water pollution was again high on the priority list in the Atlantic Canada, Ontario, Quebec and British Columbia. Garbage/waste concerns topped the list in Alberta, Manitoba and Saskatchewan. Garbage was also mentioned frequently by Ontario residents. Local air pollution was frequently cited as a concern in British Columbia (29 percent) and Ontario (28 percent).

Table 2.5.2
Major Global Environmental Concerns of Canadians by Region, 1991

Issue	Canada	Atlantic provinces	Quebec	Ontario	Man./ Sask.	Alberta	B.C.
	percent						
Water pollution	34	26	40	38	28	25	28
Air pollution	25	21	23	27	24	26	24
Ozone depletion	20	16	19	22	17	20	19
Garbage/waste	12	12	8	13	18	12	11
Oil spills	12	14	6	13	10	16	22
Industry/factories	11	8	21	6	2	7	11
Forestry/deforestation	10	2	9	9	11	18	16
Acid rain	10	13	9	12	7	8	6
Rain forest destruction	10	6	6	10	15	14	12
Nuclear/toxic waste	8	8	8	9	10	3	7
Pollution-general	7	16	6	5	11	11	5
Greenhouse effect	7	8	4	8	7	7	6

Note:
Respondents were asked to name the two most serious problems facing the world, but not necessarily their community. Up to two answers were accepted from each respondent; therefore responses will add to more than 100%. Angus Reid Group has conducted the Canadians and the Environment Survey each year since 1989. The 1991 Survey was conducted at the end of July and in the first week of August. Telephone interviews of 1 508 adults were conducted. Angus Reid Group reports that one can say with 95 percent certainty that the results are within plus or minus 2.5 percentage points, of what they would have been had the entire Canadian adult population been sampled. The margin of error is larger for regional breakdowns.
Source:
Angus Reid Group, *Canadians and the Environment*, Toronto, 1991.

Many of the items identified in Tables 2.5.2 and 2.5.3 are concerns because they have potential health effects. For example, water pollution ranked first in these two tables and when Canadians were asked for their concerns about water, the safety of drinking water is a prime concern.[1]

Table 2.5.3
Major Community-Level Environmental Concerns of Canadians by Region, 1991

Issue	Canada	Atlantic provinces	Quebec	Ontario	Man./ Sask.	Alberta	B.C.
	percent						
Water pollution	36	22	38	42	21	24	37
Garbage/waste	27	22	20	32	35	35	15
Air pollution	22	9	18	28	9	19	29
Industry/factories/pulp	12	9	14	8	6	16	18
Auto exhaust	8	3	11	6	4	8	13
Lack of recycling	7	5	6	6	9	10	9
Forestry/deforestation	6	1	5	4	7	4	17
Acid rain	5	6	7	6	1	2	3
Chemicals	5	5	4	4	15	6	4
Nuclear/toxic waste	3	3	3	3	3	4	4
Sewage problems	3	8	2	2	0	3	5
Pollution in general	3	6	3	4	4	3	2

Note:
Figures represent total mentions. Up to two answers were accepted from each respondent; therefore responses will add to more than 100%.
Source:
Angus Reid Group, *Canadians and the Environment*, Toronto, 1991.

1. Environment Canada, Communications Division.

Table 2.5.4 presents information from *Canada's Health Promotion Survey*. Conducted in 1990, this survey asked specifically about current environmental impacts on the respondents' health. About 32 percent of respondents felt their health had been affected (by a fair amount or very much) by environmental factors in the year preceding the survey, while 60 percent believed there had been little or no impact. On a provincial basis, Quebec (38 percent) and New Brunswick (35 percent) had the highest percentages of respondents who believed their health had been affected, while Newfoundland had the lowest percentage (20 percent).[1]

Other survey results show that 68 percent of Canadians strongly agreed that environmental problems are already causing health problems.[2]

Table 2.5.4

Perceived Impact of Environmental Pollution on One's Own Health, 1990

Province	Very much	A fair amount	Not very much	Not at all	Don't know
	percent				
Newfoundland	3	17	51	25	5
Prince Edward Island	4	20	49	21	6
Nova Scotia	5	24	46	18	7
New Brunswick	7	28	42	15	11
Quebec	11	27	36	19	7
Ontario	8	23	42	15	11
Manitoba	4	20	47	20	8
Saskatchewan	3	20	48	23	7
Alberta	6	23	47	17	7
British Columbia	6	22	44	20	9
Canada	**8**	**24**	**42**	**18**	**9**

Note:
Perceived impact on the individual's health in the year preceding the survey. The survey was conducted in June 1990.
Source:
Health and Welfare Canada, T. Stephens and D. Fowler Graham, editors, *Canada's Health Promotion Survey 1990: Technical Report*, Catalogue No. H39-263/2-1990, Ottawa, 1993.

Have health concerns motivated Canadians to change their behaviour to reduce risks they perceive arising from environmental sources? Drinking water quality has been noted as a prime concern to many. Table 2.5.5, taken from the 1991 *Households and Environment Survey*,[3] presents information on two actions householders might take to reduce their perceived exposure.

By consuming bottled water, consumers believe they avoid the risks they associate with tap water. By filtering tap water, consumers are also acting to remove substances in the water they fear may have an impact on their health.The results reveal that about 14 percent of households used a drinking water filter and about 16 percent purchased drinking water for home consumption in the weeks prior to the survey. Ontario had the highest percentage of households equipped with a water filter, while Quebec households were most likely to purchase bottled water. These results mirror the strong concerns expressed by Ontario and Quebec residents about water pollution presented in Table 2.5.5.

Table 2.5.5

Households with Drinking Water Filters or Purchasing Bottled Water, 1991

Province	Total households	Households with drinking water filter or purifier	Household purchasing bottled water for drinking at home[1]
	thousands	percent	
Newfoundland	177	6.8	--
Prince Edward Island	47	--	--
Nova Scotia	326	8.6	8.9
New Brunswick	251	8.0	8.8
Quebec	2 618	8.3	30.6
Ontario	3 585	18.7	13.1
Manitoba	389	12.3	6.9
Saskatchewan	359	16.2	5.6
Alberta	898	14.1	9.7
British Columbia	1 225	15.0	10.3
Canada	**9 873**	**13.9**	**16.1**

Note:
1. Households purchasing bottled water for drinking at home in the four weeks preceding the survey.
Source:
Statistics Canada, *Households and the Environment, 1991*, Catalogue No. 11-526, Ottawa, 1992.

However, water quality concerns are not the only factor motivating the use of water filters and bottled water. A confounding factor is that households use filtered and bottled water because the taste is preferred to that of tap water. Without additional research it is not possible to determine the extent to which the use of these products can be attributed to the perceived health risks of water.

Other actions taken by the public in response to their environmental concerns include participation in recycling programmes, changes in purchasing practices and the use of energy in and around the home (see Section 3.14 - **Individual Actions** for more detail).

Another way to assess public interest in the environment is to examine attitudes and actions with respect to specific environmental components. The Survey on the *Importance of Wildlife to Canadians* provides a variety of information about Canadians and their attitude toward wildlife.[4] The measures presented here touch on the recreational value of the environment to people and their desire to preserve wildlife.

Table 2.5.6 indicates that most Canadians expressed an interest in participating in activities involving wildlife such as

1. Angus Reid Group, *Canadians and the Environment*, Toronto, 1991.
2. Ibid.
3. Statistics Canada, *Households and the Environment, 1991*, Catalogue No. 11-526, Ottawa, 1992.

4. Environment Canada, *The Importance of Wildlife to Canadians: Highlights of the 1991 Survey*, Catalogue no. CW 66-103/1993E, Ottawa, 1993.

feeding and watching birds. Seventy-seven percent of Canadians said they had at least some interest in these non-consumptive activities (where the animal is not actually captured). By province, the percentages are quite similar, ranging from a low of 72 percent in Newfoundland to a high of 80 percent in British Columbia. Thirty percent of Canadians said they had some interest in joining and/or contributing to a wildlife organization. Other results in the survey reveal that 9 percent had actually done so in the survey year.

Hunting and sport fishing provide recreation for large numbers of Canadians. While the harvesting of animals from the wilderness can have a variety of environmental impacts, these activities provide the stimulus for much of the habitat protection and rehabilitation that takes place. About 16 percent of respondents had at least some interest in hunting. Interest was highest in Newfoundland (36 percent) and lowest in Ontario (11 percent). Approximately, 7 percent of respondents said they had actually hunted in 1991.

A majority of respondents indicated an interest in sport fishing (52 percent). Again Newfoundlanders expressed the greatest interest (63 percent) while interest was lowest in Ontario (49 percent). About 26 percent of Canadians said they had actually fished during the year.

Table 2.5.6

Canadians Expressing Some or Great Interest in Wildlife Activities, 1991

Province	Joining/contributing to wildlife-related organizations	Participating in non-consumptive wildlife activities	Hunting	Recreational fishing
	percent			
Newfoundland	25.0	71.7	35.8	63.0
Prince Edward Island	24.7	75.1	14.2	50.7
Nova Scotia	28.1	79.7	21.8	53.7
New Brunswick	28.2	73.1	25.6	52.1
Quebec	30.3	75.8	17.0	49.6
Ontario	27.9	76.0	11.3	48.6
Manitoba	31.1	77.5	16.8	56.8
Saskatchewan	31.4	73.9	22.3	62.6
Alberta	33.6	79.7	17.9	58.8
British Columbia	33.6	80.0	14.0	57.6
Canada	**29.9**	**76.7**	**15.6**	**52.2**

Notes:
Non-consumptive wildlife-related activities include watching, feeding and studying wildlife.
This survey was conducted in early 1992 by Statistics Canada. The survey was sponsored by federal and provincial conservation agencies under the direction of a Federal-Provincial Task Force.
The survey is conducted as a supplement to the Labour Force Survey and excludes persons under age 15 as well as residents of the Northwest Territories, Yukon, members of the Armed Forces and residents of Indian reserves and of institutions.
Source:
Environment Canada, *The Importance of Wildlife to Canadians: Highlights of the 1991 Survey*, Catalogue No. CW 66-103/1993E, Ottawa, 1993.

Finally, Table 2.5.7 presents information on public attitudes towards selected environmental protection policy measures. It is perhaps not surprising that of the four questions presented here, the policy measure receiving the greatest percentage of totally opposed responses concerned the payment of direct fees for garbage collection by the householder. For the other three items the impact would be felt initially by industry rather than the general public.

Table 2.5.7

Public Support For Selected Environmental Protection Policy Measures, 1991

Action	Completely in favour	Somewhat in favour	Ambivalent	Somewhat opposed	Completely opposed	Don't know
	percent					
Government sharply curtailing resource 'companies' access to wilderness lands	28	36	15	10	7	2
Ban on logging in old growth forests	16	27	19	21	13	3
Requiring industry to pay out of own profits for disposal of toxic wastes	51	31	9	4	3	2
Charging households a direct fee for each can or bag of garbage	19	29	11	16	23	2

Source:
Angus Reid Group, *Canadians and the Environment*, Toronto, 1991.

Summary

Based on the measures of perceptions and attitudes presented here, Canadians appear to feel strongly about the environment and to support strong protection measures. However, when trade-offs are required that affect our own consumption and behaviour patterns, are we willing to reduce things such as energy consumption, automobile use or waste production? Additional information is needed to fully answer this question.

Environmental Benefits and Impacts on Individuals

2.6 Recreation and the Environment

The environment provides people with many benefits; most are difficult to measure. Quantification of these benefits raises questions such as "What do people get out of the environment", "How does one measure the multitude of services the environment provides" and "How can individual aesthetic values be taken into account?" Although some of these questions may be impossible to answer fully, information is being collected in an attempt to begin to answer them.

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Statistics Canada has conducted a series of surveys for the Canadian Wildlife Service on the importance of wildlife to Canadians. The *Importance of Wildlife to Canadians Survey* was conducted in 1981, 1987 and 1991 (as a supplement to its *Labour Force Survey*). The objective of these surveys was the collection of socio-economic data on the importance of biological resources to Canadians. These surveys measured the economic impact of wildlife-related activities, both consumptive (hunting and fishing) and non-consumptive (birdwatching, hiking and camping).

Table 2.6.1 shows that wildlife-related expenditures[1] by Canadians totalled $8.4 billion in 1991. Primary non-consumptive trips and other wildlife related activities[2] accounted for $4.4 billion, recreational hunting accounted for $1.2 billion, and recreational fishing accounted for $2.8 billion. Canadians spent $1.6 billion on wildlife-related equipment and $1.2 billion on maintaining, improving or purchasing natural areas. Figure 2.6.1 shows that total expenditures by Canadians on wildlife-related activities have increased from $4.2 billion in 1981 to $5.1 billion in 1987 and to $5.6 billion in 1991.[3] This represents a 32.9 percent increase between 1981 and 1991. However, when inflation is taken into account, the real dollar value of expenditures has decreased from $7.1 billion in 1981 to $6.2 billion in 1987 to $5.6 billion in 1991, all measured at 1991 prices.

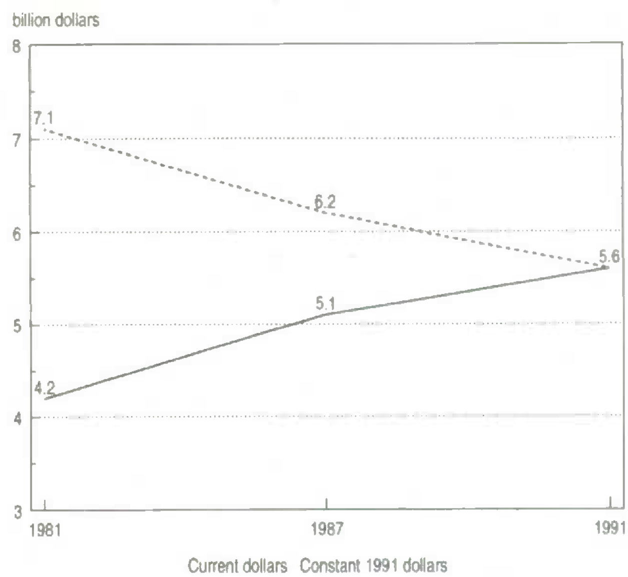
The economic value of wildlife-related activities within Canada totalled $6.3 billion in 1991 (Table 2.6.2). Hunting accounted for $1.2 billion (19 percent), recreational fishing accounted for $2.8 billion (44 percent) while primary non-consumptive trips or outings accounted for the remaining $2.3 billion (37 percent). Daily expenditures per hunting participant averaged $15.80, while recreational fishing participants averaged $35.00, and non-consumptive trips averaged $7.20. Yearly expenditures are also greater for hunting, $767 per year versus $502 per year for recreational fishing and $619 per year for non-consumptive trips.

Table 2.6.1
Wildlife-related Expenditures, 1991

Category of expenditure	Recreational hunting	Primary non-consumptive trips and other activities	All wildlife-related recreational activities
	million dollars		
Accommodation	65	267	332
Transportation	296	546	841
Food	144	403	546
Equipment	494	1 065	1 559
Other items	189	146	334
Residential activity	...	446	446
Incidental wildlife encounter during other trip or outing	...	114	114
Natural area preservation	...	1 244 [1]	1 244
Wildlife organizations	...	151	151
Sub-total	**1 187**	**4 380**	**5 568**
Recreational fishing	...	...	2 800
Total	**1 187**	**4 380**	**8 388**

Notes:
These figures include expenditures made by Canadians outside Canada.
Figures may not add due to rounding.
1. The sampling variability of this estimate is slightly higher than for other groups for reasons such as the small sample size on which the estimate is based and the degree of variation in the distribution of the characteristic measured.
Source:
Environment Canada, *The Importance of Wildlife to Canadians: Highlights of the 1991 Survey*, Ottawa, 1993.

Figure 2.6.1
Expenditures by Canadians on Wildlife-related Activities, 1981, 1987 and 1991



Source:
Environment Canada, *The Importance of Wildlife to Canadians: Highlights of the 1991 Survey*, Ottawa, 1993.

1. Expenditures are defined as expenses incurred by the participant for the purchase of goods and services to be used primarily for participation in a wildlife-related activity.
2. A primary non-consumptive trip is defined as one taken for the primary purpose of encountering wildlife to watch, photograph, feed or study.
3. These figures do not include expenditures on recreational fishing.

Table 2.6.2

Economic Value of Wildlife-related Activities in Canada, 1991

Activity	Total number of participants	Average value per participant: Daily	Average value per participant: Yearly	Average number of days per participant	Annual value for all participants
	thousands	dollars per participant		days per participant	million dollars
Hunting					
Large mammals	980	17.00	648	12	636
Small mammals	612	7.70	229	8	140
Waterfowl	394	15.60	450	4	177
Other birds	723	10.10	310	8	224
All hunting[1]	**1 500**	**15.80**	**767**	**16**	**1 178**
Recreational fishing	5 577	35.00	502	14	2 760
Primary non-consumptive trips	3 919	7.20	619	22	2 312
Total	...	...	...	...	**6 250**

Notes:
Figures may not add due to rounding.
1. Refers to hunting activity in Canada.
Source:
Environment Canada, *The Importance of Wildlife to Canadians: Highlights of the 1991 Survey*, Ottawa, 1993.

Approximately 1.5 million persons participated in recreational hunting in 1991, while over 5.5 million participated in recreational fishing and 3.9 million participated in primary non-consumptive wildlife-related trips. Participants spent an average of 22 days per year on primary non-consumptive trips, 14 days recreationally fishing and 16 days hunting (Table 2.6.2).

Table 2.6.3 provides expenditure information by province. Ontario ranked first in 1991 for total expenditures related to hunting ($325 million), primary non-consumptive trips and other related activities ($1.7 billion) and all wildlife-related recreational activities ($2.0 billion). However, from an average expenditure per participant viewpoint, Albertans and British Columbians spent over $1 000 on hunting in 1991, while Newfoundland was a close third at $919. Participants engaging in primary non-consumptive trips and other activities in Alberta spent over $1 000 in 1991. Average expenditures per capita revealed a similar pattern. Newfoundlanders spent $182 per capita on hunting, while Albertans and British Columbians spent $349 and $306 respectively on primary non-consumptive trips and other activities. British Columbia, Alberta, Saskatchewan and Newfoundland were well above the average per capita expenditure for all wildlife-related recreational activities.

Table 2.6.4 describes selected environmentally-related activities in 1992 of Canadian, American and overseas travellers in Canada who participated in overnight trips of 80 kilometres or more. The most popular trip for all three groups was a visit to a national, provincial or regional park. There were 13.9 million such trips made in 1992. Swimming (7.5 million person trips), then hunting and fishing (5.7 million person trips) were the second and third most popular recreational activities conducted by Canadians travelling at home. Visiting a zoo, museum or natural display (4.1 million

Table 2.6.3

Wildlife-related Expenditures by Province, 1991

Province	Total expenditures: Recreational hunting	Total expenditures: Primary non-consumptive trips and other activities	Total expenditures: All wildlife-related recreational activities	Average yearly expenditures per participant[1]: Recreational hunting	Average yearly expenditures per participant[1]: Primary non-consumptive trips and other activities	Average yearly expenditures per capita[1]: Recreational hunting	Average yearly expenditures per capita[1]: Primary non-consumptive trips and other activities	Average yearly expenditures per capita[1]: All wildlife-related recreational activities
	million dollars			dollars per participant		dollars per capita		
Newfoundland	80	47	127	919	490	182	106	287
Prince Edward Island	3	6	9	516 [2]	220	30	64	194
Nova Scotia	31	80	111	343	271	43	112	217
New Brunswick	50	87	137	567	583	88	152	239
Quebec	274	744	1 018	611	496	50	135	176
Ontario	325	1 696	2 021	780	486	40	123	202
Manitoba	44	114	159	663	417	52	134	229
Saskatchewan	49	124	173	660	654	65	165	298
Alberta	156	679	835	1 165 [2]	1 126	80	349	340
British Columbia	174	803	977	1 319	967	67	306	396
Canada	**1 187**	**4 380**	**5 568**	**767**	..	**55**	**170**	**239**

Notes:
Figures may not add due to rounding.
1. Based on Statistics Canada estimates of 1991 population 15 years of age and over.
2. The sampling variability of this estimate is slightly higher than for other groups for reasons such as the small sample size on which the estimate is based and the degree of variation in the distribution of the characteristic measured.
Source:
Environment Canada, *The Importance of Wildlife to Canadians: Highlights of the 1991 Survey*, Ottawa 1993.

person trips) and swimming (2.2 million person trips) were the second and third most popular activities for American and overseas travellers.

Table 2.6.4
Selected Activities of Canadian, American and Overseas Travellers, 1992

Activity	Person trips[1]			
	Canada	U.S.	Overseas	Total
	thousands			
Visit zoo, museum or natural display	4 165	2 856	1 275	**8 296**
Visit national, provincial or regional park	8 385	3 993	1 528	**13 906**
Swimming	7 487	1 745	438	**9 670**
Other water sports	4 194	414	122	**4 730**
Hunting or fishing	5 653	1 084	103	**6 840**
Cross-country skiing	917	94	28	**1 039**
Downhill skiing	1 729	313	112	**2 154**

Note:
1. Overnight trips of over 80 km or more in length.
Source:
Statistics Canada, *Domestic Travel, Canadians Travelling in Canada*, Catalogue No. 87-504, Ottawa, 1993.

Canada is fortunate to have so much to offer the recreational traveller, and wildlife-based activities are an important part of this. In 1991, an estimated 1.8 million Americans travelled to Canada to enjoy wildlife-based recreational activities for a total of 10.2 million person days, spending $842 million. One million of these visitors reported that they visited Canada to observe, photograph or feed wildlife. Thirty thousand Americans came to Canada to hunt, and 862 thousand came to fish recreationally. Americans spent $354 million on primary non-consumptive trips or outings, $38 million on hunting and $450 million on recreational fishing.

Summary

Canadians spent $5.6 billion for wildlife-related activities in 1991, a decline in real dollar terms from $7.1 billion in 1981. Surveys such as *The Importance of Wildlife to Canadians* help to quantify some of the benefits provided by the environment, but a full valuation of all environmental benefits is not possible with today's data or valuation techniques.

Technical Box 2.6.1
The Importance of Wildlife to Canadians Survey

This survey is representative of 98 percent of the Canadian population aged 15 and over. Exclusions from the survey include residents of Yukon and the Northwest Territories, residents of Indian reserves, full-time members of the Armed Forces and people living in institutions.

Expenditures on **equipment** include spending on items such as cameras, camping gear, binoculars, special clothing, recording equipment, boats, motors and other vehicles such as snowmobiles and multiple-terrain vehicles. Purchases such as guns and accessories, and rods and reels for fishing are included in consumptive activities.

Expenditures on **other items** include feed for wildlife, books, film and film processing, as well as ammunition, bait, guide fees, dog maintenance, and equipment rentals and repairs.

Expenditures on **transportation** include the cost to operate private vehicles, gas, oil, repairs, rentals, planes, trains, buses and ferries.

Expenditures on **accommodation** include expenses on campgrounds, cabins, motels.

Residential wildlife-related activities are defined as activities that take place around the home or cottage, such as watching, photographing or feeding wildlife.

Source:
Environment Canada, *The Importance of Wildlife to Canadians: Highlights of the 1991 Survey*, Ottawa 1993.

2.7 Environmental Impacts on Human Health

It is often difficult to isolate and assess the impact the physical environment has on humans. Health status is influenced by many things; the environment is only one. Other health risk factors include heredity, lifestyle and occupation. Environment-related health effects often do not appear in a population until several years after exposure. Since people move from place to place during their lifetimes, it is hard to determine when and where they were exposed to an environmental risk factor.

The relationship between the environment and human health may also be masked by the fact that humans are extremely adaptable and may take active measures to mediate environmental effects on their health. For instance, sunscreen and protective lenses may offset the negative effects of ultraviolet radiation on the skin and eyes. Nonetheless, we are not immune to our environment. The effects of a population's exposure to environmental risk factors can be assessed in part by looking at morbidity (illness) and mortality (death) statistics.

Environmental contaminants such as mercury, sulphur dioxide and furans have been associated with a variety of chronic health effects such as nervous system disorders, respiratory diseases and cancers.[1] Although understanding of these associations is limited, an examination of the long-term cancer trends, causes of death and other health indicators may provide insight into the relationship between environmental risk factors and our health. Presented in this chapter are tables summarizing causes of death, cancer incidence and mortality, asthma, and cases of foodborne disease. These do not completely describe the environment's impact on humans, but point at potential health effects.

Causes of Death

Health status can be measured by examining numbers of births and deaths, and causes of death. The age-standardized mortality rate (ASMR) is the number of deaths attributable to a certain disease for 100 000 people.[2] Another measure of the health status of a population are age-standardized incidence rates (ASIR). ASIRs are based on the same principle as ASMRs except that morbidity rather than mortality is measured. They are based on the number of occurrences of an illness or disease (for example, the number of new cases of cancer diagnosed in a year) as opposed to the number of deaths.

The five leading causes of death for both males and females in 1991 were: 1) diseases of the circulatory system, 2) cancer, 3) respiratory diseases, 4) accidents, 5) diseases of the digestive system.[3] Although the ranks of the leading causes of death have changed little over the past 40 years, the age-standardized mortality rates for these causes vary substantially (Table 2.7.1). The effect that changes in the environment have had on this variance is difficult to determine because our knowledge of the health effects of contamination is still not conclusive.

In general, Canadians are healthier and are living longer than they were forty years ago.The death rate has dropped dramatically over the past four decades from 1 230 deaths per 100 000 population in 1950 to 725 deaths in 1991. The ASMR for diseases of the circulatory system decreased from 639 deaths per 100 000 in 1950 to 282 in 1991. This decrease is attributed to increased awareness of the causes of heart disease, improved diets and exercise, as well as to the development of sophisticated medical treatments for the treatment of cardiac conditions.

Cancer was the only one of the five leading causes of death to increase between 1950 and 1991, rising from 173 to 200 deaths per 100 000. Part of this increase is attributable to increases in incidence and mortality rates for melanoma of the skin and lung cancer for females, kidney cancer for both sexes, and prostate cancer. Melanoma and kidney cancer can both be triggered by environmental factors.

Mortality rates for respiratory diseases decreased from 72 deaths per 100 000 in 1950 to 62 in 1991. Respiratory diseases have been associated with airborne contaminants such as sulphur dioxide from smelters and other industrial sources. However, there is a lack of information on incidence rates for respiratory diseases, which may be a better indication of the impacts of airbome contamination on human health.

Mortality rates for diseases of the digestive system decreased from 43 deaths per 100 000 in 1950 to 27 in 1991. The major components of digestive diseases are chronic liver disease and cirrhosis of the liver. The function of the liver is to detoxify the bloodstream. If toxins such as alcohol are absorbed into the blood, they are broken-down into elements that will either be used by the body, stored in fatty tissue or expelled. There is the potential for the liver to be damaged after prolonged exposure to environmental contaminants.

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
2. ASMR is standardized to a base population (for instance the population of Canada in 1991) to make comparisons easier over time and across regions. Standardization accommodates changes in the age distribution of the population across time and space.
3. Statistics Canada, *The Leading Causes of Death at Different Ages, Canada, 1991*, Ottawa, 1993.

Table 2.7.1

Age-standardized[1] Mortality Rates for Selected Causes, 1950-1991

Year	All causes	Diseases of the circulatory system	Cancer	Accidents	Respiratory diseases	Diseases of the digestive system	Infectious and parasitic diseases	Diseases of the nervous system	Diabetes mellitus	Congenital anomalies	Mental disorders
						per 100 000 population					
1950	**1 230.0**	638.6	172.9	75.1	72.4	43.2	38.3	17.5	16.5	10.5	4.7
1951	**1 234.9**	642.4	173.6	76.6	92.5	39.5	35.9	16.0	16.1	10.9	4.4
1952	**1 189.0**	639.4	174.9	76.9	64.8	38.9	29.0	15.2	15.6	11.2	3.8
1953	**1 181.4**	637.2	177.0	77.3	71.4	38.9	24.3	14.6	15.7	10.9	4.3
1954	**1 127.0**	614.9	176.9	73.3	60.2	37.5	18.7	13.2	15.5	10.7	3.1
1955	**1 135.7**	621.0	178.0	74.3	65.0	37.1	17.0	13.4	16.2	10.4	3.0
1956	**1 136.5**	619.0	178.9	77.2	68.4	36.5	15.4	12.6	16.8	11.0	3.3
1957	**1 143.1**	625.5	178.6	76.9	77.5	36.4	13.9	12.7	16.7	10.4	3.0
1958	**1 108.4**	614.3	178.1	71.7	66.4	37.9	11.9	11.8	16.3	10.4	3.9
1959	**1 120.9**	622.3	176.8	71.1	76.7	37.9	11.9	11.4	16.7	10.0	3.5
1960	**1 092.2**	610.5	179.3	71.0	64.1	39.3	10.6	10.9	17.4	9.6	3.4
1961	**1 069.7**	596.6	177.8	70.9	61.9	37.8	9.9	11.1	17.6	9.9	3.2
1962	**1 064.0**	589.8	180.3	72.4	63.2	36.8	9.4	10.7	17.2	10.1	2.9
1963	**1 069.1**	584.7	180.3	72.0	74.1	38.0	8.5	10.8	17.9	9.4	3.0
1964	**1 031.4**	568.9	180.0	72.8	58.9	38.0	7.5	10.3	18.8	9.1	2.7
1965	**1 039.4**	578.4	179.4	75.2	62.2	36.8	7.8	10.2	18.6	8.3	2.9
1966	**1 025.9**	562.8	180.3	75.7	66.5	36.8	7.0	9.9	18.7	8.2	3.1
1967	**1 003.7**	546.7	183.5	75.7	60.4	36.7	6.6	9.3	19.2	7.8	3.3
1968	**1 005.7**	541.7	184.0	74.9	68.6	36.5	6.5	9.6	20.1	7.6	3.4
1969	**987.5**	527.2	185.7	76.6	67.6	33.8	7.1	9.9	19.3	8.3	2.9
1970	**971.7**	515.8	186.3	74.6	67.0	33.0	7.3	9.3	20.2	8.0	2.8
1971	**956.8**	503.6	185.8	77.9	63.1	33.4	6.6	9.7	19.7	8.1	3.4
1972	**967.3**	504.6	188.9	80.9	65.3	34.4	6.8	9.9	19.7	7.9	4.0
1973	**956.8**	496.1	189.7	81.3	64.1	34.8	6.3	9.6	20.2	7.1	4.4
1974	**952.0**	495.1	189.4	79.9	63.8	34.5	5.8	9.6	19.1	7.1	4.6
1975	**930.7**	474.4	186.4	76.8	65.8	34.2	5.4	9.6	18.5	6.7	5.7
1976	**908.6**	465.8	186.0	70.0	66.3	33.2	5.1	9.1	16.7	6.6	5.7
1977	**888.2**	452.2	187.7	71.6	59.3	31.9	5.1	9.0	16.7	6.5	5.8
1978	**871.6**	435.8	189.3	71.1	59.2	32.2	4.9	9.2	15.7	6.7	6.1
1979	**849.2**	418.4	191.8	71.7	53.3	33.4	3.5	9.9	14.8	6.4	6.4
1980	**845.4**	413.2	191.5	67.3	56.7	34.5	3.8	10.6	14.6	6.5	6.7
1981	**820.2**	394.7	190.6	65.2	54.1	33.7	4.1	11.0	14.6	6.3	6.7
1982	**816.9**	387.9	192.9	59.0	58.9	32.6	4.3	11.2	14.5	5.8	7.8
1983	**799.4**	371.5	192.9	58.3	62.7	31.1	4.5	11.9	14.4	5.5	7.4
1984	**785.5**	357.7	197.0	57.4	59.0	29.7	4.4	13.3	15.2	5.3	7.3
1985	**790.9**	349.0	199.0	54.4	62.7	29.7	4.4	14.9	15.4	5.6	8.5
1986	**785.0**	343.0	199.3	55.1	64.9	29.3	4.6	15.8	15.9	5.5	9.6
1987	**766.6**	326.6	199.1	56.1	60.7	28.8	6.6	17.2	15.6	4.8	9.2
1988	**768.0**	320.1	203.0	53.1	65.4	28.2	7.1	18.2	15.5	5.3	9.6
1989	**750.7**	307.3	200.3	53.0	64.1	28.1	8.1	18.6	15.3	5.1	10.0
1990	**732.6**	287.5	199.3	49.3	62.3	26.7	8.6	18.6	15.8	5.2	11.1
1991	**724.5**	281.7	199.9	49.0	62.3	27.1	9.7	18.7	15.9	4.5	11.8

Note:
1. Rates are adjusted to the age distribution of the 1991 Canadian population.
Source:
Statistics Canada, Canadian Centre for Health Information.

Provincial Distribution of Causes of Death

Many of the provinces and both of the territories have small populations distributed sparsely over large areas of land. Despite the fact that populations are highly mobile it is still useful to examine differences in death rates across the country. This may indicate where there are excess deaths attributable to a certain disease.

The term "excess" refers to deaths that may have been avoided if the lowest mortality rates had applied in all provinces. Excess deaths are indicators of a problem. The source of the problem may be related to a combination of occupational differences, lifestyle differences and environmental factors. It is difficult to isolate these factors from each other.

Table 2.7.2 presents 1990 ASMRs for the provinces and territories. A comparison of provincial rates with national rate, shows that for all causes of death the Prairie provinces, Ontario and British Columbia had the lowest rates for males, whereas the Territories had the highest. The Canadian rate for males was 641 deaths per 100 000; Saskatchewan had the lowest rate with 590 deaths per 100 000. The Northwest Territories had the highest rate with 837 deaths per 100 000. The national ASMR for all causes of death for females was 454 deaths per 100 000. The rates were lower in Saskatchewan and Alberta. The ASMRs were higher in

Table 2.7.2

Age-standardized[1] Mortality Rates, by Selected Causes and Sex, 1990

Cause	Canada	Nfld	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	per 100 000 population												
Total all causes - Male	**641.4**	**709.8**	**704.0**	**689.1**	**652.7**	**694.7**	**627.9**	**622.7**	**590.0**	**611.8**	**593.8**	**721.9**	**837.0**
All cancers	175.7	171.9	197.4	194.4	181.8	204.9	170.6	169.8	154.9	155.7	150.5	207.5	181.2
Intestine, except rectum	17.3	21.0	24.4	19.3	18.6	18.2	18.0	18.0	15.6	13.8	14.4	-	14.7
Lung (including trachea and bronchus)	57.9	52.2	60.5	65.5	60.5	76.8	54.2	46.9	45.0	45.4	46.9	69.9	98.2
Breast	0.2	-	-	0.4	0.3	0.3	0.2	0.1	0.3	0.4	0.1	-	-
All other malignant neoplasms	100.2	98.7	112.6	109.2	102.3	109.5	98.2	104.7	93.9	96.1	89.1	137.6	68.2
Diabetes mellitus	11.6	17.6	10.7	10.4	12.5	14.3	11.9	9.9	10.3	8.1	8.7	16.9	-
Diseases of the heart	178.7	217.0	214.7	200.3	184.9	192.1	176.5	173.3	170.8	170.6	156.1	163.5	170.5
Ischaemic heart disease	147.3	182.1	165.3	157.6	140.6	155.9	152.4	142.1	131.2	137.0	124.3	107.4	96.2
All other heart diseases	31.4	34.9	49.3	42.7	44.2	36.2	24.1	31.2	39.5	33.5	31.8	56.2	74.2
Cerebrovascular disease	36.2	49.2	37.1	28.3	34.0	38.0	36.2	33.0	35.8	35.4	35.5	-	25.9
Atherosclerosis	4.9	3.4	-	4.6	4.6	4.9	5.5	4.0	3.6	5.6	4.3	-	-
Respiratory diseases (excluding infectious and parasitic diseases)	55.6	63.2	68.6	69.9	53.6	62.3	52.3	49.6	52.4	54.3	52.2	42.4	115.6
Pneumonia and influenza	19.6	24.3	24.7	27.4	15.6	16.1	20.3	18.3	21.7	18.4	21.6	25.5	12.4
Bronchitis, emphysema and asthma (excluding acute bronchitis)	7.8	6.8	12.9	7.9	6.0	11.9	5.5	5.7	6.9	9.9	7.2	16.9	11.0
All other respiratory diseases	28.1	32.1	30.9	34.7	31.9	34.2	26.5	25.6	23.8	26.0	23.3	-	92.2
Chronic liver disease and cirrhosis	9.4	9.4	-	7.9	5.0	9.3	10.6	7.3	7.0	10.4	8.5	8.6	7.7
Congenital anomalies	6.3	8.5	6.9	5.4	5.9	6.0	6.2	6.3	5.2	8.0	5.8	15.7	7.7
Causes of perinatal mortality (excl. stillbirths)	5.9	7.4	8.6	3.3	5.1	6.6	5.4	6.2	5.5	5.7	6.9	6.7	10.2
All accidents and adverse effects	62.7	60.2	88.9	66.2	75.8	68.9	44.6	63.0	76.0	81.1	78.8	168.7	177.5
All other causes	81.1	84.6	60.4	82.5	72.9	72.7	95.4	87.1	56.8	66.1	74.2	71.1	137.7
Total all causes - Female	**454.0**	**515.1**	**477.7**	**487.7**	**454.6**	**455.2**	**457.4**	**456.6**	**430.5**	**429.9**	**441.4**	**729.2**	**594.0**
All cancers	130.5	133.1	141.3	149.7	131.4	135.4	129.7	130.3	120.8	119.3	127.2	183.6	122.1
Intestine, except rectum	15.0	21.1	17.5	17.1	15.9	16.3	15.0	12.6	14.4	12.7	13.2	-	11.6
Lung (including trachea and bronchus)	23.8	13.3	33.6	29.9	25.5	23.3	23.6	23.1	16.8	20.5	28.6	62.5	43.9
Breast	27.0	22.7	22.8	30.8	23.5	28.5	27.4	26.8	26.0	24.1	25.6	33.9	-
All other malignant neoplasms	64.7	76.0	67.4	71.7	66.5	67.2	63.8	67.8	63.6	61.9	59.8	87.2	66.5
Diabetes mellitus	11.0	17.9	7.1	9.3	12.7	13.0	10.8	9.4	9.2	9.2	9.2	19.3	-
Diseases of the heart	121.5	153.7	143.6	133.2	129.1	126.7	121.2	120.3	120.7	110.9	108.4	174.9	142.9
Ischaemic heart disease	93.3	119.8	104.4	92.6	92.1	94.2	99.9	89.7	83.8	83.0	78.3	103.0	60.6
All other heart diseases	28.2	33.9	39.2	40.7	37.0	32.5	21.2	30.7	36.8	27.9	30.0	72.0	82.3
Cerebrovascular disease	37.8	43.4	41.3	36.7	34.9	35.6	38.3	37.2	41.0	34.5	41.3	24.0	27.4
Atherosclerosis	6.0	3.7	2.8	4.5	4.2	5.0	8.3	2.7	4.1	5.9	4.1	-	-
Respiratory diseases (excluding infectious and parasitic diseases)	33.4	33.5	34.8	41.8	27.2	31.5	33.0	30.0	32.9	36.2	36.7	48.8	114.4
Pneumonia and influenza	15.7	19.0	17.3	20.4	12.0	12.2	15.4	15.5	17.1	18.8	20.1	4.2	25.9
Bronchitis, emphysema and asthma (excluding acute bronchitis)	4.7	2.2	7.4	6.0	3.1	6.2	3.9	3.3	4.1	4.6	4.6	44.5	-
All other respiratory diseases	13.0	12.2	10.2	15.4	12.2	13.0	13.6	11.2	11.6	12.9	11.9	-	88.5
Chronic liver disease and cirrhosis	3.9	4.2	2.8	2.8	2.7	4.0	3.8	4.7	2.9	4.3	4.1	31.6	-
Congenital anomalies	5.2	7.1	6.7	7.2	7.2	5.3	4.5	6.4	5.1	6.0	4.4	6.9	9.4
Causes of perinatal mortality (excl. stillbirths)	4.5	5.7	1.7	4.1	4.9	4.0	4.7	3.6	2.4	4.3	6.1	-	2.3
All accidents and adverse effects	24.6	14.3	24.0	22.3	24.0	25.1	20.7	24.8	27.5	32.7	29.8	92.5	52.2
All other causes	67.2	88.5	61.5	64.5	69.4	60.4	73.7	78.6	56.9	59.0	63.0	147.5	116.6

Notes:
Data for 1991 by these selected causes and provinces are not available.
1. Rates are adjusted to the age distribution of the 1971 Canadian population.
Source:
Statistics Canada, Canadian Centre for Health Information.

the North; Yukon had the highest rate in the country at 729 deaths per 100 000.

The ASMRs for all cancers among males exceeded national rates in the Maritimes, Quebec and the North. The rates were lower in the Prairie provinces. British Columbia had the lowest rate in the country. Lung cancer had a similar regional distribution.

For the female population, ASMRs for all cancers were higher than the national rate in Prince Edward Island, Nova Scotia and Yukon. The rates were lower in Saskatchewan, Alberta and in the Northwest Territories. The mortality rates for lung cancer among females were lowest in Newfoundland with 13 deaths per 100 000 population compared with 24 deaths per 100 000 for Canada.

The most striking regional disparity in ASMRs was for respiratory diseases, where the rates in the Northwest Territories were double the national rate for males (116 deaths per 100 000 versus 56 deaths per 100 000) and more than triple for females with 114 deaths per 100 000 compared with 33 for Canada. This excess in respiratory disease deaths in the Northwest Territories may be related to several factors including extremely cold temperatures, the use of wood burning stoves, and the prevalence of mining as an occupation.

The regional disparities between ASMRs can be linked to several factors such as access to health care and national occupational, lifestyle, dietary differences, and smoking patterns. For instance, there are higher levels of stomach cancer in Newfoundland where smoked and salted foods are common. Lung, pharynx, and mouth cancer rates are highest in Quebec where smoking is more prevalent. Rates for melanoma are relatively higher in Ontario and British Columbia where there is comparatively more sunshine.[1]

Cancer Incidence and Mortality

Of all diseases and causes of death, cancer has been the most frequently associated with environmental factors. Non-Hodgkin's lymphoma, leukemia, liver, testes, bladder, kidney and brain cancers have been chosen as sites for consideration here based on evidence that they might be environmentally linked. Tables 2.7.3 and 2.7.4 show ASIRs and ASMRs for these cancers. Lung cancer for the total population and female breast cancer have also been included for purposes of comparison, as these are among the most frequently diagnosed cancers in Canada today.

Many of the environmental risk factors are only suspected and not yet established. The process of determining which environmental conditions are linked to cancer is made more difficult by the fact that cancers may have lifestyle, occupational, or dietary risk factors. For instance, bladder cancer is linked with occupational exposure to chemicals.[2] However, cigarette smoking is responsible for 61 percent of this disease in males.[3] Brain tumours also have overlapping occupational and environmental risk factors. They "have been suspected as associated with exposure to electromagnetic fields."[4] Electrical engineers and electronics technicians have a high occupational risk of developing brain tumours, as do persons working in the petroleum industry.[5]

The risk factors for kidney cancer include exposure to certain chemicals by coke oven workers. Higher levels of this cancer are found among survivors of atomic bombs. However, the main risk factor is smoking, as the kidneys help purify the blood and are therefore exposed to toxins from cigarettes that are carried in the bloodstream.[6]

1. National Cancer Institute of Canada, *Canadian Cancer Statistics 1992*. Toronto, 1992.
2. Vineis P. and L. Simonato, "Estimates of the Proportion of Bladder Cancers Attributable to Occupation", *Scandinavian Journal of Work and Environmental Health*, 12, 1986, p. 55-60.
3. Howe G.R., J. D. Burch and A.B. Miller, "Tobacco Use, Occupation, Coffee, Various Nutrients, and Bladder Cancer", *Journal of the National Cancer Institute*, 64, 1980, p. 701-713.
4. Miller, Anthony B., *Planning Cancer Control Strategies*, Chronic Diseases in Canada, 13(1) Suppl. S10-S25, 1992.
5. Desmeules, Marie, *Facts Sheet: Cancer of the Brain (ICD-9 191)*, Chronic Disease in Canada, 12(3), 1991, p. 39.
6. Tomatis L., A. Aitio, N. E. Day and E. Heseltine et al., *Cancer: Causes, Occurrence and Control*, International Agency for Research on Cancer, IARC Scientific Publication No. 100, Lyon, 1990.

Risk factors for leukemia include occupational exposure to benzene.[7] There has been mounting evidence suggesting that exposure to electromagnetic fields could also be a factor.[8]

One of the most clearly environmentally-related cancers is melanoma, which is caused by exposure to ultraviolet radiation. Although melanoma is not a particularly lethal or frequently occurring cancer in Canada, it has gained widespread attention recently because it is one of the more rapidly increasing forms of cancer and it is thought to be largely preventable.[9] The rise in incidence is attributable to the depletion of the ozone layer which has resulted in increased levels of ultraviolet radiation reaching the earth's surface.[10] However, hereditary factors such as skin pigmentation, hair and eye colour also have an impact on one's susceptibility to this disease.

Non-Hodgkin's lymphoma is linked with pesticide use among farmers,[11] electromagnetic fields and immune system deficiencies.

Incidence and Mortality Trends

Although conclusive evidence of links between environmental risk factors and cancer are difficult to establish, an examination of long term incidence and mortality trends can be revealing. Table 2.7.3 and Figures 2.7.1 and 2.7.2 show cancer incidence rates for all the cancers with some evidence of environmental risk factors, as well as for lung cancer for both sexes and breast cancer. When looking at these trends it is important to keep in mind that improvements in diagnosis and reporting may also have an impact on increases in rates. It should be noted that rates for females tend to fluctuate more than those for males because the numbers of women affected is quite low for these types of cancers, especially with breast cancer.

It is useful to separate males and females for this type of analysis because of occupational, life-style and physiological differences. In the past, females were excluded from some higher risk occupations such as mining and were less frequently employed in the manufacturing industry where use of chemicals is common. Women have not been as frequently employed in areas where there is a potentially higher risk of exposure to contaminants.

Women experience changes in hormone levels during monthly cycles and over the course of their lives. These changes have been linked to the development of certain types of cancers, such as breast and ovarian cancer and

7. Ibid.
8. Miller, Anthony B., *Planning Cancer Control Strategies*, Chronic Diseases in Canada, 13(1) Suppl. S10-S25, 1992.
9. Ibid.
10. Ibid.
11. Jordan-Simpson D. A., M.E. Fair and C. Poliquin, *Canadian Farm Operator Study: Methodology*, Health Reports, 2(2), Catalogue No. 82-003, Statistics Canada, Ottawa, 1990, p. 141-155.

Table 2.7.3
Age-standardized[1] Cancer Incidence Rates, by Selected Site and Sex, 1969-1988

Year	Bladder	Brain	Breast	Kidney	Leukemia	Lung	Melanoma	Non-Hodgkin's lymphoma	Prostate	Testes
	per 100 000 population									
Males										
1969	16.18	5.86	...	6.48	9.04	43.98	2.45	6.63	31.77	2.70
1970	16.69	5.48	...	6.72	8.99	44.83	2.70	6.22	31.70	2.20
1971	16.34	5.89	...	6.48	8.75	46.79	2.78	7.14	33.32	2.45
1972	16.69	5.93	...	6.95	8.73	48.35	2.90	6.72	34.03	2.65
1973	17.65	5.67	...	7.21	9.22	49.82	3.29	7.39	36.17	2.79
1974	18.32	6.39	...	6.86	9.58	51.31	3.52	8.04	36.34	2.95
1975	17.20	5.82	...	7.24	9.01	54.18	3.67	7.54	37.01	2.67
1976	17.46	6.21	...	7.45	8.61	56.27	4.18	7.96	37.73	2.77
1977	19.21	6.72	...	7.40	9.51	58.37	4.52	8.21	41.41	2.97
1978	20.98	6.95	...	8.07	10.14	62.94	5.13	9.92	44.81	3.08
1979	21.23	6.34	...	8.10	10.12	61.77	5.42	9.68	43.85	2.90
1980	19.88	6.88	...	8.04	10.15	60.62	5.54	9.11	43.28	3.33
1981	21.97	7.09	...	8.99	11.50	65.84	5.64	11.14	47.13	3.33
1982	20.50	7.14	...	9.37	12.01	66.80	5.99	11.82	46.41	3.45
1983	21.26	7.17	...	9.48	11.49	68.44	5.96	11.48	47.83	3.38
1984	21.40	7.47	...	9.89	11.74	70.72	6.04	11.69	49.59	3.29
1985	20.71	7.10	...	9.94	11.43	68.11	7.13	12.12	51.97	3.61
1986	20.86	7.08	...	9.89	11.56	69.71	7.11	12.33	52.80	3.58
1987	21.13	7.23	...	10.41	11.74	69.38	7.69	12.73	55.48	4.00
1988	21.10	7.54	...	11.23	10.73	69.05	8.32	13.09	56.50	3.50
Females										
1969	4.97	4.10	62.08	6.45	3.21	7.61	3.74	4.67	...	...
1970	4.52	3.97	61.20	5.43	3.32	7.24	3.37	4.75	...	...
1971	4.17	4.42	65.12	5.48	3.74	8.03	3.19	4.80	...	...
1972	4.26	3.92	65.25	5.80	3.48	9.75	3.33	5.32	...	...
1973	4.58	4.61	65.66	6.16	3.77	9.95	4.20	5.58	...	...
1974	4.85	4.16	70.51	5.97	3.87	11.04	4.09	5.25	...	...
1975	5.28	4.29	68.01	5.46	3.60	11.63	4.18	5.80	...	...
1976	4.64	4.81	68.11	5.38	3.49	12.91	4.56	5.78	...	...
1977	5.13	4.91	67.67	5.90	3.97	14.30	4.92	6.39	...	...
1978	5.76	4.97	68.69	6.53	4.05	15.79	6.24	7.13	...	...
1979	5.76	4.89	69.40	6.24	4.09	15.88	5.83	7.34	...	...
1980	5.22	5.18	65.90	7.13	4.01	16.80	6.23	6.73	...	...
1981	6.18	5.59	68.22	7.33	4.47	19.17	6.43	8.70	...	...
1982	5.28	5.08	67.94	7.21	4.38	19.95	6.10	8.90	...	...
1983	5.85	5.28	70.26	7.76	4.64	22.13	6.72	8.88	...	...
1984	5.75	5.26	71.51	7.32	5.05	23.22	6.28	8.69	...	...
1985	5.81	5.33	73.38	6.89	5.51	24.26	7.78	8.62	...	...
1986	5.24	5.08	70.30	7.31	5.71	24.93	6.92	8.72	...	...
1987	5.67	5.01	72.26	7.09	6.42	25.95	7.71	8.76	...	...
1988	5.86	5.21	77.73	7.19	5.71	26.98	7.51	8.88	...	...

Notes:
Cancer incidence rates are only available until 1988.
Rates prior to 1981 will be low due to slight under-registration in Quebec and Nova Scotia Cancer Registries.
Calculations do not include the Yukon or Northwest Territories.
1. Rates are adjusted to the age distribution of the World Standard Population.
Source:
Statistics Canada, Canadian Centre for Health Information.

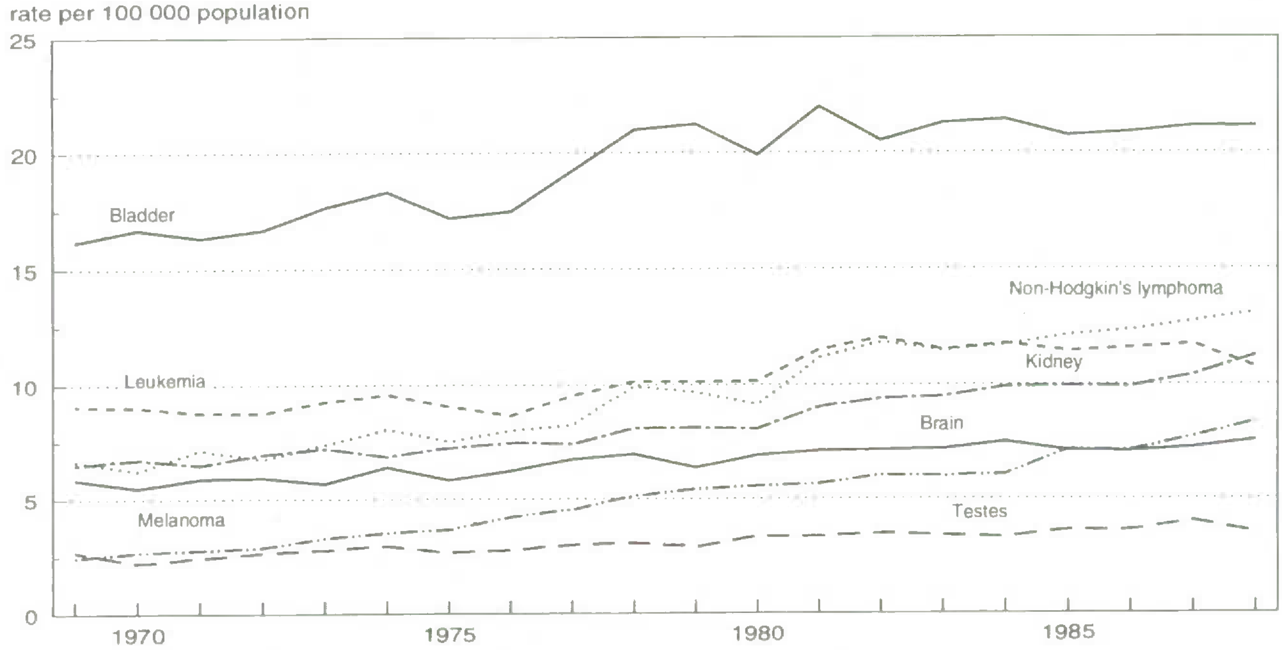
cancer of the body of the uterus. The effects of these hormonal changes on environmentally related cancers have not yet been determined.

Of the cancers analysed here, melanoma, non-Hodgkins' lymphoma and kidney cancer showed the greatest increase in rates between 1969 and 1988 for males. Melanoma ASIRs were almost three times greater in 1988 than they were in 1969, increasing from 2.5 cases per 100 000 population to 8.3 per 100 000. The change was less dramatic for females but worth noting nonetheless, as the ASIRs doubled from 3.7 cases per 100 000 in 1969 to 7.5 in 1988. Incidence rates for melanoma have risen more rapidly than all of the environmentally linked cancers for both males and females.

After melanoma, non-Hodgkin's lymphoma showed the greatest increase in ASIRs from 1969 to 1988, almost doubling in that time period from 6.6 cases per 100 000 to 13.1. Non-Hodgkin's lymphoma had the second highest increase in rates for women as well, although the increase was moderate, rising from 4.7 cases per 100 000 in 1969 to 8.9 in 1988. This increase among men may be related to the AIDS epidemic.

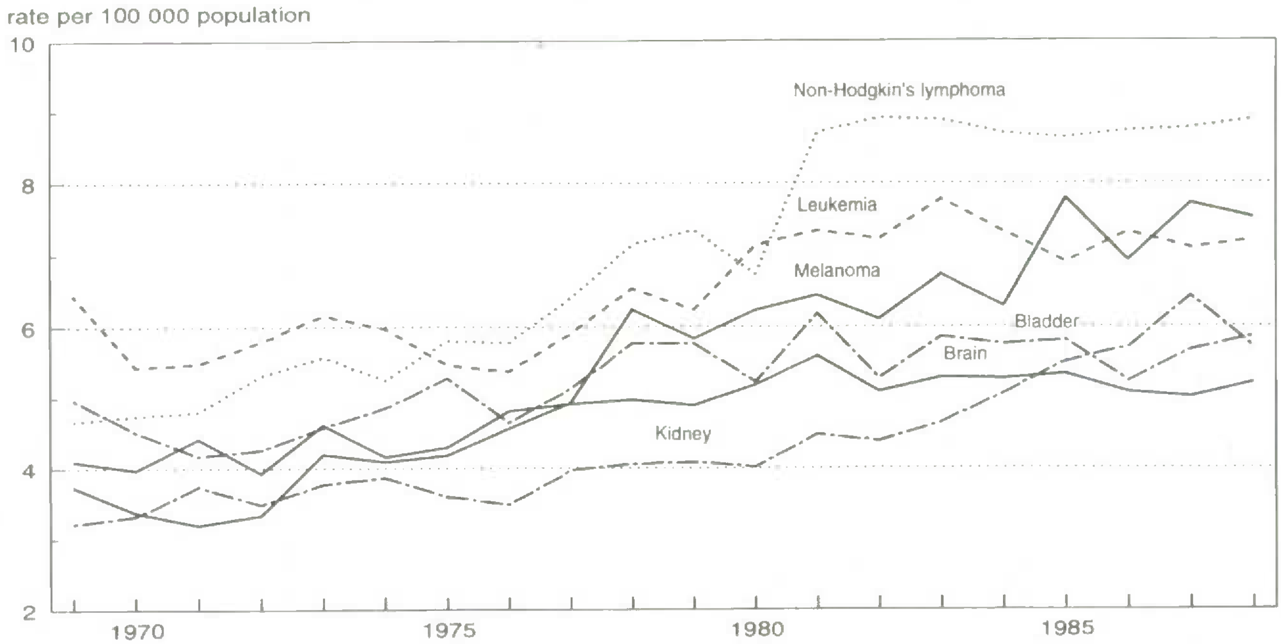
Kidney cancer was the third fastest increasing environmentally linked cancer for males; the kidney cancer ASIR for

Figure 2.7.1
Age-standardized Cancer Incidence Rates, Males, 1969-1988



Notes:
Rates are adjusted to the age distribution of the World Standard Population.
Calculations do not include the Yukon or Northwest Territories.
Source:
Statistics Canada, Canadian Centre for Health Information.

Figure 2.7.2
Age-standardized Cancer Incidence Rates, Females, 1969-1988



Notes:
Rates are adjusted to the age distribution of the World Standard Population.
Calculations do not include the Yukon or Northwest Territories.
Source:
Statistics Canada, Canadian Centre for Health Information.

men increased from 6.5 cases per 100 000 to 11.2 between 1969 and 1988. The ASIRs for kidney cancer have not been increasing as rapidly for females, only increasing by 12 percent from 6.5 to 7.2. The third greatest growth in ASIRs for females was for leukemia, which rose from 3.2 per 100 000 in 1969 to 5.7 cases per 100 000 in 1988.This represented a growth of 78 percent. The increase in ASIRs for leukemia peaked for males at 12.0 per 100 000 in 1982, (from 9.0 in 1969) but dropped to 10.7 in 1988.

There was only a slight increase in the incidence rates for cancer of the brain and bladder for both females and males and cancer of the testes for males. The ASIRs for brain and bladder cancer were consistently lower for females than for males. Bladder cancer had the highest incidence rate of all environmentally related cancers for males, increasing from 16.2 cases per 100 000 in 1969 to 21.1 cases in 1988. The incidence rates were considerably lower for females, at 5.0 per 100 000 cases in 1969 and to 5.9 per 100 000 in 1989.

Although cancer incidence for the types examined is increasing substantially, mortality rates for these types have not been increasing as dramatically. In fact there have been decreases in some cases (see Table 2.7.4 and Figures

Table 2.7.4

Age-standardized[1] Cancer Mortality Rates, by Selected Site and Sex, 1969-1990

Year	Bladder	Brain	Breast	Kidney	Leukemia	Lung	Melanoma	Non-Hodgkin's lymphoma	Prostate	Testes
					per 100 000 population					
Males										
1969	**5.74**	**4.53**	...	**3.90**	**7.29**	**38.90**	**1.09**	**4.42**	**13.50**	**0.73**
1970	5.49	4.59	...	3.56	6.92	40.68	0.99	4.02	13.75	0.76
1971	5.78	4.78	...	3.85	6.82	42.42	0.94	4.34	14.48	0.66
1972	5.44	4.72	...	3.78	7.13	43.23	1.10	4.19	13.96	0.70
1973	5.39	4.71	...	4.13	6.79	44.84	1.16	4.14	13.71	0.65
1974	5.16	4.77	...	3.85	6.99	47.06	1.31	4.45	14.41	0.77
1975	5.33	4.41	...	3.69	7.13	46.25	1.33	4.08	14.69	0.68
1976	5.00	4.72	...	3.85	6.51	47.80	1.17	4.42	13.61	0.60
1977	5.12	4.20	...	3.80	7.60	49.46	1.18	4.48	13.72	0.73
1978	5.02	4.98	...	3.40	6.65	50.61	1.49	4.39	14.31	0.51
1979	4.88	4.51	...	3.88	7.04	51.64	1.33	4.37	14.69	0.37
1980	5.04	5.34	...	3.71	7.04	53.05	1.36	5.04	14.08	0.31
1981	5.11	4.75	...	3.65	6.53	52.15	1.67	4.94	14.80	0.36
1982	5.00	5.00	...	3.96	6.68	55.08	1.65	4.81	14.35	0.35
1983	4.59	4.69	...	3.86	6.30	55.62	1.76	5.27	14.87	0.37
1984	4.83	5.09	...	4.27	6.59	57.21	1.61	4.88	14.85	0.35
1985	5.07	4.88	...	3.90	6.93	55.33	1.95	5.14	16.08	0.31
1986	4.38	4.84	...	4.01	6.60	55.95	1.72	5.45	16.45	0.30
1987	4.62	5.04	...	4.22	6.69	55.77	1.56	5.05	16.45	0.32
1988	4.89	5.12	...	4.20	6.59	57.60	1.68	5.67	17.23	0.35
1989	4.72	4.79	...	4.16	6.04	57.59	2.00	5.52	16.73	0.34
1990	4.54	5.04	...	4.24	6.06	56.72	1.96	5.61	16.95	0.25
Females										
1969	**1.58**	**3.03**	**24.06**	**4.57**	**1.84**	**5.99**	**1.02**	**3.01**	...	...
1970	1.65	2.93	23.55	4.46	1.74	6.35	0.81	2.86	...	...
1971	1.65	2.96	23.76	4.85	1.97	6.55	0.75	2.87	...	...
1972	1.44	3.21	24.42	4.50	1.74	7.92	1.06	2.99	...	...
1973	1.49	3.16	23.87	4.58	2.03	8.29	0.84	3.20	...	...
1974	1.64	3.20	23.92	4.18	1.81	9.02	1.02	3.58	...	...
1975	1.79	2.93	23.59	4.63	1.92	9.41	0.90	2.83	...	...
1976	1.46	3.13	23.06	4.02	1.69	9.57	1.00	3.07	...	...
1977	1.46	3.07	23.66	4.10	1.80	10.87	0.95	2.69	...	...
1978	1.30	3.37	22.82	4.20	1.56	11.56	1.03	3.26	...	...
1979	1.46	3.33	23.05	4.41	1.82	12.57	0.96	3.14	...	...
1980	1.50	3.58	22.89	4.24	1.73	13.13	0.96	3.19	...	...
1981	1.38	3.49	22.98	4.06	1.97	13.93	1.03	3.13	...	...
1982	1.43	3.57	22.90	4.07	1.81	14.95	1.14	3.51	...	...
1983	1.25	3.12	23.20	4.28	1.85	15.34	1.20	3.51	...	...
1984	1.41	3.31	23.50	4.05	1.94	16.94	1.13	3.27	...	...
1985	1.32	3.34	24.34	4.38	1.76	18.33	1.22	3.45	...	...
1986	1.21	3.21	24.42	3.88	1.89	18.49	0.99	3.64	...	...
1987	1.18	3.37	24.18	3.90	2.09	19.53	1.17	3.57	...	...
1988	1.38	3.45	23.92	4.01	2.08	20.39	1.06	3.47	...	...
1989	1.31	3.14	23.88	3.79	2.02	20.45	1.06	3.75	...	...
1990	1.26	3.26	23.88	3.88	2.08	20.91	0.92	3.80	...	...

Notes:

Calculations do not include the Yukon or Northwest Territories.

Cancer incidence rates are only available until 1988.

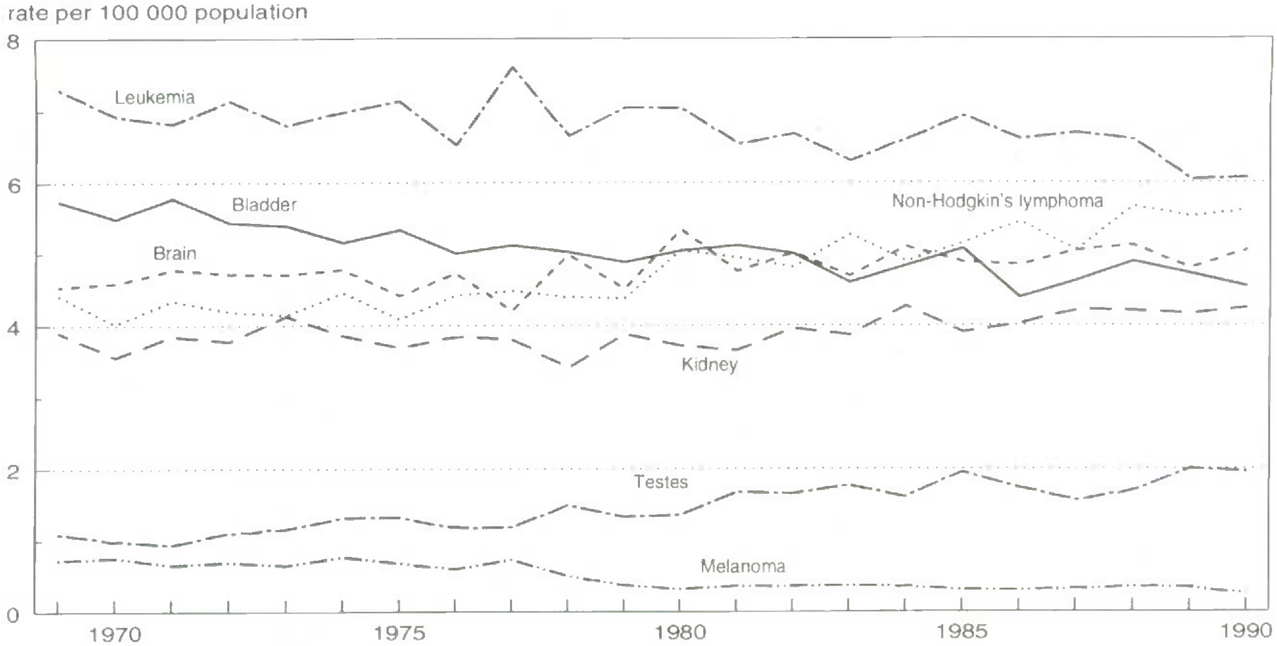
1. Rates are adjusted to the age distribution of the World Standard Population.

Source:

Statistics Canada, Canadian Centre for Health Information.

Figure 2.7.3

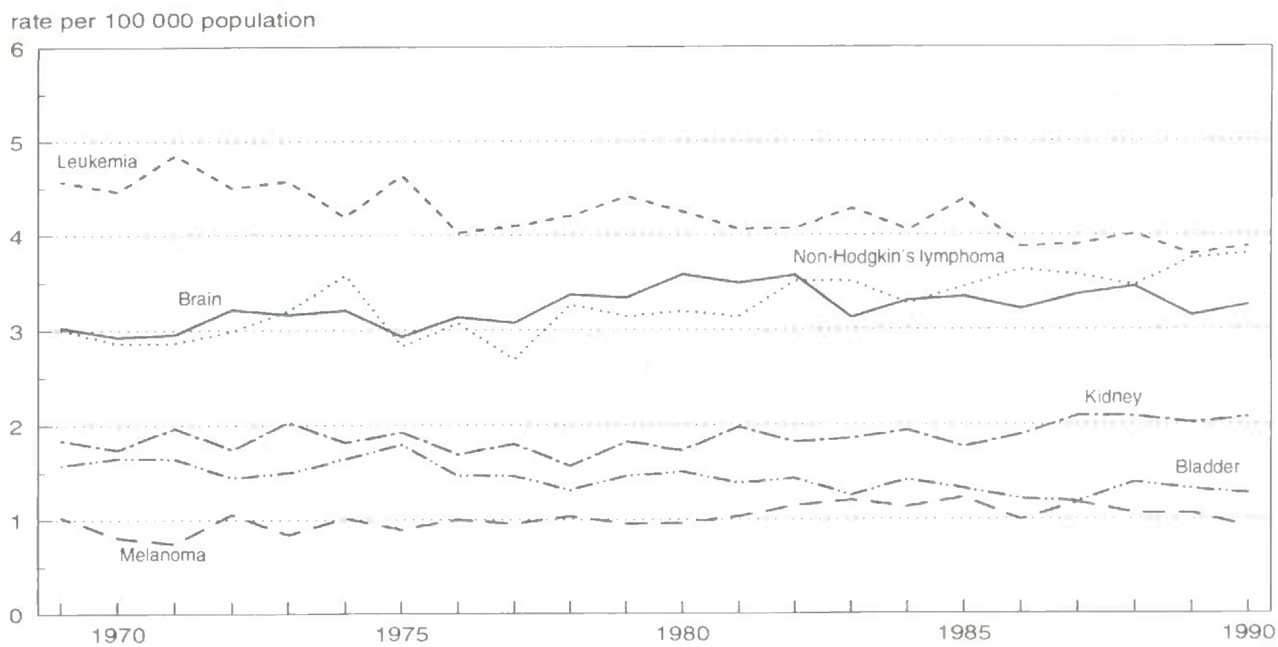
Age-standardized Cancer Mortality Rates, Males, 1969-1990



Notes:
Rates are adjusted to the age distribution of the World Standard Population.
Calculations do not include the Yukon or Northwest Territories.
Source:
Statistics Canada, Canadian Centre for Health Information.

Figure 2.7.4

Age-standardized Cancer Mortality Rates, Females, 1969-1990



Notes:
Rates are adjusted to the age distribution of the World Standard Population.
Calculations do not include the Yukon or Northwest Territories.
Source:
Statistics Canada, Canadian Centre for Health Information.

2.7.3 and 2.7.4). The exception to this is the case of melanoma where mortality increased 80 percent for males from 1.1 deaths per 100 000 in 1969 to 2.0 deaths per 100 000 in 1990. However, melanoma still had the lowest ASMR of all the environmentally linked cancers for both males and females. Among women, melanoma mortality decreased overall between 1969 and 1990, but the rates fluctuated. For males, cancer of the bladder and testes, and leukemia mortality rates have decreased in the past twenty years. The bladder cancer ASMR decreased for females as well even though incidence rates for both sexes have increased. The kidney cancer ASMR decreased for females and increased only slightly (9 percent) for males from 3.9 deaths per 100 000 in 1969 to 4.2 in 1990. For both sexes, ASMRs for non-Hodgkin's lymphoma increased from 1969 to 1990, rising from 3.0 deaths per 100 000 to 3.8 for females and from 4.4 to 5.6 deaths per 100 000 for males.

In general, mortality and incidence for environmentally related cancers were quite low, especially in comparison with lung cancer and female breast cancer. In spite of the relatively low mortality and incidence rates, these cancers have received considerable public attention because of their increased incidence.

Asthma

Asthma is a respiratory condition that can be aggravated by environmental factors. Stimuli that trigger asthma attacks include pollen, moulds and abrupt changes in the weather. There is also reason to believe that air pollution is a trigger, although this further investigation is required to confirm this link.[1] Asthmatics are also susceptible to tobacco smoke, stress and exercise.

Asthma attacks are characterized by mild to severe difficulty in breathing and may be accompanied by coughing and wheezing. These symptoms are caused by a narrowing of the air passages to the lungs.

Table 2.7.5 shows that although asthma mortality rates fluctuated, no trend or overall increase was observed during the last decade. On average, during the 1980s, there were 58 asthma deaths each year. Eleven of the 58 deaths occurred in the population aged 15 years or under.[2]

Hospital admission rates for asthma increased by 40 percent between 1980 and 1988 to 43 785 admissions per 100 000 population. However, the length of stay in the hospital decreased from 4.5 days to 3.5 days.

1. Johansen H., M. Dutta, Y. Mao, K. Chagani and I. Sladecek, *An Investigation of the Increase in Preschool-age Asthma in Manitoba, Canada*, Health Reports, 4(2), Catalogue No. 82-003, 1992, p. 379-402.
2. Wilkins, K. and Y. Mao, "Trends in Rates of Admission to Hospital and Death from Asthma Among Children and Young Adults in Canada during the 1980s", *Canadian Medical Association Journal*, 148(2), 1993, p. 185-190.

There is no evidence to suggest that there is a connection between the stabilization of asthma death rates and increased hospitalization. An examination of provincial rates revealed that a low death rate is not always associated with a high hospitalization rate.[3]

Table 2.7.5

Age-standardized[1] Asthma Mortality Rates and Number of Deaths by Sex, 1980-1989

Year	Less than 15 years		15 to 34 years		Total	
	Rate	Deaths	Rate	Deaths	Rate	Deaths
	per 100 000 population					
Males						
1980	**0.11**	**3**	**0.66**	**29**	**0.45**	**32**
1981	0.43	12	0.60	27	0.54	39
1982	0.07	2	0.67	30	0.44	32
1983	0.22	6	0.56	25	0.43	31
1984	0.15	4	0.39	17	0.29	21
1985	0.19	5	0.52	23	0.39	28
1986	0.45	12	0.75	33	0.63	45
1987	0.25	7	0.72	32	0.54	39
1988	0.26	7	0.52	22	0.42	29
1989	0.22	6	0.53	22	0.41	28
Females						
1980	**0.22**	**6**	**0.39**	**17**	**0.33**	**23**
1981	0.08	2	0.43	19	0.30	21
1982	0.04	1	0.52	23	0.34	24
1983	0.04	1	0.71	31	0.45	32
1984	0.35	9	0.75	32	0.59	41
1985	0.27	7	0.45	19	0.38	26
1986	0.12	3	0.39	17	0.29	20
1987	0.16	4	0.46	19	0.35	23
1988	0.27	7	0.49	21	0.41	28
1989	0.24	6	0.38	16	0.32	22

Note:
1. Rates are adjusted to the age distribution of the 1981 Canadian population.

Source:
Wilkins, K., Y. Mao, "Trends in Rates of Admission to Hospital and Death from Asthma Among Children and Young Adults in Canada During the 1980s", *Canadian Medical Association Journal*, 148(2), 1993.

There is a need for more information about hospitalization prevalence rates for asthma in Canada. One person can be admitted to hospital for asthma several times a year and can be counted each time. Therefore, hospital admissions are not a clear indicator of asthma incidence in the population.

Currently there are studies underway that seek to develop new technologies to study personal exposure to indoor and outdoor air pollution. The Gage Institute, in collaboration with several other organizations, including the University of Toronto, is currently monitoring forty asthmatics in Toronto and Windsor. The intention of this study is to establish a cause-effect relationship between environmental pollutants and adverse physiological effects by using a personal air-quality monitoring device. Other studies that have correlated air pollution levels with respiratory ailments have not established a direct causal relationship between the two.[4] This

3. Ibid.
4. Broder I, P. Koutrakis, C. Pilger and P. Corey, "Exposure Modelling in Epidemiological Studies", *First Annual Environment and Health Symposium, Advances and New Cross-Disciplinary Directions: Proceedings*. Toronto, June 23, 1993.

is because unrelated asthma-causing events (for example crop burning) may occur simultaneously with an air pollution event.

In order to better understand the complex relationship between air pollution and asthma attacks it is necessary to have data on the prevalence of asthma in the Canadian population. There is also a need to develop and implement methods that can measure the air quality to which an individual is exposed.

Contaminants in Food

Contaminants may enter the food chain at any stage phases from initial production to final processing and preparation. It is difficult to determine the health effects of the consumption of contaminated foods, for several reasons. For instance, potentially harmful substances are often consumed gradually in minute quantities over a long period of time. Health effects that are linked to prolonged and sustained exposure may be confounded by other risk factors such as those related to lifestyle and dietary habits.

Health Canada gathers data on foodborne diseases in Canada based on cases reported to local health authorities. These cases tend to result from short-term acute exposure to contaminants having a variety of origins (chemical, plant, bacterial, etc.). The food generally becomes contaminated after having been mishandled during the processing or preparation stages. The symptoms resulting from foodborne diseases include dizziness, nausea and vomiting and, in extreme cases, in death.

As illustrated in Table 2.7.6, the number of cases of foodborne disease fluctuated in the five years between 1982 and 1986 from a low of 5 955 cases in 1983 to a high of 9 857 in 1984. Most cases were caused by microbiological factors; 58 percent of the cases in 1985 were known to have microbiological origins. Cases of foodborne disease having a chemical origin increased in 1985 and 1986 to represent about 2 percent of the total cases. For 1983 and 1984 they accounted for only 0.3 percent and 0.8 percent of the total cases. From 1982 to 1984 there were no known cases of pesticides causing foodborne illness. In 1985, 19 such cases were reported; Watermelon obtained from a contaminated area was the source of the problem 9 of the 19 instances.[1]

Outbreaks of foodborne disease are often highly geographically concentrated. The regional distribution of cases can fluctuate dramatically from one year to the next especially in provinces and territories having small populations. Table 2.7.7 shows the distribution of foodborne disease from 1983 to 1986 across Canada.

1. Health and Welfare Canada, Health Protection Branch, *Foodborne and Waterborne Disease in Canada, Annual Summaries*, Ottawa, various issues.

Table 2.7.6
Cases of Foodborne Disease, 1982-1986

Etiology	1982	1983	1984	1985	1986	1982	1983	1984	1985	1986
	number					percent				
Known causes										
Microbiological	3 554	2 297	5 592	2 188	1 849	48.13	38.57	56.73	33.11	27.06
Parasitic	59	-	-	4	1	0.80	-	-	0.06	0.01
Animal	33	3	6	22	10	0.45	0.05	0.06	0.33	0.15
Plant	11	67	2	7	2	0.15	1.13	0.02	0.11	0.03
Chemical	103	36	82	153	165	1.39	0.60	0.83	2.32	2.41
Metal	9	2	2	36	12	0.12	0.03	0.02	0.54	0.18
Solvents	5	-	5	2	21	0.07	-	0.05	0.03	0.31
Cleaning solution	24	-	1	-	-	0.33	-	0.01	-	
Drug	1	1	-	-	-	0.01	0.02	-	-	-
Penicillin	1	-	-	-	-	0.01	-	-	-	-
Monosodium glutamate	-	-	7	10	16	-	-	0.07	0.15	0.23
Rancid compounds	19	12	24	13	16	0.26	0.20	0.24	0.20	0.23
Pesticide	-	-	-	19	8	-	-	-	0.29	0.12
Allergen	-	-	-	3	7	-	-	-	0.05	0.10
Other chemicals	13	6	11	18	33	0.18	0.10	0.11	0.27	0.48
Extraneous matter	31	15	32	52	49	0.42	0.25	0.32	0.79	0.72
Total: known causes	**3 760**	**2 403**	**5 682**	**2 374**	**2 027**	**50.92**	**40.35**	**57.64**	**35.92**	**29.66**
Unknown causes										
Probably microbiological	1 068	1 293	1 220	1 831	2 658	14.46	21.71	12.38	27.70	38.90
Probably animal	4	1	13	7	5	0.05	0.02	0.13	0.11	0.07
Probably plant	4	3	1	3	-	0.05	0.05	0.01	0.05	-
Probably chemical	55	67	50	78	80	0.74	1.13	0.51	1.18	1.17
Probably chemical or microbiological	1	-	-	2 316	2 063	0.01	-	-	35.04	30.19
Other	2 492	2 188	2 891	-	-	33.75	36.74	29.33	-	-
Total: unknown causes	**3 624**	**3 552**	**4 175**	**4 235**	**4 806**	**49.08**	**59.65**	**42.36**	**64.08**	**70.34**
Total	**7 384**	**5 955**	**9 857**	**6 609**	**6 833**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source:
Health and Welfare Canada, Health Protection Branch, *Foodborne and Waterborne Disease in Canada*, Ottawa, various issues.

Table 2.7.7

Regional Distribution of Cases of Foodborne Disease, 1983-1986

Province/Territory	Cases				Percentage of all cases				Frequency			
	1983	1984	1985	1986	1983	1984	1985	1986	1983	1984	1985	1986
	number				percent				cases per 100 000 population[1]			
Newfoundland	101	135	27	7	1.7	1.4	0.4	0.1	17.5	23.3	4.7	1.2
Prince Edward Island	-	-	200	-	-	-	3.0	-	-	-	158.7	-
Nova Scotia	23	112	452	29	0.4	1.1	6.8	0.4	2.7	12.9	51.9	3.3
New Brunswick	-	51	12	52	-	0.5	0.2	0.8	-	7.1	1.7	7.3
Quebec	726	900	1 212	1 104	12.2	9.1	18.3	16.2	11.1	13.7	18.6	17.6
Ontario	3 186	4 589	2 875	4 389	53.5	46.6	43.5	64.2	36.1	51.3	31.9	48.2
Manitoba	143	146	236	188	2.4	1.5	3.6	2.6	13.7	13.8	22.2	17.6
Saskatchewan	798	154	150	82	13.4	1.6	2.3	1.2	80.4	15.3	14.9	8.1
Alberta	495	228	590	80	8.3	2.3	8.9	1.2	21.0	9.7	25.1	3.4
British Columbia	482	813	816	892	8.1	8.2	12.3	13.1	17.1	28.3	28.4	30.9
Yukon	-	21	-	-	-	0.2	-	-	-	96.3	-	-
Northwest Territories	1	8	39	10	-	0.1	0.6	0.1	2.1	16.2	75.1	19.2
More than one province	-	2 700	-	-	-	27.4	-	-	...	...	-	-
Canada	**5 955**	**9 857**	**6 609**	**6 833**	**100.0**	**100.0**	**100.0**	**100.0**	**23.9**	**39.2**	**26.3**	**27.0**

Note:
1. Based on Census Division population estimates.
Source:
Health and Welfare Canada, Health Protection Branch, *Foodborne and Waterborne Disease in Canada*, Ottawa, various issues.

Summary

Canadians are among the healthiest people in the world and we live in a comparatively clean country. The impact of environmental risk factors on the population is difficult to assess because of other intervening variables and the inherent adaptability of humans.

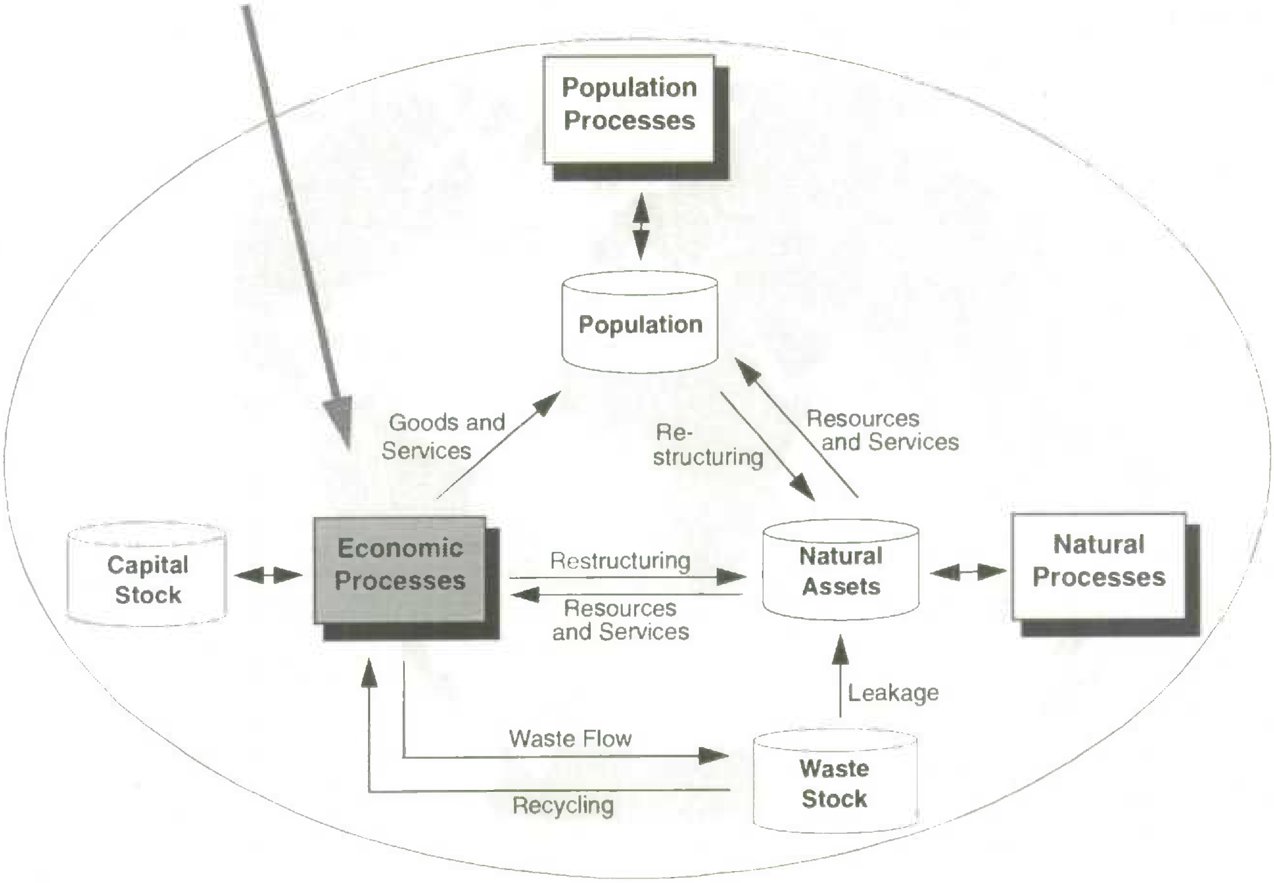
While causal linkages between environmental factors and their effect on the health status of the population are unclear, some trends should be noted. Of the five leading causes of death, cancer is the only cause for which mortality rates have increased over the past four decades. Cancer incidence rates for bladder, brain, kidney, leukemia, melanoma and non-Hodgkin's lymphoma have been increasing. Some evidence suggests that these cancers may be linked to environmental contaminants.

More data are needed on asthma incidence and on the relationship between asthma and air pollution. However, there is reason to believe that asthma attacks are related to levels of air pollution.

There are increasing numbers of people developing environmental sensitivities. They cannot drink chlorinated water, they are more sensitive to food grown using pesticides and herbicides. It is difficult to assess how much of the Canadian population is in this position, because no data are collected nationally on incidence of allergies and people often seek no medical treatment for mild allergic reactions.

It is clear that more investigation is needed into the relationship between human health and the environment.

3 Economy



Economic processes and environmental quality cannot be separated in reality, even though they are quite distinct academic disciplines. This linkage suggests the necessity of studying the forces that drive economic activity in order to understand the causes of changing environmental quality. Recognising this need, the following chapter presents statistics that describe economic conditions in Canada and illustrates, as much as possible, how closely environmental quality is tied to economic activity.

❑❑❑

There are many aspects of economic activity that might be considered when studying environmental quality. For example, it is important to know the cost of running the economy in such a way that the integrity of the environment is maintained. To answer this question, it is useful to look at the costs of industrial pollution prevention and the costs of cleaning up existing damage to the environment. It is also valuable to look at the significance of Canada's natural resources in the creation of jobs for Canadians. This question can be answered in part by looking at incomes and employment levels in natural resource-dependent industries, and at the sustainability of exploitation of these resources as well as the contribution of natural resources to the value of Canada's productive capital. A third aspect of economic activity that should be considered in the context of environmental quality, and one that encompasses the two just mentioned, is that of competitiveness. Differing environmental regulations, both within Canada and between Canada and other countries, create competitive advantages (or disadvantages) that can affect the economic viability of Canadian companies. Among other things, this will affect employment levels, consumption of natural resources and the creation of pollution. While competitiveness is difficult to measure, many decisions that affect both the economy and the environment are nevertheless made with a view to how well Canadian firms can compete with their rivals at home and abroad.

Economic Activity

This section presents data that describe economic activity using a variety of monetary and non-monetary measures.- Gross Domestic Product (GDP) statistics are used to illustrate the proportion of our economic activity that occurs in industries with significant environmental impact. Energy[1] and natural resource consumption are used as proxies for environmental impact in this case. Employment levels and investment in pollution abatement and control equipment are also related to environmental impact on an industry-by-industry basis. The section begins with a discussion of GDP.

❑❑❑

3.1 Economic Overview

Economic activity is, of course, necessary for our survival. However, we are increasingly aware that our living standard is linked to the quality of our environment as much as it is to the level of our economic output. It is a cause for concern, then, that our measurement of economic activity is often inconsistent with the need for a healthy environment. The principle indicator of economic activity is Gross Domestic Product. This is a measure of the unduplicated[2] value of the market-place production that occurs within the boundaries of a country. It is widely used as a basis of comparison for economic activity between different regions and countries.

GDP has many shortcomings as a measure of welfare (a purpose for which it was not designed but for which it is often used for want of a better indicator). That is, increasing per capita GDP does not necessarily lead to a higher standard of living. One reason why there may be a divergence between GDP and standard of living is that most aspects of the relationship between the economy and the environment are ignored in the measurement of GDP. For example, it cannot reveal whether or not the exploitation of natural resources is being carried out on a sustainable basis. Nor does it account for any reduction in environmental quality that may occur as a result of economic activity. Thus, it is possible to have at the same time rising GDP and declining environmental quality. Despite this criticism, GDP does provide a measure of economic activity that is useful for many purposes. A more complete picture, however, might incorporate the costs of resource depletion and environmental degradation. Indeed, this work is proceeding (see Chapter 5 - **Environmental Accounting)** but there is currently no unified framework for doing so that would be widely accepted.

1. In this section it is the *value* of energy consumed that is used as a measure of energy intensity. In other sections (for example, Section 3.12 - **Energy**) the *physical quantity* of energy is used instead. The latter provides a more consistent picture of energy consumption over time, since the effects of energy price changes are removed.
2. In this context, unduplicated means that each unit of production is counted only once. Thus, the value of a bushel of wheat is counted only when the farmer produces it. Subsequent use of the wheat is treated as a cost and subtracted from the value of the baker's output.

Table 3.1.1

Gross Domestic Product, Expenditure Based, 1993[1]

	Gross Domestic Product	
	billion dollars	percent
Personal expenditures	432.8	60.9
Government expenditures	167.6	23.6
Business investment	113.4	16.0
Exports	208.3	29.3
Imports	-209.1	-29.4
Statistical discrepancy	-2.4	-0.3
GDP at market prices	**710.7**	**100.0**

Note:
1. Preliminary.
Source:
Statistics Canada, *National Income and Expenditure Accounts, Annual Estimates*, Catalogue No. 13-201, Ottawa, 1994.

Table 3.1.2

Distribution of Gross Domestic Product at Factor Cost by Industry, 1961-1990

Industry	1961	1963	1965	1967	1969	1971	1973	1975	1977	1979	1981	1983	1985	1987	1989	1990
	percent															
Primary Industries	**9.9**	**10.9**	**10.1**	**9.0**	**8.6**	**7.6**	**9.5**	**9.3**	**8.6**	**10.1**	**9.6**	**9.2**	**9.4**	**7.2**	**6.4**	**6.3**
Agriculture	4.4	5.6	4.7	3.9	3.8	3.2	4.1	4.1	3.0	3.3	3.3	2.5	2.3	2.1	1.9	1.9
Fishing and trapping	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.2
Logging and forestry	1.1	1.0	1.0	0.9	0.9	0.7	0.8	0.6	0.7	0.8	0.6	0.6	0.6	0.7	0.7	0.6
Mining, quarrying and oil well	4.2	4.1	4.2	4.0	3.7	3.5	4.4	4.5	4.7	5.7	5.5	5.9	6.3	4.1	3.6	3.6
Manufacturing Industries	**24.7**	**25.4**	**26.0**	**24.5**	**24.3**	**22.4**	**22.4**	**20.3**	**19.8**	**20.5**	**19.3**	**17.9**	**19.0**	**19.2**	**19.0**	**17.9**
Service Industries	**51.0**	**49.0**	**49.6**	**50.4**	**49.9**	**51.5**	**50.4**	**51.7**	**52.5**	**51.6**	**53.0**	**53.6**	**53.3**	**55.9**	**57.0**	**57.0**
Construction	7.6	7.0	7.6	7.8	7.2	7.5	7.7	8.3	8.3	7.0	7.9	6.9	6.1	6.6	7.1	6.9
Transportation and storage	6.2	6.0	6.0	5.8	5.6	5.5	5.1	4.8	4.7	4.7	4.5	4.4	4.4	4.4	4.0	3.9
Communication	2.4	2.4	2.4	2.5	2.6	2.7	2.6	2.5	2.6	2.8	2.7	3.0	3.0	2.8	2.8	2.8
Other utility	2.4	2.2	2.2	2.1	2.2	2.3	2.2	2.0	2.5	2.8	2.8	3.2	3.3	3.3	3.1	3.0
Wholesale trade	4.8	4.7	4.8	4.8	4.8	5.0	5.0	5.2	4.6	4.7	4.8	4.6	4.9	5.2	5.3	5.4
Retail trade	7.7	7.5	7.2	7.3	7.2	7.1	6.7	6.9	6.5	6.2	6.2	5.9	6.1	6.4	6.2	6.1
Finance, insurance and real estate	12.5	11.9	11.6	11.6	11.9	12.3	11.8	12.5	13.4	13.7	13.8	15.3	14.8	15.5	15.8	15.9
Community, business, personal services	7.4	7.3	7.8	8.5	8.4	9.1	9.3	9.5	9.9	9.7	10.3	10.3	10.7	11.7	12.7	13.0
Non-business sector	**14.4**	**14.5**	**14.4**	**16.0**	**17.4**	**18.5**	**17.7**	**18.5**	**19.0**	**17.9**	**18.1**	**19.4**	**18.3**	**17.9**	**17.7**	**18.7**
Total economy	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source:
Statistics Canada, *Gross Domestic Product by Industry*, Catalogue No. 15-001, Ottawa, various issues.

Table 3.1.1 shows 1993 GDP broken down by expenditure category. The data show that 29 percent of the demand for Canadian goods and services comes from abroad. Over 60 percent of this demand comes from Canadian households (personal expenditure in Table 3.1.1).

Table 3.1.2 shows the industrial distribution of GDP during the period 1961 to 1990. Over this period service industries increased their share of GDP from 51 percent to 57 percent, while the share of primary industries declined from 9.9 percent to 6.3 percent. This major shift towards the production of services has reduced the relative importance of resource and energy intensive industries in the Canadian economy. This is not to imply that the output of the latter group of industries is not growing or that their environmental impact is diminishing. Although primary industries declined in economic importance relative to other industries, the real value of their production almost doubled from $19 billion to $35.2 billion during this period.

Table 3.1.3 provides an overview of the relative importance of each industry in terms of GDP, employment, capital,

Table 3.1.3

Industry Direct Intensities, 1990

Industry	GDP	Employment	Intensities				
			Employment	Capital[1]	Energy[2]	Resource	Subsidy
	million dollars	thousands	person per million dollars of production[3]	percent			
1 Agriculture	11 504	452.8	18.2	155.4	5.1	16.9	11.2
2 Fishing and trapping	1 014	41.0	24.0	100.6	5.3	2.0	2.5
3 Logging and forestry	3 574	55.9	6.4	30.9	2.1	19.1	0.3
4 Mining	7 947	57.4	4.2	80.0	5.9	0.9	0.4
5 Crude oil and natural gas	10 812	35.7	1.6	112.0	2.0	0.1	--
6 Quarries and sand pits	727	9.7	7.3	-	5.0	1.4	-
7 Service related to mineral extraction	1 989	35.5	8.8	-	3.8	0.4	0.1
8 Food processing	11 807	197.2	4.9	37.9	1.1	30.5	0.7
9 Beverages	2 670	23.9	4.1	76.4	1.0	0.8	--
10 Tobacco products	887	4.9	2.6	38.1	0.4	13.8	--
11 Rubber products	1 212	24.8	8.5	107.9	1.9	0.6	--
12 Plastic products	2 380	51.9	8.5	50.4	2.0	0.2	0.1
13 Leather products	478	16.5	13.8	40.1	0.8	0.2	0.1
14 Textiles	2 310	56.0	8.9	52.7	2.1	0.6	0.1
15 Clothing	2 974	103.7	14.8	14.0	0.6	1.0	0.1
16 Wood products	4 793	115.5	7.7	60.4	2.1	30.0	0.1
17 Furniture	2 057	59.1	12.6	24.9	1.1	0.2	0.1
18 Paper products	8 916	113.6	4.7	221.1	6.8	7.6	0.1
19 Printing and publishing	7 793	142.4	10.0	42.9	0.7	0.1	0.2
20 Primary metals	6 391	95.2	4.1	148.2	6.5	26.8	0.3
21 Fabricated metals	7 691	166.9	9.2	37.5	1.3	2.8	0.3
22 Machinery	4 601	85.0	7.9	26.9	0.9	0.2	0.1
23 Transport equipment	14 121	226.8	4.2	49.0	0.7	0.1	0.1
24 Electrical products	8 363	141.3	6.5	34.6	0.8	0.1	0.1
25 Non-metallic mineral products	3 378	54.5	7.1	81.7	5.0	10.3	0.1
26 Refined petroleum products	1 385	14.1	0.7	73.2	4.4	71.7	0.2
27 Chemical products	9 229	92.8	3.8	92.3	5.8	2.4	0.1
28 Other manufacturing	2 886	75.5	11.5	44.7	1.0	3.3	0.3
29 Construction	41 102	820.2	8.2	19.8	0.6	0.9	--
30 Transport	20 447	450.5	10.7	189.7	6.8	0.2	5.6
31 Pipeline transport	2 193	6.1	1.8	587.0	4.4	1.3	0.3
32 Storage	708	19.1	14.4	284.2	3.8	0.2	--
33 Communication	16 716	208.0	9.1	279.6	0.8	--	5.1
34 Electric power and other utilities	17 774	109.3	4.4	1 096.5	9.5	6.1	1.3
35 Wholesale trade	31 963	659.3	13.8	24.7	1.7	0.2	0.1
36 Retail trade	36 245	1 509.7	26.9	45.3	2.7	0.8	0.1
37 Finance and real estate	45 118	606.8	7.6	249.0	2.4	0.2	2.9
38 Insurance	3 141	74.5	6.9	...	0.4	--	0.1
39 Government royalties on resources	4 427	...	...	...	...	...	...
40 Owner occupied dwellings	41 905	...	...	...	...	...	0.3
41 Business services	27 687	706.2	18.3	...	0.5	--	0.9
42 Educational services	1 186	27.1	13.9	...	3.1	0.3	0.1
43 Health services	13 410	197.2	11.5	...	1.0	0.1	1.9
44 Accommodation and food	15 763	803.0	28.2	...	2.1	1.6	0.1
45 Amusement and recreation	5 107	129.4	13.8	...	2.0	0.1	2.3
46 Personal services	6 107	199.0	24.1	...	2.1	0.1	0.9
47 Other services	8 111	318.8	27.4	...	1.8	0.1	--
All industries	**483 018**	**9 394.0**	**9.2**	**128.7**	**3.6**	**5.1**	**1.1**

Notes:
1. End-year capital stock as a percentage of production.
2. Include purchased energy only.
3. Total production is not shown in this table.

Sources:
Statistics Canada, National Accounts and Environment Division and Input-Output Division.

energy use, resource use and subsidies. Energy and resource intensities[1] provide some perspective on the environmental impact of an industry. Energy use (in the form of fossil fuels) results in the emissions of many types of airborne wastes, including those that contribute to acid rain, to urban smog and to the expected greenhouse effect. Hydro and nuclear electricity production result in other environmental impacts such as flooding, disruption of fish and wildlife habitat and the generation of radioactive wastes (see Section 3.12 - **Energy** for more detail on the environmental impacts of energy use). Resource use contributes to the depletion of non-renewable materials such as minerals and petroleum reserves. The harvesting of renewable resources can lead to reductions in natural stocks and to the restructuring of land that can render it less attractive and/or productive for alternative uses. Highly resource intensive industries also tend to produce more wastes than other industries, because a major portion of their activity involves the refining of raw resources into semi-finished commodities.

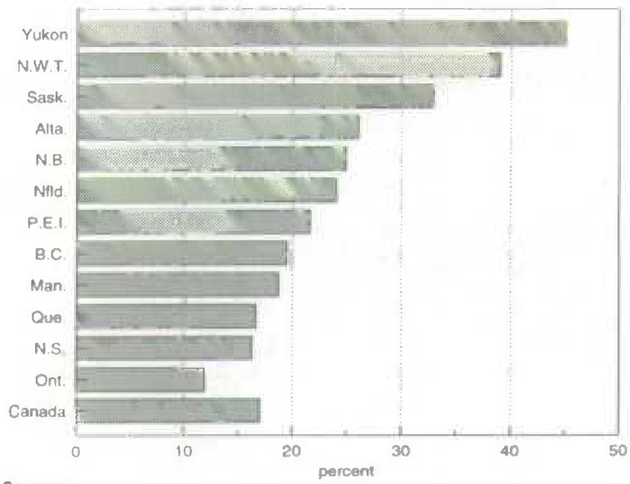
Employment and environmental issues are closely related as well. Employment intensities show the relative dependence of each industry on labour inputs. Generally, manufacturing industries are much less dependent upon labour than are service industries. Two of the four primary industries, logging and mining, also have very low employment intensities. Except for agriculture and transportation, industries with high employment intensity tend to have low energy and resource intensities. This suggests, to the extent that resource and energy intensiveness are related to high environmental impact, that a relative increase in the production of highly employment intensive industries would be beneficial to the environment. However, the example of the fishing industry shows that this principle should be applied with caution (see Section 3.2 - **Resource-dependent Industries**).

Table 3.1.3 also shows that, apart from agriculture, resource intensive industries were not heavily dependent upon operating subsidies in 1990.[2]

Ideally, it would be desirable to characterize industries according to their effect on environmental quality, but serious conceptual and data inadequacies prevent such a categorisation. No comprehensive data are available on quantities of toxic wastes flowing from industrial processes and, even if there were, it would be difficult to aggregate these data in any meaningful way.

It is possible to compare provinces and territories in terms of the importance of resource intensive industries in their respective economies (Figure 3.1.1). For the purposes here, an industry has been arbitrarily designated as resource intensive if fuel expenses comprise at least 6 percent of the value of total production. Yukon, the Northwest Territories and Saskatchewan stand out as being highly resource intensive compared to the Canadian average. It is important to note, however, that the province in which production occurs is not necessarily the province where the goods and services are consumed. This is particularly true for natural resources.

Figure 3.1.1
Proportion of GDP Generated by Resource Intensive Industries, 1990



Sources:
Statistics Canada, National Accounts and Environment Division and Input-Output Division.

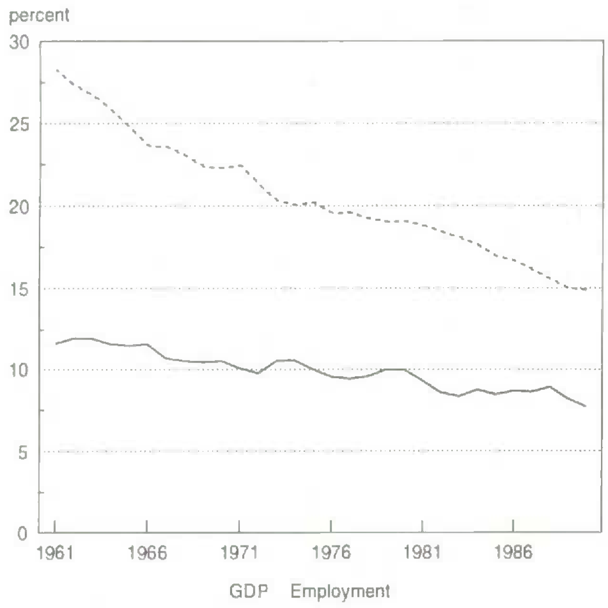
Employment and GDP in energy intensive industries are shown as a percentage of total employment and GDP over time in Figure 3.1.2. Both of these measures indicate that the relative economic importance of energy intensive industries has declined since 1961.

During a period of relatively moderate GDP growth (1979-1992), investment in pollution abatement and control equipment has grown rapidly as a percentage of total investment (see Figure 3.1.3 and Section 3.15 - **Business Sector** for more detail). Investment in pollution abatement is one of the few components of environmental expenditures for which there are some data available. As well as investment in pollution abatement, environmental expenditures include spending on activities such as environmental assessment, site remediation, storage and disposal of hazardous waste and product redesign. The latter includes, for example, expenditures aimed at reducing packaging waste, the development of non-leaded gasoline and recycled paper. Increasingly, reductions in waste emissions will be achieved through changes in industrial processes rather than through the end-of-pipe treatment of wastes that have already been generated. The environmental component of process change expenditures is inherently more difficult to measure than end-of-pipe expenditures, because of the difficulty in determining if a given process change has been undertaken for purely environmental reasons, for purely economic reasons or for a combination of the two.

1. The energy and resource intensity measures in Table 3.1.3 are calculated as the percentage of the value of energy and resource inputs to total outputs for each industry.
2. Some industrial subsidies, such as loan guarantees and accelerated capital expenditure write-offs, are not shown in this table.

Figure 3.1.2

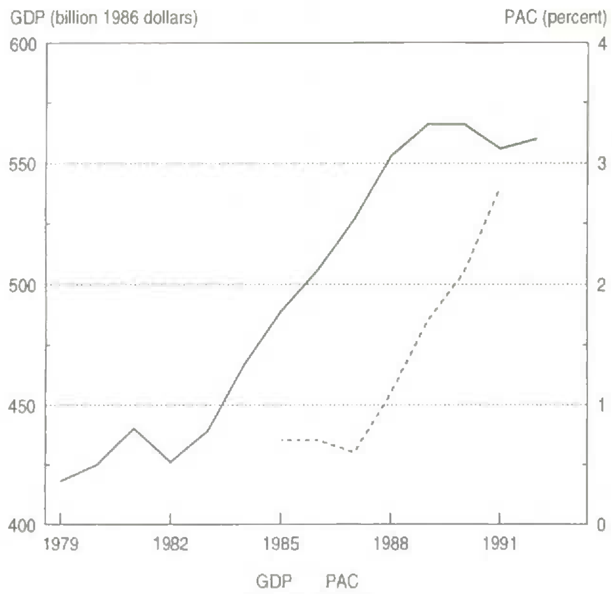
Share of Business Sector GDP and Employment by Energy Intensive Industries, 1961-1990



Sources:
Statistics Canada, National Accounts and Environment Division and Input-Output Division.

Figure 3.1.3

GDP and Pollution Abatement Share of Total Investment, 1979-1992



Note:
The pollution abatement expenditure data are based on information provided by large establishments only. Respondents were asked to allocate total investment expenditures to various categories that were not strictly defined.
Source:
Statistics Canada, Investment and Capital Stock Division.

Summary

The declining relative economic importance of natural resource-based industries and the growth of service industries has not necessarily translated into a reduction in the overall environmental impact of the Canadian economy. The production of many resource-based industries is still growing, albeit, in most cases, less quickly than the economy as a whole. Classification of industries according to their resource and energy dependence, as shown above, provides some insight into the environmental impact of these industries, but more data are needed to examine the harmful effects of the wastes generated by the economic process.

3.2 Resource-dependent Industries

The production and employment share of resource-dependent industries has been declining in relation to other industries in the Canadian economy. By 1990, resource-dependent industries like agriculture, forestry, fishing and mining, accounted for only 6 percent of Gross Domestic Product (GDP) (Table 3.1.2 in Section 3.1 - **Economic Overview**). Broadening the definition of resource-dependency to include manufacturing industries that process resource materials in their raw form, the GDP share was still just 10 percent. The service industries are now responsible for two-thirds of the market economy while construction and other manufacturing account for the remainder.

Despite their relatively small share in total GDP, resource-dependent industries have played and continue to play a crucial role in Canada's economic development. In some areas their output has grown considerably in absolute, physical terms, even if not in relative, dollar terms. For example, wheat production increased from 4 million tonnes in 1961 to 11 million in 1993. The amount of wood harvested has grown from 60 million cubic metres in 1961 to 162 million in 1991. In some other resource-dependent areas, however, production has declined in spite of technological advances. Examples include iron ore production, which dropped from 47 million tonnes in 1974 to 33 million in 1992[1], and Atlantic cod landings, which decreased from 943 thousand tonnes in 1961 to just 239 thousand in 1992 (see Section 4.3 - **Fish and Wildlife**). In the former case, the decline is a reflection of the economic viability of Canadian iron ore grades and economic changes affecting demand for iron ore products. The fisheries example, in contrast, is caused almost entirely by supply constraints.

1. Energy, Mines and Resources Canada, *1992 Canadian Mineral Yearbook*, Ottawa,1993.

❑❑❑

A geographical perspective on Canada's resource dependence is provided in Map 3.2.1. Employment in primary industries and in first-stage manufacturing industries that are directly dependent upon resources are expressed as a percentage of total employment in each sub-sub drainage basin.

Agriculture and Food Products Industry

In the developed world, agricultural specialisation is a driving force behind increased food production. Price competitiveness requires large-scale, specialised production techniques. Figure 3.2.1 indicates the increase in specialisation of selected livestock farms since 1971. For example, the percentage of pigs raised on farms specialising in only pig production climbed from 43 percent in 1971 to 82 percent by 1991.

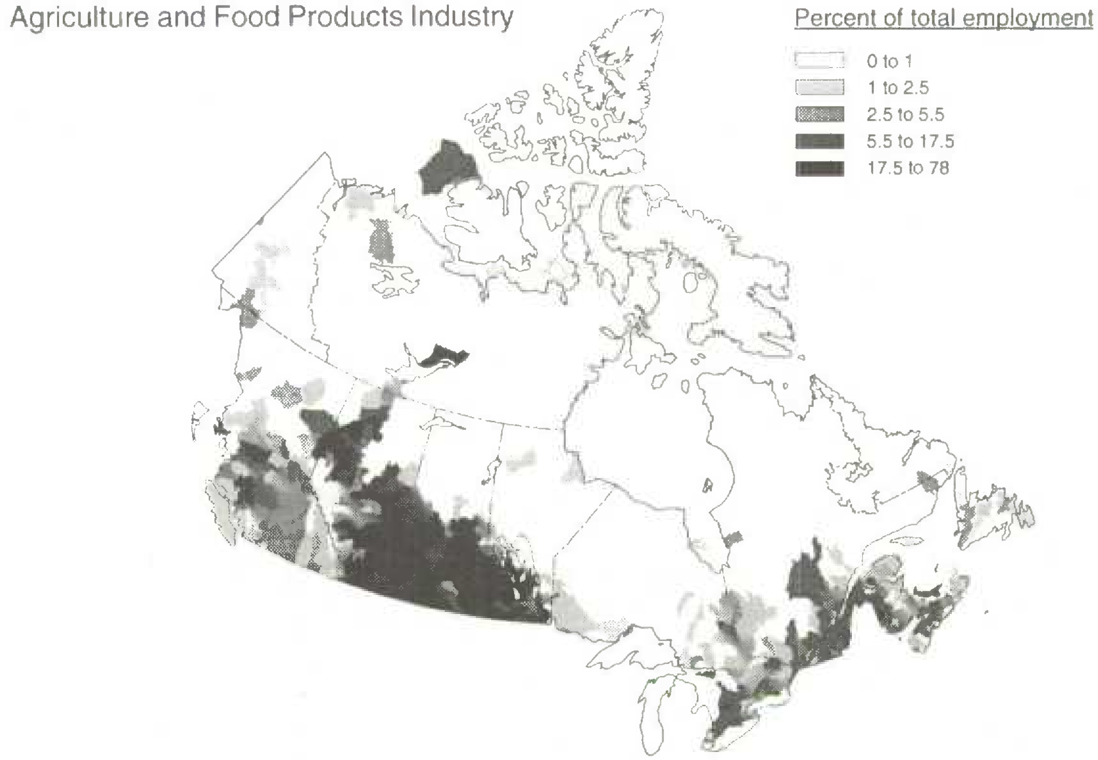
The number of farms with annual revenues greater than $50 000 (at constant 1990 dollars) increased from 55 000 to 118 000 since 1966 while the total number of farms has declined steadily (Figure 3.2.2 and Table 3.2.2).

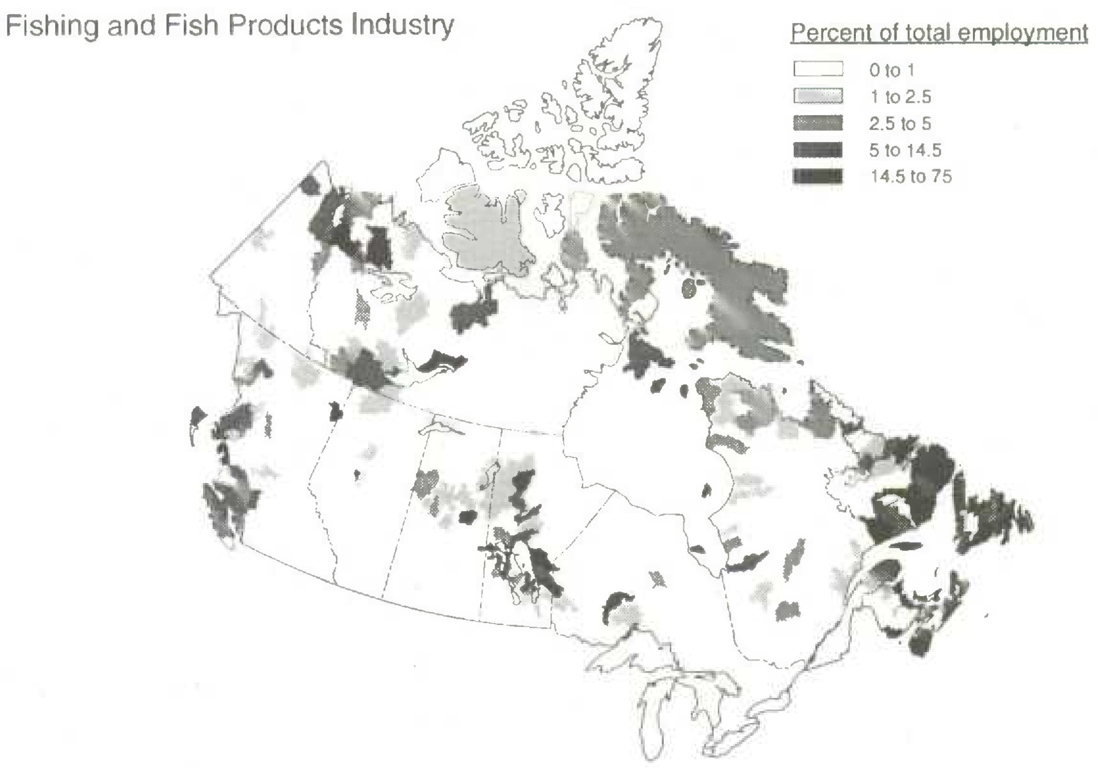
Table 3.2.1
Employment in Resource-dependent Industries, 1991

	Employment						Proportion of all industries				
Province/Territory	All industries	Total resource-dependent sector	Agriculture and food products industry	Fishing and fish products industry	Forest and forest products industry	Mining and mineral products industry	Total resource-dependent sector	Agriculture and food products industry	Fishing and fish products industry	Forest and forest products industry	Mining and mineral products industry
	persons						percent				
Newfoundland	260 864	48 451	3 856	32 025	6 921	5 649	18.6	1.5	12.3	2.7	2.2
Prince Edward Island	68 133	14 678	7 096	6 657	590	335	21.5	10.4	9.8	0.9	0.5
Nova Scotia	443 761	54 295	14 421	21 298	9 846	8 730	12.2	3.2	4.8	2.2	2.0
New Brunswick	351 131	52 500	13 711	13 216	18 351	7 222	15.0	3.9	3.8	5.2	2.1
Quebec	3 460 134	286 548	123 024	10 349	81 203	71 972	8.3	3.6	0.3	2.3	2.1
Ontario	5 484 204	374 097	186 830	3 403	55 752	128 112	6.8	3.4	0.1	1.0	2.3
Manitoba	563 966	65 418	50 296	1 571	4 242	9 309	11.6	8.9	0.3	0.8	1.7
Saskatchewan	503 187	112 652	93 646	284	3 768	14 954	22.4	18.6	0.1	0.7	3.0
Alberta	1 414 286	209 334	105 317	460	13 223	90 334	14.8	7.4	0.0	0.9	6.4
British Columbia	1 734 851	198 380	53 103	15 616	96 142	33 519	11.4	3.1	0.9	5.5	1.9
Yukon	17 047	1 188	139	39	143	867	7.0	0.8	0.2	0.8	5.1
Northwest Territories	27 616	2 043	70	397	190	1 386	7.4	0.3	1.4	0.7	5.0
Canada	**14 329 180**	**1 419 584**	**651 509**	**105 315**	**290 371**	**372 389**	**9.9**	**4.5**	**0.7**	**2.0**	**2.6**

Note:
Employment includes primary sectors and manufacturing sectors with large raw resource inputs.
Sources:
Statistics Canada, National Account and Environment Division and Census of Population.

Map 3.2.1
Resource-dependent Employment by Sub-sub Basin, 1991

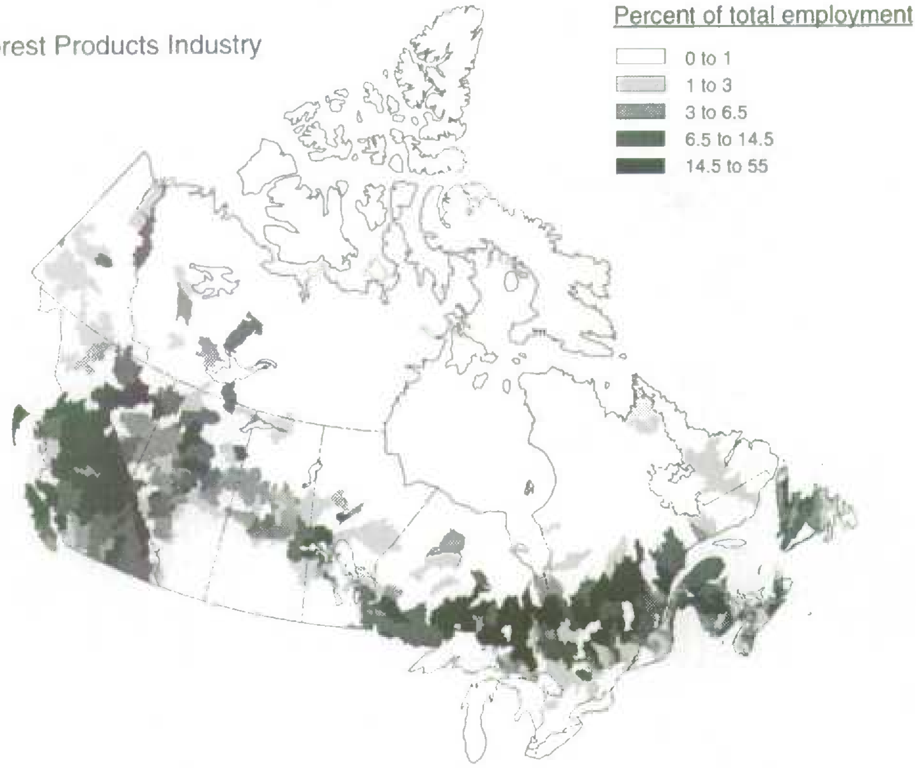




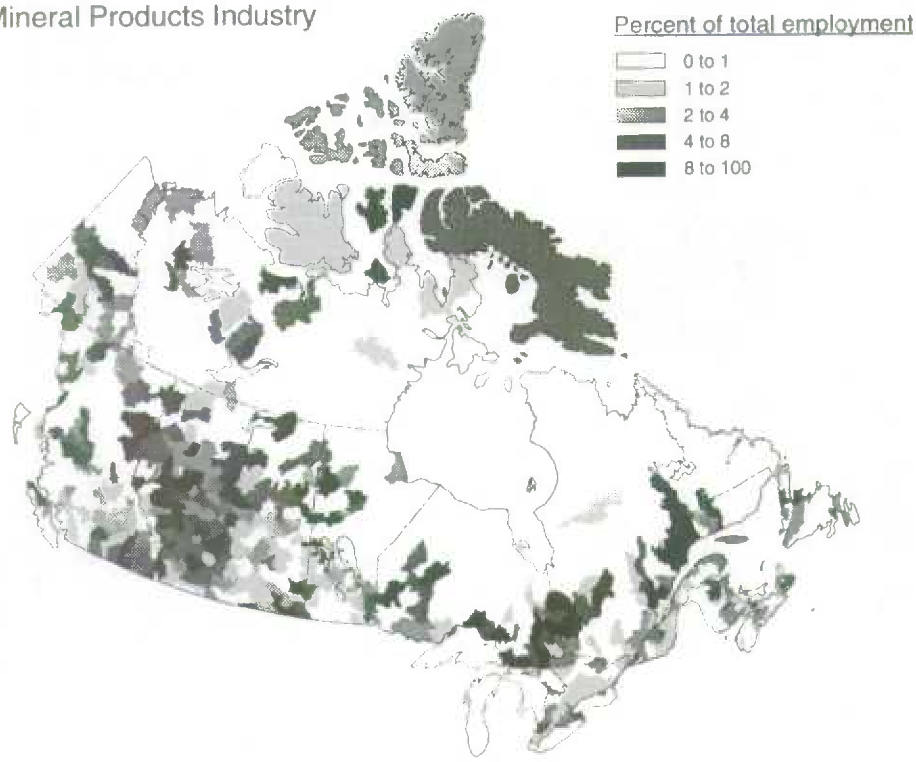
Map 3.2.1

Resource-dependent Employment by Sub-sub Basin, 1991 (Continued)

Forest and Forest Products Industry

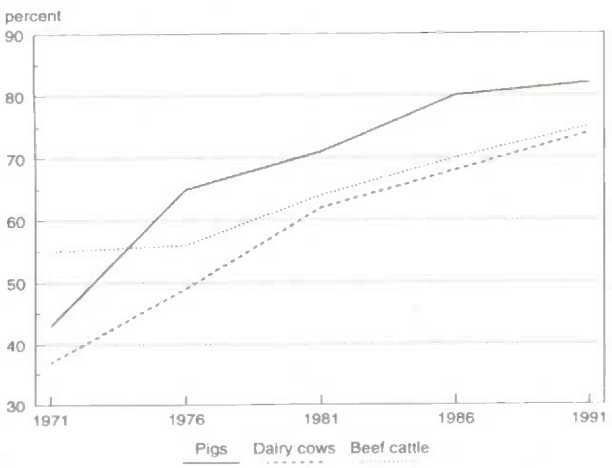


Mining and Mineral Products Industry



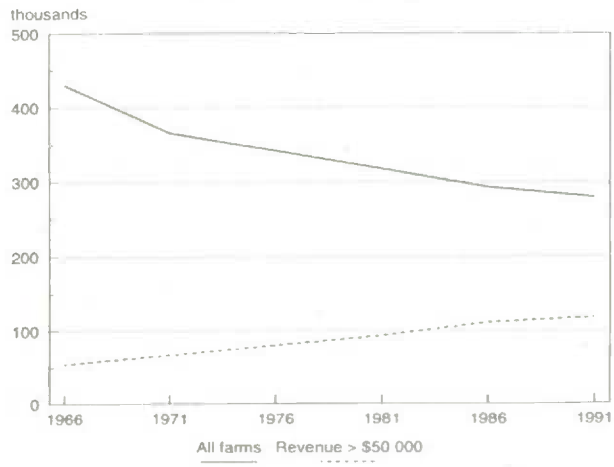
Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Figure 3.2.1
Percentage of Livestock on Specialized Farms, 1970-1991



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 3.2.2
Number of Farms by Revenue, 1966-1991



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 3.2.2
Number Of Farms By Revenue Size Class, 1966-1991

Gross farm revenue in thousands of 1990 dollars	1966	1971	1981	1986	1991
	thousand farms				
Under 2.4	69.8	54.7	44.1	31.8	23.9
2.5 to 4.9	36.9	28.9	28.4	22.4	18.6
5 to 9.9	62.2	46.9	35.4	29.7	26.6
10 to 24.9	124.7	96.2	60.0	50.2	48.7
25 to 49.9	81.8	71.8	57.0	47.5	43.9
50 to 99.9	38.7	42.5	50.3	52.6	49.9
100 to 249	14.0	20.8	33.5	44.7	49.4
250 to 499	1.7	3.0	6.9	10.0	13.2
500 and over	0.7	1.2	2.8	4.1	5.9
All farms	**430.5**	**366.0**	**318.4**	**293.0**	**280.1**

Source:
Statistics Canada, Agriculture Division.

The price of farm products (relative to general wholesale prices) has been declining. This decline is largely because world-wide supply is increasing faster than effective world demand. Increases in supply are associated in part with the adoption of more efficient farming techniques and the development of better genetic strains of field crops and livestock. However, in many countries agricultural production support through farm subsidies, has contributed to high production levels and low world prices. Low output prices compound the pressure to expand farm size in order to make more efficient use of machinery and capital.

Food preferences drive agricultural production. As a result, food preferences become indirect determinants of environmental stress from agriculture. It takes approximately seven grain equivalents to make one equivalent unit of animal protein, making animal protein a somewhat inefficient and environmentally costly food source. The annual demand for beef has declined by 14.4 kg per capita between 1976 and 1991, reaching a value of 24.7 kilograms per capita in 1991. Corn production in Ontario has increased to substitute for imported corn from the United States and to provide grain for the expansion in output of the hog, dairy and poultry industries. Corn is often planted as a wide-row monoculture, a cropping technique that is conducive to soil erosion (see Section 3.9 - **Agricultural Impacts on Land**). Non-food demand for agricultural products is still insignificant in Canada (for example, grain for ethanol, canola for ink, flax for paper).

Recently, consumers have begun to express an increasing preference for organically grown food. There are no official figures on the production of organically grown produce, partly because the definition is not easily agreed upon. Organic agriculture grown food will have an environmental impact by limiting the application of chemicals and thus requiring more crop rotations (i.e. less specialisation) to control insects and disease. Although some organic farmers can produce at the same price as non-organic producers, in general the switch to organic production will be driven by consumer willingness to pay a somewhat higher price for organically-grown products.

The substitution of capital for labour has occurred on farms in part because the price of capital has declined relative to the price of labour. This substitution has not only an environmental impact, but also an impact on farming communities, as less labour is required to farm the land. Historically, agricultural employment has declined at an average rate of 3 percent per year except between 1973 to 1983 when agricultural employment remained almost constant. This decline is small in terms of total employment in all industries, but it can be important for agriculture-dependent communities.

Forest and Forest Products Industry

During the last 20 years, Canada's share of world forest product exports has remained fairly stable, ranging between 18 and 23 percent. Production has increased considerably, but employment remains at early 1970s levels (Figure 3.2.3 and Table 3.2.3).

Figure 3.2.3
Roundwood Harvested per Employee, Forestry Industry, 1970-1992

Sources:
Statistics Canada, Industry Division and Labour Division.

Canada's primary forest products became less competitive between the mid-eighties and 1991, as a result of the appreciation in the Canadian dollar and the rising cost of wood and energy. In 1991, the cost of producing lumber in the southern United States was 10 percent higher than Canadian costs. In 1986, U.S. costs were 40 percent higher than those of Canada. Wood pulp produced by British Columbia coastal mills has been between 10 percent and 15 percent more price competitive than Swedish pulp since 1986. In the case of newsprint, southern U.S. mills have gained a considerable cost advantage over eastern Canadian producers in recent years. Costs faced by eastern Canadian newsprint mills were 4 percent lower than those in the southern United States in 1985 but were 16 percent higher by 1991.[1] Since 1991, the Canadian dollar has declined in value with respect to the U.S. dollar, improving somewhat the competitiveness of Canadian resource industries. The effect of competitive pressures is to gradually eliminate the less efficient pulp and paper mills, which also tend to be the most polluting.[2] However, these mills are often important sources of employment in remote areas where few alternative job opportunities exist.

An example of a positive economic response to an environmental issue is the newsprint recycling industry, which has grown in response to pressure from U.S. customers. Sixty-six percent of Canada's newsprint production is exported to the United States.

Table 3.2.3
Roundwood Harvest and Employment, Forestry Industry, 1979-1992

Year	Roundwood harvested	Employment	Roundwood harvested per employee
	million cubic metres	persons	cubic metres per employee
1970	121	65 562	1 845.6
1971	119	60 146	1 978.5
1972	124	57 163	2 169.2
1973	143	66 072	2 164.3
1974	138	68 328	2 019.7
1975	115	58 642	1 961.0
1976	139	56 933	2 441.5
1977	145	60 510	2 396.3
1978	156	63 917	2 440.7
1979	161	66 084	2 436.3
1980	155	64 174	2 415.3
1981	144	61 467	2 342.7
1982	127	52 210	2 432.5
1983	155	58 792	2 636.4
1984	167	59 816	2 791.9
1985	168	59 401	2 828.2
1986	177	54 628	3 240.1
1987	191	61 172	3 122.3
1988	190	60 233	3 154.4
1989	188	61 947	3 034.9
1990	163	56 865	2 866.4
1991	162	55 942	2 895.9
1992p	165	55 113	2 993.8

Sources:
Statistics Canada, *Canadian Forestry Statistics*, Catalogue No. 25-202, Ottawa, various issues.
Statistics Canada, *Survey of Employment, Payroll and Hours*, Catalogue No. 72-002, Ottawa, various issues.

Fishing and Fish Products Industry

Recent events in the Atlantic fisheries underline the fundamental link between the livelihood of resource-dependent communities and the availability and quality of natural resources.

In 1992, Canadian fisheries continued to experience a decline in overall performance with a reduction in the value of fish harvests and an increase in imports. In 1993, some fisheries were closed down altogether. Unincorporated business income has dropped sharply from the peak in the mid 1980s (Figure 3.2.4).

1. Forestry Canada, *The State of Canada's Forests 1992*, Ottawa, 1993.

2. Statistics Canada, *Environmental Perspectives 1993*, Catalogue No. 11-508, 1993, p. 24.

Figure 3.2.4
Net Income of Unincorporated Business, Fishing Industry, 1950-1993

Note:
Deflated by the Consumer Price Index.
Source:
Statistics Canada, National Accounts and Environment Division.

Major groundfish stocks on the Atlantic Coast continued to show a marked decline in 1992. A two-year moratorium on fishing the region's most important groundfish stock, northern cod, was declared in July 1992. The Northern Cod Adjustment and Recovery Program was put in place to address the hardship of 26 thousand individuals and 400 communities affected by the moratorium. In 1993, five Atlantic cod fisheries were closed, affecting between 9 thousand and 12 thousand fishermen and processing plant workers in coastal communities of Atlantic Canada and Quebec. In December 1993, all but one of the Atlantic Canada cod fisheries were closed for the 1994 season. In 1991, there were 73 thousand persons employed in industries directly dependent on the fishery in Atlantic Canada (Table 3.2.1). Map 3.2.1 shows a number of areas in Nova Scotia and Newfoundland where fishing related employment comprises from 15 percent to 76 percent of total employment.

The Fisheries Resource Conservation Council indicated in 1993 that "the state of many stocks is precarious, showing the lowest numbers of fish ever observed, the lowest-ever spawning stock of mature fish, and a high percentage of fish being taken every year by fishing, ocean conditions and predators."[1]

Mining and Mineral Products Industry

The Canadian mining and mineral products industry accounted for 2.6 percent of total employment in 1991 and exports of mineral commodities (including mineral fuels) accounted for 25.8 percent of total domestic exports in 1992.[2] Employment in the mining and mineral products sector has declined steadily since 1981 (Table 3.2.4).

Table 3.2.4
Employment in Mining, Refining and Smelting Sectors, 1961-1992

Year	Non-fuel mining	Fuel production	Total mining	Smelting and refining	Total mining, smelting and refining
	thousand persons				
1961	74.8	21.5	96.3	75.3	171.6
1962	75.2	21.1	96.3	76.5	172.8
1963	74.5	21.0	95.5	76.4	171.9
1964	75.4	21.1	96.5	81.2	177.7
1965	79.3	21.5	100.8	85.1	185.9
1966	80.4	21.7	102.1	89.2	191.3
1967	80.6	22.1	102.7	88.1	190.8
1968	82.9	22.0	104.9	88.4	193.3
1969	80.6	21.5	102.1	85.1	187.2
1970	87.3	22.8	110.1	101.2	211.3
1971	86.4	24.0	110.4	100.6	211.0
1972	82.0	25.3	107.3	98.0	205.3
1973	86.8	24.6	111.4	100.2	211.6
1974	92.4	26.3	118.7	105.5	224.2
1975	89.2	26.5	115.7	105.2	220.9
1976	89.6	28.1	117.7	101.3	219.0
1977	89.0	30.1	119.1	104.8	223.9
1978	77.3	32.6	109.9	108.3	218.2
1979	80.4	34.8	115.2	110.1	225.3
1980	87.6	38.8	126.4	116.1	242.5
1981	89.3	40.0	129.3	115.9	245.2
1982	78.7	44.8	123.5	105.7	229.2
1983	68.8	45.0	113.8	97.0	210.8
1984	69.9	45.9	115.8	96.5	212.3
1985	65.6	50.8	116.4	93.6	210.0
1986	63.8	45.6	109.4	88.8	198.2
1987	63.4	44.3	107.7	89.1	196.8
1988	65.9	44.9	110.8	91.7	202.5
1989	67.0	44.0	111.0	91.3	202.3
1990	62.1	43.5	105.6	82.4	188.0
1991[1]	57.8	42.9	100.7	75.3	176.0
1992[2]	54.5	38.1	92.6	69.5	162.1

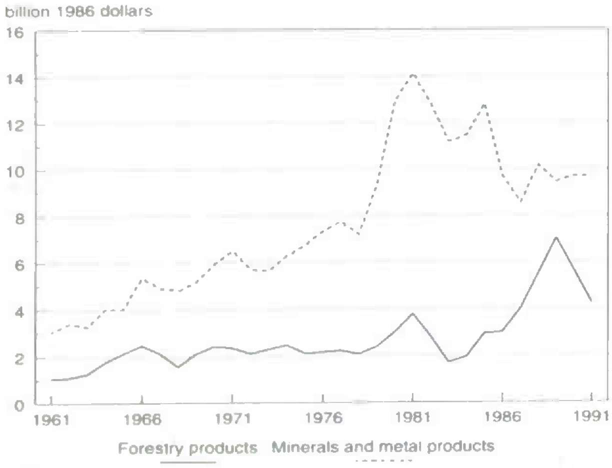
Notes:
1. Preliminary data.
2. Forecasted data.
Source:
Natural Resources Canada, *1992 Canadian Minerals Yearbook*, Ottawa, 1993, p. 58.43 and 58.45.

The Canadian mining industry is facing increasingly severe global competition. Political and economic reforms in Chile, Mexico and other developing countries with rich mineral deposits have provided new investment alternatives for mining companies.[3] Mineral prices are currently depressed (Table 3.2.5) owing to generally weak demand and high foreign production levels for some metals. Canadian investment in the mining industry (in 1986 dollars) has declined since the early 1980s (Figure 3.2.5).

1. Speech by Ross Reid, Minister of Fisheries and Oceans, Halifax, August 31, 1993.

2. Energy, Mines and Resources Canada, *1992 Canadian Minerals Yearbook*, Ottawa, 1993.
3. Ibid, p. 1.10.

Figure 3.2.5
Capital Expenditures by Selected Resource Industries, 1961-1991



Source:
Statistics Canada, Investment and Capital Stock Division.

The problem of acid mine drainage is one of the most significant environmental concerns for the mining industry, because of its role in leaching metals from tailings and waste rock dumps. The increasing awareness of adverse environmental effects of improperly handled mine wastes has led to tighter regulations. "Provincial governments are amending their regulatory and licensing procedures to ensure that operators are held fully responsible for the closure and rehabilitation of their mines".[1] These regulations imply increased costs for companies and for governments in the case of abandoned mines. A government/industry task force reviewing Canada's international competitiveness for mineral investment capital recently expressed concern that what it perceives as "complex" Canadian regulations will reduce the attractiveness of Canadian investment opportunities.[2]

Profits and Prices

The profitability of four resource based industries[3] is examined in Figures 3.2.6 and 3.2.7. In these graphs, all numbers are expressed in terms of deviations from the average of all non-financial corporations. For example, in Figure 3.2.6 the profit margin for the non-ferrous metals industry in 1980 was 20 percent higher than that of the average of all non-financial corporations. Profit margins, the ratio of operating profits to operating revenues, were above average for the oil and gas industry as well as the non-ferrous metals industry for most years examined. (Profit margins can be above average, yet profits low when revenues decline.)

Return on equity represents profits in relation to the total shareholders' investment in the industry. Figure 3.2.7 shows that only the non-ferrous metals industry fared better than the average of all non-financial corporations for most of the period in terms of return on equity. Aluminium, nickel, gold and copper are among the important metals produced by this industry.

Raw resource prices in 1992 were on a par with 1981 prices despite considerable movement within the decade while the general price level in the economy increased by 40 percentage points over the same period (Figure 3.2.8). Prices of vegetable products, non-ferrous metals and mineral fuels

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991, p. 11-18.

2. Energy Mines and Resources, "Canada's Environmental Regulatory Systems: Current Issues", Background study on Environmental Regulatory Concerns, Intergovernmental Working Group on the Mineral Industry, September, 1993, p. 69.

3. Data on profitability of enterprises is presented on a consolidated basis representing establishments in primary, manufacturing and service sectors.

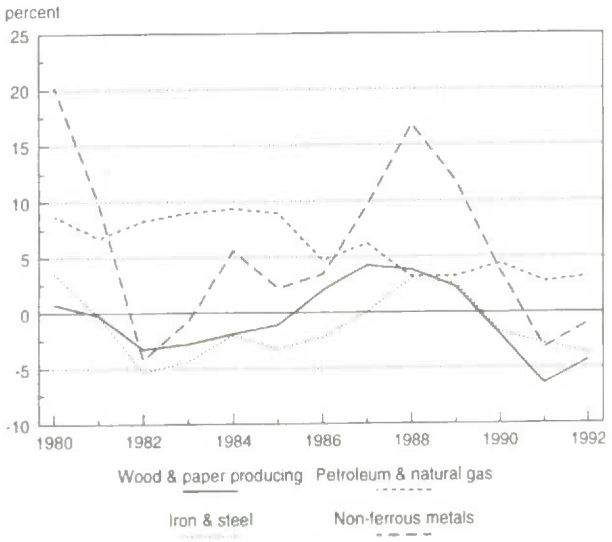
Table 3.2.5
Raw Resource Commodity Price Indexes, 1981-1992

	Commodity										
Year	Raw materials price index total	Vegetable products	Animals and animal products	Wood	Ferrous metals	Non-ferrous metals	Mineral fuels	Iron and steel scrap	Non-ferrous scrap	Pulpwood chips	GDP implicit price index
	price index (1986=100)										
1981	104.0	111.2	88.4	91.5	90.7	111.6	115.2	99.9	115.2	114.0	80.9
1982	111.8	97.3	93.1	88.0	87.8	98.8	138.6	83.8	93.9	121.0	87.9
1983	116.6	101.7	91.0	91.6	89.3	103.1	148.4	85.1	115.8	97.4	92.3
1984	120.1	109.9	96.3	94.7	97.6	102.3	150.6	104.1	113.7	100.4	95.2
1985	121.5	101.6	94.9	95.3	99.3	96.4	157.6	100.6	94.9	99.5	97.7
1986	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1987	107.3	96.6	104.8	111.6	99.4	114.1	109.7	103.6	125.6	112.8	104.7
1988	103.8	106.6	99.7	121.3	103.6	133.7	86.7	121.6	161.5	123.6	109.6
1989	107.2	108.0	101.1	122.4	100.1	127.6	98.2	121.0	153.8	142.3	114.9
1990	111.6	99.7	105.7	121.8	93.1	114.7	117.6	107.6	133.8	140.9	118.6
1991	104.7	88.9	104.5	123.7	89.9	96.7	107.1	101.5	107.3	131.8	121.6
1992	105.7	91.2	104.3	136.9	93.1	97.2	104.2	104.4	110.0	122.3	122.9

Source:
Statistics Canada, *Industry Price Indexes*, Catalogue No. 62-011, Ottawa, various issues.

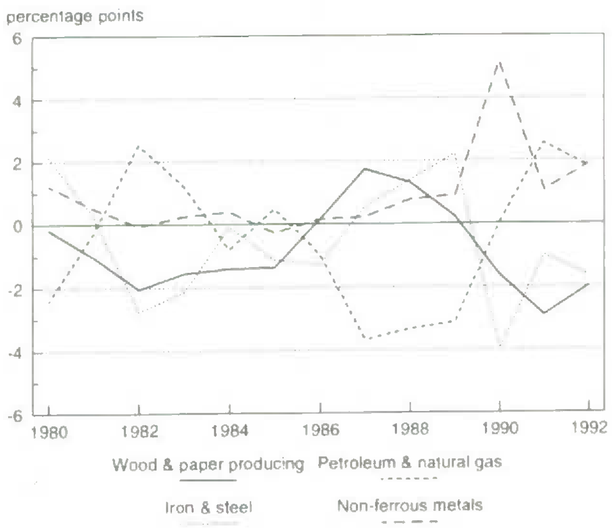
were lower in 1992 than in the previous decade, while animal and wood product prices had increased (Table 3.2.6).

Figure 3.2.6
Profit Margins of Selected Resource Industries, 1980-1990



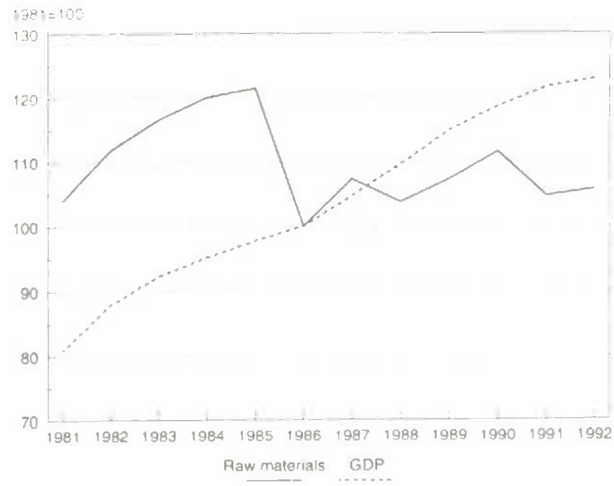
Note:
Data presented are deviations from the average profit margins of all non-financial corporations.
Source:
Statistics Canada, Industrial Organization and Finance Division.

Figure 3.2.7
Return on Equity for Selected Resource Industries, 1980-1992



Note:
Data presented are deviations from the average profit margins of all non-financial corporations.
Source:
Statistics Canada, Industrial Organization and Finance Division.

Figure 3.2.8
Raw Material and GDP Implicit Price Indexes, 1981-1992



Source:
Statistics Canada, *Industry Price Indexes*, Catalogue No. 62-011, Ottawa, various issues.

Prices are a factor in overall profitability and in determining the level of production and investment. The relatively weak prices of mineral products since 1981 are mirrored in the declining investment in this sector (Figure 3.2.5).

Summary

Resource-dependent industries, despite their decreasing relative importance in providing employment and incomes, remain an important source of export earnings for Canada and are the only means of economic support for many isolated communities. These industries are subject to economic forces such as world supply and demand, costs and profitability. Pressures to mechanise and specialise have resulted in remarkable increases in labour productivity.

3.3 Transportation

The environmental stresses from each mode of transport differ in degree and scale, but they can generally be traced back to energy use and infrastructure development (Technical Box 3.3.1).

❑❑❑

At the regional and global scales, the greatest impact of transportation on the environment results from the extensive use of fossil fuels. This use both depletes fossil fuel resources and releases polluting substances into the air. In 1992, transportation accounted for 30 percent of all energy use in Canada.[1] Of pollutants emitted to air, transportation activity accounts for substantial proportions: 66 percent of carbon monoxide, 58 percent of nitrogen oxides, and 42 percent of volatile organic compounds (see Section 3.7 - **Wastes**).

Infrastructure development is the other significant aspect of the environmental impact from transportation. The construction of roads, railways and airports takes up a great deal of land, and permanently changes the character of this land surface. Covering large areas with concrete and asphalt greatly increases the amount of runoff from precipitation and snowmelt. This results in higher-volume discharge into streams, which increases flood hazards within drainage areas. In addition, natural habitats are encroached upon and partitioned by transport infrastructure.

Transportation systems also stimulate and intensify the development of industrial, commercial and recreational activity. Stress on the local environment is then brought about by both the transportation system and by the activities that it supports.

1. Primary and secondary energy use by all modes in the transportation industry, pipeline transport and retail pump sales. Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, 1993.

Technical Box 3.3.1

Selected Environmental Impacts by Mode of Transport

Mode	Area of Impact						
	Air	Water Resources	Land Resources	Solid Waste	Noise	Risk of Accident	Other Impacts
Road transport	Local and regional air pollution: CO, HC, NOx, particulates and fuel additives (e.g. lead) Global pollution: CO_2, CFCs	Pollution of surface water and groundwater through surface run-off Modification of water systems by road building	Land taken by infrastructure Extraction of road building materials	Road vehicles and parts taken out of service Waste oil	Noise and vibration from vehicles, in cities and along main roads	Deaths, injuries and property damage from road accidents Release of material in transporting hazardous substances	Partition or destruction of neighbourhoods, farmland and wildlife habitat Congestion
Rail transport	Local, regional and global air pollution	Modification of water systems in airport construction	Land taken for terminals, track and rights of way Dereliction of obsolete facilities	Abandoned lines, vehicle stock and related equipment	Noise and vibration around terminals and along railway lines	Release of material in transporting hazardous substances	Partition or destruction of neighbourhoods, farmland and wildlife habitat
Air transport	Local, regional and global air pollution	Modification of water systems in airport construction	Land taken for terminals, track and rights of way Dereliction of obsolete facilities	Aircraft and parts taken out of service	Noise and vibration around airports	Deaths, injuries and property damage from aircraft accidents (but slight compared with road transport)	Partition or destruction of neighbourhoods, farmland and wildlife habitat
Marine and inland water transport	Local, regional and global air pollution	Release of substances, e.g. discharge of ballast water, oil spills Modification of water systems in port construction, canal cutting and dredging	Land taken for infrastructure Dereliction of obsolete port facilities and canals	Vessels and parts withdrawn from service	Noise and vibration around terminals and port facilities	Release of material in transporting hazardous substances, e.g. bulk transport of fuel	Partition or destruction of wildlife habitat

Source:
Modified from "Transport and the environment: facts and figures", *Industry and Environment*, 16, 1-2, (January-June), 1993, p. 4-10.

A final consequence of transportation systems is that plant and animal species normally separated by considerable distances can be brought into contact for the first time. A recent, serious example of this is the case of zebra mussels, which were introduced into the Great Lakes through the ballast water dumped by ships.

Transportation and the Economy

At present, for-hire trucking, air, rail and marine carriers are the main components of the transportation industry.[1] In itself, this industry accounts for a comparatively small proportion of GDP and employment. In 1992, the provision of transportation services contributed 3.5 percent of GDP (Table 3.3.1). This industry employed 421 thousand persons, accounting for about 4 percent of all employment.

Historically, railways and waterways were the principal transportation corridors. For very heavy and bulky cargo, these modes allowed large distances to be traversed efficiently. More recently, transport requirements have shifted

1. Groups 451 to 459 in the 1980 Standard Industrial Classification (SIC).

Table 3.3.1

Share of Transportation in GDP and Employment, 1961-1992

Year	GDP at factor cost			Employment		
	Total	Transportation[1]		Total	Transportation	
	million 1986 $		percent	thousands		percent
1961	156 428	6 065	3.9	..	..	..
1971	267 060	10 574	4.0	..	..	..
1981	397 090	14 536	3.7	..	..	..
1982	382 575	13 615	3.6	..	..	..
1984	418 717	16 661	4.0	9 036	440	4.9
1985	438 450	17 034	3.9	9 363	438	4.7
1986	451 839	17 493	3.9	9 626	437	4.5
1987	471 520	18 539	3.9	10 008	434	4.3
1988	492 587	19 297	3.9	10 329	440	4.3
1989	505 050	18 955	3.8	10 702	457	4.3
1990	504 787	18 636	3.7	10 796	466	4.3
1991	498 932	17 900	3.6	10 232	431	4.2
1992	503 638	17 798	3.5	9 952	421	4.2

Note:
1. The transportation sector includes air, water, rail and truck transport, urban transit systems, taxicab industries, services incidental to transportation, as well as bridge and highway maintenance industries.

Sources:
Statistics Canada, *Gross Domestic Product by Industry*, Catalogue No. 15-001, Ottawa various issues.
Statistics Canada, Survey of Employment, Payrolls and Hours.

Table 3.3.2

Road Network, 1985-1990/91

Jurisdiction / Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario	Manitoba	Sask.	Alberta	B.C.	Yukon	N.W.T.
	2-lane equivalent kilometres												
Federal[1]													
1985	13 837	..	..	..	..	..	..	..	..	..	..	..	..
1987/88	14 177	..	..	..	..	..	..	..	..	..	..	..	..
1988/89	14 735	..	..	..	..	..	..	..	..	..	..	..	..
1989/90	..	..	..	..	..	..	..	..	..	..	..	..	..
1990/91	14 743	..	..	..	..	..	..	..	..	..	..	..	..
1991/92	..	..	..	..	..	..	..	..	..	..	..	..	..
Provincial/Territorial													
1985	267 979	8 748	4 905	23 281	17 400	59 680	24 341	19 840	23 912	37 002	41 829	4 727	2 314
1987/88	277 286	8 401	4 916	23 405	17 450	59 895	24 292	20 318	25 973	38 337	47 182	4 803	2 314
1988/89	277 268	8 401	4 920	23 458	17 920	60 644	24 391	20 426	26 208	37 847	45 883	4 960	2 210
1989/90	..	..	..	..	..	..	..	..	..	..	..	..	..
1990/91	275 451	8 409	4 613	23 458	17 970	60 721	24 474	20 465	26 264	38 884	41 685	4 960	3 548
1991/92	..	..	..	..	..	..	..	..	..	..	..	..	..
Municipal													
1985	579 652	3 483	184	2 243	2 700	48 000	141 295	64 500	165 600	132 349	18 697	261	340
1987/88	583 091	3 483	322	2 275	2 700	48 000	141 577	64 500	168 765	131 128	19 709	277	355
1988/89	587 527	3 483	322	2 282	2 700	48 000	144 170	64 500	168 117	133 355	19 965	278	355
1989/90	..	..	..	..	..	..	..	..	..	..	..	..	..
1990/91	598 704	3 881	322	2 321	2 700	58 600	143 026	64 500	167 659	134 589	20 473	278	355
1991/92	..	..	..	..	..	..	..	..	..	..	..	..	..
Total													
1985	861 468	12 231	5 089	25 524	20 100	107 680	165 636	84 340	189 512	169 351	60 526	4 988	2 654
1987/88	874 554	11 884	5 238	25 680	20 150	107 895	165 869	84 818	194 738	169 465	66 891	5 080	2 669
1988/89	879 530	11 884	5 242	25 740	20 620	108 644	168 561	84 926	194 325	171 202	65 848	5 238	2 565
1989/90	..	..	..	..	..	..	..	..	..	..	..	..	..
1990/91	888 898	12 290	4 935	25 779	20 670	119 321	167 500	84 965	193 923	173 473	62 158	5 238	3 903
1991/92	..	..	..	..	..	..	..	..	..	..	..	..	..

Notes:
Comparability between provinces and road classes is imperfect, as the definitions for roads vary considerably between jurisdictions. One consequence of these variations is the practice of reporting in 2-lane equivalent kilometres. The "real" length of highway can be roughly estimated with the factor 1.02 kilometres for every 2-lane equivalent kilometre.
1. Roads under federal jurisdiction include those of the Canadian Parks Service, the Department of Indian and Northern Affairs, the National Capital Commission and Public Works Canada.

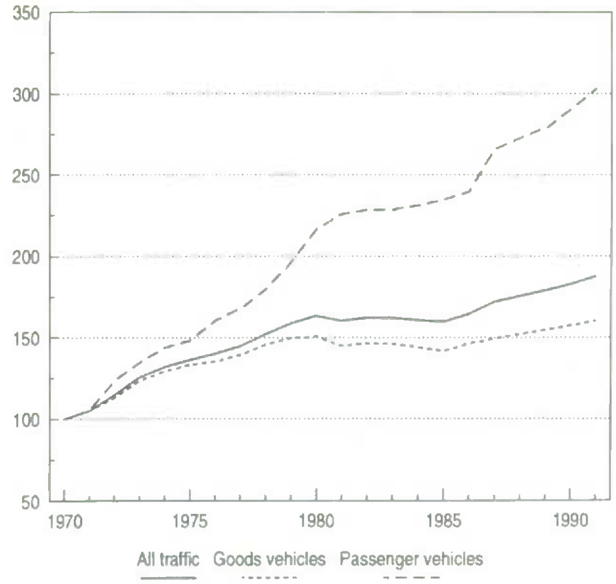
Source:
Transportation Association of Canada.

to short-distance hauls of smaller loads. In terms of their value to the transportation system, bulk movements of timber, mineral and agricultural products have become much less important than unitized, or containerized, transport of components or finished manufactured goods. By the mid 1980s, the growing importance of just-in-time production[1] contributed to even greater specialisation of transportation needs. Not only are carriers now required to provide cost-effective transportation in the correct combination of hauled weights and distances, the exact timing of these transactions has become even more critical. These conditions have encouraged the shift of cargo movement from railroads and domestic shipping lanes to trucking.

Issues similar to those noted above - trip length and frequency, along with the time and convenience of travel - also influence passenger transport patterns. Shifting preferences result from urbanisation (and *suburbanisation*) trends, along with a number of other personal considerations and preferences (see Section 3.14 - **Individual Actions**). It has also been suggested that direct and indirect government subsidies have some influence on the transport decisions of passengers.[2] For example, in middle-distance intercity trips, rail and bus are in competition with private automobiles, as well as with each other. It could be argued that passenger rail, as it provides and maintains its own infrastructure, is unfairly disadvantaged, compared with buses and private cars, whose road network is publicly financed. Bus carriers, however, would complain of direct federal subsidies to passenger rail. In either case, the financial position of the carriers influences the types of routing and general level of service they can provide.

1. A way of managing the manufacturing process such that the need for warehousing and inventory control is greatly reduced. Rather than retaining 60 to 90 days of inventory on site, manufacturers keep only one or two days of inventory and rely on an efficient system of communications and transportation to ensure that goods are delivered just in time.
2. McKeown, L., "Intercity Passenger Travel: A Comparison of Rail and Bus, 1981 to 1990," in Statistics Canada, *Rail in Canada 1990*, Catalogue No. 52-216, Ottawa, 1992, p. 149-161.

Figure 3.3.1
Trends in Road Traffic, 1970-1991



Source:
Organisation for Economic Co-operation and Development, *OECD Environmental Data Compendium 1993*, Paris, 1993.

Table 3.3.3
Motor Vehicle Registrations, 1980-1992

Vehicle type	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	thousands												
Road vehicles													
Passenger automobiles	10 256	10 200	10 530	10 732	10 781	11 118	11 586	11 686	12 086	12 380	12 622	13 061	13 322
Trucks and truck tractors	2 903	3 138	3 239	3 308	3 047	3 095	3 156	3 517	3 706	3 827	3 867	3 680	3 624
School buses	24	26	26	28	25	26	28	30	29	30	30	29	29
Other buses	28	28	28	29	27	28	29	29	31	33	34	35	35
Motorcycles	389	407	431	466	470	453	430	414	370	348	331	324	313
Registered mopeds	68	39	42	43	37	35	35	34	31	30	28	27	27
Other road motor vehicles	50	12	13	14	19	64	72	83	84	72	69	67	61
Off-road vehicles													
Snowmobiles	476	509	451	400	425	455	488	532	546	600	636	661	689
Other off-road vehicles	197	162	191	222	208	295	365	375	407	392	429	445	474
Total registrations													
Road vehicles	13 717	13 850	14 309	14 620	14 406	14 819	15 337	15 794	16 336	16 720	16 981	17 223	17 412
Off-road vehicles	673	671	642	622	633	750	853	907	953	992	1 065	1 106	1 163
All vehicles	14 389	14 521	14 951	15 242	15 039	15 570	16 190	16 701	17 289	17 712	18 046	18 329	16 575
Registrations per thousand persons													
Passenger automobiles	427	419	428	433	432	442	457	456	466	472	474	484	482
Road vehicles	571	569	562	590	577	589	605	617	831	637	638	638	630
All vehicles	598	597	608	615	602	619	639	652	667	675	678	679	672

Note:
Registrations of trucks and truck tractors decreased in 1984 due to changes in reporting requirements for Ontario.
Source:
Statistics Canada, *Road Motor Vehicle Registrations*, Catalogue No. 53-219, Ottawa, various issues.

Trends in Road Infrastructure and Traffic

Road transport accounts for the largest proportion of total transportation activity. As such, trends in road movements and infrastructure change are good indicators of general transportation patterns.

In fiscal year 1990/91, the national road network covered 889 thousand 2-lane equivalent kilometres (Table 3.3.2). Assuming an average lane width of 3 metres, the national road network is estimated to cover just over 5 300 square kilometres, of which gravel and unsurfaced roads account for about 80 percent. This is equivalent to about one half of one percent of the total land area of Canada; the equivalent figure for Western Europe is 1.3 percent.[1]

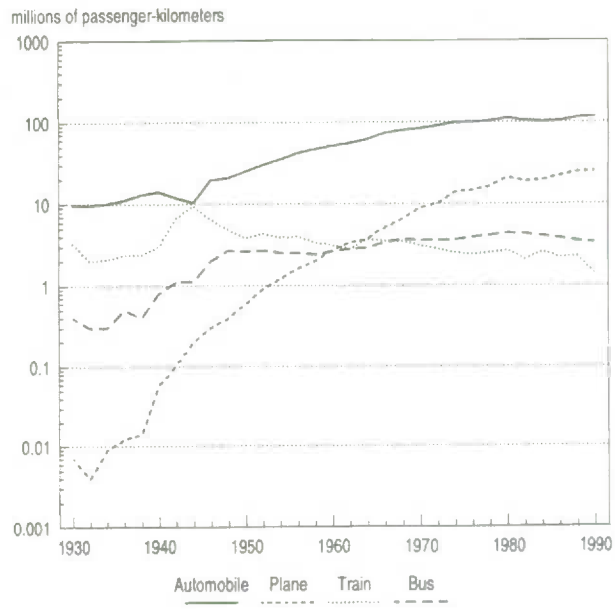
In the same year, 18.3 million vehicles were registered in Canada and, of these, 17.2 million were road vehicles (Table 3.3.3). Most road vehicles (75.8 percent) were passenger automobiles. Another 20.1 percent were trucks and truck trailers. Between 1980 and 1992, the number of passenger automobile registrations increased from 10.3 million to 13.3 million, representing an average annual increment of 2.6 percent. Natural Resources Canada projects continued modest increases in the car stocks until 2010.[2]

Road traffic[3] in Canada has increased steadily since 1970, reflecting the growth in population and economy during those years (Figure 3.3.1). Over the same period, the composition of road traffic changed. In 1970, passenger cars accounted for 69 percent of road traffic and cargo vehicles represented 31 percent. By 1991, the relative representation of passenger and cargo vehicles changed to 80 percent and 20 percent, respectively.

1. European Commission Estimates, in "Transport and the environment: facts and figures", *Industry and Environment*, 16, 1-2, (January-June), 1993, p. 4-10.
2. Natural Resources Canada, *Canada's Energy Outlook: 1992-2010*, Ottawa, 1993.
3. All figures quoted for road traffic are taken from the Organisation for Economic Co-operation and Development, *OECD Environmental Data Compendium 1993*, Paris, 1993. and are expressed in vehicle-kilometres. By this measure, the rate of vehicle occupancy and the distribution of vehicle types are not taken into account.

Figure 3.3.2

Passenger Movement, 1930-1990



Note:
Data include domestic intercity trips only.
Source:
Directions: The Final Report of the Royal Commission on National Passenger Transportation, Ottawa, 1992.

Table 3.3.4

Passenger Bus and Urban Transit, 1980-1990

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Number of vehicles											
Intercity bus	1 805	1 704	1 683	1 526	1 558	1 538	1 417	1 429	1 308	1 273	1 356
Urban transit	12 670	12 856	13 318	13 233	13 212	13 496	13 032	13 481	13 379	12 720	13 156
Other passenger bus	21 761	21 646	22 773	22 598	21 679	23 562	24 210	25 892	24 345	23 240	22 516
Total	36 236	36 206	37 774	37 357	36 449	38 596	38 659	40 802	39 032	37 233	37 028
Fare passengers (thousands)											
Intercity bus	33 282	29 585	31 187	32 032	27 834	26 943	22 871	22 686	18 262	17 233	16 991
Urban transit	1 307 199	1 368 870	1 333 121	1 382 908	1 413 676	1 448 275	1 522 160	1 469 245	1 514 979	1 520 421	1 528 400
Other passenger bus	...	...	...	...	...	...	...	...	...	...	...
Total	1 340 481	1 398 455	1 364 308	1 414 940	1 441 510	1 475 218	1 545 031	1 491 931	1 533 241	1 537 654	1 545 091
Distance run (thousand kilometres)											
Intercity bus	203 119	185 014	197 838	194 388	182 773	173 613	174 717	170 953	157 052	156 039	168 159
Urban transit	656 245	698 858	712 436	565 588	691 373	725 991	757 748	695 785	749 934	780 642	769 326
Other passenger bus	421 033	471 986	478 011	470 888	483 437	522 767	504 128	553 945	541 509	559 951	537 705
Total	1 280 397	1 355 858	1 388 285	1 230 864	1 357 583	1 422 371	1 436 593	1 420 683	1 448 495	1 496 632	1 475 190

Notes:
Although the detailed data are not available, intercity bus should in principle be included as a cargo mode. In 1990, parcel express and mail delivery contributed 25 percent of total revenue in this industry. In 1989, the coverage of the passenger bus and urban transit surveys was reduced to carriers earning $500 thousand or more. In 1987 and 1988, carriers with an annual revenue of at least $250 thousand were included; before 1987, the inclusion threshold was $100 thousand.
Source:
Statistics Canada, *Passenger Bus and Urban Transit Statistics*, Catalogue No. 53-215, Ottawa, various issues.

Passenger Movement

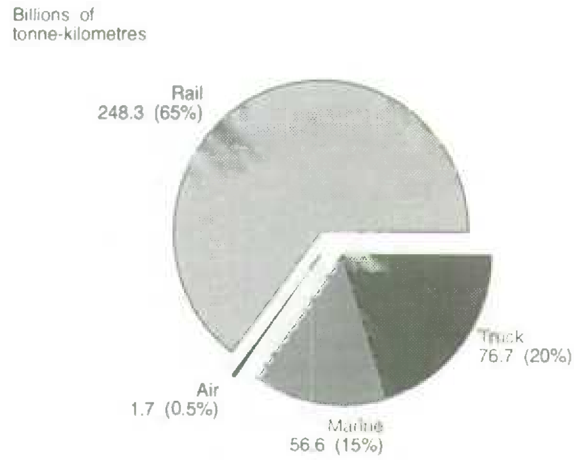
Passenger travel over short distances, including travel to work, is dominated by the automobile (Figure 3.3.2). In 1992, automobiles represented 116 million passenger-kilometres of travel, or 80 percent of domestic intercity passenger movement.

A large part of passenger road traffic can be attributed to commuters travelling to work. Only 8.1 percent of employed Canadians have paid work that is based at their homes; 11.7 million people commute to their workplaces every day.[1] This commuting activity is concentrated in and around metropolitan areas. For commuters who live and work in the same Census Metropolitan Area (CMA)[2] the average length of a return commuting trip is 20 kilometres. The average return trip is 100 to 118 kilometres for those who do not live and work in the same CMA. Most of these commuters drive their cars to their workplace (see Section 3.14 - **Individual Actions**).

Passenger bus and urban transit services grew between 1980 and 1990, when just over 1.55 billion fare passengers travelled a total distance of 1.48 billion kilometres (Table 3.3.4). The trend in the late 1980s was towards growth in ridership but a decrease in the distance run. This suggests that the growth is in short-distance traffic, of which commuter movement is an important part.

1. Statistics Canada, *Surface and Marine Transport, Service Bulletin*, Catalogue No. 50-002, November 1993, Ottawa.
2. Definition can be found in Section 2.1- **Population Distribution and Density**.

Figure 3.3.3
Freight Movement, 1990



Notes:
Marine freight includes domestic shipping only. Truck freight is based on intercity for-hire movements only. Proportions do not sum to 100 percent due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Transportation Division.

Similarly, passenger traffic by rail increased considerably in the late 1980s also partly as a result of increased commuter movement (Table 3.3.5). This was offset to some extent in 1990 by decreased intercity rail travel, due to cutbacks in rail service in certain corridors.

The position of air transport in passenger travel has changed quite dramatically over the past 60 years (Figure

Table 3.3.5
Rail Transport, 1961-1991

Year	Freight movement: Tonnes	Freight movement: Tonne-km	Passenger movement: Passengers	Passenger movement: Passenger-km	Fuel consumed[1]	Locomotives	Freight cars	Passenger cars	Track operated[2]
	thousand	million	thousand	million	million litres	units	units	units	kilometres
1961	276 444	96 108	18 784	3 155	1 561	3 547	186 387	4 737	95 242
1971	214 660	173 094	24 119	3 518	2 122	3 463	187 306	2 516	96 073
1981	279 925	234 374	24 331	3 278	8 190	4 154	179 105	1 405	92 413
1982	237 406	219 418	21 346	2 639	2 108	3 900	155 897	1 304	98 927
1983	249 576	225 380	21 199	2 932	2 142	3 783	149 432	1 337	99 444
1984	283 388	253 971	21 884	2 915	2 268	3 699	142 407	1 326	97 387
1985	271 953	242 121	22 937	3 040	2 264	3 509	130 185	1 286	95 670
1986	272 303	244 784	22 991	2 831	2 328	3 897	129 509	1 295	93 544
1987	285 455	267 764	23 701	2 709	2 317	3 855	121 679	926	94 184
1988	293 835	271 045	26 708	2 989	2 243	3 836	134 156	1 233	91 334
1989	280 779	249 036	31 079	3 178	2 167	3 809	128 540	1 281	89 104
1990	268 737	248 371	29 119	2 004	2 064	3 719	123 137	1 088	86 880
1991	274 118	260 537	4 255[3]	1 426	2 087	3 492	120 710	633	85 563

Notes:
1. 97 to 100 percent diesel.
2. The figures for track operated for 1982-1992 include lines jointly owned and lines operated under lease, contract and trackage rights. Figures for the period up to 1981 exclude lines operated under trackage rights and, as such, they cannot be compared to those for subsequent years.
3. Interurban rail services, which include the commuter rail system that accounts for the great majority of passenger movements by rail, were assigned to a different SIC category in 1991.
Sources:
Statistics Canada, *Rail in Canada*, Catalogue No. 52-216, Ottawa, various issues.
Statistics Canada, *Railway Transport Part 1 (Comparative Summary Statistics)*, Catalogue No. 52-207, Ottawa, various issues.
Statistics Canada, *Railway Transport Part 2 (Equipment, Track and Fuel Statistics)*, Catalogue No. 52-207, Ottawa, various issues.

3.3.2). From its beginning as an expensive and comparatively inaccessible means of travel in the 1930s, by the mid 1960s air travel had overtaken bus and train transport. By 1990, airlines accounted for 17 percent (25 million passenger-kilometres) of domestic intercity passenger transport. In the same year, Canadian-domiciled carriers recorded an additional 42 million passenger-kilometres in international travel (Table 3.3.6).

Water transport has only a minor share of total passenger movement. There is, however, a steady flow of passenger ferries and other small charter craft, both in Canada and between Canadian and U.S. ports, that is essential to many coastal and island communities. In 1990, 34 million passengers were transported by Canadian-domiciled ferry services (Table 3.3.7).

Cargo Movement

Because cargo movement is usually measured in tonne-kilometres, long-distance movements of heavy freight dominate the profile of this activity. This is why, despite recent fluctuations in traffic, rail continues to be the largest player in cargo transport (Figure 3.3.3). In 1990, 248 billion tonne-kilometres were transported (Table 3.3.5).

Table 3.3.6

Air Transport, 1961-1992

Year	Freight movement		Passenger movement		Fuel consumption		
	Weight		Passengers		Turbo fuel	Gasoline	Other fuel/oil
	tonnes	million	thousand	million	thousand litres		
1961	108 171	36	5 102	5 323	796 000	..	..
1971	316 453	386	12 889	18 527	2 363 000	..	..
1981	435 418	981	27 189	46 086	3 852 000	..	..
1982	410 134	1 000	24 477	44 179	3 271 000	..	..
1983	425 920	1 061	23 789	43 370	3 384 000	..	..
1984	544 692	766	27 701	46 444	3 510 000	..	..
1985	580 657	794	29 030	48 812	3 724 000	..	..
1986	441 613	860	25 691	39 929	3 967 402	65 260	2 381
1987	581 881	..	31 544	..	4 002 872	49 836	..
1988	592 700	1 516	34 753	62 140	4 500 224	40 098	148 820
1989	604 520	1 552	35 750	65 664	4 689 863	34 152	218 700
1990	631 932	1 743	36 260	66 606	4 604 785	33 991	106 156
1991r	624 668	1 573	31 779	58 077	4 064 927	29 523	110 014
1992p	618 369	1 534	32 214	62 245	3 968 339	35 605	..

Note:
Data refer to Level I, II, III and IV carriers, except for 1986 which excludes Level IV carriers.
Sources:
Statistics Canada, *Air Carrier Operations in Canada*, Catalogue No. 51-002, Ottawa, various issues.
Statistics Canada, *Aviation in Canada*, Catalogue No. 51-501, Ottawa, various issues.
Statistics Canada, *Canadian Civil Aviation*, Catalogue No. 51-206, Ottawa, various issues.

Table 3.3.7

Water Transport, 1985-1991

	1985	1986	1987	1988	1989	1990	1991p
Vessels operated	1 451	1 843	2 001	2 538	1 874	2 025	1 900
Cargo handled (thousand tonnes)	123 432	121 012	135 146	139 948	124 012	120 720	116 860
Ferry/passenger services							
Passengers carried (thousands)	27 405	30 715	31 689	30 811	31 795	33 721	33 274
Vehicles carried (thousands)	9 312	10 406	10 907	11 942	11 758	13 040	11 863
Fuel purchased (thousand litres)	1 277 000	1 220 000	1 258 000	1 294 000	1 520 470	1 491 000	..
Fuel oil	..	..	..	..	1 500 890	1 476 800	..
Gasoline	..	..	..	..	3 673	3 272	..
Lubricating oil	..	..	..	..	9 694	9 207	..
Other fuel	..	..	..	..	6 216	1 723	..

Notes:
Except for cargo handled, data refer to Canadian-domiciled carriers only. Data exclude most transborder and all international shipping. Inclusion thresholds for the survey of carriers is based on annual revenue: $100 thousand to 1987, $250 thousand in 1988 and 1989 and $500 thousand in 1990 and 1991. Cargo handling figures are taken from the survey of domestic shipping, whose sample is in principle comparable to that of Canadian-domiciled carriers. Note that cargo *transported*, as it is to be used in tonne-kilometre calculations, is *half* of the cargo handled.
Sources:
Statistics Canada, *Shipping in Canada*, Catalogue No. 54-205, Ottawa, various issues.
Preliminary data for operating statistics: Statistics Canada, *Service Bulletin: Surface and Marine Transport*, Catalogue No. 50-002, September 1993, Ottawa.

While air carriers account for less than one percent of all cargo movement, they make very important contributions to freight transport. This is because cargo transported by air, which can range from legal documents to live lobsters, generally has very high unit values and is extremely time sensitive. In 1990, 625 thousand tonnes of air freight were moved, representing 21 percent of the total tonne-kilometres carried by aircraft (Table 3.3.6).

Of all cargo modes, marine transport is most susceptible to changes in economic conditions. This is a result of heavy dependence on resource-based commodities. Through the late 1980s and early 1990s, marine shipments have been adversely affected both by the economic recession and by other random events - such as the severe drought that sharply reduced the wheat harvest of 1988 (Table 3.3.7).

In value terms, truck transport is used to move well over half of Canada's trade with the United States: 60 percent of exports and 75 percent of imports.[1] Trucking also accounts for a substantial share of domestic freight movement. Together, domestic and transborder intercity shipments by for-hire trucking amounted to 77 billion tonne-kilometres in 1990 (Table 3.3.8).

1. Statistics Canada, *Trucking in Canada 1990*, Catalogue No. 53-222, Ottawa.

Fuel Consumption and Air Emissions

The issues of fuel consumption and air pollution are closely linked because air emissions are generally proportional to consumption.[2]

The transportation sector accounts for one third of total domestic energy use.[3] This proportion has not changed very much since 1958. However, the absolute quantity consumed has risen considerably, from 776 petajoules in 1958 to 1 869 petajoules in 1992. Refined petroleum products contribute 87 percent of the energy consumed. Included are 33 billion litres of gasoline that were sold for transportation purposes in 1992 (Table 3.3.10). This is equivalent to 1 119 litres per person.

Fuel Mix

Motor gasoline and diesel, the principal fuels used by road and urban transit systems, trucking and rail, represented 60 percent of total consumption (Table 3.3.10). The remainder is heavy and light fuel oil used in shipping and aviation turbo fuel (jet fuel).

2. There could, however, be changes in the emissions per unit of fuel consumed as a result of specific emission controls or new equipment entering the market.
3. Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada 1992-IV*, Catalogue No. 57-003, Ottawa, 1993.

Table 3.3.8

Truck Transport[1], 1980-1990

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Number of Vehicles											
For-hire carriers	61 471	57 852	54 280	52 187	53 670	57 987	56 377	57 337	55 034	..	..
Private carriers	..	..	91 843	10 391	113 729	113 541	134 979	99 781	104 581	..	..
Total	..	..	146 123	62 578	167 399	171 528	191 356	157 118	159 615	144 503	138 333
Distance run (million kilometres)											
For-hire carriers	5 173.2	4 995.8	4 598.9	4 621.5	5 319.2	5 645.8	5 936.6	6 558.8	6 847.3	..	..
Private carriers	..	..	4 476.9	4 928.4	3 692.1	3 891.0	4 155.9	3 366.4	3 415.8	..	..
Total	..	..	9 075.8	9 549.9	9 011.3	9 536.8	10 092.5	9 925.2	10 263.1	..	6 000.0
Freight carried (million tonne-kilometres)											
For-hire carriers (intercity movement)	41 734	39 779	37 910	41 920	43 624	43 723	48 930	57 320	57 888	..	76 700
Fuel purchases (million litres)											
For-hire carriers	2 019.8	1 883.8	1 715.9	1 622.6	1 822.1	2 029.4	1 959.6	1 975.2	2 045.3	..	..
Private carriers	..	..	1 366.5	1 726.1	1 410.2	1 438.4	1 486.3	1 261.9	1 244.7	..	..
Total	..	..	3 082.4	3 348.7	3 232.3	3 467.8	3 445.9	3 237.1	3 290.0	..	..
of which: Gasoline (percent)	..	..	22.2	27.8	20.4	17.1	18.1	13.4	12.5	..	..
Diesel (percent)	..	..	75.5	70.1	77.1	80.2	78.8	83.7	85.0	..	..
Propane (percent)	..	..	2.4	2.1	2.5	2.5	2.8	2.7	2.4	..	..

Notes:

1. Data include Canadian-domiciled carriers only. These figures, particularly those for fuel purchases, may include adjustments for for-hire establishments. Other factors should be considered when using these data, including the levels of inclusion for various categories and the changes, between 1980 and 1990, in the sample structure of the underlying surveys.

Sources:

Davies, G.R., "Owner-operators in intercity for-hire trucking, 1978-1988", Proceedings of the Canadian Transportation Research Forum, Québec City, 1991.

Statistics Canada, *Motor Carriers, Freight and Households Goods Movers*, Catalogue No. 53-222, Ottawa, various issues.

Statistics Canada, *Trucking in Canada*, Catalogue No. 53-222, Ottawa, various issues.

Statistics Canada, *For-hire Trucking Survey*, Catalogue No. 53-224, Ottawa, various issues.

Table 3.3.9

Gross Sales of Gasoline for Motive Purposes, 1985-1992

Province/Territory	Total sales 1985	1986	1987	1988	1989	1990	1991	1992	Sales per capita 1992
	million litres								litres per capita
Newfoundland	552	550	558	587	604	550	595	600	1 035
Prince Edward Island	169	171	171	180	181	171	172	175	1 338
Nova Scotia	1 066	1 069	1 085	1 119	1 128	1 069	1 083	1 098	1 196
New Brunswick	937	935	969	1 000	976	935	910	935	1 249
Quebec	6 688	6 666	6 755	6 997	7 181	6 666	7 002	6 897	974
Ontario	11 837	12 007	12 245	12 685	12 971	11 999	12 309	12 229	1 168
Manitoba	1 471	1 466	1 464	1 492	1 492	1 466	1 386	1 390	1 249
Saskatchewan	1 863	1 858	1 816	1 802	1 684	1 859	1 614	1 620	1 609
Alberta	4 312	4 312	4 362	4 306	4 285	4 312	4 152	4 130	1 588
British Columbia	3 653	3 705	3 678	3 750	3 755	3 705	3 678	3 826	1 133
Yukon	56	57	61	65	65	57	64	68	2 345
Northwest Territories	50	34	52	43	54	34	59	60	980
Canada	**32 654**	**32 830**	**33 216**	**34 026**	**34 376**	**32 823**	**33 023**	**33 028**	**1 175**

Source:
Statistics Canada, *Road Motor Vehicles Fuel Sales*, Catalogue No. 53-218, Ottawa, various issues.

Table 3.3.10

Consumption of Refined Petroleum Products, by Mode, 1981-1992

	Total	Gasoline	Diesel	Heavy and light fuel oil	Turbo fuel
	petajoules	percent			
Road and urban transit					
1981	225.3	26.6	73.4	-	-
1985	164.6	30.6	69.4	-	-
1992	175.8	20.8	79.2	-	-
Rail					
1981	91.3	-	100.0	-	-
1985	85.5	-	100.0	--	-
1992	86.7	-	100.0	-	-
Marine					
1981	147.4	-	28.9	71.1	-
1985	74.1	-	46.5	53.5	-
1992	110.4	-	39.8	59.0	-
Air					
1981	131.7	-	-	-	100.0
1985	128.5	-	-	-	100.0
1992	138.6	-	-	-	100.0
Total					
1981	**595.7**	**10.1**	**50.2**	**17.6**	**22.1**
1985	**452.7**	**11.1**	**51.7**	**8.8**	**28.4**
1992	**511.3**	**7.1**	**52.8**	**12.7**	**27.1**

Note:
Consumption by the marine and air transport modes include sales in Canada to foreign carriers.
Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, various issues.

Table 3.3.11

Estimated Emissions from Passenger Transportation[1], 1989

Emission	Private automobile	Public transport[2] Bus	Train	Air
	grams per passenger-kilometre			
Carbon monoxide	5.20	0.18	0.34	0.17
Volatile organic compounds	0.94	0.05	0.14	0.10
Nitrogen oxides	0.75	0.40	1.54	0.34
Carbon dioxide	128.00	30.00	76.00	220.00

Notes:
1. Estimates are for trips taken between Toronto and Montréal and do not represent the situation in other transport corridors.
2. Emissions from public transport are based on actual vehicle occupancy rates.
Source:
VHB Research and Consulting Inc. and Commission estimates, in *Directions: The Final Report of the Royal Commission on National Passenger Transportation*, Ottawa, 1992.

Alternative fuels[1] represent a very small proportion of total fuel currently consumed in transportation. These fuels are at various stages of development and market readiness. For example:

- Several of the major car manufacturers have reached the pre-production prototype stage for both electric and hydrogen-powered passenger vehicles.
- Propane accounts for about 2 percent of the total fuel used in intercity trucking (Table 3.3.8). Propane has also been used by the urban transit and taxicab industries but its share of total fuel consumption continues to be very small.

These developments have potential to reduce the air emissions from transportation but there are some drawbacks to their use.[2] On one hand, if gasoline and diesel fuel were to

1. In this case, *alternative fuels* refers to all fuels other than gasoline or diesel that could be used for transportation.
2. Hijazi, N. and T. Smith, *Transportation and the Canadian Environment: R&D Priorities*, Transport Canada, Catalogue No. TP 11471E, Ottawa, 1993.

be replaced by alternative fuels, reductions in emissions could range from one percent (for electric vehicles, under the current power mix) to 100 percent (for hydrogen-powered vehicles). On the other hand, there are many technical issues that have yet to be resolved before electric and hydrogen-powered vehicles are ready for market. Most importantly, the lack of market demand for alternative fuels hinders the development of a distribution and service network.

Fuel and Energy Efficiency

In addition to the total energy consumed in transportation, the efficiency with which this energy is used should be considered. Several measures can be used to express energy efficiency of a given mode of transport but they all, in essence, describe the amount of work done with a fixed quantity of energy (Table 3.3.12).

There have been substantial improvements in the energy efficiency of transportation over the decades. Table 3.3.12 shows, among other things the energy consumed per 100 kilometres travelled by various modes of transport. The data demonstrate that engine efficiencies have increased over the last ten years.

The other measures in Table 3.3.12, show fuel consumption per passenger or per tonne. These data reflect the fuel and energy efficiencies achieved by the combination of engine technology, weight carried, and distance hauled.[1]

Fuel use is determined by several factors.For road transport, these are the number of vehicles, the average fuel efficiency of these vehicles, and the average distance travelled per vehicle. Energy efficiency in road transportation is expected to improve as a function of more effective design and increased use of alternative fuels. Although fuel demand in rail, marine and air transport is conditioned by the same factors as road transport, there is comparatively little scope for improved energy efficiency.[2]

Air Emissions

Transportation activity accounts for significant emissions of carbon monoxide, volatile organic compounds, nitrogen oxides and carbon dioxide[3]. The emissions produced are determined by the quantities of fuel consumed, and to some extent by the combustion and abatement technologies in place. As seen in Table 3.3.12, choices of transport modes for both passengers and goods can have a great deal of influence on energy use and, therefore, in air emissions.

1. Data in this table are intended to show general trends. Careful attention should be given to the accompanying notes, both on this table and on the base data tables.
2. *Canada's Energy Outlook 1992-2020*, working paper prepared by the Energy and Fiscal Analysis Division, Natural Resources Canada, 1993.
3. See Section 3.7 - **Wastes**.

While independence from scheduling and routing make the private automobile a very convenient way for passengers to travel, this choice is not without environmental cost. A private car travelling between, for example, Toronto and Montreal emits more carbon monoxide, volatile organic compounds and nitrogen oxides per passenger-kilometre than a bus, train or plane that travels the same corridor (Table 3.3.11).

The same is true of cargo transport, where even small changes in the modes used can have great effects. For example, a shift of market share (measured in tonne-kilometres) from rail to truck of as little as 2.2 percent can increase emissions from goods transportation by between 4 percent and 7 percent.[4]

Summary

Although there have been improvements in the efficiency with which transportation activities use fuel, any reduction in environmental impact is offset by the increasing total magnitude of activity. This is especially true of passenger transportation.

In general, the level of transportation activity is tied to changes in the total economy. However, within the transportation system, choices of modes are influenced by the increasingly specialized shipping and travel requirements of businesses and individuals. These preferences can change the nature of transportation's impact on the environment.

4. Sypher:Mueller International Inc., *Environmental Instruments and Transportation*, paper prepared for the National Transportation Act Review Commission, Ottawa, 1992.

Table 3.3.12

Energy Use Ratios, Selected Transportation Modes, 1961-1992

	1961	1971	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	megajoules													
Per 100 kilometres														
Passenger cars	..	..	560	530	500	480	460	450	420	420	..	..	..	..
All bus services	..	..	1 800	1 600	1 600	1 700	1 800	1 800	1 800	1 700	1 600	1 700	..	..
Intercity bus	..	..	1 700	1 700	1 700	1 700	1 800	1 700	1 800	1 800	1 900	1 900	..	..
Urban transit[2]	..	..	1 400	1 700	1 400	1 700	1 700	1 600	1 700	1 900	1 500	1 700	..	..
Other passenger bus	..	..	1 800	1 800	1 800	1 800	1 800	2 000	1 800	1 500	1 700	1 500	..	..
All trucking	..	..	..	1 300	1 300	1 300	1 400	1 300	1 200	1 200	..	..	..	..
For-hire	..	..	1 400	1 400	1 300	1 300	1 400	1 300	1 200	1 100	..	..	..	..
Private	..	..	..	1 100	1 300	1 400	1 400	1 300	1 400	1 300	..	..	..	..
Per passenger														
All bus services	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Intercity bus	..	..	110	110	100	110	120	130	130	160	180	190	..	..
Urban transit[2]	..	..	8.7	7.5	5.7	8.4	8.6	8.0	8.2	9.3	7.5	8.7	..	..
Rail[3]	22	38	33	34	33	31	32	33	31	29	30	29	..	..
Rail[4]	1 500	1 500	1 600	1 700	1 600	1 600	1 600	1 700	1 700	1 500	1 500	1 800	..	..
Air[3]	4 600	5 300	4 400	4 100	4 300	3 800	3 800	..	3 900	4 200	4 300	4 000	4 000	3 800
Air[4]	56 000	66 000	51 000	48 000	51 000	46 000	46 000	..	46 000	49 000	50 000	47 000	48 000	45 000
Per 100 passenger-kilometres														
Rail[3]	6.2	4.7	3.9	3.7	3.6	3.4	3.6	3.7	3.3	3.2	3.3	3.2	..	..
Rail[4]	1 900	2 300	2 800	3 100	2 800	3 000	2 900	3 200	3 300	2 900	2 600	4 000	..	..
Air[3]	510	380	250	220	220	230	230	..	..	220	220	210	200	180
Air[4]	540	460	300	270	280	270	270	..	..	270	270	260	260	230
Per tonne[1]														
Rail[3]	220	380	330	340	330	310	320	330	310	290	300	290	..	..
Rail[5]	220	380	330	340	330	310	320	330	310	300	300	300	..	..
Air[3]	50 000	50 000	40 000	40 000	40 000	40 000	40 000	..	40 000	40 000	40 000	40 000	40 000	40 000
Air[4]	56 000	66 000	51 000	48 000	51 000	46 000	46 000	..	46 000	49 000	50 000	47 000	48 000	45 000
Marine[5]	..	..	..	..	..	..	420	410	370	370	490	490	..	..
Per tonne-km														
Rail[3]	0.63	0.47	0.40	0.37	0.37	0.35	0.36	0.37	0.33	0.32	0.34	0.32	..	..
Rail[5]	0.63	0.47	0.40	0.37	0.37	0.35	0.36	0.37	0.33	0.32	0.34	0.32	..	..
Air[3]	50	38	25	22	23	23	24	..	..	22	22	20	20	19
Air[4]	54	46	30	27	28	27	27	..	..	27	27	26	26	23
Marine[5]	..	..	..	..	..	..	0.89	0.86	0.80	0.79	1.0	1.0	..	..
All trucking	..	..	..	..	..	..	..	..	..	..	..	..	..	..
For-hire	..	..	1.8	1.7	1.5	1.6	1.8	1.5	1.3	1.4	..	..	..	..

Notes:

Except for the figures for passenger cars, which are based on data published in Statistics Canada, *Human Activity and the Environment 1991*, Catalogue No. 11-509, Ottawa, 1991, these figures are based on summary data presented in Tables 3.3.4 to 3.3.8. All notes on those tables also apply to these data. Figures are rounded to two significant digits. Year-to-year changes and comparisons between modes should be limited to rough orders of magnitude.

1. Unless otherwise specified, data refer to the combined weight of goods and passengers. For air transport, the conversion of passenger-kilometres to passenger-tonne-kilometres generally assumes a ratio of 100 kg per person transported, to allow for accompanying baggage. For convenience, this same ratio is applied to other modes.
2. Data exclude natural gas and electricity.
3. Fuel allocated to freight and passengers, prorated by total tonnes or tonne-kilometres transported.
4. All fuel assigned to passengers.
5. All fuel assigned to freight.

Source:

Statistics Canada, National Accounts and Environment Division.

3.4 Energy and the Economy

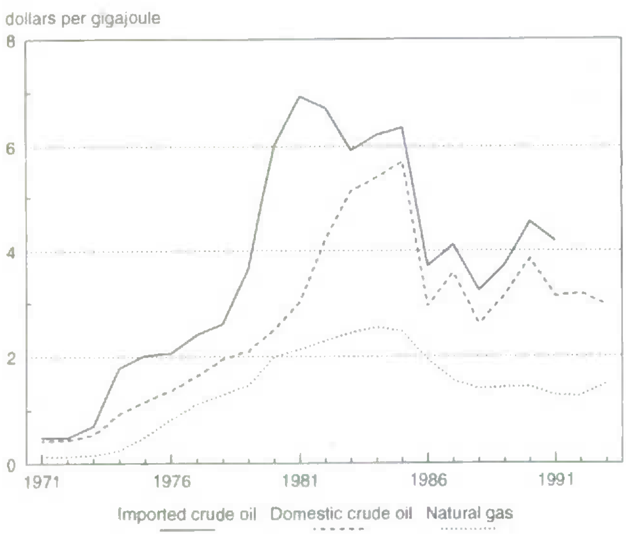
Energy production and consumption have many environmental impacts. These can be reduced by decreasing energy consumption, by using energy more efficiently and by developing alternative energy sources that are less stressful on the environment. This section examines some of the economic factors that influence the supply and demand of traditional energy sources and the development of alternative energy sources. The actual environmental impacts of energy are described more fully in Section 3.12 - **Energy**.

❑❑❑

Energy conservation has been a focus of attention since the Organisation of Petroleum Exporting Countries (OPEC) caused oil prices to rise dramatically in the early 1970s (Figure 3.4.1). By reducing oil consumption, consumers were effectively able to reduce expenditure. When oil prices declined in 1985, it was evident that energy conservation efforts had provided more than just economic benefits. The environmental advantages of reduced oil consumption had also become clear.

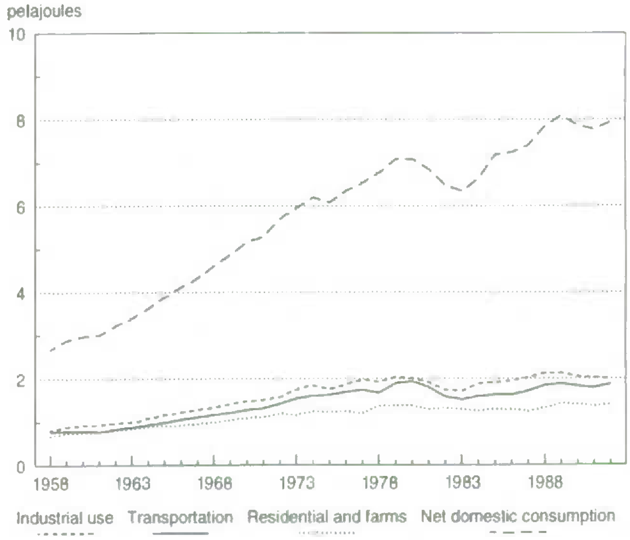
Energy prices have an important impact on the supply of and demand for energy. The growth in demand for energy in Canada has slowed since the late 1970s, owing partly to efficiency measures stimulated by high prices (Figure 3.4.2 and Table 3.4.1). Exploration for new reserves of oil and gas increased during the 1970s in response to increasing prices, and then fell as prices declined (Figure 3.4.3).

Figure 3.4.1
Crude Oil and Natural Gas Prices, 1971-1993



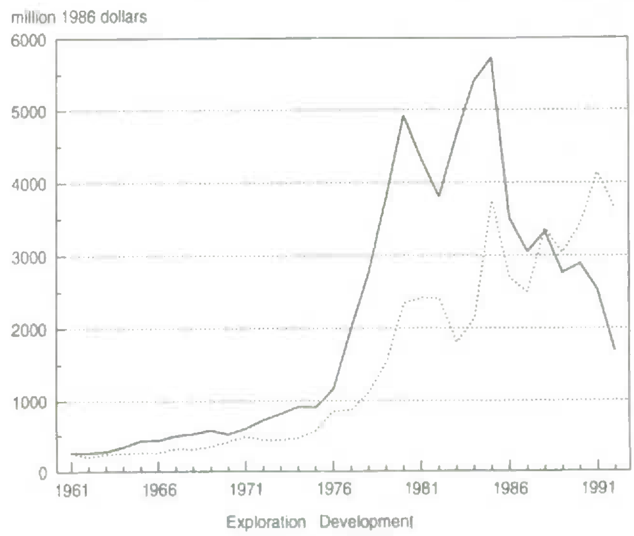
Note:
The difference between domestic and imported crude oil prices after 1985 reflects mainly transportation costs.
Source:
Canadian Petroleum Association, *Statistical Yearbook*, Calgary, various issues.

Figure 3.4.2
Final Energy Consumption, 1958-1992



Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, various issues.

Figure 3.4.3
Oil and Gas Capital Expenditures, 1961-1992



Source:
Statistics Canada, *The Crude Petroleum and Natural Gas Industry*, Catalogue No. 26-213, Ottawa, various issues.

The global energy balance has changed fundamentally since 1973, when non-OECD (Organisation for Economic Co-operation and Development) countries consumed 37 percent of world total primary energy supply. In 1989, these same countries consumed 49 percent of total supply. The energy demand of non-OECD countries grew by 4.1

Table 3.4.1

Energy Consumption, 1958-1992

Year	Producer consumption	Non-energy use	Final energy consumption: Industrial	Transportation	Residential and agriculture	Public administration, commerce and others	Net domestic consumption[1]	Losses in conversion to secondary energy	Gross availability[2]
					petajoules				
1958	196	18	808	776	674	197	2 669	23	2 692
1959	216	18	892	783	739	236	2 885	50	2 934
1960	231	22	917	786	753	261	2 971	59	3 029
1961	232	19	934	764	764	288	3 002	130	3 132
1962	273	19	978	838	805	311	3 224	135	3 360
1963	289	20	997	882	846	359	3 392	196	3 588
1964	318	21	1 085	932	889	396	3 641	139	3 780
1965	356	25	1 166	990	913	449	3 900	89	3 989
1966	381	29	1 223	1 054	915	507	4 109	154	4 263
1967	407	28	1 277	1 108	955	559	4 334	73	4 407
1968	441	29	1 335	1 165	996	634	4 600	141	4 741
1969	479	34	1 406	1 208	1 044	694	4 866	141	5 007
1970	539	34	1 474	1 275	1 093	739	5 153	217	5 370
1971	570	23	1 499	1 319	1 113	775	5 298	408	5 707
1972	621	20	1 575	1 413	1 193	874	5 697	607	6 303
1973	675	32	1 757	1 541	1 154	785	5 945	843	6 787
1974	657	39	1 846	1 601	1 240	810	6 194	927	7 120
1975	679	33	1 753	1 624	1 226	764	6 079	873	6 952
1976	671	49	1 856	1 691	1 240	842	6 351	743	7 093
1977	702	57	1 970	1 737	1 202	860	6 527	977	7 504
1978	470	476	1 912	1 667	1 359	892	6 776	615	7 391
1979	401	516	2 024	1 880	1 369	892	7 082	839	7 921
1980	398	530	2 004	1 928	1 371	853	7 084	824	7 909
1981	364	532	1 903	1 794	1 288	964	6 845	764	7 609
1982	345	458	1 733	1 574	1 318	1 050	6 478	626	7 104
1983	328	502	1 709	1 507	1 284	1 014	6 345	722	7 067
1984	343	558	1 871	1 584	1 245	1 036	6 637	817	7 454
1985	726	615	1 904	1 625	1 297	1 020	7 187	719	7 906
1986	760	609	1 940	1 622	1 285	1 021	7 236	607	7 844
1987	816	664	2 012	1 709	1 240	957	7 398	723	8 121
1988	850	677	2 122	1 839	1 326	1 021	7 836	755	8 591
1989	911	677	2 128	1 871	1 425	1 076	8 087	856	8 943
1990	906	638	2 044	1 821	1 402	1 055	7 866	750	8 616
1991	878	666	2 022	1 785	1 362	1 053	7 766	750	8 516
1992	921	680	1 990	1 869	1 403	1 067	7 930	827	8 757

Notes:
There is a break in the time series between 1977 and 1978.
This break affected mostly estimates for conversion to secondary energy, producer consumption and non-energy use.
1. Net domestic consumption is a sub total of the columns to the left.
2. Gross availability is the sum of net domestic consumption and losses in conversion.

Sources:
Statistics Canada, *Detailed Energy Supply and Demand in Canada*, Catalogue No. 57-207, Ottawa, various issues.
Statistics Canada, *Detailed Energy Supply and Demand in Canada, 1958-1969*, Catalogue No. 57-505, Ottawa, 1972.
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, various issues.

percent per annum during this period, compared to an annual growth rate of 1 percent for OECD countries.[1,2]

Projections

Canada's energy future has been examined in detail by Natural Resources Canada[3] (Table 3.4.2 gives a summary of this projection). Although their outlook is just one of the many possible futures it is based on "a set of plausible assumptions about the future" of energy supply and demand. Despite an assumed increase in energy efficiency of 0.8 percent per year, total secondary[4] energy demand is projected to be 16 percent higher than 1991 levels in 2000 and 61 percent higher by 2020. Under the same assumptions, renewable energy sources other than hydroelectric (mainly wood and alcohol fuels) are expected to increase modestly from 6 to 7 percent of total primary energy demand.

Carbon dioxide (CO_2) emissions are projected to increase by 55 percent over the scenario period (although the report warns that these estimates are extremely sensitive to changes in the underlying assumptions). Nevertheless, Natural Resources Canada states that maintaining carbon dioxide emissions at stabilized levels beyond 2000 would

1. Two-thirds of non-OECD energy demand in 1989 was from China, Eastern Europe and the former Soviet Union.
2. International Energy Agency, *Global Energy: The Changing Outlook*, OECD, Paris, 1992.
3. Natural Resources Canada, *Canada's Energy Outlook, 1992 - 2020*, Energy and Fiscal Analysis Division, Economic and financial Analysis Branch, Energy Sector, September 1993. In this reference scenario the energy related policies of federal and provincial governments are held constant over the scenario period.

4. Secondary energy demand is the sum of energy use in the residential, commercial, industrial and transportation sectors.

Table 3.4.2

Canada's Energy Outlook, 1992-2020

Variable	Annual Growth: Historical	Annual Growth: Projected 1991-2020	Change 1991-2020
	percent		
Framework			
Population	1.1[1]	0.9	33
Economic growth (real)	3.1[1]	2.5	109
Industrial	1.2[1]	3.1	150
Services	3.4[1]	2.2	92
World oil prices	–	3.3	164
Domestic natural gas prices	..	2.3	97
Electricity prices	–	0.5	16
Energy demand			
Industrial	0.8[2]	2.1	85
Transportation	0.3[2]	1.8	69
Residential	0.9[2]	0.4	14
Total primary energy	–	1.6	63
Greenhouse gas emissions (including biomass)	–	1.5	57

Notes:
1. Percent annual growth 1972-1991.
2. Percent annual growth 1981-1991.

Source:
Natural Resources Canada, *Canada's Energy Outlook, 1992-2020*, Ottawa, 1993.

appear to require significant technological, structural and life style changes."[1]

Renewable Energy Sources

Renewable energy sources include hydroelectricity, biomass, solar, wind, geothermal and ocean or tidal. On a global scale, renewable energy (including large-scale hydroelectric power) represents about 18 percent of total energy supply. Excluding large hydro and traditional biomass, it accounts for only about 2 percent.[2]

Over the course of the 1980s, solar domestic hot water systems decreased by 60 percent in price and the cost of small hydro installations (less than 15 megawatts) dropped by as much as 17 percent.[3] In general, however, alternate energy sources "...have some distance to go before they are competitive with conventional fuels outside specific market niches".[4]

A report by the World Energy Council warns that a simple and complete analysis of the question of competitiveness of renewable energy does not exist.[5] "The most controversial part of any comparison of traditional fuels and renewable sources is the external impacts [those costs not directly related to a project] of construction and operation of facilities. To expand more rapidly the use of renewables, the economic decision-making methodology would have to be updated to include the external costs of energy use, which would be generally more favorable to renewables than to fossil fuels".[6] The report cautions, however, that "some large-scale applications, especially hydro, biomass, wind, geothermal and tidal, need to be applied with sensitivity to their possible environmental impacts".[7] Although new renewable energy sources are promising in their potential, the existing investment in fossil fuel facilities and the inability of the new technologies to achieve economies of large-scale production present serious barriers to the commercialisation of new renewables. Technical box 3.4.1 outlines some of the important economic and environmental issues surrounding alternative energy sources.

Energy Research and Development

In Canada, with the decline in oil prices in the mid-1980s, the concern for energy security was reduced. Along with it federal financial support for energy research and development was also reduced. Funding emphasis changed from broad-based programmes intended to encourage energy conservation to a more targeted technology development programme.

Combined industrial and government research and development (R&D) expenditures on energy systems have declined, in 1986 dollars, from almost $1.2 billion in 1983 to less than $0.8 billion in 1991. Almost all of this decline has been in the government portion (Table 3.4.3).

Table 3.4.3

Research and Development Expenditures by Sector, 1983-1991

Sector	1983	1984	1985	1986	1987	1988	1989	1990	1991
	million 1986 dollars								
Industrial	331.0	340.7	383.1	347.6	253.9	291.8	279.1	299.7	286.3
Electric utility	107.4	112.6	119.3	141.7	185.4	185.9	195.0	182.8	187.9
Government	725.6	777.1	610.8	581.6	448.1	388.5	329.1	327.1	281.9
Total	**1 164.0**	**1 230.4**	**1 113.2**	**1 070.9**	**887.4**	**866.2**	**803.2**	**809.6**	**756.1**

Source:
Natural Resources Canada, Office of Energy Research and Development.

Table 3.4.4 shows that fossil fuel and nuclear energy accounted for 68 percent of total federal and provincial R&D expenditures in 1983. This had increased to 78 percent in 1991. Over the same period, R&D in renewable energy sources declined from 13 percent to 4 percent of the total.

1. Natural Resources Canada, *Canada's Energy Outlook, 1992 - 2020*, Energy and Fiscal Analysis Division, Economic and financial Analysis Branch, Energy Sector, September 1993, p. viii. Canada has established a national goal to stabilize emissions of greenhouse gases (other than CFCs) at 1990 levels by 2000.
2. World Energy Council, *Renewable Energy Resources: Opportunities and Constraints 1990-2020*, 1993, p. vi.
3. Natural Resources Canada, *GEOS*, Fall, 1991, p. 33.
4. Ibid., p. 34.
5. World Energy Council, op. cit., p. 1-24.
6. Ibid., p. 1-29.
7. Ibid., p. 1-30.

Table 3.4.4

Federal and Provincial Government Research and Development Expenditures, 1983-1991

Energy source	1983	1984	1985	1986	1987	1988	1989	1990	1991
	millions of 1986 dollars								
Renewable sources	94.6	72.2	41.5	23.6	19.2	16.7	9.8	12.9	11.1
Transportation and transmission	11.9	11.7	6.9	9.2	5.9	5.3	4.7	4.6	4.9
Conservation	98.8	96.1	98.0	38.9	37.4	37.6	34.6	33.8	29.8
Fossil fuels	236.0	343.8	207.0	270.5	185.5	170.0	122.9	121.0	82.6
Nuclear	257.1	231.8	246.6	229.5	192.1	158.3	140.5	138.2	137.3
Other	27.4	21.5	11.1	9.9	8.0	0.6	16.8	16.5	16.2
Total	725.8	777.1	610.8	581.6	448.1	388.5	329.2	327.1	281.8

Source:
Natural Resources Canada, Office of Energy Research and Development.

Industrial R&D has been more volatile with expenditures fluctuating between 34 percent and 53 percent of the total. Conservation and renewable energy R&D expenditures have remained relatively steady at 22 percent and 5 percent respectively. Renewable energy expenditures were mostly for large-scale hydroelectric R&D (Table 3.4.5).

A more detailed breakdown of public and private sector energy R&D expenditures for 1991 is provided in Table 3.4.6. Under the heading of conservation, transportation accounts for over 50 percent of combined private and public R&D expenditures, while under renewable energy sources the main emphasis is on large hydroelectric projects.

Table 3.4.5

Private Sector Energy Research and Development Expenditures, 1983-1991

Energy source	1983	1984	1985	1986	1987	1988	1989	1990	1991
	millions of 1986 dollars								
Renewable sources	19.3	21.8	26.8	60.1	23.1	20.3	16.3	19.6	21.1
Transportation and transmission	44.5	61.0	63.4	67.9	101.2	122.7	126.8	104.9	95.4
Conservation	75.2	69.6	78.2	87.7	64.9	77.6	90.0	96.8	108.4
Fossil fuels	230.2	222.7	265.5	185.1	151.4	160.6	159.1	178.6	157.3
Nuclear	48.1	56.5	48.8	63.9	49.8	41.0	40.7	50.0	61.7
Other	21.2	21.4	19.7	23.8	48.7	55.6	41.3	32.6	30.3
Total	438.6	453.2	502.4	488.5	439.1	477.7	474.2	482.5	474.2

Source:
Statistics Canada, Services, Science and Technology Division.

Table 3.4.6

Energy Research and Development Expenditures, 1991

Energy source	Government	Industry	Total
	million dollars		
Conservation	**36.2**	**142.0**	**178.2**
Industry	17.8	33.6	51.4
Residential and commercial	7.8	18.1	25.9
Transportation	5.9	87.7	93.6
Other	4.7	2.6	7.3
Fossil fuels	**100.4**	**220.5**	**320.9**
Enhanced oil and gas recovery	12.9	13.6	26.5
Refining, transportation and storage	8.3	60.9	69.2
Oil sands and heavy oils	28.0	88.1	116.1
Other oil and gas	30.7	52.6	83.3
Coal mining, preparation and transport	5.9	-	5.9
Coal combustion	8.7	-	8.7
Coal conversion	1.8	-	1.8
Other coal	4.1	5.3	9.4
Renewable energy sources	**13.6**	**30.2**	**43.8**
Solar heating and cooling	2.3	1.1	3.4
Photovoltaics	2.4	-	2.4
Solar thermal electric	0.5	-	0.5
Wind	1.5	1.3	2.8
Ocean/tidal energy	-	-	-
Biomass	6.2	4.6	10.8
Geothermal	-	-	-
Large hydro	-	23.2	23.2
Small hydro	0.6		0.6
Nuclear	**167.0**	**87.3**	**254.3**
Converter reactors (excluding light water)	89.0	87.3	176.3
Fuel cycles	34.8	-	34.8
Nuclear supporting technology	30.2	-	30.2
Nuclear breeder	0.2	-	0.2
Nuclear fusion	12.8	-	12.8
Power and storage technologies	**12.9**	**116.9**	**129.8**
Electric power conversion	5.7	-	5.7
Electric transport and distribution	0.2	116.9	117.1
Electric storage/electrochemistry	7.0	-	7.0
Other crossing technologies	**12.7**	**45.9**	**58.6**
Energy system analysis	2.1	-	2.1
Other	10.6	45.9	56.5
Total expenditures	**342.8**	**642.8**	**985.6**

Note:
This table is in 1991 dollars and therefore cannot be compared to the preceding summary tables, which are in 1986 dollars.
Sources:
Statistics Canada, Services, Science and Technology Division.
Natural Resources Canada, Mineral and Energy Technology Sector.

Summary

Experience since 1971 has shown that energy production and use are closely linked to energy prices. Renewable energy sources present an attractive alternative to fossil fuels with regard to air pollution and the emission of greenhouse gases, although these technologies cannot be exploited fully without careful attention to their own environmental consequences. These technologies, in general, are not currently competitive with traditional energy supply systems and considerable development must occur to overcome technical difficulties and improve efficiencies. Projections of energy consumption suggest that it will be very difficult to maintain Canada's level of greenhouse gas emissions at 1990 levels without significant changes to technologies and life styles.

Technical Box 3.4.1

Alternative Energy Sources

Solar energy

The earth receives solar energy as radiation from the sun, and the amount greatly exceeds mankind's use. A large amount of R&D work has been done in the last 20 years, with a vast amount of data generated on technology and applications, and some dramatic gains in cost effectiveness. A few of these applications are now fully commercial, but further improvement in cost, achievable through mass production and technical development, is needed for widespread applications. Solar energy avoids many of the harmful environmental effects associated with fossil fuels, although concentrated, large-scale use can lead to localized environmental impacts. A number of institutional and economic constraints must be overcome for extensive use, but with adequate support, the contribution of this resource is likely to become significant in the next several decades.

Wind energy

Wind is the result of thermal heating of the earth by the sun, and has global patterns of a semi-continuous nature. It is significantly affected by topography and weather, with seasonal, daily and hourly variations. Much of the wind resource is located along coastlines (including offshore) and in mountain regions, but significant resources are also found on plains. Estimates of global availability indicate that maximum technical potential is about twice the current global electricity production (from all current energy sources). Installed costs have fallen sharply in the last decade, and wind energy is nearly competitive for non-firm (not guaranteed) energy supply in many high-resource areas. Several constraints to wider applications of wind energy include lack of detailed understanding of this very site-specific resource, visual intrusion and aesthetics, noise, bird mortality and telecommunications interference, and availability of capital resources.

Biomass energy

Biomass encompasses a range of products derived from photosynthesis and is essentially chemical storage of solar energy. It also represents storage of carbon in the biosphere. It is distributed worldwide, and is available in some form to every country on earth, although varying significantly in capacity per hectare. In 1990, biomass (mostly non-commercial) contributed an estimated 12 percent of the total global energy supply. The energy potential from biomass significantly exceeds world energy use. Economics of biomass are very difficult to generalize, because value is often set by competing uses. Large-scale commercial usage would have significant impacts on other markets such as food and paper. The costs and energy investment of delivery, water and fertilizer must be considered, as well as the overall impact on land use and population patterns. It is the only renewable resource that is likely to significantly impact the transport fuels sector energy use by 2020 without electric vehicles. In the event of large-scale use of bio-energy, it would be necessary to guard against reduction of bio-diversity, protect areas of great natural beauty and environmental sensitivity, and control effluents and emissions.

Geothermal Energy

Geothermal techniques make use of the energy found in hot water and steam below the earth's surface, either directly (as in space heating) or to produce steam for electricity. Commercial use of geothermal energy has been developed in at least 20 countries. Although concentrated in certain areas, geothermal energy reserves of significant quantity exist in all regions of the world. To tap these resources, it is necessary to continue development of exploration, extraction and conversion technologies, and to manage the environmental issues such as small quantities of dissolved gases including hydrogen sulphide and carbon dioxide and disposal/reinjection of concentrated brines.

Ocean energy

All technologies of tapping ocean energy are very immature. Tidal energy is most advanced since it uses dams and turbines very similar to low-head hydroelectric plants. However, there may be some potentially severe adverse impacts on local ecology at many of the sites with high technical potential, and effective mitigation or avoidance strategies are necessary for development to proceed. Current use of ocean energy is limited to a few demonstration facilities. Ocean energy systems are expected to have high capital costs and must run reliably over an extended period in a hostile environment. Their action can change the local aquatic habitat, especially near river mouths. Ocean thermal and wave energy plants can produce fresh water as a by-product, and therefore are attractive to remote coastal areas without fresh water resources. Transport of energy from ocean energy plants is one of the major issues to be resolved for widespread application.

Small hydropower

Hydropower is well known throughout the world, and currently contributes about 6 percent of the total world energy production. This is due mostly to large facilities on major rivers, since these have been the focus of past development. However, to reach the maximum potential use of natural resources, smaller water flows must also be tapped. Small facilities depend on special local situations for economic viability. They have lower environmental impact than similar very large projects, but great care will be required to mitigate impacts, especially near scenic and environmentally sensitive areas. They are less disruptive of the local land use and environment than larger facilities, but typically provide less storage and must be operated nearly continuously to maintain adequate stream flow.

Source:
World Energy Council, *Renewable Energy Resources: Opportunities and Constraints 1990-2020*, 1993.

3.5 Households

Much of the effort to reduce environmental impacts is focused on industrial activity. However, people also affect the environment. What we do, where we live and what we purchase all have an impact on the environment. This section investigates the distribution, income and consumption patterns of Canadians. The unit of analysis is generally the household, which is defined as a group of individuals sharing a common dwelling unit.

❑❑❑

Consumer expenditure, to a large extent, drives industrial production. Sixty percent of the demand for Canadian goods and services came from personal expenditures in 1991.[1] This expenditure has grown from 257 billion dollars,[2] roughly 58 percent of Gross Domestic Product (GDP), to 336 billion dollars[3] over the past decade.

As household consumption grows, so does its potential to exert pressures on the environment. In addition to the impact of industry in producing these goods and services for household consumption, households generate over 10 million tonnes of solid wastes per year, produce 64 thousand tonnes of hazardous wastes[4] and consume 23 percent of Canada's energy.[5]

Dwellings

The construction of dwellings and related infrastructure, the purchase of appliances, and the consumption of energy are more closely tied to the number of households than to the number of people. Each household generally has a set of large appliances, uses electricity, fuel and water, and requires materials for the construction of the dwelling, sewer lines and water mains. These resources are generally used less efficiently if the population is distributed in smaller households.

There were 4 million more dwellings in 1991 than in 1971, an increase of over 65 percent. The number of persons per dwelling declined steadily from 3.6 to 2.7 over the same period (Table 3.5.1). The increase in the number of dwellings is due, in part, to increased numbers of lone-parent families and single-person households.

Table 3.5.1

Persons per Dwelling, 1971-1991

Year	Population: Total	Population: Average annual change	Dwellings: Total	Dwellings: Average annual change	Persons per dwelling
	thousands	percent	thousands	percent	persons
1971	21 568	..	6 044	..	3.6
1976	22 993	1.3	7 166	3.5	3.2
1981	24 343	1.1	8 281	2.9	2.9
1986	25 354	0.8	8 921	1.5	2.8
1991	27 297	1.5	10 018	2.3	2.7

Source:
Statistics Canada, Census of Population.

Map 3.5.1 shows that large portions of southern Ontario, Quebec, and the Atlantic provinces have densities of over one dwelling per square kilometre. This corresponds to areas ranging in density from populated rural areas to urban centres. At this density, a substantial amount of infrastructure, roads, sewers, commercial centres and community facilities, is required.

Income

The volume and distribution of household expenditures are closely related to income. Table 3.5.2 shows that households with higher incomes are more likely to own their home, own a car or truck, and have an automatic dishwasher, washing machine, clothes dryer or air conditioner. High-

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1. The remainder of the final demand is from government, net exports and business investment.
2. Measured in 1981 dollars.
3. Statistics Canada, *National Income and Expenditure Accounts, Annual Estimates, 1981-1992*, Catalogue No. 13-201, Ottawa, 1993.
4. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
5. Statistics Canada, *Detailed Energy Disposition Tables, 1981-1990*, National Accounts and Environment Division, working paper, 1994.

Table 3.5.2

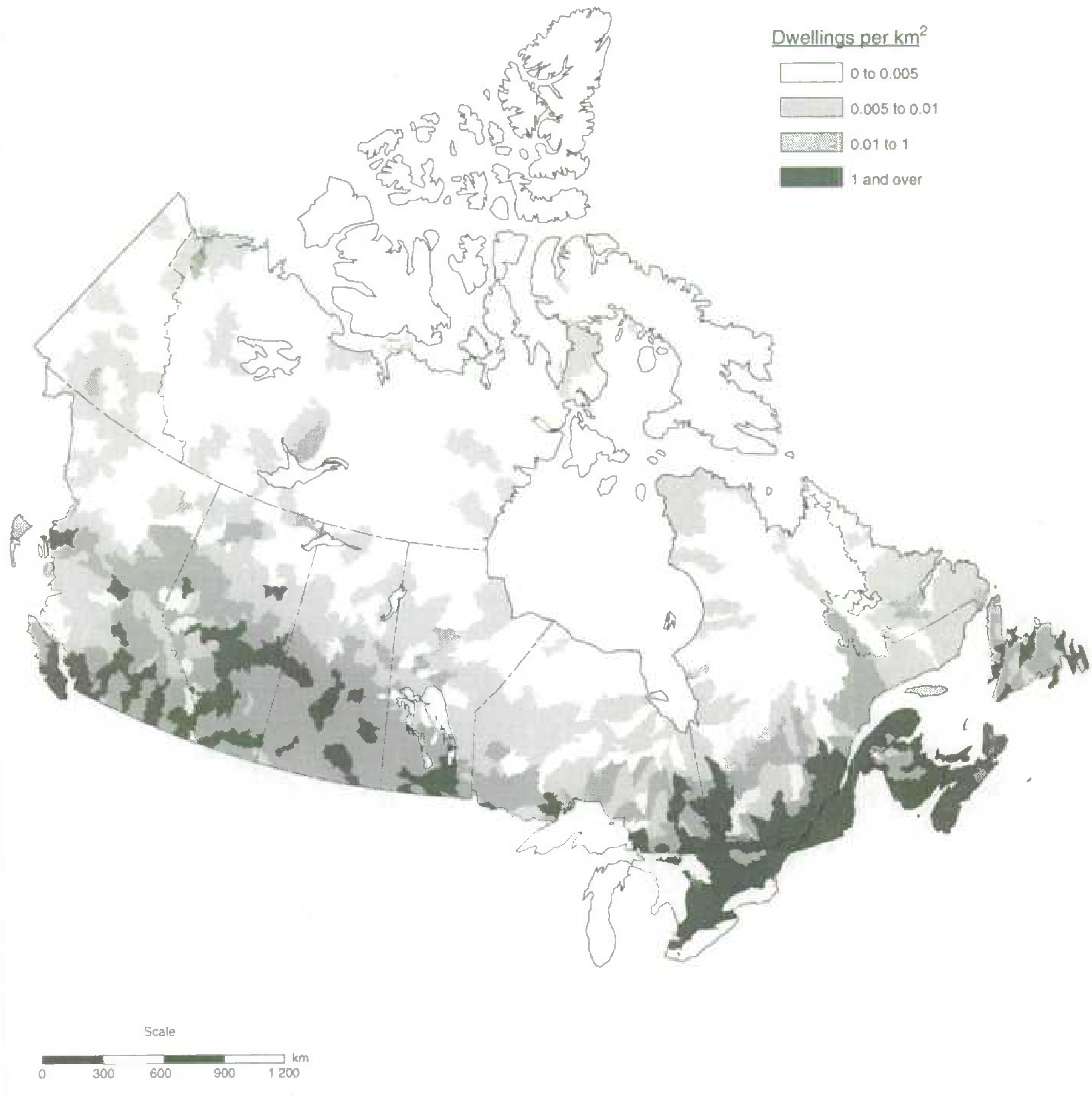
Selected Household Equipment by Income Class, 1991

Total household income	Household distribution	Home owners	Refrigerator	Automatic dishwasher	Washing machine	Clothes dryer	Air conditioner	Automobile	Van or truck	Low-flow shower head	Low-flow toilet tank	Energy efficient light bulbs
	percent											
Less than $20 000	23.0	38.7	99.2	19.1	57.3	49.3	17.7	51.5	12.1	16.5	6.1	6.7
$20 000 to $39 999	28.3	57.0	99.6	35.5	76.2	70.1	24.0	78.2	22.0	25.1	8.6	9.9
$40 000 to $59 999	23.1	72.3	99.9	51.3	85.8	82.1	28.0	87.7	26.5	32.2	10.1	12.8
$60 000 to $79 999	13.5	82.7	100.0	64.1	91.4	89.1	32.1	90.6	29.4	36.1	12.2	14.6
$80 000 and over	12.0	89.1	100.0	72.0	95.0	93.0	41.7	92.2	25.7	40.5	13.2	17.3
Canada	**100.0**	**63.6**	**99.7**	**43.7**	**78.4**	**73.4**	**26.7**	**77.6**	**22.2**	**28.1**	**9.4**	**11.4**

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, Household Facilities and Equipment Survey, Households and the Environment Survey, and Survey of Consumer Finances.

Map 3.5.1

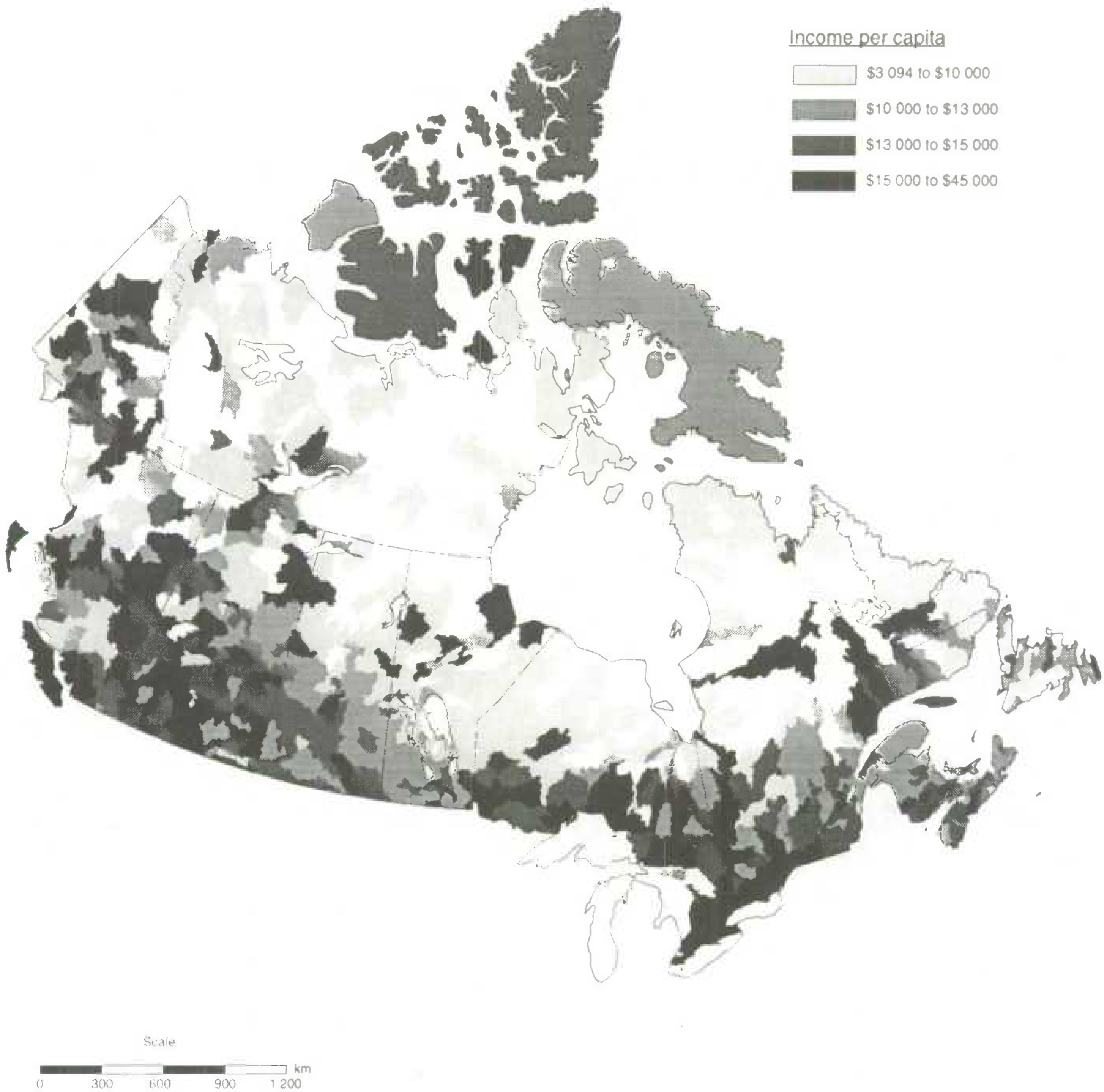
Dwelling Density by Sub-sub Basin, 1991



Source:
Statistics Canada, Census of Population.

Map 3.5.2

Income per Capita by Sub-sub Basin, 1991



Source:
Statistics Canada, Census of Population

er income households are also more likely to have invested in energy saving equipment such as energy efficient light bulbs, low-flow shower heads and low-flow toilet tanks.

Higher income households not only have different consumption patterns than their lower income neighbours, they consume more. The average expenditure for households in the lowest income quintile (the poorest 20 percent) in 1992 was $15 458, while those in the highest income quintile spent an average of $87 800.[1]

Map 3.5.2 shows the distribution of per capita income[2] across Canada. Incomes tend to be highest in densely-populated and resource-rich areas. These areas are largely concentrated along the Quebec-Windsor corridor, and throughout Alberta and British Columbia.

1. Statistics Canada, *Family Expenditures in Canada, 1992*, Catalogue No. 62-555, Ottawa, 1993.
2. Note that the income definition used for the map is per capita income derived from the 1991 Census of Population. To compare this to household income, one would multiply by the average household size.

Household Expenditure

Statistics Canada's *Family Expenditure Survey*[3] provides detailed information on household expenditures on items including those that may be considered as having an impact on the environment.

Comparing family and household expenditures from 1969 to 1992, Table 3.5.3 shows that the proportion of the aggregate expenditure on food, clothing and shelter decreased from 1969 to 1992. In 1969, these items accounted for 44 percent of total expenditure. This share had decreased to 35 percent in 1992. In 1992, personal taxes accounted for the largest portion of expenditures at 20.1 percent compared with 12.6 percent in 1969. This reflects both net in-

3. op. cit.

Table 3.5.3

Comparison of the Distribution of Expenditures[1,2], 1969-1992

Expenditure item	Share of total expenditure				Households
	1969	1978	1982	1986	1992
	percent				
Food	18.9	17.0	15.3	14.3	12.6
Shelter	15.8	16.5	17.5	16.1	17.9
Principal accommodation	15.1	15.6	16.5	15.1	16.9
Rented living quarters	5.3	4.5	4.8	4.9	5.0
Owned living quarters	6.6	7.8	8.2	7.1	8.6
Water, fuel and electricity	3.2	3.3	3.5	3.1	3.2
Other accommodation	0.8	0.9	1.0	1.0	1.1
Household operation	3.8	3.9	4.3	4.3	4.4
Household furnishings and equipment	4.1	4.4	3.6	3.6	3.0
Household furnishings	2.0	2.3	1.8	1.8	1.5
Household equipment	1.9	2.0	1.6	1.6	1.3
Services related to furnishings and equipment	0.1	0.2	0.2	0.2	0.2
Clothing	8.8	7.2	6.1	6.3	4.9
Transportation	12.5	13.0	12.1	13.2	12.5
Private transportation	11.1	11.7	10.9	12.0	11.5
Public transportation	1.5	1.2	1.2	1.2	1.0
Health care	3.4	2.0	1.9	1.8	1.9
Personal care	2.1	1.7	1.8	1.9	1.9
Recreation	4.1	5.1	4.7	5.0	5.1
Reading materials and other printed matter	0.6	0.6	0.6	0.6	0.5
Education	0.9	0.6	0.7	0.8	1.0
Tobacco products and alcoholic beverages	3.8	3.3	3.3	3.2	3.1
Miscellaneous	1.6	2.5	2.9	2.6	2.9
Total current consumption	**80.4**	**77.7**	**74.8**	**73.9**	**71.7**
Total current consumption per household (current dollars)	**$6 537**	**$14 557**	**$20 253**	**$25 994**	**$32 416**
Value index (1969=100)	100	223	310	398	496
CPI (1969=100)	100	186	279	333	427
Personal taxes	12.6	15.5	17.9	18.5	20.1
Security[3]	4.4	4.2	4.3	4.5	5.1
Gifts and contributions	2.7	2.5	3.0	3.2	3.2
Total expenditure (percent)	100.0	100.0	100.0	100.0	100.0
Total expenditure per household (current dollars)	$8 131	$18 728	$27 062	$35 179	$45 242
Value index (1969=100)	100	230	333	433	556

Notes:
Note the changeover from the spending unit (families and unattached individuals) in 1986 and prior years, to the household unit for the 1992 survey.
1. For this comparison table, the income, personal taxes and expenditure categories were changed to agree with the 1986 definition.
2. For the 1992 survey, provincial tax credits are included in income while for the 1986 survey they were considered as a negative tax.
3. *Security* includes disbursements on life insurance, social security, public and private pension plans and similar items.
Source:
Statistics Canada, *Family Expenditures in Canada, 1992*, Catalogue No. 62-555, Ottawa, 1993.

Table 3.5.4

Household Expenditure on Selected Items, 1992

Expenditure item	Average[3] per household reporting	Percentage reporting	Estimated number of households[2]	Average per household[1]	Total[4] expenditure	Percent of total current consumption[5]
	dollars	percent	thousands	dollars	million dollars	percent
Food	**5 686**	**100.0**	**9 793**	**5 686**	**55 682**	**17.5**
Shelter	**8 102**	**100.0**	**9 793**	**8 102**	**79 342**	**25.0**
Maintenance	916	44.1	4 319	404	3 956	1.2
Replacement of heating and air conditioning equipment	1 500	3.2	313	48	470	0.1
Replacement of built-in appliances	583	1.2	118	7	69	--
Caulking and weather stripping	60	6.7	656	4	39	--
Water	305	45.2	4 426	138	1 351	0.4
Fuel oil and other liquid fuel	881	15.9	1 557	140	1 371	0.4
Piped gas	712	36.5	3 574	260	2 546	0.8
Bottled gas	60	20.1	1 968	12	118	--
Fuel wood	262	12.2	1 195	32	313	0.1
Other fuel and heating costs	100	2.0	196	2	20	--
Electricity	979	86.7	8 490	849	8 314	2.6
Owned vacation home	2 258	6.6	646	149	1 459	0.5
Water and fuel	333	1.5	147	5	49	--
Electricity	488	4.3	421	21	206	0.1
Campgrounds	202	10.9	1 067	22	215	0.1
Rented vacation homes	837	4.3	421	36	353	0.1
Household operation	**1 974**	**100.0**	**9 793**	**1 974**	**19 331**	**6.1**
Cleaning supplies	257	99.2	9 715	255	2 497	0.8
Detergent and soap	127	98.6	9 656	125	1 224	0.4
Cleaning and polishing preparations	65	95.5	9 352	62	607	0.2
Toilet-bowl cleaner	23	56.1	5 494	13	127	--
Cleaning and scouring powders	21	77.7	7 609	16	157	--
Polishes and waxes	19	52.4	5 131	10	98	--
Other cleaning and polishing supplies	32	71.3	6 982	23	225	0.1
Chemical specialities	71	95.3	9 333	68	666	0.2
Bleach	18	79.2	7 756	14	137	--
Fabric softeners	35	76.3	7 472	27	264	0.1
Disinfectants and deodorizers	23	61.3	6 003	14	137	--
Paper, plastic and foil household supplies	255	99.5	9 744	254	2 487	0.8
Paper towels	35	86.4	8 461	30	294	0.1
Facial and bathroom tissue	90	98.3	9 626	88	862	0.3
Plastic garbage bags	34	75.5	7 394	26	255	0.1
Other plastic supplies	23	43.8	4 289	10	98	--
Foil supplies	20	76.5	7 492	15	147	--
Horticultural goods and services	217	71.1	6 963	154	1 508	0.5
Seeds	29	31.1	3 046	9	88	--
Nursery and greenhouse stock	112	40.9	4 005	46	450	0.1
Potted plants, cut flowers, etc.	86	41.9	4 103	36	353	0.1
Herbicides, insecticides and rodenticides	29	27.2	2 664	8	78	--
Fertilizers, soil and soil conditioners	49	40.5	3 966	20	196	0.1
Horticultural services and snow removal	247	14.6	1 430	36	353	0.1
Other household supplies	71	95.4	9 342	68	666	0.2
Dry-cell batteries	30	70.5	6 904	21	206	0.1
Household furnishings and equipment	**1 464**	**93.7**	**9 176**	**1 372**	**13 436**	**4.2**
Air conditioning and refrigeration	631	12.2	1 195	77	754	0.2
Appliances for cooking and warming food	197	37.5	3 672	74	725	0.2
Electric appliances for food preparation	85	10.6	1 038	9	88	--
Appliances for laundry	354	16.4	1 606	58	568	0.2
Other electric equipment and appliances	203	23.6	2 311	48	470	0.1
Portable electric lamps	105	15.2	1 489	16	157	--
Home and workshop tools and equipment	225	34.7	3 398	78	764	0.2
Lawn, garden and snow removal tools	208	31.3	3 065	65	637	0.2
Lawn and garden tractors and tillers	1 062	1.6	157	17	186	0.1
Power lawn-mowers	297	6.4	627	19	186	0.1
Snow blowers	733	1.5	147	11	108	--
Other lawn and garden tools	71	26.6	2 605	19	186	0.1
Clothing	**2 240**	**99.2**	**9 715**	**2 222**	**21 760**	**6.9**
Dry-cleaning service	121	63.4	6 209	77	754	0.2
Transportation	**5 743**	**98.2**	**9 617**	**5 640**	**55 232**	**17.4**
Private transportation	5 988	86.8	8 500	5 198	50 904	16.0
Purchase of automobiles and trucks	8 306	25.5	2 497	2 118	20 741	6.5
Rented and leased automobiles and trucks	1 261	11.1	1 087	140	1 371	0.4

Table 3.5.4

Household Expenditure on Selected Items, 1992 (Continued)

Expenditure item	Average[3] per household reporting	Percentage reporting	Estimated number of households[2]	Average per household[1]	Total[4] expenditure	Percent of total current consumption[5]
	dollars	percent	thousands	dollars	million dollars	percent
Operation of automobiles and trucks	3 385	86.3	8 451	2 921	28 605	9.0
Automotive fuels	1 476	83.6	8 187	1 234	12 084	3.8
Tires	311	34.1	3 339	106	1 038	0.3
Batteries	98	18.4	1 802	18	176	0.1
Maintenance and repair	562	76.9	7 531	432	4 231	1.3
Oil changes and lubrication	122	63.2	6 189	77	754	0.2
Tune-ups	193	36.8	3 604	71	695	0.2
Public transportation	642	68.9	6 747	442	4 328	1.4
Local and commuter transportation	327	57.2	5 602	187	1 831	0.6
City bus, subway and street car	281	40.2	3 937	113	1 107	0.3
Commuter bus and train	292	4.8	470	14	137	--
Local taxi service	114	28.1	2 752	32	313	0.1
Other local transportation	197	7.1	695	14	137	--
Inter-city transportation	709	35.8	3 506	254	2 487	0.8
Air	1 154	18.2	1 782	210	2 057	0.6
Rail	200	4.0	392	8	78	--
Highway bus	149	8.7	852	13	127	--
Other passenger transportation	145	8.3	813	12	118	--
Other inter-city transportation	50	10.0	979	5	49	--
Health care	**903**	**96.0**	**9 401**	**867**	**8 490**	**2.7**
Personal care	**845**	**99.9**	**9 783**	**844**	**8 265**	**2.6**
Toilet preparations and cosmetics	338	99.0	9 695	335	3 281	1.0
Toilet and other personal soap	38	91.5	8 961	35	343	0.1
Razors and razor blades	31	65.3	6 395	20	196	0.1
Disposable diapers	413	9.2	901	38	372	0.1
Personal care electric equipment	52	23.1	2 262	12	118	--
Recreation	**2 393**	**96.1**	**9 411**	**2 300**	**22 524**	**7.1**
Sporting and athletic equipment	293	43.0	4 211	126	1 234	0.4
Downhill skiing	349	4.3	421	15	147	--
Cross-country skiing	190	2.1	206	4	39	--
Fishing	124	14.5	1 420	18	176	0.1
Sleighs, toboggans and children's vehicles	66	9.1	891	6	59	--
Tents, back packs, sleeping bags	125	8.0	783	10	98	--
Other camping equipment	64	7.8	764	5	49	--
Supplies and parts for recreational equipment	81	14.9	1 459	12	118	--
Rental, maintenance and repairs	106	4.7	460	5	49	--
Recreation vehicles and outboard motors	1 130	32.3	3 163	365	3 574	1.1
Bicycles	246	13.4	1 312	33	323	0.1
Travel trailers	4 250	0.8	78	34	333	0.1
Tent trailers	1 000	0.4	39	4	39	--
Motorcycles	1 600	1.5	147	24	235	0.1
Snowmobiles	2 615	1.3	127	34	333	0.1
Boats (including canoes)	1 714	1.4	137	24	235	0.1
Other recreational vehicles	2 000	1.4	137	28	274	0.1
Outboard motors	1 429	0.7	69	10	98	--
Gasoline and other fuels	199	13.6	1 332	27	264	0.1
Home entertainment equipment and services	604	81.3	7 962	491	4 808	1.5
Recreation services	940	88.8	8 696	835	8 177	2.6
Skiing memberships	350	2.0	196	7	69	--
Skiing fees	181	9.4	921	17	166	0.1
Reading materials and other printed matter	**275**	**90.2**	**8 833**	**248**	**2 429**	**0.8**
Newspapers	136	73.7	7 217	100	979	0.3
Magazines and periodicals	100	65.9	6 454	66	646	0.2
Education	**1 031**	**41.7**	**4 084**	**430**	**4 211**	**1.3**
Tobacco products and alcoholic beverages	**1 634**	**86.3**	**8 451**	**1 410**	**13 808**	**4.3**
Miscellaneous	**1 411**	**93.7**	**9 176**	**1 322**	**12 946**	**4.1**
Total current consumption[5]	**32 416**	**100.0**	**9 793**	**32 416**	**317 447**	**100.0**

Notes:

1. This is the average of all households including those who reported no expenditures in this category.
2. The 1992 Family Expenditures Survey sampled 9 492 households. The figures above are based on an estimated 9 792 910 households for 10 provinces in Canada.
3. This is the average of those households reporting expenditures for this category.
4. Total expenditures for 10 provinces in Canada.
5. **Current consumption** includes all expenditures except: personal taxes, security, gifts and contributions.

Source:

Statistics Canada, *Family Expenditures in Canada, 1992*, Catalogue No. 62-555, Ottawa, 1994.

creases in taxes and the transfer of services, such as health insurance, from the private to the public sector.

Expenditures on water, fuel and electricity fluctuated in a narrow range between 3.1 percent and 3.5 percent of total expenditure between 1969 and 1992. Household furnishings and equipment such as couches, beds, refrigerators and stoves accounted for a slightly smaller portion of expenditure in 1992 than in 1969, decreasing from 4.1 percent to 3.0 percent.

Table 3.5.4 provides a detailed breakdown of current expenditures for Canada in 1992. In this year, shelter costs accounted for a quarter of the current expenditure of Canadian households.[1] Just over one percent of this expenditure was for home maintenance and materials. On average, 6.7 percent of households reported spending an average of $60 on caulking and weather stripping (for a total expenditure of 69 million dollars) and 1.2 percent of households each spent, on average, $583 on the replacement of built-in appliances.

Households spent $255 on detergents and soap, polishes, bleach, disinfectants and deodorizers. Some of these products contain phosphates or other potentially toxic chemicals.

More than 17 percent of total consumption, or $5 743 per household reporting, was devoted to transportation. This was the third largest share of household expenditure after shelter (25 percent) and food (17.5 percent). Over 25 percent of households reported purchasing automobiles or trucks, spending on average $8 306. More than 86 percent of the households reported expenditures on the operation of private vehicles, averaging about $3 385.

Expenditures on public transportation were reported by 68.9 percent of all households. This includes city buses and subways, as well as local taxi services. In total, over 4 billion dollars was spent on public transportation in 1992, accounting for 1.4 percent of total consumption.

Recreational activities accounted for 7.1 percent of total current consumption or $22.5 billion. Major components of this were: recreational vehicles ($3.6 billion) and recreational services ($8.2 billion).

Existing Facilities and Equipment

Expenditure data are very good indicators of current consumption, but they do not reveal what facilities and equipment households already own. Data from Statistics Canada's *Household Facilities and Equipment Survey*[2] provide dwelling characteristics, appliances and other equipment that are contained in dwellings.

Comparing the distribution of household facilities and equipment from 1982 to 1992 (Table 3.5.5) shows the increase in the proportion of households owning large appliances, vans and trucks, and recreational equipment. There has been a ten percent increase in the number of households with air conditioners and automatic dishwashers. Three-quarters of households now have clothes dryers, an increase from 66 percent in 1982.

There has been a decrease in the number of households that have two or more cars. In 1982, 28 percent of households had two or more cars, this dropped to 25 percent in 1992. However, there are significantly more vans and trucks.

The presence of bicycles, skis and ovemight camping equipment are one indication of the importance of recreational facilities and wilderness. The number of households with two or more adult-sized bicycles increased from 23 percent in 1982 to close to 30 percent in 1992. There was also a slight increase in the number of households with downhill skis, while the percentage of households with cross country skis and overnight camping equipment remained roughly the same in this time period.

Statistics Canada's *1991 Households and the Environment Survey*[3] showed that just over a quarter of households (28 percent) had low-flow shower heads and roughly 10 percent had low-flow toilet tanks. Eleven percent of households had compact fluorescent light bulbs which use less electricity to generate the same amount of light as conventional incandescent light bulbs (for more detail see Sections 3.13 to 3.16 - **Reducing Impacts on the Environment**).

1. Total consumption includes all of the expenditures of Canadian households excluding expenditures on personal taxes, gifts, security and contributions.
2. Statistics Canada, *Household Facilities and Equipment, 1992*, Catalogue No. 64-202, Ottawa, 1993.
3. Statistics Canada, *Household and Environment Survey 1991*, Catalogue No. 11-526, Ottawa, 1992.

Technical Box 3.5.1

CFCs in the home

Most Canadian households have appliances containing ozone-depleting substances. Refrigerators contain about 0.2-0.3kg of CFCs, freezers about 0.3-0.5kg, and central air conditioning units and heat pumps about 13.5 kg. About 60 percent of all new vehicles sold in Canada, and about 90 percent in the United States, have air conditioning. A typical unit in a passenger car or small commercial vehicle contains approximately 1.4-2.0 kg of CFCs. In addition, most upholstered furniture contains flexible foam, and more modern homes contain appreciable quantities of rigid foam insulation, all of which are blown with CFCs.

Source:
Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Table 3.5.5

Dwelling Characteristics, Household Facilities and Equipment, 1982 and 1992

	1982	1992	Change 1982-1992
	percent		
Dwelling characteristics			
Dwelling type			
Single detached	56.6	57.0	0.4
Single attached	8.5	9.3	0.8
Apartment or flat	32.3	31.9	-0.4
Mobile home	2.1	2.2	0.1
Tenure			
Owned	63.5	63.1	-0.4
Rented	36.5	36.9	0.4
Principal heating equipment			
Steam or hot water furnaces	20.4	15.8	-4.6
Hot air	53.6	51.8	-1.8
Heating stoves	5.0	3.1	-1.9
Electric heating	20.2	28.8	8.6
Principal heating Fuel			
Oil or other liquid fuel	31.0	16.0	-15.0
Piped gas	42.2	45.3	3.1
Electricity	21.4	33.9	12.5
Wood	4.3	3.9	-0.4
Household facilities and equipment			
Air conditioner	16.0	26.7	10.7
Microwave oven	10.3	76.0	65.7
Gas barbecue	19.9 [2]	50.5	30.6
Refrigerators	99.7	99.4	-0.3
One	84.2	80.4	-3.8
Two or more	15.4	19.0	3.6
Home freezer	54.4	57.9	3.5
Automatic dishwasher	33.7 [1]	44.2	10.5
Washing machine	77.4	78.6	1.2
Clothes dryer	66.3	74.0	7.7
Telephones	97.9	98.7	0.8
One	59.3	28.4	-30.9
Two	30.9	36.6	5.7
Three or more	7.6	33.8	26.2

	1982	1992	Change 1982-1992
	percent		
Household facilities and equipment (con't)			
Radio	98.8	98.7	-0.1
One	29.3	21.8	-7.5
Two	31.3	28.1	-3.2
Three or more	38.1	48.9	10.8
Colour television	84.8	97.5	12.7
One	72.5	54.8	-17.7
Two or more	12.3	42.7	30.4
Cable television	58.9	71.4	12.5
Video cassette recorders	6.4 [1]	73.8	67.4
One	..	64.0	...
Two or more	..	9.8	...
Camcorders	..	10.2	...
Cassette or tape recorders	54.2 [1]	72.8	34.3
Compact disk players	..	26.9	...
Home computers	..	20.0	...
Smoke detectors	65.2 [2]	90.0	24.8
Portable fire extinguishers	..	49.2	...
Households with owned vehicles	..	83.0	...
Automobiles	80.2	76.4	-3.8
One	52.0	51.9	-0.1
Two or more	28.3	24.6	-3.7
Vans or trucks	..	26.8	...
Vacation homes in Canada	6.3	6.0	-0.3
Adult-size bicycles	47.2	51.4	4.2
One	24.3	22.0	-2.3
Two or more	23.0	29.4	6.4
Downhill skis	16.6	20.2	3.6
Cross-country skis	25.3	24.9	-0.4
Boat	16.1	14.8	-1.3
Overnight camping equipment	28.3	28.6	0.3
Low flow shower head	..	28.1 [3]	...
Low flow toilet tank	..	9.4 [3]	...
Energy efficient light bulbs	..	11.4 [3]	...
Total number of households (thousands)	**8 336**	**10 056**	**1 720**

Notes:
1. Data shown are for 1983.
2. Data shown are for 1984.
3. Data shown are for 1991.

Source:
Statistics Canada, *Household Facilities and Equipment, 1992*, Catalogue No. 64-202, Ottawa, 1993.

Heating fuel

Because of Canada's climate extremes (see Section 4.11 - **Climate**), homes require some form of space heating. Although domestic heating generates relatively small quantities of air emissions (Table 3.5.6), there may still be some cause for concern in densely populated areas.

As shown in Table 3.5.7 and Figure 3.5.1, the use of oil for home heating has been declining over the past decade. This decline is due in part to the rise in fuel oil prices in the 1980s. Over 30 percent of households used fuel oil in 1982; by 1992 this had dropped to less than 20 percent.

Table 3.5.6

Selected National Emissions, 1990

Source	Carbon dioxide	Methane	Nitrogen oxide
	kilotonnes per year		
Industrial processes	28 856	1 261	31
Fuel combustion	431 538	31	47
Transportation	144 931	23	9
Stationary	286 607	8	38
Residential	40 733	2	2
Other	-	2 444	14
Total Fuel	**460 394**	**3 736**	**92**

Note:
Figures may not add due to rounding.

Source:
Environment Canada, *Canada's Greenhouse Gas Emissions: Estimates for 1990*, Catalogue No. En49-5/5-4, Ottawa, 1992.

Electricity became more common for home heating in the late 1970s when its cost was relatively low. Just over 20 percent of households used electric heat in the early 1980s. This had increased to 30 percent by 1987 and has stabilized since then. Electricity prices, however, vary greatly between regions (see Section 1.2 - **Provincial Summary Statistics** for detail on these prices). In Prince Edward Island, for example, electricity is very expensive because it must all be imported from coal generating stations in New Brunswick. Therefore, few homes in Prince Edward Island are electrically heated.

Table 3.5.7

Principle Heating Fuel by Province, 1992

Province	Oil	Gas	Electricity	Wood	Total households
	percent				thousands
Newfoundland	33.3	-	45.2	20.9	177
Prince Edward Island	82.6	-	--	13.0	46
Nova Scotia	60.5	-	25.5	11.2	329
New Brunswick	29.7	-	55.9	14.1	256
Quebec	19.4	8.5	67.8	4.1	2 656
Ontario	14.5	60.6	21.9	2.3	3 647
Manitoba	4.0	60.4	31.8	3.0	396
Saskatchewan	7.5	84.4	4.7	--	359
Alberta	2.0	93.1	2.1	--	912
British Columbia	10.2	57.2	26.8	4.9	1 278
Canada	**16.0**	**45.3**	**33.9**	**3.9**	**10 056**

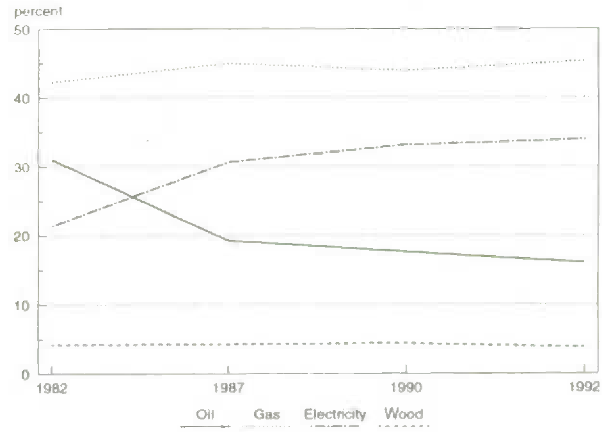
Source:
Statistics Canada, *Household Facilities and Equipment, 1992*, Catalogue No. 64-202, Ottawa, 1993.

Piped natural gas, being relatively inexpensive and clean, is the most frequently used principal heating fuel in Canada. Almost one half of all households are heated by gas. It is the fuel of choice in Alberta, where 93 percent of the households use it for heating. Natural gas is distributed via pipelines that reach only as far east as Quebec City. Many rural areas in western and central Canada are also not served. Piped gas is also not available in the Atlantic provinces.

Fewer than 4 percent of households use wood as a principal heating fuel, though many use wood for fireplaces and wood stoves as supplementary sources of heat.

Figure 3.5.1

Principal Heating Fuel, Selected Years



Source:
Statistics Canada, *Household Facilities and Equipment, 1992*, Catalogue No. 64-202, Ottawa, 1993.

Expenditures on energy

Households account for 19 percent of energy consumption in Canada. This does not include fuel used for motor vehicles. Cost and consumption tend to counterbalance each other. When the cost of fuel oil increased in the early 1970s, the demand for electricity and natural gas increased. In the case of gasoline, price increases spurred technological innovation that increased the fuel efficiency of vehicles. In 1980, the average car required 16.5 litres to travel 100 km. By 1988, automobiles averaged 12 litres to travel the same distance.[1]

The proportion spent on fuel was not much different in 1990 (6.2 percent) than it was in 1961 (6.6 percent) (Table 3.5.8). Over that time it varied from a low of 5.7 percent in 1969 and 1973 to a high of 7.7 during the early 1980s. The percent-

1. Statistics Canada, *Fuel Consumption Survey: Passenger Cars, 1979-1988*, Catalogue No. 53-007, Ottawa, 1989.

Table 3.5.8

Fuel Costs as a Percentage of Total Consumer Expenditures, 1961-1990

Fuel	1961	1963	1965	1967	1969	1971	1973	1975	1977	1979	1981	1983	1985	1987	1989	1990
	percent															
Fuelwood	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Coal	0.3	0.2	0.1	0.1	--	--	--	--	--	--	--	--	--	--	--	--
Natural Gas	0.5	0.6	0.6	0.6	0.6	0.5	0.4	0.5	0.6	0.6	0.7	0.9	0.9	0.7	0.7	0.6
Gasoline	2.6	2.4	2.5	2.6	2.6	2.7	2.7	2.9	3.0	3.0	3.7	3.7	3.6	2.9	2.8	3.0
Diesel and Fuel Oil	1.7	1.7	1.5	1.3	1.2	1.3	1.2	1.2	1.1	1.1	1.1	1.0	0.9	0.5	0.5	0.5
Electric Power	1.3	1.3	1.2	1.2	1.2	1.3	1.3	1.3	1.6	1.7	1.7	1.9	2.0	1.9	2.0	2.0
Total Fuel	**6.6**	**6.3**	**6.0**	**5.8**	**5.7**	**5.9**	**5.7**	**6.0**	**6.4**	**6.5**	**7.4**	**7.6**	**7.5**	**6.2**	**6.1**	**6.2**

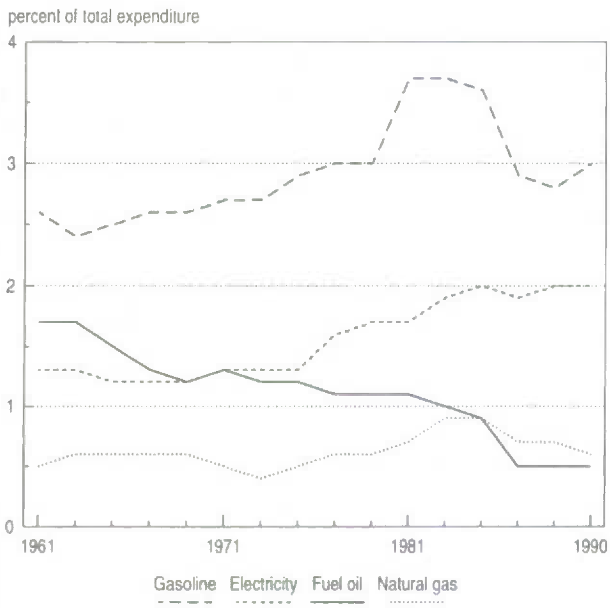
Note:
Current dollar shares.
Source:
Statistics Canada, Input-Output Division.

age of total consumer expenditures on electricity increased modestly over this time period from 1.3 percent to 2 percent. Expenditures on natural gas also increased gradually until the mid-1980s after which gas prices decreased (Figure 3.5.2).

The proportion of expenditures devoted to gasoline also increased steadily until the early 1980s when it began to climb sharply, driven by price increases. The price of regular unleaded gasoline increased from 39 cents per litre in 1980 to 47 cents in 1981. The price reached a high of 55 cents in 1985 before dropping to 49 cents per litre the next year.[1] The decrease in expenditures that followed can be attributed to moderate price decreases and reductions in consumption resulting from greater fuel efficiency.

Figure 3.5.2

Consumer Expenditures on Energy, 1961-1990



Note:
Current dollar shares.
Source:
Statistics Canada, Input-Output Division.

Summary

The consumption patterns of Canadian households are a major motivator within the economy. Consumer purchases drive industrial production, which in turn generates wastes, changes land use and consumes resources. Households also have a significant direct impact on the environment in terms of waste generation and resource consumption.

The number of dwellings is increasing at a much higher rate than the population. Between 1971 and 1991, the number of dwellings increased by over 65 percent. The amount of infrastructure and equipment has grown in parallel.

An examination of household expenditures reveals that 17.4 percent of total household consumption, on average $5 743 for each household reporting, was spent on transportation in 1992. This was the third largest share of household expenditure after shelter (25 percent) and food (17.5 percent). In total, over 4.3 billion dollars were spent on public transportation, accounting for 1.4 percent of total current consumption. Approximately 3.9 percent of consumer expenditures are for non-transportation energy: electricity and home heating.

A comparison of the distribution of household facilities and equipment from 1982 to 1992 shows that households are more likely to have resource and energy intensive equipment than they did before. There has been a ten percentage point increase in the number of households with air conditioners and automatic dishwashers. Three-quarters of households now have clothes dryers, increasing from 66 percent in 1982.

Although there is a heightened awareness and perceived importance of environmental and conservation issues (see Section 2.5 - **Perceptions and Attitudes**), Canadians continue to increase their consumption of goods which can be considered harmful to the environment. Progress in lowering energy consumption has been mainly due to price increases rather than a concerted effort to conserve resources for environmental protection reasons. Canadians continue to purchase more appliances (albeit, more energy-efficient ones) than ever before. At the same time, they continue to purchase outdoor recreational equipment and travel to "wilderness areas" in order to appreciate the environment (see Section 2.6 - **Recreation and the Environment**).

1. Statistics Canada and Energy Mines and Resources Canada, *Energy Statistics Handbook*, Catalogue No. 57-601, Ottawa, 1992.

3.6 International Trade

Almost one-quarter of the value of Gross Domestic Product is traded with foreign countries. In principle, this exchange gives Canada the opportunity to purchase products that can be made more efficiently in other countries and conversely, to sell to others what can be made at lower cost in Canada. Recent developments towards the formation of trading blocs in the European Community and North America are predicated upon the concept of mutual benefit from increased international trade.

From an environmental perspective, the net advantages from trade are not always clear. For example, the benefit of consuming tropical hardwood and bananas in Canada must be weighed against the local environmental costs of restructuring land, loss of rainforest and transportation of these products over thousands of kilometres. The traditional reasons for limiting trade have been the desire for self-sufficiency in strategic materials and the need to protect developing industries. The more recent goal of economic sustainability provides another argument for self-sufficiency:

> "Sustainable development means living within the constraints imposed by the ability of the environment to regenerate what has been mined and harvested and to absorb what has been discarded. These constraints are both global (greenhouse effect, ozone shield), and local (soil erosion, deforestation). Trade between nations or regions offers a way of loosening local constraints by importing environmental services, including waste absorption, from elsewhere. There is no mechanism for

Table 3.6.1

Export and Import Propensities, Selected Years

Commodity	Export propensities 1961	1970	1980	1990	Import propensities 1961	1970	1980	1990
	percent of production				percent of use			
1 Grains	134.5	104.4	84.1	47.1	14.3	8.8	14.6	4.2
2 Other agricultural products	7.6	7.1	9.4	11.0	8.5	9.7	10.3	12.4
3 Forestry products	5.3	4.8	2.3	1.5	2.1	2.4	2.1	2.6
4 Fishing and trapping products	28.2	29.3	23.9	22.8	17.4	21.1	19.5	4.3
5 Metallic ores and concentrates	44.9	42.5	57.0	59.6	17.7	15.2	51.8	36.2
6 Mineral fuels	31.3	49.9	40.7	44.7	53.7	51.4	45.8	35.4
7 Non-metallic minerals	52.1	54.2	59.1	36.2	33.2	35.2	34.3	37.9
Total raw materials	**28.5**	**28.9**	**34.7**	**30.6**	**17.5**	**17.0**	**28.6**	**20.0**
9 Meat, fish and dairy products	7.7	9.5	14.1	16.6	4.4	5.8	6.8	10.4
10 Fruit, vegetables and other food products	6.0	6.7	8.4	8.8	13.2	12.1	14.6	17.4
11 Beverages	15.0	17.9	15.9	11.2	11.0	11.5	15.2	17.4
12 Tobacco and tobacco products	8.5	10.6	6.3	5.7	3.1	2.7	5.8	5.5
13 Rubber, leather and plastic fabricated products	4.3	6.1	12.3	25.8	18.0	26.0	32.7	47.6
14 Textile products	5.2	5.6	9.9	15.5	32.8	29.6	33.8	39.3
15 Knitted products and clothing	0.9	4.4	5.2	5.3	8.7	11.8	19.5	35.9
16 Lumber, sawmill and other wood products	39.6	39.1	47.2	39.4	9.3	7.8	11.3	11.6
17 Furniture and fixtures	0.7	5.1	9.8	15.6	9.5	7.6	13.4	28.7
18 Paper and paper products	49.9	48.0	55.0	52.1	8.1	8.7	12.5	18.0
19 Printing and publishing	0.8	2.2	4.0	3.6	14.8	16.1	13.7	16.6
20 Primary metal products	42.1	46.1	45.5	47.7	16.6	21.3	26.7	30.8
21 Metal fabricated products	2.6	6.7	11.2	13.0	20.9	18.6	24.7	27.4
22 Machinery and equipment	21.0	32.9	42.8	51.2	63.7	63.9	78.2	82.6
23 Autos, trucks and other transportation equipment	9.2	66.5	65.8	73.7	37.4	66.7	71.3	75.3
24 Electrical and communications products	5.5	16.7	20.1	35.3	28.5	30.1	44.2	63.0
25 Non-metallic mineral products	5.8	6.7	10.3	12.4	19.0	15.9	20.9	25.3
26 Petroleum and coal products	1.1	4.2	15.9	15.9	9.3	11.4	6.9	14.8
27 Chemicals and chemical products	14.4	16.9	24.4	24.4	24.5	26.2	29.9	34.7
28 Miscellaneous manufactured products	9.1	14.4	36.4	37.5	44.6	52.2	63.3	71.1
Total manufactured products	**15.7**	**25.5**	**29.6**	**34.7**	**21.5**	**27.7**	**33.3**	**41.5**
32 Transportation and storage	6.9	8.2	6.0	5.1	2.9	3.3	2.9	2.3
33 Communication services	2.0	1.2	1.7	2.8	0.5	1.2	2.2	3.4
34 Electric power and other utilities	1.4	1.6	8.4	2.3	0.1	0.6	0.1	2.4
35 Wholesale margins	4.9	8.8	11.6	11.3	0.4	1.5	1.8	1.4
38 Finance, insurance and real estate	0.8	0.8	0.8	1.9	1.8	2.7	2.7	4.7
39 Business services	7.0	7.6	9.4	8.1	17.3	16.1	17.4	13.0
40 Personal and other miscellaneous services	0.2	0.8	0.7	1.4	0.6	1.2	1.3	1.7
41 Transportation margins	22.5	27.9	33.8	35.8	0.1	0.1	0.1	0.5
Total services	**4.5**	**5.3**	**5.5**	**5.0**	**3.1**	**3.7**	**3.6**	**4.6**
All commodities	**10.7**	**14.4**	**16.9**	**15.8**	**11.3**	**13.5**	**16.7**	**17.4**

Notes:

Exports of grain in excess of production are supplied from inventories.

Commodities that are not traded have been suppressed.

Sources:

Statistics Canada, National Accounts and Environment Division and Input-Output Division.

ensuring that these absorptive and regenerative capacities are respected on a global basis".[1]

In other words, trade can allow a country to avoid coming to terms with many of the environmental effects of its imports.

Table 3.6.1 shows the importance of traded goods and services for selected years over the period 1961 to 1990. Export propensities present exports as a percentage of the total value of production while import propensities express imports as a percentage of total use in Canada. For example, in 1961, 5.5 percent of the production of electrical and communications products (commodity no. 24) was exported. By 1990, this proportion was 35.3 percent. Over the same period, imports increased from 28.5 to 63 percent of total Canadian use of electrical and communications products.

Since 1961, exports of all goods and services have increased from 10.7 to 15.8 percent of total production and imports have climbed from 11.3 to 17.4 percent of consumption. The most striking change in the structure of Canada's international trade over the last three decades has been the increase in the relative proportion of trade in man-

1. Daly, H. and R. Goodland, "An Ecological-Economic Assessment of Deregulation of International Commerce under GATT", working paper, The World Bank, Washington, 1992.

Table 3.6.2

Energy Requirements of Exports and Imports, 1981 and 1990

Commodity	Energy requirements per dollar of production		Imports		Import energy requirements		Exports		Export energy requirements	
	1981	1990	1981	1990	1981	1990	1981	1990	1981	1990
	megajoules per 1986$		million 1986$		terajoules		million 1986$		terajoules	
1 Grains	22.8	21.4	207.8	89.5	4.7	1.9	2 638.5	2 758.2	60.2	59.0
2 Other agricultural products	22.8	21.3	1 692.7	2 081.6	38.6	44.5	1 094.9	1 817.4	24.9	38.8
3 Forestry products	15.4	14.5	133.6	264.0	2.1	3.8	123.5	98.0	1.9	1.4
4 Fishing and trapping products	21.2	17.6	185.7	69.2	3.9	1.2	292.5	357.3	6.2	6.3
5 Metallic ores and concentrates	29.6	25.7	2 049.8	2 374.4	69.8	68.9	4 988.7	6 371.2	156.4	156.6
6 Mineral fuels	22.6	29.9	5 094.1	5 343.3	116.9	152.8	4 031.7	9 718.9	92.7	284.4
7 Non-metallic minerals	26.4	26.2	452.6	728.7	16.1	23.9	1 630.7	1 155.9	44.4	37.8
Total raw materials	**25.9**	**26.5**	**9 816.3**	**10 950.7**	**252.1**	**297.0**	**14 800.5**	**22 276.9**	**386.7**	**584.3**
9 Meat, fish and dairy products	18.4	17.3	1 036.2	1 992.2	18.5	32.3	2 784.4	3 546.6	48.7	54.4
10 Fruit, vegetables, and other food products	15.5	14.6	2 048.1	3 179.3	32.2	46.6	1 269.7	1 419.5	20.4	21.4
11 Beverages	13.1	12.3	703.7	972.8	12.0	14.0	709.5	561.5	11.7	8.8
12 Tobacco and tobacco products	10.8	10.8	75.2	85.5	0.8	0.9	173.9	85.7	1.9	0.9
13 Rubber, leather and plastic fabricated products	20.9	18.2	2 459.2	4 702.4	46.6	77.4	808.4	1 840.3	17.0	33.9
14 Textile products	21.4	19.1	2 280.3	3 235.3	48.9	61.0	493.8	858.1	10.9	16.4
15 Knitted products and clothing	11.7	11.4	1 448.6	2 824.6	16.5	31.6	302.4	339.0	3.4	3.8
16 Lumber, sawmill and other wood products	15.6	13.4	808.9	1 077.1	13.1	14.6	4 585.5	5 919.9	75.7	81.3
17 Furniture and fixtures	13.4	13.0	545.4	1 638.0	7.1	21.1	391.6	711.4	5.2	9.0
18 Paper and paper products	35.7	35.5	1 347.4	2 690.8	40.4	75.4	9 625.8	11 570.5	393.5	462.1
19 Printing and publishing	12.0	13.2	1 395.6	2 118.6	16.5	28.2	284.1	413.4	3.4	5.5
20 Primary metal products	45.8	40.8	3 927.1	5 057.5	166.4	175.8	6 956.7	8 945.7	331.4	382.7
21 Metal fabricated products	23.3	20.5	4 124.1	5 152.8	89.6	101.2	1 552.3	1 901.5	36.5	38.3
22 Machinery and equipment	14.9	11.9	12 901.3	25 512.3	207.8	267.9	4 760.6	8 196.3	78.2	80.2
23 Autos, trucks and other transportation equipment	16.5	13.6	25 788.4	37 743.0	424.8	525.3	21 066.5	39 635.5	335.0	532.9
24 Electrical and communications products	11.5	9.8	7 389.0	16 518.5	86.1	148.5	2 727.4	6 054.6	28.6	48.1
25 Non-metallic mineral products	36.6	34.7	1 329.2	2 006.8	45.4	60.1	646.1	847.0	25.5	27.6
26 Petroleum and coal products	36.5	44.8	1 090.1	2 594.8	40.5	117.8	2 210.1	2 947.0	79.5	128.9
27 Chemicals and chemical products	33.1	29.5	4 913.7	9 105.5	167.4	280.7	3 163.8	5 181.9	127.7	186.1
28 Miscellaneous manufactured products	15.2	14.6	5 636.8	8 119.6	78.0	102.9	1 367.0	2 637.2	22.3	37.4
Total manufactured products	**21.9**	**18.1**	**81 248.3**	**136 327.0**	**1 558.6**	**2 183.3**	**65 879.6**	**103 613.0**	**1 656.5**	**2 159.7**
32 Transportation and storage	26.7	25.3	931.3	923.9	32.8	26.9	1 866.2	2 378.9	58.9	73.2
33 Communication services	4.4	3.4	373.0	905.2	1.5	2.7	226.5	632.9	1.0	2.0
34 Electric power and other utilities	65.2	67.5	13.6	511.9	1.0	38.4	1 119.4	505.5	81.8	38.1
35 Wholesale margins	10.7	8.6	453.1	560.3	4.8	4.8	2 928.1	5 017.1	31.2	43.4
36 Retail margins	9.8	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 Imputed rent on owner occupied dwellings	0.7	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 Finance, insurance and real estate	7.6	7.9	2 225.2	5 278.7	17.3	41.2	597.0	1 572.9	4.1	10.9
39 Business services	4.7	3.8	6 918.1	5 748.6	26.8	21.8	1 957.9	2 770.7	8.1	10.3
40 Personal and other miscellaneous services	8.8	8.4	920.5	1 207.2	9.7	12.8	370.0	1 046.3	3.6	10.0
41 Transportation margins	24.8	23.0	0.0	0.0	0.0	0.0	4 295.1	6 273.5	106.7	144.5
Other services	...	...	7 865.5	12 277.1	...	...	8 982.6	8 400.7	...	...
Total services	**15.5**	**13.6**	**19 700.3**	**27 412.9**	**93.9**	**148.6**	**22 342.8**	**28 598.5**	**295.4**	**332.4**
All commodities	**21.5**	**18.5**	**110 765.0**	**174 691.0**	**1 904.6**	**2 628.9**	**103 023.0**	**154 488.0**	**2 338.6**	**3 076.4**

Notes:
The energy requirements of a commodity is the direct and indirect energy required to produce it.
Commodities that are not traded have been suppressed.
Sources:
Statistics Canada, National Accounts and Environment Division and Input-Output Division.

ufactured goods, and transportation goods in particular. This has largely been due to the Automotive trade agreement between Canada and the United States known as the Auto Pact.

It is difficult to determine the environmental impacts of changing trade structure since there is no comprehensive indicator of the environmental effects of each traded commodity. One clear environmental link, is the impact that the energy intensity of a good or service has on the environment[1] (see Section 3.12 - **Energy**). Table 3.6.2 shows the energy requirements of traded goods and services for 1981 and 1990.[2] The first two columns present energy requirements per dollar of production of each commodity (or energy intensities). The next two columns show imports in 1981 and 1990 and the following two columns are the product of the energy intensity and imports. Similarly, the energy requirements of exports are shown as the product of the energy intensities and the dollar value of exports.[3] For example, for one 1986 dollar of primary metal products produced in 1990, 40.8 megajoules of energy were required (slightly more than the energy contained in 1 litre of gasoline). Imports of these products amounted to $5.1 billion dollars in 1990 and the total energy requirement to produce these imports is estimated at 175.8 terajoules.

Although overall energy intensities (in megajoules per 1986 dollar) have declined from 21.5 to 18.5 over the period from 1981 to 1990, the increased volume of imports and exports has led to larger trade in required energy. The most important exported good in terms of required energy in 1990 was automobiles. This commodity ranked second in 1981, following paper products. Imports of automobiles also ranked first in required energy in both 1981 and 1990. The energy to produce one dollar of automobiles is lower than the Canadian average but its high rank in terms of required energy in exports and imports is explained by the high volume of trade in this commodity.

The energy requirements of Canadian exports exceed those of Canadian imports although the gap has narrowed since 1981. In economic terms, a positive trade balance is desirable since the excess earnings can be used to reduce foreign debt or to invest abroad. A trade surplus in required energy means, however, that Canadians accept more environmental consequences from energy use in producing exports than our trading partners do[4] in producing our imports.

1. Energy is used here as a proxy for environmental impact but there are other determinants of this such as toxic chemicals, pollutants and other wastes which, although important, have not yet been systematically compiled. The energy intensity of grain production, for example, is only slightly above average but this does not take into account the problems of soil erosion or the impacts of pesticides.
2. Based upon assumptions described in "Canadian Greenhouse Gas Emissions: An Input-Output Study" in *Environmental Perspectives 1993*, Statistics Canada, Catalogue No. 11-528, Ottawa, 1993.
3. Since these multiplications are done at a more detailed level of aggregation, this result cannot be verified in Table 3.6.2.
4. Of course the global effects of energy use are not restricted to the country where the energy is used.

Other Effects of Trade

Energy intensity has been used here as a proxy for environmental impact although there are many activities that affect the environment that are not particularly energy intensive relative to the Canadian average. For example, the energy intensity of agriculture is only slightly higher than average (21.4 megajoules per 1986 dollar) but certain agricultural practices can have particularly harmful effects on soil and water quality (see Sections 3.8 - **Agricultural Chemicals** and 3.9 - **Agricultural Impacts on Lands**). The energy intensities of lumber and sawmill products (40 percent of which were exported in 1990) are lower than average at 13.4 megajoules per dollar, yet chemicals preservatives used in some lumber products have an adverse environmental impact.[5]

Another example of international trade with direct environmental relevance is the cross border transportation of wastes. This activity takes advantage of lower landfill tipping fees or incineration facilities.

Summary

Canada's international trade has increased in importance since 1961 and the change has been particularly marked in manufactured goods. Automobiles were the most important traded good in 1981 and 1990 and this commodity represented the largest single quantity of required energy, surpassing that of paper products and primary metal products. The energy intensity of traded goods and services has declined since 1981, but the increase in the volume of trade has more than compensated for this efficiency gain. Openness to trade can be beneficial to a country in terms of economic efficiency, but the economic and environmental effects are difficult to quantify.

5. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991, p.10-20.

Environmental Impacts

Almost all human activities influence the environment. Human activities generate wastes, deplete soil nutrients, change land-use, divert water, introduce exotic species and cause disturbances of many kinds. This section takes a broad overview of waste generation, agricultural impacts on land, water diversions, changes in soil nutrients and energy. An understanding of these processes is key to the reduction of their environmental impacts.

3.7 Wastes

The generation and disposal of wastes from human activity is one of the most serious environmental problems in Canada. Excessive solid wastes are creating problems for municipalities that no longer have the space to bury their garbage; emissions from automobiles and industrial processes not only cause local pollution problems but are suspected of contributing to deforestation and global climate change; effluents from sewers and factories contribute to the pollution of rivers and lakes; and toxic substances have found their way into biological food chains and into humans.

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Wastes, as defined in this section, include pollutants, effluents, emissions, residuals, hazardous wastes, toxics and contaminants. The sources of these by-products or wastes are numerous, as are their physical and chemical properties. Furthermore, each waste material has a unique pathway of entry, life cycle and impact on the environment. We have as yet no global overview of the relative contribution of each human activity to the total waste load. Information on the generation of pollutants tends to be focused on a single region, a single industry or a single type of contaminant.

Definitions and Concepts

Wastes are often categorized by their impact on the environment, source or treatment. The term **solid wastes** generally refers to the garbage collected from households and industries that requires incineration or disposal in a landfill. **Liquid wastes and effluents** are the sewage from household and industrial processes. **Wastewater** is usually not included in the definition of liquid waste and generally refers to water that has been degraded in quality by human activities. **Hazardous wastes** can be solid, liquid or gaseous and are considered to be harmful to human health or to other living organisms due to their toxic, radioactive, flammable or infectious properties. **Air emissions** include any unwanted by-products of human activities that are released to the air.

These common definitions often detract from the fact that these wastes can be transformed from one media to the other. In the Great Lakes, for example, 69 percent of the ethylbenzine loading is attributed to releases emitted via the air.[1] Most definitions also overlook the overlaps between the categories: household solid wastes in Ontario,[2] for example, contained 23.4 thousand tonnes of hazardous household wastes in 1989. Technical Box 3.7.1 presents the materials-based classification of wastes proposed by Statistics Canada.

One goal of Statistics Canada's Environment and Natural Resource Accounts Program (see Chapter 5 - **Environmental Accounting**) is to record the physical quantities of wastes generated over time and to link these flows to economic production and consumption. One component of the waste accounts has been developed to link economic activities with the emission of greenhouse gases. The results of this project are provided later in this section.

Solid Wastes

The Office of Waste Management, Environment Canada, estimates that over 32 million tonnes of solid wastes are generated each year in Canada. Residential waste accounted for almost half of this total as shown in Statistics Canada's *Survey of Local Government Waste Management Practices.*[3] In Ontario alone, the industrial, commercial and institutional sector generated about 5.4 million tonnes of solid waste in 1989.

Residential Waste Generation and Disposal

Tables 3.7.1 through 3.7.3 present information on the collection and generation of residential waste from Statistics Canada's *Survey of Local Government Waste Management Practices.* The survey was sent to all municipalities in Canada with a population greater than 10 000 and to a sample of those municipalities with a population less than 10 000. In addition, a number of municipal entities that operate as regional governments and waste commissions were also surveyed. Approximately 1 000 local governments were surveyed in all.

According to the estimates from this survey, municipal waste totalled 10.2 million tonnes for Canada in 1990. The average of 380 kilograms per capita was exceeded most markedly in Newfoundland (470 kilograms per capita), New Brunswick (450 kilograms per capita) and Quebec (440 kilograms per capita). The highest generation rates were in smaller municipalities (Table 3.7.3).

1. International Joint Commission, *1989 Report on Great Lakes Water Quality,* Windsor, Ontario, 1989.
2. Ontario Ministry of the Environment, *The Physical and Economic Dimensions of Municipal Solid Waste Management in Ontario,* Toronto, 1991.
3. Statistics Canada, "Local Government Waste Management Practices Survey", *Environmental Perspectives 1993,* Catalogue No. 11-528, Ottawa, 1993.

Technical Box 3.7.1

A Materials-based Classification of Wastes

The following classification of wastes, proposed by Statistics Canada, is based on physical and chemical properties. It provides a consistent dimension in classifying wastes, the long-term goal being to account for the sources and disposal. A structured classification, such as this, will provide a basis for better linking environmental quality (for example, chemical oxygen demand levels in water or sulphur dioxide concentrations in air) with the activities responsible for generating the wastes.

1 Waste organic matter
- 1.1 Non-volatile organic liquids
- 1.2 Volatile organic liquids
- 1.3 Plastic, rubber and synthetic textiles
- 1.4 Grease, oil and organic sludges
- 1.5 Biological-source material
  - 1.5.1 Wood and related material (e.g. bark, sawdust)
  - 1.5.2 Plant material (e.g. food scraps, agricultural debris)
  - 1.5.3 Paper
  - 1.5.4 Animal material
  - 1.5.5 Natural textiles
  - 1.5.6 Sewage
- 1.6 Other organic wastes, including mixtures

2 Waste inorganic matter
- 2.1 Metals and metallic compounds
  - 2.1.1 Radioactive
  - 2.1.2 Non-radioactive
- 2.2 Gaseous inorganic oxides (e.g. carbon dioxide)
- 2.3 compounds with nitrogen, phosphorus or sulphur functional groups (e.g. phosphates, mineral acids)
- 2.4 Minerals and mineral-based materials (e.g. mine tailings, glass)
  - 2.4.1 Radioactive
  - 2.4.2 Non-radioactive
- 2.5 Ash, soot and other particulate matter
- 2.6 Other inorganic wastes, including mixtures

3 Composite goods
- 3.1 Transportation equipment
- 3.2 Machinery and appliances
- 3.3 Furniture
- 3.4 Other composite goods

4 Waste energy: heat, noise, electromagnetic radiation

The following definitions apply to the tables:

Waste collected by municipality is the number of tonnes of residential waste collected by municipalities. It does not include collection carried out by private enterprises not under contract to a municipality. It also, in principle, does not include waste that was recycled. The results represent reported weights plus imputations for the non-surveyed entities.

Waste not collected by municipality represents the weight of residential garbage collected by private enterprises on contract directly to individual householders, apartment building owners and other landlords. It also includes estimates of garbage taken to disposal facilities by individuals or disposed of themselves (for example, by burning in rural areas).

This survey was designed to provide estimates by province but not necessarily by ecozone. Consequently, in ecozones that are comprised mainly of municipalities with a population of less than 10 000, there may be insufficient representation of sampled units to provide a reasonable estimate. Furthermore, since the survey targeted municipalities, that proportion of the population living in rural areas and not part of an organized municipality was not covered. Estimates of waste generated for this segment of the population were based upon the reported per capita waste generated by municipalities with a population less than 10 000. This waste is included in the category *Not Collected by Municipality.*

Municipal and Industrial Wastes in Ontario

An Ontario study provides some insight into the composition and relative contributions of residential, industrial, commercial and institutional solid wastes. The Ontario Ministry of Environment[1] estimated that in 1989, the residential sector produced over 4 million tonnes of solid wastes and the industrial, commercial and institutional (ICI) sector generated another 5.4 million tonnes. Recycling diverted 206 thousand tonnes of residential waste and 280 thousand tonnes of ICI waste. Most of the remaining 9 million tonnes was sent to one of Ontario's 1 400 landfill sites.

The study estimated that 40 percent of Ontario's landfill capacity would be lost in the subsequent three years. The province's landfill capacity is expensive to increase because of stringent conditions for approving new landfill sites, increased tipping fees and financial deposits required to ensure that potential long-term environmental problems are dealt with.

Ontario's residential waste was found to have been composed mainly of paper (36 percent) and organic materials (32 percent). Table 3.7.4 provides more detail on the composition of residential wastes.

Industrial wastes contained a majority of wood (22 percent) and "other" (23.6 percent). This "other" category contains potentially recyclable items (Table 3.7.5). Major contributors to the waste stream include the construction industry (29.9 percent in 1989) and communications and services (21.5 percent).

In interpreting the results of this study, it is important to note that several large components of industrial, commercial and institutional waste were not considered and are therefore not included in the figures.

1. Ontario Ministry of Environment, *The Physical and Economic Dimensions of Municipal Solid Waste Management in Ontario*, Toronto, 1991.

Table 3.7.1

Municipal[1] Waste Production and Collection by Province, 1990

Province/Territory	Population 1990[2]	Collected by municipality	Not collected by municipality	Total waste generated	Waste generated per capita
	persons	tonnes			tonnes per capita
Newfoundland	573 000	195 575	74 203	269 778	0.47
Prince Edward Island	130 800	23 717	27 803	51 520	0.39
Nova Scotia	895 400	292 952	68 937	361 889	0.40
New Brunswick	722 900	195 410	126 426	321 836	0.45
Quebec	6 776 000	2 672 667	292 344	2 965 011	0.44
Ontario	9 765 100	3 115 185	323 521	3 438 706	0.35
Manitoba	1 089 100	353 542	43 608	397 150	0.36
Saskatchewan	996 400	356 693	52 403	409 096	0.41
Alberta	2 478 400	780 344	102 353	882 697	0.36
British Columbia	3 140 300	742 985	280 399	1 023 384	0.33
Yukon	26 000	4 128	4 328	8 456	0.33
Northwest Territories	54 000	15 769	5 929	21 698	0.40
Canada	**26 647 400**	**8 748 967**	**1 402 254**	**10 151 221**	**0.38**

Notes:
1. For municipalities with population less than 10 000, estimates were based on average *per capita* waste generation.
2. 1990 population estimate.
Source:
Statistics Canada, *Survey of Local Government Waste Management Practices 1991*.

Table 3.7.2

Municipal[1] Waste Production and Collection by Ecozone, 1990

Ecozone	Population 1990[2]	Collected by municipality	Not collected by municipality	Total waste generated	Waste generated per capita
	persons	tonnes			tonnes per capita
Tundra Cordillera	300	-	117	117	0.40
Boreal Cordillera	27 700	4 478	6 547	11 025	0.40
Pacific Maritime	2 448 700	572 241	236 314	808 555	0.30
Montane Cordillera	734 300	165 866	116 637	282 503	0.40
Boreal Plains	533 800	174 742	69 225	243 967	0.50
Taiga Plains	17 600	6 053	1 151	7 204	0.40
Prairie	3 898 500	1 293 537	168 791	1 462 328	0.40
Taiga Shield	54 600	13 878	8 580	22 458	0.40
Boreal Shield	2 646 600	859 153	339 279	1 198 432	0.50
Hudson Plains	10 400	2 253	2 089	4 342	0.40
Mixed Wood Plains	14 282 300	5 056 697	173 865	5 230 542	0.40
Atlantic Maritime	1 961 700	589 907	277 127	867 034	0.40
Southern Arctic	16 500	5 234	1 554	6 788	0.40
Northern Arctic	12 500	4 234	918	5 152	0.40
Arctic Cordillera	1 900	697	56	753	0.40
Canada	**26 647 400**	**8 748 970**	**1 402 250**	**10 151 200**	**0.40**

Notes:
1. For municipalities with population less than 10 000, estimates were based on average *per capita* waste generation.
2. 1990 population estimate.
Source:
Statistics Canada, *Survey of Local Government Waste Management Practices 1991*.

Table 3.7.3

Municipal[1] Waste Production and Collection by Size of Municipality, 1990

Municipality population class	Population 1990[2]	Collected by municipality	Not collected by municipality	Total waste generated	Waste generated per capita
	persons	tonnes			tonnes per capita
Greater than 50 000	13 624 800	4 376 440	385 574	4 762 010	0.35
10 000 to 50 000	5 273 500	1 924 350	74 842	1 999 190	0.38
Fewer than 10 000	7 749 100	2 448 180	941 838	3 390 020	0.44
Canada	**26 647 400**	**8 748 970**	**1 402 250**	**10 151 200**	**0.38**

Notes:
1. For municipalities with population fewer than 10 000, estimates were based on average *per capita* waste generation.
2. 1990 population estimate.
Source:
Statistics Canada, *Survey of Local Government Waste Management Practices 1991*.

Table 3.7.4
Residential Waste Composition in Ontario, 1987 and 1989

Waste type	1987 Quantity	1987 Percent of total	1989 Quantity	1989 Percent of total
	tonnes	percent	tonnes	percent
Paper	1 423 800	36.5	1 474 000	36.4
Newsprint	650 200	16.7	673 200	16.6
Fine paper	71 500	1.8	74 000	1.8
Boxboard	167 200	4.3	173 100	4.3
Other corrugated cardboard	105 200	2.7	108 900	2.7
Magazines	159 500	4.1	165 100	4.1
Mixed paper (waxed/plastic/mixed)	57 300	1.5	59 300	1.5
Phone books	12 600	0.3	13 000	0.3
Composite packaging	11 000	0.3	11 400	0.3
Other (kraft, wallpaper, tissue)	189 300	4.9	196 000	4.8
Glass	281 200	7.2	291 200	7.2
Food/beverage containers	259 300	6.6	268 500	6.6
Other	21 900	0.6	22 700	0.6
Tinplate steel	224 800	5.8	232 800	5.7
Food/beverage containers	72 500	1.9	75 100	1.9
Appliances	97 900	2.5	101 400	2.5
Other	54 400	1.4	56 300	1.4
Aluminum	17 000	0.4	31 100	0.8
Beverage containers	-	-	13 500	0.3
Other containers	10 000	0.3	10 400	0.3
Foil (rigid and flexible)	2 800	0.1	2 900	0.1
Other	4 200	0.1	4 300	0.1
Plastic	243 600	6.2	252 200	6.2
PET[1]	3 700	0.1	3 800	0.1
HDPE[2]	11 100	0.3	11 500	0.3
Other rigid	108 100	2.8	111 900	2.8
Film	120 700	3.1	125 000	3.1
Organics	1 235 400	31.7	1 279 000	31.6
Food waste	603 300	15.5	624 600	15.4
Yard waste (leaves, grass and weeds)	472 800	12.1	489 500	12.1
Yard waste (other)	159 300	4.1	164 900	4.1
Wood waste	45 100	1.2	46 700	1.2
Construction and demolition waste	61 400	1.6	63 600	1.6
Drywall	11 100	0.3	11 500	0.3
Other	50 300	1.3	52 100	1.3
Diapers	107 200	2.7	111 000	2.7
Used tires	800	0.0	800	0.0
Household hazardous wastes	22 600	0.6	23 400	0.6
Other[3]	239 000	6.1	247 400	6.1
Total Ontario	**3 901 900**	**100.0**	**4 053 200**	**100.0**

Notes:
1. Polyethelyne terephthalate used mostly in soft-drink bottles.
2. High density polyethelyne.
3. *Other* includes clothing, textiles, batteries, footwear, furniture, leather, ash and porcelain.

Source:
Ontario Ministry of Environment, *The Physical and Economic Dimensions of Municipal Waste Management in Ontario*, Toronto, 1991.

These items include:

- construction/demolition waste not disposed in public landfill sites;
- waste from decommissioning and clean-up of spills and contaminated soils;
- road construction and maintenance wastes;
- dredging of water bodies;
- foundry sand, blast furnace slag, fly ash, bottom ash, compost and sewage sludge.

Information was also not available for all components of each industry. The agriculture industry, for example, was represented by samples taken from greenhouse wastes. The mining industry was excluded because Northern Ontario was not included in the study.

Ocean Dumping

Permits are issued by Environment Canada to allow dumping of selected wastes at ocean dumping sites. In 1991-92, 225 permits were issued for a total of 5.8 million tonnes of wastes, consisting of mostly dredged materials and excavation materials (Table 3.7.7). The majority of these wastes (62 percent) is dumped at sites off the coast of British Columbia.

Table 3.7.5
Estimated Waste Composition by Industrial Sector in Ontario

Industry	SIC major group	Waste category: OCC[3]	Office paper	Other paper	Wood	Glass	Plastic	Organics	Metal	Tires	Other
		percent									
Agriculture, fishing and forestry	01-05	32.3	-	11.5	47.2	-	-	-	-	-	9.0
Mining	06-09	..	..	..	..	..	..	..	..	..	..
Food and beverage industries	10, 11	4.4	0.8	3.7	2.0	8.6	2.0	60.6	5.1	-	12.8
Rubber, plastic and leather	15-17	9.6	0.7	1.4	18.1	-	18.8	-	5.8	31.4	14.3
Textile, knitting mills and clothing	18, 19, 24	1.0	0.4	18.1	1.7	-	8.8	-	1.3	-	68.8
Wood	25	3.5	-	-	65.8	0.1	5.7	-	1.5	-	23.4
Furniture and fixture	26	6.7	0.8	-	15.2	-	-	-	6.0	-	71.3
Paper and allied	27	6.5	13.2	-	39.0	-	0.2	13.4	20.8	-	6.8
Printing and publishing	28	1.8	5.1	81.8	2.7	-	0.2	-	0.2	-	8.2
Primary metal	29	5.6	0.1	17.3	52.0	-	-	-	1.6	-	23.4
Metal fabricating	30	4.6	0.1	11.5	11.7	-	1.1	-	48.5	-	22.5
Machinery	31	5.4	0.2	1.3	11.4	-	3.5	2.7	23.9	-	51.6
Transportation	32	4.7	0.5	1.4	12.0	0.4	-	0.2	29.3	-	51.4
Electrical products	33	12.3	2.6	33.2	38.8	-	4.1	-	7.5	-	1.5
Non-metallic mineral products	35	1.7	4.0	-	3.5	-	-	-	65.4	-	25.4
Chemical and chemical products	37	47.7	1.6	11.4	1.4	3.0	8.9	0.2	5.0	-	20.7
Miscellaneous manufacturing	39	18.5	0.7	31.4	6.5	1.2	0.8	-	21.0	-	19.8
Other major manufacturing[1]	12, 36	..	..	..	..	..	..	..	..	..	..
Wholesale trade margins	50-59	49.7	-	4.4	32.4	-	13.5	-	-	-	-
Construction	40-44	1.8	1.0	-	44.7	-	0.5	1.9	9.0	-	41.1
Transportation margins	45-47	9.2	85.0	-	5.8	-	-	-	-	-	-
Communications and services	48,70-76,85,86,77,91,92,96,97	9.0	12.9	19.8	5.9	20.8	4.2	7.1	10.4	0.1	10.0
Electric power and gas	49	13.6	40.5	-	-	-	-	-	5.9	-	40.0
Retail trade margins	60-65, 69	17.5	3.1	1.5	8.8	0.2	6.6	42.9	4.8	9.4	5.3
Other sources[2]	81-84, 98, 99	4.6	13.7	35.4	1.8	0.2	9.0	0.4	17.6	-	17.4
Total		**8.4**	**6.4**	**8.1**	**22.0**	**5.3**	**3.1**	**10.8**	**10.8**	**1.5**	**23.6**

Notes:
The data were synthesized from various studies.
1. Includes tobacco products industries and petroleum and coke industries.
2. Includes government services and other service industries.
3. Other corrugated cardboard.
Source:
Ontario Ministry of Environment, *The Physical and Economic Dimensions of Municipal Waste Management in Ontario*, Toronto, 1991.

Liquid Wastes

There is no overall inventory of liquid waste production for Canada. Several provinces have initiated water pollution abatement programs and reporting on the types and quantities of wastes generated is usually an integral part of the program. In Ontario, the Municipal and Industrial Strategy for Abatement (MISA) was established in 1978 with the objective of virtually eliminating all persistent toxics from Ontario's waterways.[1] In 1991, the program assessed 169 industrial establishments and 423 municipal sewage treatment plants. The statistics shown in Table 3.7.8 were aggregated by Statistics Canada from individual plant data provided by the Ontario Ministry of Environment and Energy. As shown in this table, the Ontario municipalities and industries which reported discharged a total of 130.9 thousand tonnes of BOD5 (5-day biochemical oxygen demand), 55.9 tonnes of copper, 741.5 tonnes of iron, 8.8 tonnes of lead, 4.1 tonnes of mercury, 1 612 tonnes of phosphorus, 115.4 thousand tonnes of suspended solids and 122.6 tonnes of zinc. A majority of the phosphate (83.9 percent) originated from municipal sources; the other substances largely came from industrial sources.

1. Ontario Ministry of Environment and Energy, *Report on the 1991 Industrial Direct Discharges In Ontario*, Toronto, 1993.

Pulp and paper mills accounted for 67.8 percent of the BOD discharged by establishments reporting. The metal mining and refining sector accounted for almost all of the copper and mercury discharged. Electric power generation plants discharged 26.6 percent of suspended solids and the pulp and paper industry was responsible for another 22.8 percent.

Of the 423 municipalities monitored in 1991, 91 were not in compliance with limits for BOD, suspended solids or total phosphorus.

Of the 169 industries monitored by the MISA program in 1991, 85 were not in compliance with numerical limits. These numerical limits are specified as either a guideline (federal or provincial) or legal requirement (control order, certificate of approval, requirement and direction, or federal regulation). Of the 85 industries not in compliance, 22 responded by making physical changes to their treatment systems, 45 implemented "best management operational procedures" to achieve compliance, 5 ceased to exist for economic reasons and the remaining 13 require further action to be in compliance (or the exceedance occurred only once and no action was required).

Table 3.7.6
Waste Generation by Industrial Sector in Ontario, 1987 and 1989

Industry	SIC major group	1987 Quantity	1987 Percent of total	1989 Quantity	1989 Percent of total
		thousand tonnes	percent	thousand tonnes	percent
Agriculture, fishing and forestry	01-05	62	1.2	75	1.4
Mining	06-09	..	..	..	..
Food and beverage industries	10, 11	440	8.5	468	8.7
Rubber, plastic and leather	15-17	135	2.6	135	2.5
Textile, knitting mills and clothing	18, 19, 24	35	0.7	38	0.7
Wood	25	27	0.5	25	0.5
Furniture and fixture	26	73	1.4	74	1.4
Paper and allied	27	80	1.5	80	1.5
Printing and publishing	28	38	0.7	42	0.8
Primary metal	29	130	2.5	139	2.6
Metal fabricating	30	148	2.9	171	3.2
Machinery	31	50	1.0	49	0.9
Transportation	32	250	4.8	255	4.8
Electrical products	33	82	1.6	81	1.5
Non-metallic mineral products	35	60	1.2	59	1.1
Chemical and chemical products	37	66	1.3	61	1.1
Miscellaneous manufacturing	39	30	0.6	34	0.6
Other major manufacturing[1]	12, 36	..	..	..	..
Wholesale trade margins	50-59	169	3.3	166	3.1
Construction	40-44	1 487	28.7	1 601	29.9
Transportation margins	45-47	139	2.7	134	2.5
Communications and services	48,70-76,85,86,77,91,92,96,97	1 140	22.0	1 155	21.5
Electric power and gas	49	33	0.6	28	0.5
Retail trade margins	60-65, 69	417	8.0	397	7.4
Other sources[2]	81-84, 98, 99	97	1.9	94	1.8
Total		**5 188**	**100.0**	**5 361**	**100.0**

Notes:
1. Includes tobacco products industries and petroleum and coke industries.
2. Includes government services and other service industries.

Source:
Ontario Ministry of Environment, *The Physical and Economic Dimensions of Municipal Waste Management in Ontario*, Toronto, 1991.

Table 3.7.7
Ocean Dumping Permits by Region, 1991-92

Material	Atlantic Permits	Atlantic Quantity	Pacific-Yukon Permits	Pacific-Yukon Quantity	Quebec Permits	Quebec Quantity	Western-Northern Permits	Western-Northern Quantity	Canada Permits	Canada Quantity
	number	tonnes	number	tonnes	number	tonnes	number	tonnes	number	tonnes
Dredged materials	34	1 632 410	19	2 749 500	29	252 200	4	196 300	86	4 830 410
Fisheries waste	124	137 177	-	-	1	70	-	-	125	137 247
Excavation material	-	-	4	864 500	-	-	-	-	4	864 500
Vessels	4	686	3	659	-	-	-	-	7	1 345
Gypsum wallboard	-	-	1	6 500	-	-	-	-	1	6 500
Concrete	2	2 100	-	-	-	-	-	-	2	2 100
Total	**164**	**1 772 373**	**27**	**3 621 159**	**30**	**252 270**	**4**	**196 300**	**225**	**5 842 102**
Percent of national total	...	30.3	...	62.0	...	4.3	...	3.4	...	100.0

Note:
The data were synthesized by Environment Canada from various studies.

Source:
Environment Canada, *Canadian Environmental Protection Act, Report for the Period April 1991 to March 1992*, Ottawa, 1992.

Table 3.7.8

Effluent Loadings for Municipal Sewage Treatment Plants and Industries, Ontario, 1991

Drainage sub-basin	Industry	Number of plants[1]	BOD[2]	Copper[3]	Iron[4]	Lead[5]	Mercury[6]	Total phosphorus[7]	Suspended solids[8]	Zinc[9]
			tonnes							
Lake Superior	Municipal	12	2 134.7	..	..	..	..	38.6	1 689.1	..
	Metal mining and refining	8	..	0.6	2.0	0.1	--	--	26.3	0.3
	Food processing	1	251.1	..	..	..	..	..	..	..
	Pulp and paper	7	24 136.0	..	..	..	..	40.8	5 555.3	..
	Electric power generation	3	..	..	..	..	..	38.0	3 314.2	..
	Total	**31**	**26 521.8**	**0.6**	**2.0**	**0.1**	**–**	**117.4**	**10 584.9**	**0.3**
Lake Huron	Municipal	115	2 156.4	..	..	..	..	91.2	1 851.9	..
	Metal, plastic fabricating and finishing	1	..	..	..	..	..	..	3.2	..
	Metal mining and refining	18	0.5	14.1	93.5	3.0	--	3.7	1 887.5	3.0
	Food processing	2	0.1	..	..	..	..	0.1	0.4	..
	Pulp and paper	4	9 709.9	..	..	..	..	30.1	4 399.8	..
	Organic chemical manufacturing	1	..	..	..	..	..	0.1	4.3	..
	Industrial minerals	2	..	--	..	--	--	0.2	58.4	0.2
	Iron and steel	1	..	..	159.4	..	..	..	532.6	15.3
	Electric power generation	4	2.1	..	..	..	..	0.2	4.4	..
	Total	**148**	**11 869.0**	**14.1**	**252.9**	**3.1**	**–**	**125.6**	**8 742.5**	**18.5**
Lake Ontario	Municipal	78	17 684.4	..	..	..	..	741.8	17 700.7	..
	Metal, plastic fabricating and finishing	3	1.0	..	1.1	--	..	--	5.2	..
	Food processing	3	3.4	..	..	..	..	0.3	16.2	..
	Pulp and paper	9	5 309.7	..	..	..	..	4.3	2 231.7	..
	Organic chemical manufacturing	5	70.0	..	..	..	..	0.4	72.9	..
	Petroleum refining	2	..	..	..	..	..	..	108.8	..
	Inorganic chemicals	7	6.7	..	..	..	..	7.0	379.7	..
	Industrial minerals	3	13.9	..	..	..	..	0.5	949.7	..
	Iron and steel	4	..	..	452.5	..	..	21.1	5 471.4	31.9
	Metal casting	2	..	..	..	..	..	8.0	366.8	..
	Electric power generation	4	3.6	..	..	..	..	0.1	14.0	..
	Miscellaneous	3	7.9	..	0.4	..	..	--	74.7	..
	Total	**123**	**23 100.6**	**..**	**454.1**	**–**	**..**	**783.6**	**27 391.6**	**31.9**
Ottawa River	Municipal	50	12 536.2	..	..	..	..	222.6	9 817.9	..
	Metal mining and refining	5	19.0	0.7	6.0	0.1	--	..	65.2	0.2
	Food processing	2	474.1	..	..	..	..	63.6	2 092.3	..
	Pulp and paper	1	480.7	..	..	..	..	..	139.8	..
	Metal casting	1	12.3	--	1.7	--	..	..	22.6	0.1
	Electric power generation	2	6.3	..	..	..	..	3.2	14.9	..
	Miscellaneous	1	0.1	..	..	..	..	--	--	..
	Total	**62**	**13 528.6**	**0.7**	**7.7**	**0.1**	**–**	**289.4**	**12 152.7**	**0.3**
St. Lawrence River	Municipal	16	1 103.8	..	..	..	..	41.2	1 261.3	..
	Food processing	2	65.9	..	..	..	..	1.9	59.0	..
	Pulp and paper	1	8 205.0	..	..	..	..	15.3	2 643.3	..
	Organic chemical manufacturing	4	305.3	..	..	..	..	0.5	807.4	59.1
	Inorganic chemicals	3	2.2	..	..	..	--	0.3	38.2	..
	Total	**26**	**7 682.1**	**..**	**..**	**..**	**–**	**59.2**	**4 809.3**	**59.1**
Lake Erie	Municipal	105	4 556.4	..	..	..	..	205.2	4 759.0	..
	Metal mining and refining	2	..	..	..	..	..	..	190.0	..
	Metal, plastic fabricating and finishing	4	..	--	--	--	..	..	3.8	0.1
	Food processing	5	90.1	..	..	..	..	2.8	67.4	..
	Petroleum refining	5	..	..	..	..	..	0.6	2 194.9	..
	Organic chemical manufacturing	7	..	..	..	4.2	..	0.2	1 884.0	..
	Inorganic chemicals	4	..	..	..	..	..	..	2 101.3	..
	Iron and steel	1	..	0.1	5.9	0.1	..	5.3	119.7	0.4
	Metal casting	2	..	..	15.0	..	..	..	346.4	..
	Electric power generation	3	..	..	1.0	..	..	..	27 386.3	..
	Miscellaneous	1	7.6	..	..	..	..	0.9	10.1	0.1
	Total	**139**	**4 654.2**	**0.1**	**21.9**	**4.4**	**..**	**215.0**	**39 063.0**	**0.7**
Hudson Bay	Municipal	33	465.6	..	..	..	..	--	450.7	..
	Metal mining and refining	11	1.9	31.8	2.9	1.2	4.1	0.3	408.5	8.6
	Pulp and paper	6	42 837.9	..	..	..	..	8.8	11 322.3	..
	Industrial minerals	1	..	..	..	..	..	0.7	5.5	..
	Total	**51**	**43 305.3**	**31.8**	**2.9**	**1.2**	**4.1**	**8.9**	**12 187.0**	**8.6**
East Lake Winnipeg	Municipal	14	228.8	..	..	..	..	13.1	273.0	..
	Total	**14**	**228.8**	**..**	**..**	**..**	**..**	**13.1**	**273.0**	**..**
Not determined	Metal mining and refining	4	..	8.5	..	--	..	..	149.7	3.3
	Miscellaneous	1	0.4	..	..	..	..	..	0.4	..
	Total	**5**	**0.4**	**8.5**	**..**	**–**	**..**	**..**	**150.0**	**3.3**

Table 3.7.8

Effluent Loadings for Municipal Sewage Treatment Plants and Industries, Ontario, 1991 (Continued)

Drainage sub-basin	Industry	Number of plants[1]	BOD[2]	Copper[3]	Iron[4]	Lead[5]	Mercury[6]	Total phosphorus[7]	Suspended solids[8]	Zinc[9]
			tonnes							
Ontario	**Municipal**	**423**	**40 866.2**	..	..	..	..	**1 352.8**	**37 803.6**	..
	All industries	**176**	**90 024.6**	**55.9**	**741.5**	**8.8**	**4.1**	**259.3**	**77 550.5**	**122.6**
	Metal mining and refining	48	21.4	55.7	104.4	4.4	4.1	4.0	2 727.2	15.4
	Metal, plastic fabricating and finishing	8	1.0	--	1.1	--	..	--	12.2	0.1
	Food processing	15	884.8	..	..	..	..	68.7	2 235.4	..
	Pulp and paper	28	88 679.1	..	..	..	..	99.3	26 292.1	..
	Petroleum refining	7	..	..	..	..	..	0.6	2 303.7	..
	Organic chemical manufacturing	17	375.2	..	..	4.2	..	1.2	2 768.7	59.1
	Industrial minerals	6	13.9	--	..	--	--	1.4	1 013.6	0.2
	Inorganic chemicals	14	8.8	..	..	..	--	7.3	2 519.2	..
	Iron and steel	6	..	0.1	617.9	0.1	..	26.4	6 123.7	47.6
	Metal casting	5	12.3	--	16.7	--	..	8.0	735.8	0.1
	Electric power generation	16	12.0	..	1.0	..	..	41.4	30 733.8	..
	Miscellaneous	6	15.9	..	0.4	..	..	0.9	85.2	0.1
Total		**599**	**130 890.8**	**55.9**	**741.5**	**8.8**	**4.1**	**1 612.1**	**115 354.1**	**122.6**
			percent of total							
Ontario	**Municipal**	**423**	**31.2**	..	..	..	..	**83.9**	**32.8**	..
	All industries	**176**	**68.8**	**100.0**	**100.0**	**100.0**	**100.0**	**16.1**	**67.2**	**100.0**
	Metal mining and refining	48	--	99.6	14.1	50.0	99.8	0.3	2.4	12.5
	Metal, plastic fabricating and finishing	8	--	0.1	0.1	0.4	..	--	--	0.1
	Food processing	15	0.7	..	..	..	..	4.3	1.9	..
	Pulp and paper	28	67.8	..	..	..	..	6.2	22.8	..
	Petroleum refining	7	..	..	..	..	..	--	2.0	..
	Organic chemical manufacturing	17	0.3	..	..	47.8	..	0.1	2.4	48.2
	Industrial minerals	6	--	0.1	..	0.4	--	0.1	0.9	0.2
	Inorganic chemicals	14	--	..	..	..	0.2	0.5	2.2	..
	Iron and steel	6	..	0.2	83.3	1.3	..	1.6	5.3	38.8
	Metal casting	5	--	0.1	2.2	0.1	..	0.5	0.6	0.1
	Electric power generation	16	--	..	0.1	..	..	2.6	26.6	..
	Miscellaneous	6	--	..	0.1	..	..	0.1	0.1	0.1

Notes:

Aggregations from individual plant data were performed by Statistics Canada, National Accounts and Environment Division.

1. Refers to the total number of establishments providing discharge information.
2. Biochemical oxygen demand, 5-day.
3. Copper, unfiltered.
4. Iron, unfiltered.
5. Lead, unfiltered.
6. Mercury, unfiltered.
7. Total phosphate.
8. Municipal sources refer to suspended solids, industrial sources refer to residue particulates.
9. Zinc, unfiltered.

Sources:

Ontario Ministry of Environment and Energy, Environmental Monitoring and Reporting Branch, *Report on the 1991 Discharges from Municipal Sewage Treatment Plants in Ontario*, Toronto, 1994.

Ontario Ministry of Environment and Energy, Environmental Monitoring and Reporting Branch, *Report on the 1991 Industrial Direct Discharges in Ontario*, Toronto, 1994.

Hazardous and Toxic Wastes

According to Environment Canada[1] more than 35 000 chemicals are in use in Canada today. Many of these, even in small quantities, are toxic to humans and wildlife or hazardous due to their radioactive, flammable or infectious properties.

Persistent Organochlorines

One group of chemicals of concern is persistent organochlorines. These are used as pesticides in industrial applications and are also generated as the by-products of certain industrial processes. Persistent organochlorines include DDT, PCBs, dioxins and furans. Due to their long persistence in the environment, they tend to accumulate in the tissues of animals. This can result in birth defects and illnesses such as eggshell thinning in birds, the disruption of endocrine metabolism and change in the activity of liver enzymes.

Since the 1970s, the production and use of several of these substances has been restricted or banned entirely. In the mid-1970s most uses of DDT were banned in Canada. By 1985, all use of DDT was discontinued in Canada. In 1977, the import, manufacture and non-electrical uses of PCBs were banned. Since 1990, the treatment and destruction of

1. Environment Canada, *Toxic Contaminants in the Environment*, Environmental Indicator Bulletin No. 93-1, Ottawa, 1993.

PCBs have been regulated and their storage has been regulated since 1992. In 1988, the Canadian Environmental Protection Act required that discharges of dioxins and furans be eliminated by 1994.

Table 3.7.9 and Figure 3.7.1 illustrate the decline in discharges of dioxins and furans from Canadian pulp mills from a level of 361 grams[1] per year in 1988 when the phase-out was announced to 12.3 grams in 1992. These discharges are derived from the pulp mills which employ the chlorine bleaching process. The number of these mills varied between 43 and 46 in number during the period.

Table 3.7.9

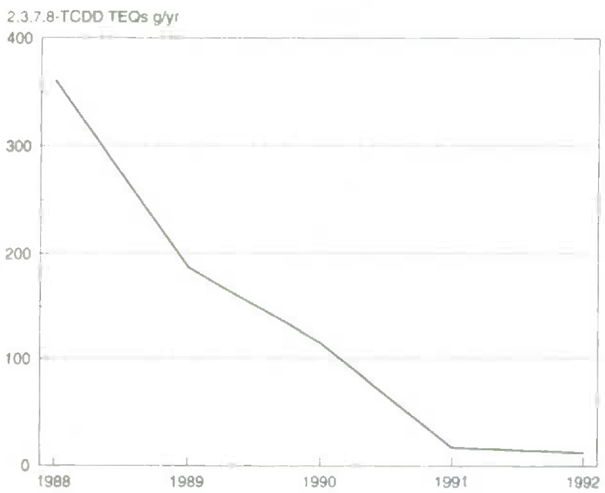
Discharges of Dioxins and Furans from Pulp Mills Using Chlorine Bleaching, 1988-1992.

Year	2,3,7,8-TCDD TEQs g/yr[1]
1988	361.0
1989	188.0
1990	114.7
1991	17.0
1992	12.3

Note:
1. Toxic equivalent grams per year.
Source:
Environment Canada, *Toxic Chemicals in the Environment*, Environmental Indicator Bulletin No. 93-1, Ottawa, 1993.

Figure 3.7.1

Discharges of Dioxins and Furans from Pulp Mills Using Chlorine Bleaching, 1988-1992



Note:
Units of the y-axis are toxicity equivalent grams for all organochlorines. See the text for more detail.
Source:
Environment Canada, *Toxic Chemicals in the Environment*, Environmental Indicator Bulletin No. 93-1, Ottawa, 1993.

1. Discharges of the various organochlorines are aggregated by their relative toxicity to the substance 2,3,7,8-TCDD which is the most toxic. Therefore, the original units are 2,3,7,8-TCDD Toxicity Equivalent (TEQ) grams.

Hazardous Wastes

The Organisation for Economic Co-operation and Development[2] (OECD) estimates that about 6 million tonnes of hazardous wastes were produced in Canada in 1990. This includes exports of 138 thousand tonnes and imports of 144 thousand tonnes. Of Canada's exports of hazardous wastes78 percent were registered as going to final disposal and the remaining 22 percent were destined for recovery. The remaining hazardous wastes are either recovered, burned or disposed in landfill sites. Most of the disposal sites are well managed and operated according to regulations. However, problems can arise when sites are abandoned by bankrupt companies and left to governments to manage. According to Environment Canada[3] there are 28 hazardous waste "hot spots" or toxic waste sites (Table 3.7.10) which have been abandoned and require action by the government.

Table 3.7.10

Abandoned Hazardous Waste Sites, 1993

Location	Nature of waste
Hodgewater Line, Nfld.	Makinson's Scrap Yard contaminated soil with PCBs and heavy metals
Five Island Lake, N.S.	Associated Electronics and Metal Salvage Ltd. contaminated drinking water with PCBs
Drummond, N.B.	Soil and groundwater contaminated by petroleum products
Rogersville, N.B.	Furnace oil spill contaminated groundwater
Harvey Station, N.B.	Soil and groundwater contaminated by petroleum products
Trois Ruisseau, N.B.	Residential wells contaminated by fuel oil leakage
Weldon, N.B.	Crude oil storage tanks contaminated soil
Upper Aboujagne, N.B.	A buried gasoline tank polluted the drinking water of local residents
Baie St. Anne, N.B.	Hydrocarbons contaminated residential wells
Welsford, N.B.	An old service station contaminated surrounding soil and groundwater
St-Jean-sur-Richelieu, Que.	Balmet Canada Inc. property contaminated with lead batteries clean-up almost complete
Montréal, Que.	Le Vidangeur de Montreal Ltd. contaminated land with industrial waste
Dorval, Que.	Ruisseaux Bouchard et Bertrand site contaminated soil with heavy metals
Mercier, Que.	Hazardous waste disposal site
Fontainebleu, Que.	Weedon, a Fontainebleu mine is now considered environmentally safe
St-Amable, Que.	Tire fire site is now considered environmentally safe
Ste-Marie-Salomée, Que.	Industrial waste dump has polluted water near the Vacher River
Ste-Julie, Que.	Industrial site with contaminated groundwater
St-Gédéon de Beauce, Que.	Hazardous wastes such as paint sludge polluted residential drinking water
St-Constant, Que.	Cleanup of the contaminated site is under consideration
Hagersville, Ont.	Tire fire site is now considered environmentally sage
Smithville, Ont.	Soil and groundwater contaminated by PCBs at the waste oil transfer facility
Rednersville, Ont.	Blackbird Holdings site where 170 drums containing solvent waste were disposed
Deloro, Ont.	Deloro mine site arsenic contaminated groundwater
Calgary, Alta.	Canada Creosote contaminated soil beneath the property and the adjacent Bow River
Cayley, Alta.	Soils at the Peerless Wood Preservers site is contaminated with wood preservative waste
Hartell, Alta.	Purity 99 refinery site has hydrocarbon contamination in the soil and groundwater
Yukon	Granger Residential Subdivision has soil contaminated with PCBs

Source:
Environment Canada, Reported in the Ottawa Citizen, *Pollution's Deadly Legacy*, p. B4, March 28, 1993.

2. Organisation for Economic Co-operation and Development, *Transfrontier Movements of Hazardous Wastes, 1989-1990 Statistics*, Paris, 1993.
3. Reported in the Ottawa Citizen, *Pollution's Deadly Legacy*, p. B4, March 28, 1993.

Gaseous Wastes: Emissions

Greenhouse Gas Emissions

The work presented below was undertaken as a pilot study for the waste and pollutant output account. This account will integrate information on the types, quantities and destinations of waste material generated by economic activity into a framework based on the Canadian input-output tables published annually by Statistics Canada.[1] In the present study information on the types and quantities of greenhouse gases released from Canadian production and consumption activity have been analyzed using an augmented version of the 1985 input-output tables. The general method for augmenting the input-output tables used here is based on the work of Victor.[2]

Greenhouse gas emissions have been chosen for this pilot account for two reasons. First, greenhouse gas emissions are currently under scrutiny in Canada and elsewhere because of the likelihood that increased atmospheric concentrations of these gases will create an enhanced greenhouse effect (Technical box 3.7.2). The federal government, for its part, has committed Canada to the stabilization of greenhouse gas emissions at 1990 levels by the year 2000.[3] It is hoped that the work presented here will aid in the effort to meet this goal. Second, in contrast to many categories of waste emissions, a good deal of data are available for estimating greenhouse gas emissions. Thus, it is possible to present a very complete pilot account of these emissions.

Table 3.7.11 lists the greenhouse gases that are included in this study. Emissions of these gases result from the activities of businesses, households[4] and governments. All three sectors purchase and consume commodities that either contain greenhouse gases that are released upon use (paints and solvents, for example) or that are converted to greenhouse gases as a result of use (fossil fuels are the most important example of the latter type of commodity). Using the emissions data discussed at the end of this section in combination with data from the 1985 input-output tables, it has been possible to estimate the 1985 greenhouse gas emissions from 49 industries and 4 categories of household and government expenditure. These estimates are shown in Table 3.7.12.

1. Statistics Canada, *The Input-Output Structure of the Canadian Economy, 1985*, Catalogue No. 15-201, Ottawa, 1989.
2. Victor, Peter A., *Pollution: Economy and Environment*, United Kingdom: George Allen and Unwin Ltd., 1972.
3. Government of Canada, *Canada's Green Plan for a Healthy Environment*, Ottawa, 1990.
4. Households in this context include non-profit organizations.

Technical Box 3.7.2
The Greenhouse Effect

The atmosphere surrounding the earth consists almost entirely of nitrogen and oxygen, with the remaining portion comprised of a variety of gases found in very low concentrations. A certain group of these trace gases is responsible for what has come to be known as the "greenhouse effect", which can be briefly explained as follows.

Short wave solar radiation passes relatively unhindered through the earth's atmosphere to the surface of the planet. Objects on the surface absorb this incoming radiation and are warmed. The warmed objects, in turn, re-emit longer wavelength (infrared) radiation back into the atmosphere. The atmosphere is less transparent to infrared radiation than it is to short wave radiation however. Trace quantities of water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and a few other gases absorb some of the outgoing infrared radiation, re-radiating it back to the earth's surface. In this way they act like the glass covering on a greenhouse. By preventing a portion of the infrared radiation from escaping to space, these "greenhouse gases" keep global temperatures much warmer than would be the case in their absence.

The greenhouse effect is a naturally-occurring phenomenon; it has not been created by human activity. However, there is concern that human-induced changes in the atmospheric concentrations of the greenhouse gases may significantly enhance the naturally occurring greenhouse effect. Although some evidence of the expected increase in global mean temperature has already been noted, an unequivocal demonstration of the enhanced greenhouse effect is not expected for at least another decade.[1] Studies have demonstrated conclusively, however, that the atmospheric concentrations of CO_2, CH_4 and N_2O have significantly increased from their pre-industrial values as a result of anthropogenic emissions.[2] Humankind has also introduced a new and extremely powerful set of greenhouse gases into the atmosphere. Known collectively as the chlorofluorocarbons (CFCs), each of these has thousands of times the ability of CO_2 to absorb infrared radiation.

1. Intergovernmental Panel on Climate Change, *1992 IPCC Supplement*, in press, 1992.
2. Although water vapour is the most important greenhouse gas in terms of overall warming power, its atmospheric concentration is not affected significantly by human activities.

Table 3.7.11
Greenhouse Gases Included in this Study

Name	Formula / Acronym
Carbon dioxide	CO_2
Methane	CH_4
Nitrous oxide	N_2O
Volatile organic carbon compounds	VOCs
Nitric oxide and nitrogen dioxide	NO_x
Carbon monoxide	CO

The electric power and other utilities industry (34) was the largest industrial emitter of CO_2 in 1985. This industry also rates as the largest industrial emitter when ranked in terms of CO_2 equivalent emissions.[1] The transportation industry (30), primary metals industry (20), agriculture industry (1) and chemical products industry (27) are the other top five industrial emitters in terms of CO_2 equivalents. The concentration of industrial greenhouse gas emissions is highlighted by the fact that these five industries alone accounted for almost 58 percent of total CO_2 equivalent emissions from industries in 1985. The top ten emitters accounted for 76 percent of total industrial CO_2 equivalent emissions.

A direct cause and effect relationship exists between fossil fuel consumption and greenhouse gas emissions. It is not surprising, then, that four of the top five CO_2 equivalent emitting industries also rank among the five largest industrial consumers of fossil fuels. The agriculture industry stands out as something of an anomaly in this regard. It ranks fourth in terms of CO_2 equivalent emissions, but eighth in terms of fossil fuel consumption. The reason for the relatively high ranking of the agriculture industry in terms of CO_2 equivalents is found in its very large emissions of CH_4 and N_2O. Farm animals, cattle in particular, release a great deal of CH_4 during their digestion processes. This accounts for almost all of the CH_4 emissions from the agriculture industry. Nitrification processes in soils to which nitrogenous fertilizers have been applied account for the very large emissions of N_2O. The agriculture industry is estimated to have accounted for 50 percent of total industrial CH_4 emissions and 26 percent of total industrial N_2O emissions in 1985.[2]

Table 3.7.12 also shows an estimated 114 926 kilotonnes of CO_2 equivalent emissions from households and governments in 1985, which represents more than 26 percent of the economy-wide emissions. The majority (93 percent) of household and government CO_2 equivalent emissions come from the consumption of motor and heating fuels.

The conventional wisdom that industry, especially heavy manufacturing, is the major polluter in the economy is borne out by the results presented in Table 3.7.12 at least in terms of greenhouse gas emissions. It should be emphasized, however, that households account for more CO_2 equivalent emissions than any single industry.

Ozone Depleting Substances

The earth is protected from the sun's ultraviolet radiation by a thin layer of ozone 20 to 40 kilometres above the surface. In the early 1980s, it was shown that the ozone layer has been developing "holes" or thin spots. Because of these holes, parts of the earth are subjected to increased intensities of ultraviolet radiation. According to Environment Canada, "Excessive exposure to UV-B [the more energetic ultraviolet radiation wavelengths] radiation is known to increase the incidence of sunburns, skin cancer, cataracts, and damage to the immune system of humans, to reduce yields of crops, and to cause disruption of marine food chains."[3]

Several chlorine and bromine compounds have been linked to stratospheric ozone depletion. These include:

- **CFCs** (chlorofluorocarbons), organic chemicals containing carbon, fluorine and chlorine,
- **halons** (1211, 1301), organic chemicals containing carbon, fluorine, bromine, and sometimes chlorine,
- **methyl chloroform** (MCF), a metal cleaning agent,
- **carbon tetrachloride** (CTC), used in the manufacture of chemicals,
- **HCFCs** (hydrochlorofluorocarbons), similar to CFCs but also containing hydrogen.

The Montréal Protocol of 1987 calls for the phase-out of production of major ozone-depleting substances. Commitments subsequent to the signing of this Protocol have accelerated the original phase-out so that the production, importation and exportation of chlorofluorocarbons, carbon tetrachloride and methyl chloroform will cease by 1996. The production of halons was ended on January 1, 1994.

1. CO_2 equivalent emissions are calculated using the concept of global warming potential (Intergovernmental Panel on Climate Change, 1992). Global warming potential (GWP) is the potential contribution to global warming over a specified time period (usually 20 or 100 years) of a given greenhouse gas relative to that of CO_2, which is assigned a GWP of 1. When 100 years is the considered time period, methane is calculated to have a GWP of 11, and nitrous oxide to have a GWP of 270. This means, for example, that the emission of one tonne of CH_4, considered over a period of 100 years from the date of emission, is equivalent to the emission of 11 tonnes of CO_2 in terms of its potential contribution to global warming.
No GWP values exist for VOCs, NO_x and CO. Thus, it is not possible to include these gases in CO_2 equivalent emission estimates. The reader is cautioned to keep this exclusion in mind when interpreting the CO_2 equivalent emission data presented here.
2. Had it been possible to include landfill CH_4 emissions in this study, other industries would have shown higher CH_4 emissions in Table 3.7.12 to the extent that they contribute to bio-degradable material in landfill sites. Since landfill CH_4 emissions represent 38 percent of total CH_4 emissions as estimated by Environment Canada (Jaques, A.P., *Canada's Greenhouse Gas Emissions: Estimates for 1990*, Report EPS 5/AP/4, Ottawa, 1992) this exclusion puts the agriculture industry in an unfairly poor light in comparison to other industries.
3. Environment Canada, *Stratospheric Ozone Depletion*, Environmental Indicator Bulletin No. 93-2, 1993.

Table 3.7.12

Greenhouse Gas Emissions by Sector, 1985

Industrial sector	Estimated 1985 greenhouse gas emissions							Rank	
	CO_2	CO_2 equivalent[1]	CH_4	N_2O	VOC	NO_x	CO	CO_2	CO_2 equivalent
	kilotonnes							rank	
Business sector									
1 Agriculture	9 525	24 663	973	16	64	127	610	8	4
2 Fishing and trapping	1 134	1 187	--	--	10	14	96	29	29
3 Logging and forestry	2 076	2 151	--	--	10	30	88	21	21
4 Mining	6 563	8 220	140	--	7	48	81	14	12
5 Crude oil and natural gas	7 845	16 459	779	--	33	184	143	11	6
6 Quarries and sand pits	474	488	--	--	1	7	10	35	35
7 Services related to mineral extraction	2 303	2 381	--	--	14	29	136	20	20
8 Food processing	4 773	4 816	--	--	10	9	33	15	16
9 Beverages	1 054	1 064	--	--	2	3	8	30	30
10 Tobacco products	63	63	--	--	--	--	--	46	46
11 Rubber products	511	514	--	--	5	2	1	34	34
12 Plastic products	350	353	--	--	1	--	2	40	40
13 Leather products	126	127	--	--	--	--	--	45	45
14 Textiles	1 263	1 269	--	--	2	2	6	27	28
15 Clothing	231	233	--	--	--	--	2	43	43
16 Wood products	1 796	1 815	--	--	48	10	860	23	23
17 Furniture	315	318	--	--	4	--	2	42	42
18 Paper products	9 985	10 046	--	--	19	38	96	7	9
19 Printing and publishing	423	427	--	--	1	1	4	38	38
20 Primary metals	24 492	25 060	--	2	15	35	449	3	3
21 Fabricated metals	2 002	2 017	--	--	12	2	8	22	22
22 Machinery	760	766	--	--	3	1	4	33	33
23 Transport equipment	2 772	2 791	--	--	28	4	11	19	19
24 Electrical products	989	995	--	--	4	1	7	31	31
25 Non-metallic minerals	12 678	12 721	--	--	5	27	62	4	7
26 Refined petroleum	8 201	8 302	--	--	51	39	240	10	11
27 Chemical products	12 612	16 903	--	16	233	29	31	5	5
28 Other manufacturing	450	454	--	--	3	1	3	36	36
29 Construction	7 511	7 848	1	1	132	93	841	12	13
30 Transport industry	33 713	34 874	14	4	98	259	614	2	2
31 Pipeline transport	4 519	4 891	32	--	--	--	--	16	15
32 Storage	418	423	--	--	--	--	3	39	39
33 Communication	1 417	1 453	--	--	8	7	63	25	26
34 Electric power and other utilities	84 540	85 300	16	2	15	272	142	1	1
35 Wholesale trade	7 239	7 537	1	1	60	48	418	13	14
36 Retail trade	8 760	8 983	1	1	44	34	305	9	10
37 Finance and real estate	11 444	11 540	--	--	9	10	66	6	8
38 Insurance	161	165	--	--	1	1	5	44	44
39 Government royalties on resources	-	-	-	-	-	-	-	-	-
40 Owner occupied dwellings	-	-	-	-	-	-	-	-	-
41 Business services	1 412	1 456	--	--	9	7	66	26	25
42 Education services	330	332	--	--	--	--	1	41	41
43 Health services	1 258	1 290	--	--	6	4	41	28	27
44 Accommodation and food	4 331	4 361	--	--	1	2	10	17	18
45 Amusement and recreation	440	445	--	--	1	1	4	37	37
46 Personal services	946	961	--	--	21	2	14	32	32
47 Other services	1 673	1 736	--	--	13	9	90	24	24
48 Operating supplies	--	--	--	--	47	--	--	47	47
49 Travel, advertising and promotion	4 300	4 536	1	1	55	39	386	18	17
50 Transportation margins	-	-	-	-	-	-	-	-	-
Sub-total, business sector	**290 181**	**324 733**	**1 958**	**44**	**1 105**	**1 430**	**6 059**		
Household sector									
Motor fuels and lubricants	40 694	44 709	11	14	374	251	2 514		
Home heating fuels	48 719	48 986	2	1	111	41	641		
All other goods	3 007	3 007	--	--	101	7	55		
Sub-total, household sector	**92 420**	**96 701**	**13**	**15**	**586**	**299**	**3 210**		
Government - current expenditures	**17 859**	**18 225**	**2**	**1**	**59**	**52**	**289**		
Total, whole economy	**400 459**	**439 659**	**1 973**	**61**	**1 750**	**1 781**	**9 558**		

Notes:

The format of this table does not correspond exactly to the national input-output tables. The following categories of final demand have been excluded: fixed capital formation, inventory change, imports and exports. These have been excluded because they do not result in direct greenhouse gas emissions.

Industries 48, 49 and 50 are fictive industries used for estimating the use of groups of commodities whose precise content is unknown.

1. CO_2 equivalent emissions include CO_2 emissions plus N_2O and CH_4 emissions expressed as equivalent CO_2 emissions.

Source:

Statistics Canada, *Environmental Perspectives 1993*, Catalogue No. 11-528, Ottawa, 1993.

As shown in Table 3.7.13 and Figure 3.7.2, the domestic supply of ozone-depleting substances has steadily decreased since the Montréal Protocol, from a high of 27.8 thousand tonnes in 1987 to 13.2 thousand tonnes in 1992.

Even though the net increase in the atmospheric concentrations of ozone-depleting substances should stop in the near future, their impact on the ozone layer is expected to continue for at least the next 50 to 100 years.

Table 3.7.13
Domestic Supply of Ozone-depleting Substances (ODSs), 1979-1992

Year	CFCs	Other ODSs[1]	Total
	kilotonnes		
1979	17.3	3.4	20.7
1980	14.0	2.8	16.8
1981	15.2	2.8	18.0
1982	14.2	3.2	17.4
1983	15.6	3.7	19.3
1984	16.9	4.7	21.6
1985	18.5	4.6	23.1
1986	19.9	5.0	24.9
1987	21.2	6.6	27.8
1988	21.0	6.6	27.6
1989	18.8	5.4	24.2
1990	13.1	4.1	17.2
1991	8.8	3.5	12.3
1992	10.7	2.5	13.2

Note:
1. Non CFC substances were aggregated by scaling the quantity figure by the ozone-depleting potential. For example, a given quantity of Halon 1301 will deplete 30 times the ozone as the same quantity of CFC-11.

Source:
Environment Canada, *Stratospheric Ozone Depletion*, Environmental Indicator Bulletin No. 93-2, Ottawa, 1993.

Figure 3.7.2
Domestic Supply of Ozone-depleting Substances (ODSs), 1979-1992

Source:
Environment Canada, *Stratospheric Ozone Depletion*, Environmental Indicator Bulletin No. 93-2, Ottawa, 1993.

Summary

The generation rates for many wastes have been decreasing since the introduction of regulations, legislation and changes in public perceptions and behaviour over the past several years. However, many of these substances will persist in the environment and will continue to have an impact for generations. Human activities are still creating new substances and generating vast quantities of solid, liquid and gaseous wastes.

A comprehensive analysis of the sources and quantities of wastes is not possible at this stage due to the lack of commonly-accepted definitions and waste classifications, incomplete data and insufficient integration of existing monitoring and survey data.

3.8 Agricultural Chemicals

Chemicals are essential to today's modern agriculture. Improved crop varieties developed over the last 40 years have increased productivity substantially, doubling yields for many crops. These new hybrid crops take up more nutrients from the soil than their lower yielding predecessors. Natural nutrient supplies are insufficient to maximize higher yield potential, making it necessary to use supplementary fertilizer nutrients. As a result, today's agriculture has become reliant on relatively inexpensive chemical fertilizers. Today's agriculture also relies on the use of chemical pesticides to prevent crop yield losses to insects, competitive weeds and plant diseases. The large-scale use of pesticides and chemical fertilizers on millions of hectares of land has inevitable impacts on the natural environment.

❑❑❑

Agricultural Fertilizers

The uptake of nutrients by agricultural crops has increased significantly with the advent of hybrid species. For example, the Western Canadian grain crop consumed an average of 200 thousand tonnes of nitrogen and 36 thousand tonnes of phosphorus annually between 1883 and 1953. By 1986, the grain crop was consuming in excess of 1.1 million tonnes of nitrogen and 170 thousand tonnes of phosphorous, a five-fold increase.[1] These nutrient consumption changes have occurred on a relatively constant 11 million hectare cropland base.

The majority of agricultural fertilizers are consumed by crops shortly after application. If all applied nutrients were taken up by the crop, there would be no environmental impact. However, factors such as crop condition, application rate, soil and climatic conditions can prevent complete fertilizer uptake. Residual fertilizer nutrients can be lost to the atmosphere, absorbed by wild plant species or be released into both surface and groundwater supplies.[2] For example, intense or prolonged rainfall can leach nutrients away from crops, carrying them into the water table or surface waterways, contaminating groundwater and polluting rivers. Excess nutrients can stimulate the growth of algae and other aquatic weeds in waterways and eventually lead to eutrophication, a process where oxygen vital for aquatic life is consumed by rotting vegetation. Lake Erie suffered from this problem in the 1970s. Today, reduced fertilizer application and better land management techniques have improved this situation considerably.[3]

Table 3.8.1 indicates a five-fold increase in fertilizer application in Western Canada between 1970 and 1990. In 1990, the three Prairie provinces purchased more than 59 percent of Canada's 3.8 million tonnes of farm fertilizer sales. In 1970, the three Prairie provinces accounted for only 28 percent of agricultural fertilizer consumption. In eastern Canada, fertilized areas and application rates have been declining in some provinces. In Ontario, fertilized area declined from 2.53 million hectares in 1980 to 2.27 by 1990. At the same time, application rates also declined from 0.54 tonnes per hectare in 1970 to 0.37 tonnes per hectare in 1990. In Quebec, fertilized areas have declined between 1980 and 1990 from 1.1 million hectares down to 997 thousand hectares. Despite this decline, total fertilizer applied continued to increase in Quebec going from an average application rate of 0.42 tonnes per hectare in 1980 to 0.47 tonnes per hectare in 1990. The Atlantic Provinces, with the exception of Nova Scotia, continue to apply fertilizer at the highest average rates in the country. National data indicate that application rates have declined from 0.22 tonne per hectare to 0.18 tonne per hectare between 1970 and 1990. At the same time, fertilized areas more than tripled from 7 million hectares to 21 million hectares.

1. Flaten,D.N. and R.A.Hedlin, "Impact of Technology on Crop Productivity in Western Canada", Proceedings of the 34th Annual Meeting of the Canadian Soil Science Society, Calgary, Alberta,1988.

2. Smith,R.A., R.B. Alexander and M. G. Wolman, "Water Quality Trends in the Nation's Rivers", *Science*, 235, 1987, p. 1607-1615.

3. Government of Canada, *The State of Canada's Environment*, Ottawa,1991.

Table 3.8.1

Commercial Agricultural Fertilizer Application by Sub-basin, 1970, 1980 and 1990

	Commercial fertilizer applied				Area fertilized				Fertilizer per hectare fertilized			
Provincial sub-basin	1970	1980	1990	Change 1980-1990	1970	1980	1990	Change 1980-1990	1970	1980	1990	Change 1980-1990
	thousand tonnes			percent	hectares			percent	tonnes per hectare			percent
Newfoundland												
North Newfoundland	1.1	0.8	1.3	57.3	679	851	2 210	159.7	1.62	0.96	0.58	-39.4
South Newfoundland	2.1	2.2	2.4	12.9	1 609	3 562	3 223	-9.5	1.28	0.61	0.76	24.8
Total	**3.2**	**3.0**	**3.7**	**25.1**	**2 288**	**4 413**	**5 434**	**23.1**	**1.38**	**0.68**	**0.69**	**1.6**
Prince Edward Island												
Prince Edward Island	44.3	55.5	60.6	9.2	56 100	107 442	102 117	-5.0	0.79	0.52	0.59	14.9
Total	**44.3**	**55.5**	**60.6**	**9.2**	**56 100**	**107 442**	**102 117**	**-5.0**	**0.79**	**0.52**	**0.59**	**14.9**

Table 3.8.1

Commercial Agricultural Fertilizer Application by Sub-basin, 1970, 1980 and 1990 (Continued)

	Commercial fertilizer applied				Area fertilized				Fertilizer per hectare fertilized			
Provincial sub-basin	1970	1980	1990	Change 1980-1990	1970	1980	1990	Change 1980-1990	1970	1980	1990	Change 1980-1990
	thousand tonnes			percent	hectares			percent	tonnes per hectare			percent
Nova Scotia												
Bay of Fundy	23.8	28.3	26.1	-7.5	32 647	74 577	69 414	-6.9	0.73	0.38	0.38	-0.6
Southeast Atlantic Ocean	2.3	3.0	2.5	-17.0	3 190	8 476	7 336	-13.4	0.73	0.35	0.34	-4.1
Cape Breton Island	1.5	2.2	3.3	45.6	2 294	5 484	5 517	0.6	0.66	0.41	0.59	44.7
Total	**27.6**	**33.5**	**31.9**	**-4.8**	**38 131**	**88 537**	**82 267**	**-7.1**	**0.72**	**0.38**	**0.39**	**2.5**
New Brunswick												
Saint John and South Bay of Fundy	32.1	43.6	35.3	-18.9	27 911	55 243	57 627	4.3	1.15	0.79	0.61	-22.3
Gulf of St. Lawrence and North Bay of Fundy	6.2	9.0	8.2	-8.2	9 255	20 753	20 509	-1.2	0.67	0.43	0.40	-7.1
Total	**38.3**	**52.5**	**43.5**	**-17.1**	**37 166**	**75 997**	**78 136**	**2.8**	**1.03**	**0.69**	**0.56**	**-19.4**
Quebec												
Saint John	2.2	4.3	2.7	-37.8	6 582	13 623	10 569	-22.4	0.34	0.32	0.25	-19.8
Cascapedia and Gulf of St. Lawrence	3.5	7.7	4.4	-43.0	9 662	22 845	15 911	-30.4	0.36	0.34	0.27	-18.2
Upper Ottawa	1.5	4.5	2.1	-53.3	4 999	12 369	7 697	-37.8	0.29	0.37	0.27	-25.0
Coulonge and Central Ottawa	2.1	3.4	3.1	-8.8	3 558	8 687	9 060	4.3	0.59	0.39	0.34	-12.6
Gatineau and Lower Ottawa	8.7	15.4	11.6	-24.5	14 715	34 145	28 642	-16.1	0.59	0.45	0.41	-9.9
Upper St. Lawrence	7.0	18.6	21.9	17.6	9 612	35 273	41 455	17.5	0.73	0.53	0.53	0.1
St-Maurice	1.3	1.6	0.9	-42.3	1 170	2 104	1 890	-10.2	1.10	0.78	0.50	-35.7
Central St. Lawrence	165.1	286.9	323.2	12.7	253 423	602 932	616 639	2.3	0.65	0.48	0.52	10.2
Lower St. Lawrence	58.6	85.7	69.3	-19.1	112 202	247 755	178 606	-27.9	0.52	0.35	0.39	12.1
North Gaspé Peninsula	10.8	16.3	13.3	-18.3	32 563	67 746	43 006	-36.5	0.33	0.24	0.31	28.7
Saguenay	6.4	13.4	12.1	-9.8	15 812	46 833	34 091	-27.2	0.41	0.29	0.35	23.9
Betsiamites	0.0	0.1	0.1	-9.5	174	157	120	-23.3	0.25	0.42	0.49	17.9
Manicouagan and Outardes	0.2	0.3	0.1	-55.0	162	512	343	-33.0	1.38	0.61	0.41	-32.9
Nottaway	0.1	0.3	0.2	-51.6	235	1 335	469	-64.9	0.34	0.24	0.32	37.6
Abitibi and North French	0.7	1.9	1.7	-10.9	3 202	5 119	6 296	23.0	0.22	0.38	0.27	-27.5
Harricanaw	0.5	1.2	1.1	-7.0	1 172	3 965	1 927	-51.4	0.45	0.29	0.56	91.3
Total	**268.8**	**461.6**	**467.8**	**1.3**	**469 243**	**1 105 400**	**996 722**	**-9.8**	**0.57**	**0.42**	**0.47**	**12.4**
Ontario												
Nipigon and Northwest Lake Superior	1.6	2.7	2.2	-18.6	4 735	11 196	8 008	-28.5	0.33	0.24	0.27	13.8
Northeast Lake Superior	0.2	0.1	0.3	318.8	187	287	220	-23.5	1.19	0.24	1.32	447.6
North Lake Huron	2.5	3.6	3.1	-13.7	6 940	14 823	15 215	2.6	0.35	0.24	0.20	-15.9
Wanipitai and French	1.7	2.9	1.6	-46.3	5 134	12 251	9 022	-26.4	0.33	0.24	0.17	-27.0
East Georgian Bay	41.7	64.6	54.7	-15.4	79 013	159 841	136 892	-14.4	0.53	0.40	0.40	-1.2
East Lake Huron	110.6	177.3	145.0	-18.2	273 954	535 885	479 100	-10.6	0.40	0.33	0.30	-8.5
North Lake Erie	373.9	507.6	423.1	-16.6	602 666	1 137 743	1 043 636	-8.3	0.62	0.45	0.41	-9.1
Lake Ontario	81.0	129.7	110.9	-14.5	155 559	362 785	304 642	-16.0	0.52	0.36	0.36	1.8
Montréal and Upper Ottawa	2.0	5.2	3.0	-42.7	9 310	27 384	17 551	-35.9	0.22	0.19	0.17	-10.5
Madawaska, Petawawa and Central Ottawa	7.3	12.3	8.6	-30.0	17 954	39 612	33 066	-16.5	0.41	0.31	0.26	-16.1
Rideau and Lower Ottawa	36.8	55.2	59.7	8.1	70 362	164 509	164 393	-0.1	0.52	0.34	0.36	8.2
Upper St. Lawrence	8.6	14.6	15.0	2.7	17 298	43 648	40 652	-6.9	0.50	0.33	0.37	10.3
Moose	0.6	0.7	0.5	-34.5	1 399	2 898	2 223	-23.3	0.45	0.25	0.21	-14.6
Abitibi	0.4	0.8	0.4	-56.4	1 335	4 398	2 272	-48.3	0.33	0.19	0.16	-15.6
Upper Winnipeg	1.2	1.8	1.9	6.4	5 026	13 419	13 044	-2.8	0.23	0.14	0.15	9.5
English	0.2	0.4	0.5	12.0	1 387	3 143	3 328	5.9	0.16	0.13	0.14	5.8
Total	**670.3**	**979.5**	**830.3**	**-15.2**	**1 252 259**	**2 533 823**	**2 273 263**	**-10.3**	**0.54**	**0.39**	**0.37**	**-5.5**
Manitoba												
Saskatchewan	0.4	1.7	1.9	13.9	5 452	13 288	11 971	-9.9	0.07	0.13	0.16	26.4
Lake Winnipegosis and Lake Manitoba	27.6	109.2	133.1	21.8	316 219	718 932	835 889	16.3	0.09	0.15	0.16	4.8
Assiniboine	20.7	121.1	136.5	12.7	248 484	750 260	910 529	21.4	0.08	0.16	0.15	-6.8
Souris	8.0	43.2	45.7	6.0	93 482	334 152	422 200	26.3	0.09	0.13	0.11	-16.1
Red	54.7	248.5	230.0	-7.4	472 963	1 248 127	1 343 562	7.6	0.12	0.20	0.17	-14.0
Winnipeg	0.6	2.2	3.6	64.8	4 721	14 817	18 276	23.3	0.12	0.15	0.20	33.6
West Lake Winnipeg	4.5	17.1	26.5	54.7	44 780	116 878	145 906	24.8	0.10	0.15	0.18	23.9
Total	**116.4**	**542.9**	**577.3**	**6.3**	**1 186 101**	**3 196 455**	**3 688 332**	**15.4**	**0.10**	**0.17**	**0.16**	**-7.8**
Saskatchewan												
Central North Saskatchewan	6.6	37.5	51.0	35.0	121 335	356 374	407 066	14.2	0.05	0.11	0.12	18.2
Battle	3.3	15.7	21.0	35.4	66 480	149 057	210 550	41.3	0.05	0.11	0.10	-4.1
Lower North Saskatchewan	11.3	82.5	115.0	38.9	236 970	954 190	1 176 900	23.3	0.05	0.09	0.10	12.6
Lower South Saskatchewan	9.2	83.4	95.0	14.4	166 627	934 552	1 075 826	15.1	0.06	0.09	0.09	-0.6
Qu'Appelle	8.7	87.7	136.0	54.5	160 901	979 333	1 636 419	67.1	0.05	0.09	0.08	-7.5
Saskatchewan	16.8	88.7	93.0	5.4	292 459	634 468	770 620	21.5	0.06	0.14	0.12	-13.2
Lake Winnipegosis and Lake Manitoba	5.2	26.6	42.0	58.6	114 479	259 097	332 553	28.4	0.05	0.10	0.13	23.6
Assiniboine	9.7	56.7	127.0	123.2	208 281	660 760	1 161 727	75.8	0.05	0.09	0.11	26.9
Souris	3.7	42.7	57.0	34.1	80 207	427 717	673 429	57.4	0.05	0.10	0.08	-14.8
Beaver	2.6	16.1	22.0	36.4	41 910	115 560	146 460	26.7	0.06	0.14	0.15	7.6
Missouri	0.6	3.5	6.0	59.3	8 480	54 744	63 091	15.2	0.07	0.06	0.09	38.2
Total	**77.7**	**541.1**	**765.0**	**41.3**	**1 498 129**	**5 525 853**	**7 654 641**	**38.5**	**0.05**	**0.10**	**0.10**	**2.0**

Table 3.8.1

Commercial Agricultural Fertilizer Application by Sub-basin, 1970, 1980 and 1990 (Continued)

Provincial sub-basin	Commercial fertilizer applied 1970	1980	1990	Change 1980-1990	Area fertilized 1970	1980	1990	Change 1980-1990	Fertilizer per hectare fertilized 1970	1980	1990	Change 1980-1990
	thousand tonnes			percent	hectares			percent	tonnes per hectare			percent
Alberta												
Upper South Saskatchewan	40.2	123.7	134.9	9.0	216 052	812 163	984 565	21.2	0.19	0.15	0.14	-10.1
Bow	25.7	53.0	48.2	-8.9	165 087	348 754	347 917	-0.2	0.16	0.15	0.14	-8.7
Red Deer	60.3	150.5	191.1	27.0	547 066	1 104 488	1 217 964	10.3	0.11	0.14	0.16	15.2
Upper North Saskatchewan	8.7	20.5	23.8	15.7	80 833	136 738	141 596	3.6	0.11	0.15	0.17	11.8
Central North Saskatchewan	35.9	117.0	157.1	34.3	362 536	902 479	1 033 333	14.5	0.10	0.13	0.15	17.3
Battle	28.7	110.5	132.8	20.2	375 541	954 410	1 025 906	7.5	0.08	0.12	0.13	11.8
Lower North Saskatchewan	2.4	11.3	15.7	39.4	32 275	131 892	180 215	36.6	0.07	0.09	0.09	2.1
Beaver	2.3	10.2	13.6	33.1	20 082	71 459	85 373	19.5	0.11	0.14	0.16	11.4
Upper Athabasca	0.9	2.6	3.3	29.8	8 229	17 784	26 893	51.2	0.10	0.14	0.13	-8.0
Pembina and Central Athabasca	11.9	35.7	40.9	14.6	107 435	231 687	243 595	5.1	0.11	0.15	0.17	9.0
Lower Central Athabasca	1.4	5.1	7.9	56.4	15 280	37 654	47 259	25.5	0.09	0.13	0.17	24.6
Upper Peace	8.2	28.1	39.1	38.8	117 739	241 978	303 712	25.5	0.07	0.12	0.13	10.6
Smoky	11.5	41.0	60.5	47.6	150 129	309 501	400 132	29.3	0.08	0.13	0.15	14.2
Central Peace	3.0	18.1	27.6	52.0	49 625	142 436	198 607	39.4	0.06	0.13	0.14	9.0
Lower Central Peace	0.2	2.5	5.8	136.6	3 542	21 548	49 033	127.6	0.06	0.11	0.12	4.0
Missouri	1.2	4.4	6.5	48.5	7 905	40 201	63 783	58.7	0.15	0.11	0.10	-6.4
Total	**242.4**	**734.2**	**908.9**	**23.8**	**2 259 356**	**5 505 173**	**6 349 884**	**15.3**	**0.11**	**0.13**	**0.14**	**7.3**
British Columbia												
Upper Peace	6.5	22.8	18.5	-18.8	50 818	148 698	134 064	-9.8	0.13	0.15	0.14	-9.9
Skeena	0.6	1.6	1.6	-0.2	3 836	12 156	8 166	-32.8	0.17	0.13	0.19	48.5
Vancouver Island	5.5	7.7	8.9	15.3	6 191	14 764	13 274	-10.1	0.89	0.52	0.67	28.2
Nechako	0.7	4.2	3.9	-8.3	5 762	27 027	33 137	22.6	0.12	0.16	0.12	-25.2
Upper Fraser	1.3	4.3	3.7	-15.5	7 796	27 844	26 114	-6.2	0.17	0.16	0.14	-9.9
Thompson	2.8	7.6	6.6	-12.6	9 239	27 405	24 380	-11.0	0.31	0.28	0.27	-1.8
Fraser	23.6	33.3	61.5	84.5	25 944	56 528	49 684	-12.1	0.91	0.59	1.24	109.9
Columbia	9.0	14.7	16.5	11.8	19 575	45 147	39 762	-11.9	0.46	0.33	0.41	27.0
Residual Sub-basins	0.1	0.6	0.9	43.2	358	2 534	2 354	-7.1	0.31	0.24	0.37	54.2
Total	**50.2**	**96.8**	**121.9**	**25.9**	**129 519**	**362 104**	**330 937**	**-8.6**	**0.39**	**0.27**	**0.37**	**37.7**
Canada	**1 539.1**	**3 500.7**	**3 810.5**	**8.9**	**6 928 292**	**18 505 200**	**21 561 732**	**16.5**	**0.22**	**0.19**	**0.18**	**-6.6**

Notes:
Changes in fertilizer tonnages may not precisely reflect the changing nutrient content of fertilizer.
Quantity estimates for 1970 and 1990 were derived from fertilizer expense data.
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Total fertilizer sales are shown in Figure 3.8.1. Sales were clearly rising between 1970 and 1985 but have declined since then. Agricultural fertilizer consumption represented 95 percent of the fertilizer market in 1980. By 1990 this share had declined to 92 percent, indicating a substantial rise in household and other non-agricultural uses of fertilizer.

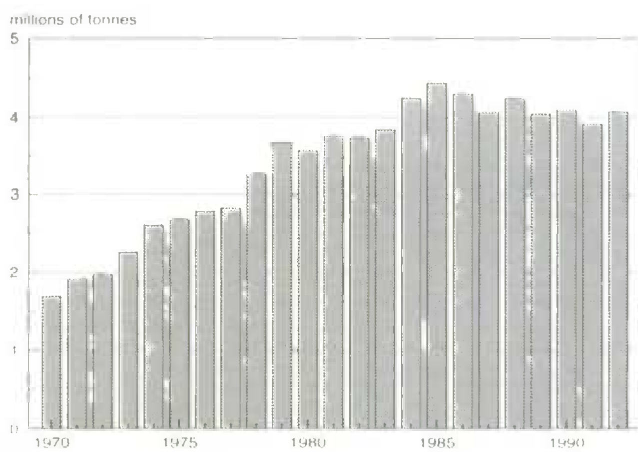
Map 3.8.1 looks at the percent change in agricultural fertilizer application by drainage sub-basin. Fertilizer tonnages applied to agricultural land have been rising. The largest increases occur in the Prairie provinces where tonnage increases range from 100 to over 1 000 percent. Changes in Eastern Canada are less pronounced, because fertilizer application began well before 1970.

Figure 3.8.2 presents percent cropland fertilized by ecozone. The highest proportion of cropland fertilized occurred in 1986, corresponding closely to the sales maxima in Figure 3.8.1.

In summary, fertilizer application rates were at their highest levels in the mid 1980s. Application rates and sales now appear to be declining in most areas of the country, with the exception of the Prairie provinces.

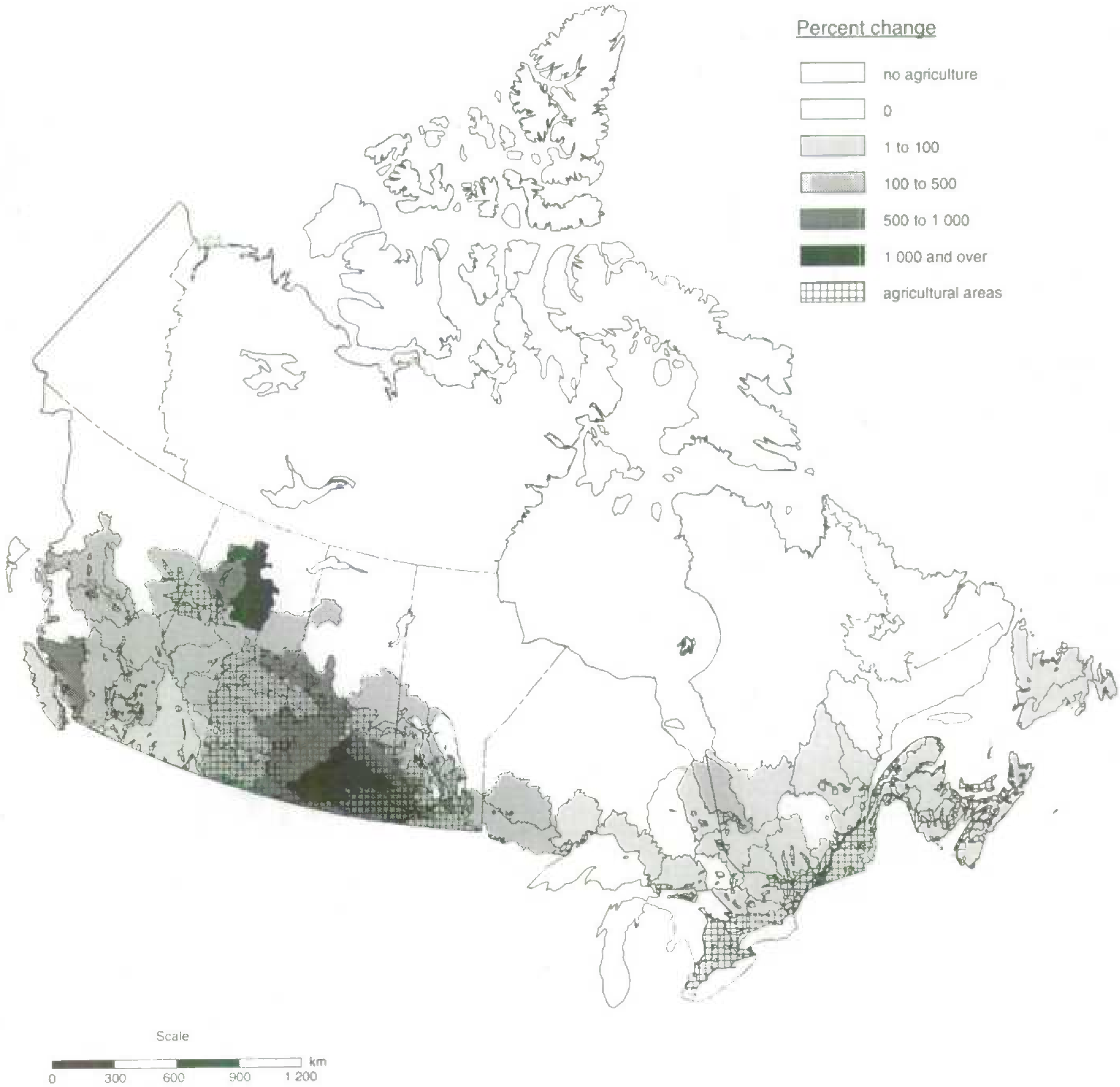
Figure 3.8.1

Fertilizer Sales, 1970-1992



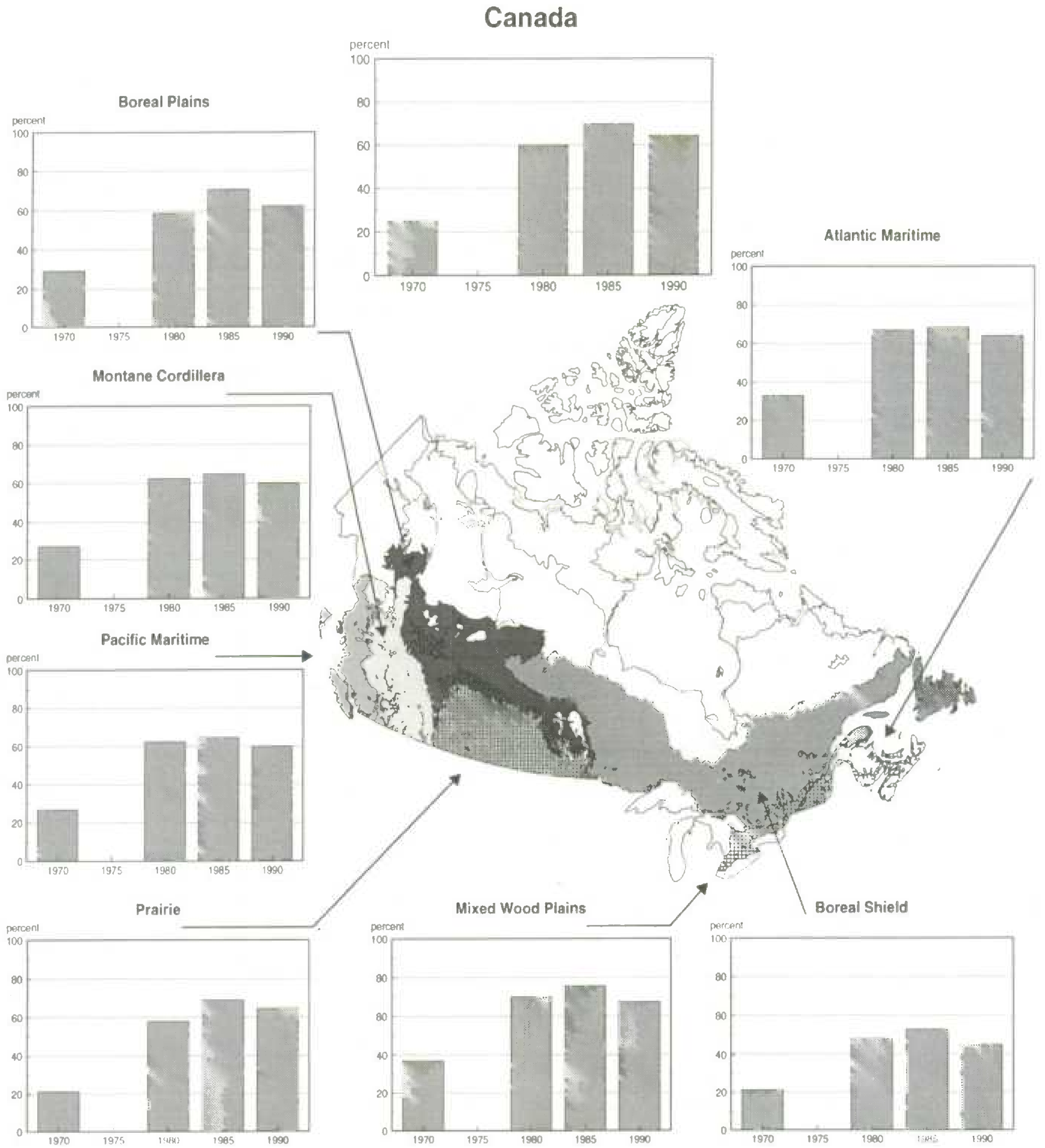
Source:
Agriculture Canada, "Canadian Fertilizer Consumption, Shipments and Trade 1991/1992", working paper, Farm Development Policy Directorate, Ottawa, 1993.

Map 3.8.1
Change in Total Fertilizer Applied by Sub-basin, 1970-1990



Notes:
Shaded areas represent drainage sub-basins where agricultural fertilizers have been applied. Sub-basins were used because fertilizer nutrients may leach into the groundwater and/or reach surface waters. These nutrients can have impacts throughout the watershed.
To isolate areas of primary concern, grid-shading is used to represent agricultural areas.
Changes in fertilizer tonnage may not precisely reflect the changing nutrient content of fertilizers.
Quantity estimates for 1970 and 1990 were derived from fertilizer expense data.
For sub-basin geographic detail, see Section 1.4 - **Geographic Units for Environmental Analysis**.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 3.8.2
Cropland Area Fertilized by Ecozone, 1970-1990



Notes:
The area of cropland fertilized increased steadily until 1985. After 1985 there is a decline in fertilized areas in each ecozone.
Data for 1975 are not available.
Agricultural areas are depicted by grid shading.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Agricultural Pesticides

Agricultural pesticides are applied to control insects, weeds and crop diseases in an effort to maintain crop quantity and quality. When the proper pesticide is applied carefully with the appropriate equipment, under favourable environmental conditions, impacts on surrounding plants and animals are minimized. Ideally, a pesticide should be selective and control a precise target organism only, then breakdown into benign constituents shortly after application. However, this is not always the case. Relatively inexpensive broad spectrum pesticides that not only eliminate their target pest but also effect non-target species in fields and waterways are often used.[1]

One way to combat pests with low environmental impact is to use farming techniques like crop rotation, organic farming and natural plant resistance. Many insects, weeds and plant diseases are highly adaptable and have the ability to rapidly develop resistance to pesticides. In 1975, it was estimated that as many as 137 insect species had developed resistance to one or more pesticide chemicals. By 1991 this figure had grown to exceed 500.[2] As more pests become pesticide resistant, there is the danger that more complex and powerful replacement pesticides (with greater environmental impact) will be required. To combat these and other environmental problems a new type of "organic farming" is evolving, where farmers adopt low-input technologies that promote crop rotation, mixed agriculture and natural pest controls instead of synthetic chemical products.

1. Wauchope,R.D., "The Pesticide Content of Surface Water Draining from Agricultural Fields - A Review", *Journal of Environmental Quality*, 1978, p. 459-472.
2. Conway, G.R, J.N. Pretty, *Unwelcome Harvest*, International Institute for Environment and Development, Earthscan Publications, 1991.

Statistics Canada's Census of Agriculture gathers information on the value of pesticides applied by farmers. Pesticide expense data are at best, only indicators of potential environmental impact. Many factors influence the environmental impacts of pesticides. These include the time of application, rainfall, stability of the pesticide, method of application, and many others.

The value of pesticides applied on farmland increased more than four-fold between 1970 and 1990 (Table 3.8.2). The most significant increases in pesticide application rates occurred in the Prairie provinces where pesticide inputs have increased ten-fold (Map 3.8.2). However, application rates per hectare of cultivated land were still much lower in the Prairie provinces, than in Ontario and Quebec, where application rates ranged as high as 38 dollars per hectare.

Figure 3.8.3 sums up the national pesticide expense situation for Canada's seven ecozones that contain agricultural activity. Application rates have risen in every ecozone with the exception of the Montane Cordillera in British Columbia. Historically, high application rates on the relatively small cropland area in this ecozone resulted from fruit crops, which use significant amounts of pesticides to prevent spoilage.

Summary

To conclude, the use of fertilizers and pesticides has increased significantly in Canada over the last 20 years. The economic benefits of their use include increased crop quality and yields. Balanced against these benefits are the environmental costs associated with both pesticide and fertilizer use.

Table 3.8.2

Agricultural Pesticide Expenditures and Application Rates by Sub-basin, 1970, 1980 and 1990

	Agricultural pesticide expenditures					Agricultural pesticide per hectare of cultivated land				
Provincial sub-basin	1970	1980	1990	Change 1980-1990	Change 1970-1990	1970	1980	1990	Change 1980-1990	Change 1970-1990
	thousand constant 1990 dollars			percent		1990 dollars per hectare			percent	
Newfoundland										
North Newfoundland	90.2	60.3	93.3	50.8	0.3	47.77	24.20	23.60	-2.60	-50.7
South Newfoundland	95.0	94.4	169.4	79.5	78.3	18.85	13.96	23.70	69.60	25.6
Total	**185.2**	**154.7**	**262.7**	**68.3**	**40.3**	**26.73**	**16.70**	**23.80**	**42.50**	**-10.9**
Prince Edward Island										
Prince Edward Island	3 718.5	6 654.1	8 962.3	34.7	141.0	19.35	33.69	51.40	52.60	165.6
Total	**3 718.5**	**6 654.1**	**8 962.3**	**34.7**	**141.0**	**19.35**	**33.69**	**51.40**	**52.60**	**165.6**
Nova Scotia										
Bay of Fundy	2 546.2	2 960.8	3 924.2	32.5	54.1	21.30	21.56	33.60	55.90	57.8
Southeast Atlantic Ocean	96.2	111.5	224.7	101.5	133.6	6.47	6.67	17.30	159.20	167.2
Cape Breton Island	49.5	24.7	299.3	1 113.8	505.2	4.98	2.47	35.60	1 342.10	615.3
Total	**2 691.9**	**3 097.0**	**4 448.2**	**43.6**	**65.2**	**18.65**	**18.90**	**32.20**	**70.60**	**72.6**
New Brunswick										
Saint John and South Bay of Fundy	3 370.7	5 003.5	6 418.4	28.3	90.4	27.46	41.23	60.50	46.90	120.5
Gulf of St. Lawrence and North Bay of Fundy	1 107.1	521.8	730.5	40.0	-34.0	19.21	9.34	17.10	82.50	-11.2
Total	**4 477.8**	**5 525.3**	**7 148.9**	**29.4**	**59.7**	**24.82**	**16.20**	**48.00**	**196.60**	**93.5**

Table 3.8.2

Agricultural Pesticide Expenditures and Application Rates by Sub-basin, 1970, 1980 and 1990 (Continued)

Provincial sub-basin	Agricultural pesticide expenditures					Agricultural pesticide per hectare of cultivated land				
	1970	1980	1990	Change 1980-1990	Change 1970-1990	1970	1980	1990	Change 1980-1990	Change 1970-1990
	thousand constant 1990 dollars			percent		1990 dollars per hectare			percent	
Quebec										
Saint John	134.9	114.4	80.4	-29.7	-40.4	3.04	3.28	2.90	-10.70	-3.6
Cascapedia and Gulf of St. Lawrence	140.4	149.7	210.4	40.6	49.9	2.57	3.09	5.90	89.60	128.0
Upper Ottawa	81.1	114.0	149.0	30.7	83.9	1.22	2.00	3.30	65.50	171.3
Coulonge and Central Ottawa	167.5	251.4	200.7	-20.2	19.8	3.77	5.47	5.30	-2.60	41.4
Gatineau and Lower Ottawa	780.2	737.1	853.5	15.8	9.4	5.60	5.94	8.70	47.00	55.9
Upper St. Lawrence	426.9	1 023.2	1 772.5	73.2	315.2	8.01	18.85	34.30	82.10	328.6
St-Maurice	109.5	163.6	142.0	-13.2	29.7	11.44	23.75	25.00	5.40	118.9
Central St. Lawrence	14 793.1	21 470.2	32 091.8	49.5	116.9	13.37	20.75	34.30	65.30	156.5
Lower St. Lawrence	2 842.2	4 004.0	5 584.1	39.5	96.4	4.68	7.64	13.00	70.30	178.0
North Gaspé Peninsula	360.3	445.1	618.8	39.0	71.7	2.45	3.57	6.20	73.90	153.5
Saguenay	392.2	664.4	1 227.1	84.7	212.9	2.68	4.87	10.50	115.40	291.4
Betsiamites	3.7	18.9	10.2	-14.5	18.2	1.98	3.64	5.60	54.40	183.8
Manicouagan and Outardes	15.3	16.6	14.5	-12.9	-5.2	23.23	28.23	22.10	-21.60	-4.7
Nottaway	3.2	4.8	0.2	-95.8	-93.7	0.77	0.64	0.10	-90.60	-92.2
Abitibi and North French	28.8	34.6	68.5	97.6	137.6	0.80	1.08	2.80	156.50	246.2
Harricanaw	15.8	19.6	45.6	132.1	188.9	0.86	0.98	4.00	303.10	359.3
Total	**20 295.1**	**29 231.6**	**43 069.3**	**47.4**	**112.2**	**8.18**	**12.98**	**22.40**	**72.50**	**173.7**
Ontario										
Nipigon and Northwest Lake Superior	48.2	57.4	113.7	98.0	135.8	2.65	3.24	8.80	173.10	234.0
Northeast Lake Superior	4.0	2.3	35.0	1 398.3	765.7	3.04	2.03	38.20	1 783.30	1 157.6
North Lake Huron	142.5	124.0	213.6	72.2	49.9	2.90	2.27	4.50	98.70	55.5
Wanipitai and French	56.4	89.3	123.5	38.4	118.8	1.66	2.58	5.00	93.80	201.2
East Georgian Bay	5 833.8	7 625.9	10 252.9	34.4	75.7	19.38	23.82	37.90	59.30	95.8
East Lake Huron	8 640.3	16 178.3	23 437.5	44.9	171.3	10.26	18.88	30.20	60.10	194.6
North Lake Erie	38 884.0	65 303.9	82 411.4	26.2	111.9	26.29	42.55	56.10	31.90	113.5
Lake Ontario	14 307.6	16 906.6	21 946.1	29.8	53.4	19.41	22.16	34.80	56.90	79.2
Montréal and Upper Ottawa	48.3	205.7	318.3	54.7	559.3	0.93	3.20	6.20	92.50	562.4
Madawaska, Petawawa and Central Ottawa	661.1	927.8	811.9	-12.5	22.8	4.19	5.66	6.30	11.70	50.8
Rideau and Lower Ottawa	3 168.9	3 709.1	5 869.1	58.2	85.2	8.71	10.67	19.50	82.50	123.5
Upper St. Lawrence	782.4	1 175.3	1 704.4	45.0	117.8	5.84	9.04	16.90	87.40	190.1
Moose	27.2	19.7	20.2	2.5	-25.8	4.45	3.28	3.90	19.20	-12.1
Abitibi	16.4	5.5	67.5	1 120.7	310.6	1.54	0.38	6.80	1 684.20	340.3
Upper Winnipeg	28.3	27.1	218.4	706.8	672.2	1.04	0.74	7.10	859.50	582.7
English	2.7	2.5	3.8	50.7	42.7	0.37	0.35	0.60	60.00	51.4
Total	**72 652.2**	**112 360.4**	**147 547.4**	**31.3**	**103.1**	**17.21**	**25.81**	**38.20**	**47.90**	**121.8**
Manitoba										
Saskatchewan	14.1	166.5	401.4	141.1	2 755.0	0.67	6.53	13.70	109.80	1 944.8
Lake Winnipegosis and Lake Manitoba	3 711.4	14 816.3	26 027.1	75.7	601.3	2.98	11.14	18.60	67.00	524.2
Assiniboine	3 252.2	16 392.6	29 162.0	76.0	787.1	2.49	12.02	21.40	77.60	757.4
Souris	1 343.1	6 598.6	10 144.6	53.7	655.3	2.26	10.41	15.90	52.90	604.4
Red	6 216.3	30 717.2	44 273.5	44.1	612.2	3.89	18.05	26.80	48.40	588.7
Winnipeg	74.7	361.3	953.8	164.0	1 177.2	1.71	7.44	22.40	200.50	1 207.6
West Lake Winnipeg	578.5	2 187.6	4 945.2	125.8	753.9	2.28	8.21	18.90	130.50	729.8
Total	**15 190.2**	**71 240.1**	**115 907.6**	**62.7**	**663.0**	**3.00**	**13.26**	**21.47**	**61.90**	**615.4**
Saskatchewan										
Central North Saskatchewan	890.9	5 214.9	8 719.0	68.5	928.2	1.35	7.30	12.40	69.70	817.8
Battle	344.1	2 445.4	5 139.8	110.2	1 393.6	1.50	9.85	16.30	65.10	984.0
Lower North Saskatchewan	3 060.7	17 890.1	31 041.8	73.5	914.1	1.19	6.67	11.50	72.60	867.2
Lower South Saskatchewan	4 557.5	21 332.3	35 215.6	65.1	672.7	1.28	5.73	9.20	60.00	616.4
Qu'Appelle	5 070.7	20 917.3	49 215.2	135.3	870.6	0.99	3.91	8.90	127.60	799.0
Saskatchewan	3 595.0	13 865.5	19 377.3	39.8	439.0	3.36	12.89	16.60	28.90	394.6
Lake Winnipegosis and Lake Manitoba	902.2	4 566.2	9 716.2	112.8	976.9	1.68	7.40	17.00	130.10	913.7
Assiniboine	2 637.8	10 506.9	29 945.2	185.0	1 035.2	1.49	5.76	15.30	166.30	929.5
Souris	1 854.0	9 450.4	22 046.8	133.3	1 089.1	0.92	4.51	9.70	114.20	950.0
Beaver	269.3	1 665.8	3 013.3	80.8	1 018.7	0.97	5.51	9.60	73.50	885.6
Missouri	668.5	1 859.4	5 334.9	186.9	698.0	0.91	2.37	6.10	158.20	572.5
Total	**23 850.8**	**109 714.2**	**218 765.1**	**99.4**	**817.2**	**1.29**	**5.65**	**10.80**	**91.30**	**740.7**

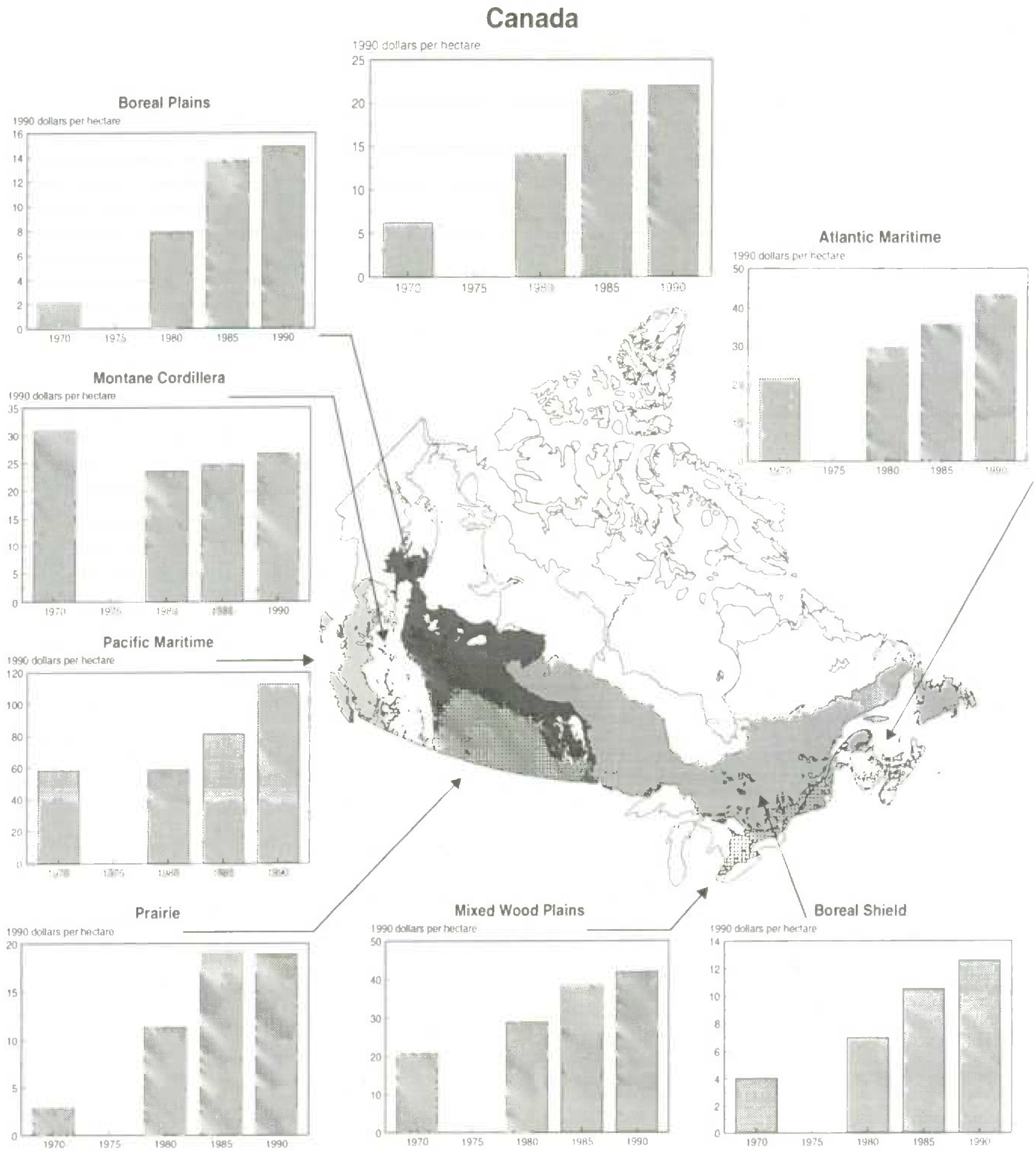
Table 3.8.2

Agricultural Pesticide Expenditures and Application Rates by Sub-basin, 1970, 1980 and 1990 (Continued)

Provincial sub-basin	Agricultural pesticide expenditures					Agricultural pesticide per hectare of cultivated land				
	1970	1980	1990	Change 1980-1990	Change 1970-1990	1970	1980	1990	Change 1980-1990	Change 1970-1990
	thousand constant 1990 dollars			percent		1990 dollars per hectare			percent	
Alberta										
Upper South Saskatchewan	4 487.3	15 309.7	25 002.7	189.6	458.0	2.35	7.18	11.50	60.70	391.1
Bow	2 113.4	5 974.3	8 818.2	148.3	317.3	2.84	7.78	12.50	61.20	341.5
Red Deer	4 704.8	18 362.2	32 890.6	187.0	599.1	2.16	7.95	13.30	67.50	516.7
Upper North Saskatchewan	567.9	1 485.6	2 845.0	203.9	401.0	1.67	4.22	7.00	66.60	321.0
Central North Saskatchewan	2 845.9	13 498.1	25 914.5	202.7	810.6	1.75	8.25	15.00	81.80	757.1
Battle	2 454.6	16 091.7	26 047.7	168.6	961.2	1.60	9.74	16.80	72.40	949.4
Lower North Saskatchewan	468.2	1 772.3	4 627.8	185.4	888.5	1.04	3.07	7.50	143.60	619.2
Beaver	125.7	751.8	1 509.9	238.5	1 100.9	0.67	3.63	5.70	55.60	743.3
Upper Athabasca	48.1	61.6	209.1	214.2	197.7	1.16	1.14	2.40	114.00	110.3
Pembina and Central Athabasca	794.3	2 561.6	5 288.9	197.1	565.8	1.34	3.95	7.60	92.90	468.7
Lower Central Athabasca	112.4	470.3	1 030.6	290.6	816.5	1.00	4.09	7.60	85.30	658.0
Upper Peace	550.5	2 611.7	7 039.0	272.8	1 178.7	1.13	4.84	12.00	147.50	960.2
Smoky	772.9	3 960.5	10 523.6	346.3	1 261.6	1.32	6.21	14.30	130.10	982.6
Central Peace	197.3	1 585.6	4 449.4	344.3	2 154.6	0.79	4.67	12.20	160.80	1 441.8
Lower Central Peace	24.8	150.4	1 058.1	403.5	4 164.5	0.71	2.75	10.10	266.90	1 321.1
Missouri	198.2	531.7	1 188.0	220.1	499.4	1.05	2.82	6.20	120.20	491.4
Total	**20 466.3**	**85 179.1**	**158 442.9**	**200.0**	**674.2**	**1.19**	**6.97**	**12.40**	**77.60**	**943.1**
British Columbia										
Upper Peace	403.8	1 733.7	2 247.6	29.6	456.6	1.36	4.80	5.90	20.80	330.9
Skeena	35.4	27.9	106.9	283.4	202.1	2.00	0.90	4.10	329.50	104.0
Vancouver Island	454.6	412.4	536.4	30.1	18.0	24.03	17.70	21.10	19.80	-12.0
Nechako	32.2	26.2	96.1	267.1	198.9	1.05	0.40	1.30	215.00	20.0
Upper Fraser	46.8	51.3	84.6	65.1	80.7	1.25	0.80	1.40	76.60	8.8
Thompson	190.2	286.8	470.2	64.0	147.2	2.91	2.30	5.90	157.60	102.7
Fraser	3 043.5	4 427.3	7 362.1	66.3	141.9	29.95	40.70	76.80	88.70	156.3
Columbia	5 269.0	5 050.1	5 377.9	6.5	2.1	52.73	45.30	60.60	33.80	14.9
Residual Sub-basins	1.7	13.5	51.2	..	..	..	..	..	..	..
Total	**9 477.1**	**12 029.0**	**16 333.1**	**35.8**	**72.3**	**14.08**	**13.40**	**19.10**	**42.70**	**35.6**
Canada	**173 005.0**	**435 185.5**	**720 887.6**	**65.7**	**316.7**	**4.04**	**9.60**	**15.80**	**64.40**	**291.2**

Notes:
Figures may not add due to rounding.
Farm input price indices were used to obtain 1990 constant dollar expenditures.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

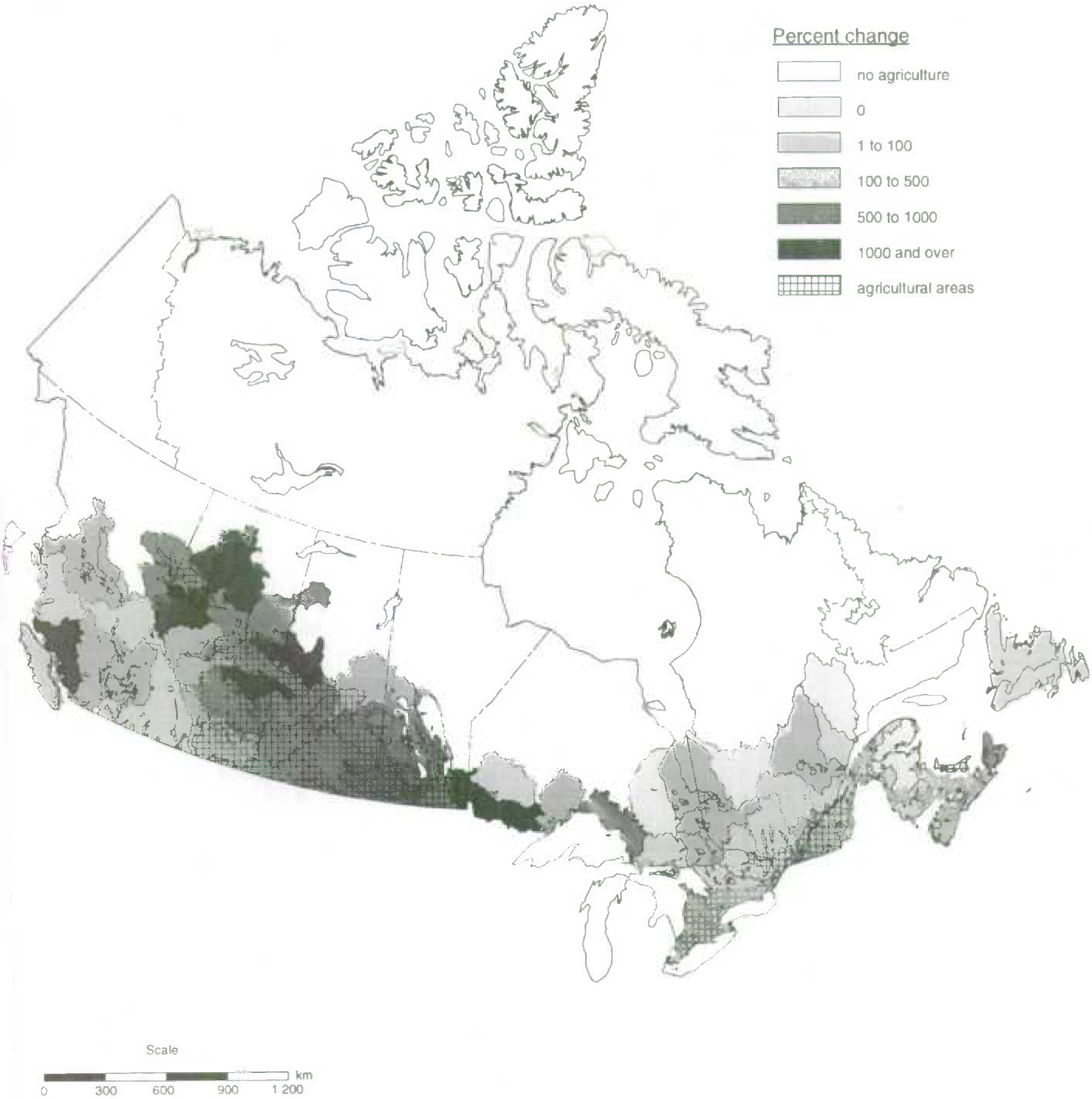
Figure 3.8.3
Agricultural Pesticide Application Rates on Cropland by Ecozone, 1970-1990



Notes:
Expenditures on agricultural chemicals can only be used as indicators of changing chemical application rates. Ideally, volume of pesticides and toxicity would be better environmental indicators.
Farm input price indices were used to obtain 1990 constant dollar value expenditures.
Agricultural areas are depicted by grid shading.
Data for 1975 are not available.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 3.8.2

Change in Agricultural Pesticide Expenditure by Sub-basin, 1970-1990



Notes:
Shaded areas represent drainage sub-basins where agricultural pesticides have been applied. Sub-basins were used because many pesticides are water soluble and may have impacts throughout the watershed. To isolate areas of primary concern, grid-shading is used to represent agricultural areas. Expenditures on agricultural pesticides can only be used as indicators of changing pesticide application rates. Ideally, volume of pesticides and toxicity would be better environmental indicators. Farm input price indices were used to obtain1990 constant dollar expenditures.
For sub-basin geographic detail, see Section 1.4 - **Geographic Units for Environmental Analysis**.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

3.9 Agricultural Impacts on Land

Agricultural activity has more widespread physical impact on the environment than any other economic activity. Globally, more than 1.47 billion hectares of land[1] have been physically restructured to some extent by agriculture, and are now producing crops, with each hectare supporting on average more than 3.5 people.[2] Canada accounts for about 2 percent of this land, even though its population is about 0.5 percent of the world total. The environmental impacts of land restructuring on this scale are enormous. Here are some examples: changing atmospheric carbon dioxide concentrations, changes in natural genetic stocks, changes to established ecosystems caused by the introduction of exotic species, large scale drainage modifications causing the increased risk of flooding, and the erosion of billions of tonnes of top soil. This section focuses on the impacts of agricultural processes on land and looks at Canadian trends for key environmental indicators.

Soil Erosion

In natural forest and grassland ecosystems, most rainfall is trapped by an undisturbed, continuous vegetative cover. This carpet of natural vegetation prevents water from running overland by intercepting and holding precipitation, allowing it to penetrate the soil where it can be used by plants. Often when the land's natural vegetation cover is removed, water begins to run over rather than into the soil and natural soil moisture levels start to decline. Increased rates of overland flow have the potential to take away significant amounts of valuable topsoil. Not only is soil washed away, but so are essential plant nutrients. Ultimately these eroded materials enter drainage networks and are carried away often destroying fish habitat, filling reservoirs, plugging water intake pipes and silting harbours far from agricultural fields. Both soil particles and excess nutrients contribute to secondary environmental problems such as eutrophication.[3]

Soil erosion increases production costs for the farmer. Nutrients lost by erosion must be replaced with supplementary fertilizers. Degraded soils also require additional tillage and irrigation, increasing farmer input costs and the potential environmental stress associated with these increased inputs. Crop quality and yields also decline on degraded soils. In all, it is estimated that land degradation costs Canadian farmers over one billion dollars annually.[4]

Table 3.9.1 and Figures 3.9.1 and 3.9.2 provide an indication of the relative provincial magnitude of soil erosion caused by water.[5] Soil erosion totals are roughly proportional to the amounts of cultivated land in each province. Saskatchewan is the province with the largest tilled land area, contributing more than 13 million hectares to Canada's total of 29 million hectares. Total soil erosion by water is also highest in Saskatchewan, with soil erosion values estimated at more than 67 million tonnes in 1991. Alberta is next, with 8 million hectares of tilled land and an estimated gross soil erosion value of 22.9 million tonnes. Eastern provincial erosion totals are lower than western ones largely because of smaller tilled land areas (Table 3.9.1).

Table 3.9.1

Agricultural Land Prepared for Seeding and Estimated Gross Soil Erosion by Water, 1991

Province	Soil erosion by water	Area prepared for seeding
	million tonnes	hectares
Newfoundland	..	2 050
Prince Edward Island	0.8	11 720
Nova Scotia	0.2	31 664
New Brunswick	0.7	61 681
Quebec	3.4	851 921
Ontario	17.0	2 508 344
Manitoba	12.6	4 219 049
Saskatchewan	67.2	13 034 981
Alberta	22.9	7 966 393
British Columbia	1.0	240 964
Canada	**125.8**	**29 028 766**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

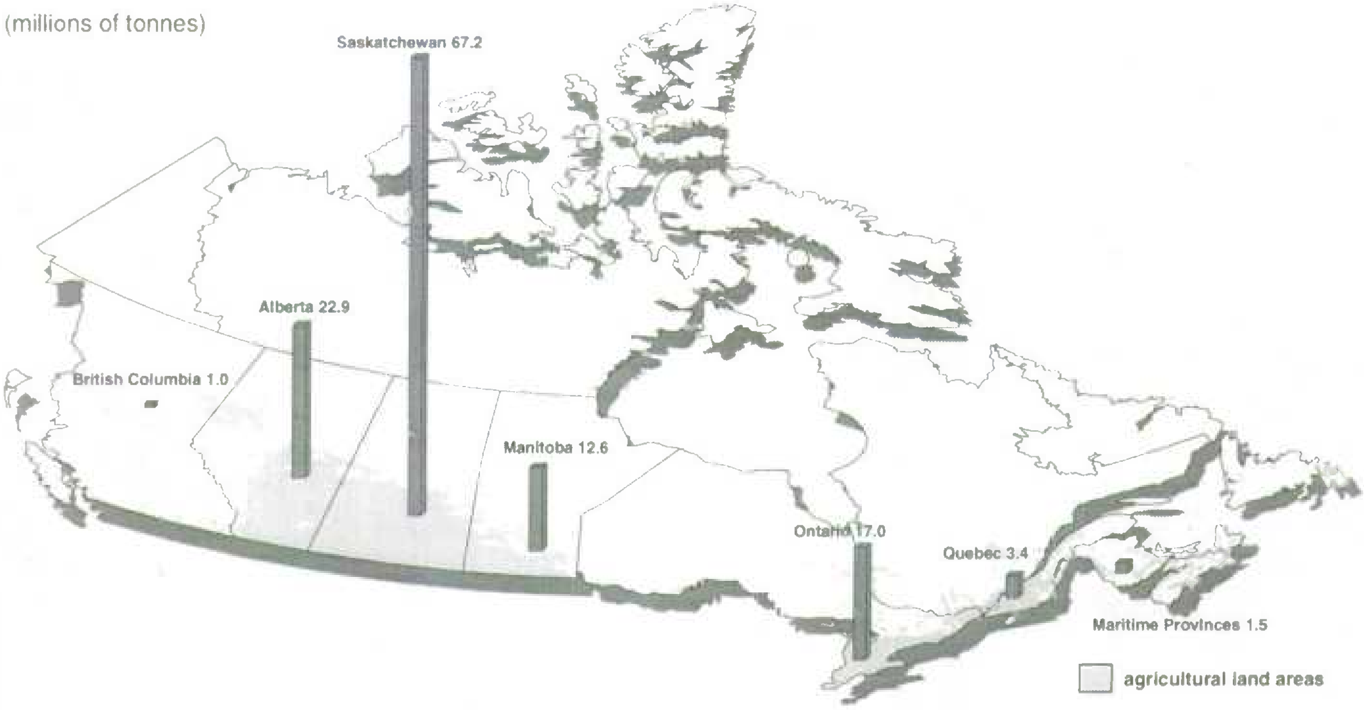
Whereas Figure 3.9.1 presents information on the magnitude of soil erosion by water, Figure 3.9.2 presents information on the rate of soil erosion in each province. Differences between the provinces are largely a consequence of variations in slope characteristics, soil texture, cropping practices and soil conservation practices on farms. Ontario farms have the highest average rate of soil erosion by water at 4.4 tonnes per cultivated hectare. Ontario has a greater proportion of land planted in wide-row crops, increasing the risk of erosion (Map 3.9.1). Land planted in crops such as corn and soybeans is more erodible than that planted in forage crops like alfalfa because wide-row crops allow rainfall energy to impact the soil directly, while forages tend to provide complete coverage.[6] The average rate of soil erosion by water in the Maritime Provinces (3.3 tonnes per hectare), is also affected by the relatively high proportion land planted in wide-row crops such as potatoes and vegetables. In the Prairie provinces the rate of soil erosion by water is highest in Saskatchewan (exceeding 3.4 tonnes per hectare), largely due to the influence of summerfallow. Summerfallow, the practice of leaving fields without a crop to increase soil

1. This land area is 1.5 times the size of Canada.
2. World Resources Institute, *World Resources 1990-91*, Oxford University Press, London, 1990.
3. Eutrophication is a process whereby excess nutrients enrich water bodies and subsequently cause excessive growth of algae and other aquatic plants. These plants are particularly deadly to animal species when they die and consume much of the water's free oxygen in the decay process.
4. Fox, M.G., and D. R. Coote, *A Preliminary Economic Assessment of Agricultural Land Degradation in Atlantic and Central Canada and Southern British Columbia*, for Regional Development Branch and Centre for Land and Biological Resources Research, Development Consulting House (DCH), Contribution 85-70, Agriculture Canada, Ottawa, 1986.
5. Data are not yet available below the province level.
6. Wischmeier, W.H., and D. D. Smith, *Predicting Rainfall Erosion Losses - A Guide to Conservation Planning*, Agricultural Handbook No. 537, Department of Agriculture, Washington, D.C., United States, 1978.

Figure 3.9.1

Estimated Total Soil Erosion by Water On Cultivated Land, 1991

(millions of tonnes)

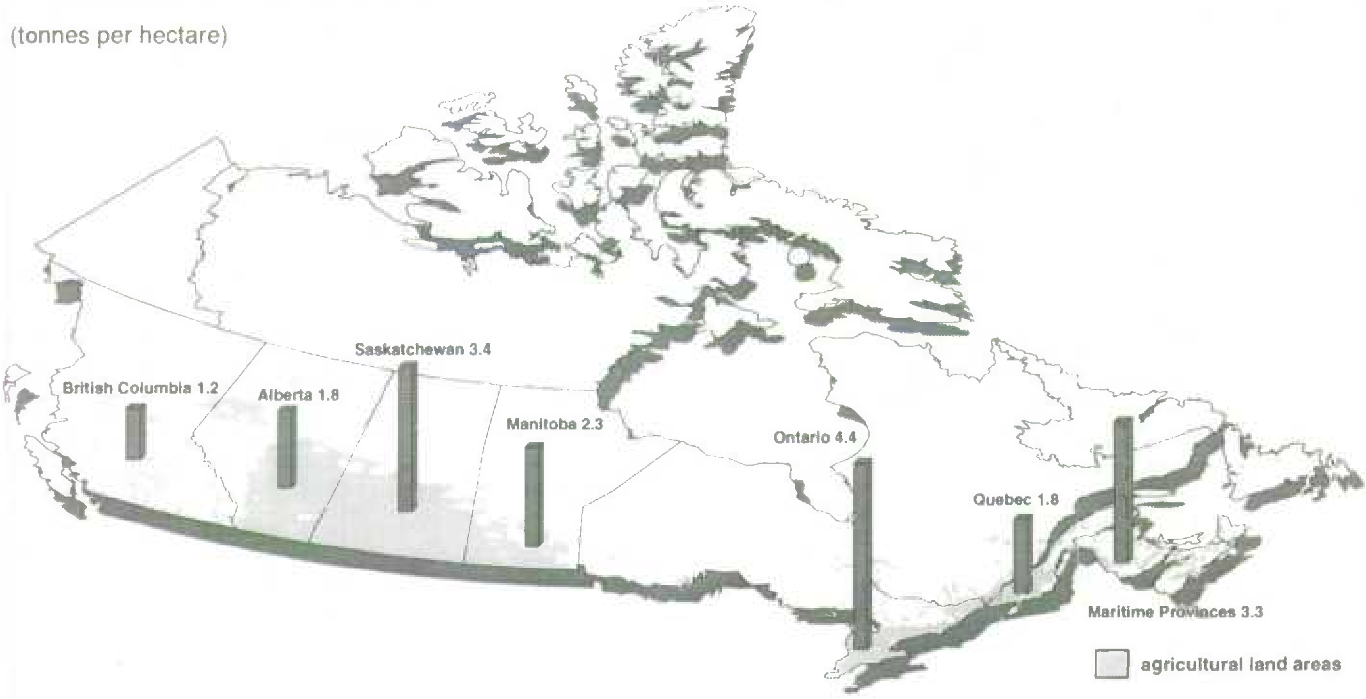


Notes:
Estimates not available for Newfoundland. Calculations are based on 1981 physical factors and 1991 crops distributions. Estimates refer only to gross soil erosion and not actual soil loss.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division. Agriculture Canada, Centre for Land and Biological Resources Research.

Figure 3.9.2

Estimated Soil Erosion Rates by Water on Cultivated Land, 1991

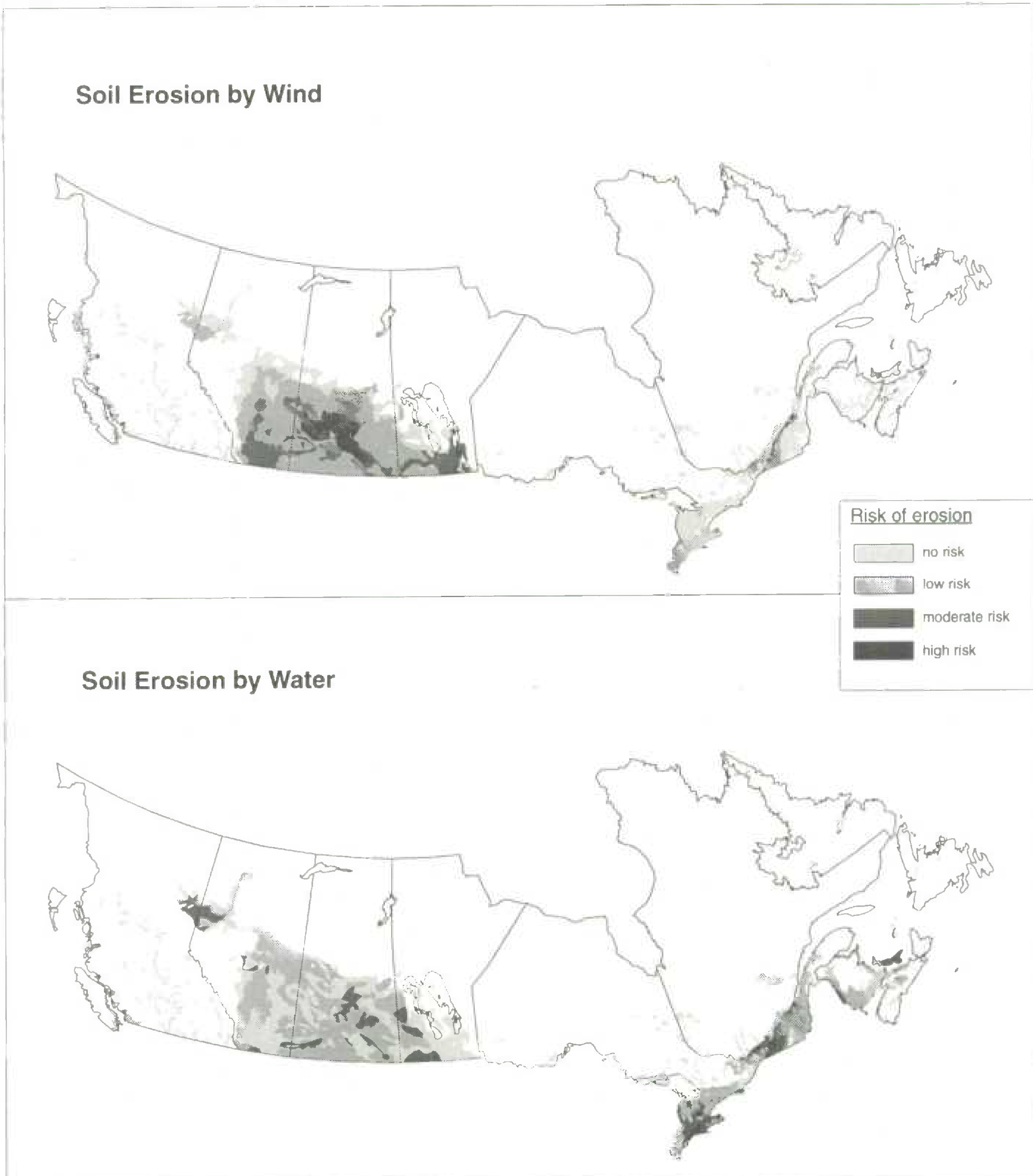
(tonnes per hectare)



Notes:
Estimates not available for Newfoundland. Calculations are based on 1981 physical factors and 1991 crops distributions. Estimates refer only to gross soil erosion and not actual soil loss.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division. Agriculture Canada, Centre for Land and Biological Resources Research.

Map 3.9.1

Risk of Soil Erosion on Agricultural Land



Note:
In order to maximize detail only the provinces with significant amounts of agriculture are shown.
Source:
Agriculture Canada, Centre for Land and Biological Resources Research, 1989.

moisture levels, has two detrimental environmental effects. The first is increased soil salinity, caused by excess soil moisture. The second is increased soil erosion resulting from the lack of vegetation cover.

Map 3.9.1 shows the risk of soil erosion by both wind and water in agricultural areas across Canada. Western provinces are more susceptible to wind erosion not only due to stronger prevailing winds, but also to the relatively flat landscape that provides little shelter from strong winds. Eastern provinces have a higher risk of water erosion because slope and rainfall factors combine to make the area more susceptible to erosion by water.

Cropping Practices

Farmland in Canada is a natural resource of finite extent and variable quality. Less than 10 percent of Canada's land area is capable of dependable agricultural production.[1] Since our land resources are limited, measuring land utilisation intensity and other agricultural indicators is important not only for evaluating the long term sustainability of agriculture but equally importantly, for determining the impact that modern agriculture has on the environment. Cropping practice trends provide an important indication of changing levels of environmental stress on agricultural land and help to answer questions about the long term sustainability of agriculture. This subsection presents trends in monoculture cropping between 1971 and 1991.[2]

From an ecological standpoint the most stable biotic communities are very complex with countless species interacting to form a diverse community network. The tropical rain forest is perhaps the most stable ecological community, deriving its stability from a multitude of checks and balances that serve to suppress the domination of any particular species, while at the same time preventing the extinction of other species.[3] In contrast, monoculture cropping systems are inherently unstable; they are more susceptible to outbreaks of insects, disease, weeds and micro-nutrient imbalances. Despite these high ecological costs, monoculture cropping systems are the most productive. They create their own economies of scale and use specialisation to increase production levels. In 1991, more than 75 percent of crops planted in Canada were grown in monoculture cropping systems (Table 3.9.2).

Wide-row Monoculture

Wide-row monocultures are most prevalent in eastern Canada. The following crop types are grown in wide-row monocultures: corn, beans, potatoes, soybeans, vegetables and tobacco. For the most part, these crops are planted with wide spacing between the crop rows.

Wide-row monoculture can be one of the most environmentally stressful forms of agriculture. Pesticide expenses per hectare on wide-row monoculture farms are 5 times the national average, while fertilizer expenses are more than 4 times the national average. And, as already mentioned, land planted in wide-row crops is more susceptible to erosion by water. Wide-row monocultures have an erosion rate 2-3 times that of a grain crop.

Nationally, wide-row monoculture cropping has increased by more than 118 percent in the past 20 years, growing from 0.68 million in 1971 to over 1.48 million hectares by 1991 (Table 3.9.2 and Map 3.9.2).

Close-row Monoculture

Crops grown in close-row monoculture are primarily grains and oilseeds.[4,5] The Prairie provinces grow more than 90 percent of Canada's grain and oilseed crops. The close-row monoculture-summerfallow system has had significant effect on prairie land resources.

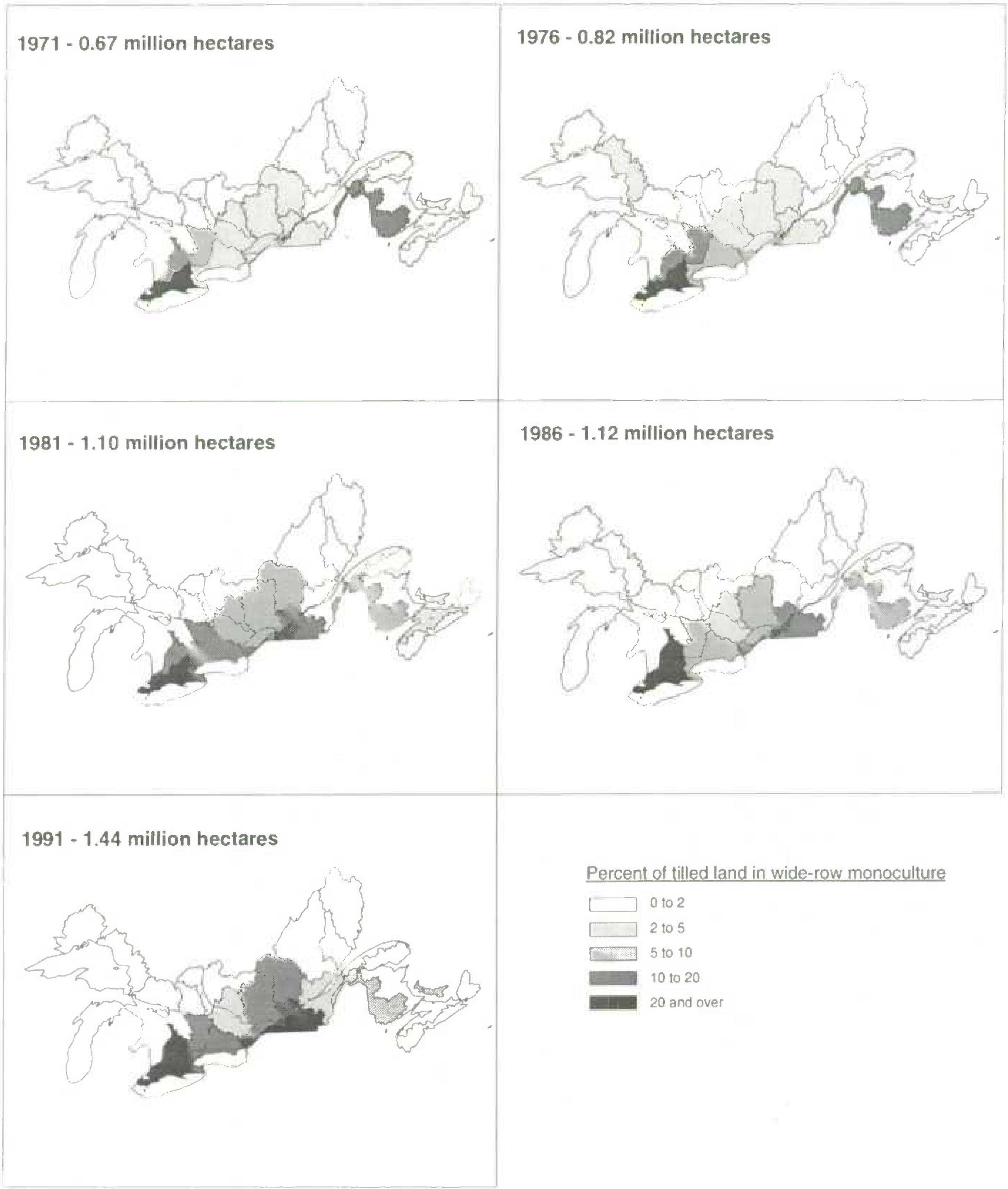
Close-row monoculture farms[6] have contributed to the decline in prairie soil organic matter levels. It was estimated in 1982 that as much as 50 percent of the nutrient rich, naturally occurring organic matter had been removed from Prairie soils in a 44 year period.[7] Although these levels may now be reaching a new equilibrium it is unlikely that organic matter levels will ever return to the high levels associated with permanent grasslands. Reduced organic matter levels decrease soil-water retention, which serves to increase run-off and resulting soil erosion. Map 3.9.3 and Table 3.9.2 indicate that national close-row monoculture levels have grown by only 3.1 percent in the last 20 years. However, the large areas associated with this type of practice continue to provide reason for concern.

On a more positive note, the 1991 Census of Agriculture indicates that soil conservation practices such as strip cropping and conservation tillage are now playing a major role in controlling the environmental stress imposed by traditional close-row monoculture systems. More than 70 percent of prairie farms use at least one erosion control practice.[8]

1. Dumanski, J., D. R. Coote, D. Luciuk and C. Lok C., "Soil Conservation in Canada", *Journal of Soil and Water Conservation*, 41:4 (July-August) 1986.
2. Monoculture is the continual planting of a single crop type.
3. Koepf, H., *Biodynamic Agriculture*, Anthroposophic press, 1986.
4. The primary crops in close-row systems are: wheat, oats, barley, mixed grains, rye, buckwheat and oilseeds.
5. Trant, D., *Measuring Environmental Stress using the Agricultural Practices Impact Model (APIM)*, unpublished working paper, National Accounts and Environment Division, Statistics Canada, Ottawa, 1992.
6. A farm is defined as close-row or wide-row monoculture if more than 80 percent of its cropland is planted in close-row or wide-row crops.
7. Rennie, D.A., "The Deteriorating soils of the Canadian Prairie", *Span*, 25:3, 1982.
8. Trant, D., "The 1991 Census of Agriculture: Land Management for Soil Erosion Control", *Environmental Perspectives*, Statistics Canada, Catalogue No. 11-528, 1993.

Map 3.9.2

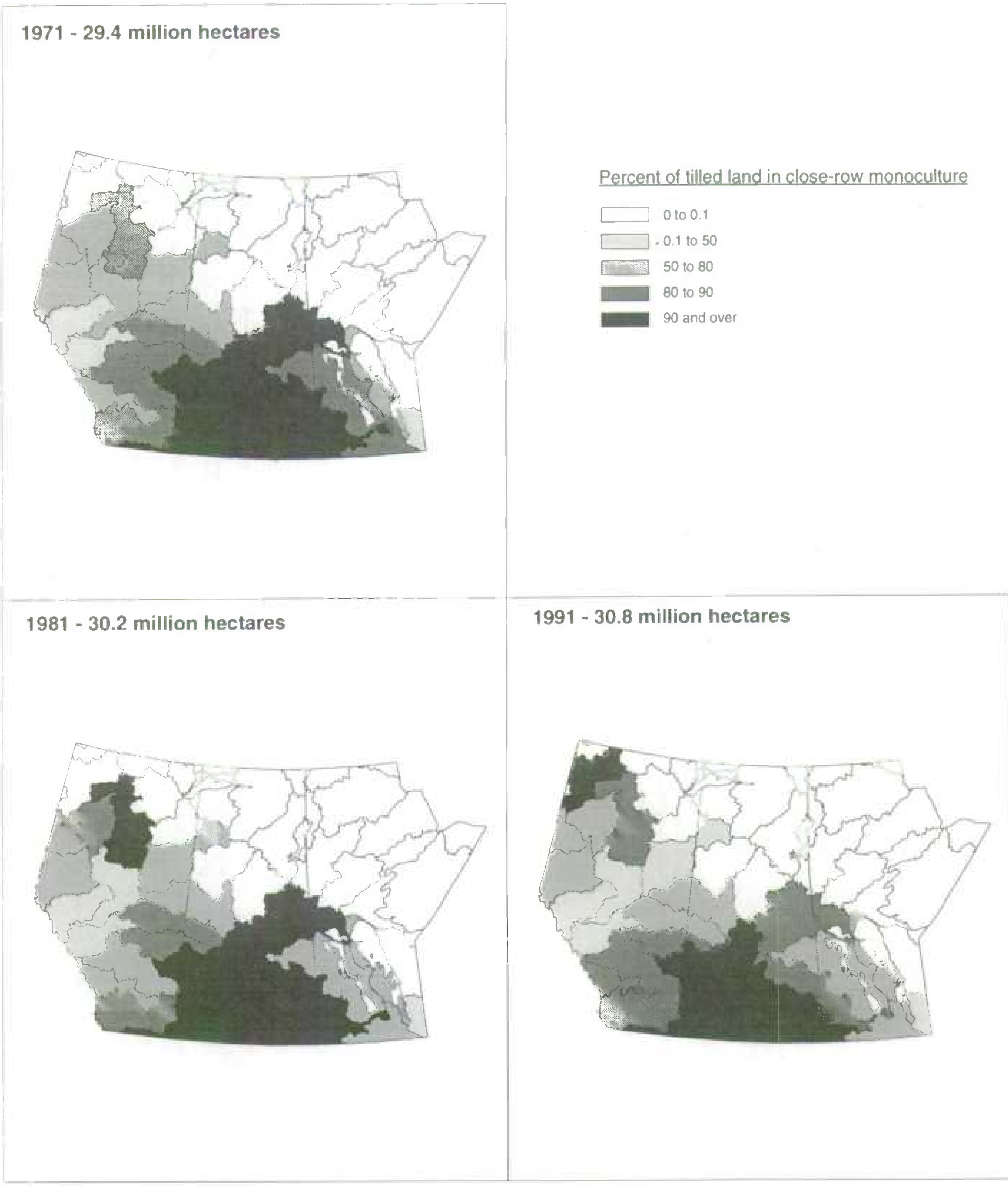
Wide-row Monoculture in the Great Lakes and Maritime Drainage Basins



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 3.9.3

Close-row Monoculture in the Prairie Provinces 1971, 1981 and 1991



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 3.9.2

Cropping Practices by Sub-basin, 1971, 1981 and 1991

Provincial sub-basin[1]	Close-row monoculture area 1971	1981	1991	Change 1971-1981	Change 1981-1991	Wide-row monoculture area 1971	1981	1991	Change 1971-1981	Change 1981-1991
	hectares			percent		hectares			percent	
Newfoundland and Prince Edward Island	**24 781**	**31 110**	**22 736**	**25.5**	**-26.9**	**4 437**	**5 809**	**8 637**	**30.9**	**48.7**
Nova Scotia	**5 027**	**5 197**	**2 299**	**3.4**	**-55.8**	**1 077**	**4 027**	**1 271**	**273.9**	**-68.4**
New Brunswick										
Saint John and South Bay of Fundy	6 222	4 361	4 069	-29.9	-6.7	15 442	10 145	9 762	-34.3	-3.8
Gulf of St. Lawrence and North Bay of Fundy	4 180	3 074	3 526	-26.4	14.7	301	920	429	205.1	-53.4
Total	**10 402**	**7 435**	**7 596**	**-28.5**	**2.2**	**15 743**	**11 064**	**10 191**	**-29.7**	**-7.9**
Quebec										
Saint John	1 261	1 658	1 603	31.5	-3.4	50	104	18	106.8	-82.4
Cascapedia and Gulf of St. Lawrence	1 467	2 488	2 070	69.7	-16.8	62	191	244	207.5	28.0
Upper Ottawa	1 149	1 310	1 633	13.9	24.7	208	360	190	73.2	-47.2
Coulonge and Central Ottawa	1 185	1 539	782	29.8	-49.2	961	1 660	897	72.8	-46.0
Gatineau and Lower Ottawa	3 360	4 390	2 676	30.7	-39.1	1 388	1 406	2 211	1.3	57.3
Upper St. Lawrence	1 190	2 265	778	90.4	-65.6	1 436	12 886	24 384	797.6	89.2
St-Maurice	367	673	228	83.2	-66.1	174	376	465	116.0	23.7
Central St. Lawrence	32 487	52 662	33 391	62.1	-36.6	38 087	113 829	208 702	198.9	83.3
Lower St Lawrence	12 216	21 026	18 263	72.1	-13.1	2 240	4 217	8 697	88.2	106.2
North Gaspé Peninsula	4 076	4 656	5 021	14.2	7.8	170	263	410	54.9	56.0
Saguenay	4 733	3 682	9 133	-22.2	148.0	659	1 459	1 410	121.4	-3.4
Betsiamites	x	x	x	x	x	x	x	x	x	x
Natashquan and Gulf of St. Lawrence	x	x	x	x	x	x	x	x	x	x
Abitibi and North French	650	533	737	-18.0	38.3	x	x	x	x	x
Harricanaw	569	105	673	-81.6	542.1	x	x	x	x	x
Residual sub-basins	x	x	x	x	x	x	x	x	x	x
Total	**65 054**	**97 166**	**77 435**	**49.4**	**-20.3**	**45 534**	**137 239**	**247 632**	**201.4**	**80.4**
Ontario										
Nipigon and Northwest Lake Superior	563	467	380	-16.9	-18.7	-	-	-	-	-
North Lake Huron	1 463	1 728	1 582	18.2	-8.5	236	183	276	-22.4	50.7
Wanipitai and French	1 957	1 661	1 168	-15.1	-29.7	-	-	-	-	-
East Georgian Bay	34 145	21 011	17 499	-38.5	-16.7	17 520	46 153	30 169	163.4	-34.6
East Lake Huron	59 300	46 919	32 455	-20.9	-30.8	68 754	121 179	223 304	76.3	84.3
North Lake Erie	116 097	66 878	41 397	-42.4	-38.1	463 584	641 276	791 690	38.3	23.5
Lake Ontario	69 204	44 554	24 131	-35.6	-45.8	28 682	94 413	72 601	229.2	-23.1
Montréal and Upper Ottawa	2 613	8 157	6 192	212.1	-24.1	-	-	-	-	-
Madawaska, Petawawa and Central Ottawa	3 925	5 100	4 555	29.9	-10.7	3 699	6 169	2 286	66.8	-63.0
Rideau and Lower Ottawa	6 566	8 917	6 226	35.8	-30.2	14 938	26 153	37 961	75.1	45.2
Upper St. Lawrence	2 865	2 727	2 309	-4.8	-15.3	3 363	8 578	11 453	155.1	33.5
Upper Winnipeg	x	x	x	x	x	x	x	x	x	x
English	x	x	x	x	x	x	x	x	x	x
Residual sub-basins	x	x	x	x	x	x	x	x	x	x
Total	**300 077**	**211 363**	**140 729**	**-29.6**	**-33.4**	**600 776**	**944 104**	**1 169 740**	**57.1**	**23.9**
Manitoba										
Saskatchewan	14 964	18 093	18 193	20.9	0.6	-	-	-	-	-
Lake Winnipegosis and Lake Manitoba	939 100	893 426	843 664	-4.9	-5.6	1 210	7 494	4 937	519.5	-34.1
Assiniboine	1 134 710	1 118 458	1 096 744	-1.4	-1.9	1 040	5 019	3 463	382.4	-31.0
Souris	511 235	490 638	520 675	-4.0	6.1	189	1 309	610	592.0	-53.4
Red	1 266 111	1 240 836	1 251 075	-2.0	0.8	1 799	25 943	23 589	1 341.8	-9.1
Winnipeg	17 643	22 044	19 780	24.9	-10.3	-	-	-	-	-
West Lake Winnipeg	162 013	160 990	136 530	-0.6	-15.2	-	-	-	-	-
Total	**4 045 775**	**3 944 486**	**3 886 661**	**-2.5**	**-1.5**	**4 238**	**39 765**	**32 599**	**838.2**	**-18.0**
Saskatchewan										
Central North Saskatchewan	543 030	574 215	541 756	5.7	-5.7	x	x	x	x	x
Battle	202 599	223 507	288 749	10.3	29.2	x	x	x	x	x
Lower North Saskatchewan	2 317 800	2 414 977	2 421 948	4.2	0.3	x	x	x	x	x
Lower South Saskatchewan	3 241 487	3 338 932	3 438 816	3.0	3.0	x	x	x	x	x
Qu'Appelle	4 743 165	4 906 814	5 122 611	3.5	4.4	x	x	x	x	x
Saskatchewan	939 214	965 394	979 350	2.8	1.4	x	x	x	x	x
Lake Winnipegosis and Lake Manitoba	467 991	531 064	447 328	13.5	-15.8	x	x	x	x	x
Assiniboine	1 589 844	1 661 755	1 737 307	4.5	4.5	x	x	x	x	x
Souris	1 848 106	1 895 937	2 100 127	2.6	10.8	x	x	x	x	x
Beaver	184 473	193 449	165 855	4.9	-14.3	x	x	x	x	x
Missouri	629 522	664 643	741 262	5.6	11.5	x	x	x	x	x
Total	**16 707 232**	**17 370 687**	**17 985 109**	**4.0**	**3.5**	**271**	**564**	**327**	**108.2**	**-42.1**

Table 3.9.2

Cropping Practices by Sub-basin, 1971, 1981 and 1991 (Continued)

Provincial sub-basin[1]	Close-row monoculture area 1971	1981	1991	Change 1971-1981	Change 1981-1991	Wide-row monoculture area 1971	1981	1991	Change 1971-1981	Change 1981-1991
	hectares			percent		hectares			percent	
Alberta										
Upper South Saskatchewan	1 549 147	1 718 390	1 721 078	10.9	0.2	3 084	5 589	3 714	81.2	-33.5
Bow	527 028	525 209	502 842	-0.3	-4.3	1 718	1 228	1 060	-28.5	-13.6
Red Deer	1 570 316	1 585 297	1 737 025	1.0	9.6	401	507	600	26.5	18.3
Upper North Saskatchewan	135 708	121 339	98 929	-10.6	-18.5	x	x	x	x	x
Central North Saskatchewan	1 182 875	1 134 607	1 120 990	-4.1	-1.2	698	168	847	-75.9	403.1
Battle	1 170 511	1 230 355	1 193 230	5.1	-3.0	x	x	x	x	x
Lower North Saskatchewan	338 492	417 365	473 968	23.3	13.6	x	x	x	x	x
Beaver	87 903	75 848	85 712	-13.7	13.0	x	x	x	x	x
Upper Athabasca	12 096	7 721	7 283	-36.2	-5.7	x	x	x	x	x
Pembina and Central Athabasca	308 744	216 635	192 149	-29.8	-11.3	x	x	x	x	x
Lower Central Athabasca	59 187	55 193	51 105	-6.7	-7.4	x	x	x	x	x
Upper Peace	361 951	414 188	399 362	14.4	-3.6	x	x	x	x	x
Smoky	385 662	462 748	462 938	20.0	0.0	x	x	x	x	x
Central Peace	176 552	268 818	266 441	52.3	-0.9	x	x	x	x	x
Lower Central Peace	25 885	47 840	78 470	84.8	64.0	x	x	x	x	x
Missouri	148 154	147 332	155 859	-0.6	5.8	x	x	x	x	x
Total	**8 040 210**	**8 428 890**	**8 547 381**	**4.8**	**1.4**	**6 063**	**7 766**	**6 301**	**28.1**	**-18.9**
British Columbia										
Upper Peace	193 576	199 206	146 654	2.9	-26.4	-	-	-	-	-
Skeena	227	373	682	63.9	83.0	-	-	-	-	-
Vancouver Island	223	1 059	314	374.8	-70.3	294	533	438	81.6	-17.8
Nechako	842	3 414	2 158	305.5	-36.8	-	-	-	-	-
Upper Fraser	1 127	1 391	2 298	23.4	65.2	-	-	-	-	-
Thompson	1 725	1 850	2 180	7.3	17.8	126	694	217	452.4	-68.7
Fraser	2 486	5 528	2 403	122.4	-56.5	1 257	4 482	2 017	256.7	-55.0
Columbia	9 425	7 451	5 591	-20.9	-25.0	375	526	604	40.4	14.8
Total	**209 630**	**220 270**	**162 279**	**5.1**	**-26.3**	**2 051**	**6 235**	**3 276**	**204.1**	**-47.5**
Canada	**29 408 200**	**30 316 600**	**30 832 200**	**3.1**	**1.7**	**680 190**	**1 156 570**	**1 479 970**	**70.0**	**28.0**

Note:
1. Includes only sub-basins where agriculture is present.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Summary

The soil erosion estimates presented here indicate that the factors that contribute to soil erosion vary widely across the country. However, the question of whether or not the situation is improving or becoming worse remains unanswered. Future studies will be able to use new information from the Census of Agriculture and detailed Soil Landscape Maps to estimate soil erosion trends for agricultural regions across the country. It will then be necessary to link these erosion estimates to regional topsoil depth information to determine soil depletion rates and whether or not the soil resource is being utilized sustainably.

Cropping practice data indicate that the trend toward monoculture cropping continues in Canada. More land is being used more intensively in an effort to maximize productivity. Some areas of the country have soils that have been severely degraded because of this kind of intense utilisation. However, with proper conservation practices it is possible to combat the effects that intense cropping practices have on the environment. Data from the 1991 Census indicate that many farmers are now using soil conservation techniques on their farms. Again, the most important question, - Is the increasingly intense use of land by today's crop production system environmentally sustainable with current conservation initiatives or do we require more conservation initiatives? - is not answered here. Future studies using data from the 1996 Census of Agriculture should help to answer this important question.

3.10 Dams and Water Diversions

Many countries divert water from where it is abundant to where it is scarce, or from where there are few people to where there are many. The Canadian model is radically different: the majority of water diversions are implemented to enhance hydroelectric power development and it is electricity, not water, which is transmitted to market.[1]

❑❑❑

Canada is blessed with an abundance of fresh surface water that is stored in a complex drainage network comprised of thousands of lakes and rivers. The damming and diversion of Canada's surface water supply has faced few physical obstacles across the country, the western mountain ranges being the most formidable. The result has been that Canada has not had to resort to the long canals and pipelines or pumping stations common to many European and American water projects, relying instead on gravity flows using mostly natural channels.

Dams and water diversions often go hand-in-hand; water supplies are retained by dams in their basin of origin, with subsequent withdrawal (diversion) into another drainage basin by pipeline, ditch or other means. In general terms, dams hold back runoff for release when it is most in demand, and diversions redirect the resource to where it is most in demand.

Interbasin Water Diversions

Compared to water withdrawal from point sources, the restructuring of water systems with dams and water diversions affects large geographic areas. Water diversions involve the transfer of large amounts of water between basins. In some cases, large tracts of land, including towns, hunting grounds and wildlife habitat, are flooded.

In producing their inventory of water diversions, Day and Quinn[2] established the following criteria to eliminate small localized withdrawals in qualifying diversions for inclusion:

- the diverted flow does not return to the stream of origin within 25 km of point withdrawal;
- the mean annual diverted flow is not less than the rate of 1 cubic metre per second.

The preceding criteria identified 54 diversions in 9 provinces, with none in the territories or Prince Edward Island (Table 3.10.1). The total flow of these 54 diversions if combined (4 400 m^3/sec), would qualify as Canada's third largest river, behind only the St. Lawrence and Mackenzie rivers. Among the uses listed in the table, hydropower dominates, with 96 percent of total water diversion being attributable to hydroelectric projects. Irrigation and municipal uses are important only on a local or regional basis.

Since the 1960s, Canada has diverted more water than any other country, mainly in three large diversion projects: the Churchill Falls Project in Newfoundland/Labrador; the Churchill-Nelson Diversion in Manitoba; and the La Grande River (James Bay Phase 1) Project in Quebec. These three projects, comprised of 7 diversions, account for two-thirds of all water diverted in Canada (Table 3.10.2), with hydroelectric power generation dominating the purpose behind all three. Generally, these projects have been the responsibility of publicly-owned, provincial power corporations.

Besides the obvious impacts due to flooding (displacement and loss of habitat), there are other problems due to diversion projects. Connecting waterbodies facilitate the movement of exotic species of marine life, for example the spread of the zebra mussel throughout the Great Lakes. Also, the natural flow of rivers is often disrupted, causing damage to the aquatic environment. Water quality can also be negatively affected if diversion channels allow pollutants to flow from one area to another (see Section 4.2 - **Water Quality**).

Table 3.10.1

Interbasin Water Diversions by Province, 1990

Province/Territory	Number of diversions	Average annual flow	Major use	Flow diverted for major use as a percentage of total
		m^3/sec		percent
Newfoundland	5	725	hydro	100
Prince Edward Island	-	-	-	-
Nova Scotia	4	18	hydro	100
New Brunswick	2	2	municipal	72
Quebec	6	1 854 [1]	hydro	100
Ontario	9	564	hydro	89
Manitoba	5	779 [2]	hydro	97
Saskatchewan	5	30	hydro	85
Alberta	9	67	irrigation	78
British Columbia	9	361	hydro	89
Yukon	-	-	-	-
Northwest Territories	-	-	-	-
Canada	**54**	**4 400**	**hydro**	**96**

Notes:
1. Excludes Beauharnois Canal flows from the St. Lawrence River.
2. Excludes floodway flows (Portage Diversion, Winnipeg Floodway, Seine Diversion) of short duration.

Source:
Day, J.C. and F. Quinn, *Water Diversion and Export: Learning from Canadian Experience*, Department of Geography Publication Series Number 36, University of Waterloo, 1992.

1. Day, J.C. and F. Quinn, *Water Diversion and Export: Learning from Canadian Experience*, Department of Geography Publication Series Number 36, University of Waterloo, 1992.
2. Ibid.

Table 3.10.2

Major Interbasin Water Diversions[1]

Province	Ecozone	Project	Contributing water body (code)	Receiving water body (code)	Average annual diversion	Use	Operational date	Owner
					m^3/sec			
Newfoundland	Taiga Shield	Churchill Falls	Julian, Unknown Rivers (3N, 3O, 3P, 3Q)	Churchill River (3N, 3O, 3P, 3Q)	196	hydro	1971	Nfld. & Lab. Hydro
Newfoundland	Taiga Shield	Churchill Falls	Naskaupi River (3N, 3O, 3P, 3Q)	Churchill River (3N, 3O, 3P, 3Q)	200	hydro	1971	Nfld. & Lab. Hydro
Newfoundland	Taiga Shield	Churchill Falls	Kanairiktok River (3N, 3O, 3P, 3Q)	Churchill River (3N, 3O, 3P, 3Q)	130	hydro	1971	Nfld. & Lab. Hydro
Newfoundland	Boreal Shield	Bay d'Espoir	Victoria, Whitebear, Grey and Salmon Rivers (2Y, 2Z)	Northwest Brook (Bay d'Espoir) (2Y, 2Z)	185	hydro	1969	Nfld. & Lab. Hydro
Quebec	Boreal Shield to Taiga Shield	James Bay	Eastmain, Opinaca Rivers (3C, 3D)	La Grande River (3C, 3D)	845	hydro	1980	J.B. Energy Corp.
Quebec	Taiga Shield	James Bay	Lake Frégate (3C, 3D)	La Grande River (3C, 3D)	31	hydro	1982	J.B. Energy Corp.
Quebec	Taiga Shield	James Bay	Caniapiskau River (3H, 3J, 3K, 3L, 3M)	La Grande River (3C, 3D)	790	hydro	1983	J.B. Energy Corp.
Ontario	Boreal Shield		Lake St Joseph (Albany River) (4G, 4H, 4J)	Root River (5Q, 5R, 5S)	86	hydro	1957	Ont. Hydro
Ontario	Boreal Shield to Mixed Wood Plains		Ogoki River (Albany River) (4G, 4H, 4J)	Lake Nipigon (2A, 2B)	113	hydro	1943	Ont. Hydro
Ontario	Boreal Shield to Mixed Wood Plains		Long Lake (Albany River) (4G, 4H, 4J)	Lake Superior (2A, 2B)	42	hydro, logging	1939	Ont. Hydro
Ontario	Boreal Shield		Little Abitibi River (4K, 4L, 4M)	Abitibi River (4K, 4L, 4M)	40	hydro	1963	Ont. Hydro
Ontario	Mixed Wood Plains	Welland Canal	Lake Erie (2G)	Lake Ontario (2H)	250	navigation, hydro	1951	Govt. of Canada
Manitoba	Boreal Shield	Churchill Diversion	Churchill River (6A, 6B, 6C, 6D)	Rat, Burntwood Rivers (5T, 5U)	775	hydro	1976	Man. Hydro
Saskatchewan	Taiga Shield		Tazin Lake (7L through to 7U)	Lake Athabasca (7L through to 7U)	25	hydro	1958	Eldor Nuclear
British Columbia	Montane Cordillera to Pacific Maritime	Kemano	Nechako River (8J, 8K, 8M)	Kemano River (8B, 8C, 8D, 8F)	115	hydro	1952	Alcan Ltd.
British Columbia	Montane Cordillera		Bridge River (8J, 8K, 8M)	Seton Lake (8J, 8K, 8M)	92	hydro	1959	B.C. Hydro
British Columbia	Pacific Maritime		Cheakamus River (8G)	Squamish River (8G)	37	hydro	1957	B.C. Hydro
British Columbia	Pacific Maritime		Coquitlam Lake (8M)	Buntzen Lake (8G)	28	hydro	1912	B.C. Hydro

Note:
1. Major diversions are defined as those involving 25 m^3/sec or more flow.
Source:
Day, J.C. and F. Quinn, *Water Diversion and Export: Learning from Canadian Experience*, Department of Geography Publication Series Number 36, University of Waterloo, 1992.

Dams in Canada

The majority of large dams in Canada,[1] have been constructed for hydroelectric purposes. Major dams have not usually been required for irrigation and water supply primarily due to the proximity of numerous lakes and rivers to Canadian towns and cities. Table 3.10.3 shows the distribution of major dams in Canada, while Table 3.10.4 shows the primary reason for construction of major dams in Canada.

Since 1970, the majority of new dams were constructed in Newfoundland/Labrador, as part of the Churchill Falls Project, and in Quebec, as part of the James Bay Hydroelectric Project.[2] Since 1984, comparatively few new large dams have been constructed in Canada.

Hydroelectric power is Canada's most important source of electricity. In 1988, falling water generated over 62 percent of the electricity produced in Canada. It is forecast that by 2005, hydroelectric production could increase by 26 percent.[3]

1. Large dams are defined by the International Commission on Large Dams as any dam higher than 15 metres, as well as dams between 10 and 15 metres in height, provided one of the following conditions is met: (a) length of crest greater than 500 metres, (b) reservoir capacity greater than 1 million cubic metres, (c) maximum discharge greater than 2 000 cubic metres per second. In addition a dam may be included if it has especially difficult foundation problems or is of unusual design.

2. Canadian National Committee of the International Committee on Large Dams, *Register of Dams in Canada*, 1984.
3. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Table 3.10.3

Large Dams[1] by Province, Selected Years

Province/Territory	Up to 1969	1970 to 1975	1976 to 1983	1984 to 1991	Total by 1991
Newfoundland	15	55	9	1	80
Prince Edward Island	-	-	-	-	-
Nova Scotia	27	1	7	-	35
New Brunswick	16	-	-	-	16
Quebec	103	3	83	-	189
Ontario	74	2	3	1	80
Manitoba	24	5	5	-	34
Saskatchewan	34	-	4	2	40
Alberta	44	2	2	5	53
British Columbia	80	4	5	-	89
Yukon	3	-	-	-	3
Northwest Territories	3	-	-	-	3
Canada	**423**	**72**	**118**	**9**	**622**

Note:
1. Large dams are defined by the International Commission on Large Dams as any dam higher than 15 metres, as well as dams between 10 and 15 metres in height, provided one of the following conditions is met: (a) length of crest greater than 500 metres, (b) reservoir capacity greater than 1 million cubic metres, (c) maximum discharge greater than 2 000 cubic metres per second.

Sources:
Canadian National Committee of the International Committee on Large Dams, *Register of Dams in Canada*, 1984.
Canadian National Committee of the International Committee on Large Dams, *Register of Dams in Canada*, draft, 1991.

Table 3.10.4

Large Dams[1] by type, Selected Years

Purpose	Up to 1969	1970 to 1975	1976 to 1983	1984 to 1991	Total by 1991
Irrigation	48	-	4	3	55
Hydroelectric	267	64	110	3	444
Flood Control	18	1	1	2	22
Water Supply	38	2	3	-	43
Recreational	4	1	-	1	6
Other	48	4	-	-	52
Total	**423**	**72**	**118**	**9**	**622**

Note:
1. Large dams are defined by the International Commission on Large Dams as any dam higher than 15 metres, as well as dams between 10 and 15 metres in height, provided one of the following conditions is met: (a) length of crest greater than 500 metres, (b) reservoir capacity greater than 1 million cubic metres, (c) maximum discharge greater than 2 000 cubic metres per second.

Sources:
Canadian National Committee of the International Committee on Large Dams, *Register of Dams in Canada*, 1984.
Canadian National Committee of the International Committee on Large Dams, *Register of Dams in Canada*, draft, 1991.

As with water diversion projects, dams can also affect the natural flow of rivers, and result in the loss of habitat. Water quality issues are associated with dams as well, including elevated mercury levels (see Section 4.2 - **Water Quality**).

Summary

In Canada, more water moves across drainage basin boundaries than anywhere else on earth. Prior to the 1970s, diversion developers were not required to address the socio-economic or environmental implications of their projects. Since that time, however, issues such as the impact on native homelands and increasing environmental awareness, has resulted in impact assessments being required for new diversion projects. This has, in part, led to more emphasis on the alternatives to water megaprojects, such as improved efficiency in energy and water use.[1]

1. Day, J.C. and F. Quinn, *Water Diversion and Export: Learning from Canadian Experience*, Department of Geography Publication Series Number 36, University of Waterloo, 1992.

3.11 Agricultural Nutrients

Commercial Fertilizers

Today's high yielding crops convert solar energy into carbohydrates, proteins and cellulose through photosynthesis.[1] This process is essentially the same today as it was more than 400 million years ago. Productivity gains in present day agricultural crops come from enhanced genetic properties and material inputs. Supplementary agricultural material and energy inputs include land preparation, crop cultivation, fertilizer and pesticide manufacturing, transporting and applying these materials and the irrigation of cropland. Most of these energy inputs come from non-renewable fossil fuel sources.

One of the most important inputs to agriculture are manufactured fertilizer nutrients.[2] About 1 percent of all energy commodities used in Canada are consumed by the agricultural fertilizer industry.[3] Much of today's crop yield increases are due to commercial fertilizer inputs.

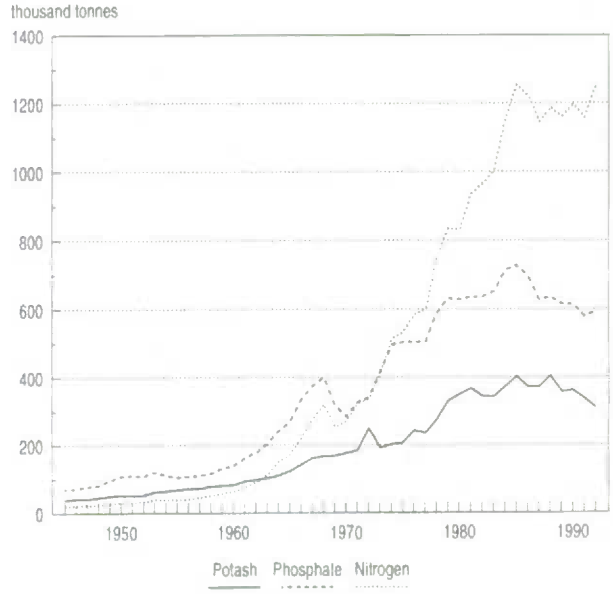
The environmental impacts of large scale commercial fertilizer application are numerous. For the most part these impacts occur during episodes of intense rainfall. Impacts can include the loss of suspended and dissolved nutrients to waterways, nutrient leaching loss to groundwater, soil acidification, and short term suppression of microbes in soils. However, under ideal conditions, and at optimum application rates, fertilizers have minimal environmental impact and are consumed almost entirely by the target crop. It should also be noted that environmental impacts of fertilizer use vary significantly across the country and are related to soil type, rainfall and crop conditions.

The nutrient content of fertilizer has increased steadily as more concentrated, more easily applied fertilizer products have been developed. Fertilizer nutrient content has increased from just over 20 percent in the 1920s to over 50 percent today.[4] Figure 3.11.1 shows the increase in fertilizer nutrient content from 1945 to 1992.

Table 3.11.1 presents statistics for fertilizer nitrogen and phosphate application by drainage sub-basin. These have been derived from fertilizer tonnage data. The table shows that the Prairie provinces have experienced the largest increases in fertilizer nutrients applied to farmland. This change may overstate the issue, as very little fertilizer was applied to Prairie cropland in the 1970s and application rates are still well below the national average (see Section 3.8 - **Agricultural Chemicals**, Table 3.8.1). Fertilizer nutrient application rates are highest in eastern drainage sub-basins.

Figure 3.11.1

Nutrient Content of Fertilizers Sold, 1945-1992



Sources:
Statistics Canada, *Fertilizer Trade*, Catalogue No. 46-207, Ottawa, various issues.
Agriculture Canada, Farm Policy Development Branch.

Livestock Wastes

In 1991, approximately 626 thousand tonnes of nitrogen and 311 thousand tonnes of phosphate were produced by animal manure on farms (Table 3.11.2).[5]

Manure was not a pollution problem on traditional, mixed farms where nutrients were cycled between crop and livestock. On today's specialised farms, however, manure production rates are so high, that manure has become a waste product.[6] Manure nutrients can pollute waterways and groundwater, ultimately affecting the health of humans reliant on that water for their drinking supply. When manure is stored properly and applied to fields in appropriate quantities, under optimum conditions, it has no significant negative environmental impact.

The volume of wastes generated by livestock in Canada is enormous. Based on ratios developed in the United States,[7] Canadian livestock are estimated to generate the waste equivalent of 220 million people, more than 8 times that generated by the Canadian population.

1. The process by which chlorophyll-containing cells in green plants use light energy to synthesize carbohydrates from carbon dioxide and water.
2. The term nutrients refers to the plant macro-nutrients - nitrogen, phosphorus and potassium.
3. Statistics Canada, *Detailed Energy Disposition Tables, 1981-1990*, National Accounts and Environment Division, working paper, 1994.
4. A tonne of fertilizer today contains on average more than twice the amount of nutrient it did in the 1920s.
5. These amounts of nutrient are equivalent to approximately 55 percent of the nitrogen and phosphate from commercial fertilizer.
6. See Section 3.2 - **Resource-dependent Industries** for more information on farm specialization.
7. National Research Council, *Ammonia*, Washington, D.C., 1979.

Table 3.11.1

Nitrogen and Phosphate Content of Commercial Fertilizer Applied on Farmland, 1970, 1980 and 1990

	Nitrogen from commercial agricultural fertilizer				Phosphate from commercial agricultural fertilizer			
Provincial Sub-basin	1970	1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990
	tonnes			percent	tonnes			percent
Newfoundland								
North Newfoundland	107	104	198	84.9	172	121	189	9.7
South Newfoundland	201	275	376	87.3	322	319	358	11.1
Total	**308**	**379**	**574**	**86.4**	**494**	**439**	**547**	**10.6**
Prince Edward Island								
Prince Edward Island	4 321	7 054	9 313	115.5	6 941	8 170	8 874	27.9
Total	**4 321**	**7 054**	**9 313**	**115.5**	**6 941**	**8 170**	**8 874**	**27.9**
Nova Scotia								
Bay of Fundy	2 319	3 593	4 020	73.4	3 724	4 162	3 831	2.9
Southeast Atlantic Ocean	227	380	382	68.5	364	440	364	-0.0
Cape Breton Island	147	285	501	241.0	236	330	477	102.3
Total	**2 692**	**4 258**	**4 903**	**82.1**	**4 324**	**4 932**	**4 672**	**8.0**
New Brunswick								
Saint John and South Bay of Fundy	3 132	5 542	5 445	73.8	5 032	6 419	5 176	2.9
Gulf of St. Lawrence and North Bay of Fundy	604	1 139	1 267	109.6	971	1 319	1 204	24.0
Total	**3 737**	**6 681**	**6 712**	**79.6**	**6 003**	**7 738**	**6 380**	**6.3**
Quebec								
Saint John	177	582	503	184.4	314	664	388	23.4
Cascapedia and Gulf of St. Lawrence	277	1 034	819	195.7	492	1 181	631	28.3
Upper Ottawa	115	610	396	243.0	205	697	305	48.9
Coulonge and Central Ottawa	165	461	584	253.1	294	526	450	53.2
Gatineau and Lower Ottawa	688	2 079	2 184	217.3	1 222	2 375	1 683	37.7
Upper St. Lawrence	556	2 517	4 115	639.7	988	2 874	3 171	221.1
St-Maurice	102	220	177	73.2	181	252	136	-24.8
Central St. Lawrence	13 065	38 713	60 640	364.1	23 193	44 213	46 720	101.4
Lower St. Lawrence	4 635	11 551	12 983	180.1	8 228	13 192	10 003	21.6
North Gaspé Peninsula	855	2 201	2 500	192.5	1 517	2 514	1 926	27.0
Saguenay	509	1 807	2 265	344.9	904	2 063	1 745	93.1
Betsiamites	7	9	11	67.8	6	10	9	41.8
Manicouagan and Outardes	18	42	35	97.2	31	48	27	-14.4
Natashquan and Gulf of St. Lawrence	4	17	14	241.2	7	19	11	48.1
Nottaway	6	42	28	342.9	11	48	22	92.2
Abitibi and North French	56	259	321	477.5	99	296	248	150.6
Harricanaw	42	157	203	386.1	74	179	156	111.0
Total	**21 278**	**62 302**	**87 780**	**312.5**	**37 766**	**71 153**	**67 629**	**79.1**
Ontario								
Nipigon and Northwest Lake Superior	244	405	470	92.5	226	377	242	7.2
Northeast Lake Superior	35	10	62	77.0	32	10	32	-1.4
North Lake Huron	385	540	664	72.6	356	502	342	-3.9
Wanipitai and French	262	437	334	27.5	243	406	172	-29.0
East Georgian Bay	6 523	9 702	11 684	79.1	6 038	9 013	6 023	-0.2
East Lake Huron	17 317	26 630	30 997	79.0	16 030	24 739	15 979	-0.3
North Lake Erie	58 544	76 226	90 428	54.5	54 195	70 814	46 617	-14.0
Lake Ontario	12 686	19 470	23 698	86.8	11 744	18 088	12 216	4.0
Montréal and Upper Ottawa	317	782	638	101.1	294	727	329	12.0
Madawaska, Petawawa and Central Ottawa	1 147	1 840	1 834	59.8	1 062	1 709	945	-11.0
Rideau and Lower Ottawa	5 757	8 283	12 750	121.5	5 330	7 695	6 573	23.3
Upper St. Lawrence	1 347	2 194	3 208	138.1	1 247	2 039	1 654	32.6
Moose	99	107	100	0.3	92	99	51	-44.1
Abitibi	70	127	79	12.8	65	118	41	-37.2
Upper Winnipeg	185	275	416	125.1	171	255	215	25.4
English	35	62	99	182.0	32	58	51	57.1
Total	**104 953**	**147 092**	**177 460**	**69.1**	**97 157**	**136 648**	**91 483**	**-5.8**
Manitoba								
Saskatchewan	101	522	664	556.9	96	286	298	210.8
Lake Winnipegosis and Lake Manitoba	6 931	34 319	47 127	579.9	6 562	18 804	21 111	221.7
Assiniboine	5 214	38 042	47 503	811.0	4 937	20 844	21 279	331.1
Souris	2 005	13 560	16 054	700.9	1 898	7 430	7 191	278.9
Red	13 743	78 054	80 724	487.4	13 010	42 768	36 160	177.9
Winnipeg	140	680	1 255	798.5	132	373	562	325.1
West Lake Winnipeg	1 132	5 374	9 284	719.8	1 072	2 944	4 159	287.9
Total	**29 266**	**170 551**	**202 612**	**592.3**	**27 707**	**93 448**	**90 760**	**227.6**

Table 3.11.1

Nitrogen and Phosphate Content of Commercial Fertilizer Applied on Farmland, 1970, 1980 and 1990 (Continued)

Provincial Sub-basin	Nitrogen from commercial agricultural fertilizer				Phosphate from commercial agricultural fertilizer			
	1970	1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990
	tonnes			percent	tonnes			percent
Saskatchewan								
Central North Saskatchewan	1 141	10 420	17 374	1 423.0	2 318	8 436	9 470	308.6
Battle	574	4 351	7 276	1 166.7	1 167	3 523	3 966	239.8
Lower North Saskatchewan	1 971	22 899	39 278	1 892.7	4 005	18 539	21 410	434.6
Lower South Saskatchewan	1 594	23 161	32 734	1 953.0	3 240	18 751	17 843	450.8
Qu'Appelle	1 504	24 355	46 478	2 989.9	3 056	19 718	25 335	729.0
Saskatchewan	2 923	24 622	32 056	996.5	5 939	19 934	17 473	194.2
Lake Winnipegosis and Lake Manitoba	904	7 396	14 484	1 501.7	1 837	5 988	7 895	329.7
Assiniboine	1 680	15 755	43 423	2 484.5	3 414	12 755	23 670	593.4
Souris	650	11 849	19 627	2 920.1	1 320	9 593	10 698	710.3
Beaver	451	4 481	7 550	1 574.7	916	3 628	4 115	349.3
Missouri	102	960	1 888	1 745.6	208	777	1 029	395.2
Total	**13 496**	**150 249**	**262 168**	**1 842.6**	**27 420**	**121 642**	**142 906**	**421.2**
Alberta								
Upper South Saskatchewan	9 805	42 344	47 846	388.0	7 754	22 760	21 031	171.2
Bow	6 280	9 746	17 115	172.6	4 966	9 746	7 523	51.5
Red Deer	14 702	27 704	67 834	361.4	11 627	27 704	29 816	156.4
Upper North Saskatchewan	2 125	3 782	8 440	297.2	1 680	3 782	3 710	120.8
Central North Saskatchewan	8 766	21 538	55 764	536.2	6 932	21 538	24 511	253.6
Battle	6 996	20 339	47 128	573.6	5 533	20 339	20 715	274.4
Lower North Saskatchewan	588	2 087	5 578	848.9	465	2 087	2 452	427.4
Beaver	554	1 878	4 857	776.2	438	1 878	2 135	387.0
Upper Athabasca	208	474	1 024	391.3	165	474	450	173.1
Pembina and Central Athabasca	2 901	6 570	14 511	400.2	2 294	6 570	6 378	178.0
Lower Central Athabasca	337	932	2 812	733.3	267	932	1 236	363.2
Upper Peace	1 995	5 179	13 863	594.8	1 578	5 179	6 093	286.2
Smoky	2 808	7 545	21 470	664.5	2 221	7 545	9 437	324.9
Central Peace	729	3 340	9 791	1 243.3	576	3 340	4 304	646.6
Lower Central Peace	53	452	2 061	3 811.8	42	452	906	2 074.2
Missouri	283	803	2 464	771.1	224	803	1 083	384.2
Total	**59 130**	**154 714**	**322 559**	**445.5**	**46 762**	**135 130**	**141 779**	**203.2**
British Columbia								
Upper Peace	1 024	6 496	5 092	397.4	895	3 108	2 140	139.1
Skeena	101	443	426	323.2	88	212	179	103.4
Gardner Canal and Central Pacific Ocean	7	12	9	35.8	6	6	4	-34.7
Knight Inlet and South Pacific Ocean	11	92	175	1 542.9	9	44	73	689.7
Vancouver Island	870	2 191	2 433	179.6	761	1 048	1 023	34.4
Nechako	105	1 199	1 059	904.3	92	574	445	382.8
Upper Fraser	210	1 238	1 007	380.5	183	592	423	130.9
Thompson	449	2 168	1 825	306.9	392	1 037	767	95.6
Fraser	3 730	9 499	16 881	352.6	3 261	4 545	7 095	117.6
Columbia	1 418	4 264	4 568	222.1	1 240	2 040	1 920	54.8
Total	**7 923**	**27 603**	**33 476**	**322.5**	**6 928**	**13 205**	**14 070**	**103.1**
Canada	**247 104**	**730 884**	**1 107 556**	**348.2**	**261 502**	**592 505**	**569 100**	**117.6**

Notes:
Nutrient tonnages for 1970 and 1990 were derived from fertilizer expense data.
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division, Census of Agriculture.

Table 3.11.2

Nitrogen and Phosphate Content of Animal Manures Produced on Farms, 1971, 1981 and 1991

Provincial sub-basin	Nitrogen from agricultural animal manures 1971	1981	1991	Change 1971-1991	Phosphate from agricultural animal manures 1971	1981	1991	Change 1971-1991
	tonnes			percent	tonnes			percent
Newfoundland								
North Newfoundland	191	363	519	171.2	86	153	213	148.1
South Newfoundland	816	761	866	6.1	365	352	388	6.2
Total	**1 008**	**1 124**	**1 385**	**37.4**	**451**	**505**	**601**	**33.2**
Prince Edward Island								
Prince Edward Island	5 007	4 832	4 544	-9.3	2 575	2 544	2 370	-8.0
Total	**5 007**	**4 832**	**4 544**	**-9.3**	**2 575**	**2 544**	**2 370**	**-8.0**
Nova Scotia								
Bay of Fundy	6 145	7 178	7 024	14.3	2 898	3 455	3 345	15.4
Southeast Atlantic Ocean	1 157	1 131	968	-16.3	544	551	474	-12.7
Cape Breton Island	609	499	454	-25.5	283	235	207	-26.9
Total	**7 912**	**8 809**	**8 446**	**6.8**	**3 724**	**4 240**	**4 026**	**8.1**
New Brunswick								
Saint John and South Bay of Fundy	3 770	4 258	4 240	12.5	1 771	2 008	1 985	12.1
Gulf of St. Lawrence and North Bay of Fundy	2 344	2 060	1 872	-20.2	1 102	1 011	895	-18.8
Total	**6 114**	**6 318**	**6 112**	**-0.0**	**2 873**	**3 019**	**2 880**	**0.2**
Quebec								
Saint John	1 596	1 057	935	-41.4	761	513	464	-39.0
Cascapedia and Gulf of St. Lawrence	1 946	1 384	1 042	-46.5	924	674	505	-45.3
Upper Ottawa	1 664	1 298	1 152	-30.7	790	626	557	-29.5
Coulonge and Central Ottawa	1 735	1 567	1 540	-11.3	823	757	743	-9.8
Gatineau and Lower Ottawa	5 208	4 327	3 718	-28.6	2 455	2 087	1 785	-27.3
Upper St. Lawrence	1 945	1 683	1 295	-33.4	911	801	605	-33.6
St-Maurice	283	183	123	-56.4	133	89	59	-55.4
Central St. Lawrence	53 061	61 892	54 493	2.7	24 894	31 532	27 400	10.1
Lower St Lawrence	31 665	34 197	31 805	0.4	15 393	17 664	16 332	6.1
North Gaspé Peninsula	4 731	3 461	2 663	-43.7	2 294	1 682	1 298	-43.4
Saguenay	5 506	4 259	3 438	-37.6	2 618	2 063	1 642	-37.3
Betsiamites	52	44	27	-46.6	24	21	13	-46.3
Manicouagan and Outardes	16	12	11	-30.1	7	6	5	-26.2
Natashquan and Gulf of St. Lawrence	45	42	30	-33.7	21	20	14	-34.6
Nottaway	107	167	109	1.7	51	81	52	2.7
Abitibi and North French	995	795	746	-25.0	476	383	363	-23.8
Harricanaw	495	515	422	-14.8	234	247	192	-17.7
Total	**111 049**	**116 883**	**103 550**	**-6.8**	**52 809**	**59 245**	**52 030**	**-1.5**
Ontario								
Nipigon and Northwest Lake Superior	532	470	407	-23.5	230	229	200	-13.4
Northeast Lake Superior	31	22	23	-27.3	13	11	11	-17.1
North Lake Huron	1 610	1 528	1 371	-14.8	713	766	687	-3.7
Wanipitai and French	847	804	649	-23.4	371	402	318	-14.4
East Georgian Bay	12 487	10 904	7 986	-36.0	5 623	5 481	3 985	-29.1
East Lake Huron	36 977	39 022	32 661	-11.7	16 857	20 097	16 829	-0.2
North Lake Erie	49 721	51 184	45 619	-8.2	23 173	26 512	23 699	2.3
Lake Ontario	29 025	27 021	23 296	-19.7	12 746	12 934	10 922	-14.3
Montréal and Upper Ottawa	1 152	1 151	1 006	-12.6	510	585	511	0.2
Madawaska, Petawawa and Central Ottawa	5 529	4 973	4 285	-22.5	2 427	2 526	2 170	-10.6
Rideau and Lower Ottawa	11 566	10 760	9 111	-21.2	5 062	5 460	4 575	-9.6
Upper St. Lawrence	4 803	4 222	3 483	-27.5	2 075	2 062	1 688	-18.7
Moose	158	141	125	-20.4	68	67	60	-11.9
Abitibi	256	293	214	-16.6	112	148	108	-3.8
Upper Winnipeg	790	794	687	-13.0	346	403	347	0.4
English	114	124	143	26.1	51	65	76	49.7
Total	**155 597**	**153 411**	**131 068**	**-15.8**	**70 377**	**77 748**	**66 184**	**-6.0**
Manitoba								
Saskatchewan	192	190	334	73.9	93	91	167	80.9
Lake Winnipegosis and Lake Manitoba	13 997	13 067	13 253	-5.3	6 942	6 386	6 747	-2.8
Assiniboine	11 289	9 969	10 620	-5.9	5 627	4 935	5 489	-2.5
Souris	4 685	4 102	3 435	-26.7	2 309	2 009	1 728	-25.2
Red	16 716	16 305	17 626	5.4	8 351	8 147	9 200	10.2
Winnipeg	627	554	689	9.9	300	268	360	19.9
West Lake Winnipeg	2 781	2 449	2 612	-6.1	1 369	1 220	1 356	-1.0
Total	**50 286**	**46 635**	**48 570**	**-3.4**	**24 991**	**23 055**	**25 047**	**0.2**

Table 3.11.2

Nitrogen and Phosphate Content of Animal Manures Produced on Farms, 1971, 1981 and 1991 (Continued)

Provincial sub-basin	Nitrogen from agricultural animal manures 1971	1981	1991	Change 1971-1991	Phosphate from agricultural animal manures 1971	1981	1991	Change 1971-1991
	tonnes			percent	tonnes			percent
Saskatchewan								
Central North Saskatchewan	22 293	24 040	28 542	28.0	10 828	11 661	14 001	29.3
Battle	11 758	10 728	9 658	-17.9	5 630	5 087	4 625	-17.8
Lower North Saskatchewan	30 091	32 762	36 983	22.9	14 731	15 880	18 202	23.6
Lower South Saskatchewan	5 203	5 618	7 921	52.2	2 553	2 674	3 790	48.5
Qu'Appelle	18 564	16 583	19 447	4.8	9 202	7 954	9 450	2.7
Saskatchewan	17 213	17 469	17 823	3.5	8 490	8 487	8 725	2.8
Lake Winnipegosis and Lake Manitoba	4 208	4 641	5 888	39.9	2 012	2 229	2 852	41.8
Assiniboine	97	100	67	-30.8	46	47	32	-30.3
Souris	2 571	2 891	3 672	42.8	1 276	1 403	1 803	41.3
Beaver	716	964	1 269	77.1	353	461	607	71.8
Missouri	5 576	5 070	4 850	-13.0	2 670	2 422	2 327	-12.9
Total	**118 292**	**120 867**	**136 121**	**15.1**	**57 792**	**58 304**	**66 415**	**14.9**
Alberta								
Upper South Saskatchewan	22 501	24 278	28 816	28.1	11 125	11 951	14 337	28.9
Bow	11 867	10 837	9 751	-17.8	5 786	5 220	4 739	-18.1
Red Deer	30 360	33 086	37 329	23.0	15 118	16 277	18 625	23.2
Upper North Saskatchewan	5 246	5 672	8 000	52.5	2 614	2 740	3 888	48.7
Central North Saskatchewan	18 704	16 729	19 622	4.9	9 402	8 133	9 665	2.8
Battle	17 364	17 641	17 998	3.7	8 706	8 697	8 939	2.7
Lower North Saskatchewan	4 252	4 693	5 953	40.0	2 075	2 293	2 933	41.3
Beaver	98	101	68	-30.7	48	49	33	-30.4
Upper Athabasca	2 593	2 919	3 708	43.0	1 306	1 437	1 847	41.4
Pembina and Central Athabasca	722	974	1 283	77.8	361	473	623	72.5
Lower Central Athabasca	7 471	9 639	11 871	58.9	3 813	4 768	5 947	56.0
Upper Peace	1 034	1 226	1 435	38.7	517	595	698	35.0
Smoky	1 443	1 484	2 214	53.4	735	721	1 086	47.7
Central Peace	2 484	2 467	3 780	52.2	1 263	1 185	1 841	45.8
Lower Central Peace	823	775	964	17.2	428	376	476	11.4
Missouri	191	115	245	28.3	100	55	123	23.4
Total	**127 152**	**132 635**	**153 037**	**20.4**	**63 396**	**64 970**	**75 800**	**19.6**
British Columbia								
Upper Peace	1 279	2 884	3 542	176.9	611	1 361	1 680	174.9
Skeena	572	757	622	8.7	271	355	290	7.3
Gardner Canal and Central Pacific Ocean	134	81	122	-9.0	63	38	57	-8.9
Knight Inlet and South Pacific Ocean	136	183	260	91.9	63	83	115	81.8
Vancouver Island	1 420	1 929	1 977	39.2	643	875	889	38.3
Nechako	728	1 406	1 679	130.6	346	665	800	131.6
Upper Fraser	1 187	1 984	1 762	48.5	561	933	829	47.8
Thompson	4 716	6 007	5 161	9.4	2 252	2 885	2 458	9.1
Fraser	11 200	14 243	14 221	27.0	4 924	6 411	6 343	28.8
Columbia	3 812	4 503	4 154	9.0	1 813	2 127	1 912	5.5
Residual Sub-basins	25	62	29	19.3	11	31	14	19.8
Total	**25 209**	**34 039**	**33 529**	**33.0**	**11 558**	**15 765**	**15 387**	**33.1**
Canada	**607 625**	**625 554**	**626 360**	**3.1**	**290 548**	**309 396**	**310 740**	**6.9**

Notes:
Nutrient tonnages were derived from livestock population data.
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division, Census of Agriculture.

3.12 Energy

Few other human activities have as wide-ranging environmental impacts as the use of energy. These impacts include: land use change; water supply and quality change; climate change; solid, liquid and gaseous waste production and others. Because the impacts are complex and broad in scope, it is difficult to do more than describe them in general terms. The actual impacts of any given energy production or consumption activity cannot be fully described in a statistical compendium.

The data that follow show signs of both improvement and decline in the relationship between Canadians' energy use and our environment. While energy use per unit of production has declined significantly in recent decades, per capita energy consumption continues to climb (Table 3.12.1). Likewise, per capita emissions of carbon dioxide from energy use are approximately 50 percent higher today than at the beginning of the 1960s, but emissions per unit of production are considerably lower (Table 3.12.8). Contrasts of these sorts highlight the complexity of the energy-economy-environment relationship.

❑❑❑

Basic Energy Indicators

Table 3.12.1 presents some basic energy indicators. By 1992, total Canadian consumption of energy commodities had increased to nearly 308 percent of its 1958 level. During the same period, total population increased by only 166 percent. Consequently, energy consumption per capita has increased significantly since 1958; with the average Canadian in 1992 consuming almost twice as much energy as in 1958.[1]

Real Gross Domestic Product (GDP) increased by 366 percent between 1958 and 1992. Because growth in energy consumption has been less rapid than growth in real GDP, energy consumption per dollar of real GDP has declined since 1958. The ratio peaked in 1973 and has since declined steadily. This decline is likely due to a combination of factors including: increased efficiency of energy use; and restructuring of the economy away from activities that consume relatively large amounts of energy.

1. Wood fuel use for home heating, which is not reflected in the statistics in Table 3.12.1, may have been more common in 1958 than today. To the extent that this is true, the increase in per capita energy consumption reported above is overstated.

Table 3.12.1

Selected Energy Indicators, 1958-1992

Year	Consumption of energy commodities[1]	Population	Real GDP	Energy consumption per capita	Energy consumption per $ of real GDP
	petajoules[2]	thousands	billion 1986 $	gigajoules per capita	megajoules per 1986 $
1958	2 852	17 120	153	167	18.59
1959	3 037	17 522	159	173	19.05
1960	3 134	17 909	164	175	19.09
1961	3 294	18 271	169	180	19.46
1962	3 491	18 614	181	188	19.26
1963	3 740	18 964	191	197	19.62
1964	3 926	19 325	203	203	19.31
1965	4 131	19 678	217	210	19.06
1966	4 408	20 048	232	220	19.04
1967	4 524	20 412	238	222	18.99
1968	4 878	20 729	251	235	19.43
1969	5 141	21 028	265	244	19.44
1970	5 545	21 324	271	260	20.43
1971	5 890	22 026	287	267	20.52
1972	6 411	22 284	303	288	21.13
1973	6 937	22 560	327	308	21.23
1974	7 209	22 875	341	315	21.13
1975	7 081	23 209	350	305	20.22
1976	7 183	23 518	372	305	19.33
1977	7 296	23 796	385	307	18.94
1978	7 389	24 036	403	307	18.35
1979	7 864	24 277	418	324	18.80
1980	7 929	24 593	425	322	18.68
1981	7 713	24 900	440	310	17.52
1982	7 062	25 202	426	280	16.58
1983	7 061	25 456	439	277	16.07
1984	7 412	25 702	467	288	15.86
1985	7 876	25 942	489	304	16.09
1986	7 789	26 204	506	297	15.40
1987	8 082	26 550	526	304	15.36
1988	8 627	26 895	549	321	15.71
1989	8 902	27 379	566	325	15.74
1990	8 738	27 791	566	314	15.44
1991	8 612	28 118	556	306	15.49
1992	8 748	28 436	560	308	15.62

Notes:

1. Includes consumption of energy commodities for non-energy purposes; as petrochemical feedstocks, for example.
2. The joule is the basic unit of measurement for energy. A 50 litre tank of gasoline contains approximately 1.7 billion joules.

Source:

Statistics Canada, National Accounts and Environment Division.

Production and Consumption of Primary Energy Commodities

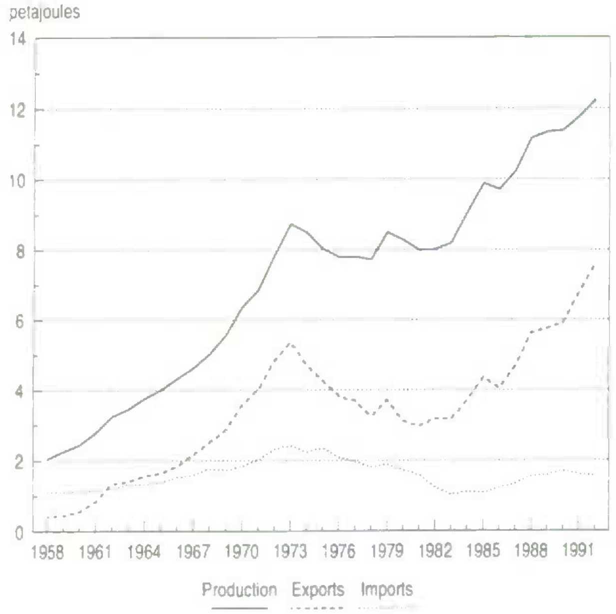
Primary energy commodities are those used directly as produced and/or those converted into secondary energy products.[2] In Canada we make use of a variety of primary energy commodities: coal, crude oil, natural gas, liquified petroleum gases,[3] hydro electricity and nuclear electricity. Nearly all energy used in the Canadian economy is derived either directly or indirectly from these primary energy commodities.[4]

2. For example, crude oil is a primary energy commodity and gasoline is a secondary energy commodity made from crude oil.
3. Propane, butane and ethane.
4. Small amounts of primary energy are also derived from the combustion of wood and other biomass, from wind, tidal and geothermal electricity generation and from solar energy. These sources of energy are small in comparison to total primary energy consumption and, therefore, are not discussed here.

Figure 3.12.1 shows that annual Canadian production of primary energy commodities has risen steadily since 1958. Production increases were very rapid between 1958 and 1973. These years of rapid increase were followed by a period of constant production between the first OPEC oil price increase in 1974 and the end of the 1981-1982 economic recession. Subsequently, production has grown at a rate similar to that in the pre-1974 period.

Figure 3.12.1

Primary Energy Commodities, 1958-1992



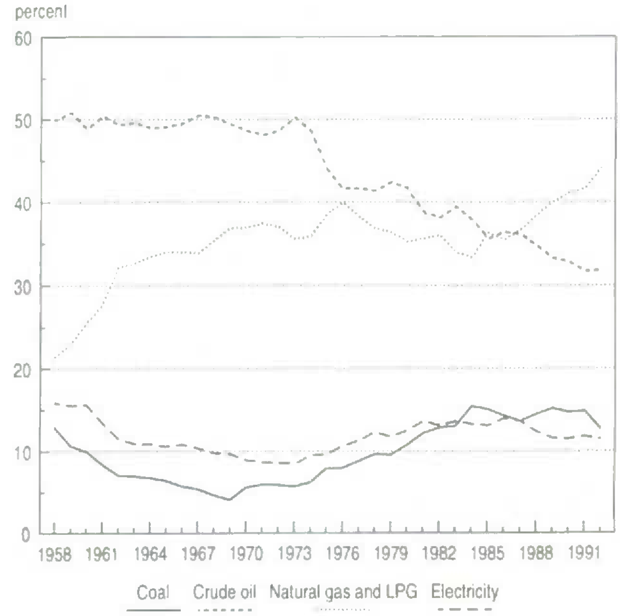
Sources:
Statistics Canada, *Detailed Energy Supply and Demand in Canada*, Catalogue No. 57-207, Ottawa, various issues.
Statistics Canada, *Detailed Energy Supply and Demand in Canada, 1958-1969*, Catalogue No. 57-505, Ottawa, 1972.
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, various issues.

Figure 3.12.2 shows that the share of each primary energy commodity in total production has varied somewhat over time. Natural gas has come to represent a larger proportion of total production today than was the case in 1958. The reverse is true for crude oil. Coal and primary (hydro and nuclear) electricity, while showing some variability over time, today represent close to the same proportion of total production as they did in 1958.

Figure 3.12.1 also shows the annual exports and imports of primary energy commodities. Canada became a net energy exporter in 1962 and has remained so ever since. The proportion of our production that is exported has increased from approximately 17 percent in 1958, to 43 percent in 1992. Energy production does not come without some environmental consequence. As net exporters of energy Canadians are accepting a degraded environment for the benefit of energy consumers elsewhere. Of course, the economic benefits and costs of external trade in energy and other commodities must be considered alongside the environmental consequences.

Figure 3.12.2

Production by Primary Energy Commodity, 1958-1992



Sources:
Statistics Canada, *Detailed Energy Supply and Demand in Canada*, Catalogue No. 57-207, Ottawa, various issues.
Statistics Canada, *Detailed Energy Supply and Demand in Canada, 1958-1969*, Catalogue No. 57-505, Ottawa, 1972.
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue 57-003, Ottawa, various issues.

Table 3.12.2 shows domestic consumption of primary energy commodities. As with total production, total domestic consumption has risen steadily since 1958. The relative importance of the various primary commodities in total consumption has changed significantly over time. Crude oil represented 52 percent of total consumption in 1958, but only 36 percent in 1992. Coal has also lost its share of relative consumption since 1958, moving from 22 to 13 percent of consumption. Both primary electricity and natural gas have gained share, as has natural gas. While natural gas represented only 13 percent of consumption in 1958, it had a 36 percent share in 1992.

From the perspective of the environmental impact of energy consumption, these shifts in primary energy consumption have been both positive and negative. On one hand, primary commodities natural gas and electricity produce the lowest air emissions per unit of energy. Thus, total air emissions from fuel consumption are probably lower today than they would be if 1958 consumption patterns had held constant. On the other hand, natural gas development has brought with it a vast network of pipelines and primary electricity generation has resulted in the restructuring of major water systems (see Section 3.10 - **Dams and Water Diversions**) and the creation of nuclear wastes.

Table 3.12.2

Domestic Consumption of Primary Energy Commodities, 1958-1992

Year	Coal	Crude oil	Natural gas[1]	Electricity	Total
			petajoules		
1958	637	1 490	366	359	2 852
1959	625	1 644	433	334	3 037
1960	559	1 715	497	362	3 134
1961	548	1 803	579	364	3 294
1962	557	1 903	662	370	3 491
1963	598	2 050	721	371	3 740
1964	621	2 092	809	405	3 926
1965	648	2 168	895	421	4 131
1966	635	2 328	982	464	4 408
1967	629	2 372	1 045	479	4 524
1968	683	2 544	1 160	490	4 878
1969	660	2 654	1 294	533	5 141
1970	708	2 860	1 418	559	5 545
1971	673	3 119	1 518	579	5 890
1972	635	3 425	1 711	641	6 411
1973	654	3 771	1 818	695	6 937
1974	665	3 931	1 851	762	7 209
1975	658	3 806	1 873	744	7 081
1976	709	3 770	1 912	792	7 183
1977	773	4 004	1 699	820	7 296
1978	789	4 011	1 712	878	7 389
1979	876	4 297	1 803	888	7 864
1980	928	4 196	1 871	934	7 929
1981	946	3 990	1 814	962	7 713
1982	1 002	3 332	1 791	936	7 062
1983	1 048	3 183	1 847	983	7 061
1984	1 167	3 170	2 016	1 058	7 412
1985	1 122	3 077	2 532	1 145	7 876
1986	1 040	3 038	2 481	1 231	7 789
1987	1 118	3 155	2 574	1 235	8 082
1988	1 200	3 339	2 810	1 278	8 627
1989	1 198	3 402	3 026	1 276	8 902
1990	1 077	3 463	2 893	1 304	8 738
1991	1 104	3 249	2 938	1 322	8 812
1992	1 137	3 175	3 124	1 312	8 748

Note:
1. Includes natural gas liquids.

Sources:
Statistics Canada, *Detailed Energy Supply and Demand in Canada*, Catalogue No. 57-207, Ottawa, various issues.
Statistics Canada, *Detailed Energy Supply and Demand in Canada, 1958-1969*, Catalogue No. 57-505, Ottawa, 1972.
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, various issues.

Electricity Production

Electricity is produced in Canada using hydro, nuclear- and fossil fuel-powered processes. Table 3.12.3 provides a breakdown of total electricity generation by each of these methods while Figure 3.12.3 shows electricity generation by process as a percentage of total production. Hydroelectric production, which represented more than 90 percent of total production in 1958, has steadily lost relative share to the other two forms of production. Since the introduction of commercial nuclear electricity in 1965, fossil fuel generation has maintained a steady 19-23 percent of total production. The continued decline in hydro's share of production since 1961 has been offset by the rise of nuclear generation to approximately 16 percent of total production in 1992.

Table 3.12.3

Electricity Production by Process, 1958-1992

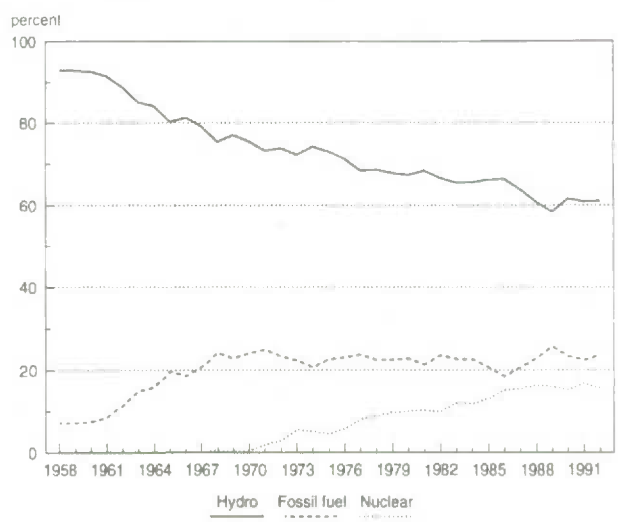
Year	Hydro	Fossil fuel	Nuclear	Total
		gigawatt hours		
1958	90 509	7 016	-	97 526
1959	97 040	7 631	-	104 670
1960	105 883	8 574	-	114 457
1961	103 919	9 794	-	113 713
1962	104 073	13 396	-	117 469
1963	103 919	18 319	-	122 238
1964	113 485	21 501	-	134 987
1965	117 875	28 987	127	146 989
1966	130 993	30 110	171	161 273
1967	133 483	35 026	152	168 660
1968	135 939	43 385	910	180 234
1969	149 403	44 257	523	194 184
1970	157 847	50 338	1 028	209 212
1971	162 102	55 105	4 227	221 434
1972	181 744	57 276	7 143	246 163
1973	194 771	60 173	15 111	270 055
1974	213 046	59 337	14 697	287 079
1975	204 420	63 278	12 569	280 268
1976	214 920	69 359	17 416	301 695
1977	222 331	76 827	26 342	325 499
1978	236 380	77 223	31 201	344 803
1979	245 371	81 351	35 272	361 994
1980	253 508	85 386	38 032	376 926
1981	265 769	83 026	40 067	388 862
1982	257 737	91 092	38 338	387 166
1983	265 997	91 893	48 993	406 883
1984	286 204	98 684	52 210	437 098
1985	303 743	94 781	60 521	459 046
1986	310 730	86 596	71 267	468 592
1987	316 321	102 752	77 262	496 335
1988	306 581	114 837	82 867	504 285
1989	290 519	127 500	79 872	497 890
1990	295 765	111 696	72 967	480 427
1991	307 356	112 784	84 930	505 070
1992	315 254	121 305	80 582	517 142

Note:
There was no production of marketed electricity at nuclear power stations prior to 1965.

Source:
Department of Natural Resources Canada.

Figure 3.12.3

Electricity Production by Process, 1958-1992



Source:
Department of Natural Resources Canada.

Hydroelectricity - Environmental Impacts

Hydroelectric power, by far the most important renewable source of energy in the world, brings with it a number of potential environmental impacts. These are outlined in Technical Box 3.12.1. The effects are numerous and complicated; it should not be assumed that all of the effects pertain to every hydroelectric development in Canada.

The physical impacts of hydroelectric development on land are perhaps the most obvious. Large surface areas must be flooded to create reservoirs. This can disrupt the migration patterns of terrestrial animals and increase seismic and landslide activity in the area around the reservoir.

Another important physical change associated with hydroelectric development is the alteration of siltation patterns. Silt normally carried downstream by a flowing river will settle in the slow-moving water of a reservoir. High in nutrient content, this silt may promote growth and diversity of aquatic species in the early years of the reservoir. However, this can be followed by eutrophication of the reservoir in later years, leading to a reduction in biological diversity. Sediment-free dam discharge water flows at higher velocities than sediment-laden water. Erosion of downstream riverbanks, deltas and seashores is a potential result of these higher discharge velocities. As well, productivity of floodlands downstream of dams may fall due to the reduction in nutrients previously provided by silt. Finally, build-up of silt in front of dams will reduce the useful life of the generating facility if water flow is restricted.

Technical Box 3.12.1

Environmental Considerations in Hydroelectricity Production

Impact category	Impacted system	Environmental consideration/effect
Physical/ Chemical	Hydrology	Smoothed discharge patterns Increased discharge water velocity Increased evaporative water losses Disrupted siltation patterns Increased turbidity Increased salinity and alkalinity Altered temperature profile Reduced dissolved oxygen content
	Local micro-climate	Increased humidity Decreased rainfall Increased cloud cover Increased fog Moderated temperature
	Land	Restructuring for road construction Increased local seismic activity Increased local landslide activity
Biological	Aquatic ecosystems	Reductions in downstream plankton populations Disruption of fish spawning routes Growth of fish populations in reservoir Possibility of magnified disease vectors
	Terrestrial ecosystems	Reduced shoreline biodiversity Disruption of animal habitat and migration routes
Human	Economic system	Reduced agricultural yields in floodlands Changed water recreation opportunities
	Sociocultural system	Relocation of population in flooded areas Political/legal challenges Loss of archeological patrimony

Source:
Organisation for Economic Co-operation and Development, *Environmental Impacts of Renewable Energy*, OECD, Paris, 1988.

Nuclear Electricity - Environmental Impacts

A number of environmental effects are potentially associated with the production of electricity using nuclear energy. These are summarized in Technical Box 3.12.2.

Uranium mine and mill tailings are considered low-level radioactive wastes. Table 3.12.4 provides a regional breakdown of tailings stored at active and inactive uranium mining and milling sites in Canada. As of 1992, approximately 203 megatonnes of tailings covering 1570 hectares were in storage.

Table 3.12.4

Uranium Mine and Mill Tailings by Region, 1992

	Waste quantity	Area covered	Site status
	megatonnes	hectares	
Northwest Territories	1.0	34 [1]	all sites inactive
Saskatchewan, North of Lake Athabasca	10.6	109	all sites inactive
Saskatchewan, South of Lake Athabasca	9.2	225 [2]	all sites active
Ontario, Bancroft Area	6.4	51	all sites inactive
Ontario, Elliot Lake Area - North	168.0	1 088	one active site
Ontario, Elliot Lake Area - South	7.5	63	all sites inactive
Total	202.7	1 570	

Notes:
1. Estimated value.
2. The total area under management is 225 hectares. Not all of this area is currently used for tailings disposal.

Source:
Underdown, G.A., Department of Natural Resources Canada, personal communication.

Technical Box 3.12.2

Environmental Considerations in Nuclear Electricity Production

Activity	Environmental consideration/effect
Uranium mining	Land subsidence Requirement for land reclamation Low-level radioactive dust release Low-level radioactive waste disposal Disposal of mine drainage water Underground water contamination
Uranium treatment/milling	Mill tailings containing toxic metals Liquid and solid chemical wastes Low-level radioactive milling wastes Low-level radioactive dust releases High water consumption Waste heat releases
Electricity generation	Gaseous radionuclide emissions Liquid radionuclide emissions High-level radioactive wastes Decontamination and decommissioning Waste heat releases

Source:
Organisation for Economic Co-operation and Development, *Environmental Impacts of Electricity Generation*, OECD, Paris, 1985.

Low-level radioactive wastes (LLRW) are also produced from post-mining/milling processing of uranium (and other radioactive materials). Table 3.12.5 shows inventory and accumulation rate data for LLRW from post-mining/milling sources.[1]

Table 3.12.5

Inventories and Accumulation Rates of Low-Level Radioactive Wastes by Source

	1991 inventory	Projected inventory - 2025	Current accumulation rate
	cubic metres		cubic metres per year
Nuclear Fuel Cycle	38 540	210 580	5 060
Research and development/ radioisotope production	86 680	168 620	2 410
Non-nuclear activities[1]	7 930	8 270	10
Historical activities	1 163 820	1 170 620	200
Decommissioning	1 820	170 600	800 [2]
Total	**1 298 790**	**1 728 690**	**8 480**

Notes:

1. Non-nuclear activities are those that are not directly related to the processing of radioactive materials, but that nevertheless produce low-level radioactive wastes. The combustion of coal and mineral processing are two examples.
2. This figure does not include wastes from the decommissioning of nuclear reactors used for commercial electricity production, since no decommissioning of these units is currently underway. Decommmissioning of commercial nuclear reactors is expected to commence after 2015; this will account for most of the projected 2025 inventory of LLRW from decommissioning activities.

Source:

Low-Level Radioactive Waste Management Office, *Inventory of Low-Level Radioactive Waste in Canada: Annual Report 1991*, LLRWMO, Ottawa, 1992.

The majority of both the current and projected inventories of post mining/milling LLRW is contaminated soil from historical activities.[2] Although historical activities are responsible for the majority of post-mining/milling LLRW, the accumulation rate of LLRW from historical activities (i.e. the rate at which new sites contaminated from historical activities are expected to be found) is very low. Over the period 1991 to 2025, the share of historical wastes in the inventory is projected to fall from 90 percent to 68 percent.

The inventory of post-mining/milling LLRW is expected to grow by 33 percent between 1991 and 2025. The majority of this increase will be due to LLRW generated in the nuclear fuel cycle (for example, the production and consumption of nuclear fuel for electricity production) and to LLRW from the decommissioning of nuclear power stations. Wastes generated in nuclear research and development and radioisotope production will also contribute to the increase in the inventory. Between 1991 and 2025, the share of stored LLRW from the nuclear fuel cycle will rise from 3 to 12 percent of the total inventory, while that from decommissioning will rise from 0.1 to 10.0 percent.

The annual production of used nuclear fuel rods (high-level radioactive waste) from electricity production in Canada is approximately 2 000 tonnes per year. At the beginning of 1993, some 17 000 tonnes of used nuclear fuel rods were in storage at Canadian nuclear power stations.[3]

Coal

Coal production is a two stage process. First, raw coal is extracted, either from underground (deep) mines or from strip mines. This is followed by processing to remove non-combustible material, leaving clean coal as the finished product.

Table 3.12.6 shows that most coal produced in Canada comes from strip mining operations; which in 1990 produced about 94 percent (by weight) of Canadian coal. Only Nova Scotia and Alberta extract any coal from deep mines, and only Nova Scotia produces a significant proportion of its coal this way (95 percent in 1990).

Table 3.12.6

Coal and Coal Waste Production by Region, 1985-1991

Year		Gross coal production: Surface	Gross coal production: Underground	Net coal production	Coal waste production	Waste per kilotonne of coal production
		kilotonnes				
1985	Atlantic	734	3 051	3 387	414	0.109
	Prairies	36 878	498	34 402	3 189	0.085
	B.C.	35 232	274	22 667	12 951	0.365
	Canada	**72 844**	**3 823**	**60 456**	**16 555**	**0.216**
1986	Atlantic	645	3 110	3 440	561	0.149
	Prairies	36 194	426	26 021	2 937	0.080
	B.C.	32 335	25	21 140	12 053	0.372
	Canada	**69 174**	**3 562**	**50 602**	**15 551**	**0.214**
1987	Atlantic	651	3 537	3 463	580	0.139
	Prairies	38 187	667	35 759	3 087	0.079
	B.C.	34 407	-	21 130	11 799	0.343
	Canada	**73 245**	**4 204**	**60 352**	**15 467**	**0.200**
1988	Atlantic	684	4 424	4 083	536	0.105
	Prairies	44 777	862	41 616	4 029	0.088
	B.C.	38 508	-	24 941	12 706	0.330
	Canada	**83 970**	**5 286**	**70 641**	**17 271**	**0.193**
1989	Atlantic	672	2 972	4 032	154	0.042
	Prairies	44 844	1 043	41 694	4 243	0.092
	B.C.	38 153	-	24 801	13 912	0.365
	Canada	**83 668**	**4 015**	**70 527**	**18 309**	**0.209**
1990	Atlantic	762	4 055	3 963	443	0.092
	Prairies	43 745	896	39 812	3 973	0.089
	B.C.	40 004	-	24 556	14 691	0.367
	Canada	**84 511**	**4 951**	**68 331**	**19 106**	**0.214**
1991	Atlantic	750	4 641	4 636	760	0.141
	Prairies	44 385	918	41 536	4 153	0.092
	B.C.	39 597	-	24 962	14 829	0.375
	Canada	**84 732**	**5 559**	**71 134**	**19 742**	**0.219**

Note:

Figures may not add due to rounding.

Source:

Statistics Canada, *Coal Mines*, Catalogue No. 26-206, Ottawa, various issues.

The potential environmental effects of coal production are summarized in Technical Box 3.12.3. It is important to point out that the actual environmental effects of coal production vary significantly with the physical and chemical properties of the coal in question, the mining process and the environmental controls employed during extraction. Thus, not all of

1. Note that not all of these sources are related to nuclear electricity production.
2. Historical wastes are those that have been generated by producers no longer operating or who otherwise cannot be held responsible for the management of the wastes.
3. Underdown, G.A., Department of Natural Resources Canada, personal communication.

Technical Box 3.12.3

Environmental Considerations in Coal Production

Activity	Environmental consideration/effect
Extraction	Land removed from other uses, particularly agriculture Land subsidence (deep mines) Surface erosion (strip mining) Large scale surface restructuring (strip mining) Acid mine drainage containing heavy metals and sulphuric acid Waste inorganic material High water consumption Dust Noise
Treatment	Wash water containing dissolved and suspended solids Solid waste Dust Noise

Source:
Organisation for Economic Co-operation and Development, *Environmental Impacts of Electricity Generation*, OECD, Paris, 1985.

the effects listed in Technical Box 3.12.3 will pertain to any given coal production site.

One of the most damaging environmental effects associated with coal production is acid mine drainage. This results from the conversion to sulphuric acid of sulphides often found in coal deposits. Streambeds accepting acid mine drainage are often coated with "yellowboy", an iron oxide deposit. The low pH of acid mine drainage may also allow heavy metals to make their way into the local hydrologic system. However, the most toxic component of acid mine drainage is sulphuric acid.[1]

Acid mine drainage does not occur to any significant extent where the sulphide concentration in the coal formation is low. The coal deposits in western Canada, where most Canadian coal is produced, do not contain high levels of sulphides. Thus, acid mine drainage should not be a major problem in western Canada. However, acid mine drainage may be a problem in coal mining regions of eastern Canada, where higher concentrations of sulphides are associated with coal formations.

Land restructuring is a second major consequence of coal production. Although deep mines do not require major restructuring of land above ground, subsidence (caving in) can result from deep mining unless specific measures are taken to avoid it. Land subsidence is not a significant problem in Canada today, since most of our operating deep mines are under the ocean floor off the coast of Nova Scotia.

Strip mining, by its very nature, requires large-scale restructuring of land. While such restructuring is in principle temporary, in practice it is costly and difficult to completely reclaim land that has been strip mined. Reclamation is one of the primary environmental concerns of strip mining operations in Canada, and accounts for a significant portion of the costs of coal production from these mines. Of the approximately 41 700 hectares (cumulative) of Canadian land disturbed by coal mining as of 1989, approximately 15 900 hectares (38 percent) had been reclaimed to some extent.[2]

Coal in its raw form contains non-combustible inorganic material that must be removed before the coal can be burned. This cleaning of raw coal results in the creation of very large quantities of waste for disposal. Today this waste is often used as backfill in land reclamation. In the past, however, the waste was allowed to remain in piles after the mine site closed. Natural reclamation of these waste piles has been slow in some cases, due to the unsuitability of the waste for plant growth.[3] Data in Table 3.12.6 show that the quantity of waste produced at coal mines is somewhat variable across the three major mining regions of Canada. For Canada as a whole, the ratio of waste production to gross coal production has remained relatively stable at approximately 0.2 tonnes per tonne since1985.

Crude Oil

Crude oil is produced in Canada mainly from subterranean reservoirs and by extraction from tar sands in Alberta. While a good deal of exploration activity occurs off-shore, there is currently no commercial, off-shore oil production in Canada.

Oil extracted from underground often comes as an emulsion with briny water. The oil must be separated from this emulsion before it is marketed, resulting in the creation of large quantities of waste brine. If not properly disposed of, this brine can negatively effect aquatic systems in the production area (Technical Box 3.12.4).

Depending on the oil in question, significant quantities of hydrogen sulphide may be released to the atmosphere during oil extraction. This can cause local odour problems, as hydrogen sulphide is detectable at very low concentrations. Of more long-term significance, hydrogen sulfide released to the atmosphere forms sulfur dioxide, one of the most important precursors to acid rain.

Oil spills and blowouts associated with oil production have been estimated to comprise between 0.01 and 0.02 percent of total production.[4] Canadian crude oil production in 1988 amounted to approximately 85 megatonnes,[5,6] suggesting that anywhere from 8.5 to 17 kilotonnes of crude oil might

1. Manahan, S.E., *Environmental Chemistry, Fourth Edition*, Brooks/Cole Publishing Company, Monterey, 1984.

2. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
3. Fording Coal Ltd., *Over Twenty Years of Reclamation at the Fording River Mine*, information pamphlet.
4. Organisation for Economic Co-operation and Development, *Environmental Impacts of Electricity Generation*, OECD, Paris,1985.
5. Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, 1989.
6. This assumes an average density for Canadian crude oil of 0.84 tonnes per cubic metre.

Table 3.12.7

Crude Oil Spills in Oil Producing Provinces, 1981-1988

	Ontario		Manitoba		Saskatchewan		Alberta		British Columbia		N.W.T.		Total	
Year	quantity	average per occurence	quantity	average per occurence	quantity	average per occurence	quantity	average per occurence	quantity	average per occurence	quantity	average per occurence	quantity	average per occurence
	tonnes													
1981	-	...	-	...	2 522.9	13.1	5 220.4	9.4	108.9	27.2	3.2	1.6	7 855.4	10.4
1982	1.7	0.9	-	...	1 616.9	12.0	8 566.4	14.8	458.6	91.7	31.8	2.9	10 675.4	14.6
1983	-	...	-	...	2 929.3	20.9	4 631.8	9.0	343.6	9.8	0.6	0.2	7 905.4	11.4
1984	2.1	0.5	-	...	2 302.9	9.6	9 455.8	14.1	233.8	13.8	9.0	4.5	12 003.7	12.9
1985	-	...	25.8	25.8	2 480.9	9.0	10 648.8	13.6	248.9	35.6	4.3	4.3	13 408.7	12.5
1986	-	...	-	...	1 739.4	5.6	6 467.0	9.7	14.3	14.3	145.2	11.2	8 365.9	8.4
1987	614.1	204.7	-	...	2 309.7	7.0	4 645.2	6.8	33.1	8.3	10.7	1.2	7 612.8	7.4
1988	-	...	4.4	0.6	1 538.3	5.6	6 395.4	5.9	111.5	55.8	8.4	0.3	8 058.1	5.7

Source:
Mezies, J., National Trends in Emergencies (NATES) Database, Environment Canada, personal communication.

Technical Box 3.12.4

Environmental Considerations in Crude Oil Production

Activity	Environmental consideration/effect
Extraction	Land removed from other uses Blowouts/spills Gaseous waste emissions, including hydrogen sulphide Damage to aquatic ecosystem Groundwater and soil contamination Brine disposal
Field treatment	Explosions and fires Land removed from other uses Gaseous waste emissions Particulate emissions Water consumption Disposal of waste water Odour Noise
Refining	Explosions and fires Solid, liquid and gaseous wastes Spills Groundwater and soil contamination

Source:
Organisation for Economic Co-operation and Development, *Environmental Impacts of Electricity Generation*, OECD, Paris, 1985.

have been spilled as a result of crude oil production. This compares well with the reported 8.1 kilotonnes of crude oil spilled in oil producing provinces in 1988 (Table 3.12.7).

Of widespread concern are catastrophic spills of oil at sea. Although it is not possible to say with certainty when, where and how much oil might be spilled, estimates have been made of the likelihood of the occurrence of marine oil spills in and around Canadian waters. The expected frequency of marine spills of greater than 20 000 tonnes[1] in Canadian waters is about once every 53 years. Marine spills of greater than 1 000 tonnes are expected to occur once every one to two years, with a median size of 15 000 tonnes. The geographic distribution of spills will likely be as follows: Atlantic coast/St. Lawrence - 55 percent; Pacific coast - 45 percent.[2]

Technical Box 3.12.5

Environmental Considerations in Natural Gas Production

Activity	Environmental consideration/effect
Extraction	Land removed from other uses Blowouts Hydrogen sulphide, methane and trace metal emissions
Field treatment	Hydrogen sulphide, methane and trace metal emissions Liquid wastes Noise Waste elemental sulphur

Source:
Organisation for Economic Co-operation and Development, *Environmental Impacts of Electricity Generation*, OECD, Paris, 1985.

Natural Gas

The environmental consequences of natural gas production are similar to those of crude oil production (Technical Box 3.12.5).

Most natural gas is sour (that is, contaminated with hydrogen sulphide and carbon dioxide) when it is extracted. Since hydrogen sulphide becomes corrosive in the presence of water, it must be removed from natural gas prior to transportation. This results in the production of large quantities of elemental sulphur, which may or may not present a disposal problem. Much of the sulphur that is produced as a result of natural gas desulphurisation is sold for use in the production of sulphuric acid. In fact, this ranks as one of the most important sources of elemental sulphur today.[3]

Carbon Dioxide Emissions from Fossil Fuel Combustion

The combustion of fossil fuels releases very large quantities of carbon dioxide into the atmosphere. This aspect of fossil

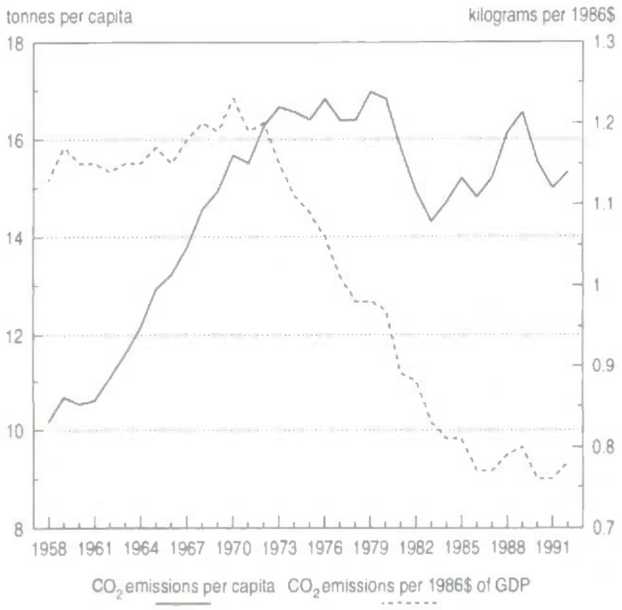
1. For the sake of comparison, the oil tanker *Exxon Valdez* spilled approximately 35 000 tonnes of oil into Prince William Sound, Alaska in 1989.
2. S.L. Ross Environmental Research Ltd., *Expected Frequency of Oil Spills from Tankers in or Near Canadian Waters*, Ottawa, 1989.
3. Manahan, S.E., *Environmental Chemistry, Fourth Edition*, Brooks/Cole Publishing Company, Monterey, 1984.

fuel consumption has received a great deal of attention in recent years. Scientists predict that increasing atmospheric concentrations of carbon dioxide (and other, so-called, greenhouse gases) will lead to a rapid warming of the earth's lower atmosphere. This, in turn, will cause changes in climatic patterns, with accompanying disruptions in social, economic and environmental processes (See Section 3.7 - **Wastes** for more information on the greenhouse effect).

In 1990, fossil fuel combustion accounted for approximately 94 percent of total carbon dioxide emissions from the Canadian economy.[1] The remainder was made up of emissions from other industrial processes. Table 3.12.8 presents a number of indicators of fossil fuel-based CO_2 emissions. It can be seen that emissions have increased significantly since 1958, both in absolute and per capita terms. In contrast, the ratio of CO_2 emissions to real gross domestic product (GDP) shows a slight upward trend until the early 1970s, followed by a significant downward trend that has continued to date. This downward trend in CO_2 emissions per dollar of real GDP is likely a result of a combination of factors: increased efficiency of fossil fuel use, restructuring of the economy away from activities that consume relatively large amounts of fossil fuels, and the increased use of energy commodities that produce less CO_2 per unit of delivered energy.

Figure 3.12.4

Selected CO_2 Emission Ratios, 1958-1992



Source:
Statistics Canada, National Accounts and Environment Division.

Table 3.12.8

Carbon Dioxide Emissions from Fossil Fuel Combustion, 1958-1992

Year	CO_2 emissions	CO_2 emissions per capita	CO_2 emissions per $ of real GDP
	megatonnes	tonnes per capita	kilograms per 1986 $
1958	174	10.17	1.13
1959	187	10.68	1.17
1960	189	10.54	1.15
1961	194	10.61	1.15
1962	206	11.07	1.14
1963	220	11.59	1.15
1964	235	12.14	1.15
1965	254	12.92	1.17
1966	265	13.23	1.15
1967	281	13.78	1.18
1968	302	14.55	1.20
1969	314	14.93	1.19
1970	334	15.67	1.23
1971	342	15.51	1.19
1972	363	16.28	1.20
1973	376	16.66	1.15
1974	379	16.56	1.11
1975	381	16.40	1.09
1976	396	16.82	1.06
1977	390	16.38	1.01
1978	394	16.39	0.98
1979	412	16.96	0.98
1980	414	16.82	0.97
1981	402	15.79	0.89
1982	387	14.91	0.88
1983	380	14.31	0.83
1984	393	14.70	0.81
1985	385	15.20	0.81
1986	376	14.80	0.77
1987	404	15.21	0.77
1988	432	16.14	0.79
1989	452	16.55	0.80
1990	432	15.54	0.76
1991	422	14.99	0.76
1992	436	15.33	0.78

Notes:
The 1990 CO_2 emissions figure reported above matches the 431.5 megatonnes of CO_2 from fossil fuel combustion reported by Environment Canada (Jaques, A.P., *Canada's Greenhouse Gas Emissions: Estimates for 1990.* Environment Canada, Ottawa, 1992.
Carbon dioxide emissions from non-combustion uses of fossil fuels (as chemical feedstocks for example) are not included in the above estimates.
Source:
Statistics Canada, National Accounts and Environment Division

1. Excluding biomass sinks and sources.

Reducing Impacts on the Environment

Human activities transform landscapes, generate wastes, consume resources and change ecological systems. Today, people are increasingly aware of the environmental problems that result from our activities. This awareness has stimulated public action to reduce human impacts on the environment, particularly where they have direct consequences for human health and the resources that support economic activities.

The following four sections present information on a variety of human interventions intended to reduce or eliminate the impacts of human activities on the natural environment. Interventions or preventative measures can be initiated by groups within society: governments, business, individuals and combination of these.

❑❑❑

3.13 Governments

An important component of the governments' role is the development of environmental legislation and programs.

In Canada, a wide variety of legislation is targeted at many different activities. Legislation can be **prohibitive** - banning an activity that is seen as undesirable. Good examples are ban on killing migratory song birds or the prohibition on the use of the pesticide DDT. Legislation can be **restrictive** - reducing impacts by reducing their causes. An example, would be the current limits placed on sulphur dioxide emissions from smelters as part of clean air regulations. The creation of parks and other protected areas is another way in which federal and partner governments protect significant and sensitive ecosystems.

Governments can also provide **incentives** to act in ways that will reduce impacts on the environment. One example would be the tax measures that allow accelerated depreciation of pollution abatement control equipment.

Table 3.13.1 lists federal and provincial environmental legislation in place in Canada. The titles of acts shown in the table are taken from the most recent compilations of public statutes published by each government. The acts cover the use and protection of resources and the management of wastes and other by-products of human activity.

Table 3.13.2 presents a summary of recent Canadian Environmental Protection Act (CEPA) enforcement actions. In fiscal year 1990-91, the number of inspections was higher than in the following year. Many of these additional inspections took place pursuant to gasoline regulations. However, prosecutions doubled from 8 to 16 between 1990-91 and 1991-92.

Table 3.13.1
Federal and Provincial Environmental Legislation

Topic	Jurisdiction	Legislation and Statute Reference
General	**Federal**	Fertilizers Act (RS85cF10); Canadian Environmental Protection Act (RS85c16(4)); Northern Pipeline Act (RS85cN26)
	Newfoundland	Forestry Act (1990c58); Environmental Assessment Act (1980c3); Municipalities Act (1979c33)
	Prince Edward Island	Environmental Protection Act (RS88E9); Environment Tax Act (RS88E83)
	New Brunswick	Mining Act (1985M14.1); Health Act (RS73H2); Environmental Trust Fund Act (1990E9.3); Clean Environment Act (RS73C6)
	Nova Scotia	Environmental Protection Act (RS89c150); Environmental Assessment Act (RS89c149); Parks Development Act (RS89c332); Trails Act (RS89c476); Health Act (RS89c195); Municipal Act (RS89c295); Weed Control Act (RS89c501); Environmental Trust Act (1990c9); Conservation Easements Act (1992c2); Ozone Layer Protection Act (RS89c331)
	Quebec	Cities and Towns Act (RScC19); Environment Quality Act (RScQ2)
	Ontario	Planning Act (1983c1); Municipal Act (RS80c302); Environmental Protection Act (RS80c141); Environmental Assessment Act (RS80c140)
	Manitoba	Municipal Act (M225); Planning Act (P80); Public Health Act (P210); Environment Act (E125)
	Saskatchewan	Pollution (by Livestock) Control Act (P16.1); Environmental Management and Protection Act (E10.2); Ecological Reserves Act (E0.01); Environmental Assessment Act (E10.1); Northern Municipalities Act (N5.1); Natural Resources Act (N3.1); The State of the Environment Report Act (S57.1)
	Alberta	Highway Traffic Act (RS80cH7); Hydro and Electric Energy Act (RS80cH13); Public Lands Act (RS80cP30); Public Health Act (1984cP27.1); Provincial Parks Act (RS80cP22); Environmental Protection and Enhancement Act (1993)
	British Columbia	Waste Management Act (1982c41); Transport of Dangerous Goods Act (1985c17); Sustainable Environment Fund Act (1990c27); Weather Modification Act (RS79c431); Skagit Environmental Enhancement Act (1984c28); Environment and Land Use Act (RS79c110); Environment Management Act (1981c14)
	Yukon	Environment Act (1992)
	Northwest Territories	Area Development Act (RS88cA8); Public Health Act (RS88cP12); Commissioner's Land Act (RS88cC11); Cities, Towns and Villages Act (RS88cC8)
Land	**Federal**	Northwest Territories Act (RS85cN27); Indian Act (RS85cI5); Fertilizers Act (RS85cF10); Yukon Act (RS85cY2); Federal Real Property Act (1992c50); National Parks Act (RS85cN14); National Capital Act (RS85cN4); Territorial Lands Act (RS85cT7); Railway Act (RS85cR3); Canadian Environmental Protection Act (RS85c16(4)); National Housing Act (RS85cN11)

Table 3.13.1
Federal and Provincial Environmental Legislation (Continued)

Topic	Jurisdiction	Legislation and Statute Reference
	Newfoundland	Municipalities Act (1979c33); Environmental Assessment Act (1980c3); Wilderness and Ecological Reserves Act (1980c2); Crown Lands Act (RS70c71); Lands Act (1991c36)
	Prince Edward Island	Planning Act (RS88P8); National Park Act (R88N1); Recreation Development Act (RS88R8); Land Protection Act (RS88L5); Municipalities Act (RS88M13); Roads Act (RS88R15); Weed Control Act (RS88w2.1)
	New Brunswick	Marshland Reclamation Act (RS73M5); Parks Act (1982P2.1); Mining Act (1985M14.1); Weed Control Act (RS73W7); Ecological Reserves Act (1975E1.1); Community Planning Act (RS73C12); Crown Lands and Forests Act (1980C38.1); Agricultural Rehabilitation and Development Act (RS73A6)
	Nova Scotia	Planning Act (RS89c346); Environmental Trust Act (1990c9); Provincial Parks Act (RS89c367); Towns Act (RS89c472); Municipal Act (RS89c295); Parks Development Act (RS89c332); Agriculture and Marketing Act (RS89c6); Weed Control Act (RS89c501); Beaches Act (RS89c32); Crown Lands Act (RS89c114); Mineral Resources Act (1990c18); Conservation Easements Act (1992c2); Environmental Assessment Act (RS89c149)
	Quebec	Preservation of Agricultural Land Act (RScP41.1); Land Use Planning and Development Act (RScA19.1); Parks Act (RScP9); Ecological Reserves Act (RScR26); Lands in the Public Domain Act (RScT8.1); Agriculture Abuses Act (RScA2); Cities and Towns Act (RScC19)
	Ontario	Drainage Act (RS80c126); Mining Act (RS80c268); Public Lands Act (RS80c413); Weed Control Act (1988c51); Topsoil Preservation Act (RS80c504); Shoreline Property Assistance Act (RS80c471); Niagara Escarpment Planning and Development Act (RS80c316); Planning Act (1983c1); Aggregate Resources Act (1989c23); Conservation Authorities Act (RS80c85); Provincial Parks Act (RS80c401); Municipal Act (RS80c302); Environmental Assessment Act (RS80c140)
	Manitoba	Crown Lands Act (C340); Planning Act (P80); Municipal Act (M225); Mines Act (M160); Provincial Park Lands Act (P20); Ecological Reserves Act (E5); Noxious Weeds Act (N110); Manitoba Habitat Heritage Act (H3); Heritage Resources Act (H39.1); Conservation Districts Act (C175)
	Saskatchewan	Planning and Development Act (P13.1); Provincial Lands Act (P31); Critical Wildlife Habitat Act (C47.1); Rural Municipalities Act (R26.1); Conservation and Development Act (C27); Prairie and Forest Fires Act (P22.1); Regional Parks Act (R9.1); Environmental Assessment Act (E10.1); Ecological Reserves Act (E0.01); Parks Act (P1.1); Environmental Management and Protection Act (E10.2); Noxious Weeds Act (N9.1)
	Alberta	Provincial Parks Act (RS80cP22); Soil Conservation Act (1988cS19.1); Public Lands Act (RS80cP30); Environmental Protection and Enhancement Act (1993); Drainage Districts Act (RS80cD39); Wilderness Areas, Ecological Reserves & Natural Areas (RS80cW8); Agricultural Pests Act (1984cA8.1); Surface Rights Act (1983cS27.1); Forest and Prairie Protection Act (RS80cF14); Planning Act (RS80cP9); Special Areas Act (RS80cS20)
	British Columbia	Islands Trust Act (RS79c68); Ecological Reserve Act (RS79c101); Skagit Environmental Enhancement Act (1984c28); Coal Act (RS79c51); Land Act (RS79c214); Riverbank Protection Act (RS79c369); Range Act (RS79c355); Municipal Act (RS79c290); Agricultural Land Commission Act (RS79c9); Park Act (RS79c309); Weed Control Act (RS79c432); Mineral Tenure Act (1988c5); Park (Regional) Act (RS79c310); Soil Conservation Act (RS79c391); Environment and Land Use Act (RS79c110); Mines Act (1989c56)
	Yukon	Environment Act (1992); Lands Act (RS86c99); Parks Act (RS86c126); Municipal Act (RS86c119); Pesticides Control Act (1989-90c20)
	Northwest Territories	Commissioner's Land Act (RS88cC11); Planning Act (RS88cP7); Territorial Parks Act (RS88cT4); Cities, Towns and Villages Act (RS88cC8); Environmental Protection Act (RS88cE7)
Water	**Federal**	Canada Water Act (RS85cC11); Fisheries Act (RS85cF14); Territorial Lands Act (RS85cT7); Northwest Territories Waters Act (1992c39); Arctic Waters Pollution Prevention Act (RS85cA12); Canadian Environmental Protection Act (RS85c16(4)); Navigable Waters Protection Act (RS85cN22); Canada Shipping Act (RS85cS9); Yukon Waters Act (1992c40); Railway Act (RS85cR3); Coastal Fisheries Protection Act (RS85cC33)
	Newfoundland	Aquaculture Act (1987c15)
	Prince Edward Island	Municipalities Act (RS88M13); Water and Sewerage Act (RS88W2)
	New Brunswick	Irish Moss Act (RS73I15); Pesticides Control Act (RS73P8); Aquaculture Act (1988A9.2); Clean Water Act (1989C6.1)
	Nova Scotia	Irish Moss Act (RS89c237); Parks Development Act (RS89c332); Towns Act (RS89c472); Water Act (RS89c500); Village Service Act (RS89c493); Environmental Protection Act (RS89c150); Aquaculture Act (RS89c18)
	Quebec	Environment Quality Act (RScQ2); Watercourses Act (RScR13); Commercial Fisheries and Aquaculture Act (RScP9.01); Mining Act (RScM13)
	Ontario	Drainage Act (RS80c126); Public Utilities Act (RS80c423); Water Transfer Control Act (1989c18); Ontario Water Resources Act (RS80c361); Shoreline Property Assistance Act (RS80c471); Environmental Protection Act (RS80c141); Conservation Authorities Act (RS80c85)
	Manitoba	Water Resources Administration Act (W70); Manitoba Hazardous Waste Management Corp. Act (H15); Ground Water and Water Well Act (G110); Rivers and Streams Act (R160); Mines and Minerals Act (M162); Water Rights Act (W80)
	Saskatchewan	Water Resources Management Act (W7); Ground Water Conservation Act (G8); Conservation and Development Act (C27)
	Alberta	Environmental Protection and Enhancement Act (1993); Hydro and Electric Energy Act (RS80cH13); Water Resources Act (RS80cW5); Drainage Districts Act (RS80cD39)
	British Columbia	Water Act (RS79c429); Riverbank Protection Act (RS79c369); Fisheries Act (RS79c137); Health Act (RS79c161)
	Yukon	Environment Act (1992); Municipal Act (RS86c119)
	Northwest Territories	Environmental Protection Act (RS88cE7)
Air	**Federal**	Canadian Environmental Protection Act (RS85c16(4))
	Prince Edward Island	Highway Traffic Act (RS88H5)
	Nova Scotia	Ozone Layer Protection Act (RS89c331); Motor Vehicle Act (RS89c293); Environmental Protection Act (RS89c150)
	Quebec	Environment Quality Act (RScQ2)
	Ontario	Environmental Protection Act (RS80c141); Farm Practices Protection Act (1988c62); Highway Traffic Act (RS80c198)
	Manitoba	Ozone Depleting Substances Act (O80); Environment Act (E125)
	Saskatchewan	Clean Air Act (C12.1); Ozone Depleting Substances Control Act (O8.1)
	Alberta	Environmental Protection and Enhancement Act (1993)
	British Columbia	Weather Modification Act (RS79c431); Motor Vehicle Act (RS79c288)
	Yukon	Environment Act (1992)
	Northwest Territories	Environmental Protection Act (RS88cE7)
Hazardous Waste	**Federal**	Hazardous Products Act (RS85cH3); Pest Control Products Act (RS85cP9); Radiation Emitting Devices Act (RS85cR1); Canadian Environmental Protection Act (RS85c16(4)); Pesticides Residue Compensation Act (RS85cP10); Food and Drugs Act (RS85cF27); Transportation of Dangerous Goods Act (1992c34); Fertilizers Act (RS85cF10)

Table 3.13.1

Federal and Provincial Environmental Legislation (Continued)

Topic	Jurisdiction	Legislation and Statute Reference
	Newfoundland	Fire Prevention Act (1991c34); Pesticides Control Act (1983c52); Aquaculture Act (1987c15); Dangerous Goods Transportation Act (1982c45)
	Prince Edward Island	Dangerous Goods Transportation Act (RS88D3); Pesticides Control Act (RS88P4); Fire Prevention Act (RS88F11)
	New Brunswick	Injurious Insect and Pest Act (RS73I9); Pipeline Act (1976P8.1); Transportation of Dangerous Goods Act (1988T11.01); Aquaculture Act (1988A9.2); Pesticides Control Act (RS73P8)
	Nova Scotia	Pipeline Act (RS89c345); Dangerous Goods Transportation Act (RS89c119); Pest Control Products (Nova Scotia) Act (RS89c341); Dangerous Goods & Hazardous Wastes Management Act (RS89c118)
	Ontario	Highway Traffic Act (RS80c198); Pesticides Act (RS80c376); Ontario Waste Management Corporation Act (1981c21); Gasoline Handling Act (RS80c185); Energy Act (RS80c139); Dangerous Goods Transportation Act (RS80c69)
	Manitoba	Manitoba Hazardous Waste Management Corp. Act (H15); Mines and Minerals Act (M162); Pesticides and Fertilizer Control Act (P40); Dangerous Goods Handling and Transportation Act (D12)
	Saskatchewan	Rural Municipalities Act (R26.1); Pest Control Act (P7); Pipe Lines Act (P12); Pest Control Products (Saskatchewan) Act (P8); Dangerous Goods Transportation Act (D1.2)
	Alberta	Special Waste Management Corporation Act (1982cS21.5); Pipeline Act (RS80cP8); Radiation Protection Act (1985cR2.1); Transportation of Dangerous Goods Control (1983cT6.5); Environmental Protection and Enhancement Act (1993)
	British Columbia	Petroleum and Natural Gas Act (RS79c323); Pipelines Act (RS79c328); Motor Vehicle Act (RS79c288); Transport of Dangerous Goods Act (1985c17); Hazardous Waste Management Corporation Act (1990c19); Pesticide Control Act (RS79c322); Health Act (RS79c161)
	Yukon	Pesticides Control Act (1989-90c20); Dangerous Goods Transportation Act (RS86c39)
	Northwest Territories	Pesticide Act (RS88cP4); Transport of Dangerous Goods Act (RS88c81Sup)
Noise	**Federal**	Aeronautics Act (RS85cA2)
	Newfoundland	Highway Traffic Act (1988c33)
	Prince Edward Island	Highway Traffic Act (RS88H5)
	New Brunswick	Agricultural Operations Practices Act (1986A5.2); Motor Vehicle Act (RS73M17)
	Nova Scotia	Motor Vehicle Act (RS89c293)
	Ontario	Farm Practices Protection Act (1988c62); Highway Traffic Act (RS80c198)
	Manitoba	Highway Traffic Act (H60)
	Alberta	Highway Traffic Act (RS80cH7)
	British Columbia	Motor Vehicle Act (RS79c288)
	Yukon	Motor Vehicles Act (RS86c118); Noise Prevention Act (RS86c121)
Solid Waste	**Federal**	Indian Act (RS85cI5); Canada Shipping Act (RS85cS9); Canadian Environmental Protection Act (RS85c16(4))
	Newfoundland	Quarry Materials Act (1975-76#15); Highway Traffic Act (1988c33); Waste Material Disposal Act (1973#82)
	Prince Edward Island	Highway Traffic Act (RS88H5); Roads Act (RS88R15); Municipalities Act (RS88M13)
	New Brunswick	Motor Vehicle Act (RS73M17); Agricultural Operations Practices Act (1986A5.2); Highway Act (RS73H5); Beverage Containers Act (1991B2.2)
	Nova Scotia	Village Service Act (RS89c493); Litter Abatement Act (1989c8); Motor Vehicle Act (RS89c293); Towns Act (RS89c472); Public Highways Act (RS89c371); Recycling Act (1989c12); Mineral Resources Act (1990c18)
	Quebec	Mining Act (RScM13)
	Ontario	Farm Practices Protection Act (1988c62); Aggregate Resources Act (1989c23); Mining Act (RS80c268); Public Lands Act (RS80c413); Ontario Waste Management Corporation Act (1981c21)
	Manitoba	Waste Reduction and Prevention Act (W40); Rivers and Streams Act (R160); Highway Traffic Act (H60); Mines Act (M160); Mines and Minerals Act (M162)
	Saskatchewan	Pollution (by Livestock) Control Act (P16.1); Highways and Transportation Act (H3); Litter Control Act (L22); Rural Municipalities Act (R26.1); Highway Traffic Act (H3.1)
	Alberta	Environmental Protection and Enhancement Act (1993)
	British Columbia	Transport of Dangerous Goods Act (1985c17); Waste Management Act (1982c41); Mineral Tenure Act (1988c5); Municipal Act (RS79c290); Hazardous Waste Management Corporation Act (1990c19); Water Act (RS79c429); Park Act (RS79c309); Soil Conservation Act (RS79c391)
	Yukon	Environment Act (1992); Municipal Act (RS86c119); Motor Vehicles Act (RS86c118)
Energy	**Federal**	Oil and Gas Production and Conservation Act (RS85cO7); National Energy Board Act (RS85cN7); Canadian Environmental Protection Act (RS85c16(4)); Canada Petroleum Resources Act (RS85c36(2)); Oil Substitution and Conservation Act (RS85cO8)
	Newfoundland	Petroleum and Natural Gas Act (RS70c294)
	New Brunswick	Oil and Natural Gas Act (1976O2.1); Pipeline Act (1976P8.1)
	Nova Scotia	Pipeline Act (RS89c345); Energy and Mineral Resources Conservation Act (RS89c147); Energy-efficient Appliances Act (1991c2); Petroleum Resources Act (RS89c342)
	Quebec	Energy Conservation Act (RScE1.1); Mining Act (RScM13)
	Ontario	Energy Act (RS80c139); Energy Efficiency Act (1988c32); Gasoline Handling Act (RS80c185); Public Utilities Act (RS80c423)
	Manitoba	Mines Act (M160)
	Saskatchewan	Pipe Lines Act (P12); Oil and Gas Conservation Act (O2)
	Alberta	Energy Resources Conservation Act (RS80cE11); Gas Resources Preservation Act (1984cG3.1); Oil Sands Conservation Act (1983cO5.5); Coal Conservation Act (RS80cC14); Pipeline Act (RS80cP8); Hydro and Electric Energy Act (RS80cH13); Oil and Gas Conservation Act (RS80cO5)
	British Columbia	Pipelines Act (RS79c328); Geothermal Resources Act (1982c14); Petroleum and Natural Gas Act (RS79c323); Energy Efficiency Act (1990c40); Coal Act (RS79c51)

Table 3.13.1
Federal and Provincial Environmental Legislation (Continued)

Topic	Jurisdiction	Legislation and Statute Reference
	Yukon	Energy Conservation Assistance Act (RS86c55)
Wildlife	**Federal**	National Parks Act (RS85cN14); Canada Wildlife Act (RS85cW9), Northwest Territories Act (RS85cN27); Yukon Act (RS85cY2)
	Newfoundland	Plant Protection Act (1978c49); Wilderness and Ecological Reserves Act (1980c2); Wild Life Act (RS70c400)
	Prince Edward Island	Natural Areas Protection Act (RS88N2); Fish and Game Protection Act (RS88F12); Forest Management Act (RS88F14)
	New Brunswick	Endangered Species Act (RS73E9.1); Ecological Reserves Act (1975E1.1), Irish Moss Act (RS73I15); Fish and Wildlife Act (1980F14.1)
	Nova Scotia	Irish Moss Act (RS89c237); Crown Lands Act (RS89c114); Provincial Parks Act (RS89c367); Environmental Trust Act (1990c9); Wildlife Act (RS89c504); Agriculture and Marketing Act (RS89c6); Parks Development Act (RS89c332); Angling Act (RS89c14)
	Quebec	Ecological Reserves Act (RScR26); Threatened or Valuable Species Act (RScE12.01); Plant Protection Act (RScP39); Hunting and Fishing Rights Act (RScD13.1); Conservation and Development of Wildlife Act (RScC61.1)
	Ontario	Game and Fish Act (RS80c182); Endangered Species Act (RS80c138)
	Manitoba	Ecological Reserves Act (E5); Heritage Resources Act (H39.1); Endangered Species Act (E111); Provincial Park Lands Act (P20); Manitoba Habitat Heritage Act (H3); Wildlife Act (W130)
	Saskatchewan	Critical Wildlife Habitat Act (C47.1); Wildlife Act (W13.1); Ecological Reserves Act (E0.01); Fisheries Act (F16)
	Alberta	Agricultural Pests Act (1984cA8.1); Wilderness Areas, Ecological Reserves & Natural Areas Act(RS80cW8); Provincial Parks Act (RS80cP22), Wildlife Act (1984cW9.1)
	British Columbia	Dogwood, Rhododendron & Trillium Protection Act (RS79c96); Park Act (RS79c309); Wildlife Act (1982c57); Creston Valley Wildlife Act (RS79c82); Plant Protection Act (RS79c329); Ecological Reserve Act (RS79c101)
	Yukon	Wildlife Act (RS86c178)
	Northwest Territories	Wildlife Act (RS88cW4)
Fish	**Federal**	Canada Wildlife Act (RS85cW9); Fisheries Act (RS85cF14); Coastal Fisheries Protection Act (RS85cC33)
	Prince Edward Island	Fish and Game Protection Act (RS88F12)
	New Brunswick	Fish and Wildlife Act (1980F14.1); Aquaculture Act (1988A9.2)
	Nova Scotia	Angling Act (RS89c14); Parks Development Act (RS89c332); Fisheries Act (RS89c173); Aquaculture Act (RS89c18)
	Quebec	Commercial Fisheries and AquacultureAct (RScP9.01); Hunting and Fishing Rights Act (RScD13.1); Conservation and Development of Wildlife Act (RScC61.1)
	Ontario	Game and Fish Act (RS80c182)
	Manitoba	Fisheries Act (F90)
	Saskatchewan	Fisheries Act (F16)
	Alberta	Environmental Protection and Enhancement Act (1993)
	British Columbia	Fisheries Act (RS79c137)
Forest	**Federal**	Territorial Lands Act (RS85cT7); Forestry Act (RS85cF30)
	Newfoundland	Plant Protection Act (1978c49); Forestry Act (1990c58)
	Prince Edward Island	Forest Management Act (RS88F14); Fire Prevention Act (RS88F11)
	New Brunswick	Plant Diseases Act (RS73P9); Crown Lands and Forests Act (1980C38.1); Injurious Insect and Pest Act (RS73I9); Forest Fires Act (RS73F20)
	Nova Scotia	Forests Act (RS89c179); Forest Enhancement Act (RS89c178); Environmental Trust Act (1990c9); Crown Lands Act (RS89c114)
	Quebec	Preservation of Agricultural Land Act RScP41.1); Plant Protection Act (RScP39); Forest Act (RScF4.1); Tree Protection Act (RScP37)
	Ontario	Forestry Act (RS80c175); Forest Tree Pest Control Act (RS80c174); Crown Timber Act (RS80c109); Forest Fires Prevention Act (RS80c173); Plant Diseases Act (RS80c380)
	Manitoba	Forest Act (F150); Fires Prevention Act (F80); Dutch Elm Disease Act (D107)
	Saskatchewan	Forest Act (F19); Prairie and Forest Fires Act (P22.1)
	Alberta	Forest Reserves Act (RS80cF15); Forest and Prairie Protection Act (RS80cF14); Forests Act (RS80cF16)
	British Columbia	Forest Act (RS79c140)
	Yukon	Forest Protection Act (RS86c71)
	Northwest Territories	Forests Management Act (RS88cF9); Forest Protection Act (RS88cF10)

Sources:
Federal and provincial tables of public statutes.

Technical Box 3.13.1

Canadian Environmental Protection Act

The Canadian Environmental Protection Act (CEPA), proclaimed in 1988, is perhaps the most important piece of federal environmental legislation. This act consolidated some or all sections of the Environmental Contaminants Act, the Canada Water Act, the Clean Air Act, the Ocean Dumping Control Act, and the Department of Environment Act. CEPA is aimed at both human and environmental health. It covers atmospheric, aquatic and terrestrial concerns and is intended to address problems before they occur. Some of the elements included in this act are:

- the authority to control the introduction of new substances into Canada;
- the authority to require testing of new and existing substances;
- provisions to control all aspects of the life cycle of toxic substances (from their creation to their disposal/destruction;
- authority to regulate fuels;
- authority to regulate emissions and effluents, as well as waste handling and disposal practices of federal departments;
- provisions to create guidelines and codes for environmentally sound practices as well as to set objectives for desirable levels of environmental quality;
- provisions to control air pollution where a violation of an international agreement would otherwise result;
- provisions to control nutrients, such as phosphates;
- provisions to issue permits to control dumping at sea;
- provisions to collect information on environmental quality and publish reports on the state of the environment.

Several provincial governments have also consolidated the major elements of their environmental legislation while work is in progress to do so in other provinces.

Table 3.13.2

Enforcement Activities - Canadian Environmental Protection Act, 1991 and 1992

Period	Inspections	Investigations	Warnings	Directions	Prosecutions	Convictions
	number of actions					
April 1990 to March 1991	2 794	61	78	5	8	6
April 1991 to March 1992	1 574	120	82	6	16	2

Source:
Environment Canada, *The Canadian Environmental Protection Act: Reports for the periods April 1990 to March 1992*, Ottawa, 1993.

Table 3.13.3 presents the details of enforcement activities conducted under the authority of CEPA in fiscal year 1991-92. The greatest number of warnings were issued in regard to the storage of waste containing PCBs. A number of other warnings were issued concerning ozone depleting substances, such as chlorofluorocarbon 12, and for ocean dumping. The only convictions came under PCB regulations.

Government activities geared toward protecting the environment, fostering more effective use of resources and conducting environmental research often go far beyond what is laid out in the legislation. Some measure of the extent of these activities can be gained by examining the expenditures of various levels of government on the environment (Table 3.13.4.).

Government agencies also play a role in efforts to rehabilitate elements of ecosystems that have suffered from the impacts of human activities. Restocking fish in depleted lakes and replanting tree seedlings on cut-over forest land are two examples. The restocking of harvested forest land is an activity that government agencies share with the forest industry. Information on this activity is presented in Section 3.16 - **Silviculture**. Underlying all of these measures are the research initiatives that provide a greater understanding of what is happening and why it is happening.

Government services can directly influence impacts on the environment. Local governments, for example, are major players in the collection and safe disposal of waste. How these services are provided - through the use of an open dump versus a highly controlled sanitary landfill, for example - determines the degree of impact on air, water, soils and biota.

The provision of recycling services and household hazardous waste collection programs to residents is another way local governments can act to reduce environmental impacts from solid wastes. In 1990 Statistics Canada conducted its first survey of local government waste management practices. Table 3.13.5 presents selected information on provision of recycling and household hazardous waste services for the 83 municipalities with populations exceeding 50 000. Most large municipalities in Canada reported a recycling program (88 percent). However, the amount of material re-

Table 3.13.3

Enforcement Activities - Canadian Environmental Protection Act, by Regulation, 1992[1]

Regulations	Inspections	Investigations	Warnings	Directions	Prosecutions	Convictions
			number of actions			
Storage of PCB wastes - interim order	240	3	44	1	-	-
Chlorobiphenyls regulations	414	31	10	1	1	2
PCB waste export regulations	21	-	4	-	-	-
PCB treatment and destruction regulations	6	2	-	-	-	-
Secondary lead smelter release regulations	49	-	-	1	-	-
Vinyl chloride release regulations	10	-	-	1	-	-
Asbestos mines and mills release regulations	20	-	1	-	-	-
Chlor-alkali mercury release regulations	23	1	1	-	-	-
Chlorofluorocarbon regulations	105	2	1	-	2	-
Gasoline regulations	263	3	-	-	-	-
Contaminated fuel interim order/regulations	1	2	-	-	-	-
Ozone-depleting substances regulation #1[2]	92	39	8	-	3	-
Ozone-depleting substances regulation #2[3]	9	-	-	-	-	-
Ozone-depleting substances regulation #3[4]	185	26	5	1	6	-
Ocean dumping regulations	100	11	8	1	3	-
Phosphorous concentration regulations	36	-	-	-	1	-
Total	**1 574**	**120**	**82**	**6**	**16**	**2**

Notes:
1. Enforcement activities presented in this table took place between April 1991 and March 1992.
2. This regulation reduces consumption of CFCs.
3. This regulation freezes consumption of halons.
4. This regulation prohibits certain uses of CFCs and halons.

Source:
Environment Canada, *The Canadian Environmental Protection Act: Report for the period April 1991 to March 1992*, Ottawa, 1993.

Table 3.13.4

Government Expenditures on Environment and Resources, 1985-1994

	1985-86	1986-87	1987-88	1988-89	1989-90[1]	1990-91[1]	1991-92[1]	1992-93[1]	1993-94[1]
					million dollars				
All Government									
Environment									
Water purification / supply	1 487.4	1 624.5	1 820.8	..	..	..	..	..	..
Sewage collection and disposal	949.4	1 096.2	1 164.2	..	..	..	..	..	..
Pollution control	209.5	244.4	261.8	..	..	..	..	..	..
Garbage and waste collection	564.4	628.7	714.5	..	..	..	..	..	..
Other	983.8	693.4	626.9	..	..	..	..	..	..
Total environment	**4 194.4**	**4 287.2**	**4 588.3**	**5 508.7**	**6 482.9**	**7 023.3**	**..**	**..**	**..**
Resource conservation and industrial development									
Agriculture	4 916.1	5 142.1	6 365.9	..	..	..	..	..	..
Fish and game	746.4	635.1	579.2	..	..	..	..	..	..
Forests	1 181.8	1 283.4	1 848.1	..	..	..	..	..	..
Mines	236.8	203.0	200.5	..	..	..	..	..	..
Oil and gas	3 763.8	2 633.9	1 722.4	..	..	..	..	..	..
Tourism	311.3	302.8	348.1	..	..	..	..	..	..
Trade and industry	2 432.1	2 706.2	2 483.9	..	..	..	..	..	..
Water	52.7	12.7	11.3	..	..	..	..	..	..
Other	1 625.4	1 671.7	1 590.2	..	..	..	..	..	..
Total resource conservation and industrial development	**15 266.3**	**14 590.9**	**15 149.7**	**13 990.4**	**12 598.5**	**11 606.4**	**..**	**..**	**..**
Total other expenditures	**204 499.5**	**214 830.9**	**231 391.8**	**245 608.6**	**268 862.6**				
Total expenditures	**223 960.2**	**233 709.0**	**251 129.8**	**265 107.7**	**287 944.0**	**..**	**..**	**..**	**..**
Federal									
Environment									
Water purification / supply	-	-	-	-	-	-	-	..	..
Sewage collection and disposal	..	-	-	-	-	-	-	..	..
Pollution control	..	..	..	..	-	..	..	..	..
Garbage and waste collection	-	-	-	-	-	-	-	..	..
Other	..	..	..	..	..	..	..	..	..
Total environment	**422.1**	**445.7**	**498.0**	**530.0**	**610.3**	**690.3**	**598.2**	**637.3**	**788.4**
Resource conservation and industrial development									
Agriculture	2 427.0	3 238.4	4 720.9	3 614.2	3 011.5	2 592.7	3 632.7	3 255.4	2 918.0
Fish and game	510.0	388.3	328.4	393.5	402.1	470.4	430.6	510.9	560.6
Forests	200.0	224.7	660.2	311.8	284.5	215.4	229.8	236.5	237.7
Mines	50.0	54.5	60.2	76.5	96.2	94.5	83.5	64.3	47.6
Oil and gas	2 893.0	1 040.5	648.8	690.8	269.4	289.0	355.6	452.9	532.7
Tourism	62.0	43.3	49.8	42.6	36.7	33.0	34.1	39.6	39.2
Trade and industry	1 306.0	1 373.7	1 585.5	1 597.3	1 617.7	1 713.3	1 511.4	1 572.4	1 693.7
Water	6.0	5.8	5.3	5.3	7.6	10.9	9.2	4.4	3.0
Other	623.0	703.0	650.5	707.8	760.0	725.5	630.2	682.0	607.9
Total resource conservation and industrial development	**8 077.0**	**7 072.2**	**8 709.6**	**7 439.7**	**6 485.7**	**6 144.7**	**6 917.1**	**6 818.4**	**6 640.4**
Total other expenditures	**108 411.9**	**113 308.5**	**121 512.4**	**128 364.5**	**141 651.8**	**152 135.9**	**157 292.1**	**162 983.3**	**165 380.7**
Total expenditures	**116 911.0**	**120 826.5**	**130 720.0**	**136 334.2**	**148 747.8**	**158 970.9**	**164 807.4**	**170 439.0**	**172 809.5**

Table 3.13.4

Government Expenditures on Environment and Resources, 1985-1994 (Continued)

	1985-86	1986-87	1987-88	1988-89	1989-90[1]	1990-91[1]	1991-92[1]	1992-93[1]	1993-94[1]
					million dollars				
Provincial									
Environment									
Water purification / supply	694.2	765.1	757.2	..	..	..	..	..	..
Sewage collection and disposal	-	-	-	..	..	..	..	..	..
Pollution control	170.6	209.4	228.2	..	..	..	..	..	..
Garbage and waste collection	-	-	-	..	..	..	..	..	..
Other	567.4	242.2	314.7	..	..	..	..	..	..
Total environment	**1 432.2**	**1 216.8**	**1 300.1**	**1 702.0**	**1 643.6**	**1 848.0**	..	..	..
Resource conservation and industrial development									
Agriculture	2 672.7	2 081.8	1 864.6	..	..	..	..	..	..
Fish and game	237.6	249.8	256.8	..	..	..	..	..	..
Forests	1 050.0	1 111.7	1 245.7	..	..	..	..	..	..
Mines	197.1	162.0	155.5	..	..	..	..	..	..
Oil and gas	1 242.5	1 633.2	1 102.3	..	..	..	..	..	..
Tourism	234.5	252.8	291.0	..	..	..	..	..	..
Trade and industry	1 068.0	1 207.3	777.8	..	..	..	..	..	..
Water	52.7	12.6	12.3	..	..	..	..	..	..
Other	912.2	878.7	804.7	..	..	..	..	..	..
Total resource conservation and industrial development	**7 667.3**	**7 589.9**	**6 510.7**	**7 581.0**	**6 843.7**	**6 867.8**	..	..	..
Total other expenditures	**98 539.5**	**104 049.8**	**111 544.4**	**118 731.2**	**126 363.9**	**135 434.8**	..	..	..
Total expenditures	**107 639.0**	**112 856.5**	**119 355.2**	**128 014.2**	**134 851.2**	**144 150.6**	..	..	..
Local									
Environment									
Water purification / supply	1 353.1	1 518.0	1 678.2	1 737.4	2 188.8	2 478.3	2 577.0	..	..
Sewage collection and disposal	992.9	1 138.0	1 208.6	1 305.3	1 783.6	2 093.0	2 321.8	..	..
Waste collection and disposal	564.4	627.8	714.5	796.0	901.4	1 085.4	1 287.3	..	..
Other	70.1	76.9	87.9	113.6	98.8	108.0	119.9	..	..
Total environment	**2 980.4**	**3 360.7**	**3 689.2**	**3 952.3**	**4 972.6**	**5 764.7**	**6 306.0**	..	..
Resource conservation and industrial development									
Agriculture	145.0	184.9	170.1	154.1	165.1	169.3	185.6	..	..
Tourism	16.5	10.4	9.4	17.2	16.1	17.1	18.8	..	..
Trade and industry	142.5	189.9	193.9	198.2	187.3	176.0	196.3	..	..
Other	136.0	153.2	196.2	252.1	238.9	251.6	292.0	..	..
Total resource conservation and industrial development	**440.0**	**538.4**	**569.5**	**621.6**	**607.4**	**614.0**	**692.7**	..	..
Total other expenditures	**38 458.1**	**40 449.0**	**43 444.0**	**46 200.8**	**49 410.4**	**53 309.5**	**57 837.1**	..	..
Total expenditures	**41 878.5**	**44 348.1**	**47 702.7**	**50 774.7**	**54 990.4**	**59 688.2**	**64 835.8**	..	..

Notes:
Figures may not add due to rounding.
1. Estimates.
Source:
Statistics Canada, Public Institutions Division.

cycled as a proportion of the total waste collected was relatively modest (9 percent). The table also indicates that the majority of major municipalities had some sort of household hazardous waste program in place. This service was usually set up in a depot format where householders are able to drop off old paint, solvents, pesticides and other hazardous products for safe disposal. These substances would have otherwise probably been destined for the local landfill. Table 3.13.6 presents additional data from the survey on programmes in place in municipalities of all sizes.

Table 3.13.5

Large Municipalities with Recycling and Hazardous Waste Programmes, 1990

	Population of CMA/CA			
	50 000-499 999	500 000-999 999	1 000 000 and over	Canada
Number of municipalities reporting	**37**	**14**	**32**	**83**
		percent		
Municipalities with recycling programmes	86	93	88	88
Material recycled as a proportion of total waste collected	9	7	10	9
Municipalities with household hazardous waste programmes	70	64	66	67

Note:
Recycling characteristics are more closely associated with Census Metropolitan Area / Census Agglomeration size than municipality size.
Source:
Statistics Canada, *Local Government Waste Management Practices Survey*, Ottawa, 1990.

Table 3.13.6

Municipalities Participating[1] in Waste Collection, Recycling and Hazardous Waste Programmes, 1990

	Region						
	Atlantic	Quebec	Ontario	Prairie	British Columbia	Yukon and NWT	Canada
Municipalities reporting	626	564	637	696	410	66	3 000
	percent of total reporting						
Collection	85	91	86	68	90	100	84
Recycling	29	42	86	43	65	48	52
Hazardous	6	21	56	31	19	37	27

Note:
1. A municipally operated or contracted programme.
Source:
Statistics Canada, Local Government Waste Management Practices Survey, 1990.

3.14 Individual Actions

Collectively, individual actions have a large impact on the environment. Many of these impacts are controlled through the actions of governments, the management of residential waste being an example. Nevertheless, there are many things people can do individually to lessen their impact on the environment.

Reductions in household waste can be achieved if people consider the packaging that will be discarded when they purchase products. Additional reductions are possible if people participate in recycling programmes, compost organic wastes, and reuse and exchange household items rather than purchasing new ones. There are also economic gains to be made as well if one trades children's toys and skates with friends or reuses plastic food containers instead of disposable plastic bags to store leftovers.

Energy use is another area where individual actions can bring about significant savings. Whether one drives a car, how frequently it is used, and for what distance are all individual decisions that affect the consumption of fossil fuels. Home heating and cooling and water heating practices, (such as the temperature setting used), are other decisions people make that can have a major impact on energy use.

In 1991, Statistics Canada conducted a survey of 43 000 households to gather data on household environmental practices. The *Household Environment Survey*[1] results provide information on the extent to which households used facilities and products that have, or are perceived to have, positive or negative effects on the environment.

Environmentally motivated actions are balanced against the desires for convenience and flexibility, comfort and safety. While many individuals would be unwilling to give up their automobiles, they seem to be eager to take other ac

1. Statistics Canada, *Households and the Environment 1991*, Catalogue No. 11-526, Ottawa, 1992.

Table 3.14.1

Recycling Activities by Province, 1991

Province	Total households	Households with access to curbside recycling or recycling depots for: Paper	Metal cans	Glass	Households using the recycling service for: Paper	Metal cans	Glass
	thousands	percent					
Newfoundland	177	11	15	7	55	59	54
Prince Edward Island	47	11	..	8	..	..	0
Nova Scotia	326	37	27	29	70	54	64
New Brunswick	251	18	15	18	66	54	61
Quebec	2 618	34	22	25	76	74	74
Ontario	3 585	72	72	72	94	94	94
Manitoba	389	40	42	39	50	56	47
Saskatchewan	359	38	56	54	70	74	74
Alberta	898	51	52	55	77	83	84
British Columbia	1 225	64	56	58	87	85	86
Canada	**9 873**	**53**	**49**	**50**	**86**	**86**	**86**

Note:
Figures may not add due to rounding.
Source:
Statistics Canada, *Households and the Environment 1991*, Catalogue No. 11-526, Ottawa, 1992.

tions to benefit the environment, if the level of inconvenience was relatively minor. The survey examined a range of these actions.

Table 3.14.1 through Table 3.14.3 present information from this survey on people's access to, and use of, recycling services.Nationally, about one-half of households had access to curbside or depot recycling services (53 percent for paper, 49 percent for metal cans and 50 percent for glass bottles), but this access varied greatly across the country. Access to recycling was highest in Ontario (72 percent for each of paper, metal cans and glass bottles). Use of available recycling services was also highest in Ontario. For those households that had access to a paper recycling service, 94 percent of Ontario households used the service versus 86 percent in the country as a whole. British Columbia ranked second in paper recycling availability at 64 percent of households, with 87 percent of these using the service. In contrast, only 11 percent of Prince Edward Island and Newfoundland households had access to paper recycling in 1991.

Table 3.14.2 indicates that persons living in large urban centres had better access to recycling than their rural counterparts. For example, for households in centres with greater than 100 000 population, 59 percent had access to paper recycling compared to 33 percent for rural households. As table 3.14.3 shows however, even among large urban centres the level of access to paper recycling services varies greatly.

The *Household Environment Survey* also indicated that households in single family homes were better served by recycling than apartment dwellers (60 percent versus 37 percent for paper recycling nationally).

Safe disposal of household hazardous wastes such as pesticides, solvents and paints is a growing concern in part because of the potential for contamination of water supplies from uncontrolled disposal. As Table 3.14.2 shows, 26 percent of households have access to a household hazardous waste disposal service; while 52 percent of these households used the service. Typically, hazardous wastes are collected at drop-off depots, which may have an impact on both the assessment of accessibility and likelihood of use by the household.

Table 3.14.2

Recycling and Disposal Activities of Households by Tenure and Community Size, 1991

Access to, and use of services by material	Tenure: Owned	Tenure: Rented	Community size: 100 000 and over	Community size: 30 000 to 99 999	Community size: Less than 30 000	Community size: Rural	Canada
	percent						
Paper							
Access	60	40	59	55	47	33	53
Use[1]	88	80	89	89	74	76	86
Glass							
Access	58	36	56	56	44	34	49
Use[1]	89	80	89	89	76	81	86
Metal cans							
Access	57	35	55	55	42	32	50
Use[1]	89	79	89	89	76	81	86
Household hazardous disposal[2]							
Access	32	17	30	30	19	17	26
Use[1]	56	38	50	50	51	67	52

Notes:
Figures may not add due to rounding.
1. Use as a percentage of those households indicating they had access to the service.
2. Disposal programmes for the safe disposal of hazardous household materials such as pesticides and solvents.
Source:
Statistics Canada, *Households and the Environment Survey 1991*, Catalogue No. 11-526, Ottawa, 1992.

Table 3.14.3

Paper Recycling by Census Metropolitan Area, 1991

CMA	With access to service[1]: percent of households	Reporting use: percent of households with access to service
Halifax	47	84
Québec	24	79
Montréal	37	77
Ottawa	70	91
Toronto	74	98
Hamilton	81	94
St. Catharines-Niagara	85	94
Kitchener-Waterloo	94	94
London	66	94
Windsor	77	95
Winnipeg	78	55
Edmonton	68	89
Calgary	47	75
Vancouver	72	93
Victoria	92	92
Canada	**53**	**86**

Note:
1. Respondents were asked if they had access to curbside or depot recycling services.
Source:
Statistics Canada, *Environmental Perspectives 1993*, Catalogue No. 11-528, Ottawa, 1993.

The survey also examined household composting practices. Composting household and garden waste is an effective way of reducing the amount of household garbage sent to landfill. Table 3.14.4 shows that nationally, 17 percent of households composted at home or used a composting service such as municipal leaf and grass clippings pick-up. Provincially, the figure was highest in British Columbia at 35 percent and second highest in Ontario at 21 percent. The survey also found that rural households were more likely to compost than urban ones (25 percent of rural households composted versus 15 percent of households in cities greater than 100 000 population).

Table 3.14.4

Composting and Yard Care Activities by Province, 1991

Province	Total households	Households that use a compost heap, container, or composting service	Total households with a yard, lawn or garden		Households with yards, lawns or gardens that use: Pesticides	Households with yards, lawns or gardens that use: Fertilizers[1]
	thousands	percent	thousands	percent	percent	
Newfoundland	177	6	146	82	11	26
Prince Edward Island	47	11	39	83	10	28
Nova Scotia	326	17	264	81	14	36
New Brunswick	251	11	215	86	16	37
Quebec	2618	5	1778	68	27	39
Ontario	3585	21	2619	73	33	49
Manitoba	389	15	299	77	25	37
Saskatchewan	359	20	300	84	35	53
Alberta	898	17	722	80	30	57
British Columbia	1225	35	916	75	24	47
Canada	**9873**	**17**	**7298**	**74**	**28**	**45**

Notes:
Figures may not add due to rounding.
1. Chemical fertilizers only; manure and compost use is not included.
Source:
Statistics Canada, *Households and the Environment 1991*, Catalogue No. 11-526, Ottawa, 1992.

Individuals can also reduce the household wastes they generate through the types of products they purchase and use. In 1992, Agriculture Canada sponsored a survey that examined the purchasing practices of grocery shoppers from an environmental perspective. Interviews were conducted with 1 000 householders. This was followed by a visual check of food storage areas in respondents' homes to determine the presence or absence of certain environmentally relevant items. As shown in Table 3.14.5, 65 percent of those interviewed reported considering environmental issues sometimes or always when food shopping. On a regional basis, British Columbia had the greatest percentage of shoppers in this category (81 percent), while the proportion was lowest in Atlantic Canada (40 percent).

Table 3.14.5

Consideration of Environmental Issues When Food Shopping, 1992

	Region					
	Atlantic	Quebec	Ontario	Prairies	B.C.	Canada
	percent					
Always	8	14	16	17	17	15
Sometimes	32	52	43	60	64	50
Rarely	25	18	16	11	11	16
Never	32	16	24	12	8	18
Don't Know	2	0	2	0	0	1

Notes:
The survey was conducted in November 1992, on a sample of 1000 households, in all provinces.
Figures may not add due to rounding.
Source:
Creative Research International Inc., Consumer Environment Study, final report, prepared for Agriculture Canada, 1993.

Respondents who considered environmental issues were then asked to identify which issues were important to them. Table 3.14.6 shows that at a national level, items related to product packaging and its ultimate disposal ranked highest. Respondents reported that packaging volume was a consideration for 42 percent of them. In Ontario, 58 percent of the respondents had considered the amount of packaging in their purchases.

Table 3.14.6

Environmental Issues Considered When Food Shopping, 1992

	Region					
	Atlantic	Quebec	Ontario	Prairies	B.C.	Canada
	percent					
Amount of packaging	34	23	58	42	46	42
Packaging is recyclable	22	31	47	36	42	38
Packaging has recycled content	20	25	40	22	25	29
Product is good for me/family	30	31	28	20	28	27
Product composition	16	20	29	23	31	25
Organic product	11	13	23	19	23	19
Production methods	3	4	9	7	9	7
Company's environmental ethics	2	2	4	5	3	3

Note:
The survey was conducted in November 1992, on a sample of 1 000 households, in all provinces.
Source:
Creative Research International Inc., *Consumer Environment Study, final report*, prepared for Agriculture Canada, 1993.

Table 3.14.7 presents consumer perceptions about the environmental sensitivity of aseptic containers. Often called juice or drink boxes, these containers can in fact be used to hold a variety of liquids (including milk) in a convenient and sanitary manner. Frequently the packages contain single servings of products and have been identified as an example of excessive product packaging. In addition, because the packages are composed of layers of paper, plastic and foil they are a challenge to recycle. Services to do this are not available to most Canadians. On the other hand, the packaging and food processing industries make the point that producing these packages consumes substantially less energy than if one were to produce a comparable number of glass bottles. They also note that because they weigh less than glass and because they can be more tightly packed for transport than bottled products, products in aseptic containers cost much less to ship in terms of money and fuel because fewer vehicle trips are required to move an equal amount of product.

Table 3.14.7

Perceptions of Environmental Sensitivity of Aseptic Containers Among Households Using Them[1], 1992

	Region					
	Atlantic	Quebec	Ontario	Prairies	B.C.	Canada
	percent					
Aseptic containers are:						
More environmentally sensitive[2]	19	18	20	20	5	17
Less environmentally sensitive	58	61	51	58	75	60
Don't know	23	21	29	22	20	23

Notes:
The survey was conducted in November, 1992 on a sample of 1 000 households, in all provinces.
1. Examples of aseptic containers are juice boxes and UHT milk containers.
2. Environmentally sensitive suggests the item is beneficial or at least less harmful to the environment than similar items.
Source:
Creative Research International Inc., *Consumer Environment Study, final report*, prepared for Agriculture Canada, 1993.

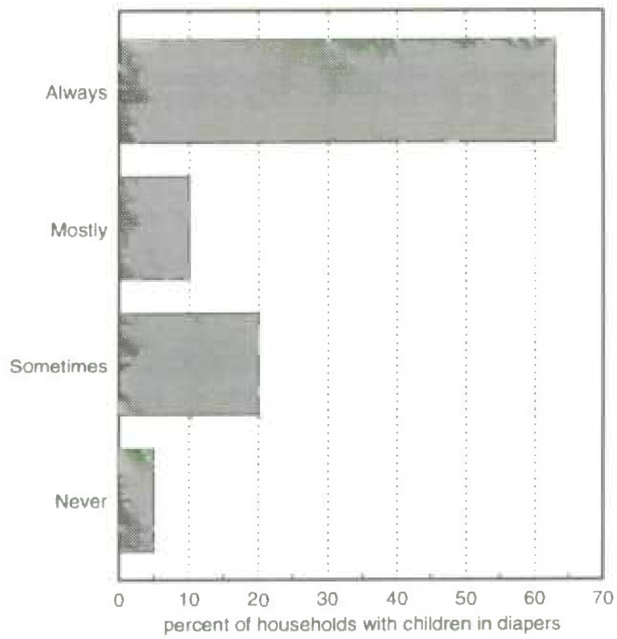
Table 3.14.7 indicates that Canadian consumers are aware of these messages. While 60 percent say aseptic containers are less environmentally sensitive, 17 percent of respondents say they are better for the environment. A further 23 percent do not know, an indication of consumer confusion.

Another convenience product with a high environmental profile is the disposable diaper. The 1991 *Household Environment Survey* asked householders with children of diaper-wearing age about their diaper of choice. Despite concerns about the large volume of disposable diapers entering the disposal stream, the convenience of this product has won-over most consumers. In households with children under two years of age, 63 percent used disposables exclusively, while only 5 percent never used them (Figure 3.14.1). A further 10 percent used them most of the time and

20 percent used them sometimes. Other results from the survey showed that the exclusive use of disposable diapers was lower in the three western-most provinces than in the provinces to the east. In British Columbia, for example, only 43 percent used disposables exclusively, compared with 77 percent in Newfoundland and 76 percent in Quebec. The time and convenience attractions of disposables is reflected in their high exclusive use among single-parent family households (75 percent), a group for whom time is generally at a premium.

Figure 3.14.1

Disposable Diaper Use, 1991



Note:
Households with children in diapers under age two. Although a question on the use of other diapers was not asked it is assumed that cloth diapers are the alternative.
Source:
Statistics Canada, *Household and the Environment 1991*, Catalogue No.11-526, Ottawa, 1992.

The *Household Environment Survey* also asked the Canadian public about a number of energy-using practices, including the use of cars and public transit in the journey to work, household heating, and the installation of specific energy-saving devices such as low flow shower heads and compact fluorescent light bulbs.

As Table 3.14.8 indicates, the automobile was the preferred method of travel to work in May 1991, despite its environmental implications. In households with at least one person working outside the home, 76 percent had at least one member driving to work, while only 15 percent of the households had someone using public transit. Households in the two lower income groups were more likely to have someone who walked to work than the higher income categories. Higher income households were somewhat more likely to have someone driving to work than the lower income groups, the percentage of homes with a public transit user was higher for the top income group than for any other category except the lowest one.

Households in large urban areas were most likely to have a public transit user. In urban areas with greater than 100 000 population 22 percent of households had a transit user versus 3 percent for small centres and 1 percent for rural areas. Conversely, rural areas had the highest percentage of households with drivers (83 percent). In part this reflects the nature of employment and the availability of public transit.

Table 3.14.8

Commuting Patterns by Household Income and Community Size, 1991

Total household income and community of residence	Works outside the home	Principal method of travel to work of persons in households where at least one member works outside the home			
		Private vehicle as driver	Public Transport	Bicycle	Walk only[1]
	percent				
Income					
Less than $20 000	28	56	19	3	16
$20 000 to $39 999	66	71	15	2	11
$40 000 to $59 999	85	79	14	2	8
$60 000 to $79 999	91	83	14	3	8
$80 000 and over	94	82	17	2	6
Community size					
100 000 and over	71	74	22	2	8
30 000 to 99 999	66	83	5	3	9
Less than 30 000	64	76	3	3	16
Rural	63	83	1	1	10
Canada	**68**	**76**	**15**	**2**	**9**

Note:
1. Persons combining walking with other forms of transport are counted under those other modes.
Source:
Statistics Canada, Household Surveys Division.

Table 3.14.9 shows that for major urban centres, Toronto (33 percent), Montréal (30 percent) and Ottawa (27 percent) respectively have the highest proportion of households with transit users. Windsor and St. Catharines-Niagara have the lowest percentage of households using transit (6 percent in each urban area).

Table 3.14.9

Commuting Patterns by Census Metropolitan Area, 1991

CMA	Households where at least one member: Has employment outside the home	Commutes to work by private vehicle as the driver	Commutes to work by public transportation
	thousands	percent of households with at least one person working outside home	
Halifax	85	65	16
Québec	174	78	17
Montréal	846	68	30
Ottawa	193	67	27
Toronto	952	69	33
Hamilton	161	80	11
St. Catharines-Niagara	81	84	6
Kitchener-Waterloo	87	83	...
London	91	80	16
Windsor	64	83	6
Winnipeg	163	74	21
Edmonton	207	77	17
Calgary	208	80	16
Vancouver	456	80	18
Victoria	68	69	13
Canada	**6 759**	**76**	**15**

Source:
Statistics Canada, "Household Activity, Household Expenditures and the Environment", *Environmental Perspectives 1993*, Catalogue No. 11-528, Ottawa, 1993.

The economic savings realized in efficiently using home heat is probably a greater factor in the popularity of this practice in Canadian homes than the environmental benefits. Nevertheless, Table 3.14.10 shows that Canadians seem to be reasonably concerned about energy efficiency when heating. Of households with thermostats, 14 percent of these have ones that can be programmed to raise and lower the temperature according to the time of day. In addition, 67 percent of households with ordinary thermostats regulate the temperature manually to make most efficient use of heating fuel. Householders in owned dwellings are somewhat more likely to do this than those in rented dwellings (71 percent versus 61 percent). Ontario has the greatest proportion of households where the thermostats in place are programmable ones (22 percent). British Columbia households are most likely to regularly lower the thermostat setting manually.

The potential for energy and water savings also contributed to the adoption of other new devices. One example, low flow shower heads, reduce water consumption and the amount of water to be heated. These items are present in 28 percent of households, with some differences apparent between rented and owned dwellings (Table 3.14.11).

Table 3.14.10

Energy Consumption Practices in Households with Thermostats by Province, 1991

Province	Households with thermostats	Households with programmable[1] thermostats	Households with non-programmable thermostats that regularly lower temperature setting
	percent		
Newfoundland	82	14	70
Prince Edward Island	90	14	72
Nova Scotia	90	11	72
New Brunswick	91	13	62
Quebec	87	7	70
Ontario	84	22	63
Manitoba	93	15	59
Saskatchewan	96	13	71
Alberta	95	16	61
British Columbia	91	10	79
Canada	88	14	67
Owned dwelling	95	17	71
Rented dwelling	76	9	61

Note:
1. Programmable thermostats can be set to raise or lower the temperature automatically according to the time of day. They are usually set to reduce temperatures at night when people are sleeping or during the daytime if people are out of the dwelling.
Source:
Statistics Canada, *Household Environment Survey*, 1991.

Results from the 1993 *Survey of Household Energy Use*[1] further indicate that 31 percent of households washed most laundry in cold water and 79 percent chose the water level according to the size of the load. In 54 percent of the households equipped with dishwashers, drying of dishes is done without heat, either by using the "air-dry" option or by opening the dishwasher's door.

Table 3.14.11

Energy and Water Conserving Devices, 1991

	Own dwelling	Rent dwelling	All households
Households with:		percent	
Low-flow showerheads	34	19	28
Low-flow toilet tanks	12	5	9
Compact fluorescent light bulbs	14	6	11

Source:
Statistics Canada, *Household an the Environment 1991*, Catalogue No. 11-526, Ottawa, 1992.

Individual actions that reduce environmental impacts are most widely embraced if they also have clear and immediate economic rewards. Temperature regulation in the home is an example. Other measures that require a limited time commitment but that have clear environmental benefits are also very popular. The use of curbside recycling is an example. Other practices that have negative environmental connotations (the use of disposable diapers for example) continue, however, if the time, comfort and convenience advantages to the individual are great enough.

1. Statistics Canada, *Survey of Household Energy Use*, 1993, Statistics Canada *Daily*, Wednesday, March 23, 1994.

3.15 Business Sector

Many impacts on the environment arise from business sector production and consumption activities. Some measures taken by the business sector to reduce its environmental impact address regulatory requirements. Others are taken to preserve economic resources, while still others are taken in keeping with public concerns about the state of the environment and public health.

Expenditures on abating and controlling pollution are a measure of business sector initiatives to reduce environmental impacts. Table 3.15.1 presents the results of the first detailed survey of these expenditures conducted by Statistics Canada. Because there are conceptual problems in measuring investments made for several reasons, this survey focused on pollution abatement and control (PAC) expenditures made solely to control or abate pollution. These are often described as "end of pipe" or "end of line" expenditures because the treatment often involves adding a device to a smokestack or outflow pipe to trap and treat emissions or effluents.

Table 3.15.1 shows that of the almost $1.2 billion in capital expenditures, the greatest share of this was spent by the paper and allied industries ($368 million). However, when considering PAC capital expenditures as a proportion of all capital expenditures, the greatest proportion of expenditures on pollution abatement and control is being made by the primary metals industries (12.3 percent of all expenditures).

Because the survey is restricted to the most easily measured portion of PAC expenditures, the results should be regarded as the lower boundary for overall private sector environmental expenditures. A survey of environmentally related expenditures prepared for Environment Canada by Dun and Bradstreet in 1991[1] reported capital and operating expenditures of $20.9 billion in 1989, over 12 times greater than the combined capital and operating figures from the Statistics Canada survey. This difference is not surprising in light of the differences in scope of the respective surveys.

Statistics Canada has also asked respondents to its regular annual Capital Repair and Expenditure Survey to indicate the purpose of their expenditures. One choice on the questionnaire since 1985 has been pollution abatement and control. The respondents are asked to assign their capital expenditures to the most relevant category. The results from this survey for 1989 differ somewhat from those of the *Pollution Abatement and Control Survey* since it is the respondents who ultimately decide what constitutes a pollution abatement and control expenditure.[2]

1. Dun and Bradstreet Canada, *Market Survey of Environmental Expenditures by Canadian Business*, Report prepared for Environment Canada, Duns Marketing Services, May, 1991.

Table 3.15.1

Pollution Abatement and Control Expenditures[1], Selected Industries, 1989

Industrial Sector	PAC operating	PAC capital	Total capital	PAC as a percentage of total capital
	million dollars			percent
Manufacturing	469	918	18 942	4.3
Paper and allied	76	368	5 501	6.7
Primary metals	258	288	2 341	12.3
Petroleum and coal	36	71	961	7.4
Chemicals	44	71	1 627	4.4
Mining	77	80	7 373	1.1
Utilities	x	106	19 486	1.1
Total economy[2]	**729**	**1 188**	**89 722**	**1.3**

Notes:
1. Pollution Abatement and Control is abbreviated to PAC in the table.
2. The total excludes capital items charged to operating expenditures and those capital expenditures made by residential construction, agriculture and fishing.

Source:
Statistics Canada, "Pollution Abatement and Control Expenditures", *Environmental Perspectives, 1993*, Catalogue No. 11-528, Ottawa, 1993.

Table 3.15.2

Capital Expenditures by Purpose, 1985-1991

Investment category	1985	1986	1987	1988	1989	1990	1991
	percent of total investment						
Expansion/ modernization/other	97.4	97.7	97.7	97.6	97.1	96.8	96.1
Pollution abatement and control	0.7	0.7	0.6	1.1	1.7	2.1	2.8
Improvement to working environment	0.9	1.0	1.1	0.9	0.8	0.7	0.8
Reduction of energy costs	0.9	0.7	0.5	0.4	0.4	0.4	0.3

Source:
Statistics Canada, *Capital Repair and Expenditure Survey.*

Table 3.15.3

PAC[1] Expenditures as a Proportion of Capital Expenditures, 1988 - 1991

	PAC[1] expenditures as a proportion of total reported capital expenditures			
	1988	1989	1990	1991
	percent			
Mining	1.5	2.4	6.2	4.7
Manufacturing	2.6	4.1	6.5	7.0
Food and Beverage	0.4	1.4	2.0	1.3
Paper and allied products	2.9	4.0	11.9	14.6
Primary metals	10.1	11.0	11.5	11.0
Transportation equipment	0.7	0.9	1.0	0.8
Petroleum and coal	1.2	1.3	1.2	2.3
Chemicals	4.8	10.3	3.5	4.8
Utilities	0.1	0.3	0.2	4.9
Total economy	**1.1**	**1.7**	**2.1**	**2.8**

Note:
1. Pollution abatement and control is abbreviated to PAC in the table.

Source:
Statistics Canada, *Capital Repair and Expenditure Survey.*

2. For a more complete discussion of the two surveys please refer to "Pollution Abatement and Control Expenditures" in *Environmental Perspectives, 1993*, Catalogue No. 11-528, Ottawa, 1993, and Statistics Canada, *Analysis of the Pollution Abatement and Control Survey*, uncatalogued, Investment and Capital Stock Division, 1992.

Table 3.15.4
Consumption and Disposition of Packaging, 1990

Material	Total consumed[1]		Total reused		Total recycled		Total disposed	
	thousand tonnes	percent	thousand tonnes	percent	thousand tonnes	percent	thousand tonnes	percent
Wood (pallets, boxes)	5 327	39.4	4 187	57.1	335	20.1	805	17.5
Paper (boxes, labels, corrugated cardboard)	3 149	23.3	899	12.3	723	43.4	1 527	33.2
Glass (bottles, carboys)	2 185	16.2	1 373	18.7	136	8.1	676	14.7
Plastic (containers, wrap)	1 358	10.0	190	2.6	95	5.7	1 073	23.4
Metal (tins, strapping)	888	6.6	362	4.9	162	9.7	364	8.0
Multi-material	193	1.4	7	--	36	2.2	150	3.2
Textiles and other (bags, wrapping)	426	3.1	318	4.4	180	10.8	--	--
Total	**13 526**	**100.0**	**7 336**	**100.0**	**1 667**	**100.0**	**4 595**	**100.0**

Note:
1. Consumption includes the amounts produced (minus exports), amounts reused and amount imported. Businesses and households are said to have "consumed" packaging when it is removed from the product purchased.
Source:
Statistics Canada, "Packaging Use and Disposition", *Environmental Perspectives, 1993,* Catalogue No. 11-528, Ottawa, 1993.

Table 3.15.2 presents capital expenditures by purpose for the years 1985 to 1991. The results show that the share of spending on pollution abatement and control has increased in recent years. Table 3.15.3 shows that this increase in PAC spending share is largely the result of the actions of the paper and allied products industry and the primary metals industry.

In addition to its pollution abatement and control measures, the private sector has also undertaken to reduce the amount of its packaging that ends up in the waste disposal stream. Environment Ministers and representatives of the private sector established the National Packaging Protocol in 1989. This program seeks to reduce the amount of packaging[1] sent for disposal in the year 2000 to 50 percent of the estimated 1988 level of 5.3 million tonnes. In order to monitor progress towards this objective, Statistics Canada has conducted two surveys of packaging use on behalf of the National Packaging Protocol Task Force. Table 3.15.4 presents some of the results to date.

1. The amount is measured by weight.

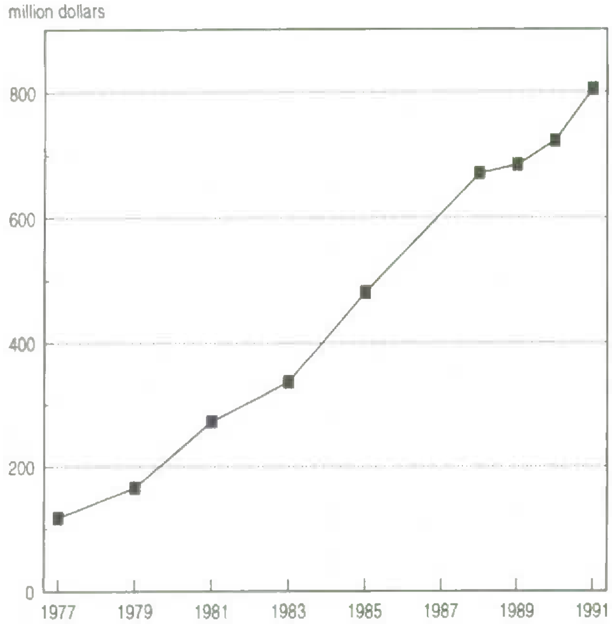
3.16 Silviculture

The vast forest-land base of Canada offers a strategic economic advantage as it permits the forest industry to accept the longer regeneration periods associated with low cost, natural regeneration. While much of the forest is regenerated naturally, regeneration on a large portion of forest-land is now enhanced through various interventions by both the public and private sectors. Interventions are carried out to ensure that a forest area is restocked to a desired species, at a particular density or within a particular time. To some extent these activities take place to lessen the impact, or at least the duration of the impact, of logging on the environment.

Silviculture is a term used to describe activities which enhance the regeneration and growth of forests. Silviculture may be as simple as removing the standing forest and waiting for natural regeneration to replace the original forest, or it may involve numerous interventions similar to agricultural activities. These interventions may include: prescribed burning, chemical or mechanical site preparation, seeding, planting, weeding / cleaning, spacing, fertilizing and thinning. These interventions, which are often intended to lessen environmental impacts, have the capacity to dramatically alter the natural succession which takes place after harvesting. From this perspective regeneration activities may warrant more careful review than logging activities in some cases.

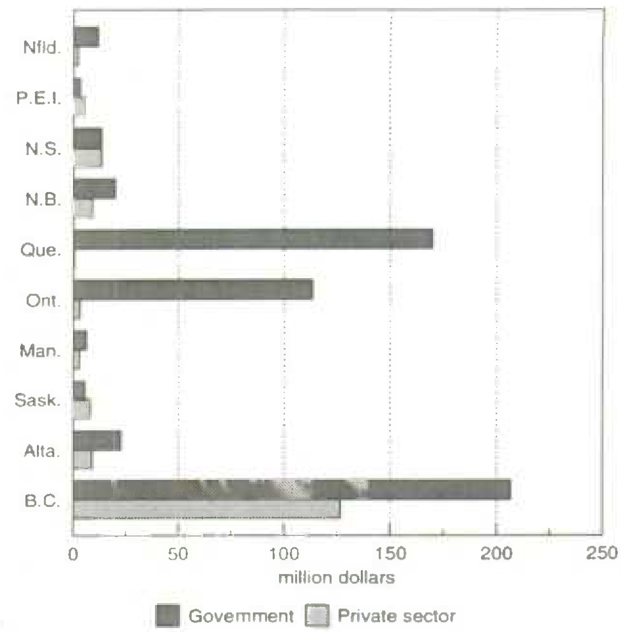
Silvicultural expenditures have increased dramatically over the past two decades and vast areas are now treated by these expenditures (Figure 3.16.1 and 3.16.2). The largest component of these expenditures is for planting new trees. A portion of these expenditures is made on treating lands that require remedial action. The provinces with the largest forest harvests, British Columbia, Quebec and Ontario, spend the greatest amount on silviculture. However, a much greater proportion of these expenditures is made by the private sector in British Columbia than in Quebec or Ontario.

Figure 3.16.1
Total Expenditures on Silviculture, 1977-1991



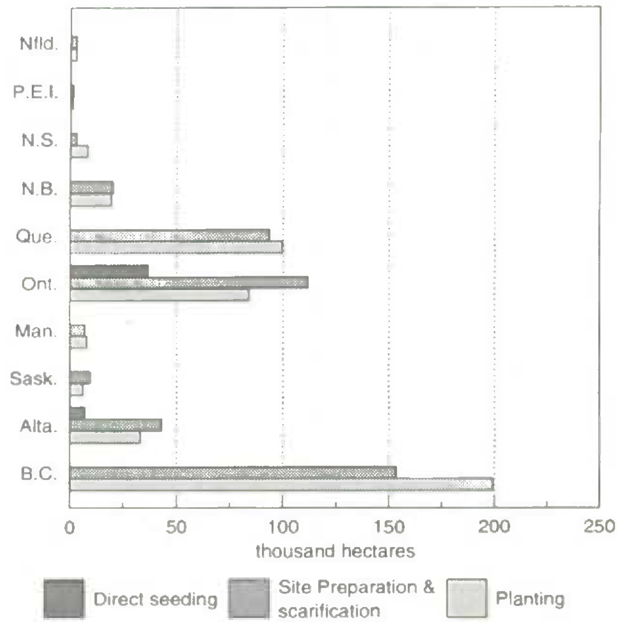
Source:
Natural Resources Canada, National Forestry Database.

Figure 3.16.3
Expenditures on Silviculture by Province, 1991



Source:
Natural Resources Canada, National Forestry Database.

Figure 3.16.2
Reforestation Activities by Province, 1991

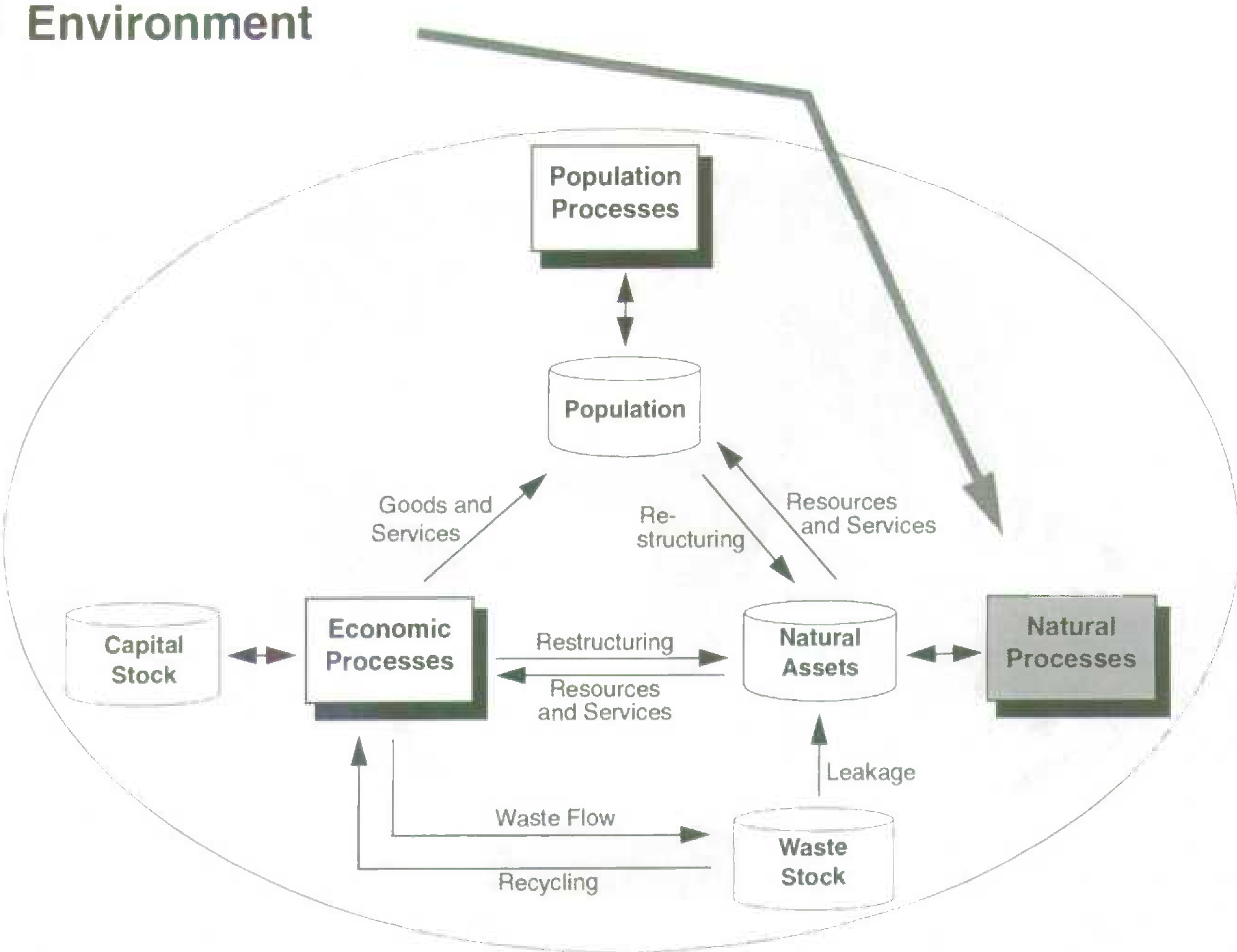


Source:
Natural Resources Canada, National Forestry Database.

Summary

Governments, business and the public each take actions to control and reduce impacts of human activities on the environment. The scale and the nature of these interventions is tempered by economic and social needs as well as the quality of the information available that is used to formulate the intervention decisions. While economic and social demands will continue to be balanced with environmental concerns in future, further developing an understanding of environmental conditions and processes will help ensure that what interventions are made are as timely and appropriate as possible.

4 Environment



Environmental Conditions

Monitoring the state of our environment contributes to our understanding of the impact that human activities have on natural ecosystems. This monitoring has in some cases led to changes in human activities. For example, in the late 1950s and early 1960s investigations into the reproductive failure and eggshell thinning of birds led to the discovery of the dangers of DDT. This pesticide was consequently banned in Canada in 1970 and in the United States in 1972. Peregrine falcon populations, once near extinction as a result of exposure to DDT, are now recovering in many regions. Research into changing lake and forest ecosystems in the late 1970s led to the understanding of the sources and effects of acid rain. As a result, legislation was enacted to reduce emissions of the gases that cause acid rain. Emissions and ambient levels of these gases have subsequently declined.

Contaminants are not the only priority for monitoring. Statistics on land use, soil quality, resource exploitation and fish and wildlife habitats all contribute to understanding the ways in which human activities alter the natural environment. The statistics that follow in this chapter describe many of these environmental conditions.

4.1 Urban Air Quality

Air quality in Canada is improving. Average pollutant concentrations in the atmosphere have generally fallen over the past decade. Most of the annual air pollution objectives were within the acceptable limits. However, short term objectives were exceeded in certain localities.

❑❑❑

In Canada, national ambient air quality objectives (NAAQOs) were set by Environment Canada based on recommendations from a Federal-Provincial Advisory Committee on Air Quality. Three levels of NAAQOs have been defined: tolerable, acceptable and desirable. These NAAQOs are based on their potential effects on human health and their impact on the environment. The long term goal of the NAAQOs is to meet the **maximum desirable** level and provide a basis for an anti-degradation policy for the unpolluted parts of the country. The **maximum acceptable** level is intended to provide adequate protection against adverse effects of pollution on humans, animals, vegetation, soil, water, materials and visibility. The **maximum tolerable** level denotes concentrations of air contaminants where immediate action is required to protect human health and the environment. Table 4.1.1 illustrates the potential health effects of selected air pollutants for each NAAQOs level.

The National Air Pollution Surveillance (NAPS) Network was established in 1969 to monitor air pollutants in major urban centres across Canada. There are over 100 monitoring stations located in industrial, commercial and residential areas where air pollution could pose a potential risk to the general population and the environment.

Five common air pollutants are monitored by NAPS. They are: sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and total suspended particulates (TSP).

- **Sulphur dioxide** is a colourless gas with a strong odour. Oil and gas processing, ore smelting and the burning of coal and heavy oil are the major generators of sulphur dioxide. The five year composite average for all cities meets the maximum desirable level (Table 4.1.2 and Figure 4.1.1).
- **Carbon monoxide** is a toxic, colourless and odourless gas generated from burning material containing carbon. Most carbon monoxide is created from running motor vehicles, heating of dwellings and industrial production. The five year composite averages for all cities meet the desirable objective of 5 parts per million (ppm) (Table 4.1.2 and Figure 4.1.2).
- **Nitrogen dioxide** is generated by human activities through high-temperature combustion processes including transportation and industrial fuel combustion. None of the cities' five year composite averages exceeded the annual maximum desirable objective (Table 4.1.2 and Figure 4.1.3).
- Ground level **ozone** monitored by NAPS should not be confused with stratospheric ozone. Ground level ozone is a secondary pollutant created from chemical reaction in the air between volatile organic compounds (VOCs) and nitrogen oxides (NO_x). This reaction occurs when high air temperature and VOCs and NO_x are present in a stagnant air mass. Peak one hour readings are used as an indicator of ozone risk because of the short term exposure effects to humans. As shown in Table 4.1.2, Hamilton has the highest five year composite average, 100 parts per billion (ppb), which is above the acceptable level of 82 ppb followed by Toronto, 93.8 ppb and Montréal, 81.6 ppb (Figure 4.1.4).
- **Suspended particulates** are emitted by natural sources and human activities. Natural source particulates include dust, smoke and pollen, while human activity particulates include combustion by-products and industrial emissions from transportation, mining operations, thermal power generation plants and waste incinerators. Table 4.1.2 shows that Hamilton had the highest five year composite average of 74.9 micrograms per cubic metre, which is above the maximum acceptable level of 70 micrograms per cubic metre. Six cities, including Montréal, Hamilton, Calgary, Vancouver, Toronto and Edmonton, recorded ranges that exceeded the maximum acceptable level for total suspended particulates (Figure 4.1.5).

Table 4.1.1

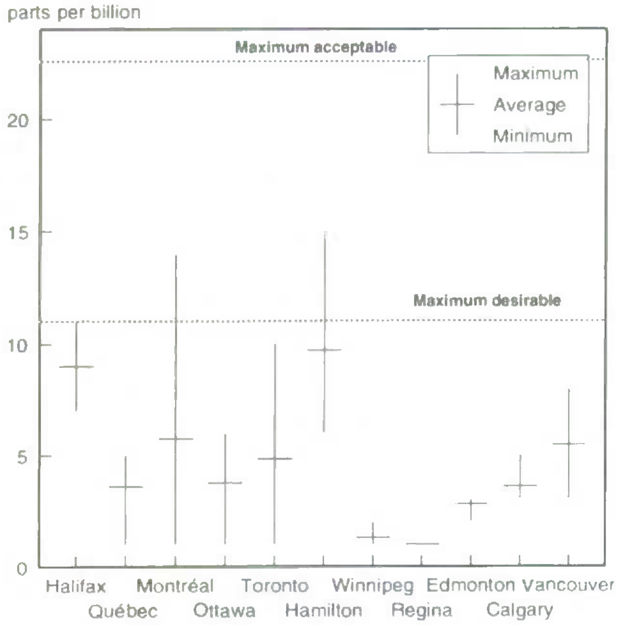
Examples of Types of Effects Used as Break Points[1,2]

National ambient air quality objectives (average time)	Sulphur dioxide (1 hr, 24 hr)	Carbon monoxide[3] (1 hr, 8 hr)	Nitrogen dioxide (1 hr)	Ozone (1 hr)	Suspended particulates[4] (24 hr)
Beyond tolerable (very poor range)	hypersensitive individuals may experience breathing difficulties; increased morbidity	physiological stress on individuals with cardio-vascular and respiratory disease; possibly increase mortality	increasing sensitivity in patients with asthma and bronchitis	impairment of respiratory function; increased respiratory function; increased respiratory symptoms	increasing sensitivity of patients with asthma and bronchitis
Maximum tolerable (Poor range)	increasing sensitivity in patients with asthma and bronchitis; odorous; increasing vegetation damage and sensitivity	increasing cardiovascular symptoms in nonsmokers with heart disease; some visual impairment	increased rate of respiratory illness from long-term exposure; odour and atmospheric discoloration	decreasing performance by some athletes exercising heavily	visibility decreased; soiling evident; increased frequency and severity of lower respiratory
Maximum acceptable (fair range)	increasing (foliar) injury to some species of vegetation	increasing cardiovascular symptoms in smokers with heart disease; blood chemistry changing	no known human health effects	increasing injury to some species of vegetation	decreased visibility
Maximum desirable (good range)	no effects	no effects	no effects	materials are affected by ambient air levels of oxidants	no 24-hour objective of total suspended particulate

Notes:
1. Examples extracted from the National Ambient Air Quality Objectives published from 1974-1978.
2. Health Canada and Environment Canada advise that the matrix is provided as an example only and does not represent the full nature or extent of the health and environmental effects.
3. In order to protect all sensitive groups of the population, ambient concentrations of CO should be such that COHb levels do not exceed 5 percent saturation in nonsmokers.
4. The levels do not apply to chemically-active particles.

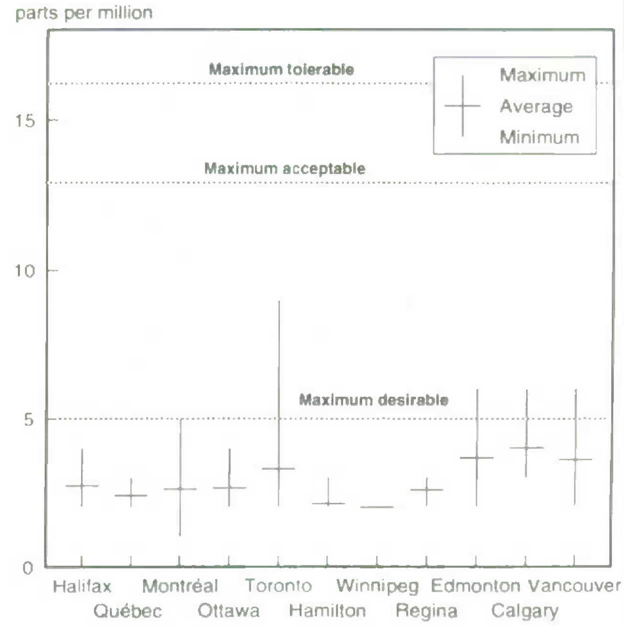
Source:
Environment Canada, Criteria for Air Quality Objectives, by the sub-committee on Air Quality Objectives, report for the Federal/Provincial Committee on Air Pollution, November, 1976.

Figure 4.1.1
Sulphur Dioxide, 1987-1991



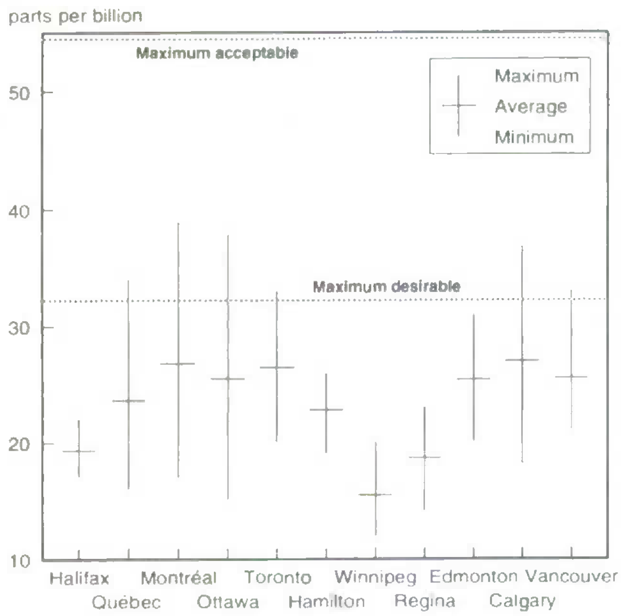
Note:
Five year composite average.
Source:
Environment Canada, Pollution Data Analysis Division, Air Quality Indicators Database, 1993.

Figure 4.1.2
Carbon Monoxide, 1987-1991



Note:
Five year composite average.
Source:
Environment Canada, Pollution Data Analysis Division, Air Quality Indicators Database, 1993.

Figure 4.1.3
Nitrogen Dioxide, 1987-1991



Note:
Five year composite average.
Source:
Environment Canada, Pollution Data Analysis Division, Air Quality Indicators Database, 1993.

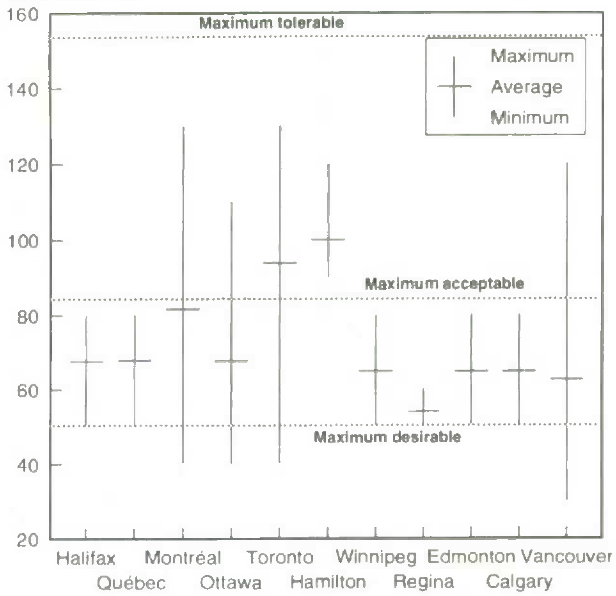
Air Quality Index

One method of making air pollution data more understandable to the general public is to transform the data into an **air quality index** (AQI). Data collected from the NAPS Network Class 1 Monitoring Stations[1] is transformed into an AQI by comparing the concentration for each pollutant to the NAAQOs. The highest sub-index is selected to give the AQI measurement for that recorded hour. If the AQI is in the poor range, the measurement is above the maximum acceptable level.

Table 4.1.3 shows that from 1987 to 1991 the AQI in some industrial centres (Hamilton, Montréal and Toronto) indicated consistently poorer air quality than that in some other cities (St. John's, Halifax, Regina and Winnipeg). Over this period, Hamilton averaged close to 60 percent good air quality and approximately 5 percent poor air quality. High suspended particulate and ozone in Hamilton are the main reasons for the poor AQI rating. Vancouver experienced a similar reduction in good air quality, with recordings of 55.3 percent in 1990 and 69.7 percent in 1991. These abnormal recordings for Vancouver can be attributed to suspended particulate and ozone as a result of the hot, dry weather experienced during those years.

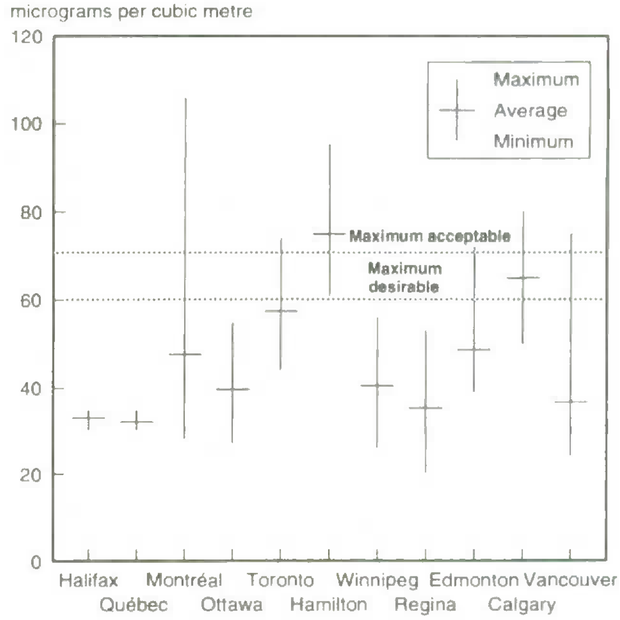
1. NAPS Class 1 Monitoring Stations conduct measurements for all five air pollutants.

Figure 4.1.4
Ozone, 1987-1991



Note:
Five year composite average.
Source:
Environment Canada, Pollution Data Analysis Division, Air Quality Indicators Database, 1993.

Figure 4.1.5
Suspended Particulates, 1987-1991



Note:
Five year composite average.
Source:
Environment Canada, Pollution Data Analysis Division, Air Quality Indicators Database, 1993.

Table 4.1.2
Urban Air Quality for Selected Pollutants, 1987-1991 (5 year composite average[1])

City	Sulphur dioxide (annual[2])			Carbon monoxide (8 hour[3])			Nitrogen dioxide (annual[2])			Ozone (1 hour[4])			Suspended particulates (annual[2])		
	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
	parts per billion			parts per million			parts per billion			parts per billion			micrograms per cubic meter		
Halifax	9.0	7	11	2.8	2	4	19.3	17	22	67.8	50	80	33.0	30	35
Québec	3.6	1	5	2.4	2	3	23.6	16	34	68.0	50	80	32.0	30	35
Montréal	5.8	1	14	2.6	1	5	26.8	17	39	81.6	40	130	47.6	28	106
Ottawa	3.8	1	6	2.7	2	4	25.5	15	38	67.8	40	110	39.7	27	55
Toronto	4.8	1	10	3.3	2	9	26.5	20	33	93.8	40	130	57.4	44	74
Hamilton	9.7	6	15	2.1	2	3	22.8	19	26	100.0	90	120	74.9	61	95
Winnipeg	1.3	1	2	2.0	2	2	15.4	12	20	65.0	50	80	40.5	26	56
Regina	1.0	1	1	2.6	2	3	18.7	14	23	54.0	50	60	35.4	20	53
Edmonton	2.8	2	3	3.7	2	6	25.4	20	31	65.0	50	60	48.7	39	72
Calgary	3.6	3	5	4.0	3	6	27.0	18	37	65.0	50	80	65.0	50	80
Vancouver	5.5	3	8	3.6	2	6	25.5	21	33	62.8	30	120	36.8	24	75
Maximum desirable			**11**			**5**			**32**			**50**			**60**
Maximum acceptable			**23**			**13**			**53**			**82**			**70**
Maximum tolerable			...			**17**			...			**153**			...

Notes:
1. The five year composite average was calculated by averaging all the measurements recorded by stations within each city that had at least four of five years of measurements.
2. Annual measurements were the 98th percentile reading or the 120th highest value for each of the five years.
3. Peak eight hour measurements were the 98th percentile reading or the 120th highest reading for each of the five years.
4. Peak one hour measurements were the 99.9 percentile reading or the 9th highest value for each of the five years.

Source:
Environment Canada, Pollution Data Analysis Division, Air Quality Indicators Database, 1993.

Table 4.1.3

Air Quality Index,[1,2] Selected Cities, 1987-1991

City	1987		1988		1989		1990		1991	
	number of hours	percent	number of hours	percent	number of hours	percent	number of hours	percent	number of hours	percent
St. John's										
Good	8 218	100.0	8 655	99.9	8 547	97.6	8 710	99.6	8 685	99.1
Fair	-	-	8	0.1	184	2.1	39	0.4	75	0.9
Poor	-	-	-	-	29	0.3	-	-	-	-
Total measured	8 218	100.0	8 663	100.0	8 760	100.0	8 749	100.0	8 760	100.0
Halifax										
Good	8 731	100.0	8 552	98.6	8 719	99.5	4 018	99.5	8 059	99.7
Fair	3	..	124	1.4	41	0.5	22	0.5	25	0.3
Poor	-	-	-	-	-	-	-	-	-	-
Total measured	8 734	100.0	8 676	100.0	8 760	100.0	4 040 [3]	100.0	8 084	100.0
Montréal										
Good	7 014	88.6	5 370	65.9	5 433	64.7	6 527	81.6	5 438	68.3
Fair	775	9.8	2 299	28.2	2 366	28.2	1 416	17.7	2 039	25.6
Poor	125	1.6	484	5.9	596	7.1	60	0.7	485	6.1
Total measured	7 914	100.0	8 153	100.0	8 395	100.0	8 003	100.0	7 962	100.0
Québec										
Good	8 449	99.8	8 632	98.7	8 408	98.7	8 431	98.5	8 538	98.7
Fair	20	0.2	111	1.3	109	1.3	129	1.5	112	1.3
Poor	-	-	-	-	-	-	-	-	-	-
Total measured	8 469	100.0	8 743	100.0	8 517	100.0	8 560	100.0	8 650	100.0
Ottawa										
Good	7 982	94.6	7 566	86.3	6 440	73.9	7 223	82.6	7 678	88.5
Fair	457	5.4	1 108	12.6	2 107	24.2	1 362	15.6	967	11.1
Poor	-	-	93	1.1	170	2.0	159	1.8	34	0.4
Total measured	8 439	100.0	8 767	100.0	8 717	100.0	8 744	100.0	8 679	100.0
Toronto										
Good	6 454	74.2	6 524	74.3	6 054	69.1	6 712	76.7	6 789	77.7
Fair	2 095	24.1	2 090	23.8	2 429	27.7	1 994	22.8	1 862	21.3
Poor	151	1.7	163	1.9	277	3.2	40	0.5	89	1.0
Total measured	8 700	100.0	8 777	100.0	8 760	100.0	8 746	100.0	8 740	100.0
Hamilton										
Good	4 316	50.5	5 000	57.0	5 576	63.8	5 740	65.5	4 905	56.1
Fair	3 682	43.1	3 299	37.6	2 903	33.2	2 798	31.9	3 306	37.8
Poor	546	6.4	477	5.4	267	3.1	222	2.5	526	6.0
Total measured	8 544	100.0	8 776	100.0	8 746	100.0	8 760	100.0	8 737	100.0
Winnipeg										
Good	8 654	98.8	8 076	92.1	7 924	90.5	8 705	99.6	8 500	97.0
Fair	106	1.2	687	7.8	823	9.4	39	0.4	260	3.0
Poor	-	-	4	..	7	0.1	-	-	-	-
Total measured	8 760	100.0	8 767	100.0	8 754	100.0	8 744	100.0	8 760	100.0
Regina										
Good	8 737	99.8	8 579	97.7	8 601	98.2	8 669	99.9	8 701	99.7
Fair	21	0.2	204	2.3	152	1.7	6	0.1	23	0.3
Poor	-	-	1	..	5	0.1	-	-	-	-
Total measured	8 758	100.0	8 784	100.0	8 758	100.0	8 675	100.0	8 724	100.0
Edmonton										
Good	6 947	79.3	7 553	86.6	7 908	90.3	7 934	90.6	7 042	80.4
Fair	1 707	19.5	1 091	12.5	803	9.2	799	9.1	1 650	18.8
Poor	106	1.2	74	0.8	49	0.6	27	0.3	68	0.8
Total measured	8 760	100.0	8 718	100.0	8 760	100.0	8 760	100.0	8 760	100.0
Calgary										
Good	7 322	83.6	7 742	88.1	8 130	92.8	8 484	96.8	8 314	94.9
Fair	1 402	16.0	969	11.0	623	7.1	267	3.0	401	4.6
Poor	36	0.4	73	0.8	7	0.1	9	0.1	45	0.5
Total measured	8 760	100.0	8 784	100.0	8 760	100.0	8 760	100.0	8 760	100.0
Vancouver										
Good	7 908	90.3	7 979	90.8	7 452	85.1	4 779	55.3	6 110	69.7
Fair	848	9.7	783	8.9	1 173	13.4	3 552	41.1	2 305	26.3
Poor	4	..	22	0.3	134	1.5	315	3.6	345	3.9
Total measured	8 760	100.0	8 784	100.0	8 759	100.0	8 646	100.0	8 760	100.0

Notes:
Figures may not add due to rounding.
1. Air quality index numbers were taken from one representative class 1 NAPS monitoring station.
2. Air quality index derived using 24 hour running average for coefficient of haze.
3. NAPS station closed for half the year.

Source:
Environment Canada, Pollution Data Analysis Division, Air Quality Indicators Database, 1993.

4.2 Water Quality

> "Few things are as insidious as bad water. It's dangerous for you and your children, but you usually can't tell if you have it. And if you do, you may not be able to find out where the problems are coming from. Water can carry some of our most serious diseases - typhoid, dysentery, hepatitis - yet still look clear in the glass. We may do battle over how we get our water and develop it, but we fear for its quality."[1]

The assessment of water quality is much more difficult than determining the quantities available (see Section 4.15 - **Water Supply and Use**). This is largely due to the number of physical, biological and chemical variables that need to be analysed when measuring water quality. To date, no exhaustive studies have been conducted regarding the overall quality of Canada's water supply, although many studies have been carried out pertaining to particular water bodies.

Even in its natural state, various polluting substances accumulate in water, including heavy metals and organic compounds. Water bodies have historically provided mankind with a convenient means of disposal for urban and industrial wastes. The disposal of wastes from human activities has introduced thousands of new synthetic pollutants into the water supply.

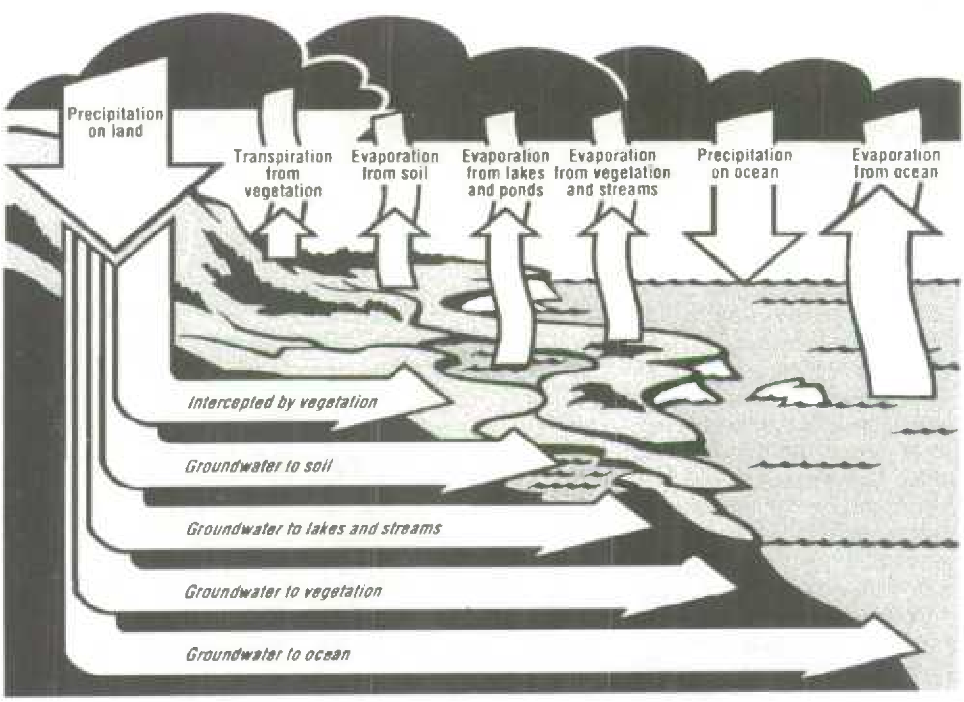
Although the quality of Canadian water remains relatively high, problems have surfaced in the industrial, agricultural and mining regions of the country. One result has been the pollution of large water bodies such as the Great Lakes, where over 360 chemical pollutants have been identified. Many of these substances are dangerous to human health and are contributing to the destruction of the aquatic ecosystems of the Great Lakes.[2] Canada's most pressing water quality problems today are not a result of naturally occurring substances, but rather are the result of human produced synthetic compounds.

Water circulates between the earth's surface and the atmosphere in a process termed the *hydrologic cycle*. Figure 4.2.1 shows the major components of this process.

1. Parfit, M., "Troubled Waters Run Deep", *National Geographic Special Edition on Water*, November 1993, p. 78-89.

2. Government of Canada, *Toxic Chemicals in the Great Lakes and Associated Effects*, Ottawa, 1991.

Figure 4.2.1
The Hydrologic Cycle



Source:
Government of Canada, *The State of Canada's Environment*, Ottawa, 1991. Adapted from Pearse *et al. Inquiry on Federal Water Policy - Final Report*, Ottawa, 1985.

Fresh Water Quality

All economic activity uses fresh water in some way, whether as a coolant, a power source, for drinking or for irrigation. A distinction between consumptive and non-consumptive uses is frequently made. However, even if the same amount of water is returned to its source after withdrawal, chances are that the water has been altered in some way. Very few human activities are non-consumptive. Ecosystem health depends on the water withdrawn being returned in its original state, not just in the same amount.

Much the same argument can be made regarding point sources and non-point sources of pollution.[1] Overall ecosystem health is not dependent on whether pollutants originate via point sources versus non-point sources. However, the distinction between these sources of pollution can be important from a water management point of view.[2]

Municipal Use

More than 10 percent of all water withdrawn in Canada is for municipal use (see Section 4.15 - **Water Supply and Use**, Table 4.15.1). Municipal water use is fast becoming one of the most critical water issues in Canada.[3]

Municipal wastewater treatment facilities not only serve households, but also commercial and some industrial requirements. These treatment facilities introduce contaminants (BOD and TSS loadings)[4] into the water system, which contribute to the excess growth of algae in rivers and lakes. This process, known as eutrophication,[5] results in the depletion of dissolved oxygen required for the survival of aquatic life.

Wastewater treatment facilities provide up to three levels of waste cleansing, including:

- *primary* treatment - removes insoluble matter;
- *secondary* treatment - removes biological impurities from water treated at the primary level;
- *tertiary* treatment - removes remaining nutrient content and chemical contaminants after secondary treatment.

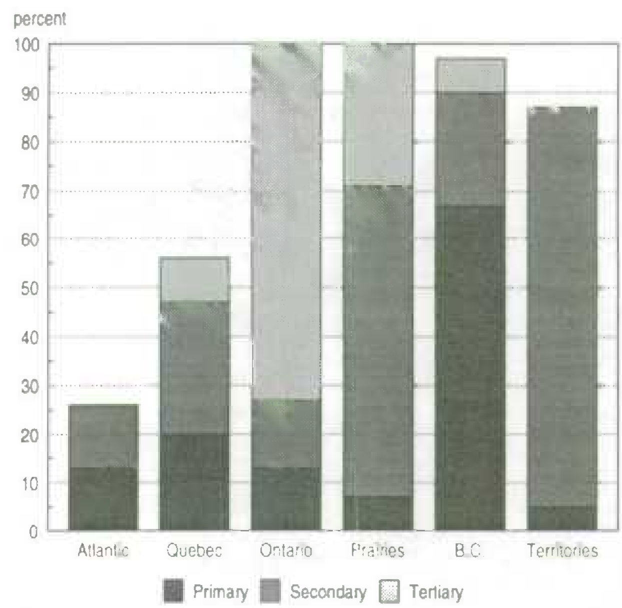
1. A point source of pollution refers to effluents discharged directly into the aquatic ecosystem. Non-point sources refer to more indirect sources of pollution such as urban and agricultural runoff or air deposition.
2. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
3. Environment Canada, *Urban Water - Municipal Water Use and waste Water Treatment*, SOE Report No. 94-1, State of the Environment Reporting, Ottawa, 1994.
4. Biochemical oxygen demand (BOD) is caused by organic decomposition resulting in oxygen depletion in water while total suspended solids (TSS) include suspended particles of non-biodegradable materials, sand, grit and fecal matter.
5. For a complete definition of eutrophication see Section 3.9. - **Agricultural Impacts on Land.**

Water treatment levels vary considerably across Canada. The quality of the wastewater returned to its source is dependent on the level of treatment applied. As shown in Figure 4.2.2, Ontario and the Prairie provinces have more secondary and tertiary treatment facilities when compared to the remaining regions of Canada. Table 4.2.1 shows that in 1991, 16 percent of the Canadian population with sewers had no treatment applied to their wastewater. Overall, 75 percent of Canadians are served by municipal sewage collection systems (the remaining 25 percent rely on septic systems). As shown in Table 4.2.2, of the 75 percent of Canadians serviced by municipal wastewater systems in 1983, 72 percent had some level of treatment applied to their wastewater - this rose to 84 percent in 1991. For the remaining 16 percent in 1991, their wastewater was released directly into receiving waters with no treatment applied.

Given the level of municipal wastewater treatment it is possible to estimate BOD, TSS and phosphorous discharges to water.[6] As shown in Table 4.2.3, despite the increase in water treatment levels, phosphorous discharges have increased since 1983.[7]

6. Environment Canada, *A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Report No. 91-1, State of the Environment Reporting, Ottawa, 1991.
7. Insufficient national data exist to determine if this increase is suggestive of a longer-term trend.

Figure 4.2.2
Municipal Wastewater Treatment by Region, 1991



Note:
Environment Canada's MUD database includes data on water use and wastewater treatment in 1 500 municipalities that have a population over 1 000.
Source:
Environment Canada, Municipal Water Use Database (MUD).

Table 4.2.1
Municipal Wastewater Treatment by Region, 1991

Region	Population with Sewers	Treatment type: None		Primary		Secondary		Tertiary	
	persons	persons	percent	persons	percent	persons	percent	persons	percent
Atlantic Provinces	1 193 270	879 156	74	154 302	13	158 210	13	1 600	-
Quebec	5 258 600	2 290 150	44	1 069 600	20	1 424 160	27	474 699	9
Ontario	8 050 290	2 526	-	1 059 260	13	1 098 590	14	5 889 920	73
Prairie Provinces	3 459 920	-	-	242 813	7	2 230 400	64	986 825	29
British Columbia	2 465 250	70 347	3	1 657 810	67	569 554	23	167 540	7
Territories	51 050	6 724	13	2 366	5	41 960	82	-	-
Canada	**20 478 400**	**3 248 900**	**16**	**4 186 150**	**20**	**5 522 870**	**27**	**7 520 580**	**37**

Note:
Figures may not add due to rounding.
Source:
Environment Canada, Municipal Water Use Database (MUD).

Table 4.2.2
Municipal Wastewater Treatment, 1983-1991

Treatment type	1983		1986		1989		1991	
	persons	percent	persons	percent	persons	percent	persons	percent
Primary treatment	2 897 954	16	2 814 708	15	3 950 312	20	4 186 145	20
Secondary treatment	5 118 124	28	4 875 956	26	5 546 447	28	5 522 865	27
Tertiary treatment	5 046 068	28	5 819 451	31	6 245 464	32	7 520 582	37
Total treatment	13 062 146	72	13 510 115	72	15 742 223	80	17 229 592	84
No treatment	5 169 852	28	5 190 319	28	3 760 337	19	3 248 781	16
Total	**18 231 998**	**100**	**18 700 434**	**100**	**19 502 560**	**100**	**20 478 373**	**100**

Note:
Figures may not add due to rounding.
Source:
Environment Canada, Municipal Water Use Database (MUD).

Table 4.2.3
Municipal Discharges[1] of BOD, TSS and Phosphorous to Fresh Water, 1983-1989

Year	BOD		TSS		Phosphorous	
	kg/day	index	kg/day	index	kg/day	index
1983	1 064 499	100.0	859 977	100.0	44 955	100.0
1986	1 099 583	103.3	892 612	103.8	47 021	104.6
1989	1 112 837	104.5	855 312	99.5	48 903	108.8

Note:
1. Municipal discharges are calculated from communities with populations greater than 1 000.
Source:
Environment Canada, *Technical Supplement to A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Technical Report Series No. 20, State of the Environment Reporting, Ottawa, 1991.

In general, the lower the level of wastewater treatment, the greater the BOD in the resulting effluent and the more oxygen is likely depleted in the receiving water body. Secondary and tertiary water treatment further reduce BOD and bacteria in the wastewater. However, the ability of any of these processes to remove toxic substances has yet to be proven.[1]

Drinking Water

Many Canadians are becoming increasingly concerned about the quality of their drinking water.[2] In 1990, Health Canada conducted a national water survey of various water treatment facilities across the country. The drinking water supplies of 39 percent of the Canadian population were tested for such substances as fluoride, chloride, nitrate, sulphate and aluminum (Table 4.2.4).

For many years fluoride has been added to drinking water supplies (where natural levels of fluoride are low) to combat dental cavities. Approximately 50 percent of the treatment facilities surveyed added fluoride to their drinking water[3].

Table 4.2.4 also shows that water treatment is quite successful in removing nitrates from the water supply. Much of the nitrates found in the water supply are the result of agriculture practices (manure and fertilizers) and human waste.

Aluminum sulphate is often added to water supplies during the water treatment process in order to remove suspended particulate matter before filtration. It is also used in the pulp and paper industry. It has been suggested that aluminum may be linked to health issues, including Alzheimers Disease and anemia.[4]

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
2. Ibid.
3. Meranger, J.C. and B. Lo, *Selected Anions and Trace Elements in Canadian Drinking Water Supplies*, paper presented before the Division of Environmental Chemistry, American Chemical Society, Washington, D.C., August 23, 1992.
4. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Table 4.2.4

Average Concentrations of Selected Compounds in Drinking Water Supplies, 1990

Province/Territory	Fluoride[1]			Chloride[2]			Nitrate[3]			Sulphate[4]			Aluminum[5]		
	Raw	Treated	Dist.[6]	Raw	Treated	Dist.	Raw	Treated	Dist.	Raw	Treated	Dist.	Raw	Treated	Dist.
	mg per litre														
Newfoundland	0.10	0.77	0.71	2.98	6.15	6.16	0.27	0.30	0.26	1.89	1.88	1.89	0.18	0.11	0.12
Prince Edward Island	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New Brunswick	0.10	0.19	0.28	10.40	12.50	12.40	2.32	0.53	0.49	6.52	12.60	12.50	0.10	0.13	0.16
Nova Scotia	0.10	0.79	0.82	7.63	10.40	11.00	0.25	0.27	0.33	7.08	11.70	11.40	0.10	0.18	0.16
Quebec	0.10	0.19	0.17	15.10	17.60	20.50	2.10	2.01	2.22	14.60	25.40	25.60	0.23	0.12	0.11
Ontario	0.11	0.50	0.55	17.60	21.00	21.10	1.94	1.71	1.65	22.90	28.80	29.10	0.13	0.19	0.17
Manitoba	0.18	0.84	0.81	33.00	33.50	34.10	1.29	0.71	0.65	67.70	73.10	72.50	0.21	0.33	0.12
Saskatchewan	0.30	1.01	0.78	7.94	10.60	10.70	3.27	1.59	1.42	154.00	171.00	172.00	0.17	0.42	0.43
Alberta	0.18	0.85	0.85	11.80	14.70	14.30	2.89	1.41	1.87	52.70	69.90	69.30	0.45	0.21	0.23
British Columbia	0.24	0.50	0.50	1.96	2.81	2.81	0.78	0.84	0.80	8.78	8.79	8.71	0.18	0.17	0.13
Yukon	0.10	0.52	0.60	1.12	1.30	1.49	0.10	0.17	0.10	27.70	27.30	27.70	0.20	0.67	0.26
Northwest Territories	0.10	0.65	0.68	1.97	3.48	3.31	0.10	0.18	0.10	3.08	3.08	3.11	0.17	0.12	0.01

Notes:

1. The Canadian Guideline Value, or M.A.C. (maximum acceptable concentration) for fluoride is 1.5 mg/l.
2. M.A.C. for chloride is 250 mg/l.
3. M.A.C. for nitrate is 45 mg/l.
4. M.A.C. for sulphate is 500 mg/l.
5. There is no Canadian Guideline Value for aluminum. The EEC Standard is 0.2 mg/l.
6. Water distributed by water supply system.

Source:

Health Canada, Environment Health Directorate, unpublished data.

Industrial Use

Industrial waste discharges are a major source of many persistent substances that are contaminating the aquatic environment. Industrial processes generate pollutants such as heavy metals, cyanides, mercury and various chlorinated organic compounds including PAHs[1] and PCBs,[2] that are more difficult to treat than those found in regular municipal wastewater.

Mining Industry

The mining industry produces many pollutants that have detrimental effects on water quality. These include heavy metals, petroleum products, arsenic, acids and suspended solids. Mining, even though as an industry it ranks low in terms of withdrawal (see Section 4.15 - **Water Supply and Use**, Table 4.15.1), reuses water many times. The wastewater generated is then held in tailing ponds where seepage into surrounding water bodies (both surface and groundwater) is sometimes a problem.

Petroleum Refining

Since 1972 the Canadian petroleum industry has significantly reduced its discharges of liquid wastes (Table 4.2.5). This reduction is partly attributable to effluent guidelines instituted by the 1973 federal Fisheries Act.

1. PAHs (polycyclic aromatic hydrocarbons) are carcinogenic compounds released into the environment from atmospheric emissions (especially the burning of fossil fuels). Sources include: coke ovens, thermal power plants, sewage, wood smoke, used oil.
2. PCBs (polychlorinated biphenyls) are a group of toxic aromatic compounds containing two benzene molecules in which hydrogens have been replaced by chlorine atoms. Formed as waste in industrial processes.

Table 4.2.5

Net Discharges[1] of Liquid Waste by the Petroleum Industry, 1972-1987

Parameter	Year					
	1972	1975	1977	1980	1983	1987
	kg per day					
Total suspended solids	20 900	15 900	15 900	7 175	5 154	4 039
Oil and grease	8 300	9 000	6 000	2 980	1 923	1 080
Ammonia nitrogen	10 900	6 700	3 500	1 533	1 205	726
Phenols	1 800	900	900	200	97	77
Sulphide	4 600	3 400	900	50	63	21

Note:

1. Net loadings represent annual average.

Sources:

Environment Canada, Environment Protection Industrial Programs Branch.

Environment Canada, *Technical Supplement to A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Technical Report Series No. 20, State of the Environment Reporting, Ottawa, 1991.

Pulp and paper industry

The pulp and paper industry is the focus of considerable attention due to its environmental impact, primarily in regard to water quality. In 1987, only the chemical industry (a major supplier to the pulp and paper industry) and the mining industry were rated as high as the pulp and paper industry amongst polluting industries.[3] The pulp and paper industry has, however, made substantial environmental improvements over the last 20 years. TSS and BOD discharges decreased by 62 percent and 45 percent, respectively, between 1970 and 1987. Over the same period, production increased by 47 percent (Table 4.2.6).

3. Sinclair, William F., *Controlling Pollution from Canadian Pulp and Paper Manufacturers: A Federal Perspective*, Environment Canada, Ottawa, 1990.

Table 4.2.6

Pulp and Paper Mill Discharges to Fresh Water, 1970-1989

Year	BOD	TSS	Production
	kg per day		
1970	2 417 025	1 422 755	36 905 000
1978	2 086 220	909 826	44 563 000
1982	1 714 851	1 211 604	46 383 000
1985	1 440 493	543 056	50 736 000
1987	1 323 557	541 404	54 325 000
1989	1 216 614	469 342	..

Source:
Environment Canada, *Technical Supplement to A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Technical Report Series No. 20, State of the Environment Reporting, Ottawa, 1991.

Mills that use elemental chlorine for bleaching have also been identified as a significant source of dioxins and furans, which are discharged in the mills wastewater. Environment Canada considers these substances to be highly toxic.[1]

In Canada, pulp and paper mills utilize treatment processes for traditional pollutants. Primary treatment removes from 80 to 90 percent of the settleable portion of the suspended solids, usually by means of gravity clarifiers or settling basins. Secondary treatment is used to remove BOD associated with the dissolved organic materials in the effluent, and normally uses a biological process. In Canada, aerated lagoons are most often used for secondary treatment. This process can reduce the BOD by 70 percent to 95 percent and render the effluent non-toxic to fish. Although these facilities do reduce toxicity, they are not effective in eliminating dioxins and furans.[2]

Table 4.2.7 shows that only 13 percent of Quebec mills had secondary treatment facilities in 1989 and the BOD factors were highest in this province. Similarly, mills located in the Prairie provinces had the lowest average BOD emissions and the highest incidence of secondary treatment. The inverse relationship between BOD emission and the incidence of secondary treatment is not perfect, however, as shown by British Columbia where the BOD emission is almost the same as the Canadian average and more than half the mills have secondary treatment facilities.

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
2. Statistics Canada, "Pulp and Paper Industry Compliance Costs", *Environmental Perspectives 1993*, Catalogue No. 11-528E, Ottawa, 1993.

Electric Power

Temperature is a very important element of water quality. Most aquatic life is adapted to tolerate yearly fluctuations in water temperatures. The discharge of warm water from by thermal electric power generating stations can upset the natural thermal regime of the receiving water body. Elevated water temperatures also cause increased evaporation. Fluctuations in the temperature regime of a receiving water body can kill temperature-sensitive organisms. Thermal pollution also tends to exacerbate the effects of toxic substances.[3] It creates ecological imbalances by encouraging the propagation of some species of aquatic life and decimating others.

Hydroelectric power generation is often promoted as an environmentally friendly source of power. However, mounting concerns over the past few years are focusing on the impacts dams have on terrestrial and aquatic ecosystems. Loss of land and land-based resources; wildlife and fish habitat destruction; conversion of wild rivers into regulated water bodies and change in the downstream river condition are all effects of hydroelectric development.

Associated water quality issues include the sedimentation of newly eroded material in the reservoir, and most importantly, the mercury methylation process induced by the flooding of organic matter (Technical Box 4.2.1). The latter resulted in a four-to-sixfold increase in mercury concentrations in fish within reservoirs at Phase I of Quebec's La Grande hydroelectric project.[4]

3. Pearse, P.H., F. Bertrand and J.W. MacLaren, *Currents of Change - Inquiry on Federal Water Policy - Final Report*, Ottawa, 1985.
4. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Table 4.2.7

Attributes of Pulp and Paper Mills[1] by Region, 1989

Region[2]	Mills	Mills with treatment facilities: Primary	Mills with treatment facilities: Secondary	Effluent: TSS	Effluent: BOD	Effluent: TSS	Effluent: BOD
	number	percent		kg per tonne per mill		thousand tonnes per day (all mills)	
Atlantic Provinces	19	81	24	13.6	24.5	118	215
Quebec	49	82	13	11.9	28.5	220	888
Ontario	27	96	27	4.6	19.1	75	304
Prairie Provinces	6	100	85	27.9	12.2	88	39
British Columbia	23	81	52	12.6	21.9	234	383
Canada	**124**	**84**	**30**	**11.4**	**23.9**	**735**	**1 829**

Notes:
1. The mills listed here discharge directly into waterbodies and not into municipal sewage systems.
2. There are no mills in the Territories.

Source:
Statistics Canada, "Pulp and Paper Industry Compliance Costs", *Environmental Perspectives 1993*, Catalogue No. 11-528, Ottawa, 1993.

Technical Box 4.2.1

Methylation - A Downside to Damming

The construction of dams for year-round hydroelectricity causes large scale changes to terrestrial and aquatic ecosystems. Flooding of organic matter (plants, tree and soils) can result in a lack of dissolved oxygen in the water. A series of biochemical reactions are induced by the absence of dissolved oxygen at the sediment-water interface, one of which is the methylation of naturally occurring inorganic mercury (by microbes that thrive in the presence of drowned organic matter) into biologically available, toxic methylmercury compounds, resulting in its subsequent incorporation into the aquatic food web.

Agriculture

Agricultural practices affect water quality through the use of irrigation for water supply, through cropping practices that may contribute to erosion and runoff, and through the application of fertilizers and pesticides. Chemical fertilizers can easily dissolve in water and find their way into groundwater and surface water supplies through percolation and surface runoff. Pesticides also reach the water supply through a variety of pathways. In Canada, 243 ingredients in over a thousand products are used in the application of pesticides to agricultural crops.[1]

Table 4.2.8 presents maximum concentrations of pesticides, as a percentage of the guideline value (for the protection of aquatic life), observed at four Canadian rivers. These rivers were chosen since they represent locations where pesticide use in Canada is the highest.[2] As shown, neither 2,4-D (a herbicide) nor lindane (an insecticide) exceeds its guideline. However, atrazine (a herbicide) exceeds its guideline in the two Ontario rivers listed, which could indicate adverse effects on aquatic life.

Irrigation channels act as an outlet for surface runoff and soil erosion from fields, carrying fertilizers and pesticides, salts and sulphates to the originating water source. It has been demonstrated in the South Saskatchewan River basin and in the Bow and Oldman rivers, that water returning from irrigation channels has concentrations of total dissolved solids up to double what they were before irrigation. Severe sedimentation in streams and rivers creates heavy oxygen demand. This adversely affects the originating rivers aquatic environment by lowering the overall quality of the river's water.[3] In Canada, the majority of irrigation takes place in the Western provinces, especially Alberta at 52 percent of all Canadian irrigation in 1970, increasing to 64 percent in 1990. Figure 4.2.3 illustrates the regional breakdown of irrigated land across Canada. Total irrigated land in Canada increased by over 70 percent from 1970 to 1990.

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
2. Environment Canada, *A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Report No. 91-1, State of the Environment Reporting, Ottawa, 1991.
3. Ibid.

Table 4.2.8

Maximum Observed Concentrations of Pesticides, Selected Rivers, 1978-1988

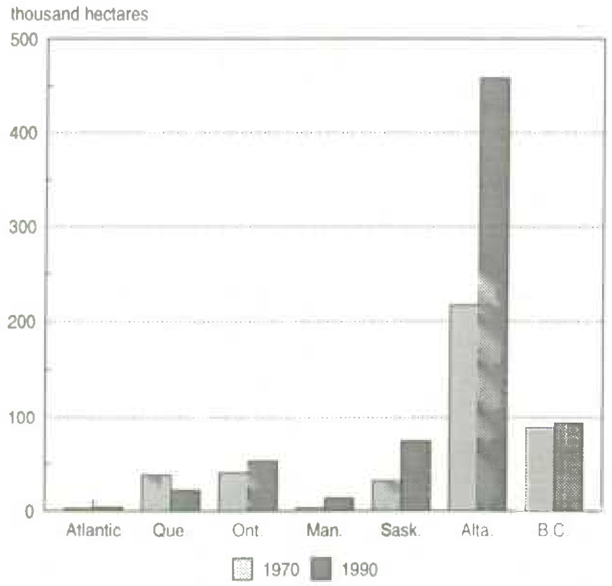
	Bow River, Alta.[1]			Qu'Appelle River, Sask./Man.[2]			Thames River, Ont.[3]			Grand River, Ont.[3]		
Year	2,4-D[4]	Atrazine[4]	Lindane[4]	2,4-D	Atrazine	Lindane	2,4-D	Atrazine	Lindane	2,4-D	Atrazine	Lindane
	percent of guideline											
1978	40	..	15.00	50	..	3.50	..	..	..	..	..	..
1979	..	..	1.25	30	..	10.00	..	..	..	..	..	..
1980	10	..	5.00	10	..	2.50	..	..	..	..	..	..
1981	10	..	1.00	40	..	1.00	..	130	17.50	..	40	9.25
1982	50	..	5.00	..	..	1.00	..	125	15.50	..	65	9.00
1983	20	..	2.00	10	..	2.00	..	170	7.50	..	130	5.75
1984	30	..	0.85	20	..	0.20	..	270	12.50	..	70	0.25
1985	40	..	3.00	30	..	3.25	..	130	12.50	..	80	0.00
1986	30	..	3.50	30	..	17.10	..	..	..	..	..	..
1987	..	..	..	30	..	2.00	..	..	..	..	..	..
1988	..	..	..	30	..	0.00	..	..	..	..	..	..

Notes:
2,4-D = 4.0 micrograms per litre of water.
Atrazine = 2.0 micrograms per litre of water.
Lindane = 10.0 nanograms per litre of water.
Micrograms = 10^{-6} grams.
Nanograms = 10^{-9} grams.
1. Samples collected monthly, 300 km downstream of Calgary.
2. Samples collected quarterly near the Saskatchewan-Manitoba border.
3. Samples collected weekly or biweekly near the mouth of the river.
4. Canadian Water Quality Guidelines for the Protection of Aquatic Life.

Source:
Environment Canada, *Technical Supplement to A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Technical Report Series No. 20, State of the Environment Reporting, Ottawa, 1991.

Irrigation and other diversion projects are coming under increased scrutiny as previously unconnected water bodies are threatened by foreign fish species and parasites that may reach them through a system of interconnected channels.

Figure 4.2.3
Area of Land Irrigated by Region, 1970 and 1990



Source:
Statistics Canada, Agriculture Division.

Groundwater

Groundwater is an important renewable resource and is the sole source of water for six million Canadians. Because it is renewable, it is easy to take groundwater for granted. However, the contamination of groundwater by industrial, agricultural and domestic activities is already a serious problem in Canada. It can be quite costly or even impossible to clean up or find an alternative water supply when a groundwater source becomes contaminated.

Water accumulates underground in areas called aquifers. Groundwater moves slowly through these aquifers and eventually reaches the surface in springs, rivers or lakes. It can take between a few weeks and many thousands of years for an aquifer to be completely emptied and refilled. The replenishment of an aquifer generally occurs in the spring when the snow melts, or after a heavy rainfall. The process of the emptying and refilling of an aquifer is referred to as the recharge period. Figure 4.2.4 illustrates the groundwater cycle.

In general, groundwater is safer for consumption than surface water because it is naturally filtered and has minimal bacterial activity. This natural purification process is hampered by household, commercial and industrial wastes that are not filtered out by soil and clay. These waste products are eventually deposited in aquifers where they contaminate the groundwater. The extent of contamination is difficult to assess because groundwater is not readily visible or accessible. Identifying the source of potential groundwater contaminants (Technical Box 4.2.2), is one way of determining areas where the quality of groundwater may be compromised. Once polluted, groundwater contamination may go undetected until surface water is affected.

A sample of groundwater contamination in Canada is summarized by source of contaminant in Table 4.2.9.

Sixty percent of the instances of groundwater contamination examined involve cases where water was polluted by runoff from landfill sites, industrial waste sites, septic systems, wastes injected into deep wells and mine wastes. Over 20 percent of the cases involved aquifer contamination resulting from industrial operations, (including seepage from underground storage tanks, such as petroleum tanks, spills and above ground materials storage).

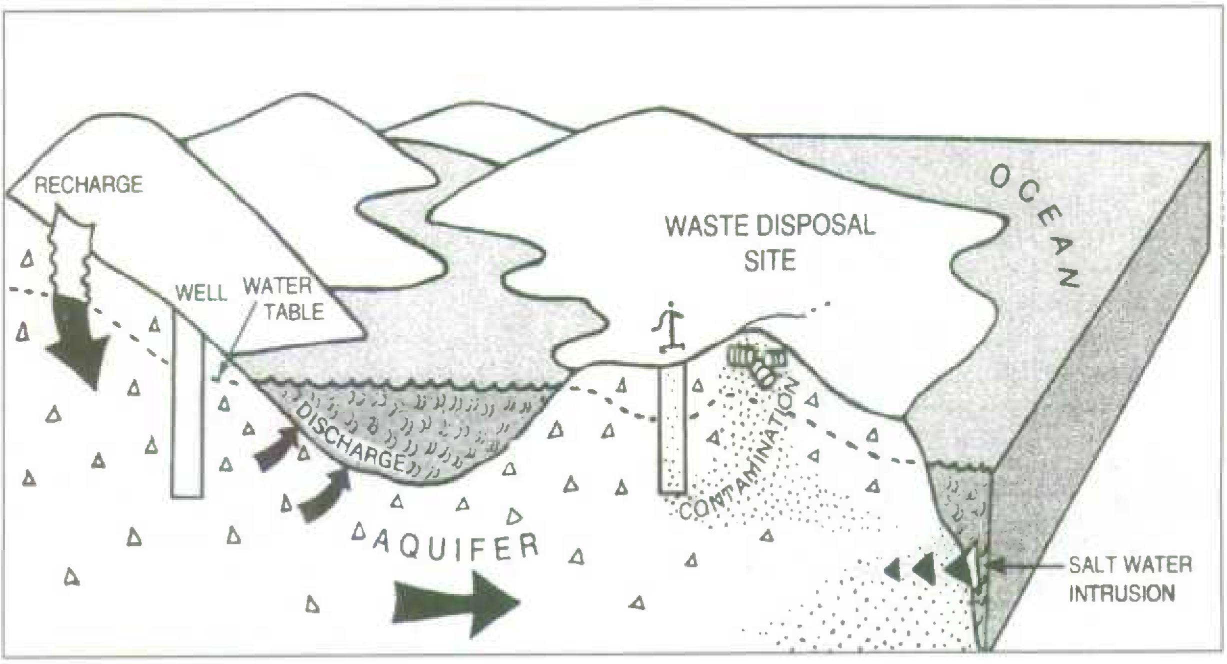
Widespread use of fertilizers and pesticides in agricultural activities also has the potential to affect groundwater. Nitrogen from fertilizer application is likely responsible for widespread nitrate contamination of shallow groundwater. Pesticides are also a concern. The results of a survey of 315

Technical Box 4.2.2
Potential sources of groundwater contamination.

Point sources
On-site septic systems
Leaky tanks or pipelines containing petroleum products
Leaks or spills of industrial chemicals at manufacturing facilities
Municipal landfills
Livestock wastes
Leaky sewer lines
Chemicals used at wood preservation facilities
Mill tailing in mining areas
Fly ash from coal-fired power plants
Landfarms and sludge disposal areas at petroleum refineries
Land spreading of sewage or sewage sludge
Graveyards
Road-salt storage areas
Wells for disposal of liquid wastes
Runoff of salt and other chemicals from roads and highways
Spills related to highway or railway accidents
Coal tar at old coal gasification sites
Ashphalt production and equipment cleaning sites
Distributed (non-point) sources
Fertilizers on agricultural land
Pesticides on agricultural land and forests
Contaminants in rain, snow, and dry atmospheric fallout

Source:
Cherry, John A. Groundwater Occurrence and Contamination in Canada, in M.C. Healey and R.R. Wallace eds., *Canadian Aquatic Resources*, Ottawa, 1987.

Figure 4.2.4
The Groundwater Cycle



Source:
Environment Canada, *A Primer on Water*, Ottawa, 1990.

private wells in Ontario showed 7 percent had detectable concentrations of alachlor, a major pesticide. Of these wells containing alachlor, 40 percent had concentrations that were targeted for action. Two municipal wells were also affected. Road salt, sea water intrusion, and the improper abandonment or improper maintenance of wells are some of the problems encompassed by the management conflicts category (Table 4.2.9).

Table 4.2.9
Categories of Groundwater Contamination, Selected Sites, 1986

Province/Territory	Waste	Industrial operations	Agricultural activity	Management conflicts	Total
Newfoundland	7	8	2	-	18
Prince Edward Island	9	-	-	-	9
Nova Scotia	1	1	-	-	1
New Brunswick	3	2	5	-	5
Quebec	46	11	3	8	70
Ontario	17	-	3	1	21
Manitoba	4	5	1	2	14
Saskatchewan	11	6	-	2	20
Alberta	2	3	2	2	9
British Columbia	3	2	-	2	7
Yukon and N.W.T.	1	-	-	-	1
Canada	**104**	**38**	**16**	**17**	**175**

Source:
Beak Consultants Limited, *Groundwater Contamination in Canada: Selected Cases, Potential Sources and Protection Strategy*, Environment Canada, Ottawa, 1986.

The 175 cases of groundwater contamination presented in Table 4.2.9 present only a sample of groundwater contamination in Canada. The total extent of groundwater contamination is unknown and there is no central source of information on contaminated wells.

Marine Water Quality

Canada's 244 000 km coastline is the longest in the world. The Atlantic, Pacific and Arctic oceans all border on Canada, providing important transportation routes, vital sources of energy and marine resources, as well as recreational and natural wildlife areas.

Although oceans have a tremendous capacity to dilute and neutralize wastes discharged into them, pollution in coastal zones can reach harmful levels. Coastal sources of pollution include discharges from industrial and oil and gas facilities, runoff from agricultural and urban areas, ocean dumping and municipal wastewater discharges. Along both the Pacific and Atlantic coasts these sources are contributing to the increasing pollution of our coastal zones. Table 4.2.10 lists the potential effects of various human activities on the marine environment.

Table 4.2.10

Potential Effects on the Marine Environment of Various Activities and Sources of Contamination

Activity or source of contamination	Bacterial/viral contamination	Oxygen depletion	Toxicity	Bio-accumulation[1]	Habitat degradation	Depletion of biota	Degradation of aesthetic values
Exploration/exploitation of oil and gas reserves		X	X	X	X	X	X
Ocean dumping	X	X	X	X	X	X	
Coastal development	X				X	X	X
Discharges of municipal wastewater	X	X		X	X	X	X
Discharges from pulp and paper mills	X	X	X	X	X	X	X
Food and beverage processing		X			X		X
Oil refineries			X	X			X
Chlor-alkali plants			X	X			
Mining wastes			X	X	X	X	X
Chemical spills and leaks		X	X	X			X
Urban and agricultural runoff	X	X	X	X	X		
Litter					X	X	X
Agriculture	X	X	X	X	X		X
Pesticides			X	X			
Atmospheric emissions	X		X	X			

Note:
1. Term describing a process by which chemical substances are ingested and retained by organisms.
Source:
Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Municipal Pollutants

Municipal wastewater discharges are a major source of pollution in marine and coastal environments. Bacteria originating in municipal wastewater have been implicated in the closure of numerous beaches and many shellfish areas along both the Atlantic and Pacific coasts.[1] As of 1989, 38 percent of all municipal wastewater discharged by coastal communities of 1 000 or more was not treated in any way. Primary treatment, accounted for 47 percent, with secondary treatment at 15 percent, and tertiary accounting for less than 1 percent.[2]

Between 1983 and 1989, BOD and TSS loadings increased on the Pacific coast owing to increasing population and industrial activity. As shown in Table 4.2.11, the BOD and TSS loadings for the Atlantic coast remained constant during this period.[3]

Table 4.2.11

Municipal Discharges[1] of BOD and TSS to Coastal Waters, 1983-1989

Year	Atlantic coast		Pacific coast	
	BOD	TSS	BOD	TSS
	kg per day			
1983	139 348	122 468	173 168	93 394
1986	142 189	124 711	190 597	108 171
1989	142 657	124 873	227 122	122 553

Note:
1. Municipal discharges are calculated from communities with populations greater than 1 000.
Source:
Environment Canada, *Technical Supplement to A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Technical Report Series No. 20, State of the Environment Reporting, Ottawa, 1991.

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991
2. Environment Canada, *A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Report No. 91-1, State of the Environment Reporting, Ottawa, 1991.
3. Ibid.

Industrial Pollutants

Coastal-based industries, including pulp and paper mills, mines and smelting plants, all release various pollutants into the marine environment. These discharges include BOD and TSS, hydrocarbons, heavy metals and chlorinated organic compounds.

Pulp and paper mills generate large quantities of organic waste. Between 1970 and 1987 pulp and paper production increased on both the Atlantic and Pacific coasts, but both BOD and TSS loadings declined. Updated manufacturing processes and the increase in use of primary treatment systems more than offset the increased waste emissions (Table 4.2.12).[4]

Table 4.2.12

Pulp and Paper Mill Discharges to Coastal Waters, 1970-1987

Year	Atlantic coast			Pacific coast		
	BOD	TSS	Production	BOD	TSS	Production
	kg per day					
1970	475 839	198 408	6 272 000	444 665	485 335	9 490 000
1978	463 450	145 191	7 090 000	335 971	269 685	9 532 000
1982	459 259	154 650	7 347 000	301 659	178 371	10 074 000
1985	342 768	125 886	7 860 000	273 815	154 976	10 543 000
1987	313 453	144 005	8 491 000	324 409	130 642	11 689 000

Source:
Environment Canada, *Technical Supplement to A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Technical Report Series No. 20, State of the Environment Reporting, Ottawa, 1991.

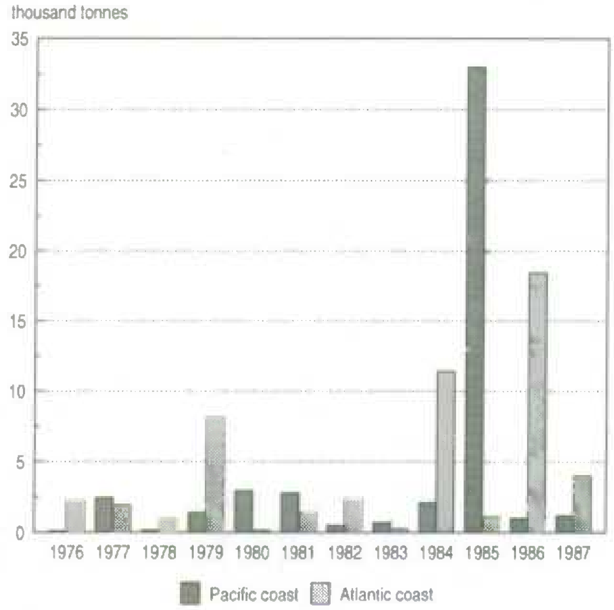
Hydrocarbons, including PAHs, enter the marine environment through spills (land and marine based), runoff and disposal of effluents. They can also be deposited via atmospheric transport. On both the Atlantic and Pacific

4. Environment Canada, *A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Report No. 91-1, State of the Environment Reporting, Ottawa, 1991.

coasts significant marine spills fluctuate from year to year (Figure 4.2.5). As shown in Table 4.2.13, petroleum and industrial waste spills accounted for the majority of waste spills on the Atlantic coast from 1976 to 1987. On the Pacific coast it was industrial spills that accounted for the majority of waste spilled.

Figure 4.2.5

Significant Marine Spills by Region, 1976-1987



Source:
Environment Canada, NATES database.

Heavy metals enter the marine environment from mining, offshore oil and gas development, ocean dumping and industrial wastewater discharge. These substances bio-accumulate in wildlife and pose potential risks to the humans who consume these animals. Mine tailings and effluents from aluminum smelters have resulted in areas of localized metal pollution along both the Atlantic and Pacific coasts. Monitoring of mine and oil and gas exploration sites in the Arctic has also revealed elevated levels of mercury, lead and other heavy metals at these sites.[1]

Table 4.2.13

Significant[1] Marine Spills by Region and Type, 1976-1987

	Atlantic coast		Pacific coast	
	percent	tonnes	percent	tonnes
Industrial waste	44	22 798.2	79	37 923.1
Petroleum	53	27 639.4	9	4 543.0
Other chemicals	2	933.1	7	3 573.5
Base	1	500.0	3	1 318.0
Other	-	310.5	2	785.0
Total	**100**	**52 181.2**	**100**	**48 142.6**

Notes:
Data are not available for the Arctic region.
1. A significant spill is one in which the spilled material exceeds 1 tonne.
Source:
Environment Canada, *Technical Supplement to A Report on Canada's Progress Towards a National Set of Environmental Indicators*, SOE Technical Report Series No. 20, State of the Environment Reporting, Ottawa, 1991.

Summary

The assessment of water quality is an intricate and complicated science. Because all life depends on water for survival, aquatic ecosystem health is regarded as a good indicator of the overall state of the environment. Environment Canada, in its 1991 publication *The State of Canada's Environment*, suggests that the focus on water quality should shift from what comes out of people's taps, to what is going into the sources of raw water. Substances that are difficult to remove from the aquatic environment need to be controlled to protect both the ecosystem and human health.

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

4.3 Fish and Wildlife

This section examines the condition of fish and wildlife in Canada by analyzing biological diversity, exotic species, and contaminant concentrations. Also presented are statistics on the activities of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

❑❑❑

Biological Diversity

Biological diversity or biodiversity is the variety of life in all its forms. It encompasses all species of plants, animals, and micro-organisms, as well as the ecosystems and ecological processes of which they are part.[1] The term wildlife should be understood to include all non-domesticated, living organisms in Canada, as summarized in Table 4.3.1.

Loss and potential loss of Canada's biological diversity serves as a useful indicator of ecological stress caused by human actions. Since Europeans began arriving in the early 1500s, 20 species or populations of animals have disappeared. Nine of them have become extinct, whereas remnant populations of the other 11 still occur elsewhere in Canada and in the world. The sea mink, passenger pigeon, great auk, longjaw and deepwater cisco, and blue walleye were devastated by over-harvesting before the advent of game laws. The black-footed ferret and the greater prairie Chicken were extirpated more recently as agricultural crops supplanted native vegetation and destroyed essential habitat. Indeed, habitat destruction now constitutes a much greater threat than over-hunting to many wildlife species. The removal of living space, or its profound alteration by toxic contaminants, acidic deposition, and other environmental changes, has created conditions under which many species can no longer live and reproduce.[2]

The economic value of the wildlife resource is enormous. For example, in 1992, fish harvesting generated over 2.6 billion in revenues,[3] while wildlife harvesting of fur bearing mammals accounted for 22.9 million.[4] These industries depend on sustained stocks of wild animals for their continued existence. Moreover, non-commercial activities like hunting, fishing, observing and photographing wildlife, also provide economic benefits to the country (see Section 2.6 - **Recreation and the Environment**).

1. Environment Canada, *A Report on Canada's Progress towards a National Set of Environmental Indicators*, SOE Report No. 91-1, Ottawa, 1991.
2. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991, p. 6-5.
3. Department of Fisheries and Oceans, preliminary data.
4. Statistics Canada, *Livestock Statistics*, Catalogue No. 23-603, Ottawa.

Table 4.3.1

Biological Diversity of Wild Species in Canada, 1990

Plant and animal groups	Known species	Suspected species
Algae and diatoms	5 323	2 800
Slime molds, fungi and lichens	11 400	3 600
Mosses and liverworts	965	50
Ferns and fern allies	141	15
Vascular plants	4 187	100
Molluscs	1 121	100
Crustaceans	3 008	1 100
Insects	33 755	32 800
Spiders, mites and ticks	3 171	7 700
Other invertebrates	6 879	5 000
Sharks, bony fish and lampreys	1 091	513
Amphibians and reptiles	83	2
Birds	578	-
Mammals	193	-
Total	**71 895**	**53 780**

Note:
Known species are those that have already been named and described, whereas suspected species are those that are believed to exist but have not been described.
Source:
Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Wildlife Status

Since 1976 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has been responsible for determining the status of wildlife species. In 1988, government agencies established an organization and a strategy called Recovery of Nationally Endangered Wildlife (RENEW). Its goal is to preserve endangered and threatened species from extinction and to prevent vulnerable species from becoming threatened or endangered by developing recovery plans for each designated species. The status designations are:

- **extinct** (species that no longer exist);
- **extirpated** (species no longer existing in a certain area);
- **endangered** (species existence is threatened by human actions; extirpation or extinction a possibility);
- **threatened** (species is slightly at risk);
- **vulnerable** (species is declining in populations, range is restricted);

As of 1993, COSEWIC has reviewed reports on, and assigned status to, 236 species, subspecies, or populations of native wild animals, fish, and plants; 80 others have been considered and found to require no designation at this time. Table 4.3.2 shows that 216 species are currently listed as endangered, threatened and vulnerable. Another 11 are considered extirpated, and nine are now extinct.

Of all human activities, agriculture which uses large land areas, has probably had the greatest effect on wildlife. By clearing forests, replacing natural vegetation with crops, draining wetlands, using insecticides and herbicides, agriculture has been responsible for reductions in the numbers and range of many species and the introduction of others into new areas.[1] Tables 4.3.3 to 4.3.7 present some of the species that are in jeopardy in Canada.

Exotic Species

Today, exotic species - organisms that have been introduced into habitats where they are not native - are considered to be agents of habitat alteration and degradation, and are a major cause in the continuing loss of biological diversity throughout the world. Some have also caused severe economic damage. They can be thought of as "biological pollutants".[2]

Thousands of species of plants and animals from around the world have been introduced into Canada. Many have no natural predators and therefore their diffusion is limited only by available resources.

Most of the recent introductions are the work of humans. Sometimes introductions were intentional, such as rusty crayfish (*Orconectes rusticus*) and purple loosestrife (*Lythrum salicaria*), and had unexpected harmful impacts. But many exotic introductions have been accidental, brought in with animals, livestock bedding and forage, vehicles, ship's ballast, commercial goods, produce and even clothing. Some exotic introductions prove to be ecologically harmless and even beneficial.

Ocean freighter traffic has greatly increased the risk of new exotics in the Great Lakes and surrounding region. Ships take on ballast water in Europe and Asia for stability during the ocean crossing. This water is pumped out when the ships pick up their loads in Great Lakes ports. Because ships now make the crossing in a matter of days rather than weeks, more exotic species are likely to survive the journey. Many exotic plants and animals arrived in the Great Lakes in this way. They have spread throughout the continent's interior in and on boats. Table 4.3.8 presents some exotic aquatic plants and animals and their adverse impacts on the environment. Two such species are the tiny zebra mussel (*Dreissena polymorpha*), a mollusc, and the Eurasian watermilfoil (*Myriophyllum spicatum*), a plant.

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991, p. 6-6.
2. Minnesota Department of Natural Resources, *A Field Guide to Aquatic Exotic Plants and Animals*, Minneapolis, 1992.

Table 4.3.2

Number of Species, Subspecies or Populations in Various Groupings Designated by COSEWIC, 1993

Group[1]	Status assessment						
	Extinct	Extirpated	Endangered	Threatened	Vulnerable	No status[2]	Total[3]
Mammals	2	5	11	7	20	36	81
Birds	3	1	11	7	21	18	61
Fish	4	2	3	11	35	21	76
Reptiles	-	1	3	3	4	1	12
Amphibians	-	-	1	-	3	-	4
Plants	-	2	23	25	28	4	82
Total	**9**	**11**	**52**	**53**	**111**	**80**	**316**

Notes:
1. Insects and molluscs are not yet considered by COSEWIC.
2. Species, subspecies or populations not considered vulnerable upon review of status report.
3. The number of status reports is directly linked to the amount of funding available.
Source:
Environment Canada, Canadian Wildlife Service, *Canadian Species at Risk*, Ottawa, 1993.

Table 4.3.3
Mammal Species in Jeopardy

Species	Status	Critical habitat	Comments	Probable stress/Limiting factors
Atlantic walrus (Northwest Atlantic population)	extirpated	coastal waters of the Maritimes and Gulf of St. Lawrence (except P.E.I.)	extirpated since the mid-19th century;	excessive commercial hunting
Black-footed ferret	extirpated	native prairie	very dependant on its major prey, the prairie dog	loss of food source
Gray whale (Atlantic population)	extirpated	continental shelf waters	extirpated before the end of the 19th century; the east Pacific stock is not in jeopardy	excessive hunting
Grizzly bear (Plains population)	extirpated	most areas west of Lake Manitoba; along the major rivers of southern Alberta	no longer considered a true inhabitant of the plains since 1880	extensive industrial activities; agriculture; human intolerance
Swift fox	extirpated	native prairie	extirpated since the 1930s; serious decrease in North America; re-introduction programs underway	hunting - over-harvested as a fur bearer; pest control - secondary poisoning from wolf control; loss of habitat
Beluga whale (St. Lawrence population)	endangered	St. Lawrence Estuary	long-term declining population; reduced range	loss of habitat - dredging, marine and port development, resource exploration; human disturbance - movement of ships, commercial fishing; pollutants and contaminants; hunting
(Ungava Bay population)	endangered	estuaries along the east coast of Ungava Bay	stocks reduced to the point where they are in immediate danger of extinction	hunting; ship traffic
Eastern cougar (Mountain Lion)	endangered	mixed and coniferous forests	long-term population decline	human disturbance; hunting
Right whale	endangered	coastal waters of both coasts of North America, from tropics to the subarctic	long-term population decline	hunting - commercially over-harvested
Sea otter	endangered	Pacific Coast	wiped out in Canada by the 1930s; re-introduced to coastal waters of Vancouver Island	hunting - commercially over-harvested
Vancouver Island marmot	endangered	alpine and subalpine areas, steep slopes, talus debris, open meadows	long-term population decline	loss of habitat
Wolverine (Eastern population)	endangered	Northern Québec and Labrador; occurs in large, sparsely inhabited wilderness areas with year-round food supplies	has declined to a very low level; no record of its existence	stress cannot be clearly determined; may be over-harvest or diminished ungulate populations
Beluga whale (Hudson Bay population)	threatened	estuaries along the east coast of Hudson Bay	stock reduced by exploitation	hunting; availability of food and summer habitat; ice conditions
Harbour porpoise (Northwest Atlantic population)	threatened	coastal waters of Bay of Fundy, the St. Lawrence River and Newfoundland	in decline in many parts of its total range; very limited reproductive flexibility	incidental catches in fishing gear; human disturbance of coastal regions; increased contamination
Humpback whale	threatened	waters of Canada's east and west coast	officially protected from commercial whaling since 1955	hunting - commercially over-harvested
Pine marten (Newfoundland population)	threatened	mature coniferous and mixed forest; restricted to a small portion of western Newfoundland	despite complete protection since 1934 from trapping, their distribution and number has declined	habitat destruction by logging and fires; excessive trapping
Peary caribou (Low Arctic population)	threatened	Arctic Islands (except Baffin); summer: forage slopes of river valleys and upland plains; winter: beach ridges	extreme variability in population	disturbance associated with increasing industrial activities; hunting; climatic vulnerability
Wood bison	threatened	summer: upland prairies, open forests and sand ridges; winter: near lakes	long-term population decline has been reversed; re-introduction programs are providing protected range	disease and genetic contamination; agricultural development; absence of suitable habitat
Woodland caribou (Maritime population)	threatened	Gaspé region; upland forest	protected in a provincial park	loss of habitat - unsuitable habitat threatens herd viability; disease - parasite infections

Notes:
Species status refers to the degree to which a species is in jeopardy. COSEWIC recognizes a number of degrees of danger to species. Definitions for the ones presented in this Table and Tables 4.3.4 to 4.3.7 are as follows:
Extirpated species: any indigenous species or subspecies or geographically separate population of fauna or flora no longer known in Canada but occurring elsewhere.
Endangered species: any indigenous species or subspecies or geographically separate population that is threatened with imminent extinction or extirpation throughout all or a significant portion of its Canadian range.
Threatened species: any indigenous species or subspecies or geographically separate population of fauna or flora that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed.
Source:
Environment Canada, Canadian Wildlife Service.

Table 4.3.4

Plant Species in Jeopardy

Species	Status	Distribution	Comments	Probable stress/Limiting factors
Blue-eyed mary	extirpated	open wooded sites near waterways; formerly, south central Ontario	only three historic sites; in Canada, no collections of this species since 1954	habitat destruction and modification due to logging and agriculture
Illinois tick trefoil	extirpated	tallgrass prairie along roadside and railroad right-of-ways	extirpated from the single historic site; no sight records since 1888	habitat destruction and modification; mowing and grazing
Cucumber tree	endangered	limited distribution in southwestern Ontario	rapid decline in population has occurred; only a few seed bearing trees	human disturbance - decline due mainly to lumbering and forest cleaning
Furbish's lousewort	endangered	banks of the upper Saint John River	herb; few plants remain in Canada	loss of habitat - farming, forestry, hydro-electric projects and flooding
Heart-leaved plantain	endangered	moist depression in undisturbed, shaded, deciduous woodland; one site remains on the eastern shore of Lake Huron	reduced population throughout its North American range	human disturbance - collecting by Natives for medical purposes; loss of habitat - development
Pink coreopsis	endangered	found in Tusket River Valley, N.S.; restricted to gravelly margins of lakes	herb; intolerant of competition	human disturbance - cottage development and reservoir construction
Pink milkwort	endangered	prairies and meadows; found at only two sites in Lambton County, Ontario	herb; low numbers (about 100) of plants left	loss of habitat - expansion of agriculture land use
Prickly pear cactus (Eastern population)	endangered	restricted to four confirmed locations in southeastern Ontario	cactus	loss of habitat - changes in vegetation cover, agricultural expansion; human disturbance - collecting
Small white lady's slipper	endangered	tall grass prairie, swampy meadows, fens, remnant prairies, edge of thickets	orchid; long-term decline throughout its range	loss of habitat - agricultural and urban development
Small whorled pogonia	endangered	one site in Elgin County, Ontario	the rarest orchid in northeastern U.S. and Canada	human disturbance - rarity attracts attention; loss of habitat
Southern maidenhair fern	endangered	Fairmont Hot Springs, B.C.	plant size; number of plants and sites are decreasing	loss of habitat - reduced hot water flow and competition from herbaceous species
Water-pennywort	endangered	found in two localities in southeastern Nova Scotia	small creeping aquatic plant of tropical origin; northern limit of its range	loss of habitat - cottage development; aquatic recreation activities
Western prairie fringed orchid	endangered	occurred near Vita, Manitoba; in ditches and in mesic and wet tall grass prairie community in parkland habitat	single location area mainly in private ownership; subject to habitat alteration	massive habitat loss - conversion for agriculture, mineral extraction, grazing; successional change; loss of pollinators
Wood poppy	endangered	rich woods, forested ravines and slopes, woodland streams, ravine bottoms; found in Middlesex County, Ontario	only several hundred plants remain; two populations have been lost in recent years	logging and predation
American ginseng	threatened	rich moist deciduous forests; found in southwestern Quebec and southern Ontario	collecting and removal of plants have caused the decline; populations greatly reduced from historical numbers	commercial harvest of Ontario wild roots; loss of habitat - clearing, logging and grazing cattle
American water-willow	threatened	occupies the floodplains of streams in Ontario and Quebec; few localities known	aquatic plant (herb) at the northern limit of its range; loss of several populations in Quebec	loss of habitat - residential, industrial and recreational development; pollutants and contaminants; climatic vulnerability
Anticosti aster	threatened	found along fast-flowing rivers in the eroded area between the low-water mark and the Boreal Forest	eight known sites, five of which were rediscovered in 1988; rare throughout its range of distribution	disturbance of the banks - human activity and regulation of water flow
Athabasca thrift	threatened	three localities on the south shore of Lake Athabasca, Saskatchewan; restricted to stable ridges and plains	herb; very limited distribution; species unique to Canada	loss of habitat - road development; pollution and contaminants
Bird's foot violet	threatened	found in Ontario near Brantford and in Turkey Point Provincial Park; occurs in open black oak savannas	spring and autumn flowering perennial; loss of 75% of its historical range	destruction of habitat - agriculture; competition from woody species due to absence of fire; horticultural collecting
Bluehearts	threatened	found in Lambton County, Ontario on a narrow stretch of Lake Huron's shoreline	herb	loss of habitat - cottage development
Giant helleborine	threatened	four localities in southern B.C.	orchid; Fairmont Hot Springs has the largest population	human disturbance - reduction of run-off from hot springs
Kentucky coffee tree	threatened	exists in southern-most Ontario; occurs in floodplains, edges of marshes and wetlands	only one reproducing population in Canada	loss of habitat - agricultural drainage and land clearing; lack of both sexes in most Ontario populations
Mosquito fern	threatened	four localities within a 35 km^2 area on the south side of Sushwap Lake, B.C.	thrives within a relatively narrow range of water chemistry; reproduces rapidly under suitable conditions	pollutants and contaminants - chemical and oil spills, road salt effects
Plymouth gentian	threatened	peaty margins of lakes in the lowest portions of the Tusket River, N.S.	herb; intolerant to competition	human disturbance - cottage development and reservoir construction
Tyrell's willow	threatened	beach and active sand dunes; found on the south shore of Lake Athabasca, Saskatchewan	herb; very limited distribution; species unique to Canada	loss of habitat - road development; pollution and contaminants - acid rain from tar sands operations in Alberta

Note:
Refer to note accompanying Table 4.3.3 for an explanation of species status.
Source:
Environment Canada, Canadian Wildlife Service.

Table 4.3.5
Bird Species in Jeopardy

Species	Status	Critical habitat	Comments	Probable stress/Limiting factors
Greater prairie chicken	extirpated	open, undisturbed native grasslands	no breeding population; no regular occurrence	loss of habitat - grain harvesting and intensive cattle grazing
Eskimo curlew	endangered	breeding: tundra and lichen woodland	almost disappeared between 1880 and 1895	human disturbance and hunting; loss of habitat
Harlequin duck (Eastern population)	endangered	breeding: turbulent mountain streams and fast rivers	very small numbers; apparently population still declining	human disturbance and hunting; marine pollution
Henslow's sparrow	endangered	meadows and large grassy fields abandoned by agriculture; breeds in southern Ontario	long-term population decline; the current population may number fewer than 10 pairs	loss of habitat due to land development and intensive cultivation
Kirtland's warbler	endangered	dense jack-pine stands	long-term population decline; now seems to be stabilized	introduction - nest parasitism; loss of habitat
Loggerhead shrike (Eastern population)	endangered	open land, flat or very gently rolling; extensive fields of rough pasture	small numbers; widespread decline of populations in eastern Canada	loss of breeding habitat - agricultural practices, housing and industrial development; lost of wintering habitat
Mountain plover	endangered	flat heavily grazed natural grassland; extreme southeastern Alberta and extreme southwestern Saskatchewan	extremely low numbers; also at the northern limit of its range	destruction of habitat - replacement of native grassland by cereal crops; a lack of suitable habitat for nesting
Peregrine falcon (anatum)	endangered	breeding: taiga region; nesting: cliffs	almost extirpated	contaminants - DDE residues leading to reproductive failure; loss of habitat; human disturbance and hunting
Piping plover	endangered	breeding: on ocean beaches or along inland lakes and sloughs	generally uncommon; periodic population declines	hunting and human disturbance
Sage thrasher	endangered	breeding: sagebrush habitat; southern interior of B.C., southeastern Alberta and southwestern Saskatchewan	since 1980, only 5 to 10 pairs have been present; continuing threats to habitat	loss of habitat - mowing, burning and herbicide treatments; residential and agricultural development
Whooping crane	endangered	breeding: marshy areas (primarily Wood Buffalo National Park)	management programs to accelerate the population recovery rate	hunting - accidental shooting; loss of habitat; competition for food and space
Baird's sparrow	threatened	idle or lightly-grazed tracts of native prairie	greatly reduced populations and range (breeding and wintering)	habitat loss - cultivation on native grasslands; pesticides and herbicides
Burrowing owl	threatened	heavily grazed pastures	long-term population decline	loss of habitat - land development; human disturbance, pollution and contaminants
Ferruginous hawk	threatened	open grasslands	greatly reduced breeding distribution	loss of food source - decrease in prey; loss of habitat
Loggerhead shrike (Western population)	threatened	grassy areas with hedgerows, windbreaks or scattered trees and shrubs	populations have diminished more rapidly than habitat has been lost; large scale decline first noticed in the early 1970s	cause of the decline is unknown; may be toxic chemical levels and/or climatic factors
Marbled murrelet	threatened	nearshore habitat throughout coastal B.C.; nesting: old-growth or older mature forests with suitable sized trees	predicted decline due to logging; reproductive potential is low	loss of habitat - removal of old-growth nesting habitat; gill netting; oil spills; industrial and recreational activities
Roseate tern	threatened	offshore islets and islands, rarely on mainland peninsulas	ground-nesting colonial species; the population has declined rapidly the last 100 years	effects of chemicals on reproduction; predation by gulls; human exploitation
White-headed woodpecker	threatened	mature stands of ponderosa pine with a high density of snags for nesting and feeding; south Okanagan Valley, B.C.	continuing slow loss of habitat causing continued declines; Canadian population fewer than 100 birds	logging of mature ponderosa pine forests; fire suppression and pesticides

Note:
Refer to note accompanying Table 4.3.3 for an explanation of species status.
Source:
Environment Canada, Canadian Wildlife Service.

Table 4.3.6
Fish Species in Jeopardy

Species	Status	Critical habitat	Comments	Probable stress/Limiting factors
Gravel chub	extirpated	Thames River drainage basin (southern Ontario); prefers clear to moderately turbid streams with consistent flow	none have been caught since 1958; at the northeastern fringe of its range; important as a pollution indicator	loss of habitat - sensitive to siltation; impoundment of riffle areas
Paddlefish	extirpated	inshore areas or moderately large tributary of the Great Lakes	none reported in Canada for 70 years; elsewhere, populations remain extant; at the northern edge of its range	reduced in part by the actions of man
Acadian whitefish	endangered	Tusket and Petit rivers in southern Nova Scotia	small population	fishing; pollution and contaminants; acidification of habitat - acid rain
Aurora trout	endangered	remote kettle lakes; limited to a small series of lakes in northeastern Ontario	disappeared from the wild in the early 1970s; management plan to rehabilitate the aurora trout	lake acidification
Salish sucker	endangered	small lowland streams in the lower Fraser Valley	numbers have declined in all populations the last three decades	increasing urbanisation; decline of suitable habitat
Blackfin cisco	threatened	prefers deep waters; Lake Nipigon and the Great Lakes (except Erie)	extirpated over much of its range; Lake Nipigon population still subject to exploitation	over-exploitation by the commercial fisheries; sea lamprey predation; hybridization
Channel darter	threatened	Lake Erie, tributaries of eastern Lake Ontario; Detroit and Ottawa rivers, tributaries of the St. Lawrence River	although its distribution has expanded, few individuals have been collected	loss of habitat due to urban land use and agricultural practices; increasing susceptibility to parasitism
Copper redhorse	threatened	found only in a few medium size rivers with steep banks and uniform depths in the lowlands of southwestern Quebec	found exclusively in Canadian waters; rare throughout its range despite its marked fecundity and longevity	deterioration of its habitat; water pollution
Deepwater sculpin (Great Lakes population)	threatened	post glacial lakes, deep and cold lakes	believed extirpated from Lake Ontario and possibly Lake Erie;	availability of deep, cold water lakes; declining water quality
Margined madtom	threatened	clear water streams of moderate current with an abundance of cover; isolated areas of the Ottawa River drainage	its occurrence may be accidental; introduction as a baitfish or dispersal from NY State through the St. Lawrence Basin	extremely specialised habitat; reduction of riffle areas; deficient oxygen
Shorthead sculpin	threatened	found only in the Flathead River in southeastern British Columbia	very small population	pollution and contaminants - run off from coal mines

Note:
Refer to note accompanying Table 4.3.3 for an explanation of species status.
Source:
Environment Canada, Canadian Wildlife Service.

Table 4.3.7
Reptile and Amphibian Species in Jeopardy

Species	Status	Critical habitat	Comments	Probable stress/Limiting factors
Blanchard's cricket frog	endangered	along muddy and sandy shores, in emergent aquatic vegetation of ponds, marshes and ditches	occurs only on Pelee Island in extreme southwestern Ontario; long-term population decline	human alteration of its habitat
Blue racer	endangered	oak savannas, pastures, prairies	commonly known only to Pelee Island	loss of habitat - agriculture, succession; killing by people
Lake Erie watersnake	endangered	rocky shoreline	watersnakes have clearly declined in numbers during the past 40 years	habitat destruction; killing by people; predation
Leatherback turtle	endangered	marine beaches which serve as nesting areas	designated endangered in Canada because of similar international status	predation
Blanding's turtle (Nova Scotia population)	threatened	darkly coloured water and peaty soils	most individuals occur within Kejimkujik National Park, Nova Scotia	availability of suitable nesting areas; low egg and hatching survivorship
Eastern Massasauga rattlesnake	threatened	wetlands; occurs only in Ontario	commonly perceived to be a threat	killing by people; habitat destruction
Spiny softshell turtle (Eastern population)	threatened	Ottawa and portions of the St. Lawrence rivers, lakes St. Clair, Erie, Ontario and Champlain	only representative of the softshell turtles in Canada	pollution and chemical contamination; loss of habitat - agriculture and urban development; severe winters

Note:
Refer to note accompanying Table 4.3.3 for an explanation of species status.
Source:
Environment Canada, Canadian Wildlife Service.

Table 4.3.8

Exotic Aquatic Plants and Animals in Canada[1]

Species	Release	Natural distribution	Comments	Adverse impacts
Curly-leaf pondweed	accidental	native to the Caspian Sea region and east Asia	most severe nuisance aquatic plant until watermilfoil appeared	forms surface mats that interfere with aquatic recreation
Eurasian watermilfoil	accidental	Europe	forms thick underwater stands of tangled stems and vast mats of vegetation at the water's surface; spreads into lakes by boats and by waterbirds	interfere with water recreation activities; can also crowd out important native water plants
Flowering rush	intentional	perennial plant from Europe and Asia	introduced as an ornamental plant; grows in shallow areas of lakes as an emergent	its dense stands crowd out native species like bulrush
Purple loosestrife	intentional and accidental	wetland plant from Europe and Asia	first spreading along roads, drainage ditches and canals then later distributed as an ornamental and honey plant; its expansion is due to lack of effective predators	invades wetlands replacing cattails and other wetland plants; forms dense stands that are unsuitable habitat for native wetland animals and plants
Chinese grass carp	intentional		introduced in southern Alberta to clean out aquatic weeds in irrigation canals; some escaped and may have found their way into natural waterways	could threaten the native fish stocks
Ruffe	accidental	native to central and eastern Europe	introduced in tanker ballast water around 1985; spreading to rivers and bays around Lake Superior	displaced the native perch population; reduced whitefish populations
Rusty crayfish	intentional for sport fishing	native to streams in the Kentucky, Ohio and Tennessee region	spread by anglers who use them as bait; prolific species	reduce native crayfish populations; can severely reduce lake and stream vegetation
Sea lamprey	accidental	native to the coastal region of both sides of the Atlantic Ocean	entered the Great Lakes through the Welland Canal about 1921 during its construction	contributed to the decline of whitefish and lake trout in the Great Lakes
Spiny water flea	accidental	native of Great Britain and northern Europe east to the Caspian Sea	probably imported in the ballast water of a transoceanic freighter; first found in Lake Huron in 1984; can now be found throughout the Great Lakes and in some inland lakes	impacts of this species are unknown; may compete with young perch and other small fish for food
White perch	accidental	native to Atlantic coastal region	invaded the Great Lakes through the Erie and Welland canals; prolific competitor of native fish species	have the potential to cause declines of Great Lakes walleye populations
Zebra mussel	accidental	native to the Caspian Sea region of Asia	discovered in Lake St. Clair near Detroit in 1988; microscopic larvae has been carried in livewells and bilgewater to Canada; millions of dollars have been spent trying to remove and control zebra mussels; filter large quantities of phytoplankton out of the water	clog water-intake systems of power plants and water treatment facilities; could lead to declining population of commercially valuable species; have severely reduced native mussel species

Note:
1. Exotic species are those introduced by man into an area where they are not found naturally.

Sources:
Minnesota Department of Natural Resources, *A Field Guide to Aquatic Exotic Plants and Animals*, Minneapolis, 1992.
Manitoba Environment, *State of the Environment: Report for Manitoba*, Winnipeg, 1993.

Table 4.3.9

Number of Bald Eagle Nest Sites and Young Raised on the North Shore of Lake Erie, 1980-1992

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Number of nests	3	4	4	5	6	7	7	7	8	8	9	10	9
Number of naturally raised young	-	1	5	5	7	6	6	6	10	7	11	11	14
Number of re-introduced young	-	-	-	6	4	6	8	8	-	-	-	-	-
Total number of young (natural plus re-introduced)	-	1	5	11	11	12	14	14	10	7	11	11	14

Source:
Environment Canada, *Bringing the Bald Eagle back to Lake Erie*, SOE Fact Sheet No. 93-3, 1993.

Contaminants

The dramatic growth in the number and variety of chemicals products since the Second World War, has led to concern for the health of both wildlife and humans. More than 35 000 chemicals are reported to be use in Canada today.[1] Just how many of these are toxic is unclear, but particular concern has focused on groups of contaminants that are associated with adverse effects on wildlife. These substances enter ecosystems by many pathways, including industrial discharges and leakage, municipal and consumer wastes, run-off from agriculture and forestry applications, and accidents. Air and water currents can disperse these contaminants over great distances. One notable group is persistent organochlorines (DDT, DDE, PCBs, dioxins, furans, mirex, dieldrin) (see Section 3.7 - **Wastes**).

The organochlorine concentration in an organism depends on many factors but, in general, the higher the animal is on the food chain, the higher this concentration will be. This bio-accumulation significantly enhances the threat that contaminants pose to the aquatic ecosystem and to human health. Within each step of the food web, increased contaminant concentrations occur in organisms. For example, the double-crested cormorant, the herring gull, and the bald eagle, have exhibited eggshell thinning, embryonic mortality, deformities and death.

Seabirds

Colonial seabirds are a good indicator species because they are high on the food chain and bio-accumulate contaminants such as synthetic organochlorine compounds in their tissues. The double-crested cormorant, an inshore feeder, serves as an indicator of the presence of contaminants in the Pacific, Atlantic, Great Lakes and St. Lawrence Estuary coastal zones. The levels of DDE, PCBs, dioxins and furans in the eggs of this species are presented in figures 4.3.1 and 4.3.2; Figure 4.3.3 shows the levels of mirex in herring gull eggs in Lake Ontario. Eggs provide an easily collected sample for monitoring purposes since female seabirds eliminate pollutants through their eggs.

DDT was widely used in Canada between 1947 and 1969 to control agricultural and forest insects. Use dropped sharply in 1970 after restrictions were introduced.[2] Concentrations of DDE (the main breakdown product of DDT) have declined substantially since that time.

The decline of PCB levels in double-crested cormorant eggs has been inconsistent at the sampling locations in Strait of Georgia, Great Lakes, St. Lawrence Estuary and Bay of Fundy. Concentrations are now fairly similar at all four sites (Figure 4.3.1). A similar decline is observed for mirex in herring gulls eggs in Lake Ontario (Figure 4.3.3).

1. Environment Canada, *Toxic Contaminants in the Environment: Persistent Organochlorines*, SOE Bulletin No. 93-1, Ottawa, 1993.
2. Ibid.

Dioxins and furans are extremely toxic compounds that readily accumulate in the fatty tissues of organisms. Effluent from pulp and paper mills using chlorine bleaching process are major sources of dioxins and furans. In the late 1980s, both dioxin and furan concentrations in eggs of double-crested cormorants were higher in the Strait of Georgia than along the Atlantic Coast (Figure 4.3.2). Regulations under the Canadian Environmental Protection Act (1988) require the elimination of dioxins and furans from the effluent of all mills using chlorine bleaching by 1994.

Fish

Pollutant concentrations in fish are also good indicators of the presence of contaminants in the environment. Like birds, fish are high in the food chain. Thus, they contain larger, more easily measured quantities of contaminants than lower life forms.[3] Figure 4.3.4 shows trends in concentrations of PCBs and DDT in Niagara River spottail shiners between 1975 and 1991. This species provides a good indication of current conditions as opposed to longer term bio-accumulation. Tissue concentrations of both chemicals have decreased dramatically since 1975, by about a factor of five. These decreases can be explained primarily by reduction in chemical use.

Figure 4.3.5 presents an inter-lake contaminant comparison for lake trout. For each lake, there is a significant decline in PCB and DDT concentrations between 1981 and 1991. The highest levels of contamination occurred close to industrial areas along Lake Ontario where industry is concentrated. However, levels of the most toxic dioxin (2,3,7,8 - tetrachlorodibenzo-p-dioxin, or TCDD) in Lake Ontario lake trout increased between 1977 and 1992 (Figure 4.3.6).[4]

Birds

By the 1970s, the bald eagle had been eliminated from much of its former territory, particularly in Eastern Canada as a result of habitat destruction, the widespread use of toxic chemicals, and the build-up of DDT and pesticides in their prey. DDT contamination resulted in the thinning of eggshells, breakage of eggs and reduced breeding success.[5] Figure 4.3.7 shows concentrations of chemicals in eggs of bald eagles from the north shore of Lake Erie in the 1970s and 1980s. By 1989, measured concentrations of DDE and dieldrin in a small sample of eggs had decreased by more than one-half, and concentrations of PCBs had decreased by as much as 80 percent. A five-year reintroduction program was started in 1983 to increase the Lake Erie bald eagle population. This recovery program has so far been a success. Young bald eagles increased from none in 1980 to 14 by 1992 (Table 4.3.9).

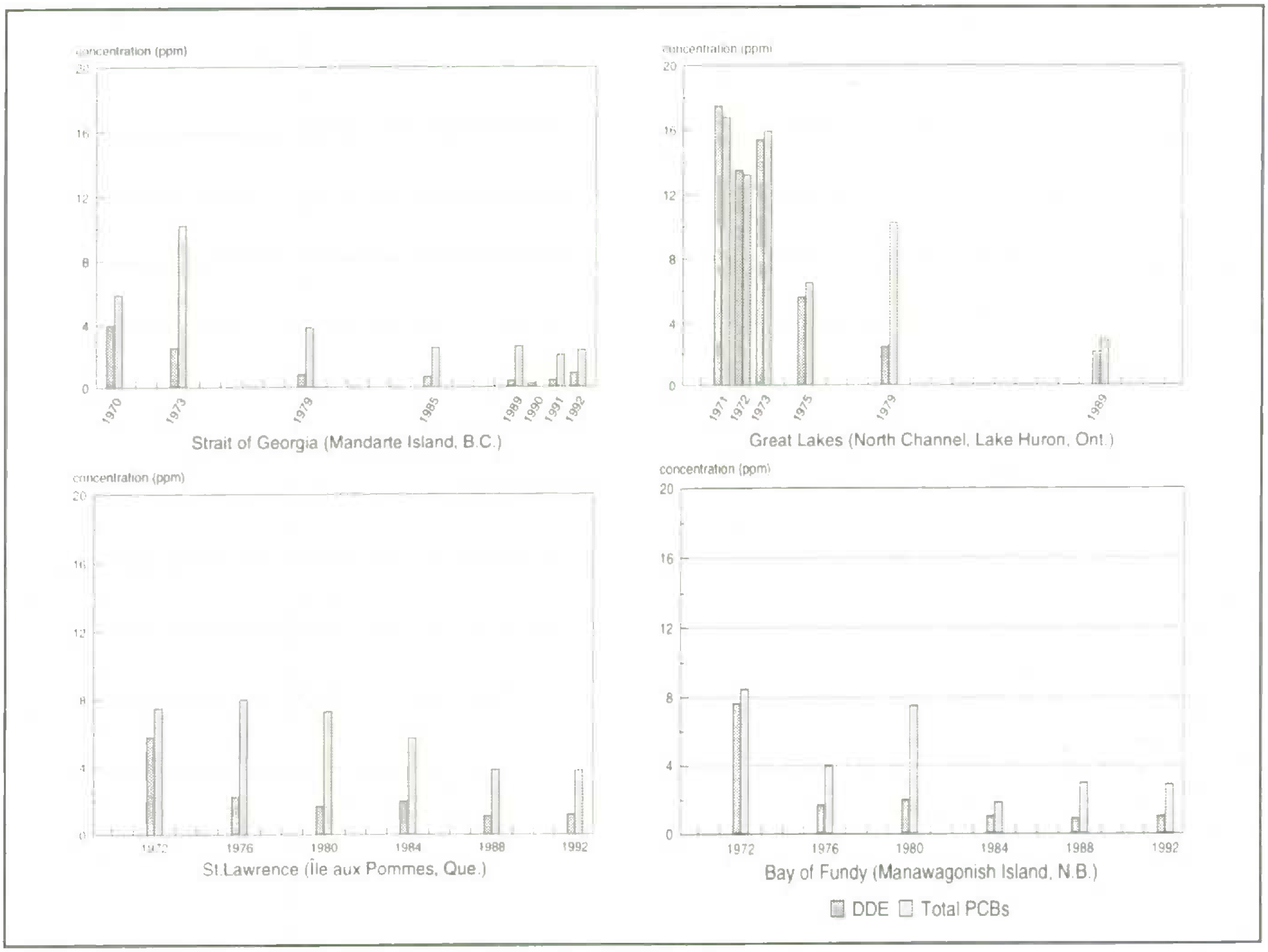
3. Environment Canada, *Trends in the Contaminant Levels in the Niagara River*, SOE Fact Sheet No. 93-2, Ottawa, 1993.
4. Government of Canada, *The Great Lakes: Making Progress*, Toronto, 1993.
5. Environment Canada, *Bringing the Bald Eagle back to Lake Erie*, SOE Fact Sheet No. 93-3, Ottawa, 1993.

Summary

Canada's wildlife resources are under increasing pressure from a wide variety of human activities. Agriculture, forestry, urbanization, industrial development and recreation all continue to effect the quality and quantity of wildlife habitats. Hopefully, future initiatives will foster a more sustainable relationship between human and wildlife populations.

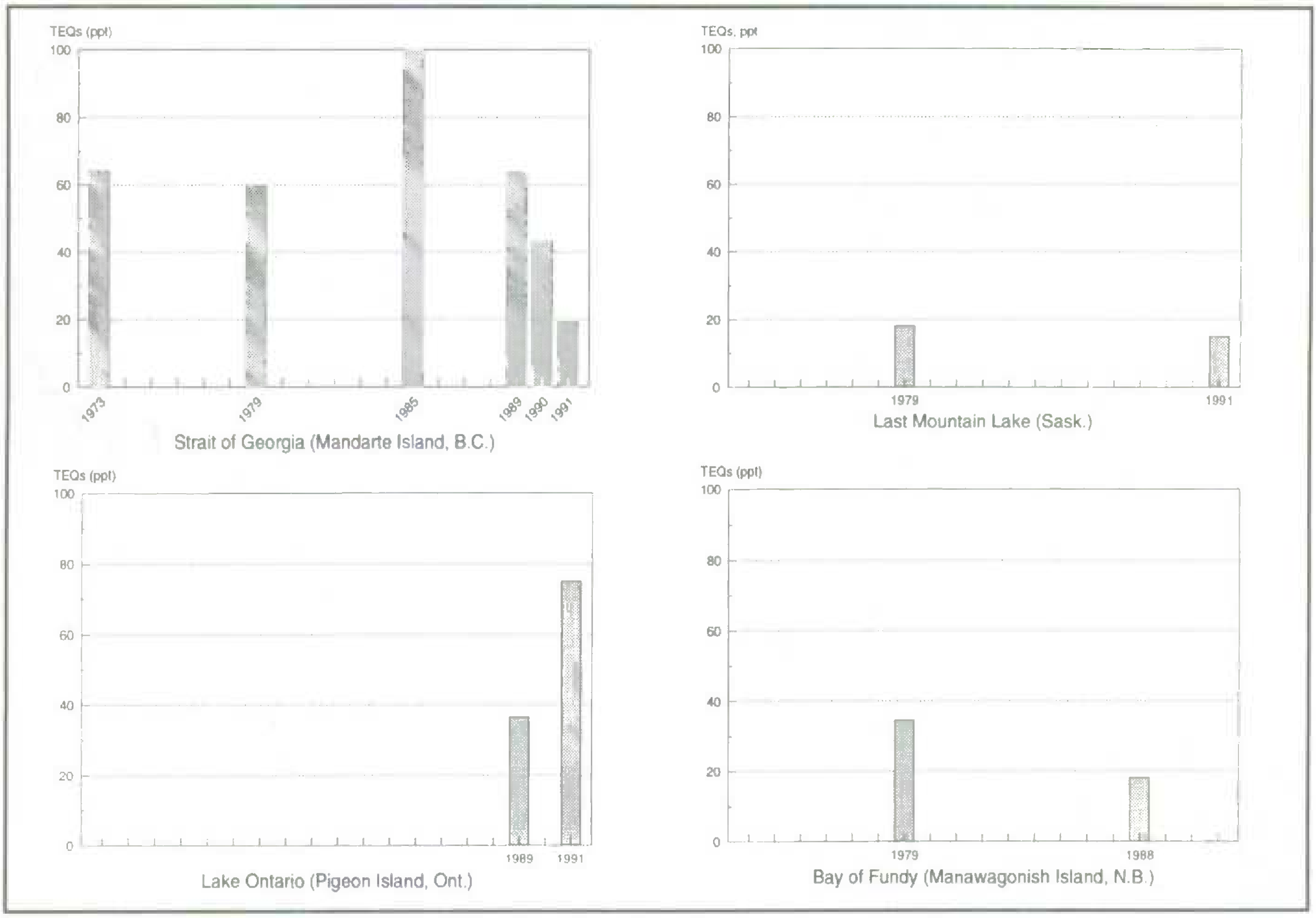
Figure 4.3.1

DDE and PCBs in Double-crested Cormorant Eggs, Selected Years



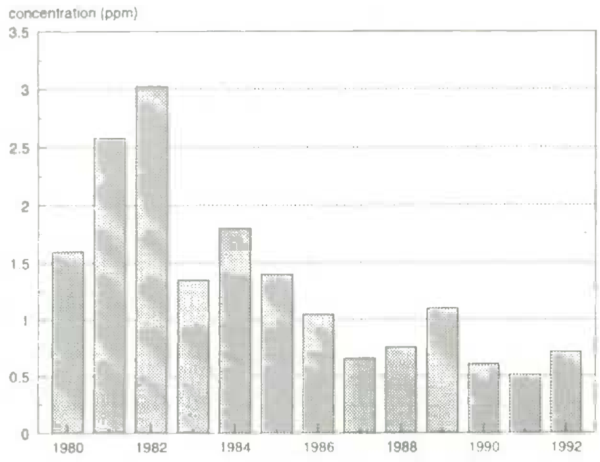
Source:
Environment Canada, *Toxic Contaminants in the Environment: Persistent Organochlorines*, SOE Bulletin No. 93-1, Ottawa, 1993.

Figure 4.3.2
Dioxins and Furans in Double-crested Cormorant Eggs, Selected Years



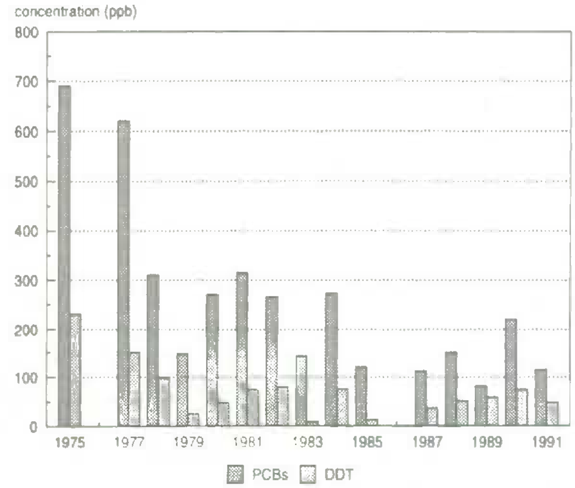
Notes:
Testing for contaminants is expensive, and therefore not all sites are monitored intensively.
To approximate total risk from the most toxic chemical forms of dioxins and furans, all are assessed by comparing their toxicity to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD), the most toxic of this group, using an internationally accepted procedure. Concentrations derived in this manner are referred to as toxic equivalents (TEQs).
Source:
Environment Canada, *Toxic Contaminants in the Environment: Persistent Organochlorines*, SOE Bulletin No. 93-1, Ottawa, 1993.

Figure 4.3.3
Mirex in Herring Gull Eggs Lake Ontario, 1980-1992



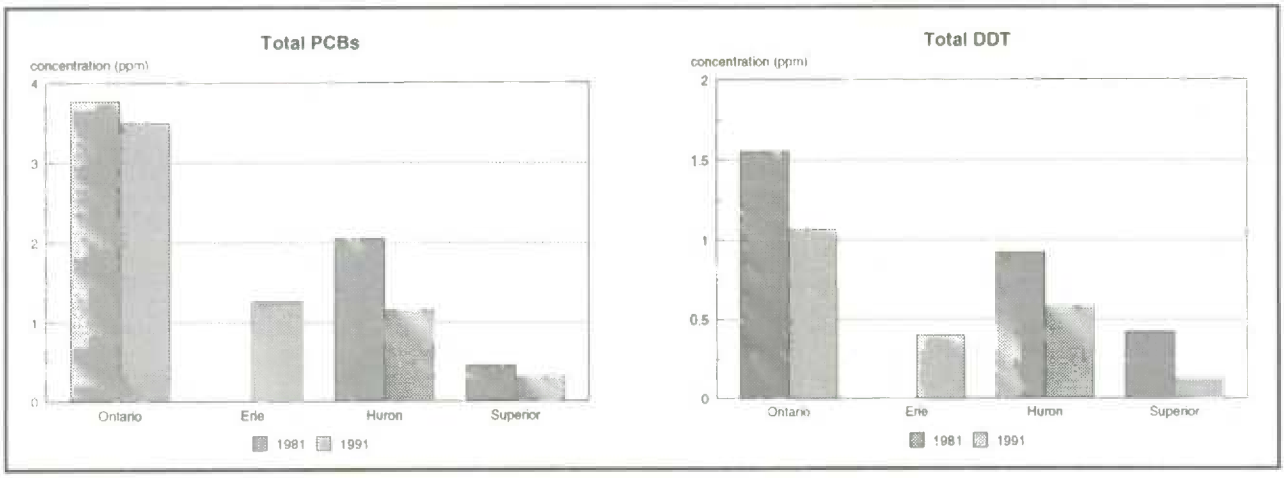
Source:
Government of Canada, *The Great Lakes: Making Progress*, Toronto, 1993.

Figure 4.3.4
PCBs and DDT in Spottail Shiners of the Niagara River, Selected Years



Note:
No data available for 1976 and 1986.
Source:
Environment Canada, *Trends in the Contaminant Levels in the Niagara River*, SOE Fact Sheet No. 93-2. Ottawa, 1993.

Figure 4.3.5
Inter-lake Contaminant Comparisons in Lake Trout, 1981 and 1991



Note:
No data available for Lake Erie in 1981.
Source:
Government of Canada, *The Great Lakes: Making Progress*, Toronto, 1993.

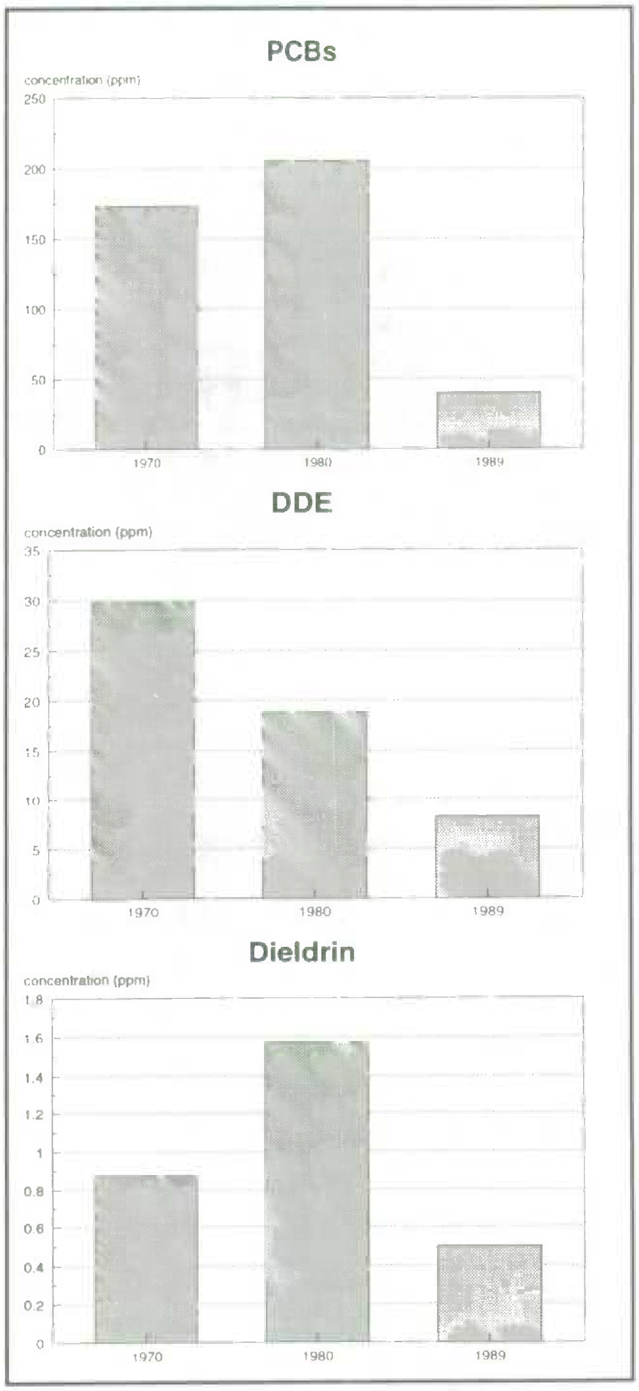
Figure 4.3.6

Dioxin (2,3,7,8 TCDD) in Lake Ontario Lake Trout, 1977-1992

Source:
Government of Canada, *The Great Lakes: Making Progress*, Toronto, 1993.

Figure 4.3.7

Chemicals in Eggs of Bald Eagles from the North Shore of Lake Erie, 1970, 1980 and 1989



Source:
Environment Canada, *Bringing the Bald Eagle back to Lake Erie*, SOE Fact Sheet No. 93-3, Ottawa, 1993.

4.4 Habitats and Protected Land

Habitats

Forests, plains, estuaries, rivers, oceans and wetland habitats are all being altered by human activities. Canada has one-quarter of the world's wetlands - 127 million hectares, or one-seventh of Canada's land area, is covered by bog, fen, marsh and swamp. It is estimated that one-seventh of Canada's pre-settlement wetlands have been converted to other uses.

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A *habitat* is a place where a plant or animal usually lives. It is often characterized by a dominant plant form or physical characteristic (i.e. the forest habitat, the river habitat). An ecosystem is a much more complex concept. It incorporates all of the interactions between the physical and biophysical environment.

This section focuses on wetlands and peatlands as a particular habitat under stress from human activities. Other habitat types such as forests, rivers, oceans, agricultural land, protected lands are discussed elsewhere in this publication (see Section 4.7 - **Agricultural Land** and Section 4.8 - **Forest Land**). Whereas forests and agricultural lands have obvious economic benefits, wetlands - marshes, swamps and bogs - have long been considered wasteland, available for conversion to "productive" uses. It is now understood that wetlands support a rich wildlife and that they provide beneficial hydrological and water-purification functions.

Wetlands and Peatlands

A wetland is land that is saturated with water long enough to promote aquatic processes: poorly drained soils, hydrophytic vegetation[1] and other biological activities adapted to a wet environment.[2] Wetlands occupy a transitional position between water and land; since they are neither solid land nor open water. Wetlands also include waterlogged soil, such as peat, where the production of plant materials has exceeded decomposition. However, not all wetlands are peatlands, therefore a thickness of 40 cm of peat has been chosen as a minimum requirement for wetlands to be classified as peatlands.[3]

Wetlands are linked to many environmental issues including: climate change, freshwater and groundwater quality and supply, wildlife habitat, soil and water conservation, and water and air pollution. Wetlands not only provide waterfowl habitat but are also essential in supporting coastal and estuarine fishery resources, protecting shorelines from erosion, protecting watersheds from flooding and removing nutrients from wastewater and runoff.

Most wetlands at risk in Canada are either privately or provincially owned. In 1990, the federal government managed only 29 percent of Canada's wetlands.[4]

Canada contains almost one-quarter of all the wetlands on earth; 14 percent of Canada, or 1.27 million square kilometres, is covered by wetlands (Tables 4.4.1 and 4.4.2). Wet-

1. Hydrophytic vegetation are plants which grow only in water or very wet soil. Algae are hydrophytic.
2. Environment Canada, *Canadian Wetland Registry - Workshop on Canadian Wetlands*, Lands Directorate, Ecological Land Classification Series No. 12, Ottawa, 1980.
3. Environment Canada, *Wetlands of Canada, 1988*, Ecological Land Classification Series No. 24, Ottawa, 1988.
4. Sustaining Wetlands Forum, *Sustaining Wetlands - International Challenge for the 90s*, Sustaining Wetlands Forum, Ottawa, 1990.

Table 4.4.1
Occurrence of Wetlands[1] and Peatlands[2], 1986

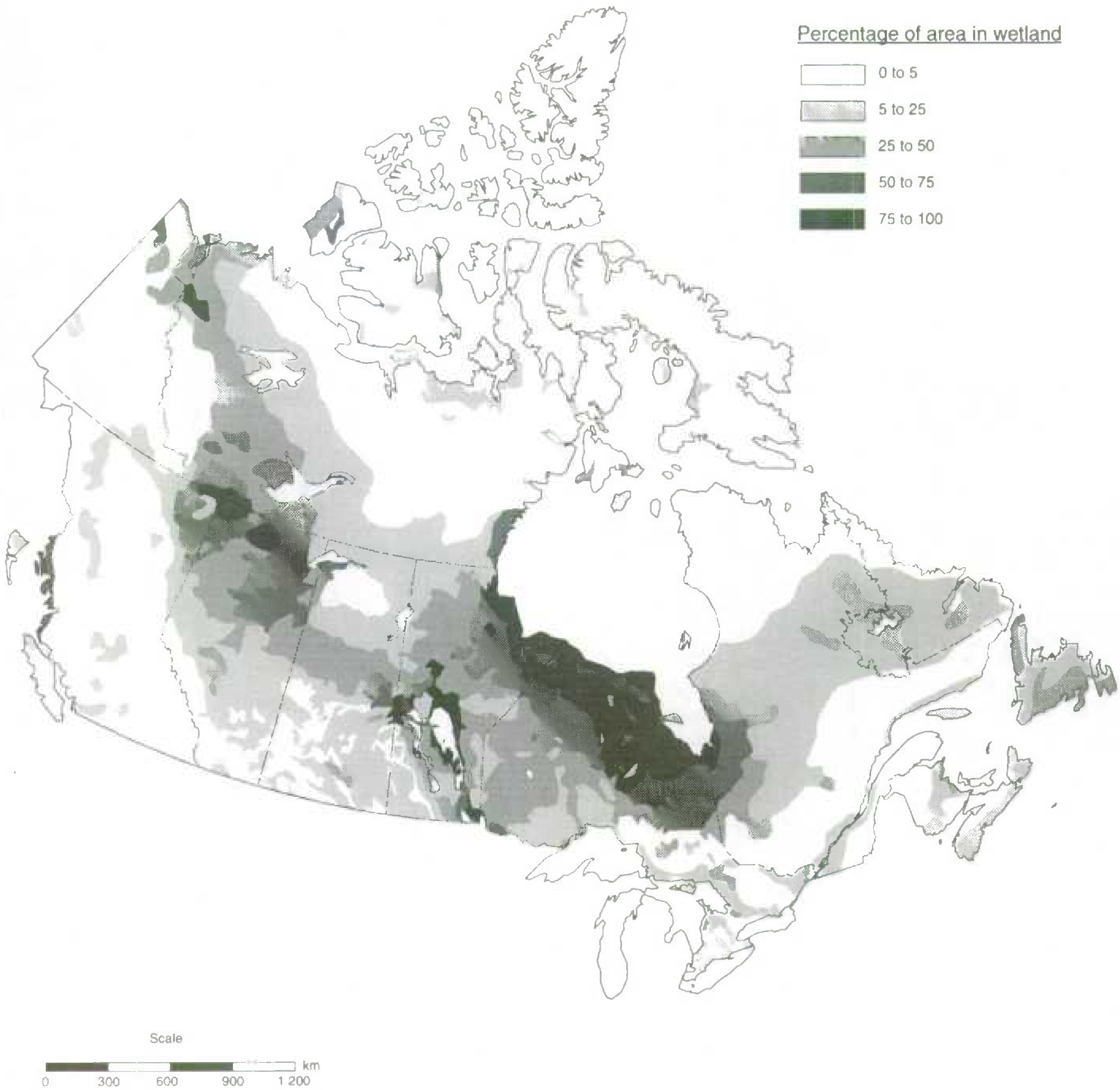
Province/Territory	Peatlands Area	Peatlands as a percentage of land area	Wetlands Area	Wetlands as a percentage of land area
	km^2	percent	km^2	percent
Newfoundland	64 290	17	67 920	18
Prince Edward Island	80	1	90	1
Nova Scotia	1 580	3	1 770	3
New Brunswick	1 200	2	5 440	8
Quebec	117 130	9	121 510	9
Ontario	225 550	25	292 410	33
Manitoba	206 640	38	224 700	41
Saskatchewan	93 090	16	96 870	17
Alberta	126 730	20	137 040	21
British Columbia	12 890	1	31 200	3
Yukon	251 110	8	277 940	9
Northwest Territories	12 980	3	15 100	3
Canada	**1 113 270**	**12**	**1 271 990**	**14**

Notes:
1. The extent and distribution of wetlands in Canada can only be estimated. Presently some provinces have completed surveys of peatlands while others are currently undertaking or planning such projects.
2. Based on both ecological and land use considerations, a thickness of 40 cm of peat is the minimum requirement for wetlands to be classified as peatlands.

Source:
Environment Canada, *Wetlands of Canada, 1988*, Ecological Land Classification Series No. 24, 1988.

Map 4.4.1

Distribution of Wetland, 1986



Source:
Energy, Mines and Resources Canada, *National Atlas of Canada, fifth edition*, Ottawa, 1991.

Table 4.4.2

Estimated Wetland Area by Province, 1986

Province/Territory	Proportion of area in wetland 0-5%	5-25%	25-50%	50-75%	75-100%	Total area	Provincial land area in wetland	Share of national wetland total
	km²						percent	
Newfoundland	580	35 960	31 380	-	-	67 920	18	5
Prince Edward Island	40	-	-	-	-	40	1	1
Nova Scotia	220	1 550	-	-	-	1 770	3	1
New Brunswick	1 280	2 940	1 220	-	-	5 440	8	1
Quebec	6 280	45 790	35 060	28 490	5 890	121 510	9	10
Ontario	1 050	6 840	47 950	86 340	150 230	292 410	33	23
Manitoba	380	22 250	70 890	51 840	79 340	224 700	41	18
Saskatchewan	3 980	41 700	36 950	12 710	1 530	96 870	17	8
Alberta	1 070	10 800	32 490	68 730	23 950	137 040	21	11
British Columbia	3 520	6 620	1 460	16 560	3 040	31 200	3	2
Yukon	22 410	75 200	95 480	65 210	19 640	277 940	9	22
Northwest Territories	1 980	1 850	7 640	3 630	-	15 100	3	1
Canada	**42 790**	**251 500**	**360 520**	**333 510**	**283 620**	**1 271 940**	**14**	**100**

Sources:
Natural Resources Canada, *The National Atlas of Canada, Fifth Edition*, Ottawa, 1991.
Environment Canada, *Wetlands of Canada, 1988*, Ecological Land Classification Series No. 24, 1988.

lands are concentrated in the central provinces and are sparsest in the north and mountainous areas. Peatlands cover 12 percent or 1.1 million square kilometres of Canada.

Map 4.4.1 was produced by the National Wetlands Working Group and illustrates the distribution of wetlands in Canada based on 5 wetland concentration classes. For example, the 0-5 percent range indicates that within this category up to 5 percent of the land cover can be classified as wetland. This map was based on a limited amount of provincial data, resource maps, and data provided by resource managers familiar with wetland areas. According to this group, the conversion of wetlands have been severe in areas such as the central prairies sloughs (70 percent converted), Atlantic salt marshes (65 percent), urban wetlands (80 to 98 percent), Pacific estuarine marshes (70 percent) and southern Ontario and St. Lawrence Valley hardwood and shoreline swamps (70 to 80 percent).

Table 4.4.3

Protected Land for IUCN Categories I to IV by Ecozone, Selected Years, 1900-1993

Ecozone	Number of sites					Area protected					Change in land area protected	Ecozone	Protected area as a percentage of ecozone area	
	1900	1930	1960	1990	1993	1900	1930	1960	1990	1993[2]	1960 - 1993	area[1]	1960	1993[2]
	sites					km^2					percent	km^2	percent	
Atlantic Maritime	55	66	120	361	386	46	2 155	6 674	17 592	17 677	165	163 428	4.1	10.8
Mixed Wood Plains	365	368	452	789	794	1 097	1 124	1 307	5 305	5 316	307	151 812	0.9	3.5
Boreal Shield	138	147	248	869	903	26 874	27 709	102 393	190 128	190 847	86	1 718 285	6.0	11.1
Prairie	16	23	59	290	292	1 185	1 795	2 502	7 195	7 208	188	521 880	0.5	1.4
Boreal Plains	7	11	42	315	329	819	49 584	52 555	67 290	67 464	28	820 833	6.4	8.2
Montane Cordillera	6	14	77	311	343	10 421	25 812	32 014	53 546	76 690	140	433 238	7.4	17.7
Pacific Maritime	-	5	46	277	335	-	1 970	2 029	37 914	41 683	1 954	282 594	0.7	14.8
Boreal Cordillera	-	-	4	25	27	-	-	7 059	25 646	35 416	402	380 113	1.9	9.3
Tundra Cordillera	-	-	1	2	3	-	-	10	10 178	14 578	149 266	282 346	-	5.2
Taiga Plains	2	3	3	22	23	3 000	7 427	7 427	12 241	12 247	65	584 208	1.3	2.1
Taiga Shield	1	1	2	19	20	-	-	1 425	33 309	33 324	2 238	1 385 003	0.1	2.4
Hudson Plains	-	-	2	24	24	-	-	3 544	174 701	174 701	4 830	392 082	0.9	44.6
Southern Arctic	-	1	2	10	11	-	23 960	25 449	90 376	90 386	255	928 475	2.7	9.7
Northern Arctic	-	-	4	12	14	-	-	2 512	45 342	79 794	3 076	1 426 724	0.2	5.6
Arctic Cordillera	-	-	-	2	2	-	-	-	59 244	59 244	..	260 256	-	22.8
Canada	**590**	**639**	**1 062**	**3 328**	**3 506**	**43 443**	**141 537**	**246 900**	**830 008**	**906 576**	**267**	...	...	...

Notes:

1. Ecozone area includes a number of freshwater bodies.
2. Includes 13 827 km^2 (222 sites) of protected area reported in more than one IUCN category.

Source:

Environment Canada, State of the Environment Reporting Directorate, National Conservation Areas Database, 1993.

Protected Land

Growing population pressures and expanding economic development have made the preservation of natural space a global concern. Conservation of natural space is essential for the preservation of biological diversity. In response to the importance of this issue, the World Conservation Union (IUCN)[1] has made it an objective to protect 10 percent of the earth's surface. Canada hopes to meet this objective by protecting 10 percent of its land area.[2]

Protected Land by Ecozone

Protected areas can be of many different sizes and types. Some consist of only a few hectares others can be as vast as the north. They can be located in and around urban areas, or can be very far settlements. The motivation for designating each protected area also varies and is usually based on its natural aesthetic value, its ecological significance or its cultural importance.

Table 4.4.3 indicates that the area of protected Land has increased from 43.4 thousand square kilometres in 1900 to over 906.6 thousand square kilomtres by 1993. This represents a nationwide increase of 267 percent over the 93 year period. Despite this increase in protected land areas there is still reason for concern. Over the 15 year period between the mid 1970s and 1990 it is estimated that Canada lost 4 percent of its wild area.[3] This area is equivalent to the area of all our national parks combined.

Table 4.4.3 also presents the distribution of protected areas by ecozone. In 1993, the Hudson Plains ecozone had the largest proportion of its area protected, with more than 174.7 thousand square kilometres, or 44.6 percent of its land area protected. The Boreal Shield contained the largest area protected with more than 190.8 thousand square kilometres, or 11.1 percent of its land area protected. There were no reported declines in protected land area by ecozone over the period of study.

1. The World Conservation Union still uses the IUCN acronym from its former name - International Union for the Conservation of Nature.
2. Government of Canada, *Canada's Green Plan*, Canada Communication Group, Ottawa, 1990.
3. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Technical Box 4.4.1

IUCN Classification of Protected Land Areas, 1990

Protection Class	Description	Examples
I	Highly protected areas maintained in a natural state and closed to extractive uses public access generally limited	- Nature reserves - Ecological reserves
II	Medium to highly protected areas - public access in designated areas	- National parks - Provincial parks
III, IV, V	Moderately protected areas Human intervention allowed as long as it is consistent with conservation objectives some controlled hunting allowed, some logging permitted - (no clear cutting)	- Natural monuments - Archeological sites - Wilderness areas - Some conservation areas

Source:

World Conservation Union, 1990.

Table 4.4.4
Government Protected Land by IUCN Category and Province, 1993

Province/Territory	IUCN category I		II		III		IV		V		I to V		Land area	Protected land as a percentage of land area
	km^2	sites	km^2	sites	km^2	sites	km^2	sites	km^2	sites	km^2	sites	km^2	percent
Newfoundland	3 992	9	2 705	86	32	2	269	5	618	1	7 617	103	371 690	2.0
Prince Edward Island	-	-	45	32	-	-	288	27	-	-	333	59	5 660	5.9
Nova Scotia	14	7	1 433	124	--	2	1 740	40	-	-	3 187	173	52 840	6.0
New Brunswick	2	3	626	50	-	-	3 308	32	-	-	3 935	85	72 090	5.5
Quebec	447	45	9 367	21	15	13	78 250	135	76 829	69	164 909	283	1 356 790	12.2
Ontario	4 346	346	53 592	121	-	-	10 776	44	8 292	638	77 008	1 149	891 190	8.6
Manitoba	569	12	13 174	18	-	-	141 741	4	11 772	69	167 256	103	548 360	30.5
Saskatchewan	4 174	4	11 190	20	45	17	1 048	25	572	270	17 030	336	570 700	3.0
Alberta	1 279	18	63 903	70	57	5	1 174	134	106	4	66 519	231	644 390	10.3
British Columbia	5 667	136	97 003	406	-	-	320	26	150	134	103 140	702	929 730	11.1
Yukon	-	-	14 568	2	-	-	6 030	3	28 853	3	49 452	8	478 970	10.3
Northwest Territories	2 624	1	98 561	33	16	1	126 736	18	4 427	1	232 364	54	3 293 020	7.1
Canada	**23 114**	**581**	**366 169**	**983**	**165**	**40**	**371 681**	**493**	**131 620**	**1 189**	**892 749**	**3 286**	**9 215 430**	**9.7**

Note:
Data are adjusted to exclude areas represented in more than one category.
Source:
Environment Canada, State of the Environment Directorate, National Conservation Areas Database, 1993.

Degree of Protection

Protection levels for protected areas vary substantially. Technical Box 4.4.1 provides a summary of the 1990 IUCN protected land classification. This classification is international and is adapted in this case to fit common Canadian land designations. Table 4.4.4 lists Canadian protected land by class. The largest area of land belonged to class 4 or was only moderately protected in 1993. The sum of IUCN classes 1-5 in 1993 represented 9.7 percent of Canada's land area.

Privately Owned Conservation Areas

Until a generation ago protected areas were perceived as fortresses, protected from development or exploitation. Today the situation is different, resulting in the intensification of internal threats such as recreational overuse. These area s are also subject to external environmental threats, like acid rain and other pollution impacts.

The philosophy of protected areas management has been changing. For example, the protection of freshwater and marine areas has grown in importance. Protective actions are no longer perceived to be the exclusive responsibility of governments and a remarkable growth in private stewardship can be observed. Table 4.4.5 presents selected non-government conservation lands.

Table 4.4.5
Selected Non-Government Conservation Lands, 1993

Organization	Number of sites	Total area
		hectares
Ducks Unlimited Canada	7 892	964 784
Nature Conservancy of Canada	191	36 339
Alberta Fish and Game Association	292	25 481
British Columbia Nature Trust	92	11 589
Manitoba Wildlife Federation	77	10 419
Ontario Heritage Foundation	39	2 400
Federation of Ontario Naturalists	13	547
Ruiter Valley Land Trust	1	175
New Brunswick Nature Trust	5	94
Total	**8 602**	**1 051 828**

Source:
Environment Canada, State of the Environment Directorate.

Other Protected Spaces

Green space in urban areas are also very important protected lands. Although no rigorous estimates yet exist, significant areas are protected as urban green space in Canada.[1]

1. A digital satellite database is being developed at Statistics Canada, known as the Urban Land Information Database. This database will estimate green spaces for major CMAs across Canada in the near future.

4.5 Soil Quality

Prime agricultural land[1] occupies less than one half of one per cent of Canada's land area. It is estimated that 37 per cent of this land can be seen from the top of Toronto's CN tower on a clear day.[2]

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Canada has a limited amount of dependable high quality land (Map 4.5.1). Land in Canada Land Inventory (CLI) classes 1-3 represents this land supply. Soils in these classes have fair to high capability for agriculture (Table 4.5.1) and are considered capable of long term crop production. Some soils in classes 4 and 5 are used for production today, although they are subject to severe limitations.

1. Canada Land Inventory - class one capability for agriculture.
2. Environment Canada, *Canada's Special Resource Lands*, Ottawa, 1979.

Technical Box 4.5.1

Canada Land Inventory Classes 1-3

Class 1 - Soils in this class have no significant limitations for crops. These deep soils are level or have very gentle slopes, are well to imperfectly drained and have a good water holding capacity. They are easily maintained in good tilth and productivity, and damage from erosion is slight. They are moderately high to high in productivity for a wide range of field crops adapted to the region.

Class 2 - Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices. These deep soils have a good water holding capacity, can be managed with little difficulty and are moderately high to high in productivity for fairly wide range of field crops. The moderate limitations of these soils may be from any one of a number of factors including mildly adverse regional climate, moderate effects of erosion, poor soil structure or low permeability, low fertility correctable with lime, gentle to moderate slopes, or occasional overflow or wetness.

Class 3 - Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices. Under good management these soils are fair to moderately fair in productivity for a wide range of field crops adapted to the region. Conservation practices are more difficult to apply and maintain. Limitations arise from a combination of two of the factors described under class 2, or from one of the following factors including climate, erosion potential, low fertility, strong slopes, poor drainage, low water holding capacity, or salinity.

Table 4.5.1

Dependable Land, Canada Land Inventory Classes 1-3

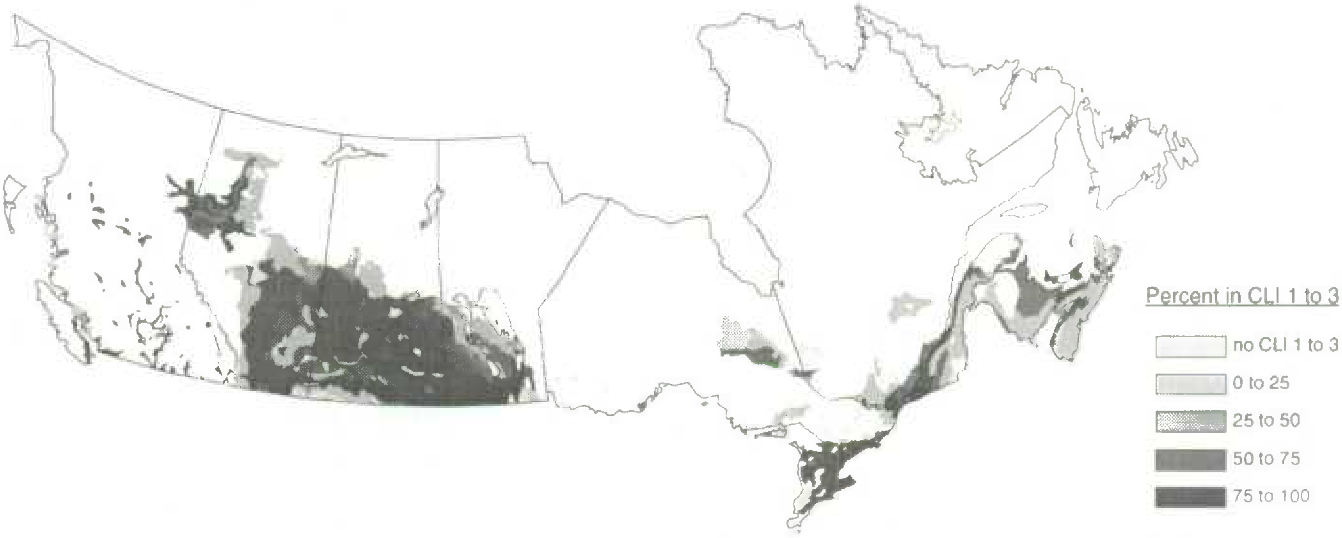
Province/Territory	Total land	Soil capability class 1	Soil capability class 2	Soil capability class 3	Proportion of land area by class 1	Proportion of land area by class 2	Proportion of land area by class 3
	km²				percent		
Newfoundland	371 690	-	-	19	-	-	-
Prince Edward Island	5 660	-	2 516	1 415	-	44.5	25.0
Nova Scotia	52 840	-	1 663	9 829	-	3.1	18.6
New Brunswick	72 090	-	1 605	11 511	-	2.2	16.0
Quebec	1 356 790	196	9 071	12 772	--	0.7	0.9
Ontario	891 190	21 568	22 177	29 088	2.4	2.5	3.3
Manitoba	548 360	1 625	25 306	24 407	0.3	4.6	4.5
Saskatchewan	570 700	9 997	58 744	94 247	1.8	10.3	16.5
Alberta	644 390	7 865	38 371	61 053	1.2	6.0	9.5
British Columbia	929 730	211	2 355	6 920	--	0.2	0.7
Yukon	478 970	-	-	-	-	-	-
Northwest Territories	3 293 020	-	-	-	-	-	-
Canada	**9 215 430**	**41 461**	**161 808**	**251 261**	**0.5**	**1.8**	**2.7**

Note:
Figures may not add due to rounding.
Source:
Environment Canada, *Agricultural Land Use Change in Canada*, Ottawa, 1992.

The CLI provides a snapshot of soil quality that is now more than 25 years old. While much of it is still valid, detecting important changes in soil quality is not possible with this data. Various new initiatives now provide indications of changing local soil quality. One federal-provincial initiative, the Soil Landscapes of Canada Project, will be of considerable help in estimating soil quality changes over time. This project has produced detailed digital maps of Canada's soils.[3] These should facilitate future research by providing scientists with the tools to properly assess and quantify changing soil quality.

3. Agriculture Canada, *Soil Landscapes of Canada Map Series*, Centre for Land and Biological Resources Research, various maps and reports, 1993.

Map 4.5.1
Dependable Agricultural Land



Note:
In order to maximize detail, only provinces with significant amounts of agriculture are shown.
Source:
Environment Canada, *Agricultural Land Use Change in Canada*, Ottawa, 1982.

4.6 Land Cover

The State of Canada's Environment[1] concludes that the use of Canada's abundant land resources is often at odds with the capabilities of that land to support these activities: 20 percent of our farmland is deteriorating as a result of modern agricultural practices, 13 percent of our forests can no longer be considered productive, and much of the best farmland in the country is being converted to urban uses.

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Land can be classified in many ways; traditionally land has been classified by its economic use. These land categories generally include forestry, recreation and conservation, agriculture, urban/industrial and other activities (Table 4.6.1). This "other" category accounts for 61 percent of Canada's land mass and is home to the more scattered economic activities: hunting and trapping, mining and transportation. The direct economic value of the "other" land may seem quite low but it is important for many other reasons such as the provision of wildlife habitat, the additional recreational space it provides for people and even more importantly for the role it plays in filtering air and water.

Table 4.6.1
Land Activity in Canada, 1985

Land use category	Description	Area[1]	Share of total
		thousand km²	percent
Forestry	Active forest harvesting or potential for future harvest	2 440	24
Recreation and conservation	Recreation and conservation within national, provincial and territorial parks, wildlife reserves, sanctuaries, etc	708	7
Agriculture	Agriculture on improved farmland (cropland, improved pasture, summerfallow) and unimproved farmland	678	7
Urban/industrial[2]	Residential and industrial activities of urban environments	72	1
Other activities	Includes hunting and trapping, mining, energy developments and transportation	6 072	61
Total		**9 970**	**100**

Notes:
1. Includes the area of all land and fresh water.
2. Includes only the 25 major metropolitan areas.
Source:
Government of Canada, *The State of Canada's Environment*. Ottawa, 1991.

Another way of classifying land is by its biophysical potential for supporting certain activities. This is the approach taken in classifying soil potential,[2] and is also used in the *Canada Land Inventory* completed in the 1960s.[3] This provides only a potential classification and does not detail actual land use. For example, land may be perfectly suitable for growing corn, but is actually being used for housing or industry. Table 4.6.2 summarizes land cover. Only 1 percent of Canada is actual built-up or urban area.

Table 4.6.2
Primary Land Cover in Canada, 1989

Land cover class	Predominant cover in class	Area[1]	Share of total
		thousand km²	percent
Forest and Taiga	Closed canopy and/or open stands of trees with secondary occurrences of wetland, barren land or others	4 456	45
Tundra/sparse vegetation	Well-vegetated to sparsely-vegetated or barren land, mostly in arctic or alpine environments	2 303	23
Wetland	Treed and non-treed fens, bogs, swamps, marshes, shallow open water and coastal and shore marshes	1 244	12
Fresh water	Lakes, rivers, streams and reservoirs	755	8
Cropland	Fenced land (including cropland and pasture land), hedge rows, farms and orchards	658	6
Rangeland	Generally, non-fenced pasture land, grazing land; includes natural grassland that is not necessarily used for agriculture	203	2
Ice/snow	Permanent ice and snow fields (glaciers, ice caps)	272	3
Built-up	Urban and industrial lands	79	1
Total		**9 970**	**100**

Notes:
Figures may not add due to rounding.
1. Includes the area of all land and fresh water.
Source:
Government of Canada, *The State of Canada's Environment*. Ottawa, 1991.

Yet another perspective to land classification is the Ecological Land Classification developed by Environment Canada[4] and described in detail in Section 1.4 - **Geographic Units for Environmental Analysis**. This approach builds upon vegetation cover, climate and physiographic information to provide a consistent geographic frame from which to interpret and integrate information from other sources.

An important issue in land use decisions is the ownership of the land. Since different jurisdictions are involved, integrated planning of land use is difficult. Land ownership (Table 4.6.3) ranges from mostly private (Prince Edward Island, Nova Scotia and New Brunswick), to mostly provincial or territorial (Newfoundland, British Columbia, Quebec and Ontario) to mostly federal.

1. Government of Canada, *The State of Canada's Environment*, Ottawa, Canada, 1991.
2. Agriculture Canada, Land Potential Database, Centre for Land and Biological Research, 1989.
3. Environment Canada, Canada Land Use Database.
4. Environment Canada, *Terrestrial Ecozones of Canada*, Ecological Land Classification Series No. 19, Ottawa, 1986.

Table 4.6.3

Land Tenure in Canada, 1990

Province/Territory	Total land	Crown land: Federal[1]	Crown land: Provincial or Territorial[2]	Private land[3]
	km^2	percent share of total land		
Newfoundland	371 690	0.7	94.9	4.4
Prince Edward Island	5 660	0.8	12.1	87.1
Nova Scotia	52 840	2.9	29.8	67.3
New Brunswick	72 090	3.0	42.9	54.1
Quebec	1 356 790	0.2	92.1	7.7
Ontario	891 190	0.8	88.8	11.1
Manitoba	548 360	0.8	78.0	21.2
Saskatchewan	570 700	2.4	57.7	37.9
Alberta	644 390	9.6	62.6	27.8
British Columbia	929 730	0.9	93.3	5.8
Yukon	478 970	99.8	0.2	0.0
Northwest Territories	3 293 020	99.9	0.1	0.0
Total	**9 215 430**	**40.3**	**50.0**	**9.7**

Notes:
This table does not account for lands under the responsibility of the First Nations Peoples.
Figures may not add due to rounding.
1. Includes federal Crown lands, national parks and federal forest experiment stations.
2. Includes provincial or territorial parks and provincial forests.
3. Includes privately owned land or land in process of alienation from the Crown.
Source:
Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

4.7 Agricultural Land

Canada's agricultural land is one of its most valuable natural assets. This land provides food and contributes to the economic security of all Canadians. However, Canada's supply of quality agricultural land is quite small in relation to our total land area. The percentage of Canadian land that is arable is also small in comparison to that of most developed countries. Canada, the world's second largest country, had more than 46 million hectares of arable land available for crop production in 1989.[1] This figure represents under 5 percent of Canada's land area or roughly 3 percent of the global stock of arable land. By comparison, the former U.S.S.R. had 233 million hectares of arable land or more than 10 percent of its land area; this represented 16 percent of global arable land resources.[2] This section provides historical data that describe the changing stock of agricultural land in Canada.

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The Census of Agriculture definitions used to classify land are shown in Technical Box 4.7.1.

Agricultural Land Use by Drainage Sub-basin

Land uses on farms are changing continually. Table 4.7.1 summarizes historical land uses data from 1901 to 1991.

1. World Resources Institute, *World Resources 1990-91*, Oxford University Press, London, 1990.
2. Ibid.

Technical Box 4.7.1

Census Definitions

Census Variable	Definition
Farmland	total area of land operated
Cropland	total area seeded for harvest
Summerfallow	land from which no crop is harvested, that is worked or sprayed during the crop season, primarily for moisture conservation
Improved land	land under crops, improved pasture or summerfallow
Unimproved land	native pasture, range land, woodland, bogs and marshes

Farmland area has been stable since the 1940s. Improved farmland areas continue to occupy an increasing share of the farmland resource, indicating that less farmland is being left idle and more land is being brought into production.

The number of farms has been steadily declining since the 1940s. Table 4.7.1 indicates that between 1941 and 1991, the number of farms declined from 733 thousand to 280 thousand. The average size of a farm has increased substantially since 1901. The decreasing number of farms on a stable land base indicates that fewer people are operating more land.

Table 4.7.2 provides a regional breakdown of farmland and farm size by drainage sub-basin. Nationally, average farm size has increased by 29 percent, between 1971 and 1991 (from a 188 hectares to 242 hectares). Regional variations in this trend are also significant. The greatest increases occurred in the east where farm sizes rose in some cases by more than by 50 percent in the last 20 years. Western Canada has the largest average farm sizes - as high as 442 hectares in Saskatchewan. Increases in average farm size are more gradual on the Prairies; they ranged from 36.7 percent in Manitoba to 13.8 percent in Alberta.

Table 4.7.1

Farms and Farmland, 1901-1991

Year	Improved farmland: Cropland	Improved farmland: Improved pasture	Improved farmland: Summer-fallow	Improved farmland: Other land[1]	Unimproved farmland	Total farmland	Number of farms	Average farm size
	million hectares						thousands	hectares per farm
1901	8.1	..	..	4.1	13.5	25.7	511.1	50.3
1911	14.4	..	1.0	4.3	24.4	44.1	682.8	64.6
1921	20.2	3.1	4.8	0.5	28.4	57.0	711.1	80.2
1931	23.6	3.2	6.8	1.1	31.3	66.0	728.6	90.6
1941	22.8	3.4	9.5	1.4	33.1	70.2	732.9	95.8
1951	25.2	4.0	8.9	1.1	31.2	70.4	623.1	113.0
1961	25.3	4.1	11.4	1.0	28.0	69.8	480.9	145.1
1971	27.8	4.1	10.8	1.0	25.0	68.7	366.1	187.7
1976	28.3	4.1	10.9	0.9	24.2	68.4	338.6	202.0
1981	30.9	4.1	9.7	1.4	19.8	65.9	318.4	207.0
1986	33.2	3.6	8.5	0.7	21.8	67.8	293.1	231.3
1991	33.5	4.1	7.9	..	..	67.8	280.0	242.1

Note:
1. Other land refers to barn yards, laneways and other unclassified lands.

Source:
Statistics Canada, *Handbook of Agricultural Statistics*, Catalogue No. 21-503, Ottawa, various issues

Some drainage sub-basins are almost entirely made up of farmland. Saskatchewan drainage sub-basins have the highest proportion in farmland of any province. Table 4.7.2 indicates that 72 percent of drainage sub-basin areas in Saskatchewan are in agricultural land. Such high concentrations of farmland indicate large scale modification of natural ecosystems.

Table 4.7.3 indicates regional changes in cropland and summerfallow areas between 1971 and 1991. These two are the largest components of improved farmland area. Cropland area has increased steadily since 1901, despite the apparent stabilization of total farmland in 1931 (Table 4.7.1). This illustrates an intensification in agricultural land use where a greater proportion of farmland is being regularly cultivated.

Table 4.7.2

Farmland and Average Farm Size by Sub-basin, 1971, 1981 and 1991

Provincial sub-basin[1]	Sub-basin area	Farmland area 1971	Farmland area 1981	Farmland area 1991	Change 1971-1991	Proportion in farmland 1991	Average farm size 1971	Average farm size 1981	Average farm size 1991	Change 1971-1991
	hundred hectares				percent		hectares per farm			percent
Newfoundland										
North Newfoundland	66 367	58.0	65.4	135.1	132.7	0.2	21	32	54	156.9
South Newfoundland	46 058	195.7	269.2	338.4	72.9	0.7	26	56	71	178.9
Total	**112 425**	**253.8**	**334.5**	**473.5**	**86.6**	**0.4**	**24**	**49**	**65**	**168.2**
Prince Edward Island										
Prince Edward Island	5 660	3 134.8	2 830.2	2 588.7	-17.4	45.7	69	90	110	58.9
Total	**5 660**	**3 134.8**	**2 830.2**	**2 588.7**	**-17.4**	**45.7**	**69**	**90**	**110**	**58.9**
Nova Scotia										
Bay of Fundy	20 860	3 797.5	3 537.6	3 054.2	-19.6	14.6	94	98	104	10.6
Southeast Atlantic Ocean	23 062	1 038.3	781.5	607.0	-41.5	2.6	79	75	85	8.5
Cape Breton Island	11 568	542.0	341.1	309.1	-43.0	2.7	85	85	95	12.3
Total	**55 490**	**5 377.8**	**4 660.2**	**3 970.3**	**-26.2**	**7.2**	**90**	**92**	**100**	**11.4**
New Brunswick										
Saint John and South Bay of Fundy	34 627	3 707.0	3 076.0	2 649.7	-28.5	7.7	105	114	126	19.2
Gulf of St. Lawrence and North Bay of Fundy	38 736	1 712.3	1 302.9	1 106.7	-35.4	2.9	87	95	97	11.2
Total	**73 363**	**5 419.3**	**4 378.9**	**3 756.3**	**-30.7**	**5.1**	**99**	**108**	**116**	**16.9**
Quebec										
Saint John	7 011	1 216.4	1 002.2	886.0	-27.2	12.6	97	123	122	26.1
Cascapedia and Gulf of St. Lawrence	21 809	1 287.9	1 001.3	758.3	-41.1	3.5	79	114	145	82.9
Upper Ottawa	33 256	1 256.7	1 146.1	972.0	-22.6	2.9	107	175	196	83.1
Coulonge and Central Ottawa	17 320	846.2	772.5	741.0	-12.4	4.3	94	102	115	22.5
Gatineau and Lower Ottawa	45 401	3 198.1	2 630.2	2 249.5	-29.7	5.0	94	97	102	8.7
Upper St. Lawrence	955	662.8	648.7	626.3	-5.5	65.6	62	71	89	44.4
St-Maurice	44 296	224.2	148.9	104.0	-53.6	0.2	70	74	82	16.9
Central St. Lawrence	34 539	17 191.3	15 235.3	14 439.6	-16.0	41.8	64	67	78	22.0
Lower St Lawrence	37 577	11 237.9	9 483.9	8 473.8	-24.6	22.6	65	70	79	22.0
North Gaspé Peninsula	13 795	2 892.8	2 239.1	1 835.0	-36.6	13.3	89	114	135	51.9
Saguenay	87 489	2 483.2	2 178.4	2 148.5	-13.5	2.5	92	111	150	62.3
Betsiamites	27 280	52.0	36.9	28.6	-45.0	0.1	104	123	143	37.4
Manicouagan and Outardes	67 763	21.6	24.5	46.4	114.8	0.1	108	91	140	30.2
Natashquan and Gulf of St. Lawrance	47 282	9.6	9.0	3.5	-63.4	--	9	13	15	64.7
Nottaway	65 559	81.9	158.7	115.7	41.2	0.2	114	203	218	91.8
Abitibi and North French	4 297	687.6	663.3	558.8	-18.7	13.0	108	155	202	86.7
Harricanaw	28 598	360.3	412.5	309.0	-14.2	1.1	108	147	197	83.0
Total	**584 227**	**43 710.6**	**37 791.7**	**34 296.1**	**-21.5**	**5.9**	**71**	**78**	**90**	**26.2**
Ontario										
Nipigon and Northwest Lake Superior	43 038	429.2	341.1	255.9	-40.4	0.6	103	97	97	-6.6
Northeast Lake Superior	40 068	24.9	23.6	28.5	14.8	0.1	44	39	48	7.2
North Lake Huron	34 378	1 631.8	1 479.3	1 313.3	-19.5	3.8	148	135	148	0.4
Wanipitai and French	19 109	944.7	787.2	584.2	-38.2	3.1	128	112	117	-8.1
East Georgian Bay	22 254	5 086.9	4 714.9	4 072.4	-19.9	18.3	68	71	76	10.6
East Lake Huron	14 810	11 484.0	10 857.2	9 996.0	-13.0	67.5	73	78	84	15.2
North Lake Erie	22 944	18 132.6	17 755.9	17 179.4	-5.3	74.9	56	63	71	28.4
Lake Ontario	28 709	12 327.4	11 419.4	9 909.4	-19.6	34.5	60	64	69	15.1
Montréal and Upper Ottawa	17 624	1 003.9	1 049.7	863.7	-14.0	4.9	120	134	138	15.1
Madawaska, Petawawa and Central Ottawa	22 903	4 026.0	3 474.4	2 865.5	-28.8	12.5	110	104	102	-6.9
Rideau and Lower Ottawa	9 009	5 621.7	4 897.0	4 503.7	-19.9	50.0	77	81	87	14.0
Upper St. Lawrence	4 454	2 525.2	2 116.4	1 691.6	-33.0	38.0	82	87	94	15.6
Moose	63 296	133.4	120.6	97.7	-26.8	0.2	122	107	111	-9.3
Abitibi	32 707	273.4	338.1	242.4	-11.3	0.7	118	156	143	21.0
Upper Winnipeg	43 435	758.0	847.4	718.5	-5.2	1.7	147	175	192	30.5
English	51 416	197.5	169.9	191.7	-2.9	0.4	169	159	186	10.3
Total	**470 153**	**64 600.2**	**60 392.4**	**54 513.8**	**-15.6**	**11.6**	**68**	**73**	**79**	**16.5**

Table 4.7.2

Farmland and Average Farm Size by Sub-basin, 1971, 1981 and 1991 (Continued)

Provincial sub-basin[1]	Sub-basin area	Farmland area 1971	Farmland area 1981	Farmland area 1991	Change 1971-1991	Proportion in farmland 1991	Average farm size 1971	Average farm size 1981	Average farm size 1991	Change 1971-1991
	hundred hectares				percent		hectares per farm			percent
Manitoba										
Saskatchewan	18 815	438.2	380.8	493.8	12.7	2.6	337	286	229	-32.2
Lake Winnipegosis and Lake Manitoba	54 912	23 932.8	23 515.7	24 850.3	3.8	45.3	261	310	367	40.5
Assiniboine	24 874	19 056.2	18 875.1	18 822.5	-1.2	75.7	249	287	336	34.8
Souris	9 040	8 066.8	6 142.5	8 141.3	0.9	90.1	297	350	395	32.9
Red	25 547	20 378.8	20 567.2	20 036.3	-1.7	78.4	167	198	225	34.9
Winnipeg	12 973	716.5	697.3	643.3	-10.2	5.0	129	147	172	33.6
West Lake Winnipeg	23 910	4 334.4	3 980.6	4 262.4	-1.7	17.6	171	202	242	41.3
Total	**170 071**	**76 923.7**	**76 159.3**	**77 249.9**	**0.4**	**45.4**	**220**	**259**	**301**	**36.7**
Saskatchewan										
Central North Saskatchewan	14 482	11 302.8	11 010.7	10 848.6	-4.0	74.9	361	404	487	34.9
Battle	4 431	3 503.0	3 556.2	4 137.3	18.1	93.4	413	479	509	23.2
Lower North Saskatchewan	41 103	35 508.5	34 928.9	34 793.7	-2.0	84.7	362	401	453	25.0
Lower South Saskatchewan	55 013	51 126.7	50 003.7	52 653.0	3.0	95.7	391	418	480	22.5
Qu'Appelle	70 192	66 251.9	66 348.7	68 593.8	3.5	97.7	344	382	433	25.9
Saskatchewan	58 186	12 903.2	12 706.8	13 549.9	5.0	23.3	233	280	319	36.6
Lake Winnipegosis and Lake Manitoba	18 789	7 778.8	8 302.0	7 410.6	-4.7	39.4	231	284	328	42.2
Assiniboine	26 964	23 767.9	23 599.8	24 391.2	2.6	90.5	227	281	329	45.1
Souris	29 449	26 970.6	26 552.1	28 436.1	5.4	96.6	353	401	447	26.7
Beaver	32 379	6 369.6	5 540.9	5 917.2	-7.1	18.3	373	369	486	30.3
Missouri	20 506	17 792.9	16 921.1	17 923.5	0.7	87.4	839	908	1 006	20.0
Total	**371 494**	**263 275.8**	**259 470.9**	**268 654.9**	**2.0**	**72.3**	**342**	**385**	**442**	**29.1**
Alberta										
Upper South Saskatchewan	45 921	35 599.1	34 880.8	39 535.8	11.1	86.1	500	504	561	12.3
Bow	25 442	13 625.5	12 384.8	12 399.4	-10.3	48.7	394	368	383	-2.7
Red Deer	49 135	41 025.2	37 849.7	41 859.9	2.0	85.2	367	367	384	4.7
Upper North Saskatchewan	27 964	5 534.3	5 061.1	6 311.9	14.1	22.6	156	156	172	10.8
Central North Saskatchewan	28 759	24 091.9	22 404.2	24 315.5	0.9	84.5	201	216	241	20.3
Battle	25 703	23 464.4	23 159.0	22 321.5	-4.9	86.8	300	321	357	19.0
Lower North Saskatchewan	10 764	10 543.2	10 859.9	10 521.0	-0.2	97.7	853	916	866	1.5
Beaver	16 973	4 145.3	3 649.7	5 034.6	21.5	29.7	260	244	330	26.9
Upper Athabasca	34 896	1 235.3	1 099.5	1 405.6	13.8	4.0	225	195	230	2.2
Pembina and Central Athabasca	41 135	9 764.1	9 863.1	10 570.1	8.3	25.7	205	215	248	21.3
Lower Central Athabasca	42 244	2 040.3	1 980.6	2 295.0	12.5	5.4	219	240	291	32.4
Upper Peace	17 550	7 888.1	7 775.8	8 544.9	8.2	48.7	299	335	435	45.4
Smoky	46 148	9 443.3	9 127.0	10 837.2	14.8	23.5	270	281	341	26.3
Central Peace	35 731	4 108.5	5 019.9	5 278.4	28.5	14.8	282	295	370	31.2
Lower Central Peace	58 730	752.8	944.7	1 627.8	116.2	2.8	264	345	381	44.3
Upper Hay	39 721	-	-	122.7	...	0.3	-	-	361	...
Missouri	6 982	6 883.5	5 025.5	5 128.9	-25.5	73.5	1 326	1 158	1 346	1.5
Total	**553 797**	**200 344.8**	**191 085.1**	**208 110.0**	**3.9**	**37.6**	**320**	**329**	**364**	**13.8**
British Columbia										
Williston Lake	72 865	53.9	109.0	75.6	40.2	0.1	449	363	329	-26.8
Upper Peace	49 133	6 716.6	7 104.9	7 862.3	17.1	16.0	387	385	481	24.3
Skeena	56 521	853.8	816.3	691.4	-19.0	1.2	286	195	174	-39.0
Gardner Canal and Central Pacific Ocean	52 379	81.7	46.0	65.5	-19.9	0.1	227	124	193	-15.1
Knight Inlet and South Pacific Ocean	43 196	97.8	106.2	97.9	0.1	0.2	104	62	44	-58.0
Vancouver Island	34 786	501.7	475.5	536.8	7.0	1.5	28	23	23	-18.6
Nechako	46 939	1 342.2	1 426.9	1 839.7	37.1	3.9	256	206	279	9.0
Upper Fraser	65 949	1 437.9	1 521.1	1 696.2	18.1	2.6	187	150	194	3.7
Thompson	55 991	5 457.9	4 481.7	4 603.5	-15.7	8.2	364	233	231	-36.6
Fraser	63 094	3 207.9	2 865.1	3 302.2	2.9	5.2	48	45	54	12.2
Columbia	102 684	3 821.5	2 793.6	2 807.6	-26.5	2.7	77	52	58	-24.8
Residual Sub-basins	...	10.9	37.7	342.8	...	...	64	171	519	...
Total	**643 538**	**23 583.8**	**21 786.0**	**23 923.4**	**1.4**	**3.7**	**128**	**109**	**124**	**-2.8**
Canada	**3 064 120**	**686 624.4**	**658 889.2**	**677 537.0**	**-1.3**	**22.1**	**188**	**207**	**242**	**29.0**

Notes:
Figures may not add due to rounding.
1. Includes only sub-basins where agriculture is present.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 4.7.3

Cropland and Summerfallow Area by Sub-basin, 1971, 1981 and 1991

Provincial sub-basin[1]	Cropland area 1971	Cropland area 1981	Cropland area 1991	Cropland area Change 1971-1991	Summerfallow area 1971	Summerfallow area 1981	Summerfallow area 1991	Summerfallow area Change 1971-1991
	hectares			percent	hectares			percent
Newfoundland								
North Newfoundland	1 034	1 626	2 485	140.4	62	197	57	-8.4
South Newfoundland	2 502	3 118	3 789	51.4	140	161	88	-36.8
Total	**3 535**	**4 744**	**6 274**	**77.5**	**202**	**358**	**145**	**-28.1**
Prince Edward Island								
Prince Edward Island	142 200	158 280	154 103	8.4	3 717	3 027	997	-73.2
Total	**142 200**	**158 280**	**154 103**	**8.4**	**3 717**	**3 027**	**997**	**-73.2**
Nova Scotia								
Bay of Fundy	82 623	95 541	90 779	9.9	2 261	4 479	999	-55.8
Southeast Atlantic Ocean	9 169	10 635	9 205	0.4	181	418	167	-7.6
Cape Breton Island	6 530	6 606	6 248	-4.3	96	256	20	-79.3
Total	**98 322**	**112 782**	**106 231**	**8.0**	**2 538**	**5 154**	**1 186**	**-53.3**
New Brunswick								
Saint John and South Bay of Fundy	93 055	92 137	87 852	-5.6	2 333	3 074	974	-58.3
Gulf of St. Lawrence and North Bay of Fundy	37 379	38 390	34 395	-8.0	1 145	2 109	577	-49.6
Total	**130 434**	**130 526**	**122 247**	**-6.3**	**3 478**	**5 183**	**1 551**	**-55.4**
Quebec								
Saint John	30 596	25 924	23 132	-24.4	429	1 119	317	-26.1
Cascapedia and Gulf of St. Lawrence	37 479	35 896	28 891	-22.9	632	1 574	215	-66.0
Upper Ottawa	44 780	43 145	34 368	-23.3	941	1 695	537	-42.9
Coulonge and Central Ottawa	26 872	29 043	27 149	1.0	353	1 016	360	1.8
Gatineau and Lower Ottawa	92 862	89 612	78 477	-15.5	2 514	3 817	908	-63.9
Upper St. Lawrence	41 242	47 862	49 769	20.7	779	1 310	221	-71.7
St-Maurice	5 853	4 903	3 970	-32.2	355	459	25	-92.9
Central St. Lawrence	827 676	850 011	835 336	0.9	15 635	21 909	6 988	-55.3
Lower St. Lawrence	414 921	394 186	350 117	-15.6	5 862	11 856	2 804	-52.2
North Gaspé Peninsula	102 446	93 747	81 011	-20.9	2 133	2 913	954	-55.3
Saguenay	91 980	97 564	95 154	3.5	2 152	2 785	951	-55.8
Betsiamites	960	923	546	-43.1	45	51	131	193.6
Manicouagan and Outardes	507	532	504	-0.6	36	38	30	-18.9
Natashquan and Gulf of St. Lawrence	344	416	151	-56.2	29	28	17	-40.8
Nottaway	2 470	4 774	2 350	-4.9	226	648	38	-83.2
Abitibi and North French	22 851	23 133	18 535	-18.9	552	1 464	51	-90.8
Harricanaw	11 379	14 368	8 995	-21.0	379	392	166	-56.2
Total	**1 755 217**	**1 756 038**	**1 638 453**	**-6.7**	**33 051**	**53 077**	**14 712**	**-55.5**
Ontario								
Nipigon and Northwest Lake Superior	13 287	13 865	10 574	-20.4	507	334	191	-62.4
Northeast Lake Superior	845	931	723	-14.5	46	19	32	-29.2
North Lake Huron	32 879	35 756	32 291	-1.8	1 138	1 374	1 330	16.8
Wanipitai and French	23 824	25 159	18 951	-20.5	1 138	1 226	1 080	-5.1
East Georgian Bay	220 091	256 142	231 946	5.4	10 256	7 372	7 012	-31.6
East Lake Huron	571 081	697 505	665 449	16.5	10 176	6 517	6 842	-32.8
North Lake Erie	1 253 067	1 424 234	1 397 020	11.5	38 750	13 676	15 904	-59.0
Lake Ontario	549 304	611 805	539 203	-1.8	24 558	20 172	18 355	-25.3
Montréal and Upper Ottawa	38 804	50 230	40 570	4.5	477	849	858	80.0
Madawaska, Petawawa and Central Ottawa	102 066	111 148	95 777	-6.2	1 282	1 948	2 632	105.3
Rideau and Lower Ottawa	247 123	266 691	258 144	4.5	5 489	6 129	5 696	3.8
Upper St. Lawrence	92 703	97 110	83 899	-9.5	1 462	1 749	1 851	26.6
Moose	4 294	4 717	3 679	-14.3	23	214	170	636.8
Abitibi	7 069	9 466	6 774	-4.2	225	250	606	169.4
Upper Winnipeg	17 765	22 871	21 640	21.8	553	1 365	792	43.2
English	4 963	5 098	5 027	1.3	202	113	308	52.0
Total	**3 179 166**	**3 632 727**	**3 411 667**	**7.3**	**96 281**	**63 309**	**63 657**	**-33.9**
Manitoba								
Saskatchewan	14 073	20 066	22 748	61.6	4 706	3 998	3 208	-31.8
Lake Winnipegosis and Lake Manitoba	862 186	1 040 183	1 169 588	35.7	276 585	168 350	80 496	-70.9
Assiniboine	874 898	1 056 173	1 171 526	33.9	371 173	226 636	121 122	-67.4
Souris	417 574	517 931	566 293	35.6	146 480	71 932	40 001	-72.7
Red	1 309 099	1 542 327	1 568 839	19.8	226 494	85 557	31 063	-86.3
Winnipeg	31 757	38 522	36 762	15.8	5 191	5 157	3 284	-36.7
West Lake Winnipeg	182 147	205 168	225 295	23.7	43 891	36 708	17 826	-59.4
Total	**3 691 734**	**4 420 369**	**4 761 050**	**29.0**	**1 074 520**	**598 338**	**296 998**	**-72.4**

Table 4.7.3

Cropland and Summerfallow Area by Sub-basin, 1971, 1981 and 1991 (Continued)

Provincial sub-basin[1]	Cropland area 1971	Cropland area 1981	Cropland area 1991	Change 1971-1991	Summerfallow area 1971	Summerfallow area 1981	Summerfallow area 1991	Change 1971-1991
	hectares			percent	hectares			percent
Saskatchewan								
Central North Saskatchewan	391 369	495 035	529 642	35.3	224 141	171 507	88 311	-60.6
Battle	132 023	172 032	244 399	85.1	83 373	62 435	55 266	-33.7
Lower North Saskatchewan	1 520 659	1 601 050	1 784 682	17.4	942 034	945 210	770 634	-18.2
Lower South Saskatchewan	2 063 359	2 131 042	2 359 167	14.3	1 364 109	1 405 944	1 277 862	-6.3
Qu'Appelle	2 988 427	2 986 891	3 427 097	14.7	1 954 180	2 109 313	1 898 000	-2.9
Saskatchewan	680 792	828 977	971 608	42.7	348 011	215 834	147 685	-57.6
Lake Winnipegosis and Lake Manitoba	322 903	414 618	439 733	36.2	182 784	168 898	85 272	-53.3
Assiniboine	1 115 347	1 209 356	1 502 629	34.7	571 116	542 545	356 315	-37.6
Souris	1 262 827	1 286 957	1 523 536	20.6	686 716	717 810	670 827	-2.3
Beaver	184 503	210 226	223 187	21.0	66 356	56 016	29 565	-55.4
Missouri	401 550	404 679	453 234	12.9	278 703	308 952	333 094	19.5
Total	**11 063 759**	**11 740 864**	**13 458 915**	**21.6**	**6 701 523**	**6 704 464**	**5 712 830**	**-14.8**
Alberta								
Upper South Saskatchewan	1 124 743	1 388 114	1 489 960	32.5	638 501	551 724	480 695	-24.7
Bow	468 400	514 723	487 797	4.1	190 981	148 599	133 062	-30.3
Red Deer	1 404 836	1 570 457	1 751 919	24.7	546 440	417 570	381 152	-30.2
Upper North Saskatchewan	245 851	237 445	276 061	12.3	34 569	26 831	15 903	-54.0
Central North Saskatchewan	1 099 863	1 205 047	1 341 819	22.0	357 583	210 580	144 247	-59.7
Battle	974 623	1 221 273	1 236 682	26.9	406 189	241 196	143 085	-64.8
Lower North Saskatchewan	256 569	313 000	369 614	44.1	149 197	178 301	158 131	6.0
Beaver	130 697	148 922	183 648	40.5	33 180	19 682	17 183	-48.2
Upper Athabasca	27 230	31 883	45 506	67.1	4 817	3 169	3 283	-31.8
Pembina and Central Athabasca	412 483	446 791	480 828	16.6	93 042	47 075	30 390	-67.3
Lower Central Athabasca	77 918	81 488	96 292	23.6	21 755	13 076	9 599	-55.9
Upper Peace	357 130	395 555	461 954	29.4	111 715	106 903	68 234	-38.9
Smoky	431 617	485 679	582 200	34.9	119 564	104 756	75 962	-36.5
Central Peace	163 494	254 795	296 796	61.7	53 655	65 381	39 614	-26.2
Lower Central Peace	23 050	38 897	77 842	237.7	8 435	13 399	15 548	84.3
Missouri	103 289	107 175	113 125	9.5	66 702	57 226	55 306	-17.1
Total	**7 321 792**	**8 441 242**	**9 292 043**	**26.9**	**2 836 326**	**2 205 468**	**1 771 395**	**-37.5**
British Columbia[1]								
Upper Peace	209 510	258 123	254 662	21.6	62 552	49 481	45 232	-27.7
Skeena	10 958	16 752	14 784	34.9	310	691	392	26.4
Vancouver Island	11 175	15 600	15 343	37.3	353	673	415	17.5
Nechako	20 022	39 045	46 349	131.5	1 169	2 684	2 358	101.7
Upper Fraser	23 690	35 975	37 569	58.6	609	1 525	1 817	198.6
Thompson	41 569	52 936	50 452	21.4	985	1 792	1 486	50.8
Fraser	56 398	73 157	68 470	21.4	1 412	3 520	2 651	87.8
Columbia	66 584	70 097	60 751	-6.8	2 291	1 954	2 327	1.6
Residual Sub-Basins	2 416	6 557	8 415	248.4	270	1 208	797	195.8
Total	**442 321**	**568 241**	**556 796**	**25.9**	**69 951**	**63 528**	**57 476**	**-17.8**
Canada	**27 828 479**	**30 965 812**	**33 507 779**	**20.4**	**10 821 587**	**9 701 906**	**7 920 948**	**-26.8**

Notes:
Figures may not add due to rounding.
1. Includes only sub-basins where agriculture is present.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Agricultural Land Use by Ecozone

The Prairie ecozone is almost entirely agricultural land. Table 4.7.4 indicates that 90 percent of the Prairie ecozone is devoted to agriculture. The Mixed Wood Plains ecozone in eastern Canada has the next highest proportion of agricultural land, with more than 50 percent of its area in agriculture. Most other ecozones have only small land proportions in agriculture.

The eastern ecozones and those in British Columbia have relatively small farm sizes while ecozones in the Prairie provinces tend to have much larger average farm sizes. All ecozones with the exception of the Pacific Maritime and Montane Cordillera, show an increase in average farm size between 1971 and 1991.

Changing cropland areas can be used as indicators of agricultural intensification. Most ecozones show an increase in cropland area, indicating not only productivity maximization but potentially higher levels of environmental stress, as less land is left idle (Table 4.7.5). Figure 4.7.1 emphasizes this trend nationally and by ecozone.

Table 4.7.4

Farmland and Average Farm Size by Ecozone, 1971, 1981 and 1991

Provincial ecozone[1]	Ecozone area	Farmland area 1971	Farmland area 1981	Farmland area 1991	Farmland area Change 1971-1991	Proportion in farmland 1991	Average farm size 1971	Average farm size 1981	Average farm size 1991	Average farm size Change 1971-1991
	hundred hectares				percent		hectares per farm			percent
Newfoundland										
Boreal Shield	126 919	253.8	334.5	473.5	86.6	0.4	24	49	65	168.2
Total	**126 919**	**253.8**	**334.5**	**473.5**	**86.6**	**0.4**	**24**	**49**	**65**	**168.2**
Prince Edward Island										
Atlantic Maritime	6 216	3 134.8	2 830.2	2 588.7	-17.4	41.6	69	90	110	58.9
Total	**6 216**	**3 134.8**	**2 830.2**	**2 588.7**	**-17.4**	**41.6**	**69**	**90**	**110**	**58.9**
Nova Scotia										
Atlantic Maritime	60 907	5 377.8	4 660.2	3 970.3	-26.2	6.5	90	92	100	11.4
Total	**60 907**	**5 377.8**	**4 660.2**	**3 970.3**	**-26.2**	**6.5**	**90**	**92**	**100**	**11.4**
New Brunswick										
Atlantic Maritime	77 047	5 419.3	4 378.9	3 756.3	-30.7	4.9	99	108	116	16.9
Total	**77 047**	**5 419.3**	**4 378.9**	**3 756.3**	**-30.7**	**4.9**	**99**	**108**	**116**	**16.9**
Quebec										
Boreal Shield	623 453	10 124.7	8 827.1	7 693.9	-24.0	1.2	92	107	130	41.3
Atlantic Maritime	63 616	15 307.7	12 618.8	11 091.6	-27.5	17.4	84	92	101	20.2
Mixed Wood Plains	29 938	18 278.2	16 345.8	15 510.7	-15.1	51.8	57	62	73	28.1
Total	**717 007**	**43 710.6**	**37 791.7**	**34 296.1**	**-21.5**	**4.8**	**71**	**78**	**90**	**26.1**
Ontario										
Boreal Shield	657 397	8 792.7	7 872.2	6 520.6	-25.8	1.0	120	119	121	0.8
Mixed Wood Plains	91 214	55 807.5	52 519.4	47 993.2	-14.0	52.6	64	69	76	18.8
Total	**748 611**	**64 600.2**	**60 391.6**	**54 513.8**	**-15.6**	**7.3**	**68**	**73**	**79**	**16.5**
Manitoba										
Boreal Shield	249 762	1 518.3	1 553.6	1 436.7	-5.4	0.6	148	164	199	34.5
Boreal Plains	92 056	17 562.0	17 011.1	18 251.5	3.9	19.8	196	230	276	40.8
Prairie	68 553	57 843.4	57 594.3	57 561.7	-0.5	84.0	231	273	313	35.5
Total	**410 371**	**76 923.7**	**76 159.1**	**77 249.9**	**0.4**	**18.8**	**220**	**259**	**301**	**36.9**
Saskatchewan										
Boreal Plains	176 917	41 995.0	41 035.7	42 586.1	1.4	24.1	263	304	354	34.6
Prairie	244 952	221 280.8	218 436.1	226 067.7	2.2	92.3	362	406	463	27.9
Total	**421 869**	**263 275.8**	**259 471.8**	**268 653.9**	**2.0**	**63.7**	**342**	**385**	**442**	**29.2**
Alberta										
Boreal Plains	343 033	57 929.6	56 250.7	66 253.6	14.4	19.3	232	239	283	22.0
Prairie	157 975	140 885.6	133 421.4	139 279.0	-1.1	88.2	375	389	416	10.9
Montane Cordillera	47 772	1 529.6	1 413.1	2 577.4	68.5	5.4	773	550	840	8.7
Total	**548 780**	**200 344.8**	**191 085.1**	**208 110.0**	**3.9**	**37.9**	**320**	**329**	**364**	**13.8**
British Columbia										
Boreal Plains	61 442	6 367.2	6 749.0	7 883.7	23.8	12.8	378	378	486	28.6
Montane Cordillera	444 718	15 552.4	13 401.0	14 417.7	-7.3	3.2	186	137	158	-15.1
Pacific Maritime	205 603	1 664.2	1 636.1	1 623.0	-2.5	0.8	20	20	19	-5.0
Total	**711 763**	**23 583.8**	**21 786.0**	**23 924.4**	**1.4**	**3.4**	**128**	**109**	**124**	**-3.1**
Canada	**3 829 490**	**686 624.4**	**658 889.2**	**677 537.0**	**-1.3**	**17.7**	**188**	**207**	**242**	**29.0**

Notes:
Figures may not add due to rounding.
1. Includes only ecozones where agriculture is present.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 4.7.5

Cropland and Summerfallow Area by Ecozone, 1971, 1981 and 1991

Provincial ecozone[1]	Cropland area 1971	Cropland area 1981	Cropland area 1991	Cropland area Change 1971-1991	Summerfallow area 1971	Summerfallow area 1981	Summerfallow area 1991	Summerfallow area Change 1971-1991
	hectares			percent	hectares			percent
Newfoundland								
Boreal Shield	3 535	4 744	6 274	77.5	202	358	145	-28.1
Total	**3 535**	**4 744**	**6 274**	**77.5**	**202**	**358**	**145**	**-28.1**
Prince Edward Island								
Atlantic Maritime	142 200	158 280	154 103	8.4	3 717	3 027	997	-73.2
Total	**142 200**	**158 280**	**154 103**	**8.4**	**3 717**	**3 027**	**997**	**-73.2**

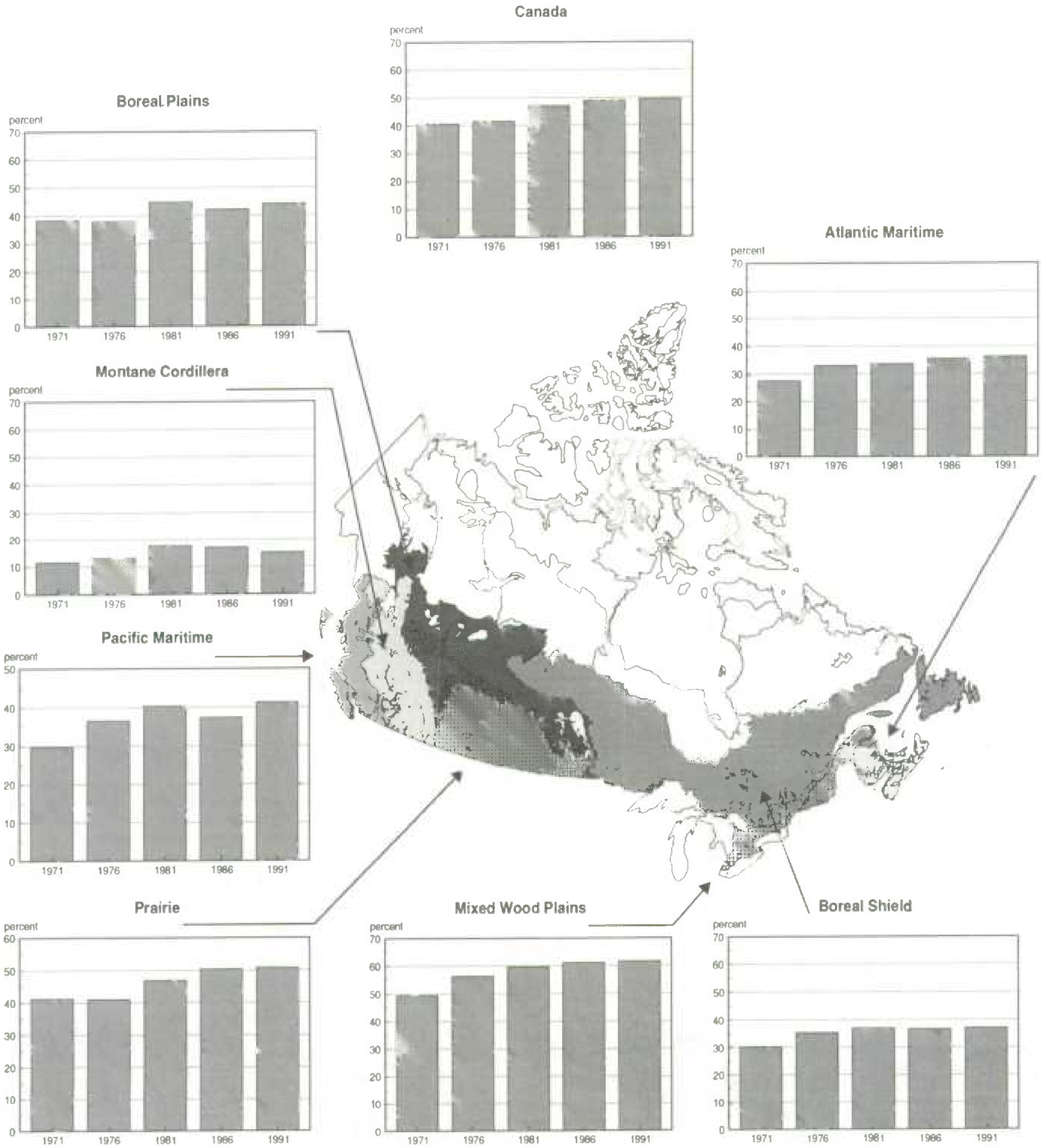
Table 4.7.5

Cropland and Summerfallow Area by Ecozone, 1971, 1981 and 1991 (Continued)

Provincial ecozone[1]	Cropland area 1971	Cropland area 1981	Cropland area 1991	Cropland area Change 1971-1991	Summerfallow area 1971	Summerfallow area 1981	Summerfallow area 1991	Summerfallow area Change 1971-1991
	hectares			percent	hectares			percent
Nova Scotia								
Atlantic Maritime	98 322	112 782	106 231	8.0	2 538	5 154	1 186	-53.3
Total	**98 322**	**112 782**	**106 231**	**8.0**	**2 538**	**5 154**	**1 186**	**-53.3**
New Brunswick								
Atlantic Maritime	130 434	130 526	122 247	-6.3	3 478	5 183	1 551	-55.4
Total	**130 434**	**130 526**	**122 247**	**-6.3**	**3 478**	**5 183**	**1 551**	**-55.4**
Quebec								
Boreal Shield	317 702	323 816	276 495	-13.0	8 043	13 351	3 161	-60.7
Atlantic Maritime	474 962	428 187	360 409	-24.1	9 388	14 659	4 153	-55.8
Mixed Wood Plains	962 553	1 004 035	1 001 549	4.1	15 620	25 067	7 398	-52.6
Total	**1 755 217**	**1 756 038**	**1 638 453**	**-6.7**	**33 051**	**53 077**	**14 712**	**-55.5**
Ontario								
Boreal Shield	206 745	229 797	199 381	-3.6	5 237	7 449	7 670	46.5
Mixed Wood Plains	2 972 420	3 402 930	3 212 286	8.1	91 045	55 860	55 987	-38.5
Total	**3 179 166**	**3 632 727**	**3 411 667**	**7.3**	**96 281**	**63 309**	**63 657**	**-33.9**
Manitoba								
Boreal Shield	63 179	81 208	84 685	34.0	13 842	13 048	7 688	-44.5
Boreal Plains	619 682	744 606	820 145	32.3	196 365	147 153	73 413	-62.6
Prairie	3 008 873	3 594 555	3 856 221	28.2	864 313	438 137	215 897	-75.0
Total	**3 691 734**	**4 420 369**	**4 761 050**	**29.0**	**1 074 520**	**598 338**	**296 998**	**-72.4**
Saskatchewan								
Boreal Plains	1 726 279	2 097 979	2 469 934	43.1	864 092	644 672	381 348	-55.9
Prairie	9 337 480	9 642 885	10 988 981	17.7	5 837 430	6 059 792	5 331 483	-8.7
Total	**11 063 759**	**11 740 864**	**13 458 915**	**21.6**	**6 701 523**	**6 704 464**	**5 712 830**	**-14.8**
Alberta								
Boreal Plains	2 345 613	2 625 524	3 054 245	30.2	597 690	459 637	315 899	-47.1
Prairie	4 958 765	5 794 401	6 206 571	25.2	2 235 592	1 744 223	1 453 182	-35.0
Montane Cordillera	17 414	21 316	31 228	79.3	3 043	1 608	2 313	-24.0
Total	**7 321 792**	**8 441 242**	**9 292 043**	**26.9**	**2 836 326**	**2 205 468**	**1 771 394**	**-37.5**
British Columbia								
Boreal Plains	204 414	254 454	252 895	23.7	61 963	49 246	42 791	-30.9
Montane Cordillera	180 873	239 828	70 608	-61.0	6 486	10 997	12 987	100.2
Pacific Maritime	57 033	73 960	233 293	309.1	1 502	3 286	1 698	13.1
Total	**442 321**	**568 241**	**556 796**	**25.9**	**69 951**	**63 528**	**57 476**	**-17.8**
Canada	**27 828 479**	**30 965 812**	**33 507 779**	**20.4**	**10 821 587**	**9 701 906**	**7 920 948**	**-26.8**

Notes:
Figures may not add due to rounding.
1. Includes only ecozones where agriculture is present.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 4.7.1
Cropland as a Proportion of Farmland by Ecozone, 1971-1991



Notes:
The amount of farmland allocated to the production of crops has been increasing steadily. Growth in cropland areas indicates not only an increase in agricultural output but also potentially higher levels of environmental stress on existing arable land.
Agricultural areas are depicted by grid shading.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

4.8 Forest Land

Most of Canada is covered by coniferous (cone-bearing) boreal and taiga forest (Map 4.8.1). Moving from north to south the presence of hardwood (broadleaved) species increases to form mixedwood stands (combinations of conifer and hardwood trees) and eventually pure hardwood stands (deciduous broadleaved trees) (Map 4.8.1). The volume of wood per hectare of land reflects natural tree growth rates as well as the effects of human activities (Map 4.8.2).

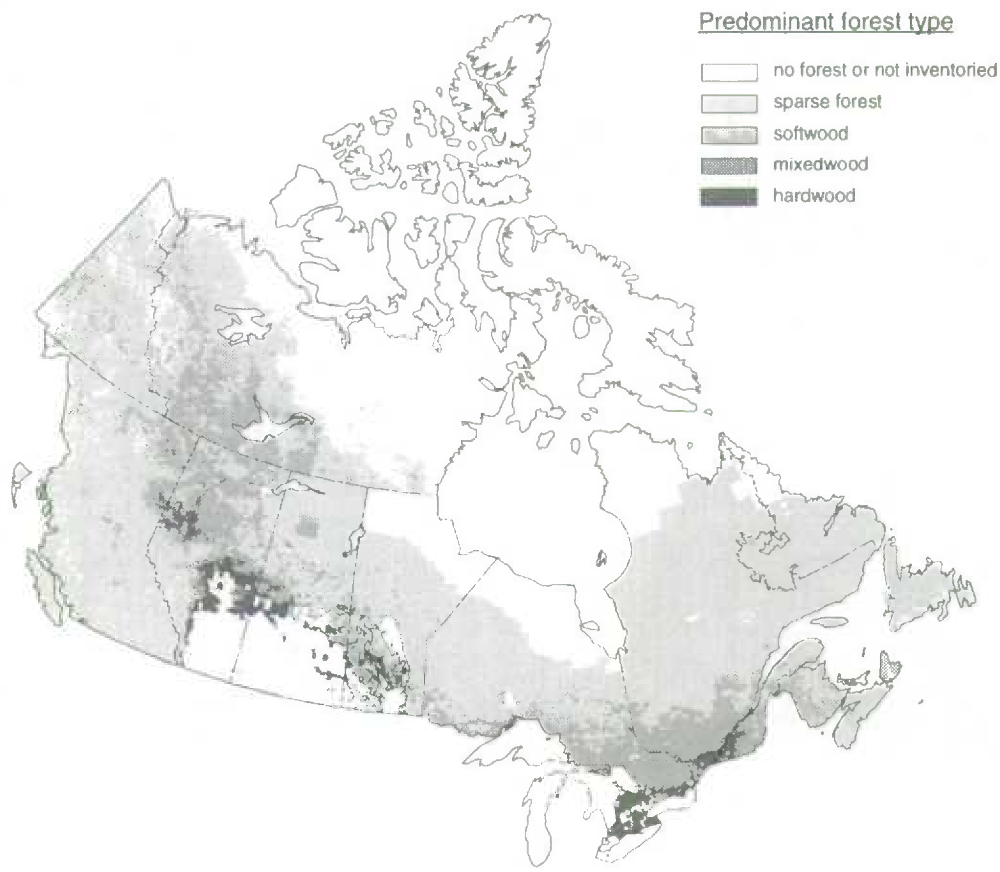
While the distribution of trees in the north and Prairies, is almost solely the result of climatic and hydrographic factors, the patterns in the south more often reflect the influence of man (Map 4.8.3). Early in Canada's history the forests near settlements in the eastern and central provinces were cleared for agriculture, grazing and development. It is now believed the area of forest land in south central Canada is increasing with the decline of agriculture on many marginal lands.

With 10 percent of the world's forest on Canadian soil it is not surprising that the Canadian forest industry is one of the largest internationally. In 1991, Canada was the fourth largest producer of paper and paperboard, the third largest producer of lumber, the second largest producer of wood pulp and the largest exporter of forest products.[1] Domestically the forest industries were responsible for 3 percent of GDP at factor cost and 15 percent of all exports in 1992.[2,3]

From an environmental perspective, the industry is also of great importance since no other industry in Canada makes such extensive use of the land base. Though the industry's tree cutting activities are the most commonly considered environmental impact, the construction of roads for access, and the conduct of silviculture and fire suppression activities also warrant consideration since their effects may be more enduring.

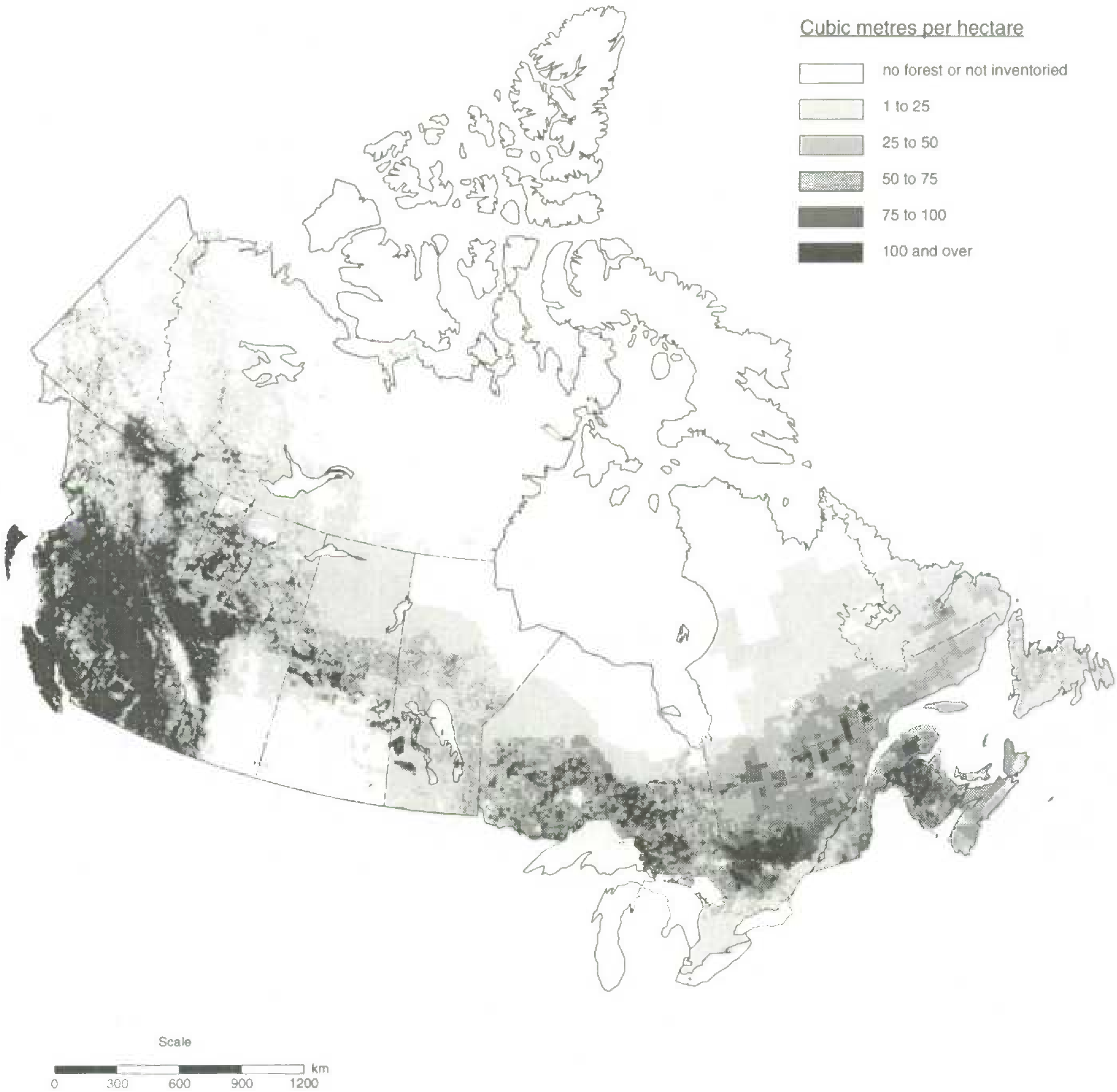
1. Food and Agricultural Organization of the United Nations, *1991 Yearbook of Forest Products*, Rome, 1991.
2. Statistics Canada, *Exports, Merchandise Trade*, Catalogue No. 65-202, Ottawa, 1992.
3. Statistics Canada, *Gross Domestic Product by Industry*, Catalogue No. 15-001, Ottawa, 1992.

Map 4.8.1
Forest Type



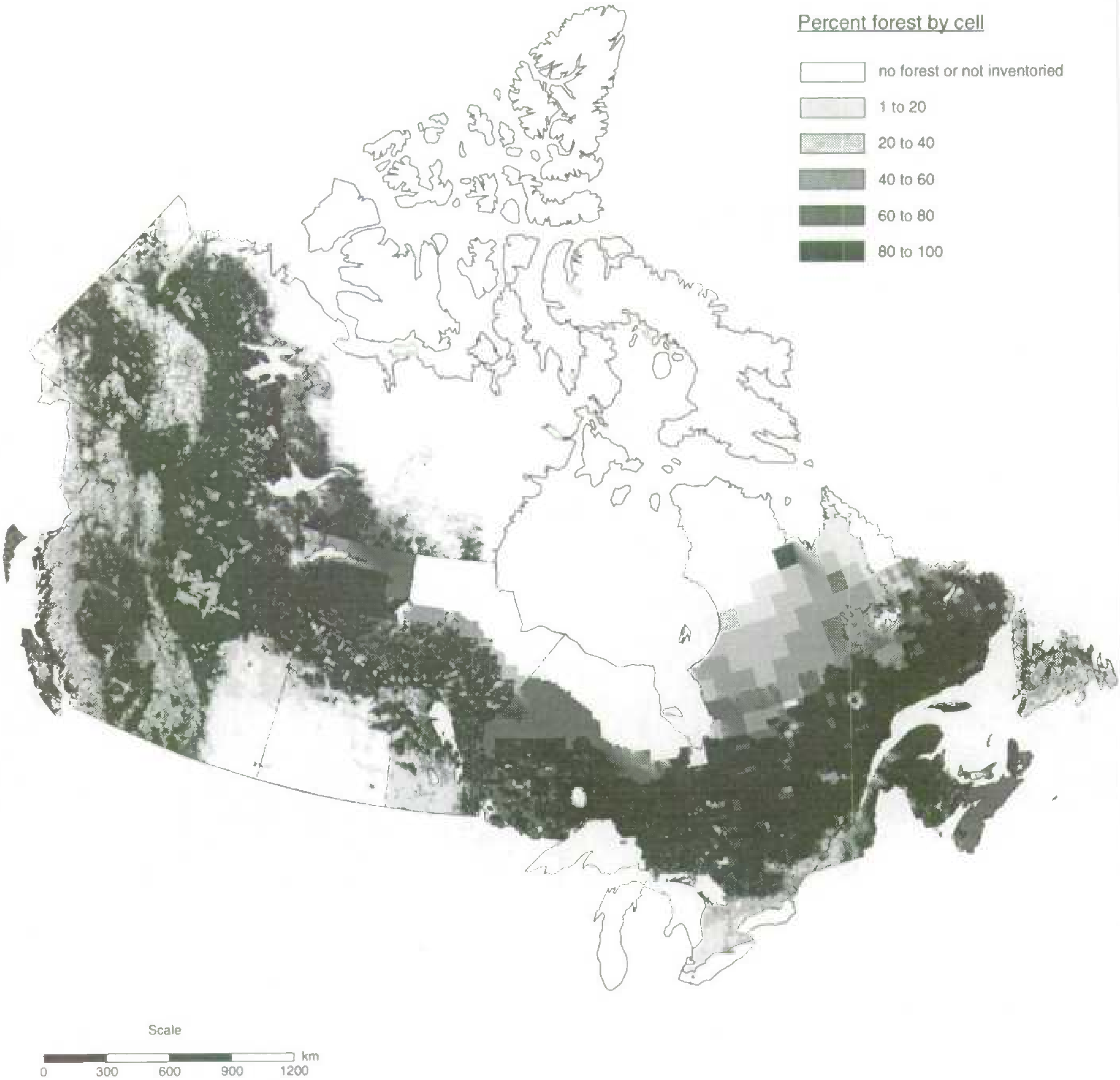
Note:
Sparse forest means less than 10 percent of land area in the cell is forested.
Source:
Natural Resources Canada, Canadian Forest Service, Petawawa National Forestry Institute, Canada's Forest Inventory 1991.

Map 4.8.2
Wood Volume, All Forest Tree Species, 1991



Note:
Volume per hectare is calculated relative to total cell land area (including rivers and lakes).
Source:
Natural Resources Canada, Canadian Forest Service, Petawawa National Forestry Institute, Canada's Forest Inventory 1991.

Map 4.8.3
Forest Cover, 1991



Note:
Percent forest is calculated relative to total cell area (including rivers and lakes).
Source:
Natural Resources Canada, Canadian Forest Service, Petawawa National Forestry Institute, Canada's Forest Inventory 1991.

4.9 Mineral Reserves

Canada's mineral reserves represent potential economic wealth. These reserves are part of Canada's natural asset stocks and are critical non-renewable inputs into the economy. Like other forms of capital, mineral resource stocks need to be maintained for use in the economic process. In Canada, mineral exploitation and mineral processing represent a significant portion of our GDP (see Section 3.1 - **Economic Overview**, Table 3.1.2). It is therefore, important to measure to what extent we are depleting our reserves. This section presents data on Canada's **established**[1] mineral reserves, that is, those reserves that are recoverable under current economic conditions with present technology.

❑❑❑

Fuel and non-fuel minerals are non-renewable resources that have no sustainable yield as is the case with renewable resources such as fisheries and forests. However, most metals can be recycled indefinitely. This is not the case for most fuels which are predominantly used for energy consumption with limited recycling of petroleum based plastics. In general, estimated world reserves and resources have risen faster than rates of production.[2,3]

In order to have "sustainable development" of Canada's minerals, we must continually assess how much resource is remaining in the ground. This is particularly important now since federal environmental policies, announced three years ago, established a target of setting aside 12 percent of Canada's land as protected areas by the year 2000. Several provinces have also adopted similar programs to help achieve this goal. This will effectively decrease the area of land open to mineral exploration and development in the future. Mineral resource evaluations are an integral part of the procedure for the establishment of new national parks and protected areas in Canada. This process helps identify possible mineral deposits before deciding on the permanent establishment of parks or boundaries of protected areas.[4] The creation of single use areas (e.g. protected and park lands) and the increase of environmental protection regulations represent limiting factors to the maintenance of Canada's mineral resource base in the future.

Also, the measurement of mineral resource stocks may be used to evaluate Canada's future potential for sustained income generation. Revenues from non-renewable resources may be converted into other forms of capital or into the development of renewable resource substitutes (see Section - 3.12 - **Energy**).

Mineral Production of Canada

The Canadian mineral industry produces over 30 different metals, over 20 non-metals, a variety of fuels including coal, natural gas and crude oil, structural materials including clay products, cement, lime, sand, gravel and stone (Technical Box 4.9.1). However, reserve data are available only for Canada's leading mineral commodities. This section presents reserve data for fuels (crude oil, natural gas, crude bitumen and coal), principal metals (copper, nickel, lead, zinc, molybdenum, silver, gold, uranium and iron) and potash.

Table 4.9.1 ranks 1992 mineral production in order of value. The value of total mineral production in Canada was $35.4 billion in 1992. Fuel production totalled $20.8 billion, representing 59 percent of the total value; metal production equalled $10.2 billion, or 28.8 percent; non-metal production was $2.2 billion, or 6.2 percent; and structural materials totalled $2.2 billion, or 6.2 percent. The data presented here in Table 4.9.1 represent about 80 percent of the value of mineral production in Canada. Canada is a leading mineral producer in the world. Tables 4.9.1 and 4.9.2 present an overview of Canada's position as an international mineral producer.

Technical Box 4.9.1

Mineral production of Canada

	Type
Metals	Antimony, bismuth, cadmium, calcium, cesium, cobalt, columbium, copper, gold, ilmenite, indium, iron, lead, lithium, magnesium, molybdenum, nickel, platinum group metals (plantinum, palladium, rhodium, ruthenium, iridium and osmium), rhenium, rubidium, selenium, silver, strontium, tantalum, tellurium, tin, uranium, vanadium and zinc
Non-metals	asbestos, barite, gemstones, graphite, gypsum, magnesitic dolomite and brucite, marl, mica, nepheline syenite, peat, potash, potassium sulphate, quartz, salt, serpentine, soapstone (talc and pyrophyllite), sodium sulphate, sulphur, titanium dioxide and tremolite
Fuels	coal, crude bitumen, natural gas, natural gas by-products and crude oil
Structural materials	clay products, cement, lime, sand and gravel, and stone

1. The term established reserves is used for oil and natural gas, recoverable reserves for coal and proven and probable reserves for metals.
2. Crowson, P., *The Infinitely Finite*, The International Council on Metals and the Environment, Ottawa, 1992.
3. Reserves represent the portion of resources that have been more precisely measured and are available for production.
4. International Working Group on the Mineral Industry, *The Canadian Mineral Industry in a Competitive World*, Ottawa, 1992.

Table 4.9.1

Value of Production and Contribution of Leading Minerals to Total Value of Production, 1992

Mineral	Value	Percentage of total value	Canada's world ranking[2]
	million dollars	percent	rank
Petroleum, Crude[1]	11 251.1	31.8	9
Natural gas[1]	5 607.7	15.8	3
Natural gas by-products	2 296.8	6.5	..[3]
Gold[1]	2 086.8	5.9	5
Copper[1]	2 062.9	5.8	4
Zinc[1]	1 727.2	4.9	1
Nickel[1]	1 679.9	4.7	2
Coal[1]	1 663.3	4.7	11
Iron ore[1]	1 129.4	3.2	8
Potash[1]	963.3	2.7	2
Cement	739.2	2.1	..
Sand and gravel	637.0	1.8	..
Uranium[1]	575.6	1.6	1
Stone	507.6	1.4	..
Salt	253.8	0.7	5
Asbestos	235.8	0.7	2
Lead[1]	230.9	0.7	5
Lime	182.8	0.5	14
Silver[1]	173.2	0.5	5
Cobalt	136.9	0.4	4
Sulphur, elemental	131.4	0.4	2
Clay products	117.3	0.3	..
Platinum group metals	117.1	0.3	3
Peat	108.2	0.3	2
Gypsum	79.2	0.2	2
Other minerals	717.1	2.0	..
Total	**35 411.5**	**100.0**	...

Notes:
1. Reserve data reported in this section.
2. Based on Canadian and world production in 1991; these rankings vary considerably depending on which data source is used and should be considered as approximate.
3. Included as part of crude petroleum production.

Sources:
Statistics Canada, *Canada's Mineral Production, Preliminary Estimates*, Catalogue No 26-202, Ottawa, 1992.
Intergovernmental Working Group on the Mineral Industry, *The Importance of the Minerals and Metals Industry to Canada*, Ottawa, 1992.
British Petroleum, *BP Statistical Review of World Energy*, London, 1992

Relative Abundance of Minerals in Canada and the World

Table 4.9.2 provides estimates of global and Canadian reserve lives for minerals currently exploited in Canada, based on present levels of worldwide and Canadian production respectively. Also presented are Canadian reserves as a percentage of world reserves. Reserve life[1] provides an indication of the relative abundance of the mineral and whether or not the mineral is becoming scarce on a global or national level. For potash, gypsum, asbestos, and zinc, Canada is endowed with large portions of the world's reserves. Reserve lives for minerals range from very large (>200 years) to very small. As discussed below, Canada's reserves of principal metals and fuels have been declining since the 1980s and generally have reserve lives of less than 15 years.

1. Reserve life is defined as stock of remaining reserves/production.

Table 4.9.2

Relative Abundance of Canadian and World Mineral Reserves

Mineral	Global reserve life	Canadian reserve life	Canadian reserve as a percentage of world reserve
	years		percent
Antimony	24	..	..
Asbestos	59	65	24
Barite	32	..	..
Bismuth	34	50	5
Cadmium	27	53	15
Coal[1]	232	93	1
Cobalt	161	21	1
Copper	35	14	4
Crude oil[1]	43	10	1
Gold	20	8	4
Gypsum	very large	56	19
Indium	16	15	26
Iron ore	178	171	8
Lead	20	20	10
Lithium	very large	very large	8
Magnesium	very large	..	..
Molybdenum	51	17	8
Natural gas[1]	65	24	2
Nickel	51	30	13
Platinum group metals	190	23	<1
Potash	very large	very large	74
Rhenium	88	9	1
Selenium	42	20	9
Silver	20	15	13
Sulphur	27	22	11
Tantalum	54	40	8
Tellurium	94	54	3
Tin	40	very small	very small
Uranium	62	45	75
Vanadium	very large	very small	very small
Zinc	19	15	15

Note:
1. Based on proven reserves only.

Sources:
Crowson, P., *The Infinitely Finite*, International Council on Metals and the Environment, Ottawa, 1992.
British Petroleum, *BP Statistical review of World energy*, London, 1992.
U.S. Bureau of Mines, *Mineral Commodity Summaries*, Washington, 1993.
Energy, Mines and Resources Canada, *Canadian Minerals Yearbook*, Ottawa, 1992.

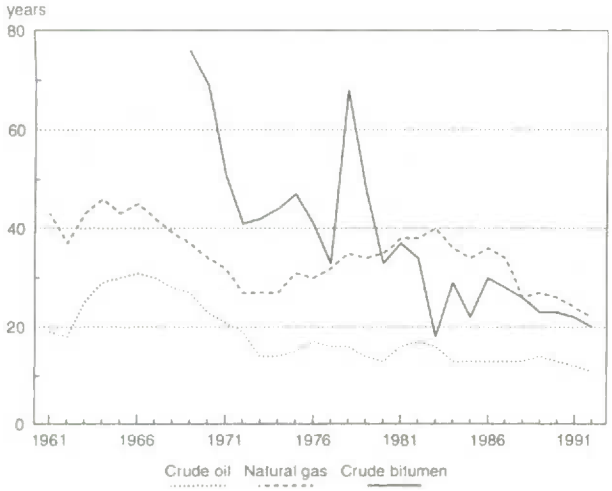
Fuel Reserves

Canada has substantial reserves of crude oil, natural gas, crude bitumen[2] and coal. Canada's reserves of crude oil continue to decline, with an estimated reserve life of 11 years based on 1992 production levels (Table 4.9.3 and Figure 4.9.1). Reserves of natural gas, crude bitumen and coal are large and have remained relatively stable during the past decade (Tables 4.9.4 to 4.9.6). The most recently estimated reserve life is 22 years for natural gas, 25 years for crude bitumen (Figure 4.9.1) and 70 years for coal. Figures 4.9.2 to 4.9.4 compare remaining reserves with cumulative production for crude oil, natural gas and crude bitumen. Recent trends in reserve data indicate that reserve depletion is not being replaced by reserve additions, especially in the case of crude oil.

2. Recovered from tar sands.

Figure 4.9.1

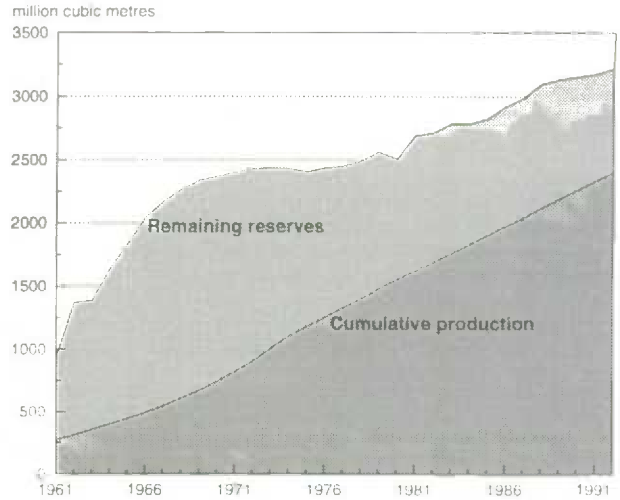
Reserve Life, 1961-1992



Source:
Statistics Canada, National Accounts and Environment Division.

Figure 4.9.2

Crude Oil, 1961-1992



Source:
Statistics Canada, National Accounts and Environment Division.

Table 4.9.3

Remaining Established Reserves of Crude Oil, 1961-1992[1]

Year	Opening stock	Gross additions	Net production[2]	Closing stock	Net change in reserves
	thousand cubic metres				
1961[3]	584 557	113 788	35 123	663 222	78 665
1962[3]	663 222	87 720	38 914	712 028	48 806
1963	1 062 733	13 944	40 758	1 035 919	-26 814
1964	1 035 919	255 384	43 033	1 248 270	212 351
1965	1 248 270	196 556	46 337	1 398 489	150 219
1966	1 398 489	208 887	50 224	1 557 152	158 663
1967	1 557 152	124 587	54 690	1 627 049	69 897
1968	1 627 049	93 668	59 030	1 661 687	34 638
1969	1 661 687	66 636	62 516	1 665 807	4 120
1970	1 665 807	26 894	69 606	1 623 095	-42 712
1971	1 623 095	37 636	76 297	1 584 434	-38 661
1972	1 584 434	22 229	82 319	1 524 344	-60 090
1973	1 524 344	6 537	99 423	1 431 458	-92 886
1974	1 431 458	-5 065	95 530	1 330 863	-100 595
1975	1 330 863	-6 280	79 897	1 224 686	-86 177
1976	1 224 686	5 921	69 683	1 180 924	-63 762
1977	1 180 924	10 227	70 872	1 120 279	-60 645
1978	1 120 279	37 426	67 647	1 090 058	-30 221
1979	1 090 058	71 415	79 469	1 082 004	-8 054
1980	1 082 004	-56 247	74 529	951 228	-130 776
1981	951 228	178 220	65 873	1 063 575	112 347
1982	1 063 575	19 314	61 756	1 021 133	-42 442
1983	1 021 133	66 074	64 488	1 022 719	1 586
1984	1 022 719	-588	73 108	949 023	-73 696
1985	949 023	39 837	73 030	915 830	-33 193
1986	915 830	98 719	70 136	944 411	28 581
1987	944 411	67 943	72 192	940 162	-4 249
1988	940 162	108 468	73 482	975 148	34 986
1989	975 148	31 677	68 832	937 993	-37 155
1990	937 993	18 350	68 386	887 957	-50 036
1991	887 957	22 359	69 014	841 302	-46 655
1992	841 302	39 697	71 265	809 734	-31 568

Notes:
1. Includes conventional and frontier areas.
2. Preliminary estimate; corrections to previous year's production included with gross additions.
3. 1961 and 1962 reported as proven reserves.

Source:
Canadian Petroleum Association, *Statistical Yearbook*, Calgary, various issues.

Table 4.9.4

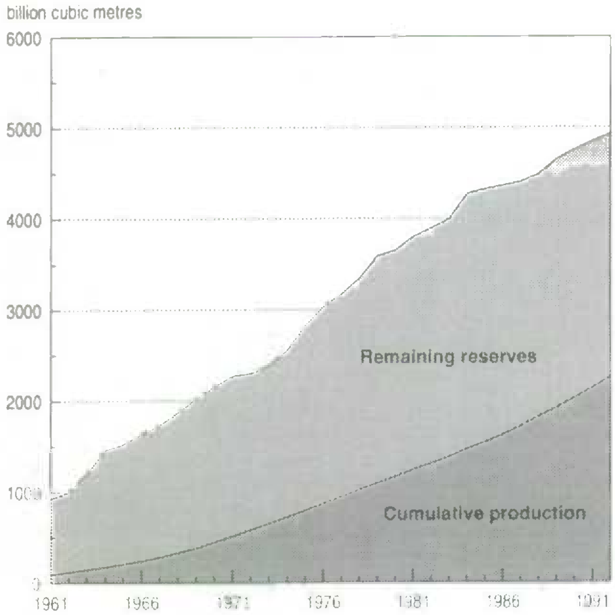
Remaining Established Reserves of Marketable Natural Gas, 1961-1992[1]

Year	Opening stock	Gross additions	Net production[2]	Closing stock	Net change in reserves
	million cubic metres				
1961[3]	760 530	91 169	19 552	832 147	71 617
1962[3]	832 147	70 930	23 565	679 512	47 365
1963[3]	879 512	74 749	24 738	1 054 466	174 954
1964	1 054 466	257 146	27 654	1 283 958	229 492
1965	1 283 958	62 203	30 860	1 315 301	31 343
1966	1 315 301	110 766	31 199	1 394 868	79 567
1967	1 394 868	86 355	34 146	1 447 077	52 209
1968	1 447 077	136 443	39 335	1 544 185	97 108
1969	1 544 185	137 938	43 792	1 638 331	94 146
1970	1 638 331	128 611	50 121	1 716 821	78 490
1971	1 716 821	101 860	55 025	1 763 656	46 835
1972	1 763 656	21 822	63 486	1 721 992	-41 664
1973	1 721 992	70 228	63 539	1 728 681	6 689
1974	1 728 681	169 925	67 140	1 831 466	102 785
1975	1 831 466	261 729	65 680	2 027 515	196 049
1976	2 027 515	209 181	71 906	2 164 790	137 275
1977	2 164 790	134 970	68 918	2 230 842	66 052
1978	2 230 842	157 213	65 842	2 322 213	91 371
1979	2 322 213	247 681	73 837	2 496 057	173 844
1980	2 496 057	66 784	70 977	2 491 864	-4 193
1981	2 491 864	138 614	67 505	2 562 973	71 109
1982	2 562 973	95 498	67 421	2 591 050	28 077
1983	2 591 050	87 478	65 933	2 612 595	21 545
1984	2 612 595	275 000	79 014	2 808 581	195 986
1985	2 808 581	57 764	82 422	2 783 923	-24 858
1986	2 783 923	38 554	76 967	2 745 510	-38 413
1987	2 745 510	27 141	79 868	2 692 783	-52 727
1988	2 692 783	78 870	101 108	2 670 545	-22 238
1989	2 670 545	163 947	102 043	2 732 449	61 904
1990	2 732 449	99 637	106 696	2 725 390	-7 059
1991	2 725 390	96 231	110 752	2 710 869	-14 521
1992	2 710 869	79 685	119 000	2 671 554	-39 315

Notes:
1. Includes conventional and frontier areas.
2. Preliminary estimate; corrections to previous year's production included with gross additions; includes adjustments for underground storage.
3. 1961-1963 reported as proven reserves.

Source:
Canadian Petroleum Association, *Statistical Yearbook*, Calgary, various issues.

Figure 4.9.3
Natural Gas, 1961-1992



Source:
Statistics Canada, National Accounts and Environment Division.

Table 4.9.5
Remaining Established Reserves of Crude Bitumen, 1967-1992

Year	Opening stock	Gross additions	Net production	Closing stock	Net change in reserves
	million cubic metres				
1967	-	-	0.4	178.6	178.6
1968	178.6	-	1.4	177.2	-1.4
1969	177.2	-	2.3	174.9	-2.3
1970	174.9	-	2.5	172.4	-2.5
1971	172.4	-	3.3	169.1	-3.3
1972	169.1	-	4.0	165.1	-4.0
1973	165.1	-	3.8	161.3	-3.8
1974	161.3	-	3.6	157.7	-3.6
1975	157.7	-	3.3	154.4	-3.3
1976	154.4	-	3.7	150.7	-3.7
1977	150.7	-36.0	3.4	111.3	-39.4
1978	111.3	215.0	4.7	321.6	210.3
1979	321.6	39.0	7.4	353.2	31.6
1980	353.2	-9.0	10.2	334.0	-19.2
1981	334.0	-	8.8	325.2	-8.8
1982	325.2	-	9.4	315.8	-9.4
1983	315.8	12.1	16.9	311.0	-4.8
1984	311.0	30.0	11.2	329.8	18.8
1985	329.8	30.1	15.6	344.3	14.5
1986	344.3	250.1	18.9	575.5	230.8
1987	575.5	18.4	20.7	573.2	-2.3
1988	573.2	14.7	21.4	566.5	-6.7
1989	566.5	-1.1	23.2	542.2	-24.3
1990	542.2	5.0	22.8	524.4	-17.8
1991	524.4	-0.1	22.6	501.7	-22.7
1992	501.7	4.3	23.8	482.2	-19.5

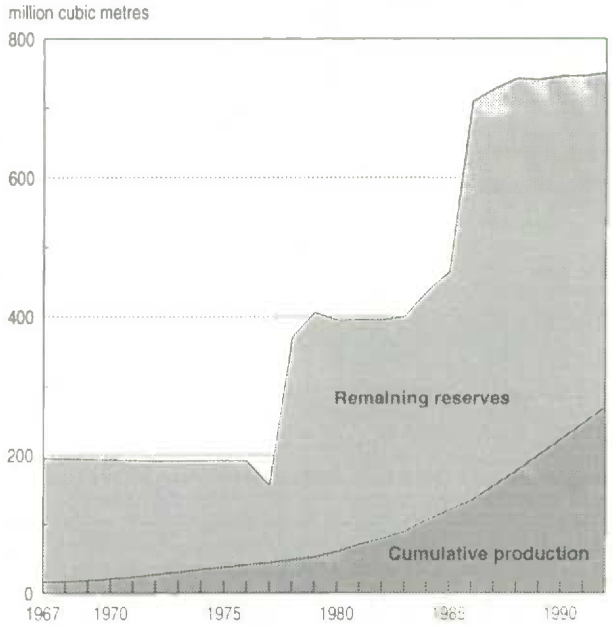
Source:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.

Table 4.9.6
Recoverable Reserves and Production of Coal, 1977-1991

Year	Remaining recoverable reserves					Gross mine production			
	Class of coal					Class of coal			
			Bituminous						
	Lignitic	Sub-bituminous	Thermal	Metallurgical	Total	Lignitic	Sub-bituminous	Bituminous	Total
	megatonnes								
1977	1 921	1 979	..	..	**5 358**	5.5	7.9	15.1	**28.5**
1978	2 117	2 182	344	1 263	**5 906**	5.1	8.3	17.1	**30.5**
1979	2 117	2 182	344	1 263	**5 906**	5.0	9.6	18.6	**33.2**
1980	2 117	2 182	344	1 263	**5 906**	6.0	10.5	20.2	**36.7**
1981	2 117	2 182	344	1 263	**5 906**	6.8	11.6	21.7	**40.1**
1982	2 263	918	1 057	2 030	**6 268**	9.5	13.0	20.3	**42.8**
1983	2 263	918	1 057	2 030	**6 268**	7.8	14.6	22.4	**44.8**
1984	2 263	918	1 057	2 030	**6 268**	9.9	15.4	32.1	**57.4**
1985	2 236	871	1 553	1 918	**6 578**	9.7	16.9	33.8	**60.4**
1986	2 236	871	1 553	1 918	**6 578**	8.3	18.2	31.3	**57.8**
1987	2 236	871	1 553	1 918	**6 578**	10.0	18.5	32.7	**61.2**
1988	2 236	871	1 553	1 918	**6 578**	12.2	20.0	38.4	**70.6**
1989	2 236	871	1 553	1 918	**6 578**	10.8	20.9	38.8	**70.5**
1990	2 236	871	1 553	1 918	**6 578**	9.4	21.3	37.6	**68.3**
1991	2 236	871	1 553	1 918	**6 578**	9.0	22.2	39.9	**71.1**

Sources:
CANMET, *Coal Mining in Canada*, Canmet Report No. 87-3E, Ottawa, 1987.
Statistics Canada, *Coal Mines*, Catalogue No. 26-206, Ottawa, various issues.
Energy Mines and Resources, *Assessment of Canada's Coal Resources and Reserves*, Catalogue No. EP 77-5, Ottawa, 1977.

Figure 4.9.4
Crude Bitumen, 1967-1992



Source:
Statistics Canada, National Accounts and Environment Division.

Metal Reserves

Reserves of copper, zinc, lead, nickel, molybdenum and silver have decreased considerably over the past decade (Table 4.9.7 and Figure 4.9.5). The reserve lives of these metals were between 14 and 30 years in 1991. The major reasons for declining reserves are increasing costs of discovering new reserves, declining exploration for base metals due to low prices and the concentration on gold exploration during the 1980s.[1]

Gold reserves steadily increased in the 1980s, but decreased by 21 percent since 1989. The estimated reserve life for gold was 8 years in 1991 (Table 4.9.7).

Based on reserves of economic interest, the estimated reserve life for uranium was approximately 45 years in 1991 (Table 4.9.8). Growing public interest to protect the environmental protection, including concerns about the use of nuclear power and storing nuclear waste, may prevent the exploration effort needed to sustain current resource levels and may contribute to a tightened supply.[2] However, nuclear power plants produce practically no greenhouse gases, a fact that may result in an increased number of nuclear power plants worldwide.[3]

1. Intergovernmental Working Group on the Mineral Industry, *The Canadian Mineral Industry in a Competitive World*, 1992.
2. See Section 3.12 · **Energy**, Technical Box 3.12.2 for environmental considerations in nuclear electricity production.
3. Energy, Mines and Resources Canada, *Uranium in Canada*, Uranium Resource Appraisal Group, Report EP 91-3, Ottawa, 1991.

Table 4.9.7
Proven and Probable Reserves of Major Metals, 1974-1992

Metal contained in proven and probable mineable ore in operating mines and deposits committed to production

	Copper				
Year	Opening stock	Gross additions	Production	Closing stock	Reserve life
	thousand tonnes				years
1974	17 033	836	821	17 048	21
1975	17 048	489	734	16 803	23
1976	16 803	562	731	16 634	23
1977	16 634	596	759	16 471	22
1978	16 471	28	659	15 840	24
1979	15 840	1 201	636	16 405	26
1980	16 405	1 142	716	16 831	24
1981	16 831	-294	722	15 815	22
1982	15 815	1 946	739	17 022	23
1983	17 022	-160	699	16 163	23
1984	16 163	419	794	15 788	20
1985	15 788	-665	739	14 384	19
1986	14 384	-354	699	13 331	19
1987	13 331	449	794	12 986	16
1988	12 986	322	759	12 549	17
1989	12 549	413	704	12 258	17
1990	12 258	-138	771	11 349	15
1991	11 349	546	780	11 115	14
1992	11 115	..	745	..	..

	Nickel				
Year	Opening stock	Gross additions	Production	Closing stock	Reserve life
	thousand tonnes				years
1974	7 119	418	269	7 268	27
1975	7 268	240	242	7 266	30
1976	7 266	301	241	7 326	30
1977	7 326	296	233	7 389	32
1978	7 389	-191	128	7 070	55
1979	7 070	302	127	7 245	57
1980	7 245	1 244	185	8 304	45
1981	8 304	-131	160	8 013	50
1982	6 013	-343	89	7 581	85
1983	7 581	-117	125	7 339	59
1984	7 339	57	174	7 222	42
1985	7 222	-5	170	7 047	41
1986	7 047	-179	164	6 704	41
1987	6 704	90	189	6 605	35
1988	6 605	-127	199	6 279	32
1989	6 279	49	196	6 132	31
1990	6 132	-145	195	5 792	30
1991	5 792	87	188	5 691	30
1992	5 691	..	189	..	..

Table 4.9.7

Proven and Probable Reserves of Major Metals, 1974-1992 (Continued)

Metal contained in proven and probable mineable ore in operating mines and deposits committed to production

Lead

Year	Opening stock	Gross additions	Production	Closing stock	Reserve life
	thousand tonnes				years
1974	9 328	276	294	9 310	32
1975	9 310	257	349	9 218	26
1976	9 218	66	256	9 028	35
1977	9 028	187	281	8 934	32
1978	8 934	297	320	8 911	28
1979	8 911	957	311	9 557	31
1980	9 557	814	252	10 119	40
1981	10 119	394	269	10 244	38
1982	10 244	-943	272	9 029	33
1983	9 029	291	272	9 048	33
1984	9 048	103	264	8 887	34
1985	8 887	-607	268	8 012	30
1986	8 012	-511	334	7 167	21
1987	7 167	-113	373	6 681	18
1988	6 681	659	351	6 989	20
1989	6 989	221	269	6 941	26
1990	6 941	-391	233	6 317	27
1991	6 317	-1 115	248	4 954	20
1992	4 954	..	319	..	..

Zinc

Year	Opening stock	Gross additions	Production	Closing stock	Reserve life
	thousand tonnes				years
1974	28 725	676	1 127	28 274	25
1975	28 274	864	1 055	28 083	27
1976	28 083	306	982	27 407	28
1977	27 407	572	1 071	26 908	25
1978	28 908	611	1 067	26 452	25
1979	26 452	3 283	1 100	28 635	26
1980	28 635	1 685	884	29 436	33
1981	29 436	980	911	29 505	32
1982	29 505	-2 462	966	26 077	27
1983	26 077	1 282	988	26 371	27
1984	26 371	910	1 063	26 218	25
1985	26 218	-1 422	1 049	23 747	23
1986	23 747	-336	988	22 423	23
1987	22 423	-524	1 158	20 741	18
1988	20 741	1 703	1 370	21 074	15
1989	21 074	1 887	1 273	21 688	17
1990	21 688	-418	1 179	20 091	17
1991	20 091	-2 560	1 083	16 448	15
1992	18 448	..	1 194	..	..

Molybdenum

Year	Opening stock	Gross additions	Production	Closing stock	Reserve life
	thousand tonnes				years
1974	294	64	14	344	25
1975	344	11	13	342	26
1976	342	50	15	377	25
1977	377	24	17	384	23
1978	384	92	14	462	33
1979	462	103	11	554	50
1980	554	8	12	550	46
1981	550	-23	13	514	40
1982	514	-6	14	494	35
1983	494	-38	10	446	45
1984	446	-42	12	392	33
1985	392	-21	8	363	45
1986	363	-6	11	346	31
1987	346	-89	15	242	16
1988	242	2	14	230	16
1989	230	18	14	234	17
1990	234	-29	12	193	16
1991	193	0	11	182	17
1992	182	..	10	..	..

Silver

Year	Opening stock	Gross additions	Production	Closing stock	Reserve life
	tonnes				years
1974	27 377	2 542	1 332	28 587	21
1975	28 587	514	1 235	27 866	23
1976	27 866	3 905	1 281	30 490	24
1977	30 490	-91	1 314	29 085	22
1978	29 085	1 580	1 267	29 398	23
1979	29 398	3 313	1 147	31 564	28
1980	31 564	3 120	1 070	33 614	31
1981	33 614	-331	1 129	32 154	28
1982	32 154	541	1 314	31 381	24
1983	31 381	1 175	1 197	31 359	26
1984	31 359	1 266	1 327	31 298	24
1985	31 298	-1 303	1 197	28 798	24
1986	28 798	-1 016	1 088	26 694	25
1987	26 694	341	1 375	25 660	19
1988	25 660	3 194	1 443	27 411	19
1989	27 411	691	1 312	26 790	20
1990	26 790	-2 072	1 381	23 337	17
1991	23 337	-3 007	1 261	19 069	15
1992	19 069	..	1 147	..	..

Gold[1]

Year	Opening stock	Gross additions	Production	Closing stock	Reserve life
	tonnes				years
1974	371	54	53	372	7
1975	372	33	51	354	7
1976	354	94	52	396	8
1977	396	23	53	366	7
1978	366	97	53	410	8
1979	410	181	51	540	11
1980	540	278	48	770	16
1981	770	122	50	842	17
1982	842	58	62	838	13
1983	838	399	70	1 167	17
1984	1 167	118	80	1 205	15
1985	1 205	237	84	1 358	16
1986	1 358	238	100	1 496	15
1987	1 496	364	112	1 748	16
1988	1 748	201	130	1 819	14
1989	1 819	83	154	1 748	11
1990	1 748	-37	163	1 548	9
1991	1 548	57	172	1 433	8
1992	1 433	..	154	..	..

Note:

1. Reserve data exclude metal in placer deposits; production data are adjusted to exclude production from placer operations.

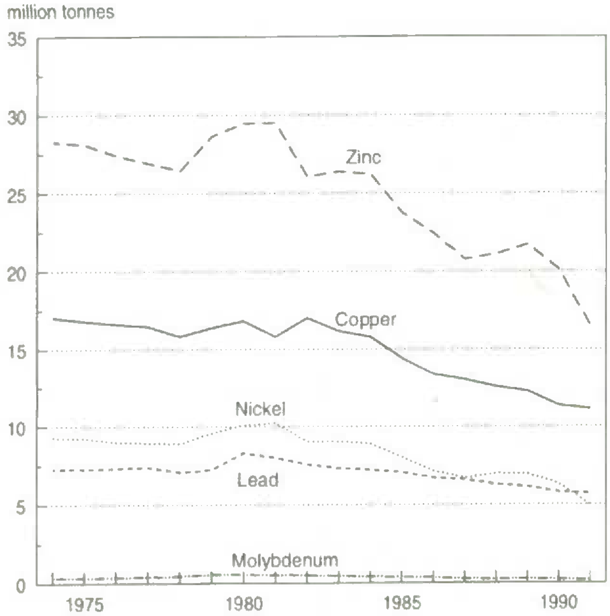
Sources:

Energy, Mines and Resources Canada, *Canadian Mineral Yearbook*, Ottawa, various issues.

Statistics Canada, *General Review of the Mineral Industries, Mines, Quarries and Oil Wells*, Catalogue No. 26-201, Ottawa, various issues.

Figure 4.9.5

Proven and Probable Reserves of Major Metals, 1974-1991



Source:
Statistics Canada, National Accounts and Environment Division.

Table 4.9.8

Estimates of Uranium Reserves Recoverable from Mineable Ore, 1973-1991[1]

	Reserve						
	Proven (measured)		Probable (indicated)				
Year	A[2]	B[2]	A[2]	B[2]	Total	Production	Net change
	thousand tonnes						
1973	65	4	91	14	174	4	..
1974	59	3	82	13	157	5	-17
1975	63	11	82	17	173	6	16
1976	79	4	88	11	182	8	9
1977	78	4	94	13	189	8	7
1978	76	4	139	16	235	8	46
1979	73	4	157	25	259	6	24
1980	67	6	163	22	258	7	-1
1981	45	2	153	12	212	8	-46
1982	32	1	144	8	185	8	-27
1983	30	-	162	41	233	7	48
1984	31	-	124	59	214	11	-19
1985	41	-	119	72	232	11	18
1986	46	1	107	95	249	12	17
1987	44	1	104	94	243	12	-6
1988	41	2	98	94	235	11	-8
1989	45	2	87	93	227	11	-8
1990	29	3	117	65	214	10	-13
1991	35	1	240	84	360	8	146

Notes:
1. From 1982 to 1991, physical losses in mining recovery and ore processing have been accounted for in the reserve estimate. Prior to 1982, these losses have not been deducted.
2. From 1983 to 1991, estimates of reserves are based on the price range of $100/kg or less for Category A and between $100 and $150/kg for Category B. Prior to 1983, these price ranges are more variable. However, for year-to-year comparability, the price range Category A is less than Category B.

Sources:
Energy, Mines and Resources Canada, Uranium Resource Appraisal Group (URAG).
Energy, Mines and Resources Canada, *Canadian Minerals Yearbook*, Ottawa, various issues.

The most recent appraisal of iron ore reserves indicates that there are approximately 6 billion tonnes of iron ore reserves remaining in Canada. At current production levels of about 35 million tonnes a year, these reserves are not significantly affected by production.[1]

Potash Reserves

Potash is important because of its use as a fertilizer. It is estimated that Canada has 14 000 million tonnes of potash reserves accessible by conventional underground mining methods. This represents almost 74 percent of the world's potash reserves. Another 30 billion tonnes, mainly in southern Saskatchewan, are available by solution mining[2] from deeper mines.[3] At current annual production levels of 7 million tonnes of potash, Canada's reserves will remain large.

Summary

The continued extraction of non-renewable resources depends on the discovery of new orebodies. Available information on Canada's mineral supplies indicates declining reserves, especially since the early 1980s. Increased environmental protection and land use regulation present limiting factors to the expansion of Canada's resource base in the future, as do low petroleum and metal prices and increasing discovery costs.

In 1991, Canada was the world's largest producer of uranium and zinc; second in gypsum, potash, nickel, sulphur and asbestos; and third in molybdenum, platinum group metals and natural gas. Canada is endowed with large portions of the world's reserves of these minerals. Minerals are of vital importance to the Canadian economy. A continued decline in Canada's mineral resource base will likely have an increasingly negative effect on Canada's economy.

1. Energy, Mines and Resources Canada, Mineral Policy Sector.
2. In solution mining, a heated brine is injected through boreholes into potash beds. The brine solution is pumped to the surface where it goes through a series of evaporators and crystallizers to recover the potash.
3. Energy, Mines and Resources Canada, *Canadian Potash 1980-2000*, working paper, Ottawa, 1992.

Natural Processes

4.10 Natural Disasters

Over the past 20 years, worldwide natural disasters have caused $300 billion in damage, affected the lives of 800 million people and killed an estimated 3 million people. Not only do these catastrophes bring tragic human suffering, they also cause serious economic disruptions in developing and developed countries alike.

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Canadians may feel relatively immune to the recent devastating natural disasters that have been reported in the media (such as the December, 1993 wildfires in Sydney, Australia and the January, 1994 earthquake in Los Angeles, California), however Canada is vulnerable to natural disasters as severe as those experienced around the world.[1] For example:

- landslides in Quebec, Alberta and British Columbia have devastated entire communities;
- few tornadoes have been as costly as the half billion dollars in damage caused in Edmonton in 1987;
- forest fires have consumed enormous amounts of timber;
- every summer brings the risk of severe wind and hailstorms to the Prairie provinces;
- floods, like the one that occurred in Winnipeg in 1993, cause millions of dollars in damage despite efforts to control these losses;
- avalanches frequently disrupt transportation and communications in the Rockies.

Table 4.10.1 presents data on major Canadian natural disasters dating back to 1583. The table is limited to geophysical and meteorological events and related phenomena. Health-related disasters (disease outbreaks) and transportation-related disasters (when not attributable to a natural event), are not included. In total, the table lists 228 disasters. It is interesting to note that the significant loss of life in ship disasters around Confederation (1867) was the catalyst for the founding of the Canadian Weather Service in 1871.[2]

Most of the ship-related disasters listed (37 events) are due to storm or wave phenomena. The incidence of marine disasters has dropped since the early 1900s; only 11 events have been recorded since 1920. Prior to 1920 there were 28 weather-related events where vessels sank. These events accounted for hundreds of lost fishing boats and many large ships, over 10 500 lives were lost. Before 1920 a total of 45 vessels were sunk (including 22 fishing boats), at a cost of close to 600 lives. Other transportation-related disasters since 1920 include aircraft accidents (3 events, over 120 lives lost) as well as marine incidents such as the *Ocean Ranger* disaster (84 deaths) in 1982.

Land-based disasters occurring near large population centres include the Regina tornado (1912), hurricane Hazel near Toronto (1954) and the Edmonton tornado (1987). Of the 228 disasters listed in Table 4.10.1, four were land-based hurricanes and 17 were tornadoes, accounting for hundreds of injuries, extensive property damage and over 225 deaths. The majority of these events occurred in southern Ontario (11 events, 149 deaths).

Table 4.10.2 presents the distribution of natural disaster by province. British Columbia has experienced the widest variety of natural disasters, the majority being earthquakes, followed by floods and avalanches. The Northwest Territories have experienced the fewest disasters, followed by Saskatchewan, Prince Edward Island and the Yukon. Regionally, the distribution of natural disasters is comparable across Canada with Atlantic Canada experiencing 72 events, central Canada 89 and western Canada 73 events. The territories have experienced 13 natural disasters, both a reflection of the small population and vast area of this region.

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1. Davenport, A.G. et al., *Toward a Canadian Program for the International Decade for Natural Disaster Reduction*, Joint Committee of the Royal Society of Canada and the Canadian Academy of Engineering, Ottawa, 1991.
2. Jones, Robert L., *Canadian Disasters an Historical Survey*, C.M.O.S. Newsletter, Vol. 20, No. 5, October, 1992 (updated by author, September 1993).

Table 4.10.1
Major Natural Disasters,[1] 1583-1993

Year	Location	Event[2]	Weather related[3]	Deaths	Description
1583	Sable Island, N.S.	Storm	Yes	85	Wreck of ship *Delight* off Sable Island
1663	Lower St. Lawrence River	Earthquake	No	-	7.5 to 8.0 (Richter Scale) earthquake, many landslides occur
1711	Quebec City, Que.	Storm	Yes	884	Fleet of ships runs aground in fog
1732	Montréal, Que.	Earthquake	No	1	7.0 (Richter Scale) earthquake, many houses damaged
1746	Sable Island, N.S.	Storm	Yes	200-300	Four French Warships sink
1775	Grand Banks, Nfld.	Hurricane	Yes	4 000	Many vessels lost
1783	Eastern Lake Ontario	Storm	Yes	190	Sloop *Ontario* sinks
1799	Sable Island, N.S.	Storm	Yes	40	Wreck of *Francis*
1813	Lake Ontario	Storm	Yes	53	Two ships sink (*Hamilton* and *Scourge*)
1814	St. Paul's Island, N.S.	Storm	Yes	799	Wreck of *Sovereign*
1825	Miramichi, N.B.	Fire	Yes	200-500	Fires caused by hot, dry summer
1826	Red River, Man.	Flood	Yes	-	Spring run-off causes widespread damage, river 14 feet above normal
1831	St. Lawrence River Basin	Earthquake	No	-	5.5 to 6.0 (Richter Scale) earthquakes (two quakes)
1841	Quebec City, Que.	Rockslide	No	32	Rockslide onto Lower Quebec City
1844	Lake Ontario and Lake Erie	Hurricane	Yes	200	Many vessels lost
1847	Newfoundland	Hurricane	Yes	300	Hurricane hits Newfoundland
1851	Prince Edward Island	Storm	Yes	150-300	Gale off P.E.I. sinks 70 U.S. fishing vessels
1855	Moncton, N.B.	Earthquake	No	-	5.5 to 6.0 (Richter Scale) earthquake
1856	St. Paul's Island, N.S.	Storm	Yes	72	Irish ship runs aground
1860	Mouth of Saguenay River, Que.	Earthquake	No	-	6.5 to 7.0 (Richter Scale) earthquake
1860	Sable Island, N.S.	Storm	Yes	30	U.S. ship *Argo* wrecked off Sable Island
1860	Sable Island, N.S.	Storm	Yes	205	Wreck of *Hungarian* off Sable Island
1861	Ottawa, Ont.	Earthquake	No	-	5.5 to 6.0 (Richter Scale) earthquake, minor damage
1863	Cape Race, Nfld.	Storm	Yes	238	Wreck of *Anglo-Saxon* on Cape Race
1865	Sorel/Trois-Rivières, Que.	Floods	Yes	45	St. Lawrence River flooding
1869	Maritimes	Storm	Yes	-	Legendary Saxby gale causes extensive damage to property and utilities
1870	Nova Scotia	Storm	Yes	191	Vessel *City of Boston* disappears off Nova Scotia
1870	Mouth of Saguenay River, Que.	Earthquake	No	-	7.0 (Richter Scale) earthquake, extensive damage to buildings
1872	Toronto, Ont.	Storm	Yes	-	On December 25 and 26 greatest two-day snowfall on record falls (58.4 cm)
1872	Vancouver, B.C.	Earthquake	No	-	7.5 (Richter Scale) earthquake east of Vancouver
1873	Cape Breton	Hurricane	Yes	360-380	Hurricane hits on August 25, over 1200 boats destroyed
1873	Prospect, N.S.	Fog	Yes	535-585	Wreck of *Atlantic* in fog
1873	Westville, N.S.	Mine[3]	No	60	Coal mine fire and explosion
1878	Toronto, Ont.	Flood	Yes	-	Heavy summer rain (13 cm in 7.5 hours) causes Don River to overflow, extensive damage
1879	Bouctouche, N.B.	Tornado	Yes	7	Tornado hits August 6, 25 families homeless, minor damage
1880	Stellarton, N.S.	Mine	No	44	Drummond Coal Mine explosion
1881	Lake Huron	Fire	Yes	500	Forest fires near Lake Huron after dry spell
1882	Georgian Bay	Storm	Yes	126	Vessel *Asia* sinks in Georgian Bay
1883	Lake Ontario	Flood	Yes	18	Lake Ontario flash flood
1885	Ottawa, Ont.	Storm	Yes	-	Heavy snow (108 cm) followed by rain (50 mm) April 2 to 6, communications paralysed
1885	Lake Superior	Storm	Yes	48	CPR ship *Algoma* sinks in Lake Superior
1886	Vancouver, B.C.	Fire	Yes	30-40	Great fire of Vancouver
1887	Nanaimo, B.C.	Mine	No	148	Mine disaster
1888	Nanaimo, B.C.	Mine	No	77	Mine disaster
1888	Valleyfield, Que.	Tornado	Yes	9	Tornado hits August 16, widespread damage from Valleyfield to St. Zotique
1889	Niagara Falls, Ont.	Storm	Yes	-	Snow storm with high winds January 9, Niagara suspension bridge blown down
1889	Quebec City, Que.	Rockslide	No	45	Rockslide onto Lower Quebec City
1891	Springhill, N.S.	Mine	No	125	Mine disaster
1894	Fraser River, B.C.	Flood	Yes	-	Heavy spring run-off, widespread damage
1897	Montréal, Que.	Earthquake	No	-	5.6 (Richter Scale) earthquake
1898	Nova Scotia	Storm	Yes	545	Two vessels (*La Bourgogne* and *Cromartyshire*) collide
1903	Frank, Alta.	Landslide	No	70	Landslide on Turtle Mountain
1906	Vancouver Island, B.C.	Storm	Yes	126	Wreck of *Valencia* off Vancouver Island
1910	Rogers Pass, B.C.	Avalanche	Yes	62	Avalanche in Rogers Pass
1910	Crowsnest Pass, Alta.	Mine	No	30	Bellevue Mine explosion
1911	Porcupine, Ont.	Fire	Yes	73	Forest fires near Porcupine, Ont.
1912	Regina, Sask.	Tornado	Yes	29	Tornado hits June 30, hundreds injured, extensive property damage
1913	Amherst County, N.S.	Flood	Yes	2	Heavy rain causes flooding, widespread damage
1913	Lower Great Lakes	Storm	Yes	270	Thirty-four ships sink in storm
1914	Newfoundland	Storm	Yes	173	Vessel *Southern Cross* disappears off Newfoundland
1914	Lanark, Ont.	Earthquake	No	-	5.6 (Richter Scale) earthquake
1914	Newfoundland	Storm	Yes	77	Four Sealing ships caught in ice off Newfoundland
1914	Rimouski, Que.	Storm	Yes	1 014	Two ships collide off Rimouski (*Empress of Ireland* and *Storstad*)
1914	Hillcrest, Alta.	Mine	No	189	Mine explosion
1915	Howe Sound, B.C.	Avalanche	Yes	57	Britannia Mine avalanche
1915	Edmonton, Alta.	Flood	Yes	-	Heavy summer rain causes North Saskatchewan River to flood, widespread damage
1916	Cochrane/Matheson, Ont.	Fire	Yes	233	Forest fire
1917	Dominion, N.S.	Mine	No	65	Coal mine explosion
1917	Chaudière River, Que.	Flood	Yes	-	Heavy rain causes river to flood, widespread damage
1918	Stellarton, N.S.	Mine	No	88	Allan Mine explosion
1918	Vancouver Island, B.C.	Earthquake	No	-	7.0 (Richter Scale) earthquake
1918	British Columbia	Storm	Yes	343	Vessel *Princess Sophia* runs aground
1922	Haileybury, Ont.	Fire	Yes	44	Forest fire
1922	Portage la Prairie, Man.	Tornado	Yes	5	Tornado hits June 22, many injured, extensive property damage
1924	La Malbaie, Que.	Earthquake	No	-	6.1 (Richter Scale) earthquake

Table 4.10.1
Major Natural Disasters,[1] 1583-1993 (Continued)

Year	Location	Event[2]	Weather related[3]	Deaths	Description
1925	Mouth of Saguenay River, Que.	Earthquake	No	-	7.0 (Richter Scale) earthquake, extensive damage to buildings
1928	Estrie River, Que.	Flood	Yes	4	Spring run-off causes flooding, widespread damage
1929	Burin Peninsula, Nfld.	Tsunami	No	27	Earthquake on Grand Banks causes "seismic sea wave" to hit Newfoundland coast
1929	Queen Charlotte Sound, B.C.	Earthquake	No	-	7.0 (Richter Scale) earthquake
1930	St. Lawrence River	Storm	Yes	30	Lightning strike causes freighter *John B. King* (carrying explosives) to explode and sink
1932	Maritime Provinces	Storm	Yes	-	Tropical storm with high winds and rains hits September 17, extensive property and crop damage
1933	Baffin Bay, N.W.T.	Earthquake	No	-	7.3 (Richter Scale) earthquake
1935	Southern British Columbia	Storm	Yes	-	Heavy snowstorm (44 cm) hits January 19, extensive damage, roads impassable
1935	Timiskaming, Que.	Earthquake	No	-	6.2 (Richter Scale) earthquake, damage as far away as Mattawa, Ontario
1936	New Brunswick	Flood	Yes	-	Spring run-off causes flooding, many bridges and dams washed out
1940	Great Lakes	Storm	Yes	69	Three ships wrecked in Great Lakes storm
1942	Newfoundland	Storm	Yes	204	Vessels *Truxton* and *Pollux* run aground off Newfoundland
1944	Southern Ontario, Quebec	Storm	Yes	-	Heavy snowstorm (52 cm) hits December 11, roads impassable
1944	Cornwall, Ont.	Earthquake	No	-	6.5 (Richter Scale) earthquake, major structural damage to buildings
1944	Windsor, Ont.	Tornado	Yes	16	Tornado hits June 17, extensive damage, many injured
1944	Whitehorse, Yukon	Earthquake	No	-	6.5 (Richter Scale) earthquake
1946	Strait of Georgia, B.C.	Earthquake	No	-	7.3 (Richter Scale) earthquake, structural damage to buildings
1946	Lake St. Clair	Tornado	Yes	17	Tornado hits June 17, widespread damage from Windsor to Tecumseh
1946	Okanagan Valley, B.C.	Storm	Yes	-	Hailstorm hits July 29, extensive fruit crop damage, hailstones 5 cm in diameter
1948	Lower Fraser River, B.C.	Flood	Yes	-	Spring run-off and heavy rains flood 200 square kilometres, extensive damage
1949	Queen Charlotte Islands, B.C.	Earthquake	No	-	8.0 (Richter Scale) earthquake, minor damage
1950	Red River, Man.	Flood	Yes	1	Spring run-off and heavy rains flood 1 760 km^2, extensive damage, 100 000 people evacuated
1952	Whitehorse, Yukon	Earthquake	No	-	6.0 (Richter Scale) earthquake south of Whitehorse
1952	Stellarton, N.S.	Mine	No	19	MacGregor Mine explosion
1953	Sarnia, Ont.	Tornado	Yes	5	Tornado and Thunderstorms hit May 21, extensive damage, many injured
1953	Lake Superior	Storm	Yes	17	Freighter sinks in high winds
1953	East Central Yukon	Earthquake	No	-	6.5 (Richter Scale) earthquake
1954	Southern Ontario	Hurricane	Yes	83	Hurricane Hazel causes widespread wind and flood damage
1955	Saskatchewan and Manitoba	Flood	Yes	-	Spring run-off and heavy rains cause extensive damage
1955	East Central Yukon	Earthquake	No	-	6.5 (Richter Scale) earthquake
1955	Vita, Man.	Tornado	Yes	-	Tornado hits June 19, hundreds injured
1956	East Central Yukon	Earthquake	No	-	6.5 (Richter Scale) earthquake
1956	Mt. Slesse, B.C.	Storm	Yes	62	Aircraft crashes into Mt. Slesse in poor weather
1956	Vancouver Island, B.C.	Earthquake	No	-	6.8 (Richter Scale) earthquake west of Vancouver Island
1956	Elkhorn and Crystal City, Man.	Storm	Yes	-	Hailstorm and tornadoes hit August 16, extensive crop and property damage
1956	Queen Charlotte Islands, B.C.	Earthquake	No	-	6.5 (Richter Scale) earthquake
1956	Springhill, N.S.	Mine	No	39	Second Springhill Mine disaster
1957	Becancour, Que.	Flood	Yes	4	Heavy summer rain causes widespread damage
1957	Vancouver Island, B.C.	Earthquake	No	-	6.8 (Richter Scale) earthquake west of Vancouver Island
1958	St. John's, Nfld.	Storm	Yes	-	Freezing rain lasts 43 hours (February 27 to March 2), major power disruptions
1958	Springhill, N.S.	Mine	No	75	Third Springhill Mine disaster
1959	St. John's, Nfld.	Storm	Yes	6	Heavy snow hits February 16, transportation and communications paralysed
1959	Listowel, Ont.	Storm	Yes	8	Heavy snow followed by rain on February 28, arena roof collapses
1959	Escuminac, N.B.	Storm	Yes	35	Twenty-two fishing boats sink
1960	Queen Charlotte Islands, B.C.	Earthquake	No	-	6.7 (Richter Scale) earthquake
1961	Montréal, Que.	Storm	Yes	-	Ice storm with high (>120 km/h) winds on February 25, extensive damage
1961	Timmins, Ont.	Flood	Yes	5	Thunderstorm causing flooding on August 31, extensive damage
1964	Port Alberni, B.C.	Tsunami	No	-	Earthquake in Alaska causes "seismic sea wave" to hit B.C. coast, widespread damage
1964	Alberta	Flood	Yes	21	Heavy rain in the Old Man and Milk River Basins in Alberta, deaths occurred in Montana
1964	Maritimes	Storm	Yes	23	Severe winter storm
1965	Stewart, B.C.	Avalanche	Yes	26	Heavy snow on Granduc Mountain
1966	Winnipeg, Man.	Storm	Yes	-	On March 4 heavy snow (36 cm) and high winds (>120 km/h) paralyse city
1966	Red River, Man.	Flood	Yes	-	Spring run-off and heavy rains cause extensive damage
1966	Lake Huron	Storm	Yes	28	Ore carrier *D.L. Morrell* sinks in storm
1966	North Shore, Que.	Flood	Yes	4	Heavy fall rain causes flooding and sidespread damage
1967	Southern Alberta	Storm	Yes	-	Heavy snowfall from April 17 to 20 (205 cm), thousands of cattle starve
1969	Montréal, Que.	Storm	Yes	15	A 60 hour snowstorm hits Montréal, 70 cm of snow falls
1969	Edmonton, Alta.	Storm	Yes	-	On August 4 hailstorm and tornadoes cause widespread damage
1970	New Brunswick	Flood	Yes	2	Spring run-off and heavy rain cause flooding, widespread damage
1970	Sudbury, Ont.	Tornado	Yes	6	Tornado hits August 20, extensive property damage, 750 homeless
1970	Queen Charlotte Islands, B.C.	Earthquake	No	-	7.0 (Richter Scale) earthquake
1970	Turtle Creek, N.B.	Storm	Yes	-	From December 24 to 28, 125 cm of snow accumulates
1971	Montréal, Que	Storm	Yes	-	On March 4 heavy snow (43 cm) and high winds (>100 km/h) paralyse city
1971	Halifax, N.S.	Flood	Yes	-	Heavy summer rain from Hurricane Beth causes flooding, widespread damage
1971	St. Jean-Vianney, Que.	Storm	Yes	31	Heavy rainstorm causes crater to develop
1972	Frase River, B.C.	Flood	Yes	-	Spring run-off and heavy rain, extensive damage
1972	Nootka Island, B.C.	Earthquake	No	-	6.2 (Richter Scale) earthquake
1972	Peace River, Alta.	Flood	Yes	-	Heavy summer rain, extensive crop and property damage
1972	Vancouver Island, B.C.	Earthquake	No	-	6.2 (Richter Scale) earthquake west of Vancouver Island
1972	Western end of Lake Erie	Flood	Yes	-	Wind driven waves cause flooding, extensive damage
1973	New Brunswick	Flood	Yes	-	Spring run-off and heavy rain, extensive damage
1974	Cambridge, Ont.	Flood	Yes	-	Heavy spring rain causes flooding, extensive damage
1974	Terrace, B.C.	Avalanche	Yes	7	Avalanche buries service station and motel, one person rescued
1974	Southern Quebec	Flood	Yes	-	Spring run-off causes flooding, extensive damage
1974	Saskatchewan and Alberta	Flood	Yes	-	Spring run-off causes flooding, extensive damage

Table 4.10.1

Major Natural Disasters,[1] 1583-1993 (Continued)

Year	Location	Event[2]	Weather related[3]	Deaths	Description
1974	Windsor, Ont.	Tornado	Yes	9	Tornado hits April 3, 30 injured, minor damage
1975	Lake Superior	Storm	Yes	29	Wreck of the *Edmund Fitzgerald*
1975	Eastern Ontario	Storm	Yes	-	April 2 to 5 heavy snow and high winds isolate several communities, extensive damage
1975	Saskatchewan	Storm	Yes	-	Thunderstorms with high winds hit June 25, extensive crop damage
1976	Maritimes	Storm	Yes	-	Heavy rain and snow storm hits February 2, power and transportation disruptions
1976	Kootenay Pass, B.C.	Avalanche	Yes	3	Avalanche in Kootenay Pass
1976	Red River, Man.	Flood	Yes	-	Spring run-off causes flooding, extensive damage
1976	Nova Scotia	Flood	Yes	-	Heavy spring rain causes flooding, extensive damage
1976	Quebec	Flood	Yes	-	Spring run-off, heavy rain and ice jams cause flooding, extensive damage
1977	Prince Edward County, Ont.	Storm	Yes	-	Heavy snow on January 28, communities paralysed, transportation disrupted
1978	Southern Ontario	Storm	Yes	12	Heavy snow and high (>115 km/h) winds, extensive damage
1978	Northwest British Columbia	Flood	Yes	-	Spring run-off causes flooding, extensive damage
1978	Cranbrook, B.C.	Storm	Yes	42	PWA 737 crashes in poor weather
1979	Frobisher Bay, N.W.T.	Storm	Yes	-	From February 8 to 17 blizzard cuts off community for ten days
1979	Manitoba	Flood	Yes	-	Spring run-off causes flooding, extensive damage
1979	Dawson, Yukon	Flood	Yes	-	Spring run-off and ice jams cause flooding, extensive damage
1979	New Brunswick	Flood	Yes	-	Spring run-off and heavy rain causes flooding, extensive damage
1979	Woodstock, Ont.	Tornado	Yes	-	Three Tornadoes hit August 9, extensive damage
1979	Alaska-Yukon Border	Earthquake	No	-	7.1 (Richter Scale) earthquake, minor property damage
1979	British Columbia	Storm	Yes	..	On December 25 the ship *Lee Wang Zin* capsizes off the Queen Charlotte Islands
1980	Port Hope, Ont.	Flood	Yes	-	Spring run-off and heavy rain causes Ganaraska River to flood, extensive damage
1980	Kelowna, B.C.	Storm	Yes	-	April 14 thunderstorm (winds > 139 km/h) uproots trees, power failures
1980	Brampton, Ont.	Tornado	Yes	-	Tornado hits May 31, extensive property damage
1980	British Columbia	Flood	Yes	-	In December flooding near Vancouver causes evacuation after a week of heavy rains
1981	Calgary, Alta.	Storm	Yes	2	Hailstorm hits July 28, extensive damage
1981	South coast, B.C.	Flood	Yes	-	Heavy rain causes flooding and landslides, extensive damage
1981	Windsor, Ont.	Flood	Yes	-	Heavy rain causes Turkey Creek to flood, extensive damage to southeastern section of city
1982	Newfoundland	Storm	Yes	84	Drilling rig *Ocean Ranger* sinks off Newfoundland in heavy snowstorm and high winds
1982	Aklavik, N.W.T.	Flood	Yes	-	Spring run-off and ice jams cause flooding, extensive damage
1982	P.E.I., Magdelan Islands, Que.	Storm	Yes	-	Succession of severe storms from February 22 to 26 cuts isolates many communities for days
1982	Montréal (Ste-Rose), Que.	Tornado	Yes	6	Tornado hits June 14, extensive property damage, 26 injured
1982	North Central New Brunswick	Earthquake	No	-	5.7 (Richter Scale) earthquake, minor property damage
1983	Gaspé, Que.	Flood	Yes	-	High tides, severe winter storm, extensive damage
1983	Regina, Sask.	Flood	Yes	-	Spring run-off, extensive damage
1983	Montréal, Que.	Flood	Yes	-	Ice jams, heavy spring rain, extensive damage
1983	Winnipeg, Man.	Storm	Yes	-	Freezing rain on March 6 causes extensive damage, disrupts transportation
1983	Southern Quebec	Storm	Yes	-	Freezing rain on December 13 causes major power disruptions throughout region
1983	Newfoundland	Flood	Yes	-	Heavy rain causes dam to burst on Exploits River, damage to Grand Falls and Bishops Falls
1984	Newfoundland	Flood	Yes	-	Ice jams, heavy spring rain, extensive damage including sinking of fishing boats
1984	Lower Fraser River, B.C.	Flood	Yes	-	Heavy rain, snowmelt, roads, bridges and fish hatchery damaged
1984	Newfoundland	Storm	Yes	-	Freezing rain on April 13 causes major power disruptions throughout province
1984	West Quebec	Tornado	Yes	1	Tornado hits July 15, 38 injured, minor damage
1984	Toronto, Ont.	Tornado	Yes	-	Tornado hits August 14, extensive damages
1984	London, Ont.	Tornado	Yes	-	Tornado hits September 2, 30 injuries, minor damage
1985	Southern Ontario	Flood	Yes	-	Heavy spring rain, melting snow, 5600 ha land flooded, extensive damage
1985	Hay River, N.W.T.	Flood	Yes	-	Ice jams, spring run-off, minor damages, one injury
1985	Barrie, Orangeville, Ont.	Tornado	Yes	12	Tornado hits May 31, 165 injuries, extensive damages, 450 homes destroyed
1985	St. Sylvere, Que.	Storm	Yes	-	Tornado hits June 19, three injuries, extensive damages
1985	Mississauga, Ont.	Storm	Yes	-	Tornado hits July 7, ten injuries, minor damages
1985	New Liskeard, Ont.	Storm	Yes	-	Hailstorm hits July 21, extensive crop damage
1985	Southwestern Quebec	Storm	Yes	-	Hailstorm hits July 30, extensive crop and property damage
1985	N.W.T., Alta., B.C.	Earthquake	No	-	6.6 (Richter Scale) earthquake October 5, felt in Edmonton and Yellowknife, minor damage
1985	N.W.T., Alta., B.C.	Earthquake	No	-	6.9 (Richter Scale) earthquake December 23, felt in Edmonton and Yellowknife, minor damage
1986	Valemont, B.C.	Avalanche	Yes	4	Avalanche buries snowmobilers
1986	Central British Columbia	Earthquake	No	-	5.4 (Richter Scale) earthquake on March 21, strongly felt in Prince George, minor damage
1986	Southern and Eastern Ontario	Storm	Yes	-	Hailstorm hits June 16, extensive crop and property damage
1986	Sask., Alta.	Flood	Yes	1	Heavy summer rainfall, extensive road and crop damage
1986	Southern Ontario	Storm	Yes	-	Hailstorm hits August 2, extensive crop damage
1986	Southwestern Manitoba	Storm	Yes	2	Blizzard hits November 8, extensive clean-up required
1986	Ottawa, Ont.	Storm	Yes	-	December 25th, Ottawa Valley hit by severe ice storm, transportation and utilities affected
1987	Eastern Canada	Storm	Yes	8	Snowstorm with high winds hits March 17, traffic disrupted, schools and businesses closed
1987	Cape Race, Nfld.	Storm	Yes	34	The trawler *Hosanna* sinks 400 km off Cape Race
1987	Quebec City, Que.	Flood/Landslide	Yes	-	Heavy spring rain and snowmelt causes flooding and landslide, extensive damage
1987	Montréal, Que.	Flood	Yes	2	Severe thunderstorm causes flash flood on July 14, extensive damage
1987	Edmonton, Alta.	Hurricane	Yes	27	Hurricane hits July 31, over 200 injured, extensive property damage
1987	Peace River District	Storm	Yes	-	Heavy summer rainfall damages crops and roads in Alberta and B.C.
1987	B.C., Yukon	Earthquake	No	-	7.6 (Richter Scale) earthquake, strongly felt in Whitehorse
1988	N.W.T.	Earthquake	No	-	6.0 (Richter Scale) earthquake March 25, strongly felt in the Mackenzie region
1988	Southern Quebec	Earthquake	No	-	6.5 (Richter Scale) earthquake November 25, strongly felt in Montréal, extensive property damage
1989	Dryden, Ont.	Storm	Yes	24	Air Ontario airplane crashes in poor weather
1989	Gulf of St. Lawrence	Storm	Yes	39	Two vessels *Johanna B* and *Capitaine Torres* sink
1989	Northern Quebec	Earthquake	No	-	6.2 (Richter Scale) earthquake on December 25, strongly felt in northern Quebec
1991	Invermere, B.C.	Avalanche	Yes	8	Skiers buried while heli-skiing in the Bugaboos
1991	Newfoundland	Storm	Yes	33	The freighter *Protektor* sinks 400 km east of Newfoundland
1991	Newfoundland	Storm	Yes	-	Severe winter storm hits December 25th, some evacuations in Placentia Bay

Table 4.10.1

Major Natural Disasters,[1] 1583-1993 (Continued)

Year	Location	Event[2]	Weather related[3]	Deaths	Description
1992	Plymouth, N.S.	Mine	No	26	Westray Mine explosion
1993	Winnipeg, Man.	Flood	Yes	-	Heavy summer rains cause minor damage to homes
1993	Yarmouth, N.S.	Storm	Yes	33	Vessel *Gold Bond Conveyor* sinks off Yarmouth

Notes:

1. The main criterion for inclusion of disasters in this table is significant impact on people. In some cases significant events are not included since they caused little damage or occurred in isolated areas.
2. Natural disasters listed here cover major geophysical and meteorological events including storms, floods, earthquakes and related occurrences such as shipwrecks and aircraft accidents.
3. While no mine disasters have been designated "Weather Related", current (1992) studies of ambient atmospheric pressure in mine entrances indicate that changing atmospheric pressure may be a contributing factor in the build-up of methane gas in mines.

Sources:

Jones, Robert L., *Canadian Disasters an Historical Survey*, C.M.O.S. Newsletter, Vol. 20, No. 5, October, 1992 (updated by author, September, 1993).
Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*. Key Porter Books Limited, Toronto, 1993.
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
The Canadian Geographic Magazine, various issues.
Environment Canada, Inland Waters Directorate, Water Planning and Management Branch.
Environment Canada, Atmospheric Environment Service.
Energy Mines and Resources Canada, Geophysics and Marine Geoscience Branch, Seismology Section.
Emergency Preparedness Canada.

Table 4.10.2

Natural Disasters by Type and Province, 1583-1993

Event	Nfld.	P.E.I.	N.B.	N.S.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.	Total
						Occurrences[1]							
Storm													
Land-based	9	5	6	5	10	14	4	1	4	3	-	1	62
Ship wrecks[2]	6	2	1	11	2	10	-	-	-	3	-	-	35
Air crashes	-	-	-	-	-	1	-	-	-	2	-	-	3
Ocean rigs	1	-	-	-	-	-	-	-	-	-	-	-	1
Flood	2	-	4	3	10	8	7	4	5	7	1	2	53
Earthquake	-	-	2	-	11	3	-	-	-	15	7	2	40
Tornado	-	-	1	-	3	10	2	1	-	-	-	-	17
Mine disaster	-	-	-	9	-	-	-	-	2	2	-	-	13
Avalanche	-	-	-	-	-	-	-	-	-	7	-	-	7
Fire	-	-	1	-	-	4	-	-	-	1	-	-	6
Hurricane													
Land-based	1	-	-	1	-	1	-	-	1	-	-	-	4
Ship wrecks	1	-	-	-	-	1	-	-	-	-	-	-	2
Tsunami	1	-	-	-	-	-	-	-	-	1	-	-	2
Rockslide	-	-	-	-	2	-	-	-	-	-	-	-	2
Landslide	-	-	-	-	-	-	-	-	1	-	-	-	1
Total	**21**	**7**	**15**	**29**	**38**	**52**	**13**	**6**	**13**	**41**	**8**	**5**	**248**

Notes:

1. The total of all occurrences (248) does not add to total occurrences in Table 4.10.1 (228) since some storms and floods affected more than one province.
2. In most instances more than one ship was lost during each event.

Sources:

See Table 4.10.1

4.11 Climate

Simply defined, climate is the average weather experienced from one year to the next at a given location. Weather, in turn, is defined as the state or condition of the atmosphere at a certain point in time.

Canada's climate is both diverse and unpredictable. It poses many different obstacles to Canadians throughout its annual cycle. Climate has both positive and negative economic impacts. For example, snow removal in eastern Canada costs millions of dollars annually. At the same time this snow generates income by supporting recreational activities like skiing, and winter carnivals. Climate dictates how we build our homes, what kind of clothing we wear and even when and where we take our vacations. Climatic extremes experienced on the prairies regularly influence crop production and ultimately farm viability.

Climate Profile

Canada has been described as a land of climatic contrasts and extremes. Even so, Canada does not yet hold any of the major world weather records[1] shown in Table 4.11.1. Table 4.11.2 provides a further comparison of weather data between a selection of Canadian and foreign cities.

Climate is influenced by landforms, water, latitude and wind direction.[2] The complex interactions among these factors influence the character of the climate experienced across the country.

- **Landforms:** Air masses forced to rise over mountains result in precipitation in the form of snow or rain. Once over the mountains the air mass descends and warms, regaining its ability to hold moisture.
- **Water:** Large bodies of water can moderate climates due to their ability to retain or lose heat. In the fall and

1. Environment Canada, *The Climates of Canada*, Ottawa, 1990.
2. Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.

Table 4.11.1

Weather Records for Canada, United States and the World

Category	Canada	United States	World
Maximum air temperature	45.0°C Midale and Yellowgrass, Sask. (July 9, 1937)	56.7°C Death Valley, CA (July 10, 1913)	58.0°C Al'azizyah, Libya (September 13, 1922)
Minimum air temperature	-63.0°C Snag, Yukon (February 3, 1947)	-62.1°C Prospect Creek Camp, AK (January 23, 1971)	-89.6°C Vostok, Antarctica (July 21, 1983)
Coldest month	-47.9°C Eureka, N.W.T. (February, 1979)	..	..
Highest sea-level pressure	107.96 kPa Dawson, Yukon (February 2, 1989)	107.86 kPa Northway, AK (January 31, 1989)	108.38 kPa Agata, Siberia USSR (December 31, 1968)
Lowest sea-level pressure	94.02 kPa St. Anthony, Nfld. (January 20, 1977)	89.23 kPa Matecumbe Key, FL (September 2, 1935)	87.64 kPa in eye of Typhoon *JUNE* in the Pacific Ocean, 17°N, 138°E (November 19, 1975)
Greatest daily precipitation	489.2 mm Ucluelet Brynnor Mines, B.C. (October 6, 1957)	1 090 mm Alvin, TX	1 869.9 mm Cilans, La Reunion Island (March 15, 1952)
Greatest monthly precipitation	2 235.5 mm Swanson Bay, B.C. (November, 1917)	2 717.8 mm Kukui, HI (March, 1942)	9 300 mm Cherrapunji, India (July, 1861)
Greatest annual precipitation	8122.4 mm Henderson Lake, B.C. (1931)	17 902.7 mm Kukui, HI (1962)	26 461.2 mm Cherrapunji, India (August 1860 to July 1861)
Greatest average annual precipitation	6 655 mm Henderson Lake, B.C.	11 684 mm Mt. Walaleale, Kauai, HI	11 684 mm Mt. Walaleale, Kauai, HI
Lowest annual precipitation	12.7 mm Arctic Bay, N.W.T. (1949)	0.0 mm Bagdad, CA (October 3, 1912 to November 8, 1914)	0.0 mm Ariza, Chile - no rain for 14 years
Greatest average annual snowfall	1 422 cm Glacier Mountain, Fidelity, B.C.	1 460.8 cm Rainer Paradise Ranger Station, WA	..
Greatest snowfall in one season	24 465.5 cm Revelstoke Mountain, Copeland, B.C. (1971-72)	2 650 cm Rainer Paradise Ranger Station, WA (1971-72)	..
Greatest monthly snowfall	535.0 cm Maines Apps. No. 2, B.C. (December, 1959)	993.6 cm Tamarack, CA (January, 1911)	..
Greatest daily snowfall	118.1 cm Lakelse Lake, B.C. (January 17, 1974)	193.0 cm Silver Lake, CO (April 14, 15, 1921)	..
Highest average annual number of thunderstorm days	34 days London, Ont.	96 days Fort Meyers, FL	322 days Bogor, Indonesia
Heaviest hailstone	290g Cedoux, Sask.	758g Cotteyville, KS	5 000 g Guangxi region, China (May 1, 1986)
Highest average annual wind speed	36 km/h Cape Warwick, Resolution Island, N.W.T.	56.3 km/h Mt. Washington, NH	..
Highest hourly wind speed	201.1 km/h Quaqtaq, Que. (November 18, 1931)	362.0 km/h Mt. Washington, NH (April 12, 1934)	..
Highest average annual hours of fog	1890 hrs Argentia, Nfld.	2 552 hrs Cape Disappointment, WA	..

Sources:
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.

Table 4.11.2

Comparison of Weather Experienced at Selected Canadian and Foreign Cities

Station	Temperature				Annual total			
	Winter		Summer					
	High	Low	High	Low	Snowfall	Precipitation	Wet days	Bright sunshine
	°C				cm	mm	days	hours
Canadian cities:								
St. John's, Nfld.	-0.5	-7.2	20.2	10.7	359	1 514	217	1 497
Charlottetown, P.E.I.	-3.0	-11.2	23.0	13.7	331	1 169	174	1 818
Halifax, N.S.	-1.6	-10.3	23.3	13.0	271	1 491	166	1 885
Fredericton, N.B.	-3.8	-14.5	25.7	13.0	290	1 109	156	1 878
Québec, Que.	-7.3	-16.6	24.9	13.2	343	1 174	175	1 852
Montréal, Que.	-5.7	-14.6	26.1	15.6	235	946	162	2 054
Toronto, Ont.	-2.5	-10.9	26.8	14.2	131	762	137	..
Ottawa, Ont.	-6.4	-15.4	26.3	14.9	227	879	156	2 009
London, Ont.	-2.7	-10.5	26.4	14.2	209	909	166	1 894
Winnipeg, Man.	-14.3	-24.2	25.9	13.3	126	526	120	2 321
Saskatoon, Sask.	-14.1	-24.3	25.4	11.5	113	349	108	2 450
Calgary, Alta.	-8.0	-17.6	23.3	9.4	153	424	113	..
Vancouver, B.C.	5.2	-0.2	21.9	12.6	60	1 113	163	1 920
Whitehorse, Yukon	-16.4	-25.0	20.3	7.9	137	261	120	..
Yellowknife, N.W.T.	-24.7	-33.0	20.7	11.8	135	267	121	2 277
Foreign cities:								
Beijing, China	6.7	-16.1	36.3	15.9	30	623	66	2 706
Calcutta, India	33.4	7.0	34.8	23.4	..	1 592	102	2 528
London, England	6.0	2.0	22.0	14.0	..	594	107	1 514
Los Angeles, U.S.A.	23.4	3.0	34.3	11.3	..	373	39	3 185
Mexico City, Mexico	23.0	2.0	26.0	10.0	..	726	133	2 366
Miami, U.S.A.	29.4	9.4	35.5	19.9	..	1 520	103	2 945
Moscow, Russia	-9.0	-16.0	23.0	13.0	161	575	181	1 597
New York, U.S.A.	7.7	-6.3	34.4	15.4	77	1 076	121	2 564
Rome, Italy	12.3	3.4	30.9	17.7	..	749	76	2 491
Rio de Janeiro, Brazil	26.7	13.7	30.9	19.3	..	1 093	131	2 351
Shanghai, China	11.6	-4.8	36.0	18.2	25	1 143	98	1 877
Sydney, Australia	19.7	3.9	29.3	14.7	..	1 205	152	2 440
Tokyo, Japan	13.8	-6.4	32.3	17.9	20	1 563	104	2 021

Sources:
Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.
Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*, Key Porter Books Limited, Toronto, 1993.

early winter, water acts as a heat source, warming the land nearby. In the spring and early summer water is cooler than the surrounding air and land keeping the land temperature lower.

- **Latitude:** Latitude effects climate in two ways. First, the curvature of the earth results in the spreading of sunlight over a greater area on the ground as one moves further towards the extremes of latitude. Second, sunlight must travel a greater distance through the atmosphere, which also decreases the energy reaching the earth's surface.
- **Wind direction:** Generally precipitation increases the further east you move from the centre of the continent. Since the prevailing wind direction in Canada is from west to east, air masses travel eastward across the continent picking up moisture from vegetation, land, rivers and lakes and releasing it further along their path.

The following six tables present a climate profile for Canada based on a thirty-year period called a "normal".[1] Table 4.11.3 begins the profile with a listing of the monthly and annual temperature and precipitation for selected cities across Canada.

Table 4.11.4 presents provincial data on "number of days with" thunderstorms, fog and frost. The remaining three tables present provincial weather facts for temperature, precipitation, snow, wind and sunshine hours. Included in all provincial weather breakdowns are the corresponding weather stations where the measurements were collected.

Table 4.11.8 lists all weather stations referred to in this section. The station names are presented by province/territory and ecozone, with location given by latitude and longitude. Map 1.4.4 in Section 1.4 - **Geographic Units for Environmental Analysis,** shows the location of these stations, which are part of the Canadian synoptic weather station network.

Weather Distinctions

Distinctive or favourable regional weather is sometimes trumpeted by advertising agencies and travel agents as attractive reasons to travel or relocate to a certain place. Table 4.11.9 presents the rankings of Canadian cities in terms of a number of climate features. For this analysis, 75 Cana-

1. A normal is defined as an average of weather components (temperature, precipitation, wind) over a period of 30 consecutive years. In this instance the normal is based on the years 1951 to 1980 inclusive.

Table 4.11.3

Temperature and Precipitation for Selected Cities

Station	January			April			July			October		
	Average temperature		Total	Average temperature		Total	Average temperature		Total	Average temperature		Total
	Afternoon	Morning	precipitation	Afternoon	Morning	precipitation	Afternoon	Morning	precipitation	Afternoon	Morning	precipitation
	°C		mm	°C		mm	°C		mm	°C		mm
St. John's, Nfld.	-1	-7	156	5	-2	116	20	11	75	10	3	146
Charlottetown, P.E.I.	-3	-11	117	6	-2	82	23	14	84	12	4	106
Fredericton, N.B.	-4	-15	103	9	-1	80	26	13	89	13	2	97
Moncton, N.B.	-3	-13	125	8	-2	90	24	13	95	13	2	99
Saint John, N.B.	-3	-13	149	8	-2	107	22	12	103	12	3	128
Halifax, N.S.	-2	-10	153	8	-1	115	23	13	94	13	4	134
Montréal, Que.	-6	-15	72	11	1	74	26	16	90	13	4	76
Québec, Que.	-8	-17	90	8	-2	73	25	13	117	11	2	91
Hamilton, Ont.	-3	-10	63	11	1	79	26	15	71	14	5	61
Kitchener, Ont.	-4	-10	60	11	1	75	26	15	84	14	5	69
London, Ont.	-3	-11	75	12	1	81	26	14	72	15	4	73
Ottawa, Ont.	-6	-15	61	11	0	59	26	15	86	13	3	68
Sault Ste. Marie, Ont.	-6	-15	74	8	-2	64	24	11	56	12	3	74
Toronto, Ont.	-3	-11	50	12	1	70	27	14	71	15	4	62
Windsor, Ont.	-1	-9	55	13	3	83	28	17	83	16	6	57
Churchill, Man.	-24	-31	15	-5	-15	23	17	7	46	1	-4	43
Winnipeg, Man.	-14	-24	21	9	-2	39	26	13	76	12	1	31
Regina, Sask.	-13	-23	17	9	-3	24	26	12	53	12	-2	19
Saskatoon, Sask.	-14	-24	18	9	-3	21	25	12	54	11	-1	17
Calgary, Alta.	-6	-18	16	9	-3	33	23	9	65	12	-1	18
Edmonton, Alta.	-11	-22	24	9	-3	20	22	9	22	11	-2	15
Vancouver, B.C.	5	0	154	13	5	60	22	13	32	14	8	114
Victoria, B.C.	6	0	154	13	4	39	22	11	18	14	6	78
Dawson, Yukon	-27	-34	17	5	-9	10	22	9	47	-1	-8	29
Whitehorse, Yukon	-16	-25	18	6	-5	10	20	8	34	4	-3	22
Iqaluit, N.W.T.	-22	-30	26	-9	-19	26	11	4	63	-2	-8	44
Yellowknife, N.W.T.	-25	-33	13	-1	-13	10	21	12	34	1	-4	35

Notes:
All figures are averages for the period 1951-1980.
Temperature measurements are taken "mid" afternoon and "early" morning.
Sources:
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
Environment Canada, *Canadian Climate Normals*, Ottawa, various issues.
Environment Canada, *Principal Station Data*, Ottawa, various issues.

Table 4.11.4

Provincial Weather Facts: Occurrences of Thunderstorms, Fog and Frost

Province/Territory	Thunderstorm[1] days		Fog[2] days		Frost[3] days	
	days[4]	Station	days	Station	days	Station
Newfoundland	7	Daniels Harbour	206	Argentia A	259	Nain
Prince Edward Island	11	Summerside A	47	Charlottetown A	175	O'Leary
New Brunswick	13	Fredericton A	106	Saint John A	215	Nine Mile Brk. (Camp 68)
Nova Scotia	12	Debert A	127	Sable Island	194	Northeast Margaree
Quebec	27	St. Hubert	85	Cape Hopes Advance	296	Cape Hopes Advance
Ontario	34	Windsor A	76	Mount Forest	254	Winisk A
Manitoba	26	Rivers A	48	Churchill A	258	Churchill A
Saskatchewan	25	Wynyard	37	Collins Bay	238	Stony Rapids
Alberta	26	Edmonton Int'l A	39	Whitecourt	269	Lake Louise
British Columbia	24	Prince George	226	Old Glory Mountain	280	Alexis Creek Tautri Creek
Yukon	11	Snag	61	Komakuk Beach A	296	Komakuk Beach A
Northwest Territories	12	Fort Smith A	196	Resolution Island	340	Isachsen

Notes:
Average refers to the value of the particular element averaged over the period from 1951-1980.
1. A thunderstorm is reported when thunder is heard or lightning or hail is seen.
2. Fog is a suspension of small water droplets in air that reduces horizontal visibility at eye level to less than 1 kilometre.
3. Frost is said to occur if the temperature falls to 0°C or lower.
4. A "day" is counted only once, regardless of the number of individual occurrences of the phenomenon that day.
Sources:
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.

Table 4.11.5

Provincial Weather Facts: Temperature

Province/Territory	Warmest temperature on record °C	Date	Station	Coldest temperature on record °C	Date	Station	Annual average[1] temperature: Warmest °C	Station	Coldest °C	Station
Newfoundland	41.7	Aug. 11, 1914	Northwest River	-51.1	Feb. 17, 1973	Esker 2	6.3	Holyrood Ultramar	-3.8	Wabush Lake A
Prince Edward Island	36.7	Aug. 19, 1935	Charlottetown	-37.2	Jan. 26, 1864	Kilmahumaig	5.9	Charlottetown CDA	4.8	O'Leary
New Brunswick	39.4	Aug. 18, 1935	Nepisiguit Falls	-47.2	Feb. 2, 1955	Sisson Dam	6.2	St. Andrews	1.6	Upsalquitch Lake
Nova Scotia	38.3	Aug. 19, 1935	Collegeville	-41.1	Jan. 31, 1920	Upper Stewiacke	7.6	Sable Island	4.9	Trafalgar
Quebec	40.0	July 26, 1921	Ville Marie	-54.4	Feb. 5, 1923	Doucet	7.6	Montréal Lafontaine	-7.2	Koartak
Ontario	42.2	July 20, 1919	Biscotasing	-58.3	Jan. 23, 1935	Iroquois Falls	9.7	Windsor University	-5.5	Winisk A
Manitoba	44.4	July 11, 1936	St. Albans	-52.8	Jan. 9, 1899	Norway House	3.3	Morden CDA	-7.2	Churchill A
Saskatchewan	45.0	July 5, 1937	Midale	-56.7	Feb. 1, 1893	Prince Albert	5.0	Maple Creek North	-4.6	Collins Bay
Alberta	43.3	July 21, 1931	Bassano Dam	-61.1	Jan. 11, 1911	Fort Vermillion	5.9	Bow Island Rivers	-2.7	Fort Chipewyan A
British Columbia	44.4	July 16, 1941	Lillooet	-58.9	Jan. 31, 1947	Smith River	10.7	Sumas Canal	-3.2	Cassiar Yukon
Yukon	36.1	June 14, 1969	Mayo	-63.0	Feb. 3, 1947	Snag	-1.0	Whitehorse Riverdale	-11.4	Komakuk Beach A
Northwest Territories	39.4	July 18, 1941	Fort Smith	-57.2	Dec. 26, 1917	Fort Smith	-2.2	Fort Liard	-19.7	Eureka

Note:
1. All figures are averages for the period from 1951-1980.
Sources:
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.

Table 4.11.6

Provincial Weather Facts: Precipitation

Province/Territory	Average[1] annual precipitation: Greatest mm	Station	Least mm	Station	Average[1] annual snowfall: Greatest mm	Station	Least mm	Station	Greatest amount of snow on the ground any month: Depth cm	Station
Newfoundland	1 699.7	Burgeo	739.8	Nain	322.8	Woody Point	91.6	St. Shotts	313	Hopedale
Prince Edward Island	1 169.4	Charlottetown	921.0	Montague	330.6	Charlottetown CDA	173.3	Montague	156	Charlottetown CDA
New Brunswick	1 444.4	Saint John A	909.6	Upsalquitch Lake	448.8	Dawson Settlement	176.2	Southwest Head	252	Harvey Station
Nova Scotia	1 630.7	Ingonish Beach	973.7	Pugwash	406.7	Cheticamp	104.1	Baccaro	183	Nappan
Quebec	1 559.8	Mont Logan	295.9	Cape Hopes Advance	648.4	Mont Logan	161.6	Havre aux Maisons	259	Blanc-Sablon
Ontario	1 191.1	West Guilford	569.0	Kenora TCPL	430.0	Searchmont	74.0	Lakeview MOE	219	Gravenhurst
Manitoba	696.1	Peace Gardens	402.3	Churchill A	332.7	Island Lake	94.9	Lundar	175	Glenlea
Saskatchewan	530.1	Brabant lake	287.9	Nashlyn	348.6	Collins Bay	58.0	Aylesbury	224	Hudson Bay
Alberta	1 072.0	Waterton Park HQ	270.8	Empress	642.9	Columbia Icefield	59.9	Empress	179	Parker Ridge
British Columbia	6 655.0	Henderson Lake	205.6	Ashcroft	1 433.0	Glacier NP Mt. Fidelity	20.4	Carnation Creek	450	Whistler Roundhouse
Yukon	590.6	Tuchitua	135.9	Komakuk Beach A	365.7	Keno Hill	60.1	Komakuk Beach A	149	Hour Lake
Northwest Territories	663.2	Cape Dyer A	61.0	Rea Point	602.4	Cape Dyer A	28.6	Rea Point	241	Cape Dyer

Note:
1. All figures are averages for the period from 1951-1980.
Sources:
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.

Table 4.11.7

Provincial Weather Facts: Wind and Sunshine

Province/Territory	Wind: Highest wind speed km/hour	Station	Wind: Highest percent of calms km/hour	Station	Average[1] annual bright sunshine: Greatest hours	Station	Least hours	Station
Newfoundland	28.0 (W)	Bonavista	17.1	Wabush Lake A	1 572	Churchill Falls A	1 303	St. Shotts
Prince Edward Island	22.4 (SSW)	Summerside A	4.4	Summerside A	1 967	Tignish	1 817	East Baltic
New Brunswick	22.4 (W)	Miscou Island	11.8	Fredericton A	2 010	Chatham A	1 373	Summit Depot
Nova Scotia	25.7 (W)	Sable Island	16.9	Greenwood A	1 969	Shearwater A	1 449	Sable Island
Quebec	32.0 (NW)	Grindstone Island	20.4	Gaspé A	2 054	Montréal Int'l A	1 158	Mont Logan
Ontario	21.0 (SW)	Bruce Ontario Hydro	30.2	White River	2 203	Thunder Bay A	1 635	New Liskeard
Manitoba	22.7 (WNW)	Churchill A	21.0	Norway House A	2 460	Delta U	1 828	Churchill A
Saskatchewan	22.9 (W)	Swift Current A	12.8	La Ronge A	2 537	Estevan A	2 073	Cree Lake
Alberta	21.5 (W)	Pincher Creek	39.7	High Level A	2 490	Coronation A	1 724	Banff
British Columbia	33.7 (NW)	Cape St. James	48.5	Quesnel A	2 244	Cranbrook A	949	Stewart A
Yukon	14.1 (SSE)	Whitehorse A	57.5	Dawson A	1 844	Whitehorse A	1 789	Watson Lake A
Northwest Territories	35.3 (NW)	Resolution Island	35.1	Eureka	2 277	Yellowknife A	1 443	Mould Bay A

Note:
1. Figures are averages for the period from 1951-1980.
Sources:
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.

Table 4.11.8
Weather Station Names and Locations

Province/Territory/ Ecozone	Station	Airport[1]	Latitude (N)	Longitude (W)
			degree/minutes	
Newfoundland				
Taiga Shield	Churchill Falls	✓	53.33	64.06
	Wabush Lake	✓	52.56	66.52
Boreal Shield	Argentia	✓	47.18	54.00
	Bonavista		48.40	53.07
	Burgeo		47.37	57.37
	Daniels Harbour		50.14	57.35
	Gander Int'l	✓	48.57	54.34
	St. Anthony		51.22	55.38
	St. John's		47.34	52.44
Southern Arctic	Nain	✓	56.33	61.41
Prince Edward Island				
Atlantic Maritime	Charlottetown	✓	46.17	63.08
	Summerside	✓	46.26	63.50
Nova Scotia	Debert	✓	45.25	63.27
Atlantic Maritime	Greenwood	✓	44.59	64.55
	Halifax		44.39	63.36
	Sable Island		43.56	60.01
	Sydney	✓	46.10	60.03
Quebec				
Taiga Shield	Border	✓	55.20	63.13
Boreal Shield	Baie Comeau	✓	49.08	68.12
	Blanc Sablon		51.25	57.13
	Chicoutimi		48.26	71.04
	Doucet		48.13	76.37
	Matagami	✓	49.46	77.49
	Sept-Iles	✓	50.13	66.16
	Val d'or	✓	48.04	77.47
Mixed Wood Plains	Montréal		45.30	73.36
	Québec		46.49	71.14
	Sherbrooke		45.25	71.54
	Trois-Rivières		46.21	72.33
Atlantic Maritime	Gaspé	✓	48.46	64.29
	Grindstone Island		47.23	61.52
Northern Arctic	Cape Hopes Advance		61.05	69.33
Ontario				
Boreal Shield	Kenora	✓	49.47	94.22
	North Bay	✓	46.21	79.26
	Red Lake	✓	51.04	93.48
	Sault Ste Marie	✓	46.29	84.30
	Sudbury		46.30	81.00
	Thunder Bay		48.24	89.19
	Timmins	✓	48.34	81.22
	White River		48.36	85.17
Hudson Plains	Winisk	✓	55.14	85.07
Mixed Wood Plains	Hamilton		43.15	79.51
	Kingston	✓	44.13	76.36
	Kitchener		43.27	80.29
	London		42.59	81.14
	Niagara		43.06	79.04
	Oshawa		43.54	78.51
	Sarnia		42.55	82.18
	Toronto		43.39	79.23
	Windsor		42.18	83.01
	Ottawa-Hull		45.25	75.42
Manitoba				
Prairie	Brandon	✓	49.55	99.57
	Portage la Prairie	✓	49.54	98.16
	Winnipeg		49.53	97.09
Boreal Shield	Norway House	✓	53.58	97.50
	Thompson	✓	55.48	97.52
Hudson Plains	Churchill	✓	58.44	94.04
Saskatchewan				
Boreal Plains	La Ronge	✓	55.09	105.16
	Stony Rapids	✓	59.15	105.50
Prairie	Estevan Sfts		49.12	103.04
	Hudson Bay		52.52	102.24
	Moose Jaw	✓	50.20	105.33
	North Battleford	✓	52.46	108.15
	Prince Albert		53.10	105.45
	Regina		50.27	104.37
	Saskatoon		52.07	106.38
	Swift Current	✓	50.17	107.41
	Yorkton	✓	51.16	102.28
Taiga Shield	Collins Bay		58.11	103.42
Alberta				
Montane Cordillera	Banff		51.11	115.34
Boreal Plains	Edson	✓	53.35	116.28
	Fort McMurray	✓	56.39	111.13
	High Level	✓	58.37	117.10
	Whitecourt		54.08	115.40
Prairie	Calgary		51.03	114.05
	Edmonton		53.33	113.28
	Edmonton	✓	53.18	113.35
	Lethbridge	✓	49.38	112.48
	Medicine Hat	✓	50.01	110.43
	Red Deer	✓	52.11	113.54
	Vermilion	✓	53.21	110.50
Taiga Shield	Fort Chipewyan		58.46	111.07
British Columbia				
Pacific Maritime	Cape St James		51.56	131.01
	Ucluelet RCAF		48.58	125.32
	Vancouver		49.15	123.07
	Victoria		48.26	123.22
Montane Cordillera	Cranbrook	✓	49.37	115.47
	Kamloops	✓	50.42	120.27
	Lillooet		50.41	121.56
	Old Glory Mountain		49.09	117.55
	Penticton	✓	49.28	119.36
	Prince George	✓	53.53	122.41
	Revelstoke		51.00	118.12
	Vanderhoof		54.05	124.02
Boreal Plains	Smith River	✓	59.54	126.26
Yukon				
Boreal Cordillera	Dawson	✓	64.03	139.08
	Snag	✓	62.22	140.24
	Whitehorse	✓	60.43	135.04
Boreal Plains	Watson Lake	✓	60.07	128.49
Southern Arctic	Komakuk Beach	✓	69.35	140.11
Northwest Territories				
Taiga Plains	Fort Smith		60.00	111.52
Taiga Shield	Yellowknife	✓	62.28	114.27
Northern Arctic	Arctic Bay		73.02	85.09
	Eureka		79.59	85.56
	Isachsen		78.47	103.32
	Mould Bay	✓	76.14	119.20
	Resolute	✓	74.43	94.59
	Resolution Island		61.18	64.53
Arctic Cordillera	Cape Dyer	✓	66.35	61.37

Notes:
Weather stations are depicted graphically in Section 1.4 - **Geographic Units for Environmental Analysis**, Map 1.4.4.
1. These weather stations are located at airports.
Source:
Atmospheric Environment Service, Environment Canada.

dian cities of over 10 000 in population, and a nearby official Environment Canada weather station, were chosen. Although in some instances the Canadian record for certain weather elements may be held by a smaller community, these 75 cities were selected since they represent approximately 70 percent of the total Canadian population.

The Wind Chill Factor

Wind chill is the term used to describe what cold weather feels like from the combined effect of cold temperature and high winds. Body heat loss increases with a rise in wind speed, so that at the same temperature a person will feel colder when the wind is blowing. For example, it feels just as cold at a temperature of -1°C with a 60 kilometre per hour wind speed as it does at -18°C with an 8 kilometre wind.[1] The wind chill factor is used as an indicator of the likelihood of frostbite and hypothermia (the excessive loss of body heat). Wind reduces a person's temperature by evaporating moisture and removing heat from the skin. Wind chill does not apply to inanimate objects that are not heated. Wind chill values tend to be higher over terrain and on street cor-

1. Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*, Key Porter Books Limited, Toronto, 1993.

Table 4.11.9

City Weather Rankings [1]

Warmest summers[2]		Coldest winters[2]		Coldest places[3]		Warmest places[3]		Snowiest cities[4]	
City	°C	City	°C	City	°C	City	°C	City	cm
Kamloops, B.C.	27.2	Yellowknife, N.W.T.	-29.9	Yellowknife, N.W.T.	-5.2	Vancouver, B.C.	9.9	Sydney, N.S.	450
Penticton, B.C.	26.9	Thompson, Man.	-28.6	Thompson, Man.	-3.4	Victoria, B.C.	9.5	Sept-Iles, Que.	313
Windsor, Ont.	26.5	Prince Albert, Sask.	-23.8	Whitehorse, Y.T.	-1.0	Windsor, Ont.	9.1	Timmins, Ont.	259
Kelowna, B.C.	26.4	Fort McMurray, Alta.	-22.9	Fort McMurray, Alta.	0.2	Penticton, B.C.	9.0	Moncton, N.B.	252
Medicine Hat, Alta.	26.0	Brandon, Man.	-21.8	Prince Albert, Sask.	0.5	St. Catharines, Ont.	8.9	Charlottetown, P.E.I.	224
St. Catharines, Ont.	25.7	Timmins, Ont.	-21.7	Sept-Iles, Que.	0.9	Kamloops, B.C.	8.6	Chicoutimi, Que.	219
Estevan, Sask.	25.7	Yorkton, Sask.	-21.6	Timmins, Ont.	1.2	Sarnia, Ont.	8.0	Baie-Comeau, Que.	183
Moose Jaw, Sask.	25.6	Val-d'Or, Que.	-21.3	Val-d'Or, Que.	1.2	Hamilton, Ont.	7.6	Québec, Que.	179
Châteauguay, Que.	25.5	Winnipeg, Man.	-21.2	Yorkton, Sask.	1.4	Belleville, Ont.	7.5	Owen Sound, Ont.	175
Sorel, Que.	25.3	Saskatoon, Sask.	-20.7	Baie-Comeau, Que.	1.5	Toronto, Ont.	7.2	Corner Brook, Nfld.	156

Cities with lowest annual average snowfall		Most days below freezing[5]		Fewest days below freezing[5]		Longest frost-free period		Shortest frost-free period	
City	cm	City	days	City	days	City	days	City	days
Victoria, B.C.	47	Thompson, Man.	241	Vancouver, B.C.	51	Vancouver, B.C.	223	Thompson, Man.	64
Vancouver, B.C.	55	Yellowknife, N.W.T.	225	Victoria, B.C.	58	Victoria, B.C.	202	Whitehorse, Y.T.	76
Penticton, B.C.	73	Whitehorse, Y.T.	225	Prince Rupert, B.C.	97	Windsor, Ont.	182	Timmins, Ont.	91
Kamloops, B.C.	86	Prince Albert, Sask.	216	Penticton, B.C.	123	St. Catharines, Ont.	174	Fort McMurray, Alta.	92
Saskatoon, Sask.	105	Red Deer, Alta.	212	Windsor, Ont.	130	Nanaimo, B.C.	174	Prince George, B.C.	93
Brandon, Man.	106	Timmins, Ont.	212	St. Catharines, Ont.	131	Hamilton, Ont.	170	Val-d'Or, Que.	94
Regina, Sask.	107	Fort McMurray, Alta.	211	Kamloops, B.C.	135	Sarnia, Ont.	167	Prince Albert, Sask.	95
Medicine Hat, Alta.	108	Val-d'Or, Que.	208	Sarnia, Ont.	140	Belleville, Ont.	165	Sherbrooke, Que.	102
Estevan, Sask.	110	Edmonton, Alta.	207	Belleville, Ont.	142	Kingston, Ont.	162	Red Deer, Alta.	107
Winnipeg, Man.	115	Brandon, Man.	205	Hamilton, Ont.	145	Montréal, Que.	158	Thunder Bay, Ont.	107

Wettest cities[6]		Driest cities[6]		Most thunderstorms[7]		Fewest thunderstorms[7]		Sunshine capitals[8]	
City	mm	City	days	City	days	City	days	City	hours
Prince Rupert, B.C.	2 552	Medicine Hat, Alta.	271	London, Ont.	36	Victoria, B.C.	3	Estevan, Sask.	2 500
St. John's, Nfld.	1 482	Lethbridge, Alta.	265	Windsor, Ont.	35	Prince Rupert, B.C.	3	Medicine Hat, Alta.	2 433
Sydney, N.S.	1 480	Kamloops, B.C.	263	St. Catharines, Ont.	31	St. John's, Nfld.	4	Moose Jaw, Sask.	2 396
Halifax, N.S.	1 474	Moose Jaw, Sask.	260	Kitchener, Ont.	31	Vancouver, B.C.	6	Calgary, Alta.	2 395
Saint John, N.B.	1 433	Brandon, Man.	258	Portage La Prairie, Man.	30	Yellowknife, N.W.T.	6	Saskatoon, Sask.	2 381
Moncton, N.B.	1 229	Saskatoon, Sask.	257	Toronto, Ont.	28	Whitehorse, Y.T.	6	Brandon, Man.	2 380
Québec, Que.	1 208	Penticton, B.C.	257	Winnipeg, Man.	28	Corner Brook, Nfld.	6	Winnipeg, Man.	2 377
Charlottetown, P.E.I.	1 201	Regina, Sask.	256	Montréal, Que.	26	Sept-Iles, Que.	7	Swift Current, Sask.	2 375
Corner Brook, Nfld.	1 186	Calgary, Alta.	254	Hamilton, Ont.	26	Charlottetown, P.E.I.	9	Regina, Sask.	2 365
Vancouver, B.C.	1 167	Swift Current, Sask.	253	Edmonton, Alta.	25	Sydney, N.S.	9	Yorkton, Sask.	2 331

Sunniest winters[9]		Sunniest summers[9]		Blowing snow[10]		Glaze capitals[10]		Foggiest cities[11]	
City	hours	City	hours	City	days	City	days	City	days
Winnipeg, Man.	358	Yellowknife, N.W.T.	1 037	Chicoutimi, Que.	37	St. John's, Nfld.	38	St. John's, Nfld.	121
Calgary, Alta.	353	Medicine Hat, Alta.	957	Regina, Sask.	28	North Bay, Ont.	20	Whitehorse, Y.T.	102
Estevan, Sask.	349	Estevan, Sask.	955	Moose Jaw, Sask.	28	Sydney, N.S.	19	Timmins, Ont.	101
Fredericton, N.B.	348	Swift Current, Sask.	939	St. John's, Nfld.	27	Sudbury, Ont.	19	Fort McMurray, Alta.	78
Thunder Bay, Ont.	342	Regina, Sask.	933	Charlottetown, P.E.I.	26	Charlottetown, P.E.I.	17	Prince George, B.C.	67
Saint John, N.B.	338	Moose Jaw, Sask.	933	Swift Current, Sask.	26	Moncton, N.B.	17	Val-d'Or, Que.	62
Halifax, N.S.	336	Lethbridge, Alta.	924	Portage La Prairie, Man.	25	Ottawa-Hull, Ont./Que.	17	Prince Albert, Sask.	59
Moose Jaw, Sask.	323	Saskatoon, Sask.	923	Sault Ste Marie, Ont.	25	Val-d'Or, Que.	16	Sherbrooke, Que.	57
Saskatoon, Sask.	322	Winnipeg, Man.	898	Winnipeg, Man.	24	Halifax, N.S.	16	Red Deer, Alta.	53
Yorkton, Sask.	321	Cranbrook, B.C.	894	Owen Sound, Ont.	24	Thompson, Man.	16	Thunder Bay, Ont.	49

Table 4.11.9
City Weather Rankings (Continued)[1]

Fog-free cities[11]		Most humid cities[12]		Windiest cities[13]		Clearest skies[14]		Cloudiest skies[15]	
City	days	City	kPa	City	km/hr	City	hours	City	hours
Penticton, B.C.	2	Windsor, Ont.	1.8	St. John's, Nfld.	24	Estevan, Sask.	2 979	Prince Rupert, B.C.	6 123
Kamloops, B.C.	8	Kingston, Ont.	1.7	Swift Current, Sask.	22	Swift Current, Sask.	2 740	St. John's, Nfld.	5 916
Medicine Hat, Alta.	10	London, Ont.	1.7	Sydney, N.S.	20	Brandon, Man.	2 737	Chicoutimi, Que.	5 297
Lethbridge, Alta.	13	Kitchener, Ont.	1.6	Regina, Sask.	20	Winnipeg, Man.	2 706	Prince George, B.C.	5 258
Kelowna, B.C.	15	Montréal, Que.	1.6	Charlottetown, P.E.I.	19	Portage La Prairie, Man.	2 652	Vancouver, B.C.	5 240
Whitehorse, Y.T.	15	Hamilton, Ont.	1.6	Lethbridge, Alta.	19	Yorkton, Sask.	2 651	Val-d'Or, Que.	5 142
Portage La Prairie, Man.	16	Toronto, Ont.	1.6	Halifax, N.S.	18	Regina, Sask.	2 628	Sydney, N.S.	5 107
Winnipeg, Man.	17	Owen Sound, Ont.	1.5	Saint John, N.B.	18	Moose Jaw, Sask.	2 613	Halifax, N.S.	5 075
Cranbrook, B.C.	17	Ottawa-Hull, Ont./Que.	1.5	Sudbury, Ont.	18	North Battleford, Sask.	2 595	Whitehorse, Y.T.	5 067
Edmonton, Alta.	18	Charlottetown, P.E.I.	1.5	Winnipeg, Man.	18	Prince Albert, Sask.	2 512	Owen Sound, Ont.	4 980

Notes:
1. Only cities of over 10 000 included in analysis. The Canadian record for some weather elements may be held by smaller communities.
2. Summer: average daytime temperature during June, July and August. Winter: average nighttime temperature in December.
3. Coldest: lowest annual average temperature. Warmest: highest annual average temperature.
4. Annual average snowfall.
5. Average number of days per year with freezing temperatures.
6. Wettest: total annual precipitation. Driest: most number of days without measurable precipitation.
7. Days per year with thunderstorms.
8. Greatest number of hours of sunshine per year.
9. Winters: most hours of sunshine during December, January and February. Summers: most hours during June, July and August.
10. Greatest number of days per year with: blowing snow; freezing precipitation.
11. Greatest and fewest number of days per year with fog.
12. Highest average vapour pressure during June, July and August.
13. Greatest average annual wind speed.
14. Annual number of hours per year with clear skies - between zero and two-tenths cloud cover.
15. Annual number of hours per year with overcast skies - between eight-tenths and complete cloud cover.

Source:
Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*, Key Porter Books Limited, Toronto, 1993.

ners than in forest clearings and streets sheltered by tall buildings.

Wind chill is expressed either in terms of heat loss in watts per square metre (watts/m^2) or as an equivalent air temperature in degrees Celsius. The equations in Technical Box 4.11.1 can be used to calculate the wind chill equivalent temperature (WET) in degrees Celsius (^{o}C) or the wind chill factor (WCF) in watts per square metre for given values of air temperature (^{o}C) and wind speed in kilometres per hour.

Examples of the effects of wind chill are presented in Table 4.11.10 while Table 4.11.11 presents wind chill in both WET and WCF. Wind chill values are provided in forecasts by Environment Canada when wind chill values exceed 1 600 watts/m^2 (-25^{o}C). Warnings are issued when values exceed 2 500 watts/m^2 (-50^{o}C), the point at which exposed flesh freezes in less than 1 minute.

Canadian recordings of wind chill began in 1953. Since that time, the coldest wind chill on record in Canada of -92 ^{o}C was experienced at Pelly Bay, Northwest Territories, on January 13, 1975. Table 4.11.12 presents provincial examples of the coldest wind chill days experienced across the country.

Technical Box 4.11.1
Wind Chill Equations

Wind Chill Equivalent Temperature in ^{o}C (WET):

$$WET = 33 - \frac{(12.1 + 6.12\sqrt{W} - 0.32W)\,(33 - T)}{27.8}$$

Wind Chill Factor in watts/m^2 (WCF):

$$WCF = (12.1 + 6.12\sqrt{W} - 0.32W)\,(33 - T)$$

where

T = ambient air temperature in ^{o}C

W = wind speed in kilometres per hour

Note:
This calculation gives meaningful values of WET and WCF for any air temperature lower than 5^{o}C, and for any wind speed between 7 and 80 kilometres per hour.

Source:
Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*, Key Porter Books Limited, Toronto, 1993.

Table 4.11.10

Examples of Wind Chill Effects

Wind Chill Factor	Equivalent Temperature	Effects
watts/m²	°C	
700	-3	Conditions considered comfortable when dressed for skiing.
1 200	-11	Conditions no longer pleasant for outdoor activities on overcast days.
1 400	-18	Conditions no longer pleasant for outdoor activities on sunny days.
1 600	-25	Freezing of exposed skin begins for most people depending on the degree of activity and amount of sunshine.
2 300	-50	Conditions for outdoor travel, such as walking, become dangerous.
		Exposed areas freeze in less than one minute for the average person.
2 700	-66	Exposed flesh freezes within half a minute on average.

Source:
Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*, Key Porter Books Limited, Toronto, 1993.

Table 4.11.11

Wind Chill Equivalent Temperature (WET) and Wind Chill Factor (WCF)

Wind	Temperature															
	0 °C		-5 °C		-10 °C		-15 °C		-20 °C		-25 °C		-30 °C		-35 °C	
km/h	WET	WCF	WET	WCF	WET	WCF	WET	WCF	WET	WCF	WET	WCF	WET	WCF	WET	WCF
10	-2.0	933	-7.0	1 075	-12.0	1 216	-17.0	1 358	-22.0	1 499	-27.0	1 641	-32.0	1 782	-38.0	2 009
20	-7.0	1 092	-13.0	1 257	-19.0	1 423	-25.0	1 588	-31.0	1 753	-37.0	1 919	-43.0	2 084	-50.0	2 246
30	-11.0	1 189	-17.0	1 369	-24.0	1 549	-31.0	1 729	-37.0	1 909	-44.0	2 089	-50.0	2 269	-57.0	2 449
40	-13.0	1 253	-20.0	1 443	-27.0	1 633	-34.0	1 823	-41.0	2 013	-48.0	2 202	-55.0	2 393	-62.0	2 583
50	-15.0	1 298	-22.0	1 494	-29.0	1 691	-36.0	1 887	-44.0	2 084	-51.0	2 280	-58.0	2 477	-66.0	2 673
60	-16.0	1 327	-23.0	1 529	-31.0	1 730	-38.0	1 931	-45.0	2 132	-53.0	2 334	-60.0	2 535	-68.0	2 736

Sources:
Environment Canada, *The Climates of Canada*, Ottawa, 1990.
Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*, Key Porter Books Limited, Toronto, 1993.
Colombo, J.R. (ed.), *The 1994 Canadian Global Almanac*, Macmillan Canada, Toronto, 1993.

Table 4.11.12

Coldest Wind Chill Days by Province

Province/Territory	Wind Chill		Location	Date	Temperature	Wind
	°C	watts per square metre			°C	kilometres per hour
Newfoundland	-71	2 814	Wabush Lake	20/01/75	-41	40
Prince Edward Island	-57	2 450	Charlottetown	18/01/82	-32	37
Nova Scotia	-53	2 309	Sydney	18/01/82	-25	59
New Brunswick	-61	2 547	Charlo	18/01/82	-31	54
Quebec	-77	3 001	Nitchequon	20/01/75	-42	56
Ontario	-70	2 753	Thunder Bay	10/01/82	-36	54
Manitoba	-76	2 938	Churchill	18/01/75	-41	56
Saskatchewan	-70	2 757	Swift Current	15/12/64	-34	89
Alberta	-68	2 740	Red Deer	15/12/64	-35	61
British Columbia	-69	2 749	Old Glory Mountain	15/12/64	-36	50
Yukon	-83	3 152	Komakuk Beach	12/02/75	-50	40
Northwest Territories	-92	3 357	Pelly Bay	13/01/75	-51	56

Source:
Phillips, D.W., *The Day Niagara Falls Ran Dry! Canadian Weather Facts and Trivia*, Key Porter Books Limited, Toronto, 1993.

4.12 Forest Fires

Forest fires are most common in the boreal forest region of Canada. In fact, the predominant tree species in this region have reproductive systems adapted to take advantage of forest fires. Some species of pine and spruce have late-to-open cones (serotinous) which release their seeds after exposure to the heat of a fire. This ensures that the species is well placed to form the next forest.

❑❑❑

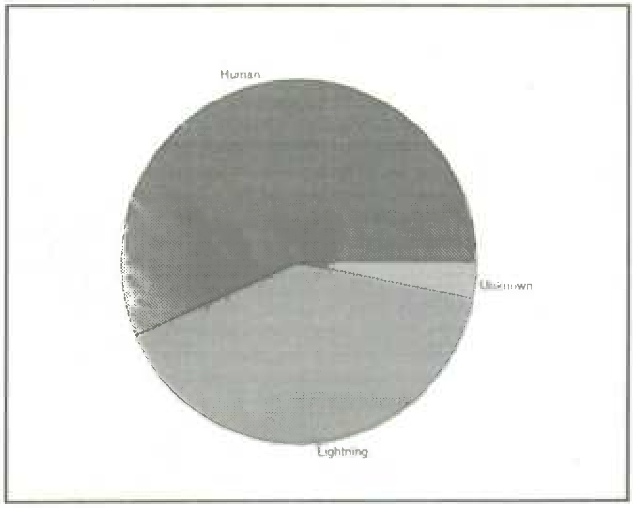
While forest fires temporarily contribute to the concentration of atmospheric carbon dioxide, the overall tendency of boreal forests is to assimilate and incorporate carbon dioxide. Fires increase the rate at which carbon dioxide is assimilated by stimulating vigorous regrowth.

Forest fires may be started naturally, by lightning strikes, or by humans. Figure 4.12.1 indicates that people are responsible for starting a greater number of fires than lightning. However, lightning caused fires to burn on average more than seven times the area of fires ignited by human activity (Figure 4.12.2). This is primarily due to the location of the fires ignited by people. Generally, fires started by humans occur in southern Canada where there are man-made obstacles to the spread of fire and where the risks to humans elicit a more significant and rapid suppression response. Without human fire suppression initiatives a larger area of forest would be burned.[1]

The area burned by fires is largely determined by weather, and can vary tremendously both in extent and location from year to year (Table 4.12.1). Therefore statistics for relatively short periods of time, such as those in Figure 4.12.2, must be interpreted with caution. While Manitoba shows the greatest area burned in this period, this is primarily the result of one large fire in that province in 1989 (Figure 4.12.3).

Figure 4.12.1

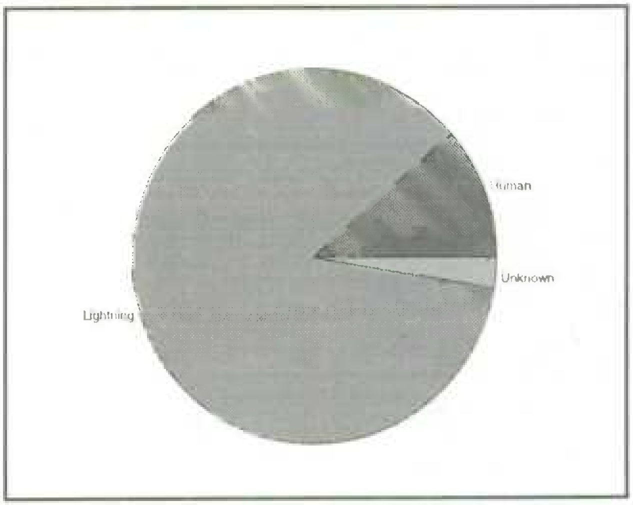
Total Number of Forest Fires by Cause Class, 1982-1991



Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Figure 4.12.2

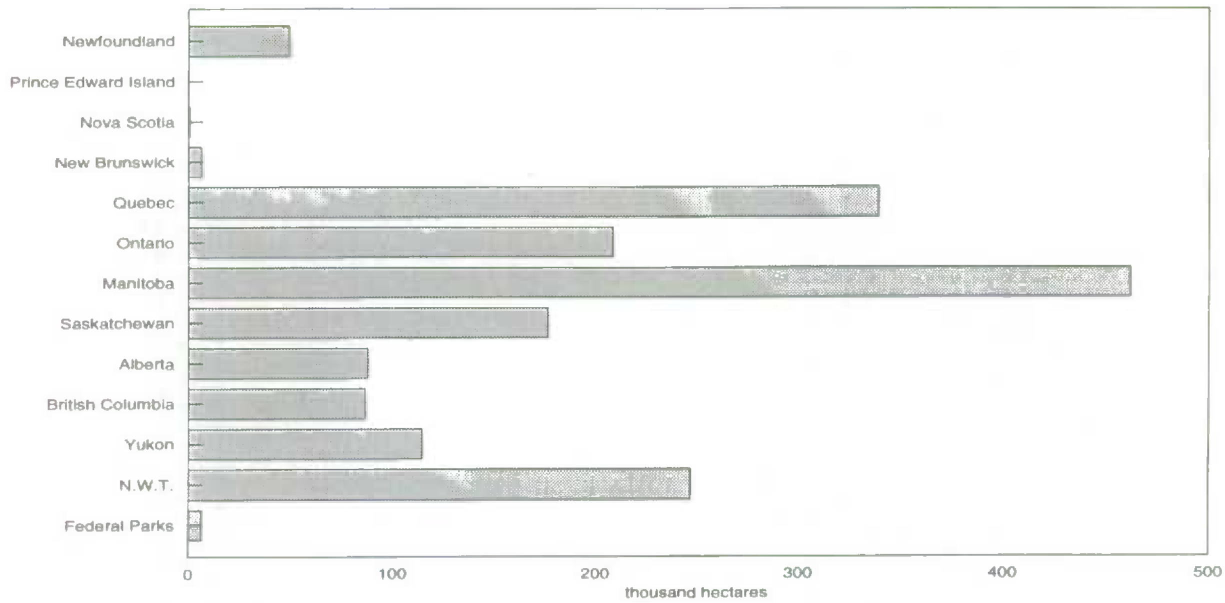
Total Area Burned by Cause Class, 1982-1991



Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

1. Ward, P.C. and A.G. Tithecott, *The impact of fire management on the boreal landscape of Ontario*, Ontario Ministry of Natural Resources, Aviation, Flood and Fire Management Branch, Publication No. 305,1993.

Figure 4.12.3
Average Annual Forest Land Burned, 1982-1991



Note:
Area burned in Federal Parks is excluded from the provincial and territorial estimates.
Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Table 4.12.1
Forest Land Burned and Number of Fires, 1982-1991

Year	Total area burned				Number of fires			
	Human	Lightning	Unknown	Total	Human	Lightning	Unknown	Total
	hectares				number			
1982	70 755	1 617 451	9 385	1 697 591	5 770	2 852	319	8 941
1983	99 933	1 093 122	1 120	1 194 175	5 423	3 290	217	8 930
1984	88 091	546 234	131 057	765 382	4 772	4 484	312	9 568
1985	244 266	488 309	24 685	757 260	5 607	3 329	421	9 357
1986	118 588	664 876	166 659	950 123	4 657	2 111	319	7 087
1987	112 699	946 122	26 808	1 085 629	7 180	3 697	427	11 304
1988	113 051	1 221 881	1 138	1 336 070	5 969	4 490	282	10 741
1989	749 068	6 788 619	21 883	7 559 570	5 610	6 277	298	12 185
1990	120 457	719 717	90 748	930 922	4 900	4 909	302	10 111
1991	311 706	1 262 092	709	1 574 507	5 919	4 153	264	10 336
Total	**2 028 614**	**15 348 423**	**474 192**	**17 851 229**	**55 807**	**39 592**	**3 161**	**98 560**

Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Harvesting and Extraction

4.13 Agriculture and Forest Harvests

This section focuses on the land-based harvesting activities of agriculture and forestry. These are both renewable resource harvesting activities and they both impose similar stresses on the environment. These activities have significant impacts on nutrient supplies, soil quality and biodiversity.

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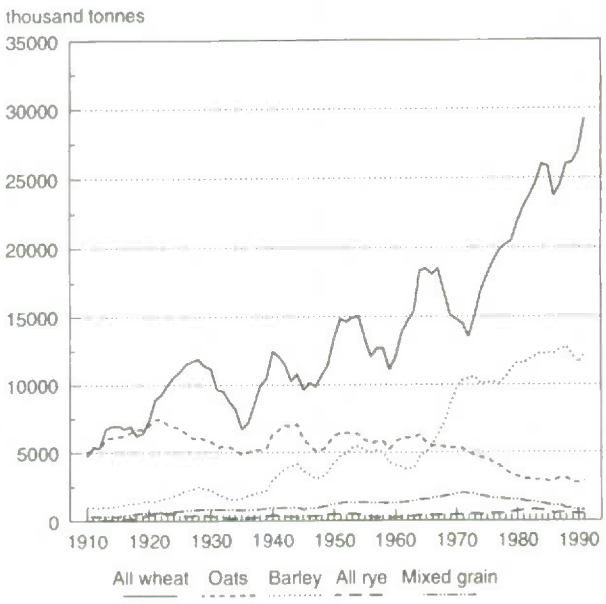
Agriculture

Crop production has more than quadrupled since 1910 (Figures 4.13.1 and 4.13.2).[1] Many factors have contributed to the rise in agricultural crop production. New technologies involving mechanization, genetic research, nutrient science and irrigation enable the agricultural industry to be more productive than ever before. Increased output does not come without costs to the environment. Pollution of waterways and land degradation are the direct results of increased production efforts.

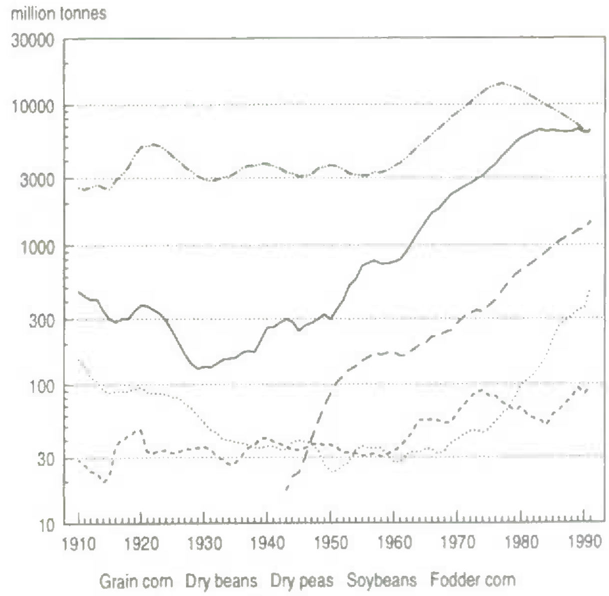
Figure 4.13.1
Selected Grain Crop Production, 1910-1991



Note:
Five year moving average.
Source:
Statistics Canada, Agriculture Division.

1. Only major crops are included in Figures 4.13.1 and 4.13.2

Figure 4.13.2
Selected Field Crop Production, 1910-1991

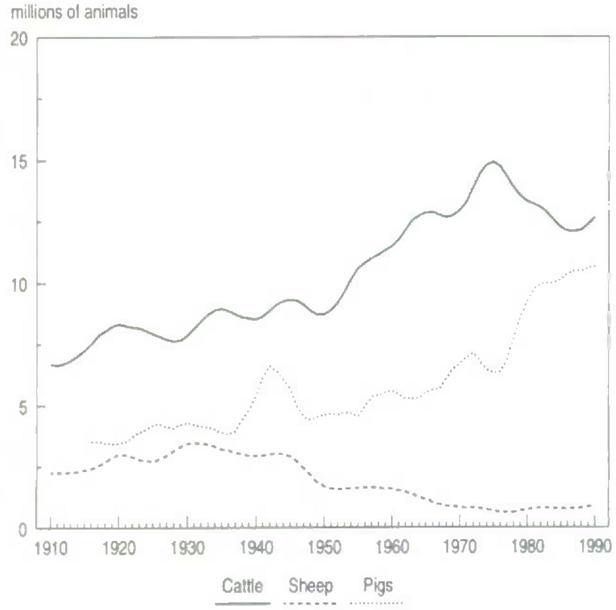


Notes:
Five year moving average.
This figure uses a log scale to compare trends of differing magnitude.
Source:
Statistics Canada, Agriculture Division.

Livestock can also have significant environmental impacts. Figures 4.13.3[2] indicates large increases in cattle and pigs and a significant decline in sheep. The number of cattle has more than doubled while the number of pigs has tripled since 1908. These animals produce large volumes of solid, liquid and gaseous wastes. Section 3.11 - **Agricultural Nutrients** outlines the potential impact that increasing livestock numbers have on the environment.

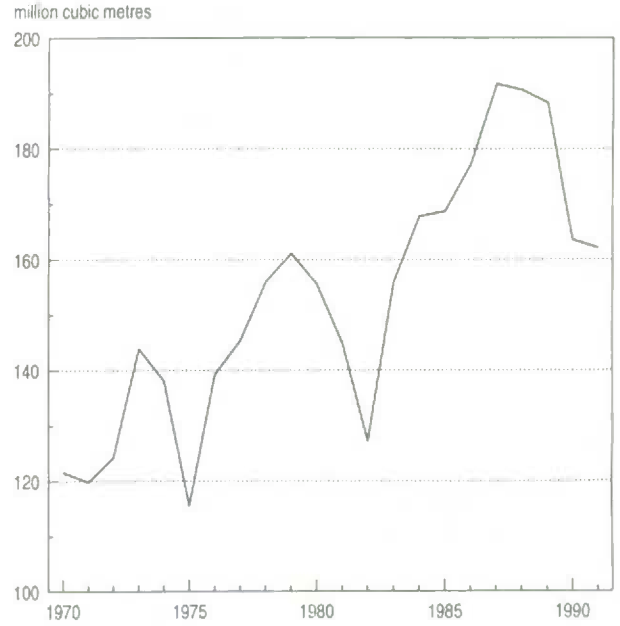
2. Only major livestock groups are included in Figure 4.13.3.

Figure 4.13.3
Selected Livestock Production, 1910-1991



Note:
Five year moving average.
Source:
Statistics Canada, Agriculture Division.

Figure 4.13.4
Roundwood Volume Harvested, 1970-1991



Note:
Roundwood corresponds to sections of tree stems, with or without bark. It includes logs, bolts, posts, pilings, fuelwood and other products still "in the round".
Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Forests

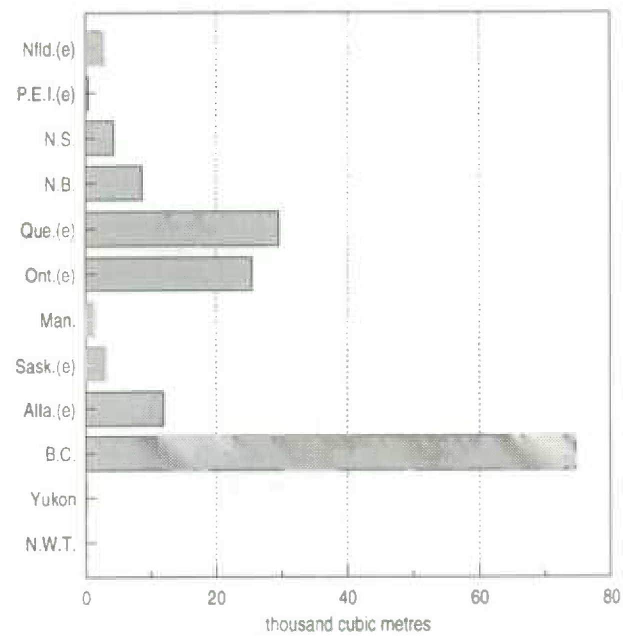
Early in Canada's history, forests were viewed primarily as obstacles to agriculture and transport or as sources of wood, game and furs. Recently, other benefits forests provide have received more attention. These other benefits include biodiversity preservation, recreation opportunities, soil erosion protection and carbon fixing.

Despite the shrinking relative importance of the resource sector to the national economy, forest harvest levels have increased, over time (Figure 4.13.4).

The combination of older, larger trees and higher growth rates allowed British Columbia to harvest more than twice the volume of wood of any other province in 1991 (Figure 4.13.5), from an area smaller than that harvested in Quebec or Ontario (Figure 4.13.6).

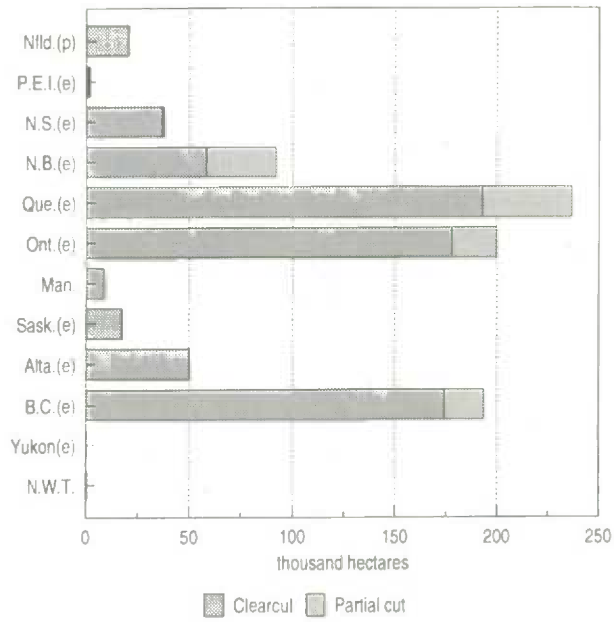
Partial cutting methods are being promoted and investigated as alternatives where clear-cutting may have unacceptable impacts on other values such as fish habitat, water resources or aesthetics. Despite an increase in the use of partial cutting, the predominant method of harvest is by clear-cutting.

Figure 4.13.5
Roundwood Volume Harvested, 1991



Notes:
Roundwood corresponds to sections of tree stems, with or without bark. It includes logs, bolts, posts, pilings, fuelwood and other products still "in the round".
Estimated data (e).
Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Figure 4.13.6
Forest Area Harvested, 1991

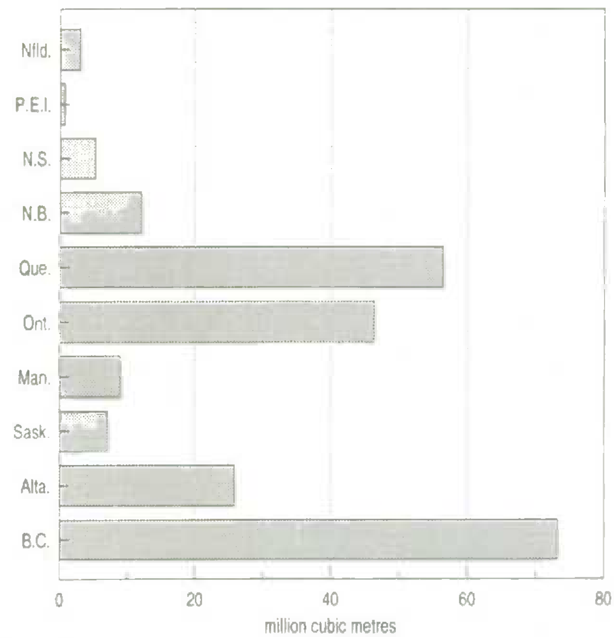


Note:
Estimated data (e), predicted (p).
Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Differences in forest type, ownership pattern, and provincial policy mean that forestry practices vary considerably across the nation. Nonetheless, all government agencies charged with management of forest resources proclaim sustained yield management as their goal. Sustained yield management means that timber is not to be depleted at a rate that exceeds its capacity to regrow. The measure of the sustainable level of depletion, determined using the area available for harvest and the growth rate on this land, is known as the annual allowable cut (AAC) (Figure 4.13.7).

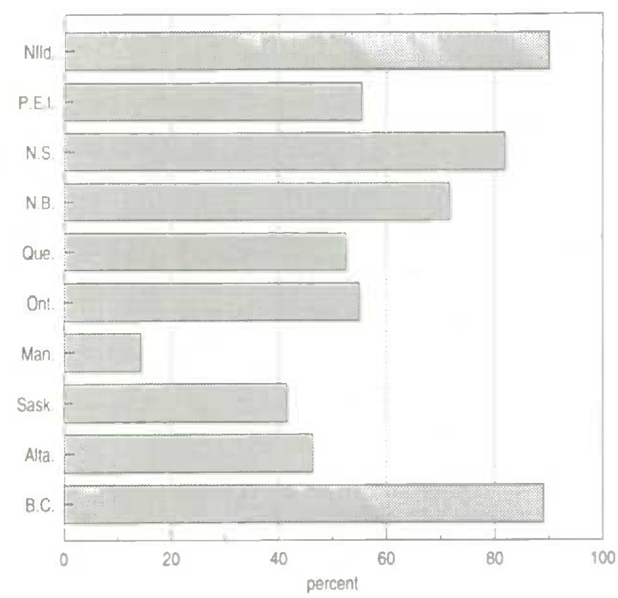
Two other measures, AAC utilization and harvest ratio, were created as an attempt to describe the extent to which the resource is exploited. The AAC utilization statistic is the volume harvested in one year divided by the annual allowable cut for that year (Figure 4.13.8). The principal difficulty with this measure is that some provinces allow harvests to fluctuate on a yearly basis, but balance them over multi-year periods. Therefore, the utilization statistics may vary substantially from year to year. Unfortunately, provincial multi-year data for AAC are not readily available to calculate utilization over a longer period. Another difficulty with this statistic is that areas may be excluded from AAC calculations. This can happen with private, unregulated forests, areas that are currently inaccessible, or where there is an overabundance of supply.

Figure 4.13.7
Annual Allowable Cut - Volume



Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

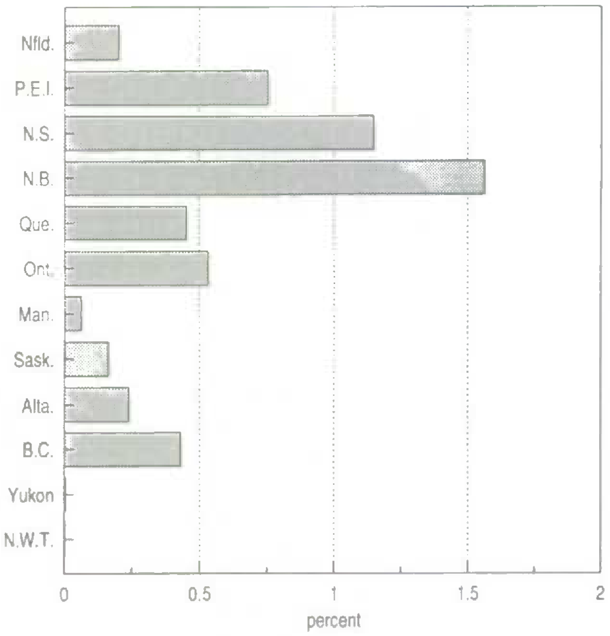
Figure 4.13.8
Annual Allowable Cut Utilization, 1991



Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

The other measure, harvest ratio, is calculated by dividing the area harvested by the area of stocked, productive, non-reserved forest (Figure 4.13.9). This measure is also sensitive to the annual harvest fluctuation problem. As well, it presents a more simplistic view of forest harvesting in the context of the resource, requiring more knowledge on the part of the user. For example, the harvest ratio for Ontario is exaggerated because some of the province's productive, non-reserved forest is not inventoried and is therefore not included in the harvest ratio (also a problem in Quebec, and Manitoba).

Figure 4.13.9
Area Harvested per Hectare of Stocked, Timber-productive, Non-reserved Forest, 1991



Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Beyond the temporary removal of, and perhaps change in, forest cover that follows timber harvesting, there may be a more enduring impact resulting from forestry activity. This is the provision of access to previously wild areas by the many roads that are constructed during forestry operations. In addition to the physical scars left by abandoned roads, many roads remain active and thereby reduce the area of remote wilderness. The map of forest access shows that most of southern Canada, which coincides with the most productive forest land, is now accessible (Map 4.13.1).

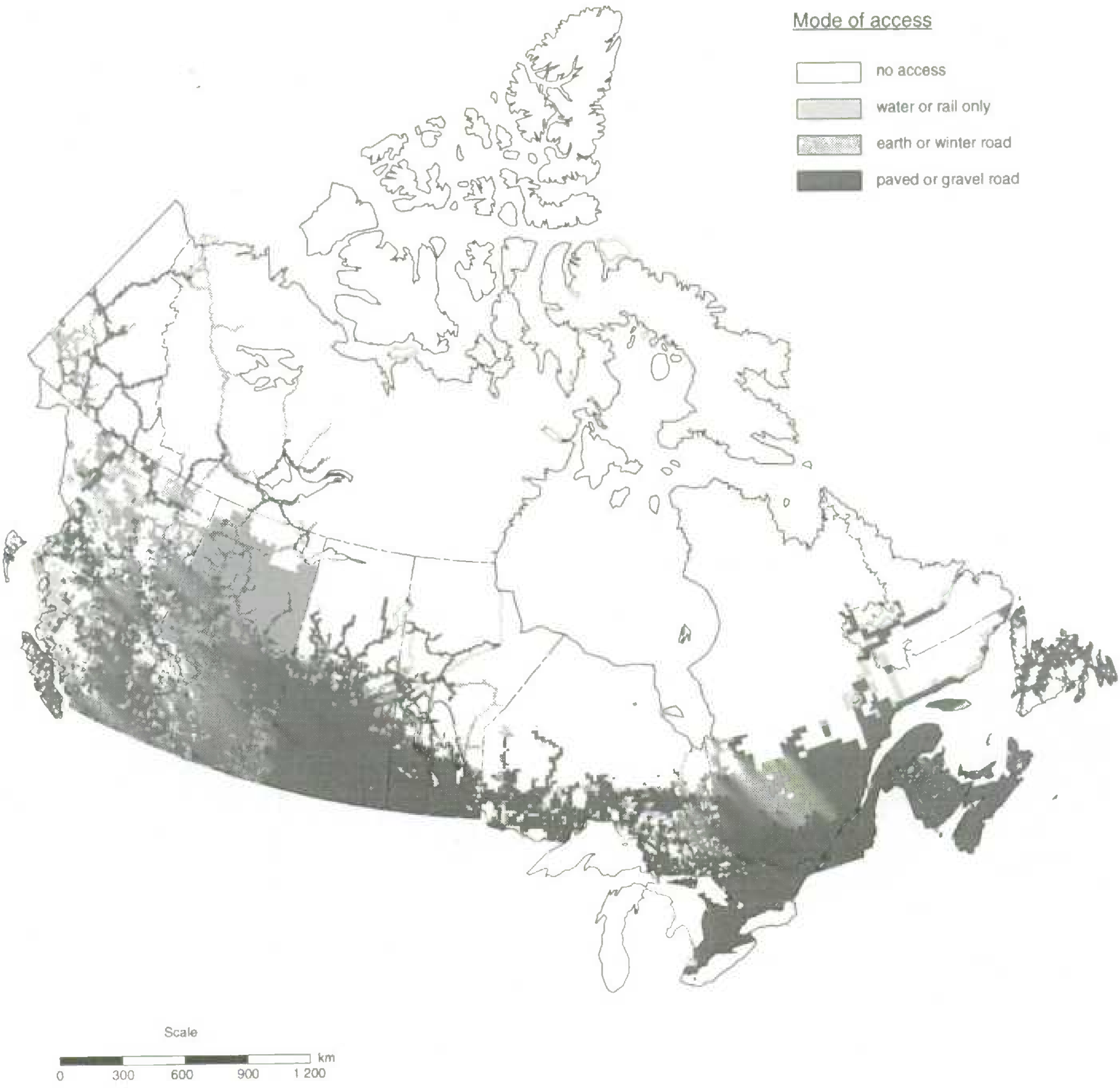
Table 4.13.1
Forestry Statistics, 1991

Province/Territory	Annual allowable cut	Roundwood volume harvested	Annual allowable cut utilization	Area harvested
	thousand cubic metres		percent	thousand hectares
Newfoundland	3 017	2 718	90.1	20 584
Prince Edward Island	746	414	55.5	2 091
Nova Scotia	5 275	4 322	81.9	37 566
New Brunswick	12 052	8 643	71.7	91 916
Quebec	56 395	29 585	52.5	236 815
Ontario	46 362	25 433	54.9	199 719
Manitoba	8 948	1 278	14.3	8 518
Saskatchewan	7 107	2 957	41.6	17 522
Alberta	25 794	11 934	46.3	50 160
British Columbia	73 000	65 000	89.0	193 654
Yukon	...	79	...	350
Northwest Territories	...	47	...	467
Canada	**238 697**	**152 410**	**63.9**	**859 362**

Note:
Some values were estimated.
Source:
Natural Resources Canada, Canadian Forestry Service, National Forestry Database.

Map 4.13.1

Forest Access, 1991



Source:
Natural Resources Canada, Canadian Forestry Service, Petawawa National Forestry Institute, Canada's Forest Inventory, 1991.

4.14 Fish and Wildlife Harvests

Canada's economy has traditionally relied heavily on the extraction and harvesting of natural resources in industries such as agriculture, mining, forestry and fishing. In 1992, fish harvesting generated over $2.6 billion in revenues,[1] while wildlife harvesting of fur bearing mammals accounted for $22.9 million.[2] Harvesting for direct human consumption is only one factor affecting the long-term sustainability of fish and wildlife species. Pollution, climate change and habitat destruction also threaten the survival of many species (see Section 4.3 - **Fish and Wildlife**).

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Commercial Fisheries

Canada's fisheries represent an important renewable resource. However, recent events, such as the moratorium on cod harvesting off Labrador and North-East Newfoundland, have emphasized the difficulty of maintaining fish stocks.

The coastal, inland and sea fisheries are within the exclusive jurisdiction of the federal government. This responsibility is delegated to the Department of Fisheries and Oceans, acting under the authority of the *Fisheries Act*. In the early 1970s, the International Commission for the Northwest Atlantic Fisheries (ICNAF), of which Canada is a member, began to develop the concept of Total Allowable Catch (TAC) for certain fish species (the ICNAF was replaced by NAFO[3] in 1979). The concept of TAC was applied to individual countries in the 1970s as a response to increases in fishing pressure during the 1960s. TACs are based on projections prepared by fishery scientists using the most recent data for each species. Setting TAC levels is difficult because of natural variation in stocks. For example, stocks vary from year to year because of environmental conditions, the number of fish reaching maturity, changes in the growth and mortality of the fish, annual fluctuations in migration routes and losses to predation.[4]

The problem of maintaining a fishery is made more complex by the need for international cooperation. In 1977, the government of Canada extended its fisheries jurisdiction to 200 miles off-shore in an attempt to better manage the fishery and increase fish harvests for Canadian fishermen. While Canada has sole jurisdiction over fisheries within the 200-mile limit, it cannot control foreign vessels fishing in international waters. Since fish stocks range freely beyond the 200-mile limit, Canada must rely on other countries to adhere to the TAC allotted for each species outside the 200-mile limit. In addition, stocks that cross the Canada-U.S. border, the Canada-Greenland border and the Canada-Saint-Pierre and Miquelon (France) border are shared resources, and therefore difficult to manage.[5]

One of the main goals of fisheries management is to find a balance between economic prosperity and social value within a framework of biological conservation. The management process attempts to allocate the resource among different groups, such as commercial, recreational and native fisheries. A combination of licensing, regulation and enforcement are used.[6] The TAC is generally used to manage marine fish such as capelin, herring, mackerel, tuna, groundfish and shellfish.

Atlantic Fisheries

The Atlantic fisheries account for the largest proportion of the commercial catch in Canada. For most species, landings peaked in the mid 1960s and early 1970s, followed by close adherence to the TAC in the mid to late 1970s when Canada assumed responsibility for managing stocks within the 200-mile limit. Despite these attempts at stock management, catches and landed values of most species have continued to decline.

Table 4.14.1 provides Atlantic and Pacific coast catch and landed value data for a number of groundfish,[7] pelagic[8] and shellfish species. The Atlantic coast fishery experienced a 33 percent decline in the catch of groundfish between 1989 and 1992, and a 21 percent decline in the catch of pelagic and other finfish. The shellfish catch increased by 2 percent during that same period. The decline of groundfish stocks, particularly cod, has had the greatest impact on the catches and landing values in the Atlantic fisheries. Between 1991 and 1992, the data show a decline in cod catches and landings of 161 886 tonnes. Between 1989 and 1991, the total Canadian catch decreased from 1.61 million tonnes to 1.33 million tonnes.

Cod catches and landings declined in all regions between 1990 and 1992 from higher levels during the mid to late 1980s. Table 4.14.2 provides yearly cod data from 1960 to 1992. In 1992, the TAC was lowered substantially in the Newfoundland and Labrador fishing region and the northern cod fishery was reduced to zero, effectively closing the fishery. Figures 4.14.1 through 4.14.4 show that, in general, the peak landings of the mid-to-late 1960s were followed by a decline in the early 1970s, a recovery in the late 1970s and early 1980s, and a decline in landings in the late 1980s and early 1990s.

1. Department of Fisheries and Oceans, preliminary data.
2. Statistics Canada, *Livestock Statistics*, Catalogue No. 23-603, Ottawa, 1993.
3. Northwest Atlantic Fisheries Organization.
4. Department of Fisheries and Oceans, *Resource Prospects for Canada's Atlantic Fisheries, 1989-1993*, Ottawa, 1988.
5. Ibid.
6. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.
7. Collective term to describe species that feed near the ocean bottom.
8. Fish that swim near the surface, often in large schools.

Table 4.14.3 provides groundfish catch and landings data by fishing area. Groundfish are bottom dwelling fish such as haddock, flatfish, redfish and cod. Throughout the 1970s and 1980s, the TAC was set at a level that was believed would attain maximum sustainable yields. The TAC was seldom reached in practice. Total groundfish landings remained between 1 and 2 million tonnes during the 1960s and early 1970s but hovered around 1 million tonnes throughout much of the late 1970s, 1980s and early 1990s. During that time period, an increasing proportion of total landings were made by Canadian fisherman. A notable decline in total groundfish landings occurred in 1992, when groundfish landings totalled 645 000 tonnes, a 29 percent decrease from the previous year. Figure 4.14.5 depicts groundfish TAC, as well as total and Canadian landings.

Table 4.14.4 provides groundfish TAC and landings data by species type. Both total and Canadian landings of all 4 groundfish species declined between 1990 and 1992. Cod landings have exceeded those for all other groundfish species since 1960, although the share of cod in total landings has been steadily declining. Total flatfish, redfish and cod landings have been, in general, below TAC, but haddock landings have exceeded TAC in recent years (Figures 4.14.6 and 4.14.7).

A number of possible causes have been put forward to explain the dramatic decline in cod stocks. Some blame the decline on poor data and uncertainties in assessments, abusive fishing practices such as dumping and discarding, over-fishing by foreign countries outside 200 miles, predation by seals, or adverse environmental conditions. While all of these factors may have contributed, in part, to the decline, it has not been possible to determine the relative importance of each factor.

Table 4.14.1

Nominal Catches and Landed Values of Fish by Species, 1989-1992

Species	1989						1990					
	Atlantic coast		Pacific coast		**Canada**		Atlantic coast		Pacific coast[1]		**Canada**	
	Quantity[2]	Value	Quantity[2]	Value	**Quantity[2]**	**Value**	Quantity[2]	Value	Quantity[2]	Value	**Quantity[2]**	**Value**
	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**
Groundfish												
Cod	426 090	219 733	9 142	4 519	**435 232**	**224 252**	395 329	243 070	6 233	3 375	**401 562**	**246 445**
Haddock	26 043	25 378	-	-	**26 043**	**25 378**	22 147	24 204	-	-	**22 147**	**24 204**
Redfish	76 152	21 994	24 456	14 993	**100 608**	**36 987**	81 412	22 688	27 739	18 443	**109 151**	**41 131**
Halibut	2 366	10 148	6 196	18 696	**8 562**	**28 844**	2 415	10 819	5 033	21 065	**7 448**	**31 884**
Flatfishes	70 295	39 076	6 476	4 871	**76 771**	**43 947**	63 657	36 233	7 184	5 551	**70 841**	**41 784**
Turbot	17 183	12 282	609	116	**17 792**	**12 398**	19 602	16 554	2 602	601	**22 204**	**17 155**
Pollock	44 255	19 813	434	63	**44 689**	**19 876**	38 385	20 213	676	185	**39 061**	**20 398**
Hake	14 303	6 512	74 706	11 333	**89 009**	**17 845**	15 187	7 651	79 453	12 833	**94 640**	**20 484**
Cusk	3 404	1 837	-	-	**3 404**	**1 837**	3 543	2 219	-	-	**3 543**	**2 219**
Catfish	1 998	520	-	-	**1 998**	**520**	1 536	401	-	-	**1 536**	**401**
Other	2 415	1 868	10 065	18 355	**12 480**	**20 223**	2 948	2 404	10 618	23 497	**13 566**	**25 901**
Total	**684 504**	**359 161**	**132 084**	**72 946**	**816 588**	**432 107**	**646 161**	**386 456**	**139 538**	**85 550**	**785 699**	**472 006**
Pelagic and other finfish												
Herring	229 239	31 263	41 008	67 609	**270 247**	**98 872**	260 450	37 503	41 056	73 169	**301 506**	**110 672**
Mackerel	20 799	5 468	-	-	**20 799**	**5 468**	21 806	6 196	-	-	**21 806**	**6 196**
Tuna	728	8 290	180	451	**908**	**8 741**	471	7 158	275	830	**746**	**7 988**
Alewife	11 183	4 079	-	-	**11 183**	**4 079**	7 921	2 097	-	-	**7 921**	**2 097**
Eel	883	2 904	-	-	**883**	**2 904**	948	3 709	-	-	**948**	**3 709**
Salmon	942	4 093	84 894	256 100	**85 836**	**260 193**	687	3 147	96 396	263 413	**97 083**	**266 560**
Skate	78	7	353	45	**431**	**52**	125	7	183	37	**308**	**44**
Smelt	1 464	1 178	..	1	**1 464**	**1 179**	1 082	817	..	1	**1 082**	**818**
Capelin	91 819	19 365	-	-	**91 819**	**19 365**	126 930	17 369	-	-	**126 930**	**17 369**
Other	2 258	8 767	3 639	2 644	**5 897**	**11 411**	2 987	6 492	4 353	2 624	**7 340**	**9 116**
Total	**359 393**	**85 414**	**130 074**	**326 850**	**489 467**	**412 264**	**423 407**	**84 495**	**142 263**	**340 074**	**565 670**	**424 569**
Shellfish												
Clams	14 560	12 226	7 647	19 672	**22 207**	**31 898**	22 657	17 085	6 643	16 149	**29 300**	**33 234**
Oysters	2 738	6 023	3 721	2 938	**8 459**	**8 961**	2 685	1 297	4 547	3 613	**7 232**	**4 910**
Scallop	92 188	93 116	75	315	**92 263**	**93 431**	83 283	86 930	-	-	**83 283**	**86 930**
Squid	3 160	740	35	47	**3 195**	**787**	5 569	2 769	-	-	**5 589**	**2 769**
Lobster	43 957	265 981	-	-	**43 957**	**265 981**	46 699	227 187	-	-	**46 699**	**227 187**
Shrimps	43 660	74 698	3 119	9 900	**46 779**	**84 598**	37 282	74 091	2 701	9 643	**39 983**	**83 734**
Crab	24 094	47 020	1 522	6 089	**25 616**	**53 109**	26 873	49 488	2 167	9 311	**29 040**	**58 799**
Other	3 459	3 727	5 118	6 196	**8 577**	**9 923**	2 046	1 565	5 463	7 299	**7 511**	**8 864**
Total	**227 816**	**503 531**	**21 237**	**45 157**	**249 053**	**548 688**	**227 116**	**460 412**	**21 521**	**46 015**	**248 637**	**506 427**
Miscellaneous items	...	11 669	...	8 711	...	20 380	...	4 657	...	8 304	...	12 961
Total sea fisheries	**1 271 713**	**959 775**	**283 395**	**453 664**	**1 555 108**	**1 413 439**	**1 296 684**	**936 020**	**303 322**	**479 943**	**1 600 006**	**1 415 963**
Inland fisheries	...	...	...	...	**51 199**	**82 690**	...	...	...	...	**44 718**	**66 413**
Grand total	**1 271 713**	**959 775**	**283 395**	**453 664**	**1 606 307**	**1 496 129**	**1 296 684**	**936 020**	**303 322**	**479 943**	**1 644 724**	**1 482 376**

Note:

This table is continued on the next page.

Table 4.14.1

Nominal Catches and Landed Values of Fish by Species, 1989-1992 (Continued)

Species	1991[1]						1992[1]					
	Atlantic coast		Pacific coast		**Canada**		Atlantic coast		Pacific coast		**Canada**	
	Quantity[2]	Value	Quantity[2]	Value	**Quantity[2]**	**Value**	Quantity[2]	Value	Quantity[2]	Value	**Quantity[2]**	**Value**
	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**
Groundfish												
Cod	308 325	226 576	11 910	6 064	**320 235**	**232 640**	186 522	152 023	10 111	5 519	**196 633**	**157 542**
Haddock	21 949	30 697	-	-	**21 949**	**30 697**	21 947	30 204	-	-	**21 947**	**30 204**
Redfish	92 501	24 859	23 422	16 916	**115 923**	**41 775**	97 990	27 706	24 752	18 252	**122 742**	**45 958**
Halibut	2 034	9 000	4 311	21 771	**6 345**	**30 771**	1 573	7 233	4 289	20 206	**5 862**	**27 439**
Flatfishes	64 226	35 186	7 890	5 824	**72 116**	**41 010**	48 500	29 245	7 802	5 728	**56 302**	**34 973**
Turbot	20 143	17 608	2 287	601	**22 430**	**18 209**	22 454	19 255	3 545	863	**25 999**	**20 118**
Pollock	40 724	23 985	2 580	600	**43 304**	**24 585**	34 056	24 007	3 006	911	**37 062**	**24 918**
Hake	63 892	22 109	98 055	15 388	**161 947**	**37 497**	38 293	17 735	97 197	18 025	**135 490**	**33 760**
Cusk	4 417	3 216	-	-	**4 417**	**3 216**	5 077	4 271	-	-	**5 077**	**4 271**
Catfish	1 385	349	-	-	**1 385**	**349**	1 282	385	-	-	**1 282**	**385**
Other	3 625	2 271	11 083	33 761	**14 708**	**36 032**	3 641	1 687	8 954	26 339	**12 595**	**28 026**
Total	**623 221**	**395 856**	**161 538**	**100 925**	**784 759**	**496 781**	**461 335**	**313 751**	**159 656**	**93 843**	**620 991**	**407 594**
Pelagic and other finfish												
Herring	214 924	29 201	39 741	75 000	**254 665**	**104 201**	215 384	27 799	34 531	46 369	**249 915**	**74 168**
Mackerel	25 658	7 502	-	-	**25 658**	**7 502**	25 874	7 070	-	-	**25 874**	**7 070**
Tuna	486	6 910	144	342	**630**	**7 252**	494	7 468	309	789	**803**	**8 257**
Alewife	7 532	1 935	-	-	**7 532**	**1 935**	3 441	2 237	-	-	**3 441**	**2 237**
Eel	974	4 163	-	-	**974**	**4 163**	742	1 990	-	-	**742**	**1 990**
Salmon	480	2 286	82 070	172 473	**82 550**	**174 759**	283	1 095	64 856	161 284	**65 139**	**162 379**
Skate	1 133	243	248	50	**1 381**	**293**	491	78	259	52	**750**	**130**
Smelt	1 094	1 038	-	-	**1 094**	**1 038**	874	775	1	2	**875**	**777**
Capelin	49 790	7 228	-	-	**49 790**	**7 228**	30 966	4 813	-	-	**30 966**	**4 813**
Other	2 469	8 987	3 683	2 400	**6 152**	**11 387**	4 001	13 936	3 348	1 800	**7 349**	**15 736**
Total	**304 540**	**69 493**	**125 886**	**250 265**	**430 426**	**319 758**	**282 550**	**67 261**	**103 304**	**210 296**	**385 854**	**277 557**
Shellfish												
Clams	12 703	11 811	5 057	13 669	**17 760**	**25 480**	16 804	15 360	4 033	18 623	**20 837**	**33 983**
Oysters	1 802	3 118	4 482	3 464	**6 284**	**6 582**	600	992	5 000	4 000	**5 600**	**4 992**
Scallop	79 373	81 158	-	-	**79 373**	**81 158**	91 315	99 646	-	-	**91 315**	**99 646**
Squid	2 617	785	-	-	**2 617**	**785**	1 352	366	-	-	**1 352**	**366**
Lobster	47 600	276 220	-	-	**47 600**	**276 220**	41 560	313 968	-	-	**41 560**	**313 968**
Shrimps	40 424	85 455	4 226	12 145	**44 650**	**97 600**	39 241	81 241	3 505	10 864	**42 746**	**92 105**
Crab	36 127	69 303	1 887	8 688	**38 014**	**77 991**	37 861	58 817	2 492	9 336	**40 353**	**68 153**
Other	4 612	5 154	8 886	8 869	**13 498**	**14 023**	4 340	4 580	13 831	14 130	**18 171**	**18 710**
Total	**225 258**	**533 004**	**24 538**	**46 835**	**249 796**	**579 839**	**233 073**	**574 970**	**28 861**	**56 953**	**261 934**	**631 923**
Miscellaneous items	...	9 428	...	8 863	...	18 291	...	10 530	...	8 230	...	18 760
Total sea fisheries	**1 153 019**	**1 007 781**	**311 962**	**406 888**	**1 464 981**	**1 414 669**	**976 958**	**966 512**	**291 821**	**369 322**	**1 268 779**	**1 335 834**
Inland fisheries	...	...	...	...	**77 184**	**73 402**	...	...	...	...	**64 907**	**63 000**
Grand total	**1 153 019**	**1 007 781**	**311 962**	**406 888**	**1 542 185**	**1 488 071**	**976 958**	**966 512**	**297 821**	**389 322**	**1 333 686**	**1 398 834**

Notes:
Pacific cod includes grey cod only.
1. Preliminary data.
2. Quantity in tonnes, live weight. Hake catches include over-the-side sales to foreign vessels.
Source:
Department of Fisheries and Oceans Canada, Industry Development and Programs Directorate.

The TAC and landings of pelagic species in the Atlantic fishery have not experienced the same declines as seen in the groundfish fishery. However, this fishery accounts for a smaller portion of total landings. Canadian landings of all pelagic fish have varied from a high of 506 000 tonnes in 1968 to a low of 85 000 tonnes in 1960. The Canadian portion of pelagic landings declined throughout the 1970s but increased again throughout the 1980s (Table 4.14.5, Figure 4.14.8).

Table 4.14.6 provides a summary of finfish[1] catch statistics for the Atlantic coast. The 1992 preliminary figures present the lowest total landings for groundfish since 1960, as well as a decline in pelagic landings. Figure 4.14.9 displays the effect on total and Canadian landings of finfish before and after the TAC was established in 1973.

1. Includes pelagic, groundfish and salmon species.

Table 4.14.2

Total Allowable Catch and Landings of Cod by Fishing Area, Atlantic, 1960-1992

Year	Scotian Shelf			Gulf			Newfoundland and Labrador			Total cod		
	TAC	Landings		TAC	Landings		TAC	Landings		TAC	Landings	
		Total	Canadian		Total	Canadian		Total	Canadian		Total	Canadian
	thousand tonnes											
1960	...	82	38	...	160	85	...	620	216	...	863	339
1961	...	98	35	...	166	94	...	678	169	...	942	298
1962	...	112	41	...	153	96	...	611	180	...	875	317
1963	...	121	44	...	145	102	...	673	197	...	938	343
1964	...	124	52	...	145	91	...	778	171	...	1 047	313
1965	...	148	67	...	132	93	...	818	153	...	1 098	313
1966	...	162	67	...	120	84	...	825	157	...	1 107	307
1967	...	131	82	...	121	73	...	997	150	...	1 248	285
1968	...	164	71	...	136	94	...	1 174	157	...	1 475	322
1969	...	127	53	...	119	96	...	1 024	144	...	1 271	293
1970	...	113	41	...	170	90	...	748	122	...	1 031	253
1971	...	112	49	...	140	79	...	667	107	...	920	235
1972	...	116	50	...	124	75	...	677	90	...	917	216
1973	96	108	44	...	116	62	841	511	71	936	735	177
1974	105	96	36	63	115	63	888	522	58	1 056	733	157
1975	110	81	35	50	103	60	764	396	59	924	580	154
1976	79	66	34	85	110	70	451	304	89	615	480	193
1977	15	67	46	70	96	77	268	253	112	352	416	235
1978	15	69	63	93	116	97	235	218	131	342	404	291
1979	73	88	80	121	139	122	290	260	168	484	486	370
1980	89	105	98	129	152	134	267	250	186	485	508	418
1981	99	114	105	128	163	142	289	251	185	516	529	432
1982	135	127	118	153	163	144	319	322	248	607	612	510
1983	153	112	101	162	167	151	342	314	255	657	593	507
1984	144	105	93	167	159	141	358	311	237	669	574	472
1985	122	108	101	167	150	134	373	334	238	662	593	474
1986	91	94	88	152	150	130	373	374	234	616	618	452
1987	83	89	84	126	120	117	363	345	250	571	554	452
1988	72	85	77	128	102	103	367	357	288	567	545	468
1989	63	76	69	131	102	99	315	367	257	509	544	426
1990	65	79	73	111	94	91	273	322	221	449	495	384
1991[1]	86	76	69	83	79	75	272	254	159	441	410	304
1992[1]	86	73	67	78	68	64	82	99	61	246	239	192

Notes:

Includes surveillance estimates of catches in the NAFO Regulatory area, foreign catches made outside the 200-mile zone on straddling stock and on Flemish Cap.

The TAC was not introduced until the early 1970s.

Figures may not add due to rounding.

1. Preliminary data.

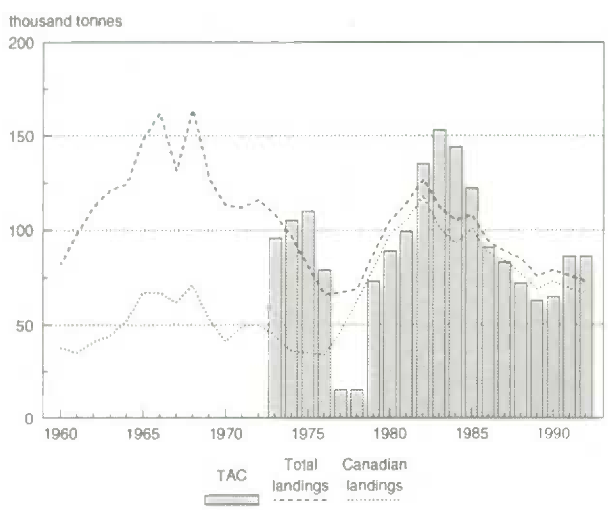
Source:

Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.1

Scotian Shelf Cod TAC and Landings

Atlantic region, 1960-1992



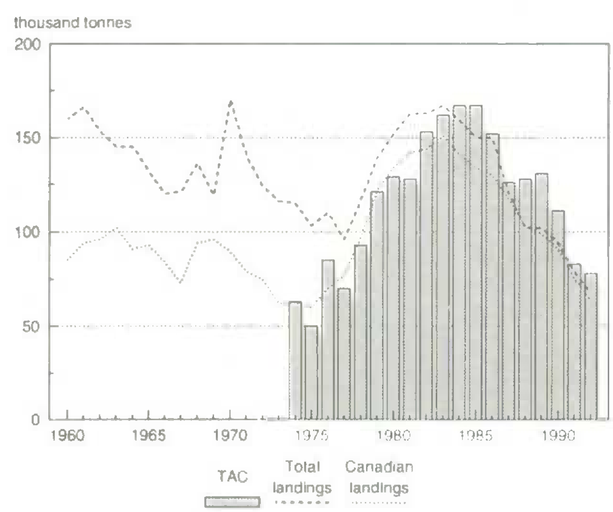
Source:

Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.2

Gulf Cod TAC and Landings

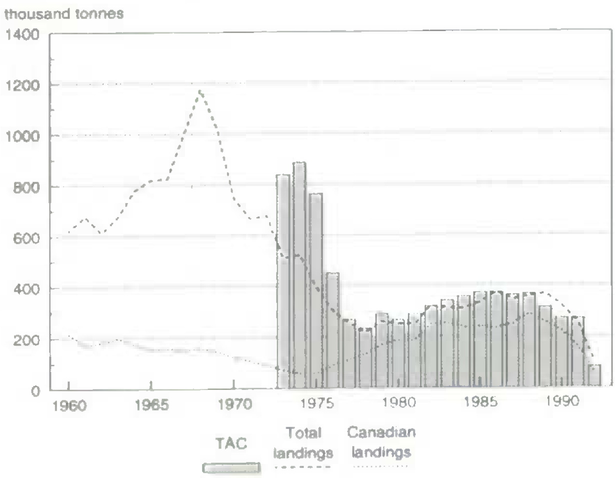
Atlantic region, 1960-1992



Source:

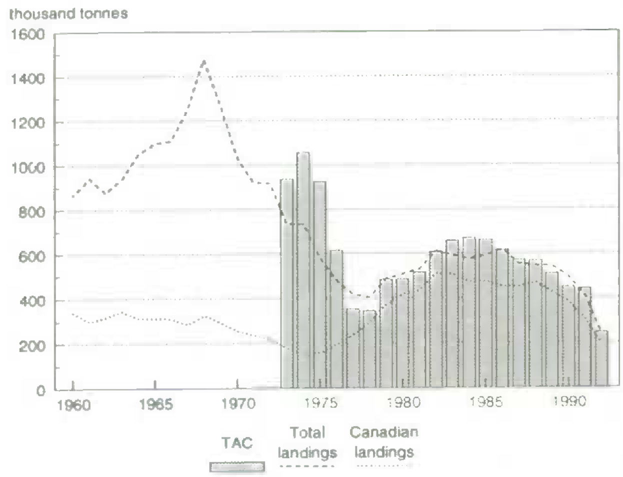
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.3
Newfoundland and Labrador Cod TAC and Landings
Atlantic Region, 1960-1992



Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.4
Total Cod TAC and Landings
Atlantic region, 1960-1992



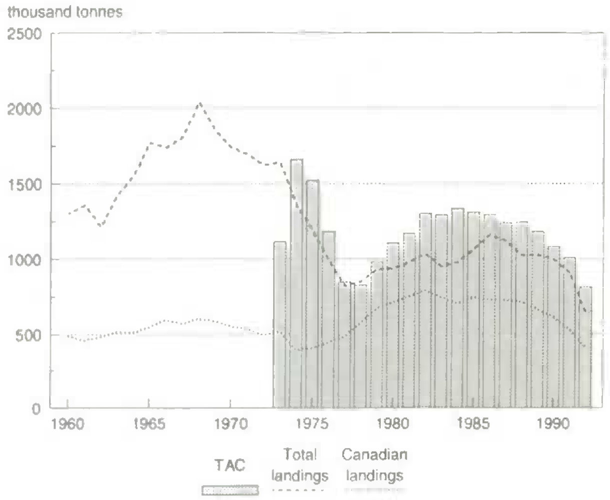
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Table 4.14.3
Total Allowable Catch and Landings of Groundfish by Fishing Area, Atlantic, 1960-1992

Year	Scotian Shelf			Gulf			Newfoundland and Labrador			Total groundfish		
		Landings			Landings			Landings			Landings	
	TAC	Total	Canadian	TAC	Total	Canadian	TAC	Total	Canadian	TAC	Total	Canadian
	thousand tonnes											
1960	...	261	116	...	184	108	...	854	265	...	1 299	490
1961	...	277	119	...	187	115	...	891	225	...	1 356	459
1962	...	321	132	...	168	112	...	724	239	...	1 213	482
1963	...	461	142	...	178	130	...	784	241	...	1 423	513
1964	...	430	166	...	189	123	...	931	222	...	1 551	510
1965	...	540	181	...	202	145	...	1 030	220	...	1 771	546
1966	...	505	192	...	212	163	...	1 022	240	...	1 739	595
1967	...	336	161	...	213	149	...	1 257	239	...	1 807	569
1968	...	359	179	...	248	188	...	1 433	238	...	2 040	604
1969	...	342	150	...	230	193	...	1 281	245	...	1 853	588
1970	...	431	120	...	283	195	...	1 021	237	...	1 735	553
1971	...	437	145	...	244	178	...	1 017	212	...	1 698	535
1972	...	392	134	...	224	174	...	1 007	188	...	1 622	496
1973	165	557	135	...	270	211	951	817	172	1 116	1 643	518
1974	357	342	118	73	200	146	1 232	816	131	1 662	1 358	395
1975	387	346	129	60	191	147	1 074	656	132	1 521	1 192	408
1976	323	275	116	125	180	139	736	543	190	1 184	998	445
1977	204	217	144	102	134	115	543	470	228	848	821	487
1978	190	244	177	125	157	138	512	446	263	827	848	577
1979	251	250	182	152	188	171	580	494	318	983	931	671
1980	377	299	229	160	200	182	572	436	303	1 108	936	713
1981	398	312	246	163	213	193	609	452	310	1 170	977	749
1982	439	318	240	217	212	193	645	505	355	1 302	1 035	788
1963	419	261	208	226	210	193	648	479	340	1 293	950	741
1984	426	281	187	248	203	185	662	494	332	1 336	979	704
1985	376	295	209	248	205	189	689	563	346	1 313	1 064	744
1986	340	293	202	235	208	188	720	658	340	1 295	1 160	730
1987	321	259	190	213	192	189	706	671	349	1 240	1 121	728
1988	328	256	171	214	176	176	704	592	370	1 245	1 025	717
1989	333	261	162	217	174	171	633	594	332	1 184	1 029	665
1990	321	240	162	198	170	166	566	588	286	1 084	998	614
1991[1]	306	240	165	170	154	150	535	513	216	1 012	907	530
1992[1]	301	187	151	175	159	156	338	299	104	815	645	411

Notes:
Includes surveillance estimates of catches in the NAFO regulatory area, foreign catches made outside the 200-mile zone on straddling stocks and on Flemish Cap.
The TAC was not introduced until the early 1970s.
Figures may not add due to rounding.
1. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.5
Groundfish TAC and Landings
Atlantic region, 1960-1992



Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.6
Flatfish TAC and Landings
Atlantic region, 1960-1992

Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Table 4.14.4
Total Allowable Catch and Landings of Main Groundfish Species, Atlantic, 1960-1992

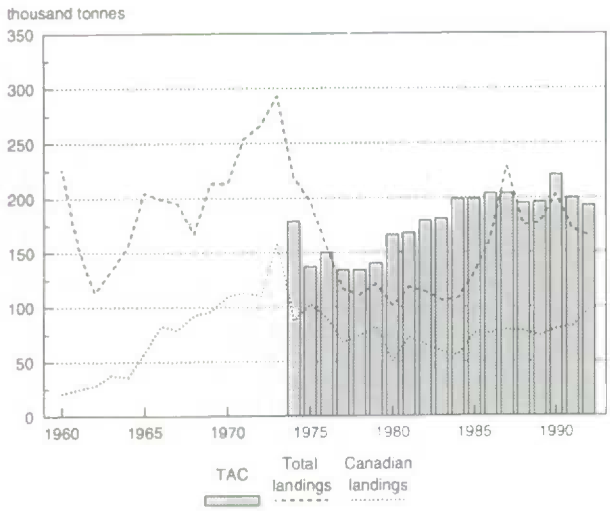
	Haddock			Flatfish			Redfish			Cod		
		Landings			Landings			Landings			Landings	
Year	TAC	Total	Canadian	TAC	Total	Canadian	TAC	Total	Canadian	TAC	Total	Canadian
	thousand tonnes											
1960	...	117	50	...	54	49	...	227	21	...	863	339
1961	...	173	63	...	49	44	...	155	25	...	942	298
1962	...	132	62	...	44	42	...	113	28	...	875	317
1963	...	119	48	...	64	53	...	134	38	...	938	343
1964	...	133	57	...	88	73	...	155	36	...	1 047	313
1965	...	242	50	...	134	97	...	205	58	...	1 097	313
1966	...	196	60	...	169	117	...	199	83	...	1 107	307
1967	...	110	56	...	198	122	...	195	79	...	1 248	285
1968	...	91	50	...	235	115	...	167	93	...	1 475	322
1969	...	58	44	...	216	131	...	213	96	...	1 271	293
1970	...	38	26	...	220	141	...	213	110	...	1 031	253
1971	...	41	29	...	234	134	...	254	113	...	920	235
1972	19	23	17	...	224	122	...	266	110	...	917	216
1973	19	22	18	111	219	123	...	293	159	936	735	177
1974	0	20	15	240	193	101	179	219	87	1 056	733	157
1975	15	25	20	233	189	96	137	197	103	924	580	154
1976	23	21	19	192	172	111	150	155	90	615	480	193
1977	23	35	26	196	162	125	134	116	67	352	416	235
1978	24	50	42	184	168	133	134	111	74	342	404	291
1979	28	39	34	188	171	143	140	121	82	484	486	370
1980	76	69	53	194	151	138	166	101	50	485	508	418
1981	83	66	56	214	151	129	168	118	72	516	529	432
1982	88	52	44	226	135	112	179	114	66	607	612	510
1983	79	43	37	220	119	91	181	106	59	657	593	507
1984	67	40	32	218	127	96	199	108	56	669	574	472
1985	40	43	35	230	155	99	199	131	76	662	593	474
1986	37	50	42	257	173	96	204	163	76	616	618	452
1987	28	31	27	254	171	106	204	229	79	572	554	452
1988	31	32	29	246	132	85	195	175	78	567	545	468
1989	31	29	26	226	127	82	196	177	74	509	544	426
1990	24	23	22	169	149	78	221	203	80	449	495	384
1991[1]	12	23	22	172	169	73	200	171	82	441	410	304
1992[1]	12	24	22	172	141	62	193	165	97	246	239	192

Notes:
Includes surveillance estimates of catches in the NAFO regulatory area, foreign catches made outside the 200-mile zone on straddling stocks and on Flemish Cap.
The TAC was not introduced until the early 1970s.
1. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.7

Redfish TAC and Landings

Atlantic region, 1960-1992

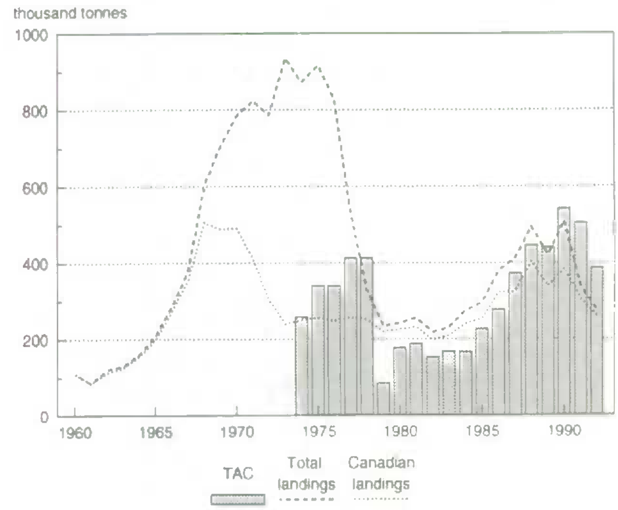


Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.8

Pelagic TAC and Landings

Atlantic region, 1960-1992



Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Table 4.14.5

Total Allowable Catch and Landings of Main Pelagic Species, Atlantic, 1960-1992

Year	Capelin			Herring			Mackerel			Total Pelagic Fish		
	TAC	Landings		TAC	Landings		TAC	Landings		TAC	Landings	
		Total	Canadian		Total	Canadian		Total	Canadian		Total	Canadian
	thousand tonnes											
1960	...	-	-	...	111	111	...	-	-	...	111	111
1961	...	-	-	...	85	85	...	-	-	...	85	85
1962	...	-	-	...	121	112	...	-	-	...	121	112
1963	...	4	4	...	117	114	...	9	6	...	130	125
1964	...	4	4	...	143	140	...	13	11	...	160	155
1965	...	4	4	...	189	183	...	16	11	...	209	198
1966	...	4	4	...	259	256	...	22	12	...	285	271
1967	...	3	3	...	339	338	...	34	11	...	376	352
1968	...	2	2	...	516	493	...	81	11	...	599	506
1969	...	2	2	...	568	473	...	132	13	...	702	488
1970	...	3	3	...	551	472	...	231	16	...	784	490
1971	...	2	1	...	449	397	...	373	15	...	824	413
1972	...	68	1	...	309	285	...	410	16	...	787	303
1973	...	267	5	...	249	214	...	419	21	...	935	240
1974	258	285	13	...	246	220	...	340	17	258	871	250
1975	340	364	3	...	265	240	...	287	14	340	916	256
1976	340	360	9	...	227	223	...	242	16	340	829	248
1977	412	226	9	...	229	228	...	78	20	412	533	257
1978	412	85	9	...	217	217	...	28	25	412	330	251
1979	85	24	13	...	177	177	...	33	30	85	234	220
1980	21	28	16	156	188	188	...	25	22	177	242	226
1981	40	41	26	147	186	186	...	28	19	187	255	232
1982	43	42	31	110	150	150	...	26	16	153	218	198
1983	51	41	29	117	161	161	...	30	20	168	231	210
1984	52	61	42	115	181	181	...	33	17	187	274	240
1985	52	53	36	175	187	187	...	55	30	227	295	253
1986	102	83	67	175	225	225	...	71	30	277	379	322
1987	83	64	32	289	265	265	...	83	27	372	412	325
1988	111	113	89	334	291	291	...	90	24	445	494	403
1989	132	119	91	308	227	227	...	74	20	440	419	338
1990	217	170	88	325	274	274	...	66	23	542	509	384
1991[1]	196	49	49	309	231	231	...	59	26	505	339	306
1992[1]	103	26	26	283	208	208	...	40	26	386	273	259

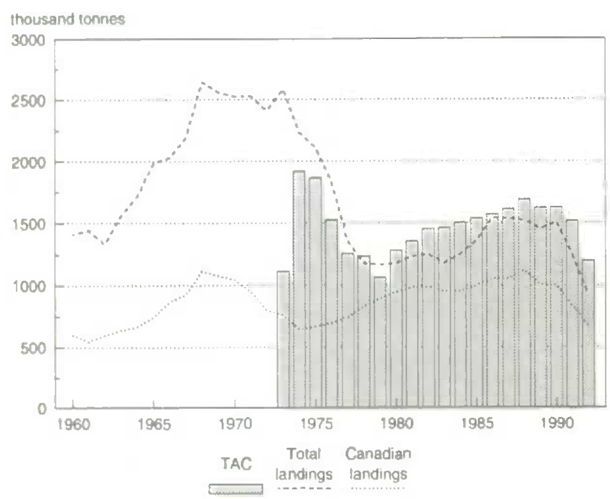
Notes:
Includes surveillance estimates of catches in the NAFO regulatory area, foreign catches made outside the 200-mile zone on straddling stocks and on Flemish Cap.
The TAC was not introduced until the early 1970s. No TAC has been introduced for mackerel.
1. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Table 4.14.6
Total Allowable Catch and Landings of Finfish, Atlantic, 1960-1992

Year	Pelagic fish			Groundfish			Salmon			Total		
	TAC	Landings		TAC	Landings		TAC	Landings		TAC	Landings	
		Total	Canadian		Total	Canadian		Total	Canadian		Total	Canadian
	thousand tonnes											
1960	...	111	111	...	1 299	490	...	2	2	...	1 411	602
1961	...	85	85	...	1 356	459	...	2	2	...	1 442	545
1962	...	121	112	...	1 213	482	...	2	2	...	1 336	596
1963	...	130	125	...	1 423	513	...	2	2	...	1 555	639
1964	...	160	155	...	1 551	510	...	4	2	...	1 715	667
1965	...	209	198	...	1 771	546	...	3	2	...	1 983	746
1966	...	285	271	...	1 739	595	...	4	2	...	2 028	869
1967	...	376	352	...	1 807	569	...	4	3	...	2 187	924
1968	...	599	506	...	2 040	604	...	3	2	...	2 642	1 113
1969	...	702	488	...	1 853	588	...	4	2	...	2 559	1 078
1970	...	784	490	...	1 735	553	...	4	2	...	2 524	1 045
1971	...	824	413	...	1 698	535	...	5	2	...	2 527	950
1972	...	787	303	...	1 622	496	...	4	2	...	2 413	800
1973	...	935	240	1 116	1 643	518	...	5	2	1 116	2 583	760
1974	258	871	250	1 662	1 358	395	...	4	3	1 920	2 233	647
1975	340	916	256	1 526	1 192	408	...	5	2	1 866	2 113	667
1976	340	829	248	1 184	998	445	...	4	3	1 524	1 830	696
1977	412	533	257	848	821	487	...	4	3	1 260	1 358	746
1978	412	330	251	827	848	577	...	3	2	1 239	1 180	830
1979	85	234	220	983	931	671	...	3	1	1 068	1 168	893
1980	177	242	226	1 108	936	713	...	4	3	1 286	1 181	942
1981	187	255	232	1 170	977	749	...	4	2	1 357	1 235	983
1982	153	218	198	1 302	1 035	788	...	3	2	1 455	1 256	988
1983	168	231	210	1 293	950	741	...	2	1	1 461	1 183	952
1984	167	274	240	1 336	979	704	...	1	1	1 503	1 254	945
1985	227	295	253	1 313	1 064	744	...	2	1	1 540	1 361	998
1986	277	379	322	1 295	1 160	730	...	3	2	1 572	1 541	1 054
1987	372	412	325	1 240	1 121	728	...	3	2	1 612	1 536	1 054
1988	445	494	403	1 245	1 025	717	...	2	1	1 690	1 520	1 122
1989	440	419	338	1 184	1 029	665	...	1	1	1 624	1 450	1 004
1990	542	509	384	1 084	998	614	...	1	1	1 626	1 508	1 000
1991[1]	505	339	306	1 012	907	530	...	1	1	1 517	1 247	836
1992[1]	386	273	259	815	645	411	...	1	-	1 201	920	671

Notes:
Includes surveillance estimates of catches in the NAFO regulatory area, foreign catches made outside the 200-mile zone on straddling stocks and on Flemish Cap.
The TAC was not introduced until the early 1970s. No TAC has been introduced for salmon.
1. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Figure 4.14.9
Finfish TAC and Landings
Atlantic region, 1960-1992



Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

The Atlantic fisheries have experienced historically high landings of snow crabs, scallops, shrimp and lobster in recent years. Snow crab landings have been above 20 000 tonnes per year since 1978, reaching a high of 50 195 tonnes in 1982 (Table 4.14.7). Scallop landings fluctuated between 2 000 and 12 000 tonnes since 1960, remaining around 9 000 to 10 000 tonnes in recent years. Shrimp landings rose above 10 000 tonnes in 1978. In 1992, 38 038 tonnes of shrimp were landed, a 273 percent increase. Lobster landings have increased in a similar fashion. Throughout the late 1960s and 1970s, lobster landings remained below 20 000 tonnes. However, landings had increased to over 40 000 tonnes in 1992. These increased landings are due primarily to an increase in the numbers of young lobsters surviving to reach the minimal commercial size (most likely due to improved environmental conditions), although greater fishing effort could also be a factor.[1]

1. Government of Canada, *The State of Canada's Environment*, Ottawa, 1991.

Table 4.14.7

Atlantic Coast Snow Crab, Scallop, Shrimp and Lobster Catch, 1960-1992

Year	Snow crab	Scallop	Shrimp	Lobster
	tonnes			
1960	..	4 576	..	22 732
1961	..	8 854	..	21 510
1962	..	8 515	..	20 992
1963	..	7 223	..	20 094
1964	..	5 496	..	18 981
1965	-	3 609	11	18 366
1966	30	2 853	95	16 871
1967	399	4 227	278	15 904
1968	4 652	5 081	271	16 882
1969	8 633	5 215	273	18 156
1970	7 677	4 641	572	16 553
1971	6 926	3 424	1 084	17 210
1972	6 960	3 726	665	14 870
1973	9 913	2 583	1 793	16 091
1974	10 456	4 879	3 317	14 293
1975	7 042	7 028	4 528	17 498
1976	10 743	9 401	5 037	16 087
1977	14 495	12 036	8 523	17 836
1978	21 479	12 152	10 210	19 177
1979	30 858	9 429	13 329	21 577
1980	28 359	8 574	13 614	20 092
1981	39 128	12 141	17 437	21 697
1982	50 195	8 358	12 757	22 803
1983	41 238	6 255	16 442	27 662
1984	42 890	4 884	11 617	28 681
1985	41 266	5 246	12 945	32 639
1986	41 942	6 682	18 615	37 949
1987	26 276	8 613	28 120	39 497
1988	29 022	9 113	39 334	40 530
1989	21 944	9 610	43 578	43 674
1990	26 180	9 775	37 120	47 667
1991[1]	34 148	9 270	38 283	48 278
1992[1]	36 373	10 683	38 038	41 717

Notes:
Historical lobster catch data is available from 1893-1960 in *Human Activity and the Environment 1991*, Catalogue No. 11-509, Table 4.3.2.6, p. 198.
1. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

The Atlantic salmon is widely prized as both a game and a commercial fish. However, the salmon fishery suffers from the pressures of habitat loss, dam construction, the re-routing of waterways, acidic deposition, and contaminants from human activities such as mining, pulp and paper production and agriculture.

Table 4.14.8 provides catch data for Atlantic coast salmon from 1960 to 1992. In recent years, the commercial catch has been in decline, while the recreational catch has remained stable. In 1992, the recreational catch accounted for 198 tonnes, or 42 percent of the total Canadian catch. The Department of Fisheries and Oceans is involved in a number of enhancement projects in an attempt to increase salmon stocks.[1]

Table 4.14.8

Atlantic Coast Salmon Catch, 1960-1990

Year	Canadian catch	Non-Canadian catch	Total catch[1]	Recreational catch[2]
	tonnes			
1960	1 636	60	1 696	..
1961	1 583	127	1 710	..
1962	1 719	244	1 963	..
1963	1 861	466	2 327	..
1964	2 069	1 539	3 608	..
1965	2 116	861	2 977	..
1966	2 369	1 370	3 739	..
1967	2 863	1 606	4 469	..
1968	2 111	1 127	3 238	..
1969	2 202	2 210	4 412	..
1970	2 323	2 146	4 469	..
1971	1 992	2 689	4 681	..
1972	1 759	2 113	3 872	..
1973	2 434	2 341	4 775	..
1974	2 539	1 917	4 456	..
1975	2 485	2 030	4 515	..
1976	2 506	1 175	3 681	..
1977	2 545	1 420	3 965	..
1978	1 545	984	2 529	..
1979	1 287	1 395	2 682	..
1980	2 680	1 194	3 874	..
1981	2 437	1 264	3 701	..
1982	1 798	1 077	2 875	..
1983	1 424	310	1 734	..
1984	1 112	297	1 409	..
1985	1 133	864	1 997	171
1986	1 559	960	2 519	222
1987	1 784	966	2 750	169
1988	1 311	893	2 204	222
1989	1 139	337	1 476	159
1990	911	274	1 185	185
1991[3]	711	472	1 183	148
1992[3]	470	237	707	198

Notes:
1. Canada, Denmark (Greenland and Faroe Islands) and Norway.
2. Recreational catch values are included in Canadian catch.
3. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

1. Department of Fisheries and Oceans Canada.

Pacific Fisheries

The Pacific fisheries have not experienced the same depletion of groundfish stocks as seen on the Atlantic coast, even though harvests have grown considerably over the past decade. Groundfish catches increased from 1989 to 1991, but declined slightly in 1992 (Table 4.14.1). Landings of salmon, economically the most important fishery on the Pacific coast, were at a maximum in 1985/86 and have varied around an average of approximately 85 000 tonnes since 1985 (Table 4.14.10). Pelagic and other finfish catches, exclusive of salmon, declined 12 percent between 1991 and 1992. Shellfish catches increased from 21 237 tonnes in 1989 to 28 861 tonnes in 1992, a 36 percent increase (Table 4.14.1).

Between 1980 and 1990, the international catch[1] of salmon and groundfish in the Northeast Pacific increased by 53 percent and 118 percent respectively (Table 4.14.9). The catch of herring has varied between 49 000 and 68 000 tonnes, averaging around 50 000 tonnes in recent years. The total international catch of all species in 1990 was over 1.4 million tonnes. It should be noted that the United States and Canada increased their shares of the total international catch during the 1980s.

Table 4.14.9

International Catch[1] by Species Groups in the Northeast Pacific, 1980-1990

Year	Salmon[2]	Groundfish	Herring	Total
		tonnes		
1980	437 033	313 686	50 740	**801 459**
1981	540 173	361 210	67 963	**969 346**
1982	494 181	454 499	57 226	**1 005 906**
1983	587 616	516 872	61 387	**1 165 875**
1984	528 375	590 959	53 348	**1 172 682**
1985	655 346	538 897	53 558	**1 247 801**
1986	588 320	449 145	48 762	**1 086 227**
1987	503 707	527 015	59 047	**1 089 769**
1988	540 377	555 632	56 921	**1 152 930**
1989	638 028	659 092	57 784	**1 354 904**
1990[3]	669 797	682 230	49 189	**1 401 216**

Notes:
1. Catch includes Canada, United States, Japan, the former USSR and European countries.
2. Does not include catch by the former USSR.
3. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

The Canadian commercial catch of salmon, groundfish, shellfish and herring in the Northeast Pacific grew steadily from 1980 to 1991 (Table 4.14.10). However, 1992 estimates show a decline in total catches, as well as the declines in groundfish, salmon and herring catches previously noted. Canada's share of the international catch of salmon, groundfish and herring combined grew from 14 percent in 1980 to 20 percent in 1990 (compare Tables 4.14.9 and 4.14.10). Table 4.14.11 shows commercial catches of groundfish in the Northeast Pacific from 1978 to 1990. These catch figures include Canada, United States, Japan, the former USSR and European countries. The table shows a steady increase in total groundfish catch, from 211 073 tonnes in 1978 to 682 230 tonnes in 1990.

1. Catch includes Canada, United States, Japan, the former USSR and European countries. Salmon does not include catch by USSR.

Table 4.14.10

Canadian Commercial Catch by Species Groups in the Northeast Pacific[1], 1980-1992

Year	Salmon	Groundfish	Invertebrates	Herring	Other	Total
			tonnes			
1980	53 817	35 023	8 878	25 155	7 053	**129 926**
1981	78 840	37 602	8 347	37 960	20 388	**183 137**
1982	65 600	52 404	7 850	28 598	3 391	**157 843**
1983	74 602	63 047	9 832	39 820	4 242	**191 543**
1984	50 281	69 023	13 031	33 703	3 130	**169 168**
1985	107 361	61 056	16 384	25 767	4 168	**214 736**
1986	100 242	85 476	16 729	16 341	3 629	**222 417**
1987	66 695	119 058	23 453	37 615	4 619	**251 440**
1988	87 455	116 910	23 118	31 601	6 763	**265 847**
1989	84 894	132 084	21 237	41 008	4 172	**283 395**
1990[2]	96 396	139 536	21 521	41 056	4 811	**303 322**
1991[2]	82 070	161 538	24 538	39 741	4 075	**311 962**
1992[2]	64 856	157 557	28 261	34 531	3 917	**289 122**

Notes:
1. Includes a small amount of pelagic fish in addition to the categories shown.
2. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Table 4.14.11

Catch[1] of Groundfish in the Northeast Pacific, 1978-1990

Year	Sablefish	Flatfish[2]	Halibut	Pacific cod	Hake	Rockfish[3]	Other	Total
				tonnes				
1978	21 478	50 748	12 453	19 707	8 525	37 771	60 391	**211 073**
1979	30 633	52 748	12 764	27 191	18 713	42 587	71 971	**256 607**
1980	19 270	44 620	12 764	41 398	42 246	62 345	91 043	**313 686**
1981	24 154	43 090	14 807	36 028	71 916	69 422	101 791	**361 210**
1982	30 323	44 475	17 257	32 841	99 263	70 687	159 653	**454 499**
1983	26 683	44 624	21 730	39 619	113 378	56 725	214 113	**516 872**
1984	28 117	38 427	25 802	27 492	121 632	50 125	299 364	**590 959**
1985	30 163	36 032	30 664	18 062	64 410	52 123	305 443	**538 897**
1986	39 608	33 331	36 365	29 366	130 325	65 745	112 365	**449 145**
1987	44 109	44 128	37 383	49 354	184 964	71 388	95 689	**527 015**
1988	47 872	42 631	42 662	47 699	205 292	82 431	87 045	**555 632**
1989	45 744	43 855	37 768	53 530	293 881	88 657	95 657	**659 092**
1990[4]	41 597	55 297	34 707	82 471	264 984	92 359	110 815	**682 230**

Notes:
1. Catch includes Canada, United States, Japan, the USSR and European countries.
2. Other than halibut.
3. Other than Pacific ocean perch.
4. Preliminary data.
Source:
Department of Fisheries and Oceans Canada, Biological Sciences Directorate.

Table 4.14.12

Nominal Catches and Landed Values of Freshwater Fish by Province and Species, 1990

Species	Quantity								Value							
	Canada	N.B.	Que.	Ont.	Man.	Sask.	Alta.	N.W.T.	**Canada**	N.B.	Que.	Ont.	Man.	Sask.	Alta.	N.W.T.
	tonnes[1]								thousand dollars							
Alewife	**907**	907	...	...	...	...	...	...	**301**	301	..	..	..	..	..	..
Arctic char	**70**	...	...	...	...	...	...	70	**372**	..	..	..	..	..	..	372
Burbot	**51**	...	...	51	...	...	...	...	**9**	..	..	9	..	..	..	..
Carp	**782**	...	31	63	668	-	...	...	**283**	..	35	37	211	0	..	..
Catfish	**70**	...	-	70	...	...	...	...	**69**	..	0	69	..	..	..	..
Eel	**339**	74	178	87	...	...	...	...	**946**	227	494	225	..	..	..	..
Lake trout	**620**	...	...	224	26	303	...	67	**630**	..	..	439	11	150	..	30
Perch	**7 151**	...	209	6 483	458	...	1	...	**20 138**	..	372	18 371	1 391	..	4	..
Pike	**2 633**	...	7	106	1 344	737	261	178	**2 529**	..	6	173	1 270	666	256	158
Rock bass	**12**	...	...	12	...	...	...	...	**7**	..	..	7	..	..	..	..
Salmon	**2**	-	...	2	...	...	...	...	**2**	0	..	2	..	..	..	..
Sauger	**2 245**	...	...	77	2 168	...	...	...	**3 639**	..	..	192	3 447	..	..	..
Shad	**340**	6	24	310	...	...	...	...	**29**	9	17	3	..	..	..	..
Smelt	**8 118**	1	-	8 115	...	...	...	...	**3 648**	56	0	3 592	..	..	..	..
Sucker (mullet)	**1 513**	...	-	506	668	339	...	...	**483**	..	0	169	219	95	..	..
Sunfish	**127**	...	46	81	...	...	...	...	**158**	..	70	88	..	..	..	..
Sturgeon	**253**	16	223	14	...	...	...	...	**967**	1	872	94	..	..	..	..
Tomcod	**23**	...	23	...	...	...	...	...	**16**	..	16	..	..	..	..	..
Tullibee[2]	**977**	...	...	918	49	1	9	...	**1 438**	..	..	1 411	22	1	4	..
Whitefish	**8 577**	...	10	2 377	2 327	941	1 577	1 345	**10 112**	..	14	5 300	1 805	557	1 205	1 231
White bass	**1 661**	...	...	1 661	...	...	...	...	**2 420**	..	..	2 420	..	..	..	..
Yellow pickerel	**7 206**	...	14	3 311	3 265	520	42	54	**16 863**	..	69	9 322	6 223	1 073	85	91
Other fish	**1 063**	3	300	493	148	39	-	80	**1 355**	64	341	490	286	56	0	118
Total 1990	**44 718**	**1 007**	**1 065**	**24 961**	**11 121**	**2 880**	**1 890**	**1 794**	**66 414**	**658**	**2 306**	**42 413**	**14 885**	**2 598**	**1 554**	**2 000**
Total 1989	**51 201**	**2 371**	**1 067**	**25 612**	**14 699**	**3 904**	**1 594**	**1 954**	**82 690**	**1 733**	**2 489**	**48 123**	**21 538**	**4 165**	**1 912**	**2 730**

Notes:
Not all provinces are represented in the table due to a lack of data.
1. Quantity in tonnes, live weight.
2. Includes lake herring, chub and cisco.
Source:
Department of Fisheries and Oceans Canada, Industry and Programs Directorate.

Commercial Freshwater Fisheries

Canada is well known for its abundance of fresh water, including some of the world's largest rivers and lakes. This abundance of freshwater provided the commercial freshwater fisheries with over $66 million in landed values in 1990.[1] However, pressure on freshwater resources is increasing in areas of high population densities and habitat destruction. Human-induced stresses such as water diversion projects, dams, forestry, mining and acidic deposition are contributing to the decline and contamination of freshwater fish stocks. The contaminated fish may become unfit for human consumption and pass contaminants up the food chain as predators feed on these fish.

Throughout the 1980s, the commercial catch of freshwater fish remained over 40 000 tonnes per season. The commercial freshwater fisheries catch was over 51 000 tonnes of fish in 1989, and just under 45 000 tonnes in 1990 (Table 4.14.12). A comparison of the freshwater and ocean fisheries reveals that in 1990, the commercial freshwater fishery accounted for 2.7 percent of the total commercial tonnage of fish caught and 4.2 percent of the total value. Whitefish, smelt, perch, yellow pickerel, sauger and pike are the most important of the more than 20 species harvested by freshwater commercial fishermen.

1. Department of Fisheries and Oceans Canada, Industry Development and Programs Directorate.

Aquaculture

As fisheries worldwide reach their catch limits and exploit the few remaining untapped fishing opportunities, there will be increased pressure to find new sources of fish. The unpredictable rise and fall of fish stocks from season to season, as well as the decline in some stocks of freshwater and marine species, has led to attempts at ensuring an alternate, sustainable supply of fish.

One method of ensuring supply is known as enhancement. Enhancement has been practised for over a century, but has become more successful in recent decades. Examples include the artificial fertilization of lakes and streams, the construction of artificial spawning beds for trout and salmon, and the construction of artificial surfaces to enhance the deposition of spat (young) by mussels, oysters and scallops. More sophisticated techniques include hatcheries designed to rear young fish, helping them reach maturity before releasing them into the wild.

Table 4.14.13

Production and Value of Selected Farmed and Captured Fish Species, 1991

	Salmon				Trout and Char				Mussel				Oyster			
	Tonnage		Value		Tonnage		Value		Tonnage		Value		Tonnage		Value	
	tonnes	percent	million dollars	percent	tonnes	percent	million dollars	percent	tonnes	percent	million dollars	percent	tonnes	percent	million dollars	percent
Farmed	29 000	26.0	220.0	54.6	4 828	87.9	24.5	98.0	4 046	53.6	5.1	53.1	6 218	49.7	6.3	57.3
Captured	82 365	74.0	183.0	45.4	665	12.1	0.5	2.0	3 499	46.4	4.5	46.9	6 302	50.3	4.7	42.7
Total	**111 365**	**100.0**	**403.0**	**100.0**	**5 493**	**100.0**	**25.0**	**100.0**	**7 545**	**100.0**	**9.6**	**100.0**	**12 520**	**100.0**	**11.0**	**100.0**

Source:
Department of Fisheries and Oceans Canada, Industry Development and Programs Directorate.

The second method of ensuring supply is an extension of hatcheries known as the aquaculture industry. Aquaculture is the managed rearing of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. This requires some form of intervention in the rearing process to enhance production such as regular stocking, feeding and protection from predators.

The Department of Fisheries and Oceans, as the lead federal agency for aquaculture development in Canada, has played a key role in its development. The aquaculture industry grew from $7 million in 1984 to more than $258 million in 1991, and Fisheries and Oceans predicts the industry will grow to $630 million by the year 2000. The aquaculture industry accounted for more than $266 million in domestic and export sales ($53.3 million in exports). This figure is expected to rise to $543 million by the year 2000. The commercial aquaculture sector provided 5 200 jobs, 2 800 in the production sector and 2 400 in the supply and services sector. Fisheries and Oceans suggest that most experts anticipate that aquaculture will be a substantial part of the future Canadian fishery.

The principle species produced by the aquaculture industry in Canada are salmon, trout, mussels and oysters. Table 4.14.13 portrays the importance of aquaculture in the production of the above species. Today, when ordering trout, mussels or oysters in a restaurant, there is a greater than 50 percent chance it was harvested from a fish farm. A quarter of all salmon originates from aquaculture, with a value of over $200 million dollars. Almost 90 percent of trout and char, and over 50 percent of mussels and oysters are produced by aquaculture. Aquaculture has the advantage of producing the most marketable species. An example of this is evident in Table 4.14.13, where farmed salmon make up only 26 percent of the total tonnage produced, but provide almost 55 percent of the total value (i.e. aquaculture salmon is worth two times the value of wild salmon).

Commercial aquaculture takes place in all 10 provinces and in one territory. Atlantic salmon, mussels, quahogs, and steelhead are farmed primarily in the Atlantic provinces (Table 4.14.14). Trout production is concentrated mainly in the central provinces (mostly Ontario), salmon and oyster production primarily in British Columbia and New Brunswick (primarily in the Bay of Fundy for salmon), and mussel production in Prince Edward Island. The Pacific aquaculture industry produced 24 000 tonnes of fish species worth $140 million in 1991, while the Atlantic aquaculture industry accounted for 16 000 tonnes of fish worth $97.1 million.

Table 4.14.14

Production and Value of Selected Aquaculture Species, 1991

	Aquaculture					
Species	Pacific		Central		Atlantic	
	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars
Atlantic Salmon	3 400	30.4	100	0.9	9 667	84.3
Char	...	...	19	0.2	...	...
Chinook	15 470	102.8	80	0.4	...	...
Clams	136	0.6	...	...	...	...
Coho	291	2.0	...	...	...	...
Mussels	...	...	90	0.1	3 955	5.0
Oysters	4 800	3.8	...	...	1 418	2.5
Quahogs	...	...	...	...	473	0.7
Steelhead	...	...	...	...	76	0.3
Trout	...	...	3 857	19.8	726	4.2
Other	...	...	...	...	3	0.1
Total	**24 097**	**139.6**	**4 146**	**21.4**	**16 318**	**97.1**

Source:
Department of Fisheries and Oceans Canada, Industry Development and Programs Directorate.

The Department of Fisheries and Oceans estimates the Pacific aquaculture industry will produce 66 500 tonnes of fish valued at $274 million by the year 2000, an increase of 176 percent and 96 percent respectively over 1991 figures (Tables 4.14.14 and 4.14.16). The central aquaculture industry is expected to experience a four fold increase in quantity and an increase in revenue of over 160 percent by 2000. The Department of Fisheries and Oceans projects the greatest growth will occur in the Atlantic aquaculture industry. Total quantity produced is expected to increase from 16 318 tonnes in 1991 to 66 100 tonnes by the year 2000, an increase of 305 percent. Revenue from these fish species is expected to grow by $203 million, a 209 percent increase.

Table 4.14.15

Production of Selected Fish Species by Aquaculture, 1989-1995

Species	1989	1990	1991	1995[1]
		tonnes		
Salmon	16 254	21 117	29 000	35 000
Trout	3 629	4 497	4 808	5 500
Oyster	6 489	6 774	6 218	8 000
Mussel	3 391	3 598	4 046	6 700
Total	**29 763**	**35 986**	**44 072**	**55 200**

Note:
1. Projected.
Source:
Department of Fisheries and Oceans Canada, Industry Development and Programs Directorate.

Table 4.14.16

Projections of the Production and Value of Selected Aquaculture Species, 2000

Species	Aquaculture					
	Pacific		Central		Atlantic	
	tonnes	million dollars	tonnes	million dollars	tonnes	million dollars
Existing Species						
Salmon/Trout	40 500	247.0	14 900	48.6	34 000	207.0
Oysters	23 000	18.0	...	...	5 000	8.0
Manila Clams	700	2.5	...	...	...	...
Scallops	...	...	200	3.0	3 100	48.0
Mussels	...	...	500	0.5	18 000	20.0
New Species						
Sablefish	2 000	3.0	...	...	...	...
Geoducks	100	2.2	...	...	...	...
Sturgeon	...	...	900	4.0	...	...
Cod	...	...	...	...	4 000	7.0
Others	200	1.3	...	...	2 000	10.0
Total	**66 500**	**274.0**	**16 500**	**56.1**	**66 100**	**300.0**

Source:
Department of Fisheries and Oceans Canada, Industry Development and Programs Directorate.

Sport fishing

Within Canada's landmass of almost ten million square kilometres are a quarter of a million square kilometres of lakes, rivers and streams that provide anglers with an abundant supply of fishing opportunities. In addition to freshwater, Canada has over 240 000 kilometres of coastline bordering on three oceans. Within these waters are 950 species of fish, 75 being of primary interest to anglers.[1] Almost five million licensed anglers took advantage of these opportunities in 1990 (Table 4.14.17).

Table 4.14.17

Total Number of Licensed Anglers by Province, 1990

Province/Territory	Resident	Non-resident Canadian	Non-resident non-Canadian	Total
Newfoundland	134 924	2 810	1 166	**138 900**
Prince Edward Island	11 308	1 001	360	**12 669**
Nova Scotia	68 726	1 062	2 126	**71 914**
New Brunswick	86 792	1 871	4 644	**93 307**
Quebec	1 174 661	28 090	33 073	**1 235 824**
Ontario	1 436 858	24 015	554 927	**2 015 800**
Manitoba	138 396	7 319	29 647	**175 362**
Saskatchewan	144 340	20 833	18 505	**183 678**
Alberta	240 728	4 603	4 643	**249 974**
British Columbia				
Freshwater	310 396	40 860	39 065	**390 321**
Tidal	237 218	49 045	78 530	**364 793**
Yukon	7 824	2 669	4 538	**15 031**
Northwest Territories	7 397	4 805	2 368	**14 570**
Total	**3 999 568**	**188 983**	**773 592**	**4 962 143**

Source:
Department of Fisheries and Oceans Canada, Industry Development and Programs Directorate.

The popularity of sport fishing in Canada is readily apparent from the number of licensed anglers and the number of fish harvested from lakes, rivers and oceans. Almost 300 million fish were caught by anglers in 1990, 156 million of those were kept, for a total of 56 167 tonnes of fish harvested. The average number of fish caught by resident anglers was 61, and the average number of fish kept was 36. The average weight of fish kept in Canada was 17 kilograms per angler. Newfoundland had the largest average weight of fish kept at 37 kilograms as well as the highest average catch of fish per angler (131) and the highest average fish kept per angler (104). Table 4.14.18 describes in detail the species of fish caught and kept by province. The most popular species of fish kept were trout, smelt, walleye and perch.

The quality of our environment is an important factor in the continued popularity of sport fishing. The *Survey of sport fishing*[2] found that the two most important conditions in determining the choice of fishing destination are water quality and the lack of pollutants in fish. The survey also found that other important factors include the natural beauty of the area, the lack of angler crowding, the presence of a favourite species, the size of fish, the absence of other recreationalists and the catch rate.

Over the past decade, there has been an increase in the importance placed on sustainable development and environmental protection. This trend may have increased the desire of anglers to practice "catch and release" methods of fishing to help keep fish stocks healthy. The 1990 survey reported that 38.4 percent of active anglers practised voluntary catch and release fishing methods, 2.3 percent practised mandatory methods and 17.6 percent practised both methods (1.3 percent unknown). The percentage of anglers not practising catch and release was 38.1 percent (2.3 percent unknown).

1. Department of Fisheries and Oceans Canada, *Survey of sport fishing in Canada*, 1985.

2. Ibid.

Table 4.14.18

Sportfish Caught and Kept by Species and Province, 1990

Province/Territory	Bass[1]	Cod	Kokanee	Mackerel	Northern pike	Panfish	Perch	Rockfish	Salmon[2]	Smelt	Trout[3]	Walley	Whitefish	Other	Total	Average catch per angler[4]	Total weight of fish kept (tonnes)[5]
	thousand fish[5]																
Newfoundland																	
Caught	...	3 678	...	213	54	...	...	...	210	1 508	10 315	...	...	1 807	**17 785**	131	...
Kept	...	3 307	...	201	27	...	...	...	113	1 437	7 902	...	...	1 095	**14 082**	104	4 972
Prince Edward Island																	
Caught	...	24	...	84	...	...	22	...	...	211	672	...	...	20	**1 033**	92	...
Kept	...	19	...	71	...	...	2	...	...	198	407	...	...	6	**703**	63	146
Nova Scotia																	
Caught	460	203	...	676	...	...	617	...	6	1 234	2 330	...	...	432	**5 958**	92	...
Kept	27	178	...	611	...	...	62	...	3	1 207	1 443	...	...	252	**3 783**	58	990
New Brunswick																	
Caught	217	...	...	258	...	...	269	...	96	396	2 259	...	11	679	**4 185**	56	...
Kept	42	...	...	195	...	...	39	...	24	360	1 533	...	2	212	**2 407**	33	562
Quebec																	
Caught	2 881	...	...	...	6 817	...	5 927	...	204	...	33 327	7 703	...	14 742	**71 601**	60	...
Kept	1 006	...	...	...	3 524	...	3 983	...	157	...	26 315	4 861	...	9 931	**49 777**	43	15 444
Ontario																	
Caught	25 995	...	...	...	14 949	15 057	22 656	...	2 055	22 488	7 852	27 758	862	9 796	**149 468**	73	...
Kept	5 490	...	...	...	3 184	5 178	9 887	...	823	21 413	3 350	11 827	383	2 957	**64 492**	35	26 534
Manitoba																	
Caught	442	...	...	...	3 825	...	1 087	...	...	...	354	4 693	...	1 172	**11 573**	64	...
Kept	56	...	...	...	493	...	379	...	...	...	149	1 851	...	252	**3 180**	20	2 505
Saskatchewan																	
Caught	...	...	...	...	3 847	...	2 571	...	...	...	502	3 426	84	350	**10 780**	48	...
Kept	...	...	...	...	1 341	...	1 494	...	...	...	222	1 607	55	104	**4 823**	42	3 580
Alberta																	
Caught	...	...	...	...	3 408	...	4 929	...	...	...	2 487	1 495	891	444	**13 654**	61	...
Kept	...	...	...	...	1 132	...	2 202	...	...	...	734	457	497	96	**5 118**	23	3 130
British Columbia Tidal																	
Caught	...	...	...	...	...	...	...	1 470	3 965	...	...	...	...	1 162	**6 597**	22	...
Kept	...	...	...	...	...	...	...	634	2 339	...	...	...	...	609	**3 582**	12	8 589
British Columbia Freshwater																	
Caught	169	...	1 258	...	71	...	65	...	523	...	6 111	78	291	1 073	**9 639**	30	...
Kept	32	...	962	...	23	...	38	...	152	...	2 589	39	128	471	**4 434**	14	3 434
Yukon																	
Caught	...	...	...	...	61	...	...	...	10	...	89	...	4	157	**321**	24	...
Kept	...	...	...	...	17	...	...	...	4	...	34	...	2	48	**105**	10	39
Northwest Territories																	
Caught	...	...	...	...	196	...	...	...	...	...	189	57	2	111	**555**	35	...
Kept	...	...	...	...	23	...	...	...	...	...	42	23	2	41	**131**	13	278
Total																	
Caught	**30 164**	**3 905**	**1 258**	**1 231**	**33 228**	**15 057**	**38 143**	**1 470**	**7 069**	**25 837**	**66 487**	**45 210**	**2 145**	**31 945**	**303 149**	**61**	**...**
Kept	**6 653**	**3 504**	**962**	**1 078**	**9 764**	**5 178**	**18 086**	**634**	**3 615**	**24 615**	**44 720**	**20 665**	**1 069**	**16 074**	**156 617**	**36**	**70 203**

Notes:
Other includes several species of fish where there are less than 1000 catches.
Figures may not add due to rounding.
1. Includes largemouth, smallmouth and striped bass.
2. Includes black, bright, chinook, coho, landlocked, pink and sockeye salmon.
3. Includes brook, brown, cutthroat, grey, lake, rainbow, sea and other trout.
4. These figures represent resident anglers only.
5. These figures include resident, non-resident Canadian and non-resident non-Canadian anglers.
Source:
Department of Fisheries and Oceans Canada, Industry and Programs Directorate.

Commercial Hunting and Trapping

Although the fur industry has been in decline in recent years, the importance of fur harvesting in Canada's history is indisputable. Canada's vast wilderness and ample supply of fur bearing mammals attracted thousands of settlers eager to harvest furs for the European market. The changing demand for furs owing to fashion and the prevailing public attitude towards fur clothing has caused the number of pelts harvested annually, and their value, to fluctuate greatly over time.

During the 1991-1992 season 951 876[1] fur-bearing mammals valued at over $22 million were harvested (Table 4.14.19). The most popular furs, beaver, marten and muskrat, make up over 60 percent of the total number of wild furs taken. Ontario, Quebec and Alberta accounted for a total of 603 592 pelts, representing 63 percent of all pelts harvested in Canada. The value of these furs totalled $13 million.

As well as trapping of wild animals, the fur industry also engages in fur farming, a process similar to aquaculture. In 1991, over 40 000 farmed fox pelts and over 926 000 mink pelts were sold for a combined value of $22.5 million, equalling the value of trapped furs (Table 4.14.20). Ontario, Nova Scotia, British Columbia and Quebec accounted for a combined total of 847 266 mink and fox pelts valued at over $19 million.

Figures 4.14.10 through 4.14.13 show the variations in values and quantities of the most sought after furs: (muskrat, marten and beaver). All three fur species experienced large declines in numbers harvested during the 1980s, followed by slight increases in the early 1990s.

As some species become more valuable for their fur, and in some cases for their body parts, illegal harvesting will continue to grow. One animal, valued for its pelt as well as its non-fur parts is the bear. Figure 4.14.13 shows the number and value of bears harvested from 1958 to 1992. The number of bears harvested increased from 1958 to 1978, but declined between 1978 and 1988 only to increase again in recent years. As numbers of certain valued species decline, they may become more valuable, thereby increasing the chances of illegal poaching.

1. Does not include data for seals in the Northwest Territories.

Table 4.14.19

Animal Pelts Taken, 1991-92

Species	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.
	number												
Wild													
Badger	**933**	-	-	-	-	-	-	98	331	504	-	-	-
Bear	**2 544**	11	-	-	-	870	19	576	259	69	459	-	281
Beaver	**219 737**	1 719	467	2 769	6 483	48 610	73 495	16 226	25 800	37 137	5 131	298	1 602
Coyote	**43 682**	...	30 [1]	865	788	4 075	2 912	4 421	9 586	19 885	1 043	63	14
Ermine	**30 388**	1 269	5	232	404	8 921	2 881	1 832	3 107	7 643	3 715	103	276
Fisher	**15 381**	-	-	...	178 [5]	2 093	2 922	3 516	4 685	1 738	179 [2]	...	70
Fox	**56 810**	2 841	1 014	894	1 144	22 197	7 791	7 081	7 178	2 427	409	154	3 680
Lynx	**11 542**	108 [3]	-	...	-	978	932	530	1 129	2 215	2 017	1 403	2 230
Marten	**184 222**	2 909	-	-	1 883	34 828	58 058	8 098	4 493	13 678	34 165	4 981	21 129
Mink (wild)	**46 512**	3 138	292	1 362	1 448	8 121	12 388	6 309	5 338	2 122	2 322	255	3 417
Muskrat	**204 112**	2 145	2 948	11 115	17 226	58 213	50 564	15 028	20 429	16 802	4 421	546	4 677
Otter	**12 026**	520	-	378	324	2 773	5 029	1 288	1 035	312	328	4	35
Raccoon	**23 493**	-	330	1 997	914	4 552	13 885	1 019	565	71	160	-	-
Squirrel	**95 974**	461	25	3 800	298	2 909	1 559	4 462	9 261	65 713	6 806	408	272
Wildcat	**448**	-	-	311	10	12	5	-	13	27	70	-	-
Wolf	**3 155**	47	-	-	-	520	566	244	221	332	64	139	1 022
Wolverine	**686**	-	-	-	-	-	7	73	16	30	142	217	201
Other	231 [4]	-	-	25	-	58	133	-	-	11	4	-	884
Total 1991-1992	**951 876 [4]**	**15 168**	**5 109**	**23 748**	**31 100**	**199 730**	**233 148**	**70 801**	**93 446**	**170 716**	**61 435**	**8 571**	**38 906 [5]**
Total 1990-1991	**735 251 [4]**	**8 818**	**3 493**	**18 276**	**21 893**	**163 006**	**228 306**	**50 780**	**66 038**	**90 583**	**39 370**	**9 113**	**3 557 [5]**
Ranch-raised pelts													
Fox	40 517	2 900	1 900	8 300	6 900	8 863	3 616	752	920	1 949	4 417	...	...
Mink	926 632	2 700	12 600	228 000	14 700	84 106	351 863	38 840	634	35 088	158 101	...	...
Total, 1991	**967 149**	**5 600**	**14 500**	**236 300**	**21 600**	**92 969**	**355 479**	**39 592**	**1 554**	**37 037**	**162 518**	...	...

Notes:
Trapping season in most cases is the winter.
Ranch-raised pelt data is not included.
1. Data include Newfoundland.
2. Data include Yukon.
3. Data include Nova Scotia.
4. Data do not include seals in the Northwest Territories.
5. Seals reported in "other" not included in total.
Source:
Statistics Canada, *Livestock Statistics*, Catalogue No. 23-603, Ottawa, 1993.

Table 4.14.20

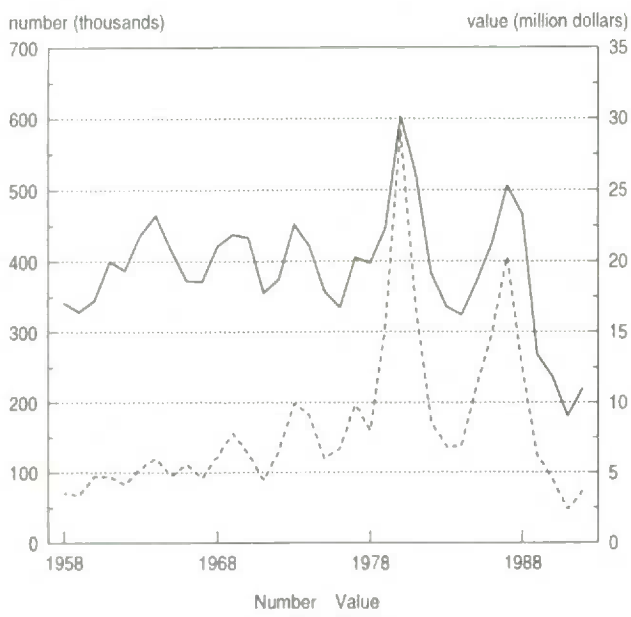
Value of Animal Pelts Taken, 1991-1992

Species	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Y.T.	N.W.T.
Wild													
Badger	**11 599**	-	-	-	-	-	-	725	3 369	7 505	-	-	-
Bear	**712 843**	880	-	-	-	91 431	8 819	41 184	15 250	4 682	270 391	-	280 206
Beaver	**3 651 009**	29 223	10 629	41 923	105 997	912 896	1 251 620	245 824	364 863	564 854	96 309	4 619	22 252
Coyote	**1 507 453**	...	1 082 [1]	22 706	22 655	125 999	75 916	164 682	288 387	765 175	38 455	1 953	443
Ermine	**104 862**	508	9	573	1 143	31 134	7 577	6 229	8 682	31 489	16 569	350	599
Fisher	**-783 000**	-	-	...	7 696 [3]	104 210	136 399	192 853	245 028	85 284	8 647 [2]	...	2 883
Fox	**993 608**	52 022	24 341	14 766	22 708	446 620	140 947	105 491	81 193	37 773	6 712	3 080	57 955
Lynx	**999 170**	6 752 [3]	-	...	-	72 978	64 671	42 798	109 317	200 413	187 460	136 091	178 690
Marten	**10 371 796**	174 540	-	-	77 259	2 006 093	3 053 270	468 469	267 846	793 324	1 905 382	318 784	1 306 829
Mink (wild)	**1 634 104**	72 174	9 119	39 675	46 799	280 499	467 523	256 776	159 305	81 018	94 134	9 435	117 647
Muskrat	**444 297**	4 290	9 074	25 009	35 658	126 322	127 927	31 559	39 022	27 387	9 107	1 365	7 577
Otter	**601 486**	25 480	-	17 006	16 103	155 038	240 789	73 674	36 381	17 045	18 640	132	1 198
Raccoon	**246 055**	-	3 604	12 282	6 014	28 177	184 532	5 859	4 267	349	971	-	-
Squirrel	**129 709**	461	16	3 610	232	3 084	1 138	5 578	8 744	96 598	9 460	530	258
Wildcat	**20 873**	-	-	12 655	373	529	133	-	630	2 078	4 475	-	-
Wolf	**559 816**	6 204	-	-	-	69 337	35 415	28 365	35 587	37 274	4 632	11 537	331 465
Wolverine	**147 696**	-	-	-	-	-	1 190	11 512	3 780	5 829	26 474	46 221	52 690
Other	**561 [4]**	-	-	76	-	188	255	-	-	31	11	-	14 807 [5]
Total 1991-1992	**22 919 937 [4]**	**365 782**	**56 792**	**190 281**	**334 941**	**4 454 535**	**5 798 121**	**1 681 578**	**1 671 651**	**2 758 108**	**2 689 182**	**534 097**	**2 360 692 [4]**
Total 1990-1991	**15 484 058 [4]**	**178 341**	**26 213**	**146 756**	**196 744**	**2 941 786**	**4 916 491**	**1 125 332**	**789 543**	**1 272 730**	**1 607 470**	**429 870**	**1 852 782 [4]**
Ranched raised pelts													
Fox	1 874 769	137 547	90 117	383 999	319 688	409 210	162 098	34 653	41 055	87 603	208 799	...	...
Mink	20 577 425	54 702	267 149	4 638 168	315 490	1 801 573	8 219 161	912 119	12 855	730 835	3 625 373	...	...
Total, 1991	**22 452 194**	**192 249**	**357 266**	**5 022 167**	**635 178**	**2 210 783**	**8 381 259**	**946 772**	**53 910**	**818 438**	**3 834 172**	...	...

Notes:
Trapping season in most cases is the winter.
Ranch-raised pelt data is not included.
1. Data include Newfoundland.
2. Data include Yukon.
3. Data include Nova Scotia.
4. Data do not include seals in the Northwest Territories.
5. Seals reported in "other" not included in total.
Source:
Statistics Canada, *Livestock Statistics*, Catalogue No. 23-603, Ottawa, 1993.

Figure 4.14.10

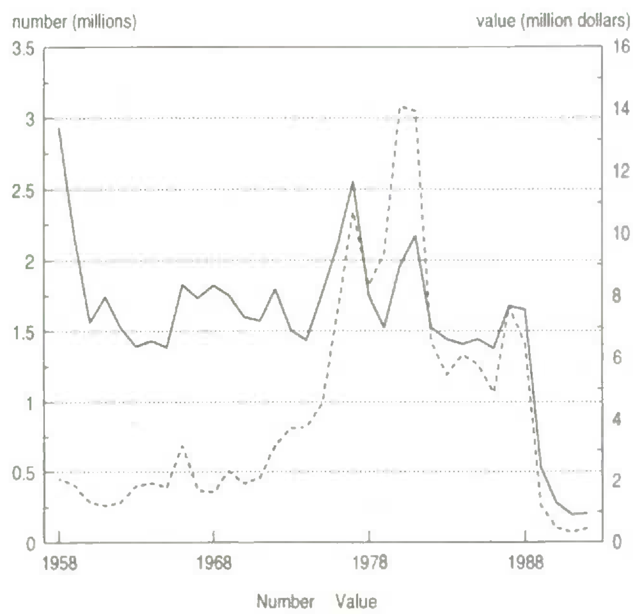
Beaver Pelts Taken, 1958-1992



Source:
Statistics Canada, *Livestock Statistics*, Catalogue No. 23-604, Ottawa, 1993.

Figure 4.14.11

Muskrat Pelts Taken, 1958-1992

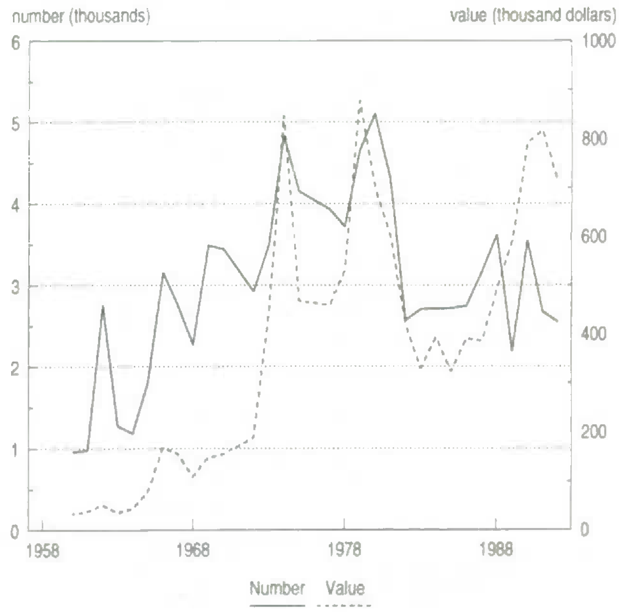


Source:
Statistics Canada, *Livestock Statistics*, Catalogue No. 23-604, Ottawa, 1993.

Figure 4.14.12
Marten Pelts Taken, 1958-1992

Source:
Statistics Canada, *Livestock Statistics*, Catalogue No. 23-604, Ottawa, 1993.

Figure 4.14.13
Bear Pelts Taken, 1960-1992



Source:
Statistics Canada, *Livestock Statistics*, Catalogue No. 23-604, Ottawa, 1993.

Summary

Commercial fish harvesting remains an important part of the Canadian economy. However, the Atlantic fishery has been devastated by declining fish stocks, resulting in the near closure of the entire fishery. One bright spot that remains is the shellfish industry. The Pacific coast fishery appears to be sustaining its harvest levels, with no apparent declines in stock levels. An improved understanding of the causes that have contributed to the decline in the Atlantic fishery are necessary to prevent this from occurring again in the future.

Aquaculture is recognized as a growing source of employment and offers the possibility for social and economic improvement in communities with limited economic alternatives, such as those affected by the recent moratorium on cod fishing. Sport fishing remains an important recreational activity for Canadians and its success is dependant on the health of Canada's lakes and rivers.

Technical Box 4.14.1
Data Collection Methods:

There are a number of data collection methods employed by the Department of Fisheries and Oceans. One estimation technique uses sales receipts from fish buyers that record quantity and value of all marine fish species sold. A second source information on fish quantities comes from fishing logs kept on each fishing vessel. Information such as catch, landings, amount of gear and location are all collected from these logs. A third method uses research vessels that complete in-depth surveys for specific species. A fourth method employs a radio survey of fishing vessels who report their catches to Fisheries officials.

The Department of Fisheries and Oceans is confident that their overall estimates are accurate. However, it is acknowledged that miss-reporting does occur, particularly when stocks are low and there is increased competition for fewer fish. In addition, the scientific estimation techniques may not always reflect true fish stock levels. Finally, fish landings are not actual catches; dumping and discarding occur in some fleets and are not taken into account. This affects the accuracy of the projections.

4.15 Water Supply and Use

Water covers almost three quarters of the earth's surface as oceans, rivers, lakes, glaciers and snow. Water is not only present on the earth's surface and underground, but also in the atmosphere. The *hydrologic cycle*[1] (see Section 4.2 - **Water Quality**, Figure 4.2.1) describes how water circulates between the earth and the atmosphere. Of the earth's estimated 1.3 billion cubic kilometres of water, only 2.53 percent is accounted for by the earth's freshwater supply. Of this, only 0.4 percent is truly accessible, with the remainder either underground or locked in glaciers.[2]

The most obvious uses of water occur in nature. Water supports life on earth by providing special local environments for fish and wildlife. It is also a substance which is required by all living organisms, and is an important input that drives much of our industrial processes.

The use and consumption of water are termed *instream* uses and *withdrawal* uses. *Instream* uses include the natural environment in which wildife and fish exist, and human activities such as fishing, shipping and hydroelectric power generation. *Withdrawal* uses refer to land-based water uses. Water withdrawn from its source (a river or lake) is directed to a variety of users, recollected, and redirected back to its original source. Often, less water is returned than originally withdrawn because of the consumptive nature of most withdrawal uses. Furthermore, the water returned to its natural setting is often more contaminated than when it was originally withdrawn. Regionally the highest water withdrawals in Canada for 1991 occurred in Ontario (Table 4.15.1).

As population increases so does the demand for both surface water and groundwater supplies. Along with increased use comes increased effluents originating from human activities. The management of water resources, both water use and water quality, is becoming increasingly important.

1. In the *hydrologic cycle*, water precipitates from the atmosphere to the oceans or to the land surface (where it flows overland and underground back to the oceans), and then evaporates or transpires back to the atmosphere from the land and the oceans.
2. Environment Canada, *Water - here, there and everywhere*, Fact Sheet No. 2, Ottawa, 1988.

Table 4.15.1

Water Withdrawal and Consumption by Region, 1981, 1986 and 1991

Region	Water withdrawals[1]						Change	Water	Water consumption as a percentage of water withdrawal
	Agriculture	Mining	Manufacturing	Thermal power	Municipal	Total	1981-91	consumption[2]	
	million cubic metres (MCm)						percent	MCm	percent
Atlantic Provinces									
1981	12	86	640	1 837	307	2 882	...	127	4.41
1986	13	212	958	2 490	339	4 012	...	193	4.81
1991	15	77	601	2 126	356	3 175	10.2	118	3.72
Quebec									
1981	82	107	2 319	308	1 369	4 185	...	416	9.94
1986	89	52	1 521	986	1 484	4 132	...	387	9.37
1991	100	74	1 616	1 005	1 703	4 498	7.5	383	8.51
Ontario									
1981	148	124	4 414	14 930	1 450	21 066	...	715	3.39
1986	166	100	3 763	19 967	1 602	25 598	...	794	3.10
1991	186	87	3 457	23 095	1 660	28 485	35.2	512	1.80
Prairie Provinces									
1981	2 338	197	382	1 846	579	5 342	...	1 981	37.08
1986	2 688	142	357	1 867	675	5 729	...	2 254	39.34
1991	3 014	50	447	2 025	685	6 221	16.4	3 630	58.35
British Columbia[3]									
1981	545	134	2 182	360	558	3 779	...	653	17.28
1986	603	87	1 385	54	617	2 746	...	651	23.71
1991	676	75	1 161	106	698	2 716	-28.1	724	26.66
Canada									
1981	**3 125**	**648**	**9 937**	**19 281**	**4 263**	**37 254**	**...**	**3 892**	**10.45**
1986	**3 559**	**593**	**7 984**	**25 364**	**4 717**	**42 217**	**...**	**4 279**	**10.14**
1991	**3 991**	**363**	**7 282**	**28 357**	**5 102**	**45 095**	**21.1**	**5 367**	**11.90**
Percent of total									
1981	8.39	1.74	26.67	51.76	11.44	100.00	..	..	..
1986	8.43	1.40	18.91	60.08	11.17	100.00	..	..	..
1991	8.85	0.80	16.15	62.88	11.31	100.00	..	..	..

Notes:
1. Figures for some sectors have been extrapolated and rounded.
2. Sectoral data for the Yukon and Northwest Territories are included with British Columbia.
3. Consumption data does not include data for the mining sector due to the inclusion of minewater in the discharge data.

Source:
Environment Canada, Water and Habitat Conservation Branch.

Water Withdrawal

In 1991, five water use sectors accounted for a gross water use[1] in Canada of 57 935 million cubic metres (MCm). These five sectors, in order of largest withdrawal, include: thermal power generation, manufacturing, municipal use, agriculture, and mining. From 1981 to 1991 gross water use in Canada increased by 2.5 percent from 53 billion cubic metres (BCm) in 1981 to 58 BCm in 1991 (Table 4.15.2). Gross water use is the sum of water intake plus recirculation. Table 4.15.2 also presents gross water use by sector. The highest water use levels occur in the mining and manufacturing industrires. Table 4.15.3 provides a further breakdown of water use in the mining and manufacturing sectors for the years 1981 and 1991.

Thermal Power Generation

This sector includes both conventional and nuclear power generating plants. Next to fuel, water is the most important resource used in thermal power generation. In 1991 these plants accounted for more than 62.9 percent of the total water withdrawn. Water is used both as steam to drive generators to produce electricity, as well as in the condensor cooling process. Production of one kilowatt-hour of electricity requires 140 litres of water for fossil fuel plants and 205 litres for nuclear power plants.[2]

Manufacturing

In manufacturing, water is used as a raw material, a coolant, a solvent, a source of energy and as a means of transportation. Many thousands of litres of water are involved in the manufacture of plastics, paper and metals. The production of one car requires the use of approximately 120 thousand litres of water - 80 thousand to produce one tonne of steel and 40 thousand for the fabrication process.[3] In 1991, manufacturing accounted for 16.2 percent of water withdrawals in Canada.

Municipal Use

Municipal use consists of all water withdrawn by municipal water supply facilities, distributed to domestic, commercial

1. Gross water use represents the amount of water used during a process, which is normally equal to water intake. However some sectors reuse the same water many times (for instance, for cooling purposes), in which case the gross water use could be equal to several times the water intake. The recirculation of water ultimately reduces overall withdrawal requirements of these industries.

2. Environment Canada, *Water Works!* Fact Sheet No. 4, Ottawa, 1990.
3. Ibid.

Table 4.15.2

Water Withdrawal and Consumption by Sector, 1981, 1986 and 1991

Sector	Water withdrawal		Recirculation		Gross water use[1]		Consumption		Discharge[2]		
	Quantity	Change 1981-91	Quantity	Change 1981-91	Quantity	Change 1981-91	Quantity	Change 1981-91	Quantity	Change 1981-91	Use rate[3]
	MCm	percent	MCm	percent	MCm	percent	MCm	percent	MCm	percent	
Agriculture											
1981	3 125	...	-	...	3 125	...	2 412	...	713	...	1.0
1986	3 559	...	-	...	3 559	...	2 752	...	807	...	1.0
1991	3 991	12.1	-	...	3 991	12.1	3 089	12.2	902	11.8	1.0
Mining[4]											
1981	648	...	2 792	...	3 440	...	178	...	470	...	6.0
1986	593	...	2 038	...	2 631	...	164	...	429	...	4.3
1991	363	-38.8	1 223	-40.0	1 587	-39.7	..	...	499	16.3	4.4
Manufacturing											
1981	9 937	...	10 747	...	20 684	...	494	...	9 443	...	2.2
1986	7 984	...	7 813	...	15 796	...	405	...	7 579	...	2.0
1991	7 282	-8.8	6 806	-12.9	14 088	-10.8	520	28.4	6 762	-10.8	1.9
Thermal power generation											
1981	19 281	...	1 868	...	21 149	...	168	...	19 113	...	1.1
1986	25 364	...	4 480	...	29 844	...	271	...	25 093	...	1.2
1991	28 357	11.8	4 810	7.4	33 167	11.1	567	109.2	27 790	10.8	1.2
Municipal[5]											
1981	4 263	...	-	...	4 610	...	640	...	3 623	...	1.0
1986	4 717	...	-	...	4 716	...	689	...	4 022	...	1.0
1991	5 102	8.2	-	...	5 102	8.2	510	-26.0	4 251	5.7	1.0
Total[6]											
1981	**37 254**	**...**	**15 407**	**...**	**53 008**	**...**	**3 892**	**...**	**33 362**	**...**	**1.4**
1986	**42 217**	**...**	**14 331**	**...**	**56 546**	**...**	**4 281**	**...**	**37 930**	**...**	**1.3**
1991	**45 095**	**8.8**	**12 839**	**-10.4**	**57 935**	**2.5**	**4 686**	**9.5**	**40 204**	**6.0**	**1.3**

Notes:
1. Gross water use equals new water withdrawal plus recycled water.
2. Discharge equals water withdrawal minus consumption.
3. The ratio of gross water use to water withdrawal, an index of recirculation.
4. Consumption data not available for mining sector due to inclusion of minewater in discharge data.
5. Excludes water supplied to industry. Includes estimates for rural residential water use.
6. Figures may not add due to rounding. For 1991 the consumption total does not include the mining sector data.

Source:
Environment Canada, Water and Habitat Conservation Branch.

Table 4.15.3

Water Use in the Mining and Manufacturing Sectors, 1981, 1986 and 1991

Sector	1980 SIC Code[1]	Employees	Plants	Water withdrawal[2]	Recirculation[3]	Gross water use[4]	Consumption[5]	Total water discharge[6]	Use rate[7]
		number		million cubic metres					
Mining sector									
Mining industries	6								
1981		86 742	198	527.30	1 741.81	2 269.11	130.30	396.91	4.3
1986		65 734	228	507.35	1 163.77	1 671.12	121.45	385.90	3.3
1991[8]		55 068	202	363.60	1 223.24	1 586.84	..	499.48	4.4
Crude petroleum and natural gas industries	7								
1981		8 669	53	121.01	1 050.29	1 171.30	47.92	73.09	9.7
1986		8 372	49	86.02	873.45	959.47	42.92	43.10	11.2
1991[9]		..	..	..	..	..	..	..	..
Mining sector total									
1981		**95 411**	**251**	**648.31**	**2 792.10**	**3 440.41**	**178.22**	**470.00**	**7.0**
1986		**74 106**	**277**	**593.37**	**2 037.22**	**2 630.59**	**164.37**	**429.00**	**7.2**
1991[9]		..	..	..	..	..	..	..	..
Manufacturing sector									
Food industries	10								
1981		140 976	1 273	352.12	101.52	453.64	17.08	335.04	1.3
1986		155 371	1 288	563.93	148.30	712.23	23.46	540.47	1.3
1991		140 468	1 027	347.20	192.74	539.94	27.10	320.10	1.6
Beverage industries	11								
1981		26 949	240	77.72	15.28	93.00	13.63	64.09	1.2
1986		23 138	217	62.62	106.83	169.45	12.09	50.53	2.7
1991		20 173	131	73.36	16.43	89.79	11.74	61.61	1.2
Rubber products industry	15								
1981		21 623	86	27.99	59.62	87.62	3.38	24.61	3.1
1986		21 201	86	23.31	66.69	90.00	2.35	20.96	3.9
1991		19 402	69	20.72	55.71	76.43	2.01	18.70	3.7
Plastic products industries	16								
1981		24 437	364	26.18	684.35	710.53	3.88	22.30	27.1
1986		31 745	438	29.93	66.37	96.30	2.62	27.31	3.2
1991		33 217	396	41.62	266.85	308.46	2.85	38.77	7.4
Primary textile industries	18								
1981		26 634	106	106.50	49.85	156.34	4.45	102.05	1.5
1986		20 067	123	94.85	29.70	124.55	2.08	92.77	1.3
1991		16 219	79	258.58	170.07	428.64	31.80	226.77	1.7
Textile products industry	19								
1981		7 128	56	17.17	0.73	17.91	0.74	16.43	1.0
1986		6 329	72	12.76	11.94	24.70	1.36	11.40	1.9
1991		7 160	46	13.61	19.58	33.19	1.40	12.22	2.4
Wood industries	25								
1981		43 594	360	72.84	57.29	130.13	4.30	68.54	1.8
1986		49 051	341	56.02	7.97	63.99	1.98	54.04	1.1
1991		42 408	340	59.21	5.07	64.27	12.35	46.85	1.1
Paper and allied products industries	27								
1981		96 331	271	2 899.35	4 611.76	7 511.11	159.52	2 739.83	2.6
1986		93 809	291	3 028.85	2 979.02	6 007.86	199.91	2 828.94	2.0
1991		86 301	264	2 911.89	2 181.19	5 093.07	178.96	2 732.93	1.7
Primary metal industries	29								
1981		111 972	171	2 718.60	1 692.26	4 410.86	37.68	2 680.92	1.6
1986		103 695	221	1 718.18	1 349.86	3 068.03	42.92	1 675.26	1.8
1991		89 725	190	1 560.58	1 688.48	3 249.06	69.88	1 490.70	2.1
Fabricated metal products industries	30								
1981		30 136	324	30.21	130.21	160.42	0.78	29.43	5.3
1986		47 711	537	25.18	113.56	138.73	0.95	24.23	5.5
1991		36 005	427	19.37	29.55	48.91	0.66	18.71	2.5
Transportation equipment industries	32								
1981		149 876	329	108.77	72.84	181.60	2.87	105.90	1.7
1986		173 371	435	117.30	236.94	354.24	3.72	113.58	3.0
1991		141 022	376	81.52	36.18	117.70	6.84	74.68	1.4
Non-metallic mineral products industries	35								
1981		39 270	674	82.62	530.25	612.87	14.33	68.29	7.4
1986		38 930	588	89.67	69.90	159.57	18.04	71.63	1.8
1991		35 111	501	136.56	155.65	292.21	46.43	90.13	2.1
Refined petroleum and coal products industries	36								
1981		11 785	42	563.07	1 456.97	2 020.04	34.18	528.89	3.6
1986		9 756	32	487.15	1 068.12	1 555.27	33.49	453.66	3.2
1991		9 392	30	445.20	1 011.55	1 456.76	34.41	410.80	3.3
Chemical and chemical products industries	37								
1981		64 424	572	2 853.27	1 283.62	4 136.90	196.99	2 656.28	1.4
1986		56 276	566	1 673.87	1 557.66	3 231.54	59.24	1 614.63	1.9
1991		56 344	551	1 312.67	976.93	2 289.60	93.86	1 218.80	1.7

Table 4.15.3

Water Use in the Mining and Manufacturing Sectors, 1981, 1986 and 1991 (Continued)

Sector	1980 SIC Code[1]	Employees	Plants	Water withdrawal[2]	Recirculation[3]	Gross water use[4]	Consumption[5]	Total water discharge[6]	Use rate[7]
		number		million cubic metres					
Manufacturing sector total									
1981		795 135	4 868	9 936.41	10 746.50	20 683.00	493.81	9 442.60	2.1
1986		830 450	5 235	7 983.62	7 812.86	15 796.50	404.21	7 579.41	2.0
1991		732 947	4 427	7 282.09	6 805.98	14 088.00	520.29	6 761.77	1.9

Notes:
1. The 1981 data were aggregated to 1980 SIC (Standard Industrial Classification) codes.
2. Amount of water withdrawn for a particular activity over a given amount of time.
3. Water used at least twice.
4. Gross water use equals new water withdrawal plus recycled water.
5. Water lost during production.
6. Discharge equals water withdrawal minus consumption.
7. The ratio of gross water use to water withdrawal, an index of recirculation.
8. Consumption data not available for the mining sector due to the inclusion of minewater in discharge data.
9. Crude petroleum and natural gas industry data are not available for 1991.

Source:
Environment Canada, Water and Habitat Conservation Branch.

and industrial users. Municipal networks supply the majority of Canadians with their water. However, in 1991 this sector accounted for only 11.3 percent of all water withdrawn in Canada.

Agriculture

The agriculture sector uses water for both livestock watering and crop irrigation. Although the majority of farms rely on precipitation for their water needs, in 1991 the agriculture sector still accounted for 8.8 percent of all water withdrawals in Canada. Irrigation is a highly consumptive use of water (mainly due to evaporation) since only a small fraction of the water withdrawn returns to its source.

Mining

Mining, as defined here, includes all mining industries (metal and non-metal mining) as well as fossil fuel extraction industries (crude petroleum and natural gas). Although mining has a gross water use almost equivalent to that of agriculture, it ranked as the lowest in terms of withdrawal use in 1991 (0.8 percent), largely due to the amount of water that this sector recirculates.

Surface water supplies much of the water required for all water use sectors. However, in some areas of the country groundwater plays an important role in providing water for all aspects of human consumption.

Groundwater

Groundwater is found almost everywhere, in the spaces between sand and gravel and the cracks in porous rock. One of the characteristics of groundwater is that it moves very slowly through water-bearing rock and soil. Therefore contaminants may not appear in the groundwater until long after they have been released.

Groundwater is an important renewable resource that is vital to many aspects of our lives at home, in industry and in agriculture. However, the very activities which are sustained by groundwater use are endangering its quality. The contamination of groundwater by industrial, agricultural and domestic activities is already a serious problem.

In 1981, just under 1.5 billion cubic metres of groundwater were used in the municipal, rural, agricultural and industrial sectors (Tables 4.15.4 and 4.15.5). This represented just over one third of the total water use for that year.

Dependence on groundwater varies across the country. One million people rely on groundwater in the Atlantic provinces, including the entire population of Prince Edward Island (Figure 4.15.1). In the Northwest Territories, where surface water tends to be cleaner than most other areas of the country, less than one percent of the population depend on groundwater for their domestic water needs. In total, over 6 million Canadians rely on groundwater for their domestic needs.

Municipal and Rural Use

As shown in Table 4.15.4, the greatest share (30 percent) of groundwater used in 1981 was by the municipal sector (451 MCm). Just less than one third of water distributed through municipal networks was groundwater. The remainder came from surface sources such as rivers and lakes. Groundwater is often preferable to surface water because it is generally cleaner and does not have to be filtered or purified to the same extent as surface water.[1]

Most municipalities that rely on groundwater have small populations. Even though 38 percent of all municipalities used groundwater in 1981, this represented only 11 percent of the municipal population in Canada.[2]

1. Groundwater is naturally cleaner than surface water because of the natural filtration process that occurs as water seeps through layers of sand, clay and rock before it becomes contained in an aquifer.
2. Hess, Paul J., *Ground-Water Use in Canada, 1981*, Environment Canada, Inland Waters Directorate, Technical Bulletin No. 140, 1986.

Table 4.15.4

Estimated Total Water Use and Groundwater Use by the Municipal and Rural Sectors, 1981

Province/Territory	Municipal water use			Rural water use		
	Total	Groundwater	Groundwater use as a percentage of total water use	Total	Groundwater	Groundwater use as a percentage of total water use
	thousand cubic metres		percent	thousand cubic metres		percent
Newfoundland	103 529	2 369	2.3	11 374	10 236	90.0
Prince Edward Island	8 481	8 481	100.0	6 247	6 247	100.0
Nova Scotia	103 545	9 932	9.6	27 121	24 409	90.0
New Brunswick	155 565	31 757	20.4	24 388	21 949	90.0
Quebec	1 604 120	86 440	5.4	55 538	50 026	90.1
Ontario	1 769 290	198 038	11.2	84 077	75 670	90.0
Manitoba	126 703	5 115	4.0	15 327	13 794	90.0
Saskatchewan	107 412	27 899	26.0	24 732	22 259	90.0
Alberta	364 808	17 214	4.7	38 719	34 847	90.0
British Columbia	514 931	60 452	11.7	53 541	21 417	40.0
Yukon	5 416	3 494	64.5	134	67	50.0
Northwest Territories	3 539	19	0.5	566	6	1.1
Canada	**4 867 339**	**451 210**	**9.3**	**341 764**	**280 927**	**82.2**

Source:
Hess, Paul J., *Ground-Water Use in Canada, 1981*, Environment Canada, Inland Waters Directorate, Technical Bulletin No. 140, 1986.

Table 4.15.5

Estimated Total Water Use and Groundwater Use by the Agricultural and Industrial Sectors, 1981

Province/Territory	Agricultural water use			Industrial water use		
	Total	Groundwater	Groundwater use as a percentage of total water use	Total	Groundwater	Groundwater use as a percentage of total water use
	thousand cubic meters		percent	thousand cubic meters		percent
Newfoundland	385	347	90.1	211 225	1 072	0.5
Prince Edward Island	3 082	2 774	90.0	3 135	927	29.6
Nova Scotia	4 752	4 277	90.0	1 150 990	6 846	0.6
New Brunswick	3 599	3 239	90.0	1 056 680	18 474	1.8
Quebec	82 257	64 075	77.9	2 497 160	25 265	1.0
Ontario	147 801	91 007	61.6	19 185 700	33 054	0.2
Manitoba	51 924	41 513	80.0	152 757	10 657	7.0
Saskatchewan	311 734	46 700	15.0	838 714	16 011	1.9
Alberta	1 957 470	82 922	4.2	1 383 510	23 027	1.7
British Columbia	544 604	67 395	12.4	2 730 930	179 850	6.6
Yukon	..	..	..	10 378	..	..
Northwest Territories	..	..	..	14 907	9 168	61.5
Canada	**3 107 612**	**404 249**	**13.0**	**29 236 072**	**324 351**	**1.1**

Source:
Hess, Paul J., *Ground-Water Use in Canada, 1981*, Environment Canada, Inland Waters Directorate, Technical Bulletin No. 140, 1986.

In rural areas over 80 percent of the population relied on groundwater from private wells or small local distribution networks for their domestic needs. As shown in Table 4.15.4, in all but one province (British Columbia) and both territories, over 90 percent of the water used in rural areas was groundwater.

Agriculture

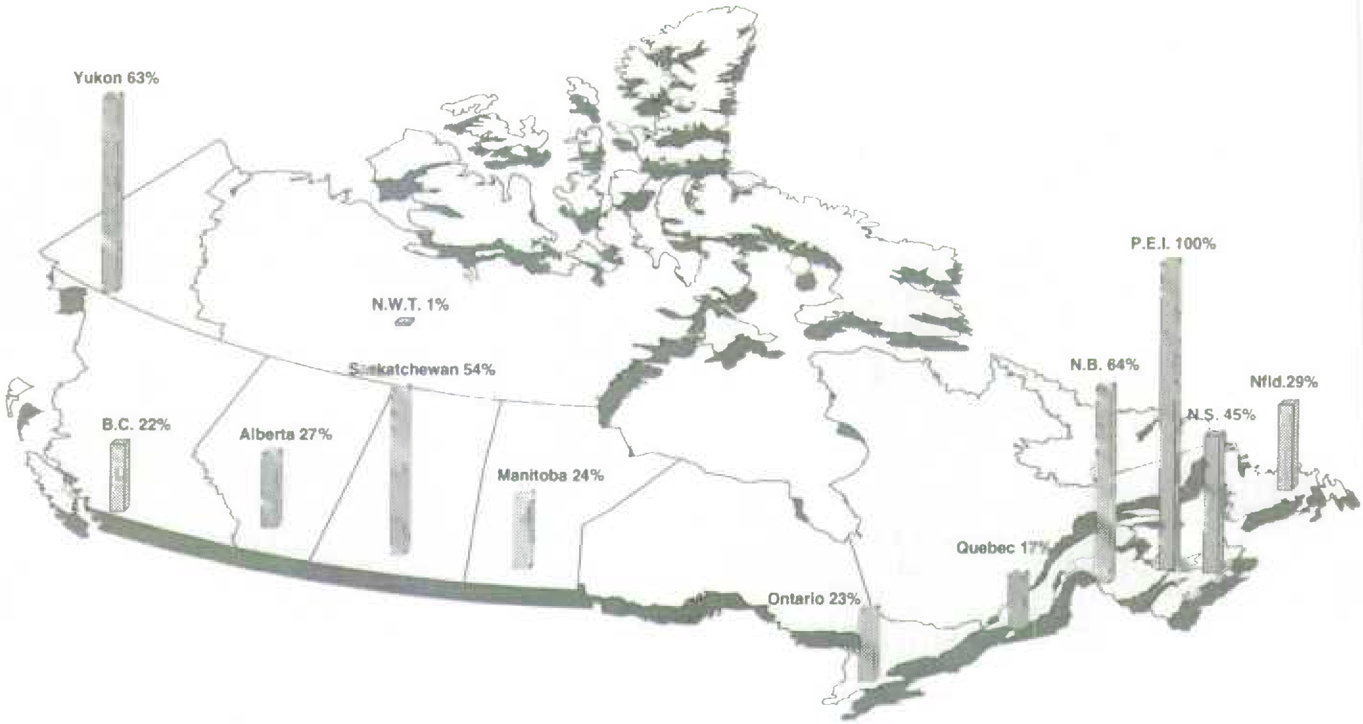
The agricultural sector consumed 28 percent of all groundwater used in 1981.[1] This represented the second greatest share of groundwater consumption, after the municipal sector. Groundwater comprised 13 percent of all the water consumed for irrigation and livestock watering in 1981.

Table 4.15.5 shows that 90 percent of agricultural water use in the Atlantic provinces was supplied by groundwater sources, while in Alberta the figure was four percent. In the Atlantic provinces, virtually all groundwater is used for livestock watering. The amount of water used for the purposes of irrigation was too small to obtain separate amounts of surface water and groundwater.

Although many of today's agricultural practices rely upon groundwater, they also contribute significantly to its contamination through the widespread use of pesticides and fertilizers (see Section 4.2 - **Water Quality**).

1. The extent and location of groundwater is very difficult to measure (as with any subsoil reserves). National data on groundwater in Canada are not extensive.

Figure 4.15.1
Population Reliant on Groundwater, 1981



Note:
Municipal, domestic and rural use only.
Source:
Environment Canada, *Groundwater - Nature's Hidden Treasure*, Fact Sheet No. 5, Ottawa, 1990.

Industrial use

The industrial sector comprises all users whose water is self-supplied. Excluding water obtained by municipal distribution networks, industry consumed 78 percent of all water used in Canada in 1981. Only one percent of this was groundwater.

The industrial sector combines four sub-sectors: manufacturing, mining, thermal power and aquaculture industries. Roughly 44 percent of the groundwater used in the industrial sector was used in aquaculture. Much of this water was consumed in British Columbia where 126 MCm were used for these programmes (Table 4.15.5). Groundwater is preferred to surface water because its temperature is relatively constant, which is essential to the survival of fish.

The manufacturing sub-sector used over 9.2 MCm of groundwater in 1981, accounting for only 1 percent of total water use. In the mining sub-sector, 12 percent or 79 MCm of the water used was groundwater. In the thermal sub-sector over 19 BCm of water were used, with less than 0.1 percent being groundwater.

In the municipal, rural and agricultural sectors the quality of the groundwater supply is extremely important due to the type of uses involved (human consumption, food production). Water quality in the industrial sector is not required to have the same quality standards, therefore, in some applications, low-grade brackish water can be used.

The importance of groundwater to the rural areas of Canada and the Atlantic provinces may be obscured by the great volumes of surface water withdrawn by agriculture, industry and cities in the rest of the country. Therefore, in rural areas of the country, where groundwater is of great importance, there is a need to monitor supplies and quality in order to provide stewardship of this valuable resource.

5 Environmental Accounting

Canada is a resource-rich country with a large quantity of arable land, vast areas of natural forests, rich mineral deposits, considerable hydroelectric power potential, abundant clean air and water, diverse wildlife, wide-ranging wilderness areas and extensive offshore resources. Canada has a very low population density, with the inhabitants distributed primarily in a narrow band across the most southerly portion of the country. For much of its history, Canada has taken its natural resources for granted and has treated them, essentially, as abundant free goods. However, like other countries, Canada in recent years has become increasingly aware of its finite resource base. More and more, its governments are looking beyond the conventional, growth-oriented focus of macro-economic policy to the new target of sustainable development. The change in policy has quickly given rise to a requirement for supporting statistical frameworks and indicators.

The Canadian System of National Accounts (CSNA) provides such a statistical framework and tool for developing indicators with which the impact of the Canadian economy on the environment may be measured.[1] Statistics Canada is currently developing a new component of the national accounts that will integrate environmental factors into the traditional CSNA. The goal of these accounts is to provide data on the physical quantities and monetary values of Canada's natural resource stocks; on the depletion and uses of these resources; on waste emissions to the environment; and on environmental protection expenditures.

This chapter summarizes the developmental work that has been completed so far by Statistics Canada in environmental accounting. To date, some accounts have been completed, such as the natural resource stock accounts of oil and natural gas, and the waste output account of greenhouse gas emissions, while other accounts are less advanced. Canada's natural resources are vast and the task of building environmental accounts is expected to take several years.

The first section of this chapter describes each of the four accounts in the environmental accounting component: **Natural Resource Stock Accounts, Natural Resource Use Accounts, Waste Output Accounts and Environmental Protection Expenditure Accounts.** The next section presents preliminary results for the physical and monetary accounts of crude oil, natural gas and crude bitumen reserves which are part of the Natural Resource Stock Accounts.

1. The Canadian System of National Accounts comprises Income and Expenditure Accounts, Input-Output Accounts, Industry Product Measures, Balance of Payments, International Investment Position, Financial Flow Accounts, National Balance Sheet Accounts and Provincial Economic Accounts.

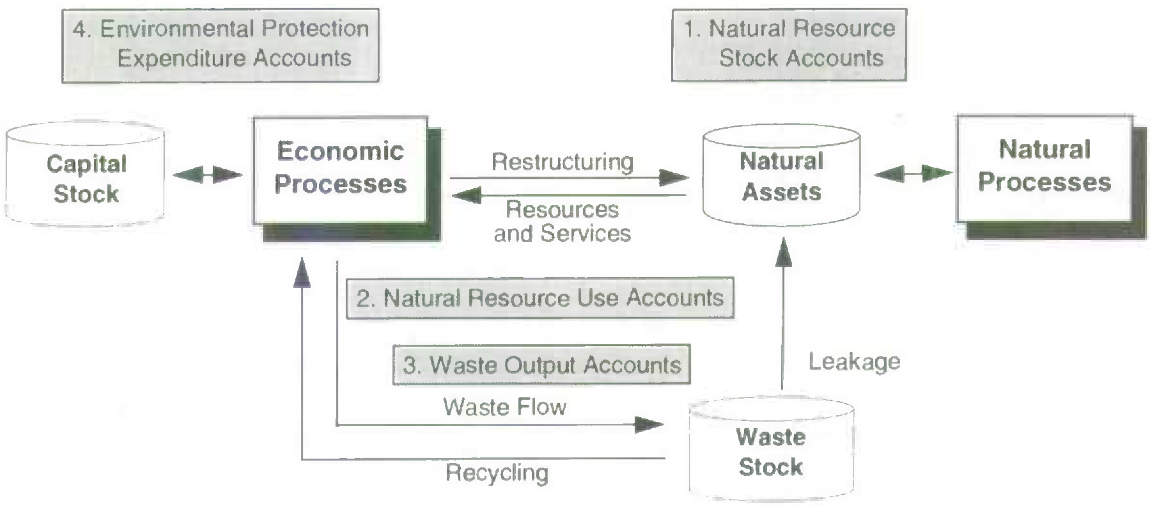
Environmental Accounts in the Canadian System of National Accounts

The environmental accounts will be a satellite component of the existing CSNA with four distinct accounts:

- **Natural Resource Stock Accounts**, recording the known size and composition of Canada's natural resource assets as they evolve over time, in both physical and monetary terms;
- **Natural Resource Use Accounts**, recorded in physical terms, showing when and how non-produced goods and services are brought into the economic sphere and used in production and consumption activities, and highlighting the role of selected produced goods that are important in analyses of certain environmental issues;
- **Waste Output Accounts**, recorded in physical terms, reporting the types and quantities of waste products that are generated in the economy and relating these to economic output; and
- **Environmental Protection Expenditure Accounts**, identifying current and capital expenditures, by business, government and households, that are intended to conserve or protect natural resources and the environment.

Figure 5.1 presents the four environmental accounts in the context of the Population-Environment Process (PEP) Framework used throughout this publication (see Section 1.3 - **The Population-Environment Process Framework**). The natural resource stock accounts are depicted by the stock component of natural assets; the natural resource use accounts describe the restructuring and the recycling of natural assets by economic processes; the waste output accounts describe the wastes from economic processes that enter into the environment and become part of the waste stock; and the environmental protection expenditure accounts show operating costs and capital expenditures within economic processes and the produced capital stock.

Figure 5.1
Environmental Accounting Component of the PEP Framework



Source:
Statistics Canada, National Accounts and Environment Division.

5.1 Natural Resource Stock Accounts

Table 5.1.1 outlines the different natural resource stocks that will be included in the Natural Resource Stock Accounts, and the status and time period covered by the physical and monetary accounts. Below is a description of each account.

Mineral Resource Accounts

Canada has large reserves of crude petroleum, natural gas and crude bitumen (tar sands). The value of annual production of these non-renewable minerals was about $19 billion in 1992, accounting for 54 percent of all mineral output in the country. One of the first priorities in Statistics Canada's environmental accounting project has been to develop physical and monetary accounts for these important national assets. Separate resource accounts have been developed for each of Canada's oil and gas producing provinces: Alberta, Saskatchewan, British Columbia, Manitoba and Ontario. The accounts cover the period from 1961 to 1992, and are presented in both physical and monetary units. The methods of monetary valuation include the "net price" and "present value" methods as presented in the following section.

In addition to fossil fuel minerals, Canadian mines supply over 30 different types of metals, more than 20 types of non-metallic minerals and various structural materials including clay products, sand, gravel and stone. Reserve data are available for some, but not all of these mineral commodities. In some cases, the minerals are so abundant there is no foreseen need for an accounting of the available stocks.

Physical accounts for the eight of the nine metals listed in Table 5.1.1 are now available, covering the period 1974-1992 (see Section 4.9 - **Mineral Reserves**, Table 4.9.7). For the monetary accounts, it is preferable to organize the data by mine type rather than by type of metal, since most metal deposits in Canada are polymetallic. This fact is reflected in the following classification of metal mines used by Statistics Canada:

- Gold mines
- Copper and copper-zinc mines
- Nickel-copper mines
- Silver-lead-zinc mines
- Molybdenum mines
- Uranium mines
- Iron mines
- Miscellaneous metal mines

The same methods of monetary valuation used in the oil and gas accounts, namely the net price and present value methods, will be used for the metal accounts.

Table 5.1.1
Natural Resource Stock Accounts

Type of natural resource stock	Provinces and Territories covered	Physical accounts	Monetary accounts
Crude oil	Alberta, Saskatchewan, British Columbia, Manitoba and Ontario	1961-1992	1961-1989[1] Net price Present value[2]
	Frontier areas (N.W.T., Yukon and Arctic Islands) and East coast offshore	not completed	not completed
Natural gas and by-products (natural gas liquids)	Alberta, Saskatchewan, British Columbia and Ontario	1961-1992	1961-1989[1] Net price Present value[2]
	Frontier areas (N.W.T. and Yukon) and East coast offshore	not completed	not completed
Crude bitumen 1. Surface mineable 2. In-situ	Alberta	1967-1990	1967-1990
Coal	British Columbia, Alberta, Saskatchewan, New Brunswick and Nova Scotia	not completed	not completed
Metals (copper, nickel, zinc, lead, gold, silver, molybdenum, iron, uranium)	Canada	not completed 1974- present planned	not completed[3] 1974- present planned
Potash	Saskatchewan and New Brunswick	not completed	not completed
Timber	Ontario	1953-1991 (available November,1994)	1953-1991 (available November,1994)
	Remaining provinces	not completed	not completed
Wildlife (pilot project)[4] 1. big game (e.g. moose, deer and bear) 2. small game (e.g. rabbit, grouse and pheasant) 3. other mammals (e.g. beaver, fox and racoon) 4. fish (e.g. groundfish, pelagic and other finfish, and shellfish)	Canada	not completed, 1990 initially	not completed market values (fur production) and non-market values planned
Land 1. Recreational land 2. Forest land 3. Wilderness land	Canada	not completed	not completed

Notes:
1. 1961-1990 for Alberta.
2. Net price, present value and replacement cost values have been calculated for Alberta.
3. The value of many of the by-products from metal mining will be included in the monetary value of Canada's metal reserves even though the physical accounts are not developed.
4. Not all species to be included in the wildlife accounts are listed.

Timber Accounts

Forests cover approximately half of Canada's land mass. The trees are important for many reasons: they offer a natural habitat for wildlife, they help preserve biodiversity, they provide protection against flooding and soil erosion, they purify and store water, they sequester carbon, they are used for human recreation and they provide lumber, pulp and other products, such as maple syrup and Christmas trees, for the market economy. Government owns and controls 94 percent of the forest land area in Canada and regulates the harvesting by industry. "Taking stock" of these significant national assets is one of the most important goals of Statistics Canada's environmental accounting project.

The objective of the timber accounting work is to develop annual time series estimates of the magnitude, age distribution, type and location of Canada's productive timber assets, over as long an historical time period as possible. Productive timber assets are the stocked, timber-productive, nonreserved forest land in Canada.

A tree population accounting model has been developed which is used to simulate the growth of a forest over time. The model is dynamic, and takes into account factors such as natural regeneration and growth, replanting, harvesting, fire loss and loss due to insect infestation and disease. It includes empirically derived, parametric growth and mortality distributions by age class, district and cover type. The model can be used to evolve the timber stock from one year to the next, given data on fire loss and harvesting. With the aid of this model framework, and using the most recent Canadian Forest Inventory from the Canadian Forestry Service as a base, a consistent physical database has been constructed that depicts the development of the timber stock through time.

The second goal is to explore the monetary valuation of the national timber asset. Two methods are presently being considered. The first is a net price method and the second is a present value method, both are similar to the methods used for oil and gas reserves. The present value of the forest can be calculated from the "rent" from the timber stock divided by the discount rate.

As was noted, the forest is valuable for many reasons other than as a source of timber. These other dimensions of its value will be studied separately, as part of the effort to develop comprehensive land accounts.

The timber accounting work has commenced with a pilot project focused on the province of Ontario. This province, which accounts for 37.5 million of the country's 219.6 million hectares of stocked, timber-productive, nonreserved forest land, has been divided into 24 forest districts corresponding to management regions defined by the regulatory authority (the Ontario Ministry of Natural Resources). Separate timber accounts are being constructed for each district over the period 1953 to date. The volume of timber in each district is further decomposed by cover type (softwood, hardwood and mixedwood) and by single-year age class (1 to 180 years). Changes in the volume of available timber of each cover type, in each age class, within each district are accounted for over time in terms of (i) natural growth net of mortality, (ii) harvesting, (iii) fire loss and (iv) conversion to parkland and roads.

Alternative valuation methods are now being explored for the monetary accounts of Ontario's timber resources. The geographic dispersion of the forest complicates the valuation problem of timber resources since the value of a given stand of trees varies directly with its distance from the nearest mill and the ease of transport to that mill. The task of valuation is especially problematic in the case on Ontario's timber resources because of the vertically integrated character of the Ontario logging industry which means that "clean" market prices for logs are not always available. Also, substantial costs of forest management are borne by government which must be spread over the entire forest, both timber-productive and not timber-productive, and which should, in some cases, be amortized. It is expected that the Ontario forest accounts will be completed within the next year, at which time attention will shift to the development of similar accounts for the other provinces.

Wildlife Accounts

The wildlife accounts are still at a very early stage of development. This section briefly describes the nature of Canada's wildlife assets and the accounting approach that is being considered. Section 4.14 - **Fish and Wildlife Harvests** provides detailed statistics on wildlife.

Canada's wildlife is quite diverse. Big and small game animals are hunted primarily for their meat value, especially by Canada's indigenous peoples, and also for "trophy" value by recreational hunters. A variety of other mammals are trapped or hunted mostly for their fur value. In 1991, 950 000 animal pelts were harvested from the wild, valued at $23 million, and an additional 970 000 pelts were raised commercially on ranches, valued at $22 million. Beaver, muskrat and marten accounted for most of the pelts taken from the wild; virtually all of the commercially raised pelts were mink and fox.

Inshore and offshore fish are also important wildlife resources. From the offshore fishery, Canadians harvested 542 000 tonnes of groundfish worth $390 million, 369 000 tonnes of pelagic and other finfish valued at $272 million, and 252 000 tonnes of shellfish worth $623 million in 1992. Lobster, salmon and cod were the three most important catches in value terms that year, although the cod fishery had to be closed indefinitely the following year because of extremely low stock levels.

Ideally, time series estimates of wildlife population - by species, geographic location and age - would be compiled for the physical accounts. Market-price-based monetary accounts could then be developed by multiplying the physical quantities by net price estimates, calculated as the difference between the average market price of each species and the unit cost of harvesting. In practice, wildlife population data do not generally exist. Some estimates are available for selected species in particular years, for larger mammals especially, but even these are restricted to particular areas of the country and are widely separated in time. It will, however, be possible to prepare fairly detailed wildlife use, or harvest, accounts.

Land Accounts

Statistics are already available in the Canadian National Balance Sheet Accounts on the value of land used for residential, industrial and agricultural purposes. However, these estimates are highly aggregated and they exclude recreational land, forest land and other wilderness land. The construction of a much more detailed and comprehensive land account, covering all of Canada's 10 million square kilometres of territory, is planned as part of the environmental accounting project.

A key element in the valuation of land is its geographic location and for this reason, the land account will be developed as a geographic information system. Data will be geocoded at the most detailed level possible in order to permit alternative regional aggregation (for example, by ecozones, by drainage basins or by politically-defined regions). The database will incorporate information from diverse sources including the *Censuses of Population, Agriculture and Mines*, the *Annual Survey of Manufactures*, the *Canada Forest Inventory* (from Natural Resources Canada), the *Canada Land Inventory* (from Environment Canada) and satellite imagery data (from the Canada Centre for Remote Sensing). For each parcel of land identified separately in the database, information pertaining to use (possibly based on the United Nations' Economic Commission for Europe Standard International Classification of Land Use)[1], cover type (kind of soil, geology and vegetation, based on the Canada Land Use Monitoring Program land cover classification) and estimated market value will be stored. The resolution will be higher for populated areas and lower for remote wilderness areas. Values based on the market values of other land parcels with similar characteristics will be imputed where direct observations are unavailable. Land transformation accounts will also be developed, recording changes in land use and value over time.

1. United Nations Statistical Commission and European Commission for Europe (ECE), *Draft ECE Standard International Classification of Land Use*, Third Plenary Session, Conference of European Statisticians, Geneva, 1985.

5.2 Natural Resource Use Accounts

Product flows are well articulated within the existing Canadian System of National Accounts. The system provides annual input-output tables that show production and use of commodities based on a 627-commodity classification, a 216-industry classification and a 136-category final demand classification.

Progress on the Resource Use Accounts to date has been limited to two specific areas: energy use accounts and water use accounts.

With regard to the energy use accounts, detailed disposition tables have been developed measuring the use of eight major energy-related commodities - coal, crude oil, natural gas, fuel oil, motor gasoline, liquified petroleum gases, electricity and coke - by each of the 216 industries and 136 final demand categories in the input-output framework. The accounts are available as time series from 1981 to 1990. The energy accounts can be used, in combination with the input-output tables, to calculate the "energy intensiveness" of particular goods and services or industries - that is, the total energy required, both directly in the producing sector and indirectly in the sectors producing the inputs required by the producing sector - per unit of output.[1]

With regard to water use accounts, these are being constructed using data from the Survey of Water Use in Canadian Industry, conducted for Environment Canada by Statistics Canada in 1972, 1976, 1981, 1986 and 1991. The survey covers about 6 000 establishments in manufacturing, mineral extraction and electricity generation industries. Virtually all of the large industrial water consumers are included in the survey, with the important exception of the agriculture industry. The survey is designed to obtain information about gross water usage, the sources of the water used, the purposes for which the water is used, what sorts of treatment, if any, are applied to the water prior to its discharge and the destination of the water upon discharge.

5.3 Waste Output Accounts

Like all modern industrial economies, Canada's economy generates large quantities of waste materials in the course of production and consumption of goods and services that are disposed of in the natural environment.

The first part of the waste account to be developed has been the greenhouse gas emissions account.[2] The greenhouse gas account is based on the commodity-by-industry input-output framework. In this approach, the "make" and "final demand" matrices of the input-output system are augmented with sub-matrices recording the annual emissions of several greenhouse gases associated with the production and final consumption of commodities. Both sub-matrices are derived by applying technical coefficients to the product flows. Six gases or groups of gases are considered: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), volatile organic compounds (VOCs), nitric oxide and nitrogen dioxide (collectively, NO_x) and carbon monoxide (CO).

Industrial emissions in a particular year are estimated by applying technical coefficients to industry output. The coefficients are composed of two parts, one associated with the consumption of fossil fuels and the other reflecting all other greenhouse gas emissions by the industry. Emission coefficients for each kind of fuel are weighted by the corresponding direct input coefficients for the fossil fuels from the input-output tables. There are six aggregated greenhouse gas emission coefficients for each industry, one for each type of greenhouse gas, and they are applied to annual output to calculate the flow of each greenhouse gas each year. Emissions associated with final demand categories are estimated by applying technical coefficients separately to each commodity in each final demand category.

The greenhouse gas emissions account is already proving to be a useful tool for policy analysis. In 1990, the Government of Canada undertook to stabilize annual emissions of these gases at 1990 levels by the year 2000. Determining what regulatory or other steps may be necessary to achieve this objective requires a clear understanding of the relationship between greenhouse gas emissions and the level and composition of economic activity. Assessing progress toward the target also requires regular, comprehensive measurement of annual emissions. The account is proving to be useful for both purposes.

Additional waste output accounts are planned for some other substances, to be developed with an approach similar to that just described for greenhouse gases. A key problem is a lack of data on waste outputs. Environment Canada is currently developing a new survey of waste emissions, called the National Pollutant Release Inventory, and this will be an important source. First results from the survey are expected in 1995. Statistics Canada has also conducted pilot surveys of waste management activity, one addressed to municipal governments and the other to establishments engaged in waste disposal. The expenditures reported in these surveys are, in principle, already accounted for in the product flow matrices of the core national accounts, but they will be highlighted and shown in greater detail in the environmental satellite account.

1. Statistics Canada, "Energy Consumption", *Environmental Perspectives 1993*, Catalogue No. 11-528, Ottawa, 1993.
2. Statistics Canada, "Canadian Greenhouse Gas Emissions: An Input-Output Study", *Environmental Perspectives 1993*, Catalogue No. 11-528, Ottawa, 1993.

5.4 Environmental Protection Expenditure Accounts

The fourth account of the Canadian environmental satellite accounts will be a decomposition of the core accounts to show environmental protection expenditures separately from other intermediate and final expenditures. The share of business costs accounted for by outlays of this type is important for a number of analytical purposes.

Since 1985, Statistics Canada's Annual Survey of Private and Public Investment in Canada has requested information on the share of investment spending attributable to pollution abatement and control (PAC). Initially the question applied only to establishments in manufacturing industries, but the coverage has since been extended to include firms in mining and electric power industries. More comprehensive statistics were collected in a recent pilot survey by Statistics Canada for the year 1989, covering operating costs as well as capital expenditures.

For the government sector, it will be possible to develop time series for different kinds of environmental protection expenditures by making use of existing public accounts records. Work along these lines is currently under way. For the household sector, some data are available from a recent survey of household behaviour vis-à-vis the environment and from other surveys of family expenditures, but important source data deficiencies remain.

Natural Resource Stock Accounts of Crude Oil, Natural Gas and Crude Bitumen Reserves

These accounts represent part of the Natural Resource Stock Accounts described earlier. Physical accounts have been completed for crude oil, natural gas and crude bitumen for the provinces of Alberta, British Columbia, Saskatchewan, Manitoba and Ontario, accounting for most of Canada's fuel reserves. Monetary accounts have been completed for crude oil and natural gas reserves for the provinces mentioned above, and are presented here, while the monetary accounts for crude bitumen are still under development.

5.5 Physical Accounts

Estimates of the quantity of reserves of non-renewable resources are continually being revised. In the development of physical accounts, the McKelvey Box is used to distinguish between mineral **resources** from mineral **reserves** (Figure 5.5.1). Resources are a concentration of naturally occurring material in the Earth's crust that is in such a form and amount that economic extraction of the commodity from the concentration is currently or potentially feasible. Reserves are those part of resources that have been geologically proven to exist and are economically exploitable, given the existing technology, at the time of determination.[1] The vertical axis of the box represents the degree of economic feasibility and the horizontal axis represents the degree of geological certainty. Economically recoverable resources are located in the top left-hand corner of the diagram (i.e. established reserves). The feasibility of resource extraction decreases through to the lower right-hand part (i.e. resources).

In the physical and monetary accounts of oil and natural gas reserves in Canada, only **established** reserves are included since these reserves are developed and have a high probability of being extracted in the near future. Established reserves are defined as those reserves recoverable using current technology and under present and anticipated economic conditions, and have been proved by drilling, testing and production. They also include a portion of contiguous recoverable reserves that are interpreted with reasonable certainty to exist.[2] The term **remaining** established reserves simply means the initial stock of established reserves less cumulative production.

Table 5.5.1 and Figures 5.5.2 to 5.5.4 present the remaining established reserves of crude oil, natural gas and crude bitumen[3] in Alberta, Saskatchewan, British Columbia, Manitoba and Ontario. These reserve data account for almost 75 percent of Canada's oil and natural gas reserves and 100 percent of Canada's crude bitumen reserves; and 96.5 percent of oil production, 99.5 percent of natural gas production and 100 percent of crude bitumen production in Canada for 1992.

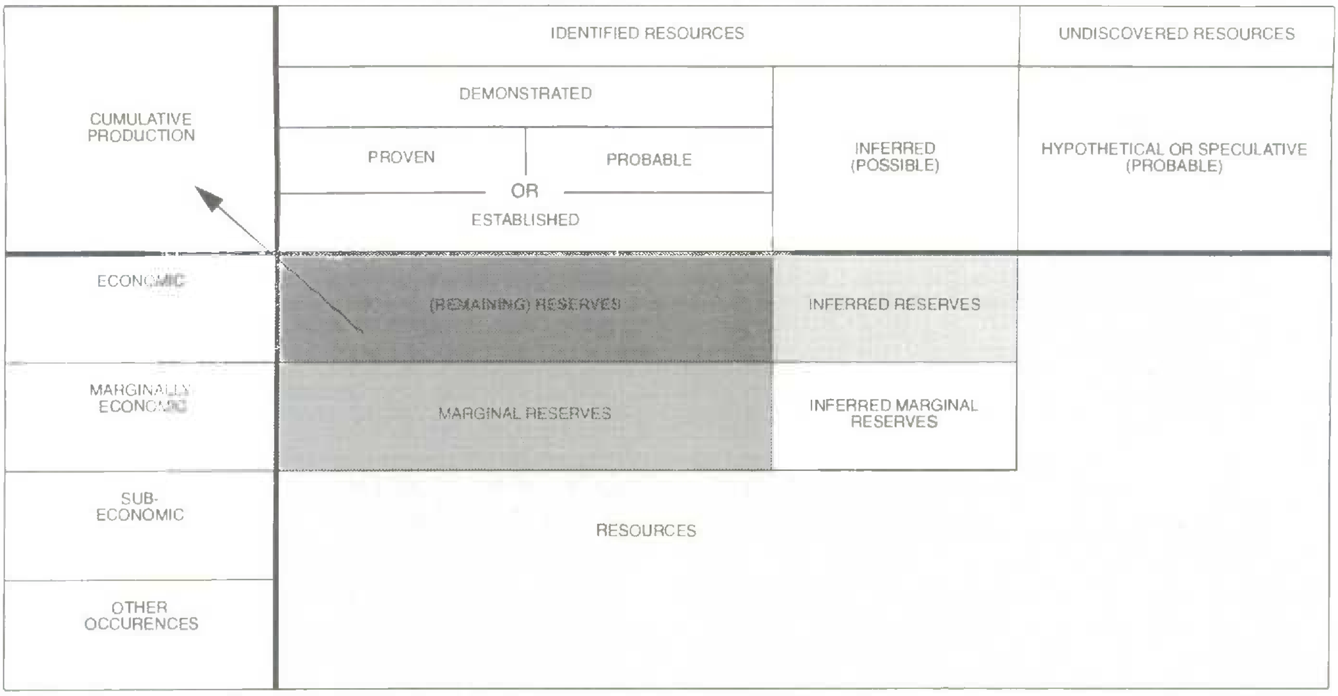
The physical accounts in Table 5.5.1 consist of opening and closing stocks of remaining established reserves; reserve additions as the result of discoveries, development, enhanced oil recovery and revisions; and depletion of reserves where:

$$\text{opening stock} + \text{reserve additions} - \text{depletion} = \text{closing stock}$$

Remaining established reserves of crude oil have declined by 59 percent since 1969 and by 10 percent for natural gas since 1982. The recent increase in the reserve stock of

1. For more complete definitions of resources and reserves, see U.S. Bureau of Mines, *A Resource/Reserve Classification for Minerals*, Mineral Commodity Summaries, Washington, D.C., 1993.
2. Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, 1990.
3. Reserves of crude bitumen occur entirely in northern Alberta and is the primary product of the non-conventional oil sector or from "oil sands". Crude bitumen is extracted from surface mining operations or by in-situ methods, similar to those used in conventional oil wells.

Figure 5.5.1
Classification of Crude Oil and Natural Gas Reserves and Resources



Notes:
The certainty of the estimate of physical tonnages improves from right to left on the horizontal axis and is dependent on geologic characteristics of the deposit such as quality, tonnage, thickness and depth; amount of exploration and development expenditures; and technological improvements. The economic profitability improves from bottom to top on the vertical axis and boundaries between resources and reserves fluctuate depending on resource prices, extraction costs and technological improvements.
For Canadian reserves of crude oil and natural gas, the term established is used which is approximately equal to proven plus probable reserves.
The area in dark grey represents those reserves accounted for in the natural resource stock accounts and "marginal reserves" approximates those resources defined as remaining ultimate potential described in the text.
Sources:
Modified after McKelvey, V.E., *Mineral Resource Estimates and Public Policy*, American Scientist, 1972.
U.S. Bureau of Mines, *Mineral Commodity Summaries*, Washington, D.C., 1991.

crude bitumen is attributable to reserve additions from the Syncrude Project, Alberta in 1986. However, reserves of crude bitumen have decreased by 16 percent since their peak in 1986. As supplies of conventional crude oil decline, Canada will have increasingly to rely on imported oil and the extraction of higher cost, lower quality resources of oil from non-conventional sources (e.g. tar sands) and from frontier areas to meet domestic demand.

Figures 5.5.5 to 5.5.10 show annual additions and depletion of oil, natural gas and crude bitumen reserves. Recent trends indicate that reserve depletion is not being replaced by reserve additions in the cases of crude oil and natural gas. This reflects the decline in exploration and development expenditures for oil and natural gas from $5.1 billion (1986 dollars) in 1985 to $2.6 billion (1986 dollars) in 1992 for the provinces indicated above. This decrease in exploration and development effort was the result of the price collapse of oil in 1986 as well as the gas surplus over the past several years.

The physical accounts are used to give some indication of **reserve lives** at current extraction rates. These are calculated by dividing the stock of remaining reserves by current depletion for a given year (Table 5.5.2). However, reserve life based on current levels of established reserves and production rates needs to be carefully interpreted. It answers the question: "How long would reserves last if no more were discovered, beyond those which have already been established, and if production continued at the current annual rate?" For some purposes, this is not the most relevant question, since the level of established reserves can and does change over time in response to the level of exploration activity (which is influenced by price, government incentives, technological change and indeed, the level of remaining established reserves itself). Reserve lives as calculated here are a useful short-term indicator of resource supply, given prevailing conditions, but they are unlikely to be a reliable indicator of the ultimate, long-term supply.

Reserve lives for crude oil for each of the provinces have declined to less than 10 years of supply by 1992. This trend is most evident in Alberta where approximately 55 percent of Canada's total crude oil reserves occur (compared with less than one percent in Ontario). Reserve lives for natural gas have also declined, from over 25 years in the early 1980s to less than 20 years in the 1990s. The results for Ontario are quite erratic. This province's natural gas re-

Table 5.5.1

Physical Accounts of Remaining Established Reserves of Crude Oil, Natural Gas and Crude Bitumen, 1961-1992[1]

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Crude oil (millions of cubic metres)																
Opening stock	672	710	744	786	1120	1170	1295	1348	1429	1429	1411	1369	1306	1226	1175	1105
Gross additions	74	73	83	376	97	177	108	140	65	53	33	25	20	43	10	-20
Depletion	35	38	41	44	46	51	56	60	63	71	75	86	101	95	80	73
Closing stock	710	744	786	1120	1170	1295	1348	1429	1429	1411	1369	1306	1226	1175	1105	1012
Natural gas (billions of cubic metres)																
Opening stock	990	1100	1130	1160	1213	1282	1308	1370	1469	1530	1561	1561	1563	1685	1751	1676
Gross additions	125	54	54	81	99	58	97	137	110	80	59	68	190	135	-7	129
Depletion	16	23	25	27	30	32	35	38	47	50	60	65	70	69	69	66
Closing stock	1100	1130	1160	1213	1282	1308	1370	1469	1530	1561	1561	1563	1685	1751	1676	1738
Crude bitumen (millions of cubic metres)																
Opening stock	..	..	..	..	..	..	-	179	177	175	172	169	165	161	158	154
Gross additions	..	..	..	..	..	..	179	-	-	-	-	-	-	-	-	-
Depletion	..	..	..	..	..	..	-	1	2	2	3	4	4	4	3	4
Closing stock	..	..	..	..	..	..	179	177	175	172	169	165	161	158	154	151

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Crude oil (millions of cubic metres)																
Opening stock	1012	967	942	902	859	830	779	792	776	790	774	753	738	707	657	614
Gross additions	29	48	43	35	39	16	82	58	87	53	50	60	38	18	24	45
Depletion	73	72	81	75	67	65	67	73	70	68	69	72	68	68	66	70
Closing stock	967	942	902	859	827	779	792	776	790	774	753	738	707	657	614	590
Natural gas (billions of cubic metres)																
Opening stock	1738	1790	1911	1977	2028	2085	2148	2126	2106	2080	2032	1956	1932	1958	1978	1965
Gross additions	125	197	148	125	134	132	52	57	58	32	3	78	130	132	86	90
Depletion	72	76	82	73	78	69	74	76	84	79	79	102	104	110	99	125
Closing stock	1790	1911	1977	2028	2085	2148	2126	2106	2080	2032	1956	1932	1958	1978	1965	1929
Crude bitumen (millions of cubic metres)																
Opening stock	151	111	322	353	334	325	316	310	329	343	574	572	565	542	524	502
Gross additions	-36	215	39	-9	-	-	12	30	30	250	18	15	-1	5	1	4
Depletion	3	5	7	10	9	9	17	12	15	19	20	22	22	23	23	24
Closing stock	111	322	353	334	325	316	310	329	343	574	572	565	542	524	502	482

Notes:
Figures may not add due to rounding.
1. Includes Alberta, Saskatchewan, British Columbia, Manitoba and Ontario.
Sources:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.
British Columbia Ministry of Energy, Mines and Petroleum Resources, *Hydrocarbon and By-product Reserves in British Columbia*, Victoria, various issues.
Saskatchewan Department of Energy and Mines, *Reservoir Annual*, Regina, various issues.
Manitoba Department of Energy and Mines, *Oil Activity Review*, Winnipeg, various issues.
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

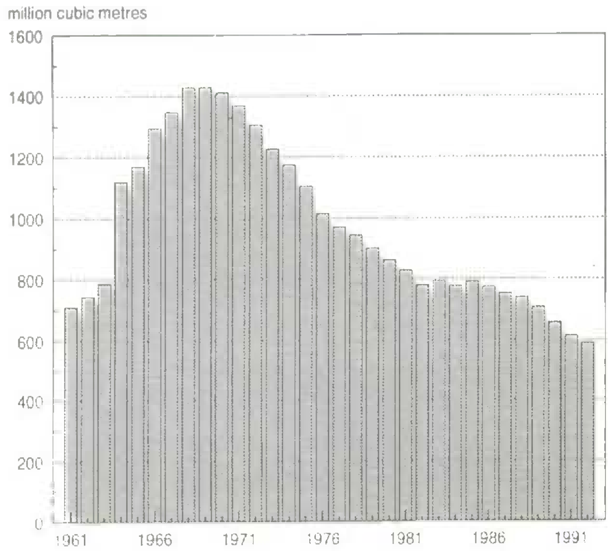
Table 5.5.2

Reserve Life Index (Years) for Oil and Natural Gas Reserves, 1981-1992

	Crude oil reserves					Natural gas reserves			
Year	Alberta	Saskatchewan	British Columbia	Manitoba	Ontario	Alberta	Saskatchewan	British Columbia	Ontario
					years				
1981	12	14	11	14	10	26	33	36	14
1982	12	12	12	14	9	30	34	37	21
1983	12	11	11	11	10	28	40	38	28
1984	11	10	9	10	11	26	36	36	62
1985	11	10	10	11	9	24	33	33	7
1986	12	10	9	10	7	25	30	32	...
1987	12	9	8	10	6	24	27	27	47
1988	11	10	9	10	7	18	18	24	81
1989	10	10	10	10	5	19	13	20	21
1990	10	10	9	10	6	18	13	18	21
1991	9	10	9	10	6	21	12	20	15
1992	8	9	9	10	5	15	11	17	40

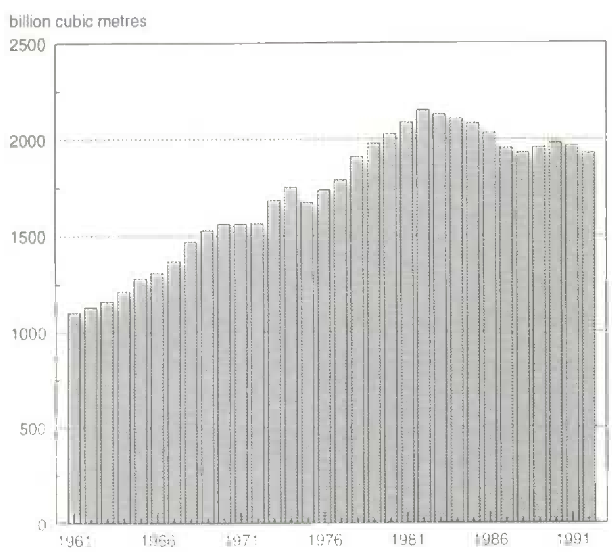
Note:
Reserve life index is defined as the stock of remaining reserves divided by current production which gives the reserve life in years.
Source:
Statistics Canada, National Accounts and Environment Division.

Figure 5.5.2
Remaining Established Reserves of Crude Oil, 1961-1992



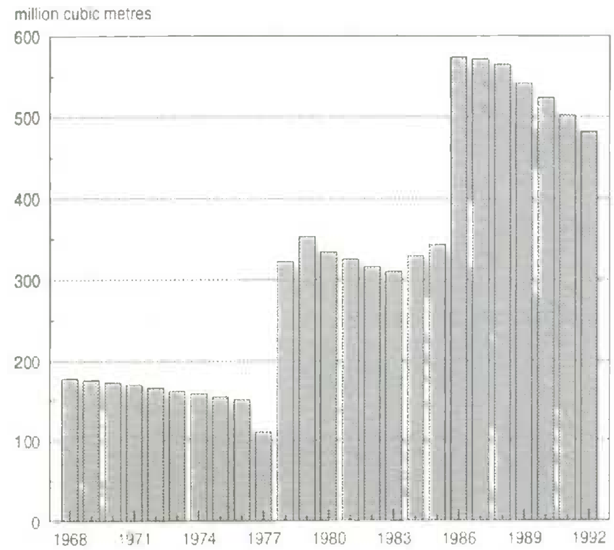
Sources:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.
British Columbia Ministry of Energy, Mines and Petroleum Resources, *Hydrocarbon and By-product Reserves in British Columbia*, Victoria, various issues.
Saskatchewan Department of Energy and Mines, *Reservoir Annual*, Regina, various issues.
Manitoba Department of Energy and Mines, *Oil Activity Review*, Winnipeg, various issues.
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

Figure 5.5.3
Remaining Established Reserves of Natural Gas, 1961-1992



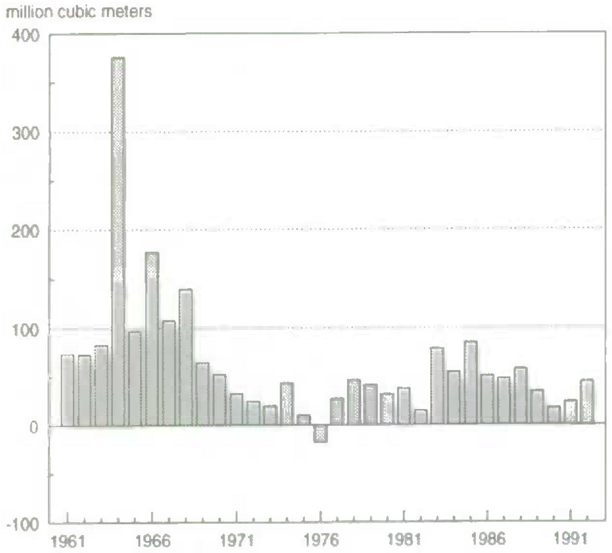
Sources:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.
British Columbia Ministry of Energy, Mines and Petroleum Resources, *Hydrocarbon and By-product Reserves in British Columbia*, Victoria, various issues.
Saskatchewan Department of Energy and Mines, *Reservoir Annual*, Regina, various issues.
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

Figure 5.5.4
Remaining Established Reserves of Crude Bitumen, 1968-1992



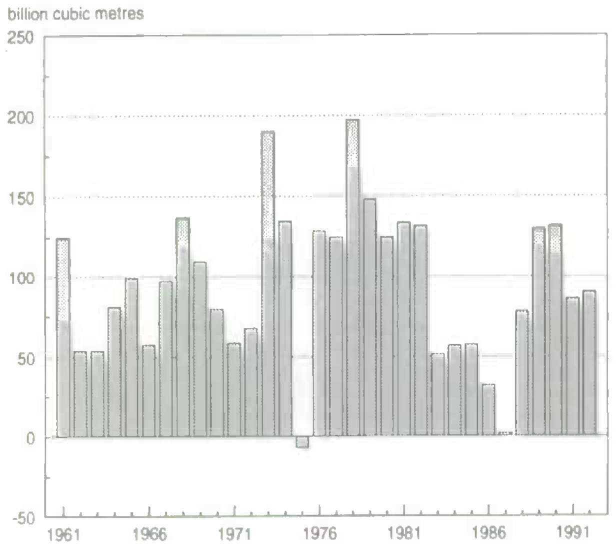
Source:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.

Figure 5.5.5
Reserve Additions of Crude Oil, 1961-1992



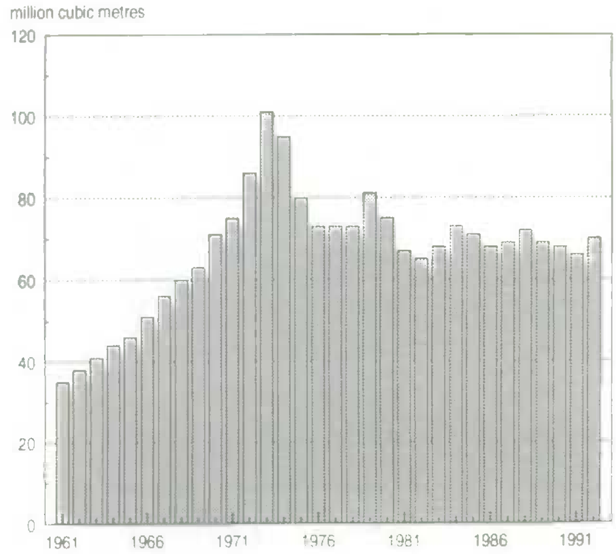
Sources:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.
British Columbia Ministry of Energy, Mines and Petroleum Resources, *Hydrocarbon and By-product Reserves in British Columbia*, Victoria, various issues.
Saskatchewan Department of Energy and Mines, *Reservoir Annual*, Regina, various issues.
Manitoba Department of Energy and Mines, *Oil Activity Review*, Winnipeg, various issues.
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

Figure 5.5.6
Reserve Additions of Natural Gas, 1961-1992



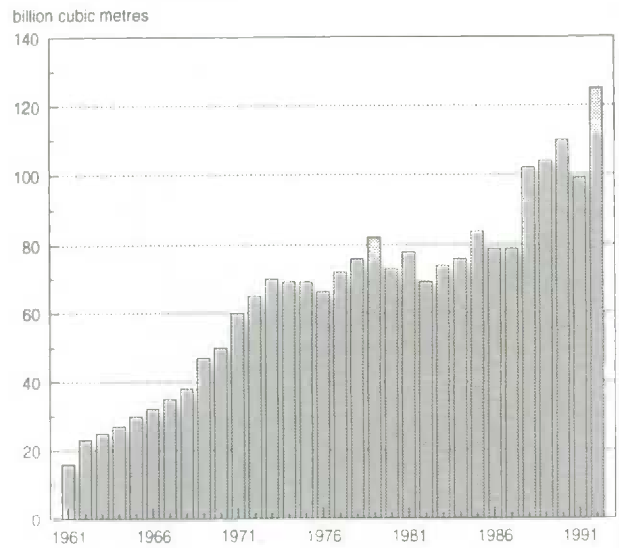
Sources:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.
British Columbia Ministry of Energy, Mines and Petroleum Resources, *Hydrocarbon and By-product Reserves in British Columbia*, Victoria, various issues.
Saskatchewan Department of Energy and Mines, *Reservoir Annual*, Regina, various issues.
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

Figure 5.5.7
Reserve Depletion of Crude Oil, 1961-1992



Sources:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.
British Columbia Ministry of Energy, Mines and Petroleum Resources, *Hydrocarbon and By-product Reserves in British Columbia*, Victoria, various issues.
Saskatchewan Department of Energy and Mines, *Reservoir Annual*, Regina, various issues.
Manitoba Department of Energy and Mines, *Oil Activity Review*, Winnipeg, various issues.
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

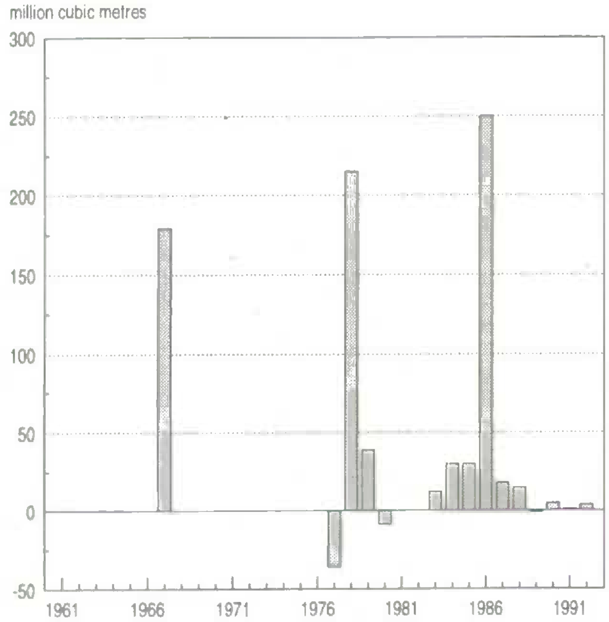
Figure 5.5.8
Reserve Depletion of Natural Gas, 1961-1992



Sources:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.
British Columbia Ministry of Energy, Mines and Petroleum Resources, *Hydrocarbon and By-product Reserves in British Columbia*, Victoria, various issues.
Saskatchewan Department of Energy and Mines, *Reservoir Annual*, Regina, various issues.
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

Figure 5.5.9

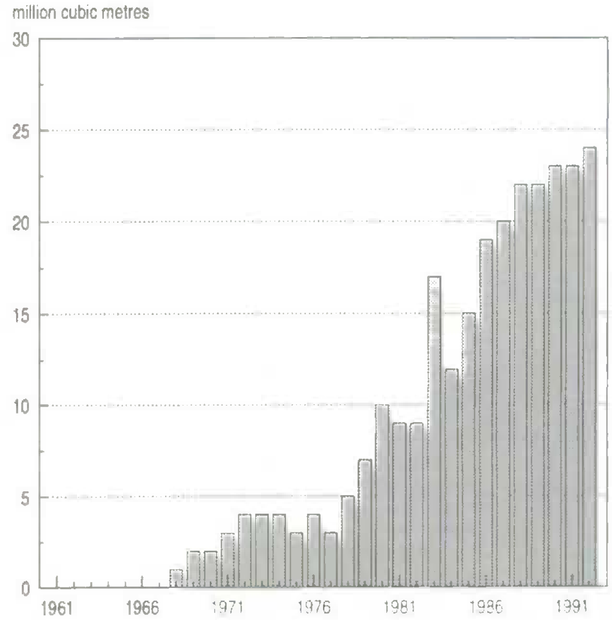
Reserve Additions of Crude Bitumen, 1967-1992



Source:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.

Figure 5.5.10

Reserve Depletion of Crude Bitumen, 1967-1992



Source:
Alberta Energy Resources Conservation Board, *Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur*, Calgary, various issues.

serves represent fewer than one percent of Canada's total reserves, however.

A **replacement ratio**[1,2] of reserves has also been derived from the physical accounts. This is the ratio of additions to reserves during a given period to the extraction (or depletion) and negative revisions of the resource during the same period. Ratios less than one indicate that extracted reserves of oil and natural gas are not being replaced by reserve additions in a given time period (Table 5.5.3).

It is most evident in Alberta that crude oil reserve additions are not keeping up with annual depletion of the reserve stock. In this province the replacement ratio is less than one since 1986. This is particularly important since 74 percent[3] of Canada's crude oil production is from Alberta. Results indicate that Saskatchewan is maintaining its crude oil reserve base with ratios near one. For natural gas, similar trends are observed, however, depleted reserves are being replaced at higher rates compared to crude oil. For example, in 1992, the indicator is 0.51 for crude oil in Alberta compared with 0.70 for natural gas. Again, these results are more important in Alberta since 82 percent of Canada's natural gas production comes from that province. The replacement ratio shows that, in general, reserve depletion is not being replaced by reserve additions even at an average re-investment rate of 82 percent by the petroleum industry over the past two decades.[4] This indicator does not measure to what extent income from the extraction of these resources has been used in the development of non-conventional and renewable resource substitutes and other forms of produced capital.

1. In Organisation for Economic Co-operation and Development work, indicators of "sustainable resource use" have been calculated for the renewable resources, forests and water. In this study, this ratio is called a **replacement ratio** for the oil and natural gas use in Canada. Since non-renewable resources, such as oil and natural gas, cannot be replaced in the long term, as in the case of renewable resources, the concept of sustainable resource use is a short-term notion. Thus, for non-renewable resources, the term "quasi-sustainability" is used according to which these resources should be depleted at the rate of development of a renewable substitute or the income from these resources should be reinvested in financial or other produced assets in order to generate future income. This long-term perspective is not adopted here.
2. Organisation for Economic Co-operation and Development, *Natural Resource Accounts: Taking Stock in Organisation for Economic Co-operation and Development Countries*, Organisation for Economic Co-operation and Development Monograph No. 84, Paris, 1994 (forthcoming).
3. Statistics Canada, *The Crude Petroleum and Natural Gas Industry*, Catalogue No. 26-213, Ottawa, 1992.
4. Re-investment ratio is investment to cashflow. Natural Resources Canada, *Canada's Energy Outlook, 1992-2020*, Ottawa, 1993.

Table 5.5.3
Replacement Ratio of Oil and Natural Gas Reserves, 1981-1992

Year	Crude oil reserves					Natural gas reserves			
	Alberta	Saskatchewan	British Columbia	Manitoba	Ontario	Alberta	Saskatchewan	British Columbia	Ontario
	years								
1981	0.56	0.60	0.06	1.00	...	1.71	2.48	1.89	1.77
1982	0.33	0.71	0.38	1.33	0.04	1.95	3.33	1.28	1.91
1983	1.17	1.40	0.67	1.31	1.18	0.59	5.36	0.37	3.90
1984	0.75	1.52	0.14	0.84	2.24	0.59	6.97	0.72	1.29
1985	1.14	1.26	1.72	1.98	1.38	0.59	3.64	1.03	0.18
1986	0.79	0.98	0.30	0.53	0.25	0.31	2.87	0.29	...
1987	0.61	1.15	0.33	0.51	0.17	0.12	1.67	0.14	2.31
1988	0.64	1.59	0.63	0.46	3.72	0.73	2.24	0.47	2.59
1989	0.43	0.88	2.39	0.49	1.05	1.26	1.88	0.93	0.06
1990	0.30	1.04	0.38	1.17	1.36	0.97	1.63	2.35	0.22
1991	0.31	1.03	0.44	0.72	0.61	0.73	0.74	1.81	0.83
1992	0.51	1.18	1.20	0.21	0.56	0.70	0.47	0.93	1.38

Note:
Replacement ratio is the reserve appreciation during a given year over the depletion and any negative revisions of the reserves during the same period.
Source:
Statistics Canada, National Accounts and Environment Division.

Remaining Ultimate Potential

In order to forecast future oil and natural gas supplies, two estimates of established reserves are reported: **remaining** established reserves and **yet-to-be** established reserves, the sum of which is **remaining ultimate potential** established reserves. Yet-to-be established reserves are based on estimates of future reserve growth from new discoveries and reserve additions from existing oil and natural gas pools; and anticipated economic conditions. Ultimate potential is approximated by the medium grey area (i.e. marginal reserves) in Figure 5.5.1. These reserve data are used to estimate future oil and natural gas supplies in Alberta and Canada. Table 5.5.4 shows the remaining and yet-to-be established reserves for crude oil, natural gas and crude bitumen in Alberta and Canada.[1] The inclusion of yet-to-be established reserves doubles the reserve life index of crude oil and natural gas in Alberta and increases the reserve stock of crude bitumen by ninety times. The frontier resource base is also large but production from these resources will depend on megaprojects, such as Hibernia and Terra Nova from Newfoundland's offshore, coming onstream in the 1990s. Ultimate potential reserves of oil and natural gas increase by three times when resources from frontier areas are included in the Canadian resource base.

1. Data presented in Table 5.5.4 are derived from different sources and definitions may differ. For example, data for Alberta are based on reserves whereas data for Canada are based on reserves and resources.

Table 5.5.4
Established Reserves and Ultimate Potential of Crude Oil, Natural Gas and Crude Bitumen in Alberta and Canada

Year	Remaining established	Yet-to-be established	Remaining ultimate potential	Reserve life[1]
	million cubic meters			Years
Alberta (1992)				
Crude oil	442	547	989	18
Natural gas	1 638 000	2 091 000	3 729 000	36
Crude bitumen	482	48 249	48 732	2 030
1. Canada[2] (1991)				
Crude oil	652	1 461	1 669-2 113[3]	25 [3]
Natural gas	2 006 000	3 105 000	4 178 200-5 111 760[3]	37 [3]
2. Frontier areas (1991)				
Crude oil	..	..	3 496[3]	..
Natural gas	..	..	7 748 000[3]	..
Canada, total (1+2)				
Crude oil	..	..	5 165-5 610[3]	..
Natural gas	..	..	11 926 000-12 859 000[3]	..

Notes:
1. Reserve life is remaining ultimate potential divided by current production.
2. Data include alberta but exclude frontier areas and crude bitumen.
3. Data taken from Natural Resources Canada. The lower estimate represents "Commercial resources" which is established reserves plus 70 percent of yet-to-be established reserves. The upper estimate is the sum of remaining established reserves plus yet-to-be established resources. The reserve life is lower estimate divided by current annual production.
Source:
Statistics Canada, National Accounts and Environment Division.

5.6 Monetary Accounts

Mineral deposits should be viewed as capital assets that represent national wealth. In order to include these assets as part of the national wealth estimate, a monetary value must be imputed so that these assets of natural capital can be included with other assets in the Canadian National Balance Sheet Accounts. This imputed value is based on the concept of economic rent which is the difference between

Table 5.6.1

Monetary Value of Crude Oil and Natural Gas Reserves, and Produced Capital, 1961-1989[1]

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
	million dollars														
Net capital stock of non-produced assets															
1. Net price															
Crude oil	4 006	4 208	4 983	7 149	6 977	7 234	6 733	7 979	8 159	10 136	11 684	12 686	17 616	32 152	36 372
Natural gas	46	463	2 717	3 441	4 001	4 075	4 843	4 980	3 769	2 303	1 404	2 018	5 042	17 288	33 470
Total	4 052	4 671	7 699	10 590	10 978	11 309	11 577	12 959	11 928	12 439	13 088	14 704	22 658	49 440	69 842
2. Present value															
Crude oil	..	..	..	2 861	3 460	3 481	3 378	3 222	3 197	3 512	4 452	5 477	7 603	11 103	15 073
Natural gas	..	..	..	416	948	1 231	1 352	1 368	1 342	1 262	1 166	974	1 114	2 328	5 162
Total	..	..	..	3 277	4 408	4 713	4 730	4 590	4 539	4 774	5 618	6 452	8 717	13 432	20 234
Net capital stock of produced assets	**2 004**	**2 142**	**2 342**	**2 550**	**2 781**	**3 036**	**3 307**	**3 436**	**3 738**	**4 052**	**4 711**	**5 021**	**5 478**	**6 584**	**7 716**

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	million dollars													
Net capital stock of non-produced assets														
1. Net price														
Crude oil	38 718	46 755	54 057	56 277	59 789	66 303	85 045	117 798	117 151	116 846	33 507	52 937	19 604	28 941
Natural gas	54 868	66 208	66 725	89 661	127 758	118 687	147 043	129 642	129 737	124 194	63 711	36 272	23 065	20 605
Total	93 586	112 963	120 781	145 938	187 547	184 990	232 088	247 440	246 888	241 040	97 218	89 208	42 669	49 546
2. Present value														
Crude oil	19 529	23 686	26 176	29 879	31 263	30 830	35 079	45 392	50 635	61 526	58 711	49 924	34 952	21 568
Natural gas	10 038	16 851	21 632	26 664	28 291	26 855	31 307	39 656	36 618	41 505	40 213	32 057	23 881	14 913
Total	29 567	40 537	47 808	56 543	59 553	57 686	66 386	85 048	87 253	103 031	98 924	81 981	58 833	36 481
Net capital stock of produced assets	**8 631**	**9 745**	**11 491**	**14 412**	**19 042**	**23 492**	**27 355**	**28 531**	**30 579**	**33 865**	**34 321**	**35 424**	**37 156**	**37 999**

Notes:
Figures may not add due to rounding.
1. Includes Alberta, British Columbia, Manitoba, Ontario and Saskatchewan.
Source:
Statistics Canada, National Accounts and Environment Division.

the price of the resource and all costs of extraction including a normal return on the capital used to find, develop and extract the reserves but excluding royalties and taxes.

Table 5.6.1 presents the monetary value of the closing stock of crude oil and natural gas reserves for Alberta, Saskatchewan, British Columbia, Manitoba and Ontario from 1961 to 1989. The monetary values are imputed using two methods: the net price and the present value.

The net price or dollar value per unit of the oil or natural gas is calculated as the value of production less operating costs and the opportunity cost of produced capital used by the petroleum industry (i.e. a return on produced capital and a depreciation charge) divided by the quantity of resource extracted in a given period. The net price per unit is then multiplied by the quantity of remaining reserves to obtain the total value of the closing stocks.

The present value estimate of the reserve stock is calculated by using a 4-year moving average of the net price to reduce the impact of price fluctuations and discounting these values over the life of the reserves at a long-term industrial bond rate.[1] For both the net price and present value methods, negative stock values, which imply a negative return to the natural capital, have been set to zero.

The value of Canada's oil and natural gas reserve stocks fell by 79 percent based on the net price method from 1985 to 1989, and by 65 percent based on the present value method over the same period. This was mainly due to the collapse of the price of oil from $221 per cubic metre in 1985 to $122 in 1989 and the price of natural gas from $94 per thousand cubic metre to $54 over the same period.

Also included in Table 5.6.1 is the value of the net capital stock of produced assets used by the petroleum industry. These assets include exploration and development drilling, natural gas processing plants and other production facilities. Capital expenditures have increased significantly since the early 1980s, from $14 billion in 1979 to $38 billion in 1989. This suggests that as the stock of reserves declines and as reservoirs become smaller and less accessible over time, the capital cost per cubic metre is increasing. Current exploration and development costs leave little rent available in the existing price environment.[2]

1. For a more complete explanation see Born, A., *Development of Natural Resource Accounts for Crude Oil and Natural Gas Reserves in Alberta, Canada*, Statistics Canada, National Accounts and Environment Division, Discussion Paper No. 11, Ottawa, 1992.
2. Heath, M., *Alberta's Conventional Oil Supply How Much? How Long?*, Canadian Energy Research Institute, Study No. 44, Calgary, 1992.

Summary

The purpose of this chapter has been to summarize Statistics Canada's plan and progress with respect to the new national accounts environmental component. The plan entails the addition of natural resources to the National Balance Sheet Accounts and their measurement, as time series, both in physical and in monetary terms. Initial work has focused on the two most important natural resources in Canada, oil and gas reserves and timber. Future work on natural resources will deal with other mineral and metal stocks, land, wildlife and possibly hydroelectric energy potential. Alternative valuation methods are being considered for these assets since, at this stage, there is no consensus on this issue.

With respect to other environmental services, such as those provided by water and air, current efforts are centred on the development of specialized resource use accounts. Energy disposition accounts have already been developed and are currently being updated. Water use accounts are next on the agenda. Waste output accounts have been developed for greenhouse gas emissions and are already proving to be valuable for policy analysis. Attention is now focussing on how waste product flows should be classified and measured. Finally, in the area of environmental protection expenditures some survey data are already available pertaining to business sector outlays. Presently, efforts are concentrating on compiling statistics on government sector environmental protection spending from existing public accounts records.

Physical accounts of economically exploitable reserves and ultimate potential reserves can be used to calculate reserve lives and sustainable resource use. This information along with data from other environmental accounts developed at Statistics Canada can be used as tools to measure both economically and environmentally sustainable development.

For example, one concept of sustainable development suggests that society should maintain its capital, both manmade and natural. Traditional national accounting procedures have treated natural capital as a "free good", assigning an implicit value of zero, when such goods were considered abundant. But natural capital is no longer a free good but rather, a limiting factor in economic development compared to produced capital. Petroleum production is now limited by geologic deposits and potential climatic changes due to increased atmospheric CO_2 levels,[1] not simply by refining capacity.[2] For example, in Canada, excluding frontier reserves, reserves of crude oil have declined by 59 percent since 1969 and CO_2 emissions have increased since 1958 (see Section 3.12 - **Energy**, Table 3.12.8). Environmental accounting as a measure of sustainability means that we need to be able to monitor the depletion of natural resources as well as examine the environmental impact of the consumption of these natural resources.

The use of natural resource assets generates substantial amounts of revenue and makes an important contribution to the Canadian economy. Evaluation of the nation's future potential for sustained income generation can be enhanced by detailed analysis of national and provincial assets and liabilities. The extraction and harvesting of natural resources, in particular oil and natural gas, generate a significant amount of revenue to provincial governments in the form of royalties, stumpage fees and land costs. In Alberta, for example, studies indicate that conventional oil will continue to generate revenue for the province over the next 15 to 20 years. However, if the industry does not continue to reinvest in further exploration and development for more reserves, this source of income will diminish.[3] This is of importance as Canada faces importing greater amounts of conventional oil supplies to meet domestic demand.[4]

1. The combustion of fossil fuels accounts for approximately 94 percent of total carbon dioxide emissions from the Canadian economy (see Section 3.12 - **Energy**).
2. Goodland, R. et al., *The Urgent Need for a Rapid Transition to Global Environmental Sustainability*, The World Bank, Washington, D.C., 1992.
3. Heath, M., *Alberta's Conventional Oil Supply: How Much? How Long?*, Canadian Energy Research Institute, Study No. 44, Calgary, 1992.
4. For example, it is expected that Canada will become a net importer of oil after 2008 (Natural Resources Canada, *Canada's Energy Outlook 1992-2020*, Ottawa, 1993).

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