Environmental Indicators

(Sixth Edition)

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Contents

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List of figures

Introduction

Air quality

List of tables

Introduction

Environmental misperceptions are rampant

Newspapers in Canada, like those in much of the developed world, give extensive coverage to alarming claims about environmental degradation and related health impacts. Claims linking increasing rates of asthma and deaths due to air pollution are carried uncritically as are laments regarding humanity's supposedly increasing "ecological footprint" and associated loss of biodiversity on Earth. In a poll conducted for Natural Resources Canada, 65% of respondents to the survey of Canadians' environmental attitudes felt that forest management and over-cutting are the primary threat facing the country's forests today (Decima, 2002).

Through surveys of college students, The Fraser Institute has found a strong disconnect between Canadian student perceptions of environmental trends (mostly negative) and the reality of environmental trends (mostly positive): 65% of the students attending Fraser Institute seminars believe that air quality is deteriorating. Fifty-eight percent of students are convinced that annual forest harvests exceed regrowth. Seventy-three percent of students believe we need to expand recycling programs and further control waste to avoid a "trash crisis."

But the reality of the state of the environment is quite different from the portrayals of alarmists or the understanding of the public. Things are, in fact, improving dramatically in the developed world as improvements in technology, higher incomes, and democratic systems have created an ever-increasing ability to protect the environment. There is every reason to believe that similar improvements will be seen globally as developing countries open to international trade and have access to advanced technologies. And locally, while many Canadians are unaware of it, the majority of environmental trends in Canada have been positive for decades.

If it matters, measure it

The Fraser Institute believes strongly in the idea of public policy debate infused by hard data, and sound logic. We published our first Environmental Indicators report in 1997, going to the original data sources (primarily governmental) to compile evidence that might show us the real state of environmental progress. What we have found is a story of optimism that is simply not understood by a large section of the population.

- One of the most far-reaching environmental improvements is the increasing quality of the air Canadians breathe. Ambient levels of sulphur dioxide, a pollutant produced by burning coal and oil, which can cause breathing problems and aggravation of respiratory disease, decreased 72.2% from 1974 and 2001 (figure 0.1).
- Ambient levels of particulate matter, which can irritate lung tissue and reduce visibility in the air, decreased 50.7% from 1974 to 1999 (figure 0.1).
- Improvements in technology have resulted in an 82.6% decrease in ambient levels of carbon monoxide from 1974 to 2001 despite the fact that there has been a 30% increase in total vehicle registrations over the same period (Statistics Canada 2000: 121) (figure 0.2).
- The decline in ambient lead levels is the greatest success story in the efforts to reduce air pollution. Ambient lead levels fell 94% in Canada from 1974 to 1998, a concentration so low that it no longer needed measuring, and resources were diverted from lead measurement to other activities (figure 0.2).
- Nitrogen dioxide, a highly reactive gas emitted by both natural and industrial activities, is a cause for concern because it combines with volatile organic compounds to produce ozone, considered to be a precursor to smog. Canadian ambient levels of nitrogen dioxide decreased 34.4% from 1974 to 2001 (figure 0.1).

This is not to say the news is all good—there is still a problem with ground-level ozone which, for reasons not fully understood, is increasing despite decreases in precursor chemicals—but clearly, the trends in air quality have been astonishingly good.

The same seems to be true of Canada's water quality, though the quality of the nation's surface water is more difficult to assess. Data measurement and analysis of environmental water quality fall under provincial jurisdiction and procedures across the country are far from standardized. However, where pollutants and water quality have been measured sufficiently to evaluate trends, definite improvements are evident.

- For example, in British Columbia, which monitors 33 water bodies based on a set of Provincial Water Quality Objectives, 50% of the water bodies evaluated are in Good or Excellent condition, and 94% of the water bodies are rated to be at least Fair. Only 2 water bodies are considered Borderline, and none are rated to be Poor (BCMWLAP, 2002).
- The Great Lakes constitute the largest system of fresh surface water on earth, containing roughly 18% of the world's fresh water supply. Since the 1960s, levels of toxic contaminants such as DDE and PCBs decreased dramatically in each of the great lakes (figures 0.3, 0.4). Levels of DDE decreased 86% in Lake Ontario, 89% in Lake Erie, 85% in Lake Michigan, 91% in Lake Superior, and 93% in Lake Huron from 1974 to 2002. PCB levels showed similar trends, decreasing 89% in Lake Ontario, 82% in Lake Erie, 80% in Lake Michigan, 87% in Lake Superior, and 92% in Lake Huron relative to their levels in the mid-1970s.

Another concern often voiced by environmental alarmists is that Canadians produce too much waste so that we are headed for a "garbage crisis." Although the total amount of waste generated in Canada each year is increasing, one survey indicates that the per-capita levels of garbage generation has fallen in several provinces in recent years (Nova Scotia, New Brunswick, Manitoba and British Columbia) (figure 0.5). Further, calculations based on the similar waste production of our neighbour to the south showed that even the United States could put 1,000 years worth of its garbage in a single square of land, about 71 km (44 miles) on each side and about 37 meters (120 feet) deep (Wiseman, 1990). Canada, with about one-tenth the population of the United States, would require about one-tenth of this area.

Still another commonly voiced concern is that Canada's forests are disappearing. This just isn't the case. Because most of Canada's forests are growing on crown land, the provincial governments determine appropriate levels for the annual allowable cut (AAC) based on area and volume of forest and predicted growth rates. Although total harvest volume in Canada increased 65.3% from 1970 to 1999, at no time did the harvest level exceed the defined AAC. In fact, in only two years during this period (1989 and 1999), did the harvested volume exceed 80% of the AAC. Canadian forestry management practices are stable. According to one study, the volume of Canada's forest actually increased 4% between 1979 and 1994 (FPAC, 2003).

There is much cause for optimism about the state of Canada's environment. Environmental trends across the board are improving and should continue to improve in coming years. In this study, 31 out of 37 indicators of environmental quality show improvement or have remained stable (table 0.1). Although there are a few problem areas left, such as ozone levels, as air quality policy analyst Joel Schwartz has shown, even that problem should be extinguished in coming decades (Schwartz, 2003). While environmental alarmists publish a steady stream of scary reports based on dubious science, all it takes is a quick look at the data to show that the reality of environmental progress is overwhelmingly positive. As the Beatles used to sing, "Things are getting better all the time."

The structure of this report

This report brings together available data concerning environmental trends in five primary categories: air quality; water quality; natural resources; land use and condition; and solid wastes. Each of these sections contains trend data and a general discussion. In some cases, the discussion points to the need for more data. Five other categories including carbon dioxide emissions, oil spills, pesticides, toxic releases and wildlife are also considered under the "secondary" indicators heading. For these topics, less conclusive data are available. In some cases, such as carbon dioxide emissions, it is unclear whether the indicator contributes to an environmental problem. In other cases, wildlife, for example, available data make it difficult to draw reliable conclusions.

Table 0.1: Summary of Environmental Indicators

Indicator	Status
Primary Indicators	
Air	
Sulphur Oxides	Improving
Nitrogen Oxides	Improving
Ozone	Deteriorating
Total Suspended Particulates	Improving
Carbon Monoxide	Improving
Lead	Improving
Water	
PCBs in eggs of double-breasted Cormorants: Bay of Fundy	Improving
DDE in eggs of double-breasted Cormorants: Bay of Fundy	Improving
PCBs in eggs of double-breasted Cormorants: St. Lawrence Estuary	Improving
DDE in eggs of double-breasted Cormorants: St. Lawrence Estuary	Improving
Shellfish Contaminants	Improving
Trend in BC surface water quality	Improving
Trend in BC ground water quality	Improving
PCBs in eggs of blue-herons: UBC	Improving
DDEs in eggs of blue-herons: UBC	Improving
DDE levels in herring gulls of the Great Lakes	Improving
DDE levels in herring gulls of the Great Lakes	Improving
Phosphorous levels: Great Lakes	Improving
Nitrate levels: Great Lakes	Deteriorating
Percentage of population served by primary wastewater treatment	Improving
Percentage of population served by secondary wastewater treatment	Improving
Percentage of population served by tertiary wastewater treatment	Improving
Solid Waste	
Waste disposal per capita	Deteriorating
Total materials prepared for recycling	Improving
Transboundary movement of hazardous waste	Deteriorating
Land Use	
Total agricultural land	Stable
Total protected area	Improving
Natural Resources	
Total water withdrawals	Deteriorating
Total water withdrawals as a percentage of resource available	Stable
Forest harvest volume above annual allowable cut	Stable
Percent of forest area protected	Improving
Total energy consumption	Deteriorating
Energy consumption per capita	Improving
Energy consumption per GDP	Improving
Secondary Indicators	
Oil Spills	
Number of oil spills	Improving
Quantity of oil spilled	Improving
Pollutant Releases	
Total pollutant releases	Improving

Note: This table shows only indicators that are widely acknowledged to constitute environmental harms and for which there was sufficient data over time to construct a reliable series.

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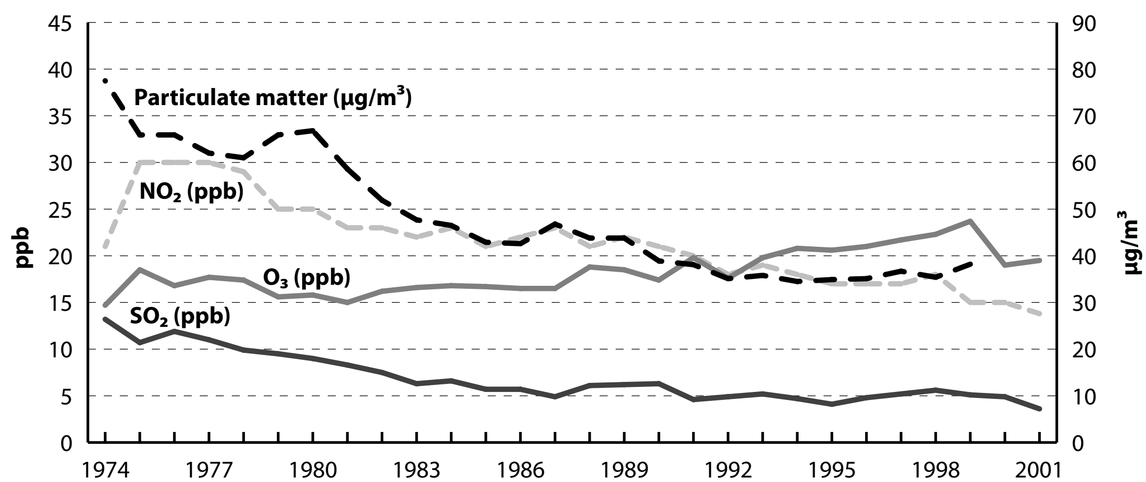
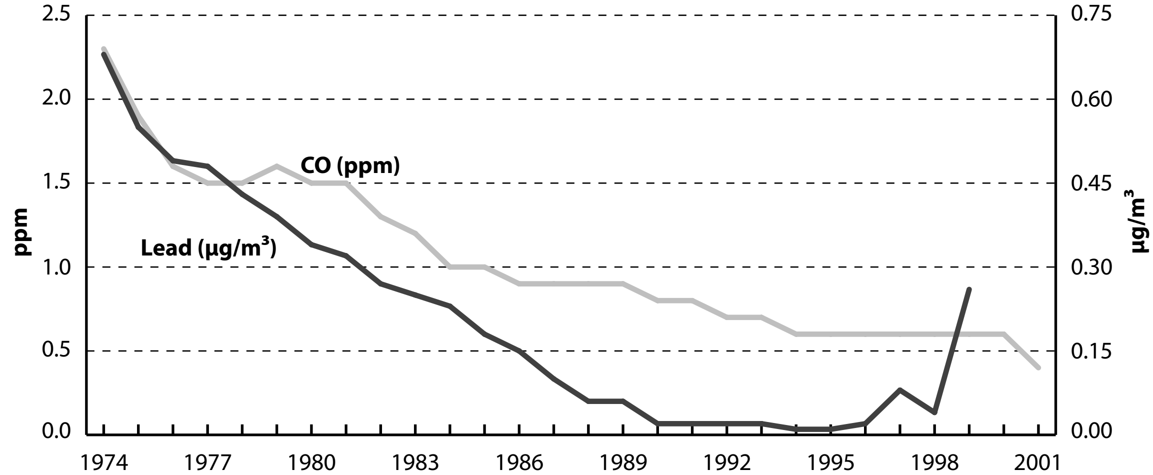
Figure 0.1: Air pollution trends in Canada—nitrogen dioxide, sulphur dioxide, ozone, and particulate matter



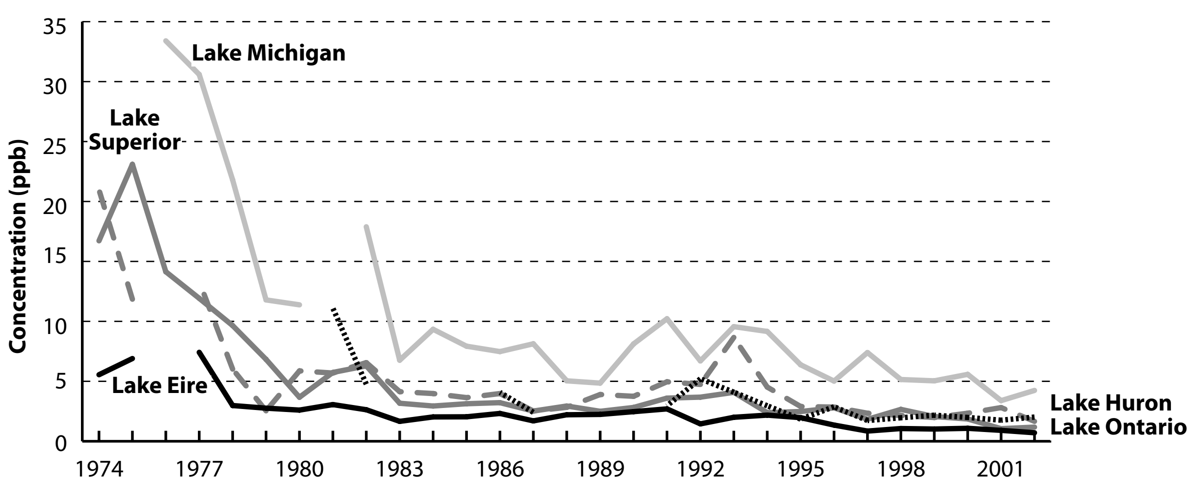
Source: Environment Canada (2003), *National Air Pollution Surveillance (NAPS) Network Annual Summary for 2002*.

Figure 0.2: Air pollution trends in Canada—carbon monoxide and lead



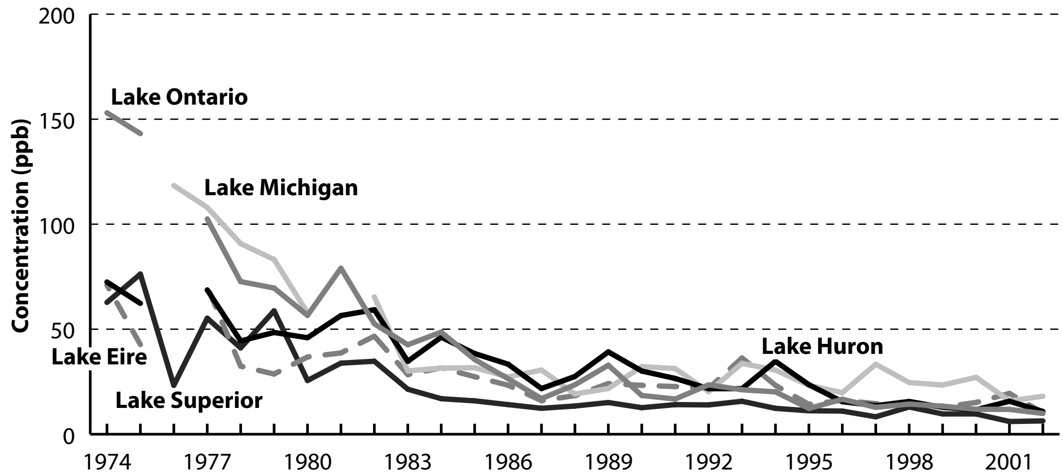
Source: Environment Canada (2003), *National Air Pollution Surveillance (NAPS) Network Annual Summary for 2002.*

Figure 0.3: DDE levels in Herring Gulls of the Great Lakes



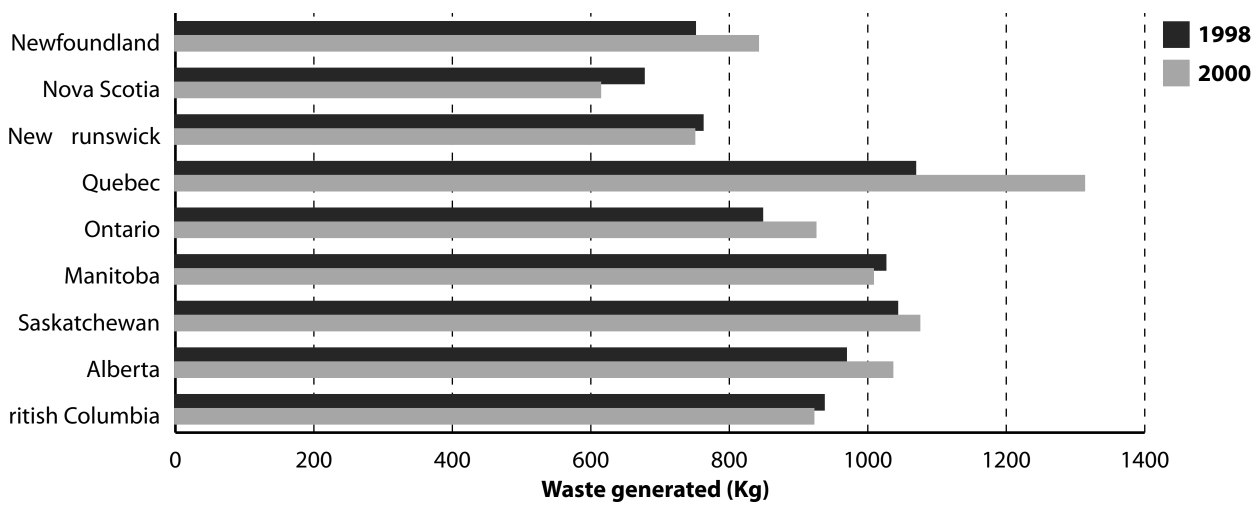
Source: Environment Canada (2003), *Contaminants in Herring Gull Eggs from the Great Lakes: 25 Years of Monitoring Levels and Effects* (January 31), <http://www.on.ec.gc.ca/wildlife/factsheets/fs_herring_gulls-e.html>; Council on Environmental Quality (1996), *Environmental Quality along the American River: The 1996 Report of the Council on Environmental Quality.*

Figure 0.4: PCB levels in Herring Gull Eggs in the Great Lakes



Source: Environment Canada (2003), *Contaminants in Herring Gull Eggs from the Great Lakes: 25 Years of Monitoring Levels and Effects* (January 31), <http://www.on.ec.gc.ca/wildlife/factsheets/fs_herring_gulls-e.html>; Council on Environmental Quality (1996), *Environmental Quality along the American River: The 1996 Report of the Council on Environmental Quality*.

Figure 0.5: Per-capita levels of waste generated, by province, 1998 and 2000



Source: Statistics Canada (2000), *Waste Management Industry Survey: Business and Government Sectors*.

Primary environmental indicators

1 Air Quality

Citizens continue to be concerned about the quality of air that they breathe. As public awareness surrounding the environment has grown, so too has concern surrounding issues such as urban smog and industrial emissions and how these issues affect the health of our population. The purpose of this section is to examine objectively the underlying pollutants that degrade air quality. An analysis of these pollutants will illustrate trends in air quality across Canada and North America, show how they compare to standards set by national and international health bodies, and tell us what to expect in the future.

Measuring air quality

What to measure?

The air that we breathe is incredibly complex. Pure air consists of 21% oxygen and 78% nitrogen by volume, plus traces of other substances and gases both natural and man-made. Regulations designed to improve air quality target six main pollutants: sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ground level ozone (O_3), carbon monoxide (CO), particulate matter (PM), and lead (Pb). These substances, either principle components or precursors to smog, which may have adverse effects on human health, are primarily produced by automobiles and industrial activity (Health Canada, 2001). It is important to recognize that many of these pollutants are also the result of natural biological and chemical processes not significantly influenced by human action; this report does not examine data for these sources.

How to measure?

Two techniques are commonly used to measure air quality: ambient concentrations and emissions estimates. Ambient concentrations are the actual measured amount of pollutant in the air, usually reported in parts per million (ppm), parts per billion (ppb), or micrograms per cubic metre ($\mu g/m^3$). Emission estimates are calculations of the amount of a particular pollutant emitted by various sources over a given period. These calculations, based on many assumptions about human activity and industrial technology, attempt to model the amount of each pollutant emitted over a certain time period.

Ambient concentrations

The National Air Pollution Surveillance (NAPS) network was established in 1969 to trace common air contaminants in Canada. In 1970, 43 monitoring instruments were tracking pollutant levels in 14 urban centres (Furmanczyk, 1987: 2). As of 2001, the network consisted of 253 stations in 56 cities across the country.

In the United States, the Environmental Protection Agency (EPA) manages more than 5000 monitoring sites across the country in order to monitor air quality. Established under the *Clean Air Act*, pollutants are assessed based upon National Ambient Air Quality Standards (NAAQS) (EPA, 2003).

In Mexico, monitoring of air quality began at a much later date than it did in the rest of North America; however, several measures have been taken in recent years to increase its capabilities. In 1988, Mexico passed the *General Law of Ecological Balance and Environmental Protection*. This law prohibits the emissions of any pollutants that might cause ecological damage and provides guidelines for ambient air quality and emission limits for fixed and mobile sources of pollution. Although it does not designate national objectives for air management, it does provide for the setting of state and local quantitative environmental goals or targets. Mexico expanded its air quality monitoring in 1997 to include several of its largest cities, including Mexico City, Guadalajara, Monterey, Ciudad Juarez, Tijuana, Queretaro, Mexicali, Tula, Aguascalientes, Minatitlan, and Toluca (OECD, 1998: 80–81).

Emission estimates

The second technique used to determine air pollutant concentrations, emission estimates, involves a set of calculations that estimate the amount of a particular pollutant emitted by various sources over a given period of time. These calculations are based upon a variety of assumptions, including the level of industrial activity, changes in technology, fuel-consumption rates, vehicle miles traveled, and other activities that are known to contribute to air pollution. Although these emission estimates provide useful information regarding air quality trends, they are deemed less reliable as indicators than measurements of ambient concentrations due to their dependence on assumptions, and the fact they are only estimates. Notably, these emissions estimates do not account for pollutants produced via natural sources.

Performance assessment

In order to make a meaningful assessment of the outcomes of air-quality measurements over time, results must be compared against the air-quality objectives set by various national and international health and environmental organizations. Such comparisons determine not just whether air quality is improving or deteriorating but also whether, at present levels, the pollutants measured pose a risk to human or environmental health.

In the 1970s, the federal government implemented objectives to protect human health and the environment. These objectives identify acceptable thresholds over given time periods for each common pollutant. Until 1998, Canada used a three-tiered system of National Ambient Air Quality Objectives (NAAQO) that defines maximum desirable, acceptable, and tolerable levels of air pollution for periods of one year, 24 hours, eight hours, or one hour, depending on the pollutant, with standards becoming more stringent over longer time periods (table 1.1). Since 1998, Canada has adopted the maximum acceptable objective as the target to achieve through regulatory air-quality management actions and a maximum tolerable objective where immediate action is required (Health Canada, 2001). According to Environment Canada,

> [t]he maximum desirable objective, the strictest of the three objectives, defines a level of pollutant that acts as a long term objective for air quality. The maximum acceptable objective is intended to provide adequate protection against adverse effects on human health, animals, vegetation, soil, water, materials, and visibility. Finally, the maximum toler-

Table 1.1: National Ambient air Quality Objectives

Air Contaminant	Desirable	Acceptable	Tolerable	WHO
Sulphur Dioxide (ppb)				
1 hour	172	334	na	175
24 hour	57	115	306	44
Annual	11	23	na	17
Nitrogen Dioxide (ppb)				
1 hour	na	213	532	110
24 hour	na	106	160	
Annual	32	53	na	21–26
Ground Level Ozone (ppb)				
1 hour	51	82	153	
8 hour	na	na	na	60
24 hour	15	25	na	
Annual	na	15	na	
Suspended Particulates (µg/m3)				
24 hour	na	120	400	*
Annual	60	70	na	
Carbon Monoxide (ppm)				
1 hour	13.1	30.6	na	25
8 hour	5.2	13.1	17.5	10

Note *: The WHO sets no guidelines for particulate matter because there is no evident threshold for effects on morbidity and mortality.

Source: Health Canada (2001), *National Ambient Air Quality Objectives*, <http://www.hc-sc.gc.ca/hecs-sesc/air_quality/naaqo.htm>.

> able objective defines concentrations of air contaminants where action is required to protect human health and the environment. When air pollutants reach this level of concentration appropriate action is required without delay to protect the health of the general population (Environment Canada 1999).

In the United States, the Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS) for pollutants that can harm public health and the environment. Under the *Clean Air Act*, two types of national air-quality standards are set: primary standards, which set limits to protect public health and secondary standards, which set limits to protect public welfare, including protection against decreased visibility and damage to crops and buildings (EPA, 2003).

International standards for air quality also exist. For example, the World Health Organization's Guidelines for Air Pollution Control also identifies acceptable thresholds for common air pollutants. Table 1.1 compares Canada's NAAQOs to the American NAAQS and the WHO standards with a brief description of the health side effects associated with each pollutant.

Performance analysis

In order to make a systematic assessment of air quality in North America, this report will examine the status of each pollutant based upon the following criteria, where applicable.

1 National trends

Ambient concentrations are assessed in order to identify quantifiable changes in pollutants over time. Both annual averages and individual station mean readings are examined. National averages for each pollutant are derived via the mean of all station means measured through the NAPS network. The objective is to determine whether air quality is improving or deteriorating over time at the national level. Comparatively, individual station analysis examines ambient concentrations for select stations in order to determine if localized areas are experiencing chronically poor results not evident in the national average. The strictest NAAQO objective for each pollutant has been illustrated in all graphs of ambient pollutants to provide a benchmark for good air quality.

2 Conformance with standards

The purpose of this analysis is to make a quantitative comparison of air quality in Canada, the United States, and Mexico against the strictest air-quality objectives. Annual and short-term objectives are both examined to determine how levels of conformance have changed over time. In Canada, additional analysis will include the percentage of stations with readings exceeding the NAAQO short-term standard. These figures are calculated by dividing the number of stations with at least one reading above the NAAQO standard by the total number of stations that recorded a reading.

When interpreting this data, it is important to understand that one reading above the standard may not be critical, considering that many stations have several thousand readings a year. Moreover, measurements can be influenced by meteorological factors, including temperature, sunlight, air pressure, humidity, wind, and rain. Despite these limitations, the data provides a good complement to the annual data, illustrating changes in the number of stations meeting short-term concentration objectives.

3 City trends

This analysis assesses the performance of 13 Canadian, 10 American, and several Mexican urban centers over the past three decades (where data is available) according to each of the six most important pollutants. Where data permits, cities have been categorized according to population size in order to provide a better basis for comparison and examined according to each pollutant concentration over time. These three categories include large, medium, and small cities, each categorized by the relative size of each country.

In Canada, the cities examined include: Toronto, Montreal, Ottawa-Hull, Vancouver (large), Calgary, Edmonton, Quebec, Winnipeg (medium), and Hamilton, Halifax, Regina, St. John's, Saint John (small). Additionally, in order to provide an account of *individual* city performance, tables have been provided to document each cities quantifiable performance over time. In the United States, the examined include: New York, Los Angeles, Chicago, Houston (large) and Detroit, San Jose, Indianapolis, San Francisco, Buffalo, Seattle (medium). In Mexico, Mexico City, Guadalajara, Monterey and Toluca have been assessed based on data available through SEMARNAP.

3 Pollutant by source

This analysis uses emission estimates to examine the sources of each pollutant over time. This helps to determine which sources are primarily responsible for each pollutant and how technology is improving the emissions of various sources over time. Trend graphs have been developed where data permit.

Limitations of Analysis

Although this report uses the best data available, some limitations should be recognized.

- Monitoring stations are primarily located in urban centres; therefore, results are not necessarily representative of general air quality. Given that stations are typically located in areas of higher pollution (urban centres), sampling is skewed to produce artificially higher pollutant levels than would be achieved through a sampling program across each country.
- The number of stations within the monitoring network is always changing. Stations are regularly added at new locations, while old stations may be decommissioned. As a result, data may be derived from different locations each year, potentially introducing a small sampling errors when trends are analyzed over time.
- Stations are often unable to collect enough data to provide a mean value for every year. As a result, some stations are not represented in each year, thus introducing a small sampling error.

Sulphur dioxide

Sulphur dioxide (SO_2) is a colourless gas that, in sufficient concentrations, has a pungent odor similar to burning matches. The largest contributing source of atmospheric SO_2 is burning fuel that contains sulphur, usually coal and oil (EPA, 2001). This activity is most prevalent in manufacturing and industrial activity, often dominated by electrical generation. Other common industrial sources of SO_2 include, but are not limited to, steel mills, petroleum refineries, and pulp and paper mills (MOE, 2003). Environmental factors such as thermal inversion, wind speed, and wind concentration also affect measured levels.

SO_2 is known to have impacts on both human health and the environment. Health effects associated with high levels of SO_2 include breathing problems, respiratory illness, and aggravation of respiratory disease. People with asthma or chronic lung conditions are particularly sensitive to high concentrations of SO_2 (OMOE, 2003). SO_2 is also known as a precursor to acid rain. Following emission into the atmosphere, SO_2 is chemically converted into forms of sulphuric and nitric acid. These subsequently fall back to earth in forms of precipitation. High enough concentrations of acid rain can cause the acidification of lakes and streams, accelerated corrosion of buildings and monuments, and impaired visibility.

Trends for sulphur dioxide

Canada

Ambient SO_2 levels in Canada have improved dramatically over the past three decades. The ambient annual national mean for SO_2 decreased by 72.2% between 1974 and 2001 (figure 1.1). These improvements are marked by two distinct periods of improvement: rapid improvement during the first 10 years, followed by a second phase of slower improvements. This is likely the result of addressing the most serious sources of pollutant first, leaving less significant sources to be addressed in more recent years.

During the period from 1977 to 2001, there was a significant reduction in the number of monitoring stations that recorded readings in excess of Canada's NAAQO quality standards (non-conforming stations). The percentage of stations exceeding the one-hour objective fell for both the *Desirable* and *Acceptable* standards, falling from 42.2% to 14.7%, and 19.3% to 5.3%, respectively (table 1.2). Moreover, a similar trend was experienced for the 24-hour objective where the percentage of non-conforming stations also fell for both the *Desirable* and *Acceptable* standards, from 53% to 10.5% and 22.9% to 6.3%, respectively, over the same period. Given that a station counts as non-conformant after registering one reading in excess of the standard over the entire year, these levels may be artificially high; since there are 8,760 hours in a year, one reading may in fact be insignificant.

Canadian cities have also successfully reduced SO_2 levels (figures 1.2, 1.3, 1.4). During the period from 1974 to 2001, nine of the 13 cities examined showed reductions in their levels of ambient SO_2, with eight of these nine experiencing reductions of 50% or greater. Quebec City and Ottawa experienced the greatest reductions in SO_2, achieving reductions of 91% and 80%, respectively. Cities showing increases include Halifax, Regina, Edmonton, and Calgary. These may or may not represent overall trends, however, as very limited data was available for each of these urban centres. It is important to note that despite these increases, all cities successfully met the NAAQO strictest annual health standard, categorized as "desirable." As a rule, the large and medium cities were substantially below the desirable standard while several of the small cities measured ambient levels much closer to the standard.

Estimates of sulphur dioxide emissions reaffirm the decreasing trend. Sulphur dioxide in Canada fell 42% from 1980 to 1997 (figure 1.5). The increased use of technology and control devices by industry, such as widely used sulphur dioxide scrubbers, has contributed to this substantial decline. Improvements in the processes used, smelter

Table 1.2: Percentage of stations with readings exceeding sulphur dioxide standards

	1 hour objectives		24 hour objectives			Total number
	> Desirable	> Acceptable	> Desirable	> Acceptable	> Tolerable	of stations
1977	42.2	19.3	53.0	22.9	1.2	83
1982	35.8	8.6	40.7	6.2	2.5	81
1987	23.6	6.9	18.1	2.8	0	72
1992	22.1	10.4	18.2	3.9	0	77
1997	20.7	10.3	17.2	3.4	0	58
1999	25.8	12.9	14.5	3.2	1.6	62
2001	14.7	5.2	10.5	6.3	0	95

Source: Environment Canada (2003), *National Air Pollution Surveillance (NAPS) Network Annual Summary for 2002.*

closures, acid-plant adoption, the use of low-sulphur coal, the adoption of coal blending and washing procedures, and the conversion to cleaner burning fuels (e.g., natural gas and light oil) have also contributed to this decline (EPA, 1996: 29).

Industrial processes and power generation are responsible for the majority of SO_2 production in Canada, together accounting for 81% of total emissions (OECD, 2002). Although total emissions have fallen significantly, the combined share of these two sources has remained relatively stable, falling only 3% since 1980. To maintain this level, improvements in industrial processes have resulted in a decreased proportion of pollutant share over the period, falling 5.3%, while power generation improved less quickly and gained 2.1%. Over the same period, mobile emissions grew 58%, rising from 2.95% to 4.68% of total production.

United States

Ambient concentrations of sulphur dioxide have been decreasing for nearly three decades across the United States (figure 1.6). EPA monitoring data show that SO_2 concentrations fell by 62% from 1980 to 2001 (EPA, 2001).

Consistently, analysis of ambient SO_2 levels in American cities reveals that SO_2 levels have decreased in both the large and medium cities examined (figures 1.7, 1.8). Among large cities, decreases as large as 40% were recorded in Houston while the smallest reduction, 14.2%, took place in Chicago. In medium-sized cities, the largest improvements occurred in Indianapolis, decreasing 44.4%, while in San Francisco SO_2 concentrations remained constant over the same period.

Emission estimates also indicate that total SO_2 emissions have decreased by 25.3% from 1980 to 1997 (figure 1.9). Much of this decrease is attributable to improvements in industrial technology, where emissions fell by 62.2%. Comparatively, mobile sources showed the largest increase in emissions at 76.7%. Despite these fluctuations, the largest single contributor to SO_2 emissions in the United States remains coal-fired power-generating plants, which account for 67.3% of total SO_2 emissions (OECD, 2002).

Mexico

Monitoring data in Mexico also reveal a declining trend in ambient sulphur dioxide. Total ambient SO_2 concentrations in the Zona Metropolitana del Valle de México (ZMVM) decreased by 71.4% from 1989 to 1998 (figure 1.10). Similarly, ambient concentrations in Guadalajara and Monterrey fell 52.6% and 8.3%, respectively. Valle de Toluca, however, recorded an increase in SO_2 concentrations of 42.9%. Although data is very limited, Tijuana and Mexicali both recorded reductions in ambient SO_2 concentrations, falling 40% and 57.1%, respectively (SEMARNAP, 1999).

Mexican SO_2 emissions estimates indicate that emissions are on the rise (figure 1.11). During the period between 1994 and 1998, emissions increased by almost 9%. Although data is limited, much of this increase is attributable to increases in emissions by power generation (proportionally the largest emitter of SO_2 in Mexico) and industrial combustion, both which have increased by approximately 20%. In contrast, mobile and industrial processes have shown decreases of 55.3% and 14.3%, respectively.

Nitrogen dioxide

Nitrogen dioxide (NO_2) is a highly reactive gas that is formed through the combination of nitric oxide (NO) with oxygen. This reaction is typically the result of lightning, volcanic activity, bacterial action in soil, and forest fires. Most of the nitrogen oxide compounds needed for this reaction, however, originate from human activities. Nitrogen oxides (NO_x) are the sum total of NO, NO_2, and other oxides of nitrogen. The combustion of fossil fuels by automobiles, power plants, industry, and household activities all contribute to their concentrations in the environment.

Levels of NO_x in the environment are of concern because they actively combine with volatile organic compounds (VOCs) in the presence of sunlight to form ground-level ozone, which is a primary component of urban smog. Nitrogen oxides also play a major role in atmospheric photochemical reactions that contribute to acid rain. However, because NO is so readily converted to NO_2 in the environment, environmental agencies generally track only NO_2. Nitrogen dioxide is also the easiest of the nitrogen oxides to detect because of its presence in higher concentrations.

Trends for nitrogen dioxide

Canada

From 1974 to 2001, ambient levels of nitrogen dioxide in Canada decreased by 34.4% (figure 1.12). Annualized concentrations of NO_2 have steadily declined in Canada, remaining well below NAAQO standards over the identified period. With the annual average falling from 21.0 to 13.8 ppb, NO_2 levels have remained well below the desirable standard of 32 ppb. On a non-aggregate basis, data indicates that since 1990, over 99% of all stations have recorded annual means either at, or below, the desirable standard, while 100% of the stations met the acceptable standard.

Short-term levels of ambient nitrogen dioxide also improved significantly, with far fewer stations recording readings in excess of the 1-hour and 24-hour standards (table 1.3). In 1977, 13.6% of monitoring stations reported at least one reading in excess of the 1-hour maximum acceptable level, and 15.9% had a reading that exceeded the 24-hour acceptable level. In contrast, 2001 showed less than 1% of stations exceed the 1-hour and 24-hour acceptable levels (which are the strictest standards as there are no 1-hour or 24-hour desirable standards set for NO_2).

City data shows similar trends. From 1975 to 2001, only Halifax and Montreal recorded increasing levels of nitrogen dioxide. The other cities for which data are available recorded decreasing levels. The greatest improvements were in St. John's and Edmonton where ambient levels of NO_2 decreased by 48.8% and 44.3%, respectively (figures 1.13, 1.14, 1.15).

The sources of NO_2 emissions remained relatively unchanged from 1980 to 1996 (figure 1.16). In 1980, the largest three contributing sources, mobile, power generation, and industrial combustion, accounted for approximately 96% of total emissions. In 1996, these same sources still accounted for 89% of emissions, with small decreases being shown in mobile sources and increases in industrial processes.

United States

Ambient concentrations of NO_2 decreased by 29.5% in the United States from 1980 to 2001 (figure 1.17). Medium-sized American cities had fairly stable NO_2 levels between 1990 and 1999 (figure 1.18). Although some larger cities such as Los Angeles, New York, and Houston all showed slight decreases in NO_2 concentrations, Chicago showed a 22% increase over the same period (figure 1.19) However, data indicate that NO_2 emissions increased by 4.4% in the United States from 1987 to 1999 (figure 1.20). Mobile sources increased by 16.1% and continue to represent the largest single source of emissions. Comparatively, power generation remains the second largest source of emissions but fell by 18.6% over the same period.

Mexico

The limited data available for Mexico indicate mixed trends for ambient NO_2 over the past decade. From 1989 to 1998, ambient concentrations in Valle de Mexico fell 27.5% while

Table 1.3: Percentage of stations with readings exceeding nitrogen dioxide standards

	1-hour objectives		24-hour objectives		Total number
	> Acceptable	> Tolerable	> Acceptable	> Tolerable	of stations
1977	13.6	0	15.9	0	44
1982	16.3	0	8.2	0	49
1987	0	0	2	2	49
1992	0	0	0	1.6	61
1997	0	0	0	0	78
1999	0.9	0	0.9	0	106
2001	0.9	0	0	0	111

Source: Environment Canada (2003), *National Air Pollution Surveillance (NAPS) Network Annual Summary for 2002.*

concentrations in Guadalajara rose sharply by 95.4%. Concentrations in Monterrey fell 10.5% over the same period (figure 1.21).

From 1990 to 1998, total emissions of NO_2 are estimated to have increased by 18.2% in Mexico. The majority of this increase is attributable to power generation and mobile emissions, which rose 5% and 18%, respectively, to account for a combined 80.7% of total emissions (figure 1.22).

Ground-level ozone

Ground-level ozone (O_3) is a colourless and odorless gas known to aggravate a variety of respiratory conditions. It is formed just above the earth's surface through the reaction of NO_x and volatile organic compounds (VOCs). Since this chemical reaction is facilitated by the presence of heat and sunlight, ozone is typically a greater concern during summer months.

Because ozone is the primary contributor to urban smog, regulators target emissions of both NO_x and VOCs to combat the problem. VOCs are a subgroup of hydrocarbons (HCs) that enter the atmosphere through evaporation of automotive fuel (from the fuel tanks of automobiles and spills), paints, coatings, solvents, and consumer products such as lighter fluid and perfume. VOCs also occur naturally as a result of photosynthesis.

Increasing levels of ozone have led regulators to develop more stringent standards. In 1998, 12 Canadian Ministers of the Environment endorsed the Canada-wide Accord on Environmental Harmonization. This agreement included the development of Canada-wide standards for both ozone and particulate matter. The recommended standard for ozone was stipulated at 65 ppb averaged over eight hours, to be achieved by 2010.

Much of the concern over ozone levels stems from a Canadian study examining NO_x and VOCs that states the current 1-hour maximum acceptable level for ozone does not fully protect human health. It also reports that there is "no discernible human health threshold for ground-level ozone," meaning that any improvement in ambient ozone levels is expected to have public health benefits (Environment Canada, 1997a: 3).

Trends for ground-level ozone

Canada

Ambient levels of ground-level ozone (O_3) increased by 32.7% between 1974 and 2001 (figure 1.23). Annualized ozone levels have become of increasing concern because they consistently measure above NAAQO objectives. Because no maximum desirable objective is set for an annual period, the acceptable value of 15 ppb acts as the strictest standard for performance assessment. Annual concentrations surpassed this objective in 1975 and have risen steadily since, now registering 19.5 ppb or 30% above the acceptable standard. In 2001, less than 10% of individual stations recorded means below this objective level.

Data on the percentage of stations with readings exceeding short-term concentration objectives also indicate that ozone levels are increasing (table 1.4). The percentage of stations reporting at least one reading in excess of the desirable 1-hour standard increased from 95.1% in 1977 to 97.6% in 2001. However, the percentage of stations exceeding the acceptable standard fell from 78% to 47%, while the percentage exceeding the tolerable standard fell from 14.6% to zero.

City data also reflects this trend. All cities examined recorded mean concentrations of ozone in excess of the maximum 15 ppb (figures 1.24, 1.25, 1.26). Moreover, all Canadian cities measured, with the exception of Halifax, Saint John, and Hamilton, experienced increases in ozone levels.

VOC emissions, which contribute to the formation of ground level ozone, increased 27.2% between 1980 and 1997 (OECD, 2002) (figure 1.27). Mobile and industrial sources, which accounted for approximately 76% of the total emissions in 1980, accounted for only 69.9% of production in 1997. Reductions over this period were reported in the mobile sources (reduced by approximately 19%) while increases were reported by industrial sources.

United States

The United States has been more successful in its efforts to manage ozone. Ambient levels of ozone in the United States decreased 31.6% from 1980 to 2000 (figure 1.28).

Table 1.4: Percentage of stations with readings exceeding ozone standards

	1 hour objectives			Total #
	> Desirable	> Acceptable	> Tolerable	of stations
1977	95.1	78	14.6	41
1982	96	78	2	50
1987	93.4	54.1	3.3	61
1992	94.1	48.5	0	68
1997	97.9	56.7	0	141
1999	98.7	58.4	0	154
2001	97.5	46.9	0	166

Source: Environment Canada (2003), *National Air Pollution Surveillance (NAPS) Network Annual Summary for 2002.*

This is further reflected in data that estimate that VOC emissions also decreased by 14% from 1987 to 1999. Power generation, which remains the largest emission source by volume, decreased by 5% during this period but remains responsible for 49% of total VOC emissions. Solvents and industrial processes recorded the largest improvements by sources recording decreases of 36% and 24%, respectively.

Mexico

The limited data available for Mexico reveal mixed trends for ambient levels of ground level ozone within the cities examined (figure 1.30). Mexico City and Monterrey showed decreases of 12% and 4%, respectively, while Toluca recorded an increase of 20%. Unfortunately, no VOC emission data were available for Mexico.

Total suspended particulates

Suspended particulates are small pieces of dust, soot, dirt, ash, smoke, liquid vapour, or other matter in the atmosphere. Sources may include forest fires and volcanic ash as well as emissions from power plants, motor vehicles, waste incineration, and dust from mining.

Particulates are an irritant to lung tissue and may aggravate existing respiratory problems and cardiovascular diseases. Once lodged in the lungs, certain particulates may contribute to the development of lung cancer. The smallest particulates pose the greatest threat to human health because they are able to reach the tiniest passages of the lungs. Canada's National Ambient Air Quality Objectives (NAAQOs) exist only for total suspended particulates although they are being changed to reflect the importance of measuring the smallest particulates. The Canada-wide Accord on Environmental Harmonization in 1998 led to the development of Canada-wide standards for particulate matter. The new standard focuses on particulates smaller than 2.5 microns, known as PM-2.5. The recommended standard is 30 μg/m³ averaged over 24 hours, to be achieved by 2010. Some provinces have already developed provincial standards for PM-10 and PM-2.5 (Environment Canada, 2002).

Trends for total suspended particulates

Canada

Ambient levels of total suspended particulates (TSP) decreased by 54.2% from 1974 to 2001 (figure 1.31). Efforts to reduce suspended particulates have resulted in annualized concentrations that are well below NAAQO standards. In fact, TSP levels have remained well below the desirable standard of 60 μg/m³ since 1981. The data indicates that since 1990, over 87% of all stations have recorded annual means either at, or below, the desirable standard, while 100% of the stations met the acceptable standard.

Short-term concentrations also improved dramatically. In 1977, 81.7% of monitoring stations reported at least one reading in excess of the 1-hour maximum acceptable level, and 9.6% exceeded the 24-hour acceptable level. In contrast, 2001 showed 2.9% percent of stations to exceed the acceptable 1-hour objective while none of the stations exceeded the tolerable 24-hour levels (table 1.5).

City data also reflects this trend. From 1975 to 2001, each of the cities for which we have data recorded net reductions in ambient levels of TSP (figures 1.32, 1.33, 1.34). Quebec and Montreal showed the greatest improvements, with decreases of 73.2% and 70.3%, respectively.

Following a sharp reduction between 1980 and 1985, emissions estimates have since been steadily on the rise. Emissions have increased by 20% since 1985. Industrial processes accounted for 70% of total TSP emissions in 1980 but only 47.0% in 1996 (figure 1.35). Categories such as non-industrial combustion activities and miscellaneous sources, however, have reported increases during this time.

United States

From 1990 to 2001, ambient levels of PM-10 decreased by 8.2% in the United States (figure 1.36). All medium sized cities in the United States, except Buffalo, showed a marked decrease in PM-10 between 1990 and 1999 (figure 1.37). The average decrease was 28.1%. All four large cities showed decreases in concentrations of PM-10 over the same period (figure 1.38). The average decrease in large cities was 15.9%.

Table 1.5: Percentage of stations with readings exceeding total suspended particulate standards

	24 hour objectives		Total #
	> Acceptable	> Tolerable	of stations
1977	81.7	9.6	104
1982	66.1	2.8	109
1987	58	2	100
1992	46.1	0	89
1997	37.8	2.7	74
1999	51.9	7.4	54
2001	2.9	0	34

Source: Environment Canada (2003), *National Air Pollution Surveillance (NAPS) Network Annual Summary for 2002.*

Emissions levels in the United States have also exhibited a decreasing trend over the past decade (figure 1.39). During the period from 1980 to 1999, total emissions of PM-10 fell by 9%. Following a sharp reduction in the early 1990s, concentrations of PM-10 have continued to decline, although more gradually.

Mexico

Although available data for Mexico are very limited, ambient levels of TSP do appear to be declining, although it would be premature to calculate trends (figure 1.40). Unfortunately, no emissions data are available for Mexico.

Carbon monoxide

When fuel and other substances containing carbon burn without sufficient oxygen, carbon monoxide (CO), a highly toxic, colourless, odourless gas is produced. Trace amounts of CO occur naturally in the atmosphere but most emissions come from automobiles. Levels of CO are of particular concern to monitoring organizations because of their effect upon human health: CO reduces the capacity of red blood cells to carry oxygen to body tissues. Since CO poisoning occurs as a result of short-term exposure, health guidelines do not include annual recommendations for ambient CO levels. However, 8-hour and 1-hour guidelines are available.

Trends for carbon monoxide

Canada

Ambient levels of carbon monoxide have been dramatically reduced over the past three decades. From 1974 to 2001, ambient levels of CO registered a decrease of 82.6% (figure 1.41). These reductions have occurred despite a greater than 30% increase in total vehicle registrations over the same period (Statistics Canada, 2000: 121). The decreases in ambient CO represent Canada's second most effective campaign at eliminating pollutants, second only to decreases in lead.

The percentage of stations with readings exceeding short-term NAAQO levels has also decreased over the past two decades (table 1.6). Whereas 68.8% of stations had at least one reading exceeding the 1-hour desirable level in 1977, in 2001 zero stations recorded exceedences. Similarly, the percentage of stations exceeding the 8-hour desirable objective fell from 85.4% to zero over the same period. There have been no readings in excess of the 1-hour and 8-hour objectives since 1992.

City data reveal trends similar to the annual national means (figures 1.42, 1.43, 1.44). All cities, with the exception of Saint John, show net reductions in CO relative to 1974 levels. Most cities, including: Ottawa-Hull (89.1%), Quebec City (83.3%), Calgary (81.0%) and Vancouver (79.9%), show significant reductions.

Carbon monoxide emission estimates decreased 12.4% between 1970 and 1997 (figure 1.45). These reductions can partially be attributed to cleaner automobiles and more fuel-efficient industrial processes. To meet American motor-vehicle regulations adopted in the early 1970s, exhaust-gas recycling systems (EGRS) were installed and some older vehicles were retired. This led to vastly reduced emissions per vehicle. For example, North American cars built in 1993 emitted 90% less NO_x, 97% less hydrocarbons, and 96% less CO than cars built two decades earlier (Bast, Hill and Rue, 1994: 111). There has also been an 87.5% reduction in CO emissions from incinerators between 1980 and 1995. In 1995, the two main sources of CO emissions were transportation (39.2%) and open sources (primarily forest fires) (figure 1.45).

Table 1.6: Percentage of stations with readings exceeding carbon monoxide standards

	1 hour objectives		8 hour objectives			Total #
	> Desirable	> Acceptable	> Desirable	> Acceptable	> Tolerable	of stations
1977	68.8	4.2	85.4	12.5	4.2	48
1982	50	7.7	88.5	11.5	5.8	52
1987	22.6	0	54.7	5.7	3.8	53
1992	7.1	0	35.7	0	0	56
1997	4.3	0	17.4	0	0	46
1999	0	0	0	0	0	51
2001	0	0	0	0	0	84

Source: Environment Canada (2003), *National Air Pollution Surveillance (NAPS) Network Annual Summary for 2002.*

United States

Ambient levels of carbon monoxide in the United States have declined significantly over the past three decades (figure 1.46). During the period from 1980 to 2001, total ambient concentrations have fallen 61.8%, representing an average annual decrease of 4.28%.

Medium- and large-sized cities in the United States have shown equally impressive decreases in CO. Figure 1.47 shows that the trend between 1990 and 1999 in CO concentration in cities of medium size. The average decrease was 38.12%. Similarly, figure 1.48 shows that, for large cities, the average decrease was 39.22%.

Emissions levels in the United States have also decreased slightly, by 5.3% between 1987 and 1999 (figure 1.49). Mobile sources are responsible for 79.6% of carbon monoxide emissions in the United States and have consistently been the largest source of CO since measurement began.

Mexico

The limited data available for Mexico show that ambient levels of carbon monoxide have decreased overall (figure 1.50). In Mexico City, ambient levels of CO decreased 45.9% from 1989 to 1998. Guadalajara and Monterrey also reported decreases of 51.3% and 4.6%, respectively. CO emissions estimates were unavailable for Mexico.

Lead

Lead is a soft, dense, bluish-grey metal. Its high density, softness, low melting point, and resistance to corrosion make it useful in piping, batteries, weights, gunshot, and crystal. Until recently, automobiles were the source of most lead emissions although small quantities of lead are naturally present in the environment. Lead is the most toxic of the main air pollutants. When it is inhaled, it accumulates in the body's tissues. In high concentrations, it can cause damage to the nervous system and the brain, seizures, and behavioural disorders. In addition, recent evidence suggests that exposure to lead may be associated with hypertension and heart disease (USEPA, 1995: 2–6).

Because of lead's toxicity, environmental and health guidelines for lead are stricter than those for other air pollutants. Canada is committed to reducing levels as low as technologically feasible although no explicit objectives have been set. The maximum set by the World Health Organization (WHO) for the protection of human health is 1.0 μg/m^3.

Trends for lead

Canada

The decline in ambient lead concentration is the greatest success story in Canada's efforts to reduce air pollution. Ambient lead concentrations fell 94% in Canada between 1974 and 1998 (figure 1.51). Although the Canadian average has been below the WHO's standard throughout this period, it was not until 1982 that all but one individual station reported means below the health standard.[1] Levels in Canada are currently so low that most stations have discontinued monitoring lead levels.

Analysis of individual city recordings further supports evidence of declining concentrations of lead (figures 1.52, 1.53, 1.54). During the period from 1975 to 2001, all cities experienced net reductions in their recorded concentrations of lead.

United States

The trend of ambient lead concentrations in the United States have been similar to those in Canada. The maximum reading for ambient lead concentration in each annual quarter has decreased 92.3% between 1980 and 2001 (figure 1.55).

The trend in cities across the United States has been similar to the national average. Most cities have shown consistent downward trends in lead concentrations (figures 1.56, 1.57). The exceptions are Chicago, which has had an erratic trend, and Seattle, which had a large spike in 1998 but then had similar levels as other medium-sized cities in 1999.

Mexico

There is no equivalent data for lead available for comparison.

Note

1 The one exception is a station located in Quebec which is situated near a lead mine. When the mine reopened in 1997, the station's annual mean was 1.51 μg/m^3, though it declined to 0.77 μg/m^3 in 1999.

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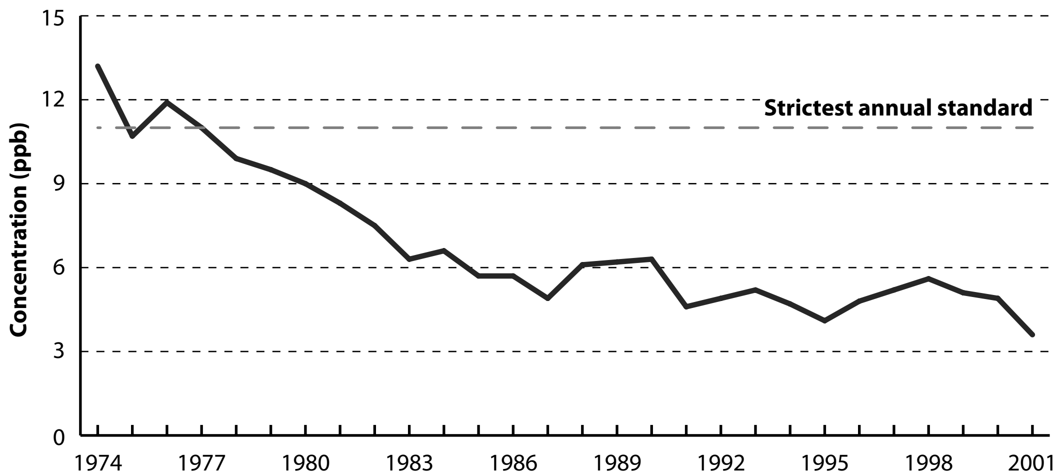
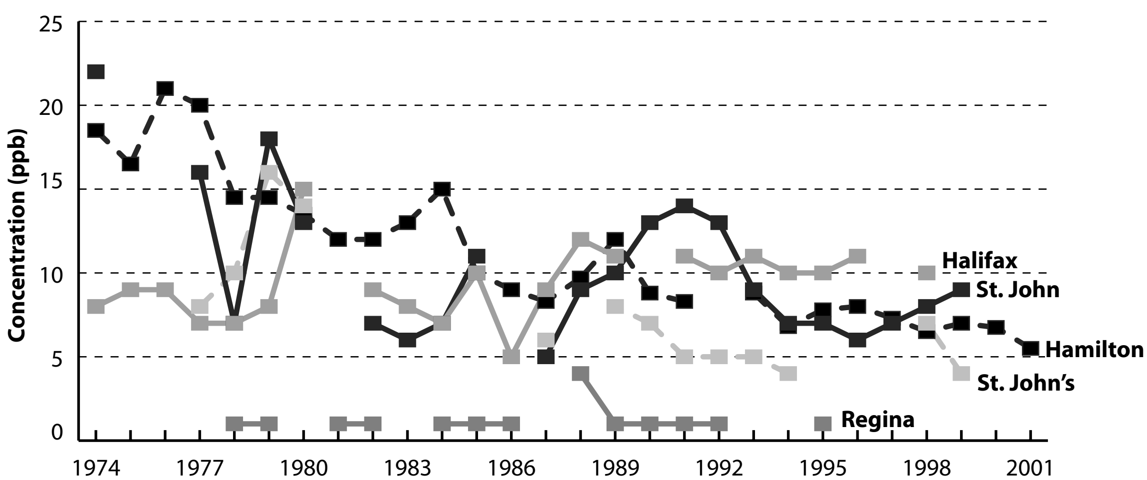
United States Environmental Protection Agency (1996). *National Air Quality and Emissions Trends Report, 1995*. Research Triangle Park, NC: USEPA.

Figure 1.1: Ambient levels of sulphur dioxide (ppb)



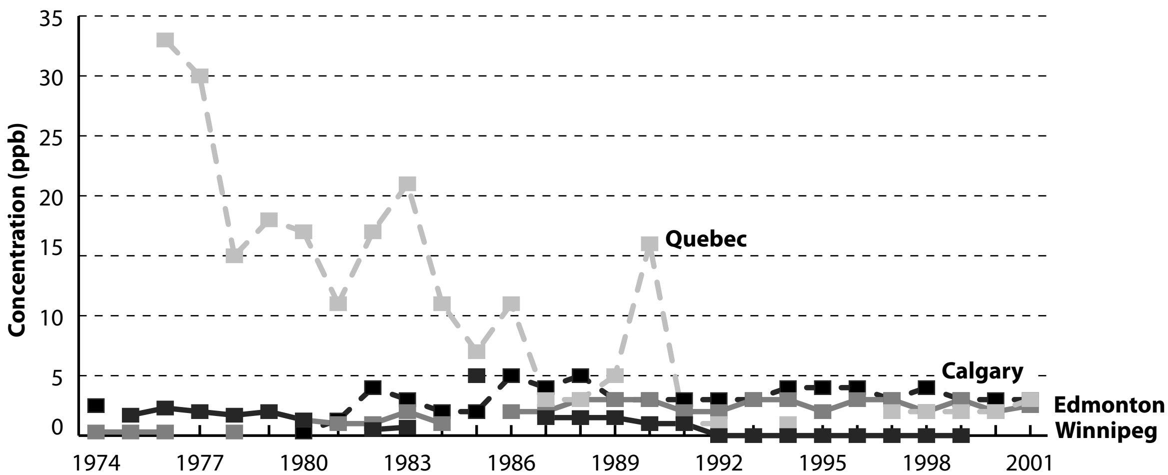
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data.*

Figure 1.2: Ambient levels of sulphur dioxide—small cities, 1974–2001



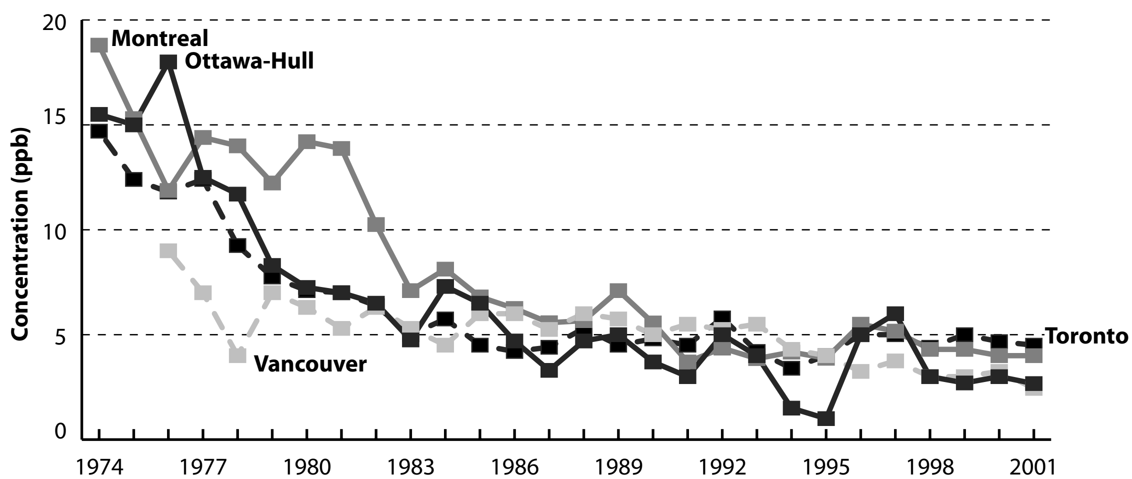
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data.*

Figure 1.3: Ambient levels of sulphur dioxide—medium cities, 1974–2001



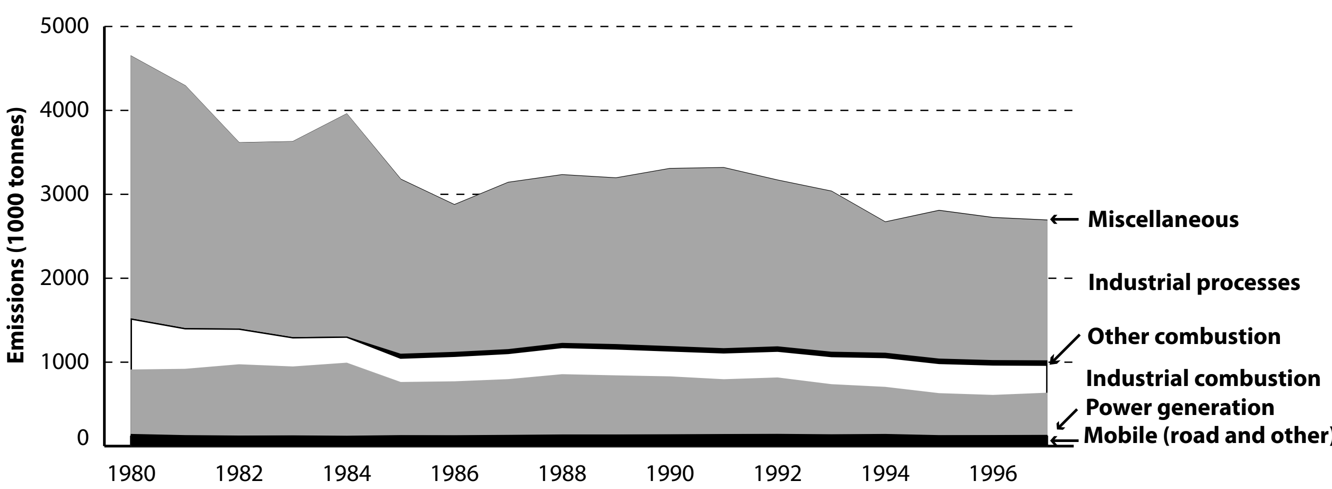
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.4: Ambient levels of sulphur dioxide—large cities, 1974–2001



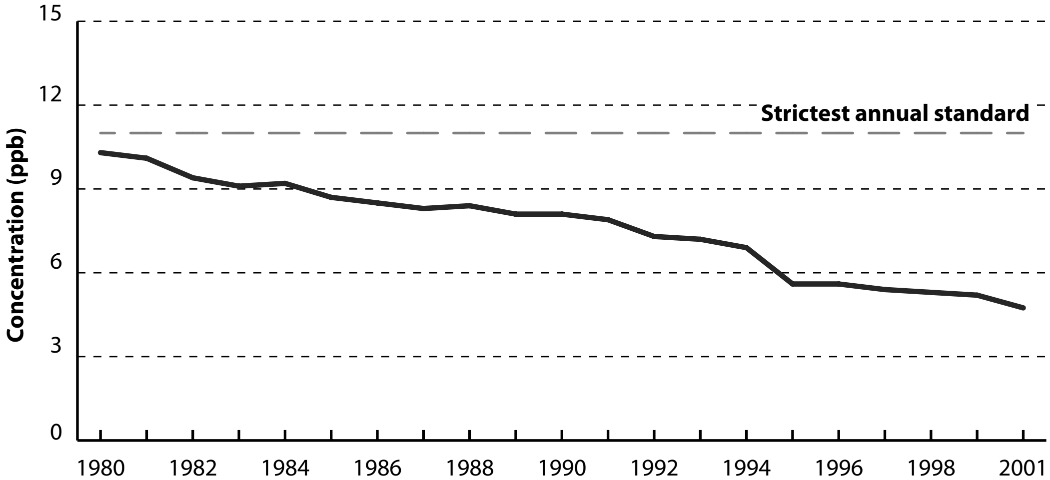
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.5: Sulphur oxides emissions, by source, 1980–1997



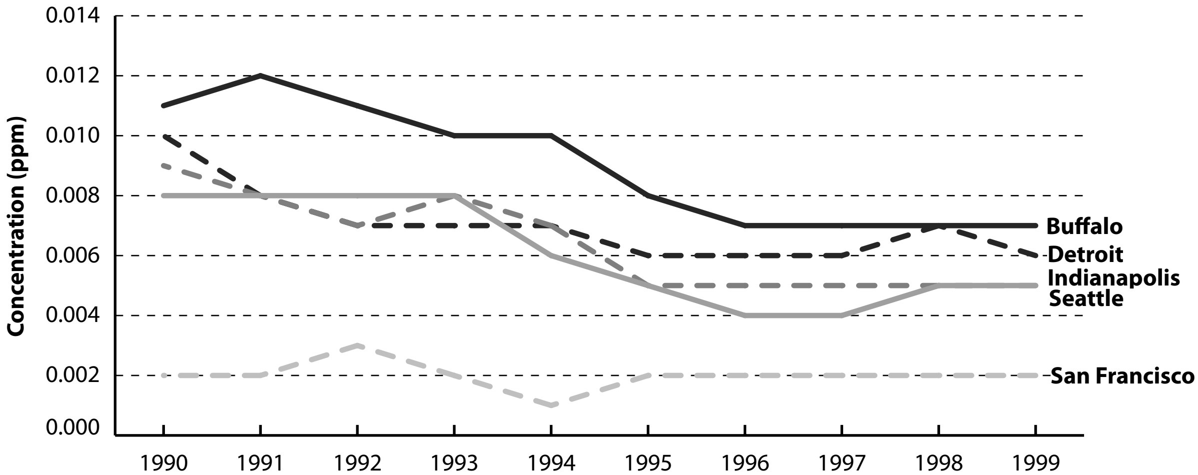
OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 1.6: US ambient levels of sulphur dioxide (ppb)



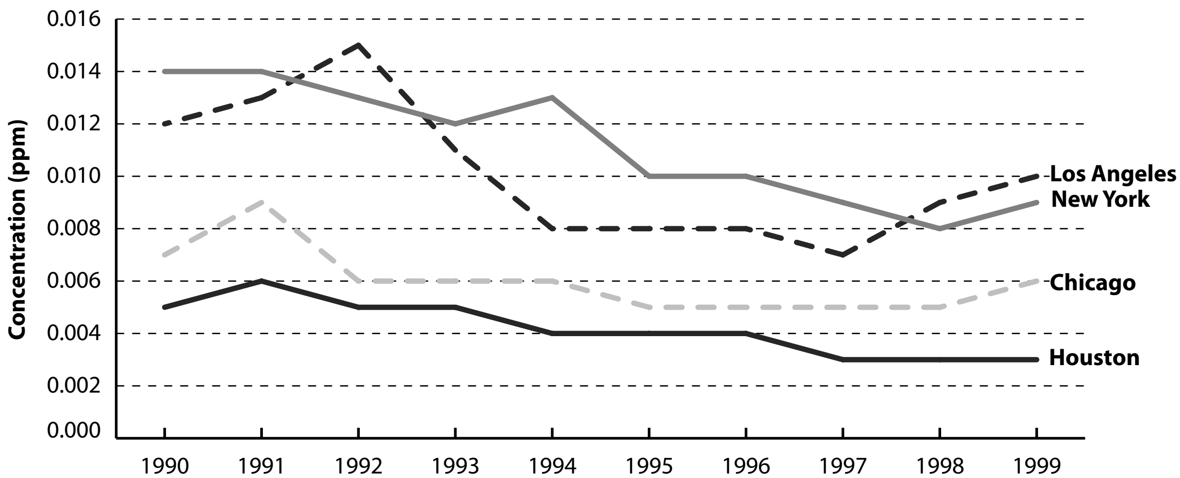
Source: *EPA National Air Quality and Emissions Trend Report 1999*; *EPA National Air Quality: 2001 Status and Trends Report* (for 2001 values).

Figure 1.7: US sulphur dioxide ambient concentrations—select medium cities



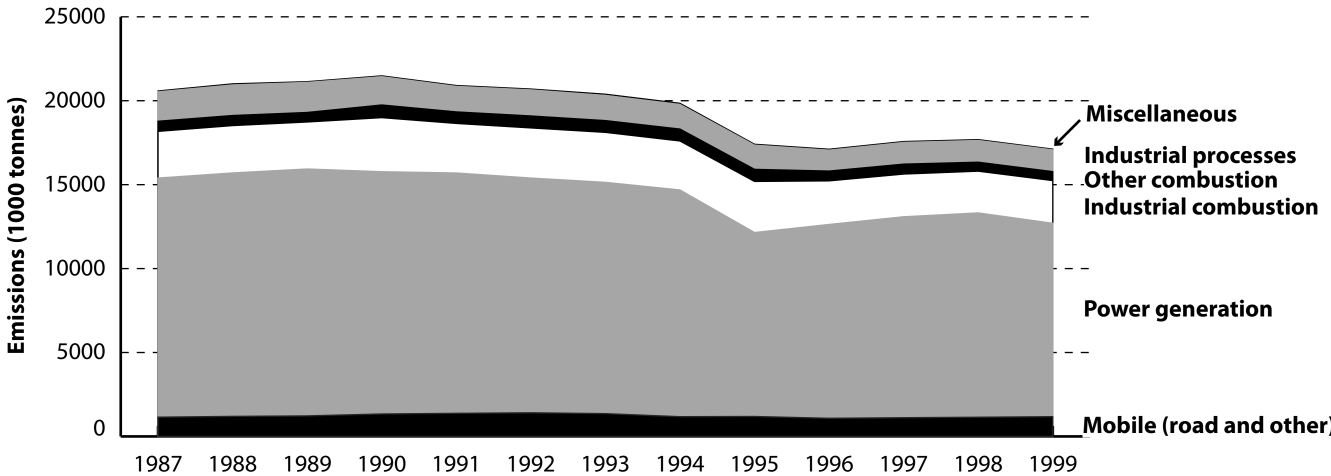
Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.8: US sulphur dioxide ambient concentrations—select large cities



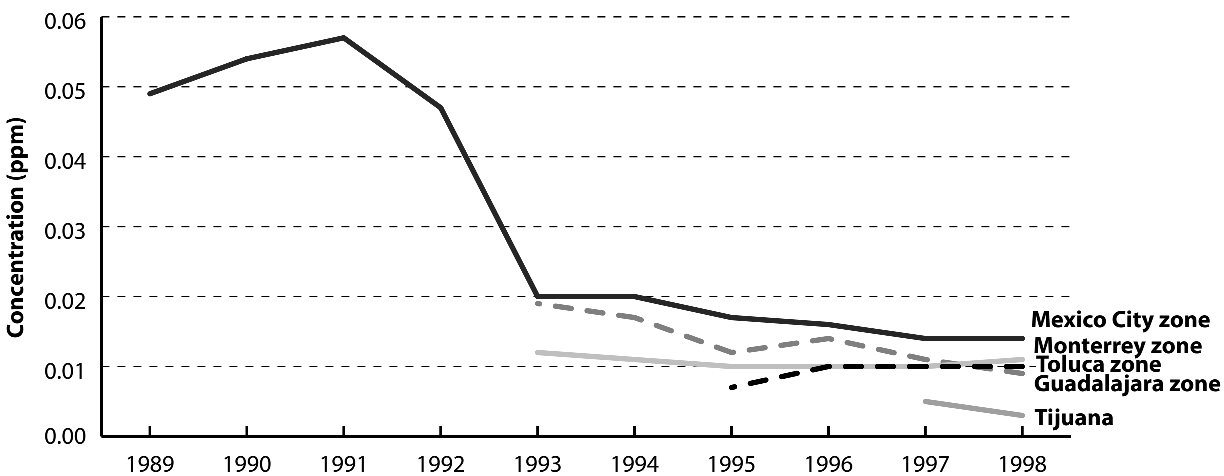
Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.9: US sulphur dioxide emissions by source, 1999



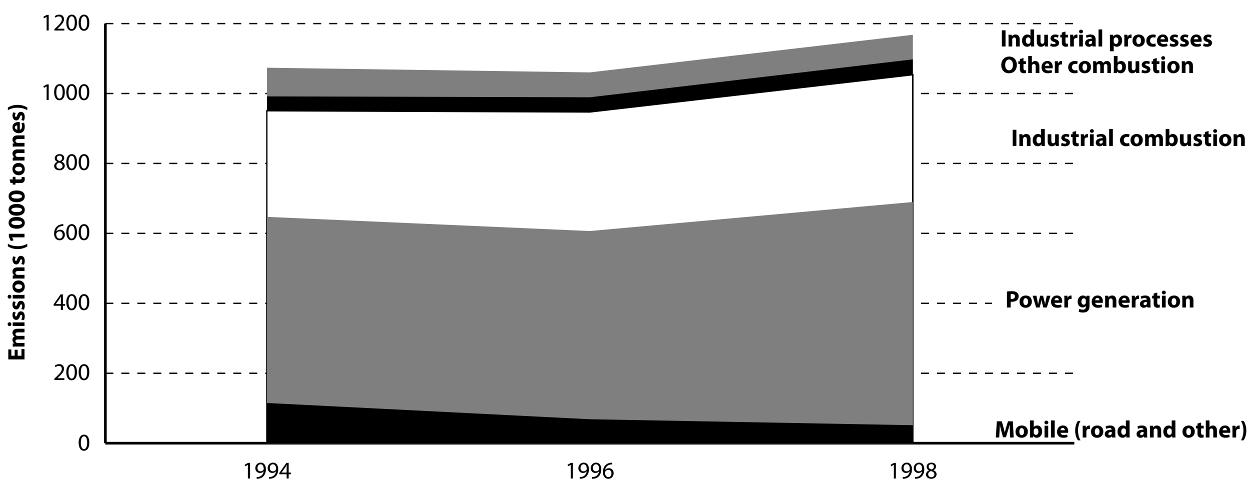
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 1.10: Mexican annual ambient sulphur dioxide concentrations



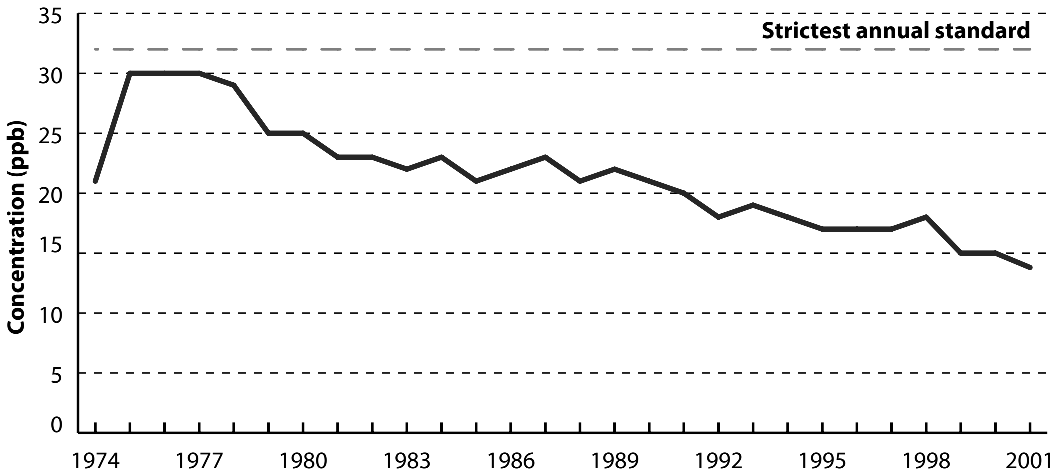
Source: SEMARNAP (1999), *Instituto Nacional de Ecología, 1999.*

Figure 1.11: Mexican sulphur dioxide emissions by source



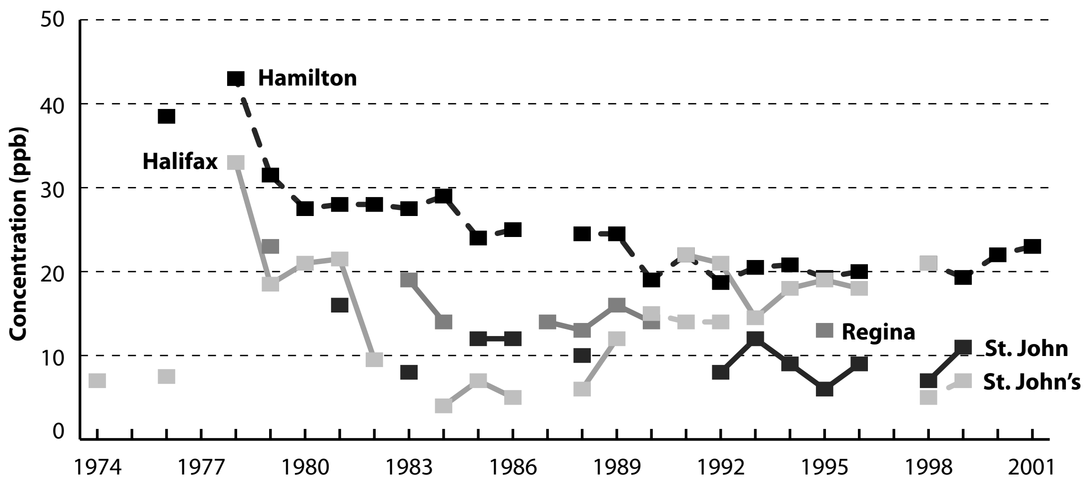
Source: Organisation for Economic Cooperation and Development (2002), *Environmental Data Compendium 2002*.

Figure 1.12: Ambient levels of nitrogen dioxide (ppb)



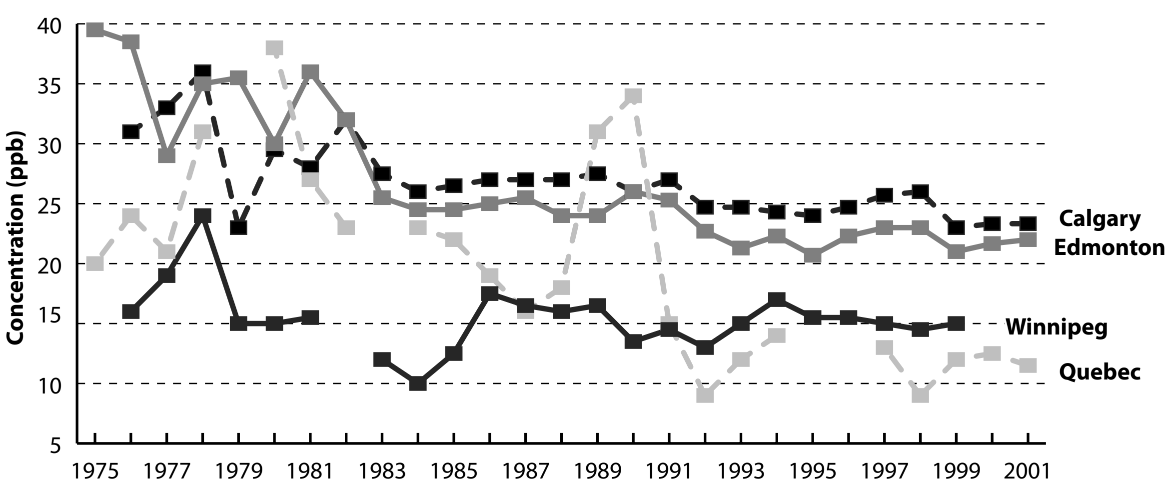
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.13: Nitrogen dioxide—small cities, 1974–2001



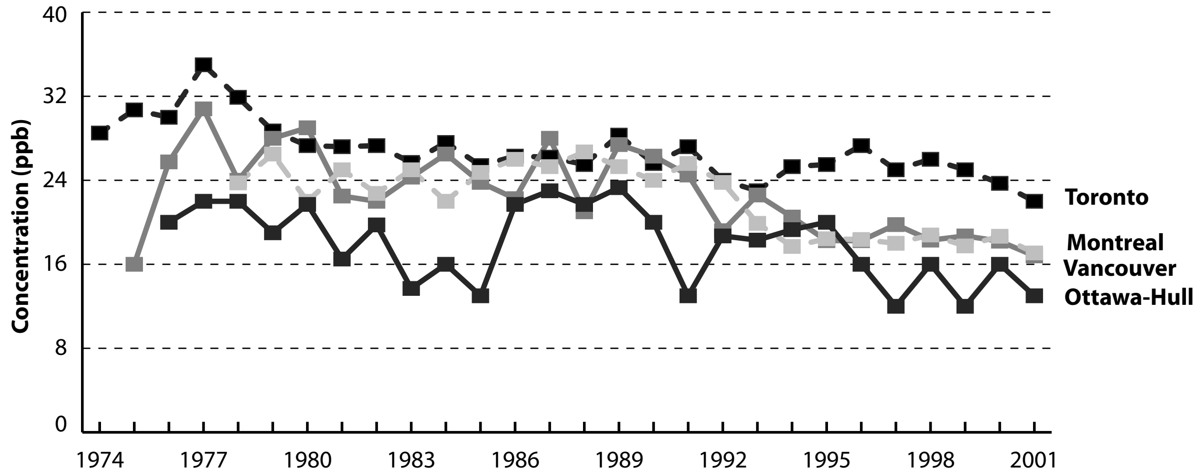
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.14: Nitrogen dioxide—medium cities, 1974–2001



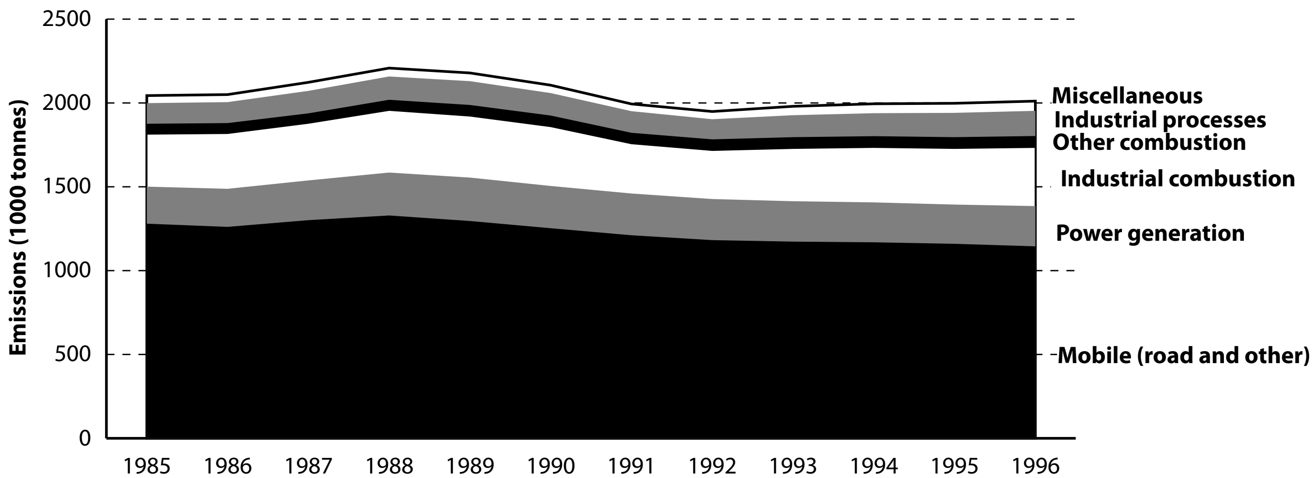
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.15: Nitrogen dioxide—large cities, 1974–2001



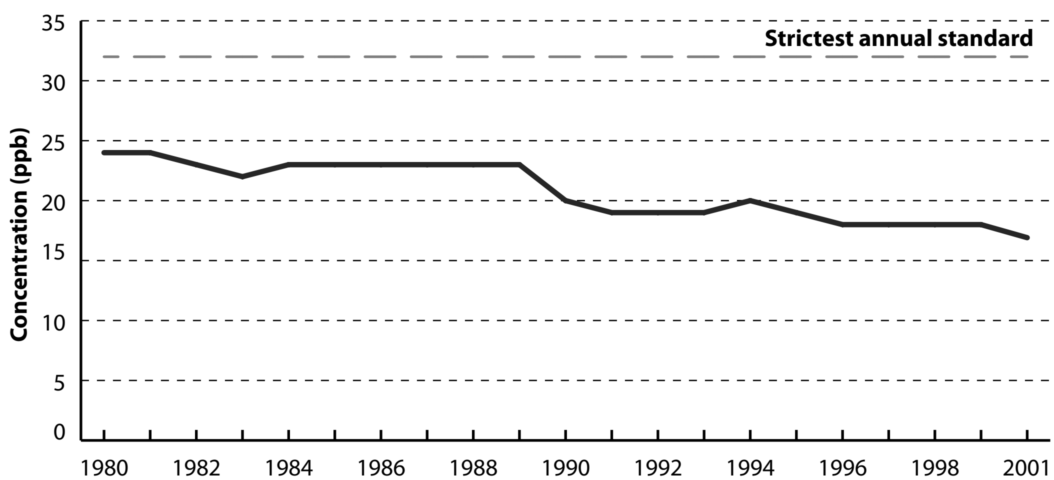
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.16: Nitrogen oxides emissions, by source, 1985–1996



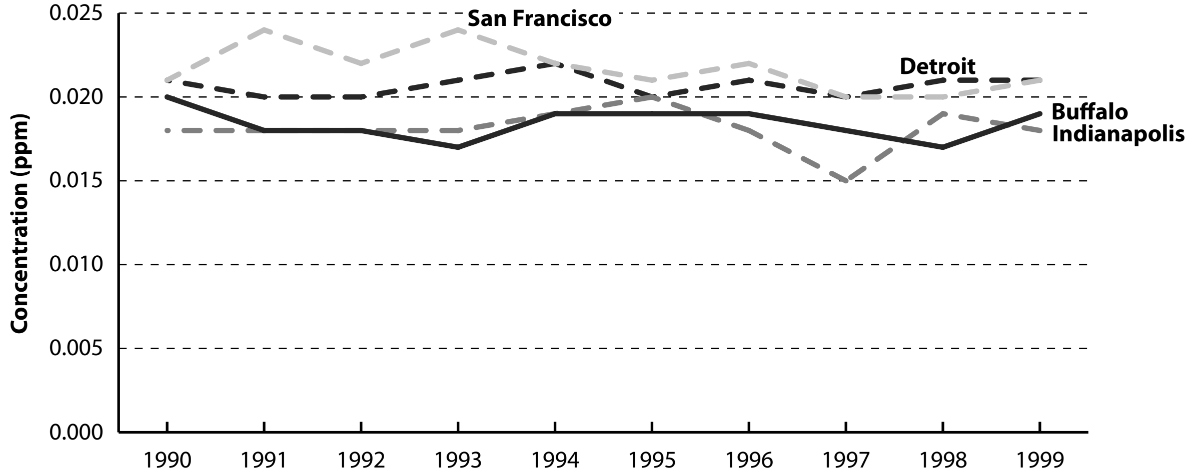
Source: Organisation for Economic Cooperation and Development (2002), *Environmental Data Compendium 2002*.

Figure 1.17: US ambient levels of nitrogen dioxide (ppb)



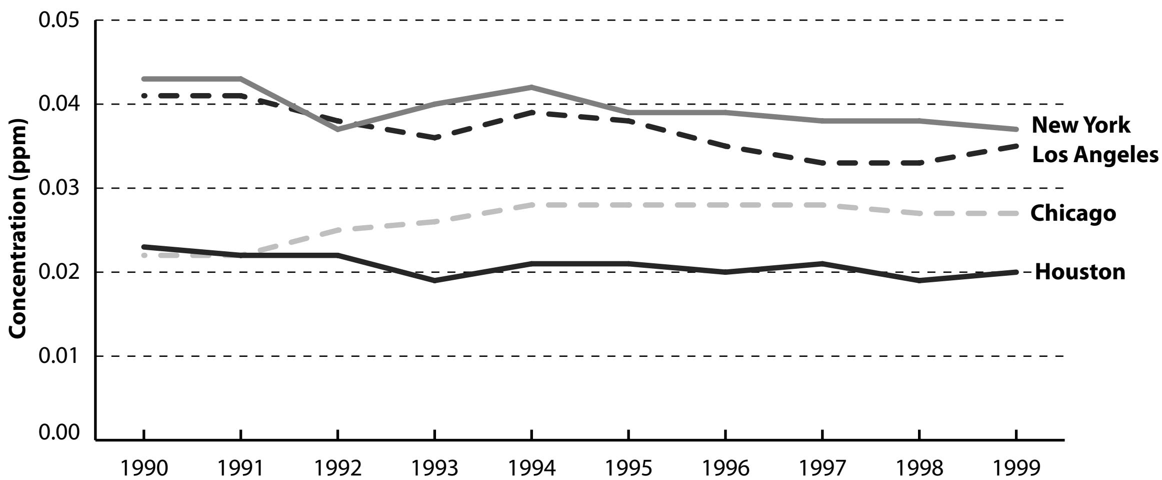
Source: *EPA National Air Quality and Emissions Trend Report 1999*; *EPA National Air Quality: 2001 Status and Trends Report* (for 2001 values).

Figure 1.18: US nitrogen dioxide ambient concentrations—select medium cities



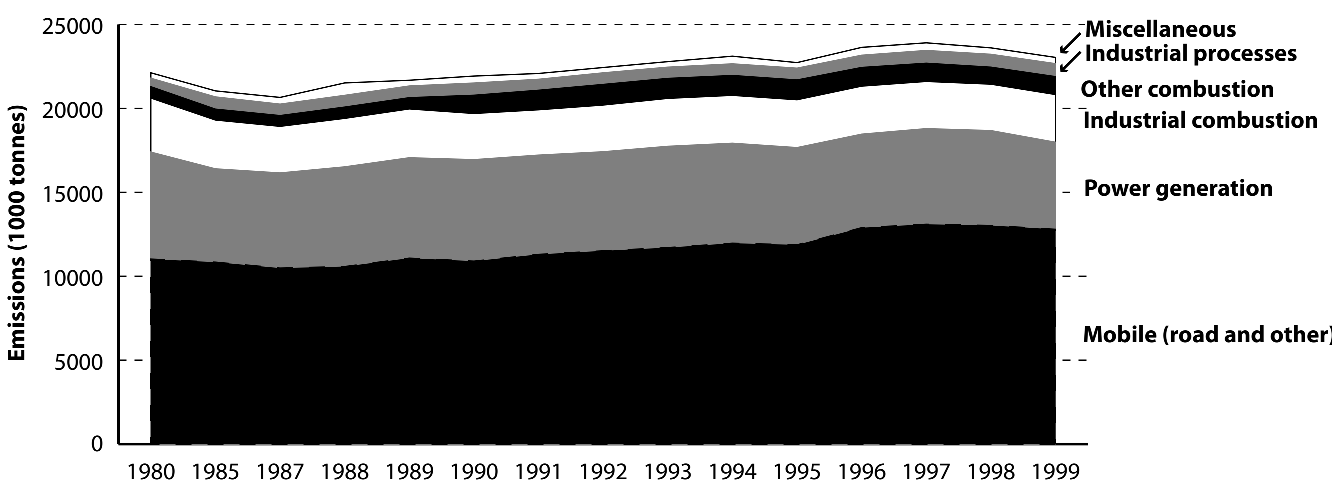
Source: *EPA National Air Quality and Emissions Trend Report 1999*.

Figure 1.19: US nitrogen dioxide ambient concentrations—select large cities



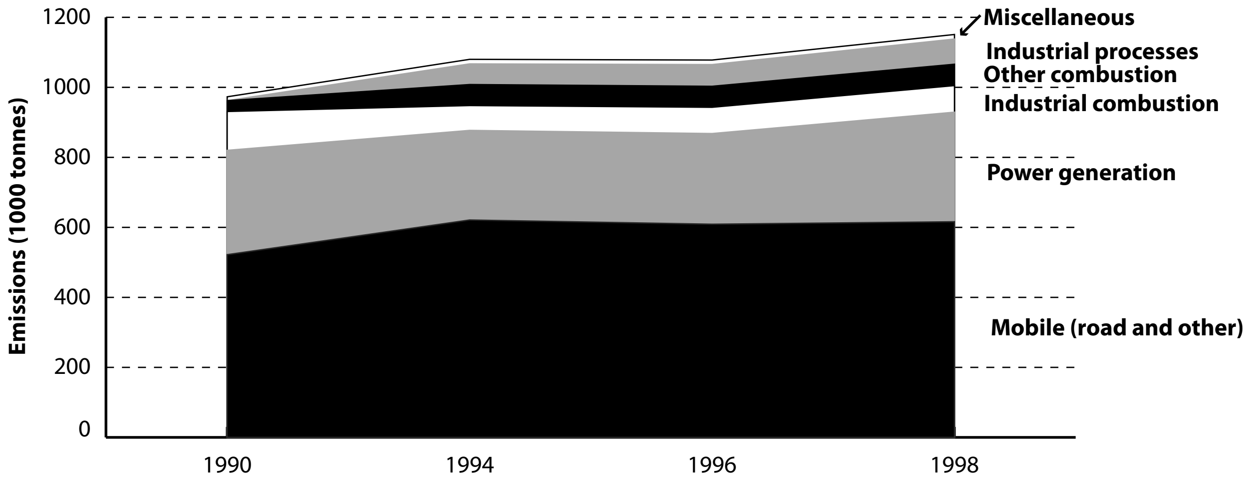
Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.20: US nitrogen dioxide emissions by source, 1980–1999



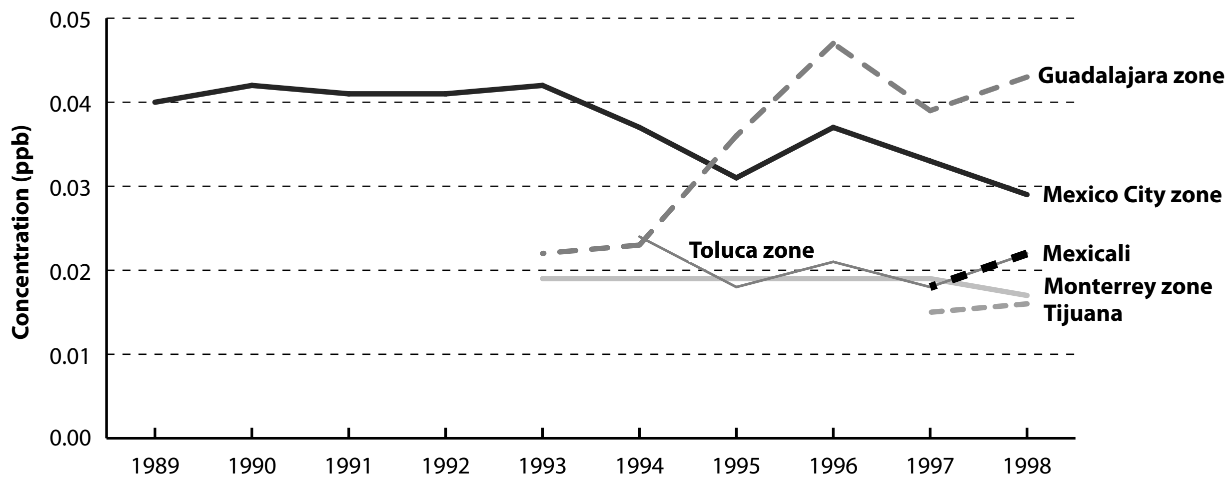
Source: Organisation for Economic Cooperation and Development (2002), *Environmental Data Compendium 2002*.

Figure 1.21: Mexican nitrogen oxides emissions by source



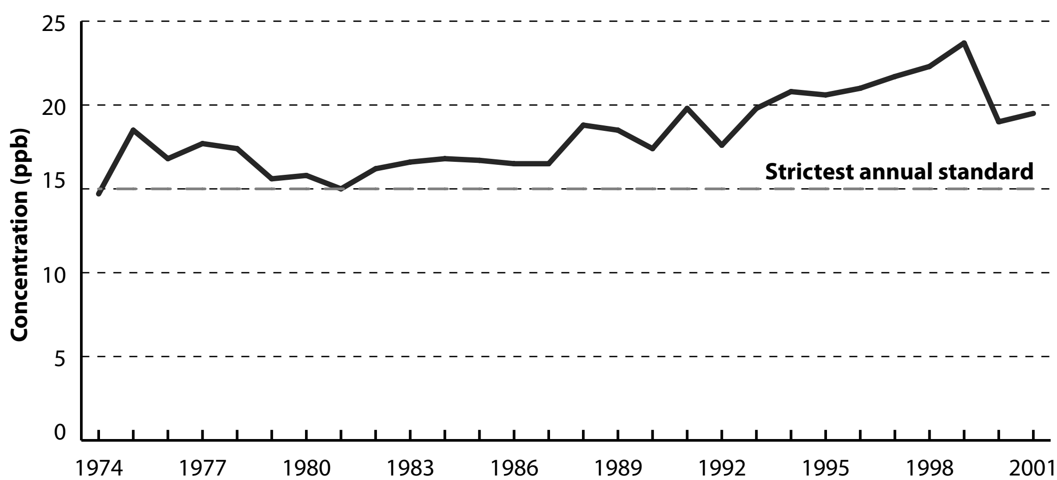
Source: SEMARNAP (1999), *Instituto Nacional de Ecología, 1999*.

Figure 1.22: Mexican annual nitrogen dioxide ambient concentrations (ppb)



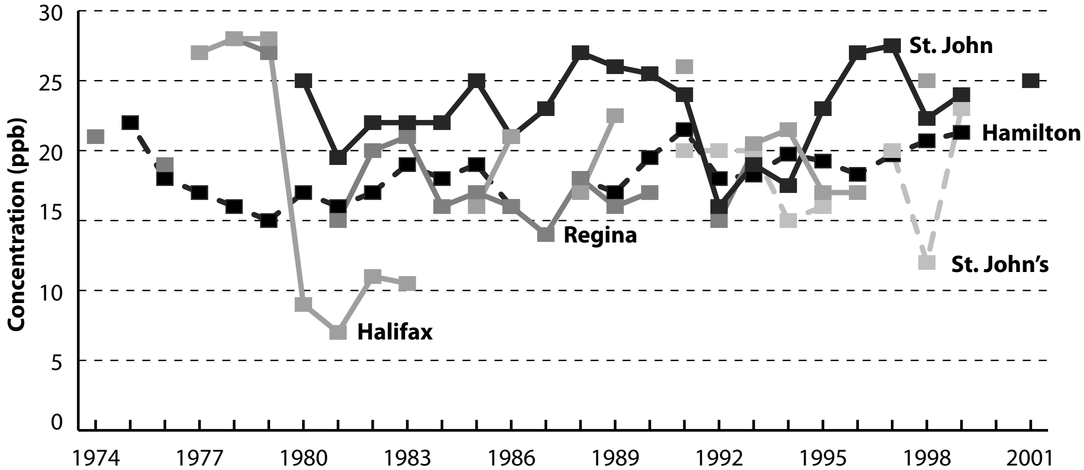
Source: SEMARNAP (1999), *Instituto Nacional de Ecología, 1999*.

Figure 1.23: Ambient levels of ozone (ppb)



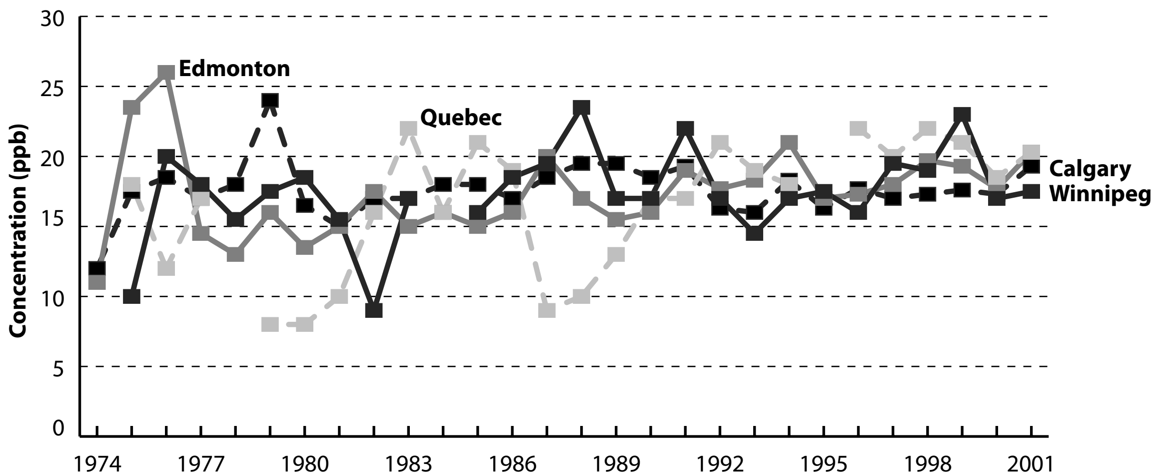
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.24: Ozone—small cities, 1974–2001



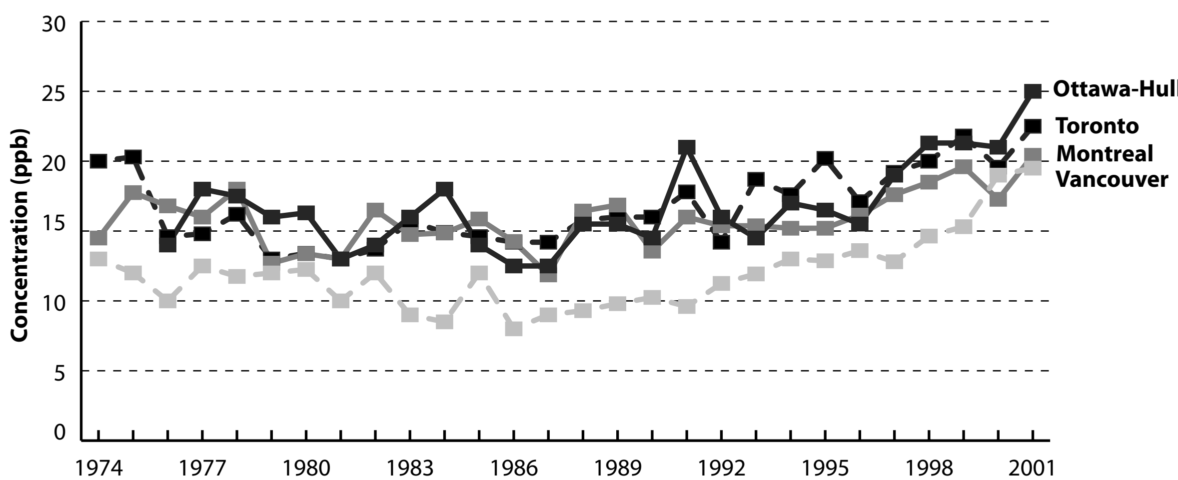
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.25: Ozone—medium cities, 1974–2001



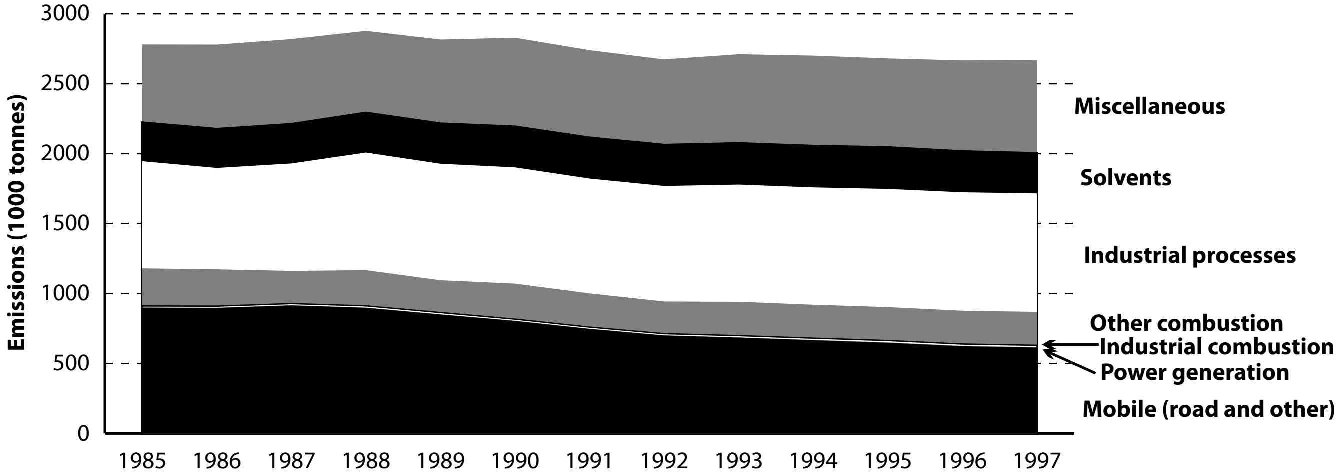
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.26: Ozone—large cities, 1974–2001



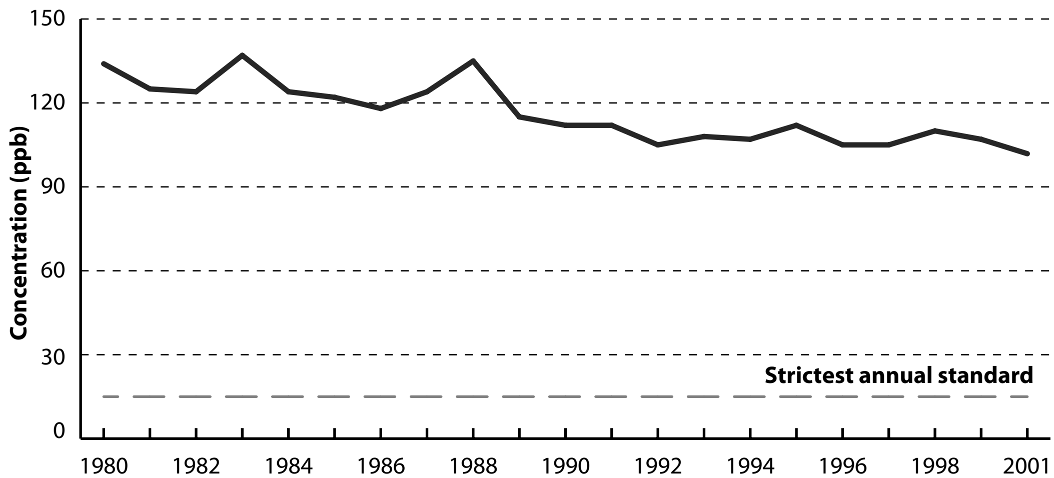
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.27: VOC emissions by source, 1985–1997



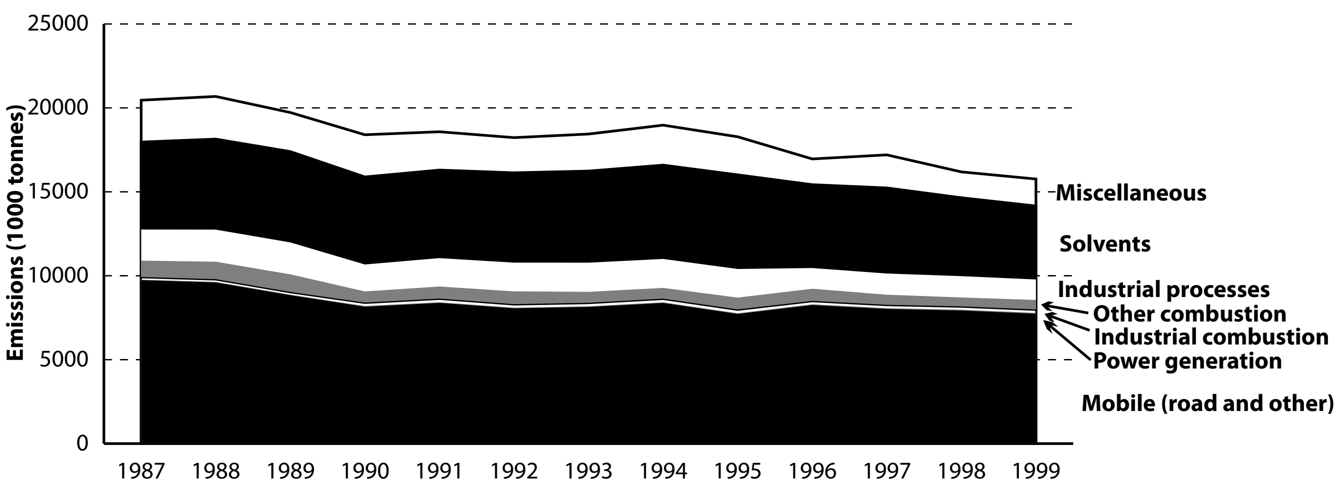
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 1.28: US ambient levels of Ozone (ppb)



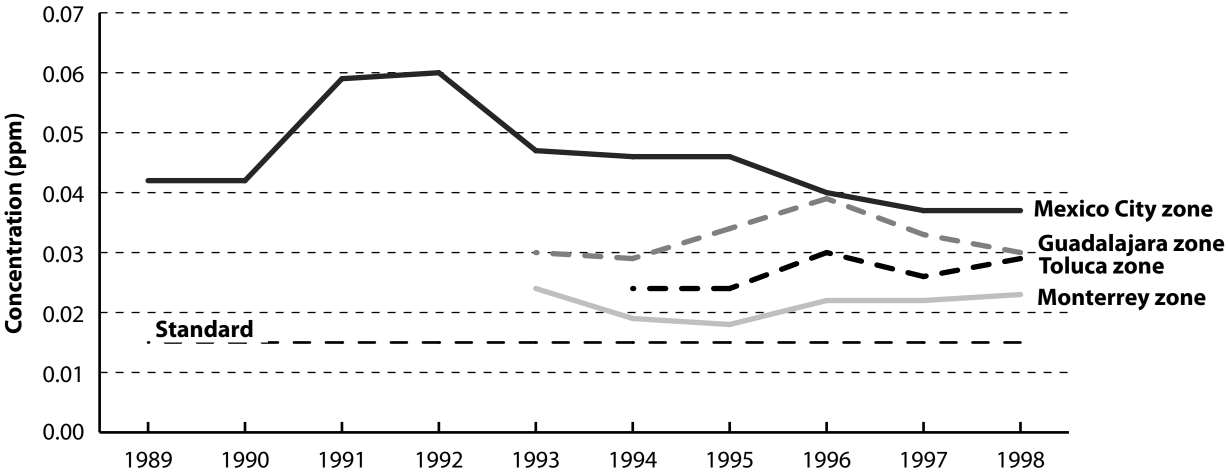
Source: *EPA National Air Quality and Emissions Trend Report 1999*; *EPA National Air Quality: 2001 Status and Trends Report* (used to derive the 2001 values).

Figure 1.29: US VOC emissions by source, 1987–1999



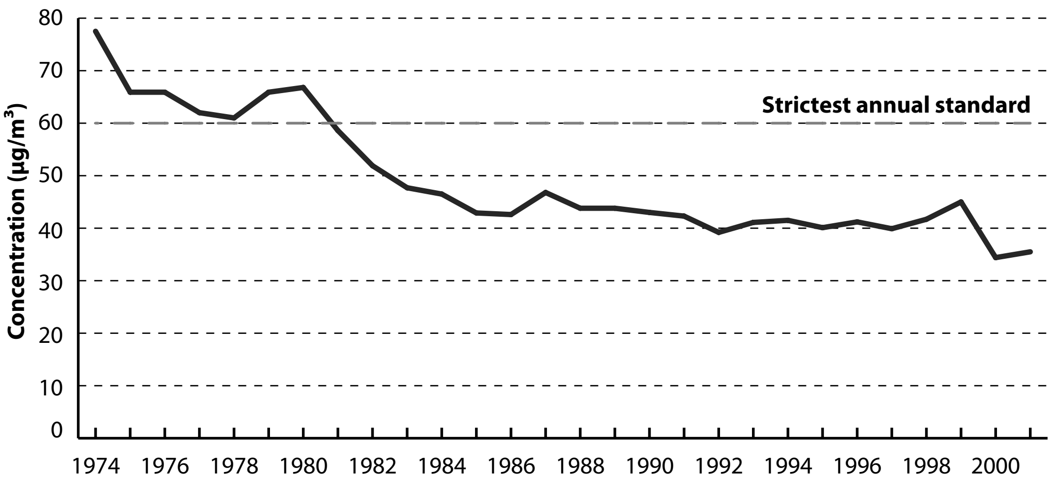
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 1.30: Mexican annual ambient ozone concentrations (ppm)



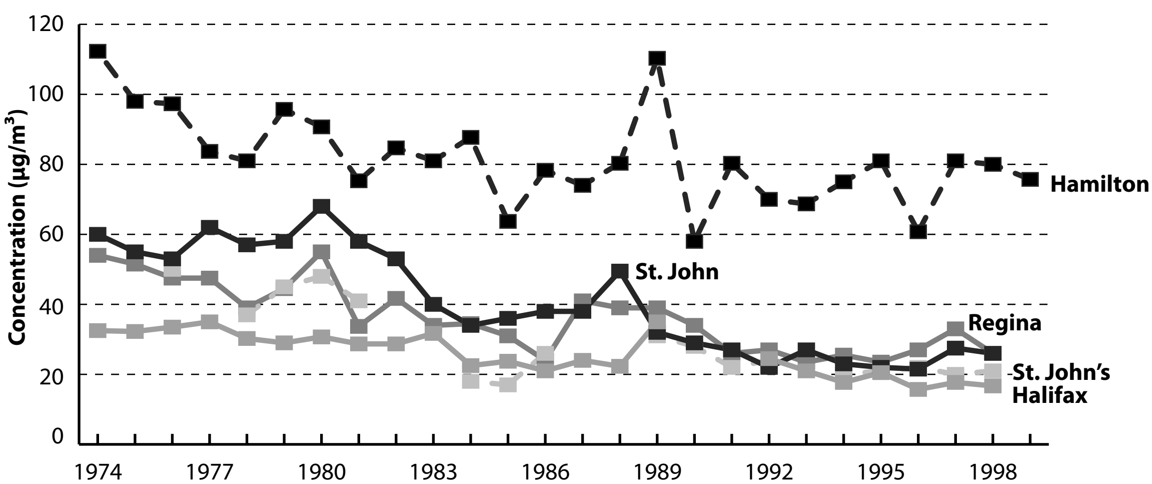
Source: SEMARNAP (1999), *Instituto Nacional de Ecología, 1999*.

Figure 1.31: Ambient levels of suspended particulates



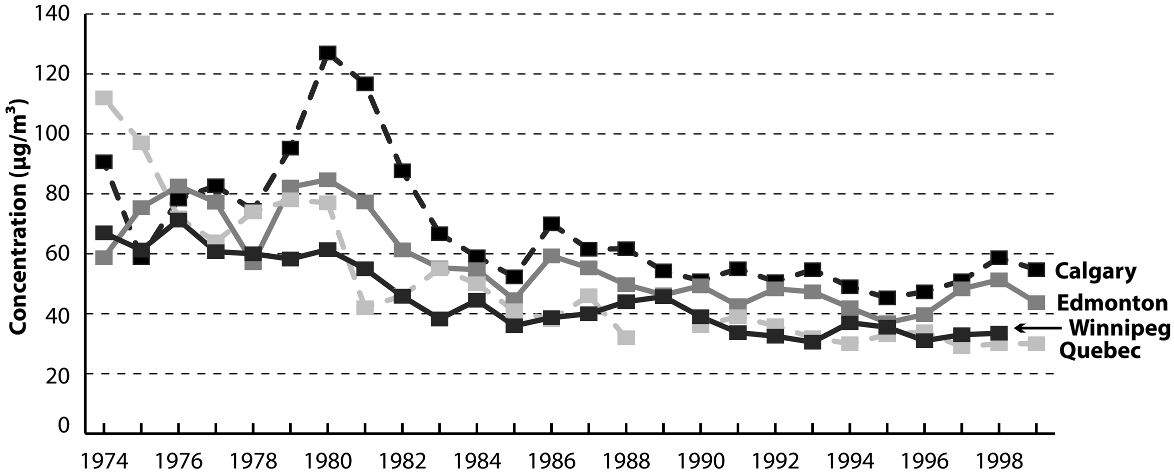
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.32: Total suspended particulates—small cities, 1974–1999



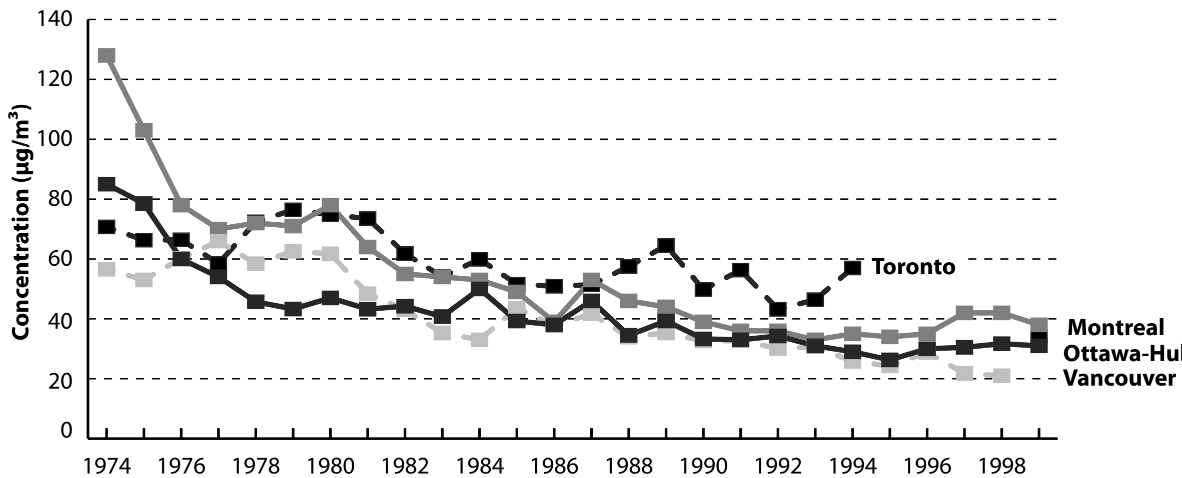
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.33: Total suspended particulates—medium cities, 1974–199



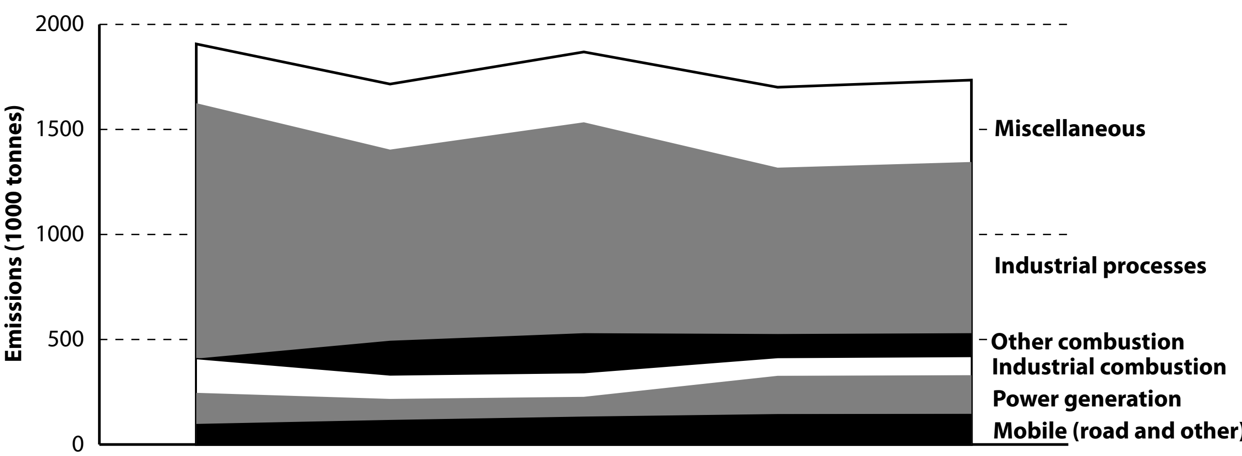
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.34: Total suspended particulates—large cities, 1974–2001



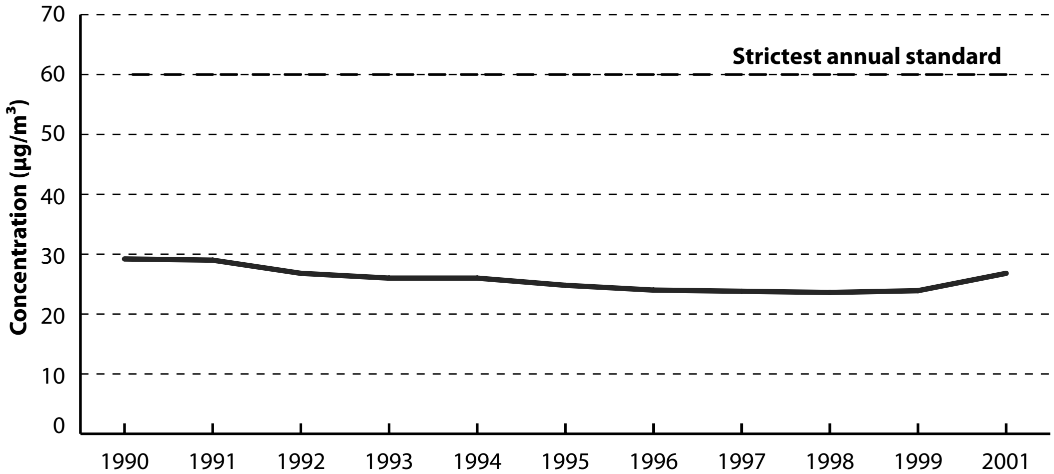
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.35: Total suspended particulates by source, 1980–1996



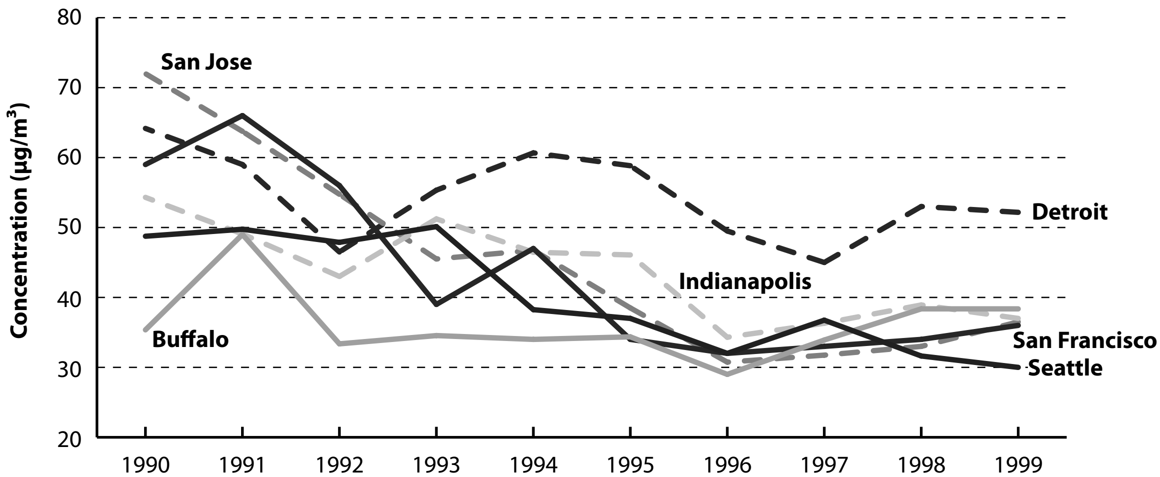
Source: Organisation for Economic Cooperation and Development (2002), *Environmental Data Compendium 2002*.

Figure 1.36: US ambient levels of PM-10



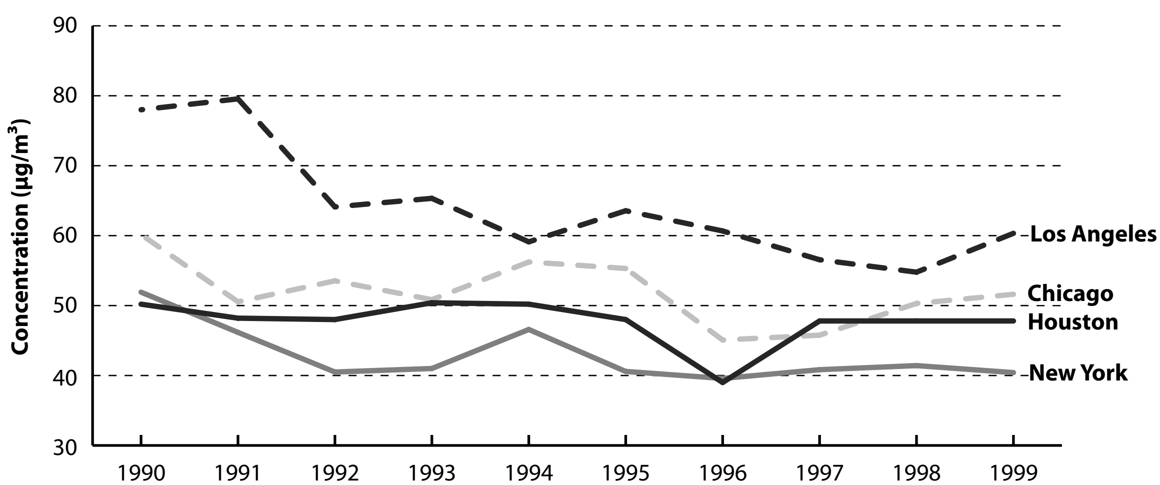
Source: *EPA National Air Quality and Emissions Trend Report 1999*; *EPA National Air Quality: 2001 Status and Trends Report* (for 2001 values).

Figure 1.37: US PM-10 ambient concentration—select medium cities



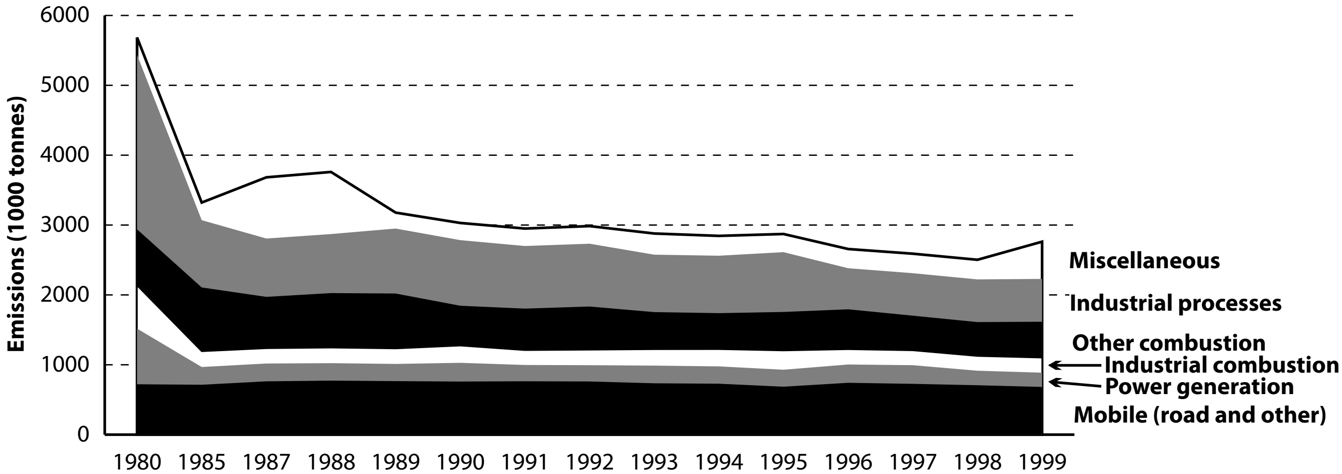
Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.38: US PM-10 ambient concentration—select large cities



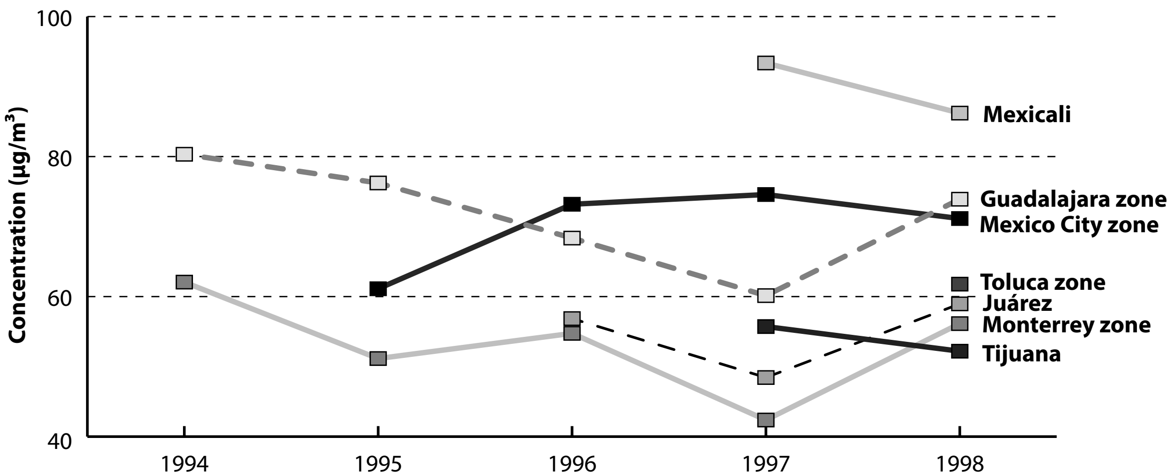
Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.39: US total suspended particulates emission estimates by source



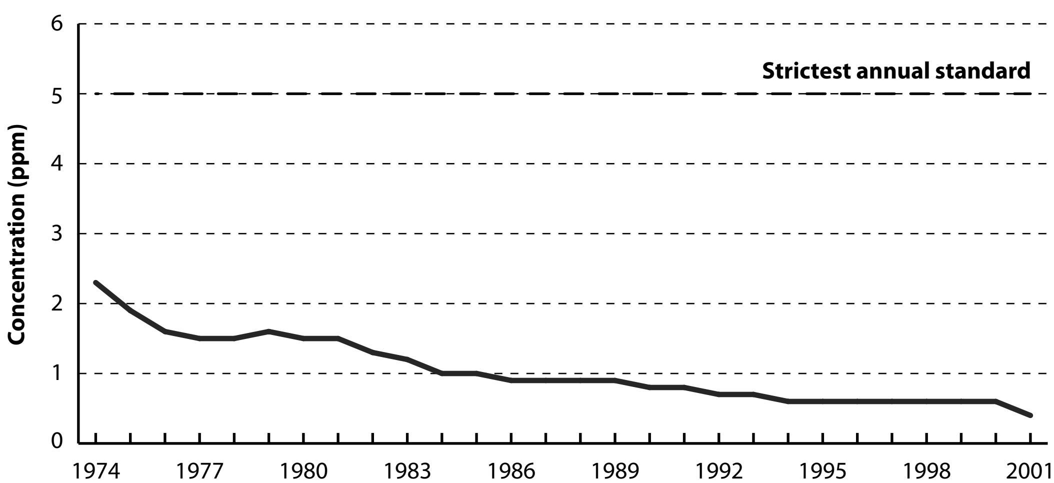
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 1.40: Mexican annual ambient PM-10 concentrations



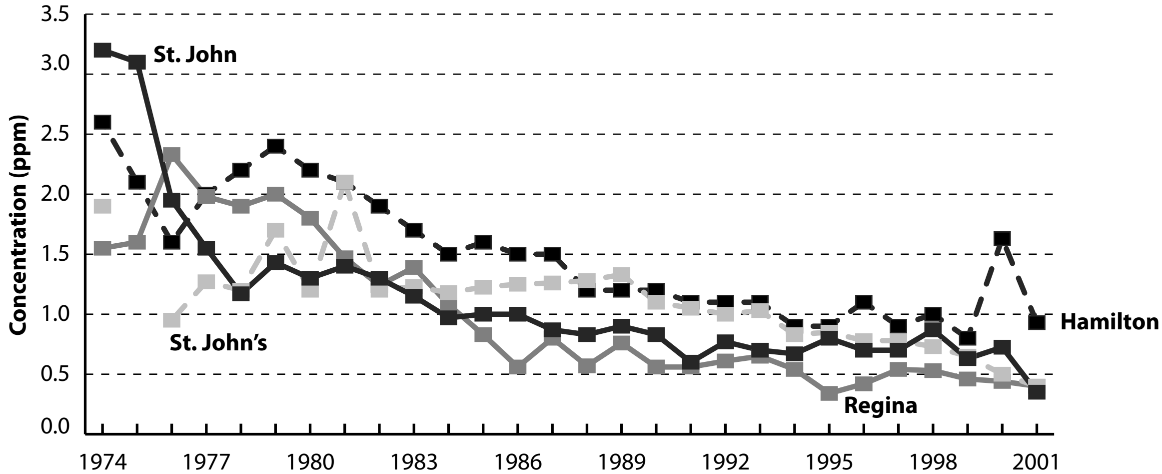
Source: SEMARNAP (1999), *Instituto Nacional de Ecología, 1999*.

Figure 1.41: Ambient levels of carbon monoxide



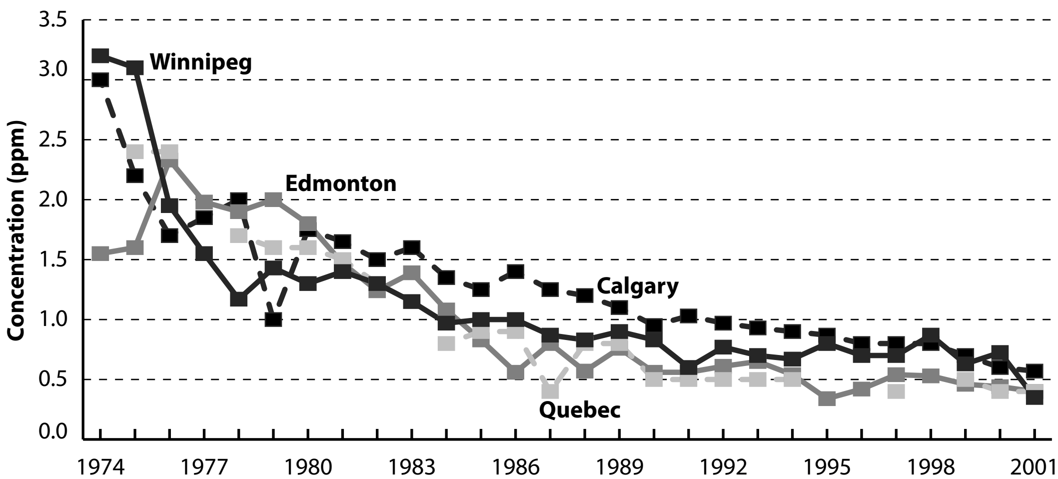
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.42: Carbon monoxide—small cities, 1974–2001



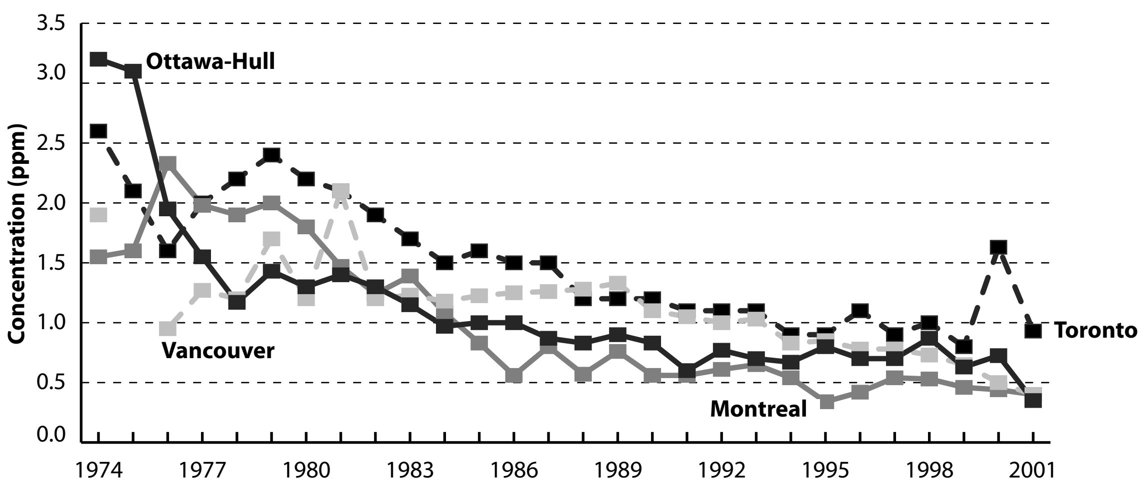
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.43: Carbon monoxide—medium cities, 1974–2001



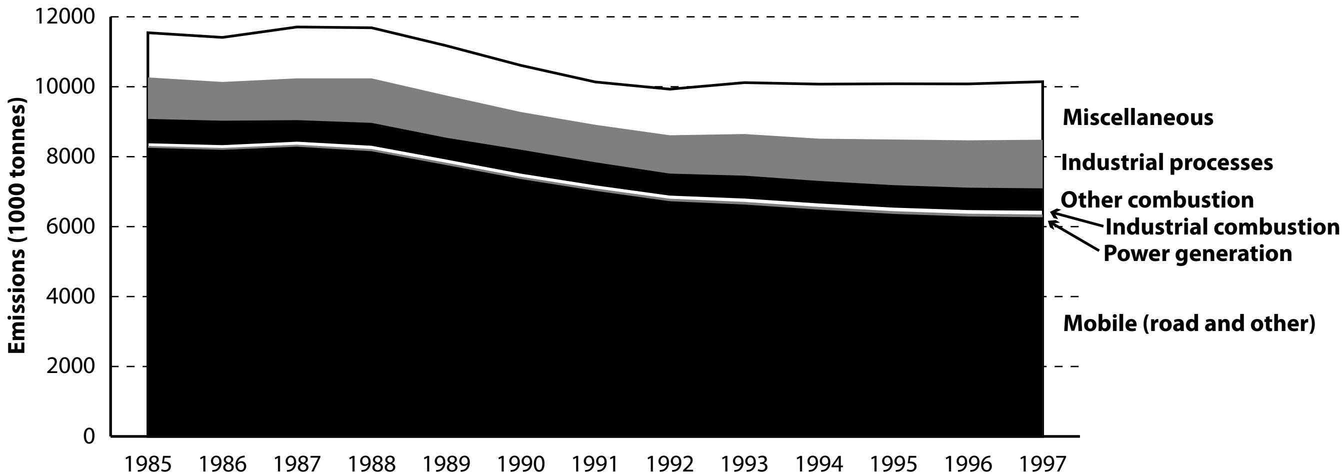
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.44: Carbon monoxide—large cities, 1974–2001



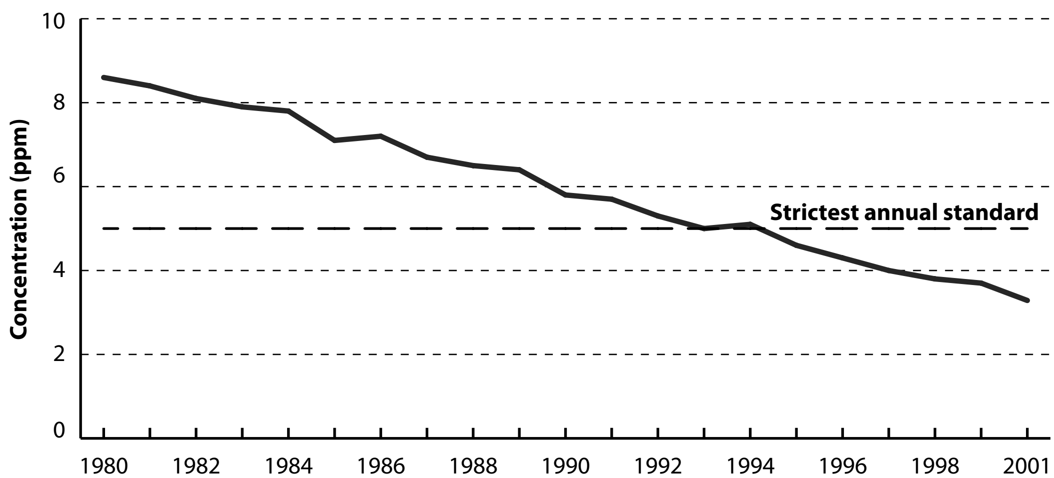
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.45: Carbon monoxide emissions by source



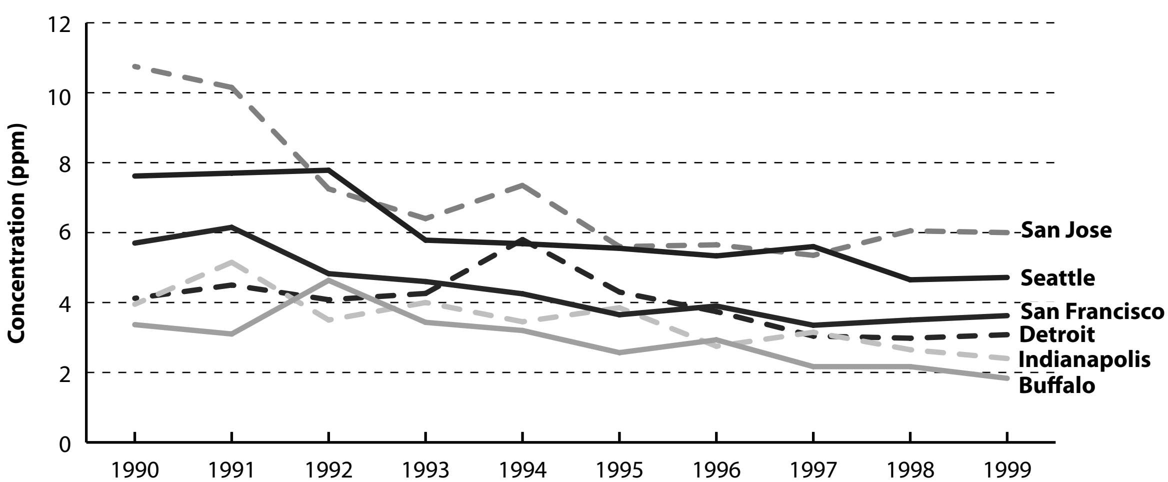
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 1.46: US ambient levels of carbon monoxide



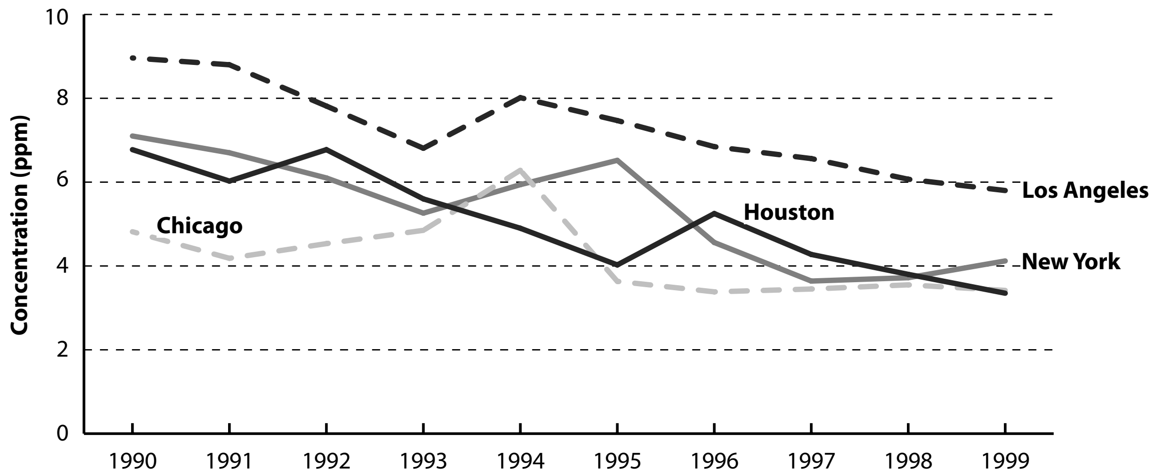
Source: *EPA National Air Quality and Emissions Trend Report 1999*; *EPA National Air Quality: 2001 Status and Trends Report* (used to derive the 2001 values).

Figure 1.47: US carbon monoxide ambient concentrations—select medium cities



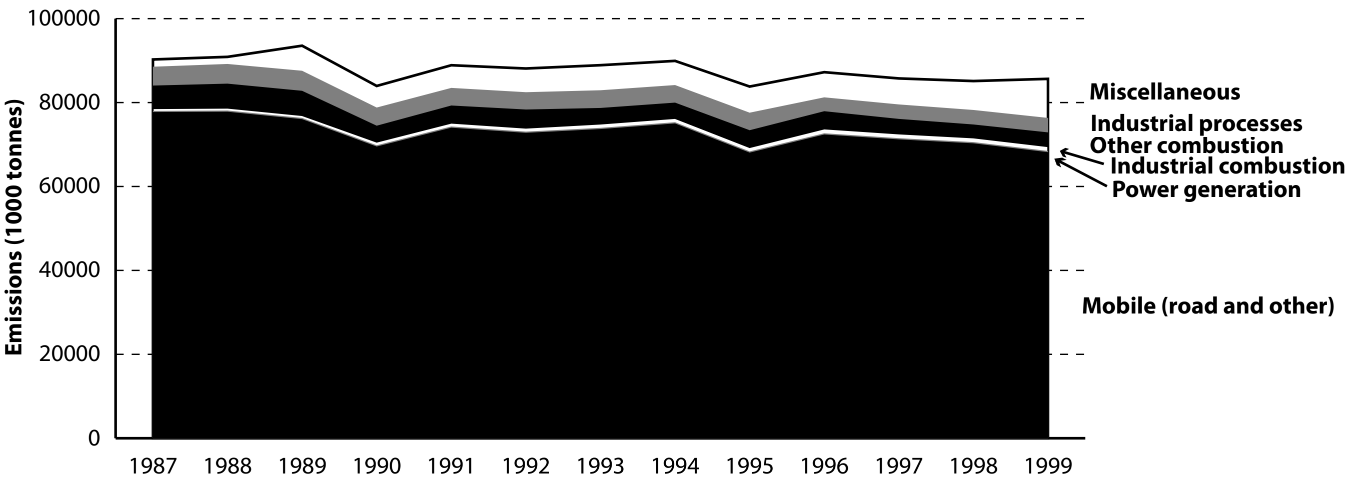
Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.48: US carbon monoxide ambient concentrations—select large cities



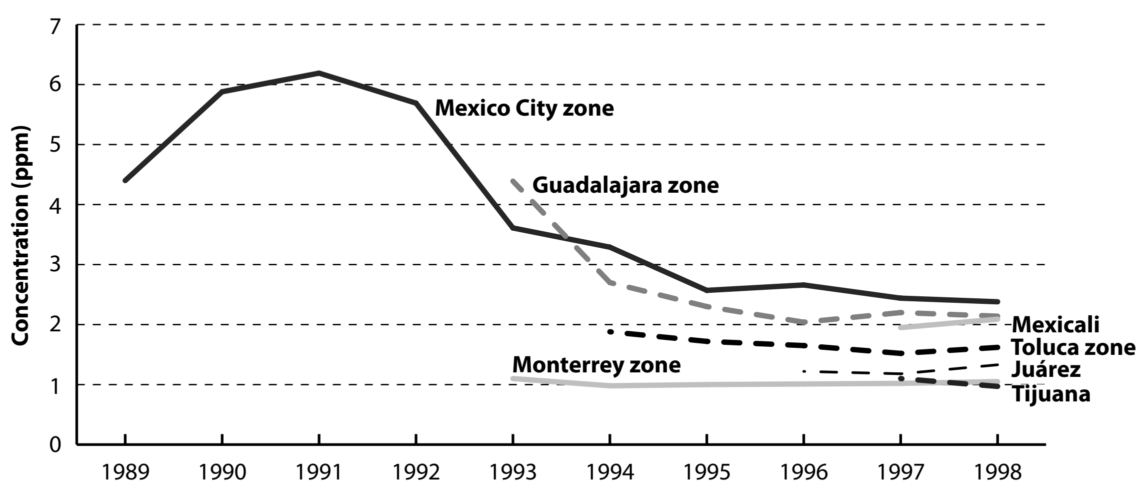
Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.49: US carbon monoxide emissions, 1987–1999



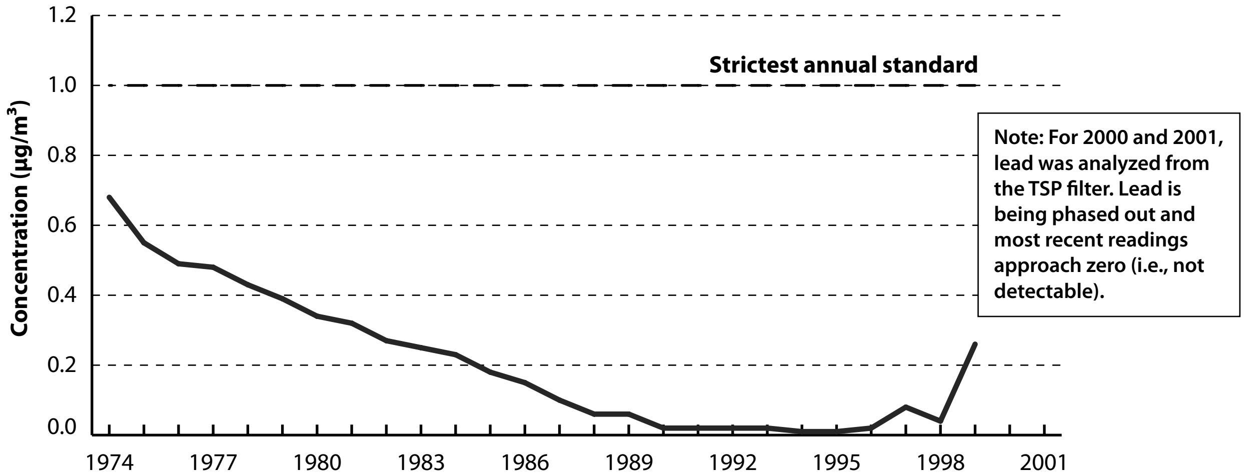
Source: OECD (2002), *OECD Environmental Data Compendium 2002.*

Figure 1.50: Mexican annual ambient carbon monoxide concentrations, 1989–1998



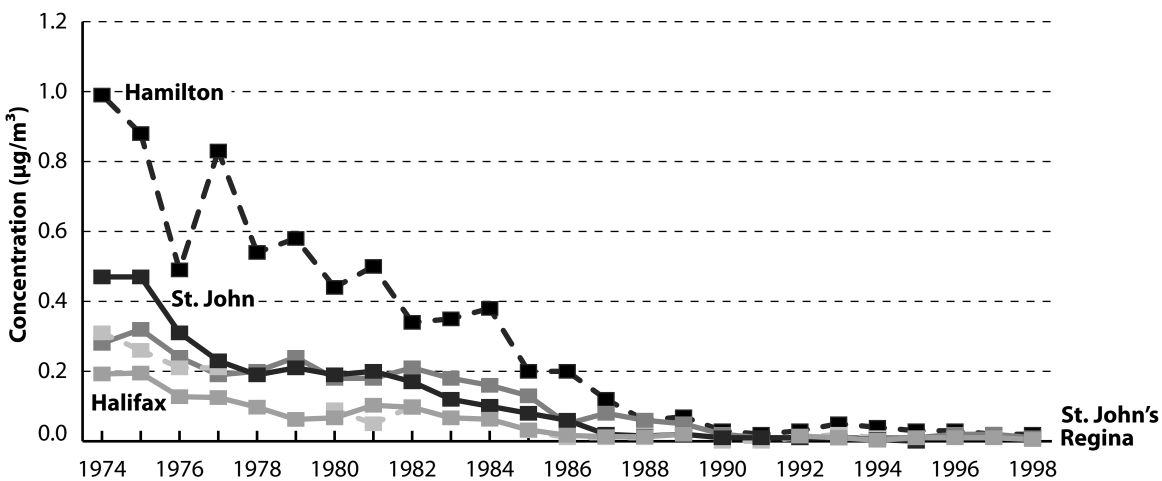
Source: SEMARNAP (1999), *Instituto Nacional de Ecología, 1999.*

Figure 1.51: Ambient levels of lead, 1974–2001



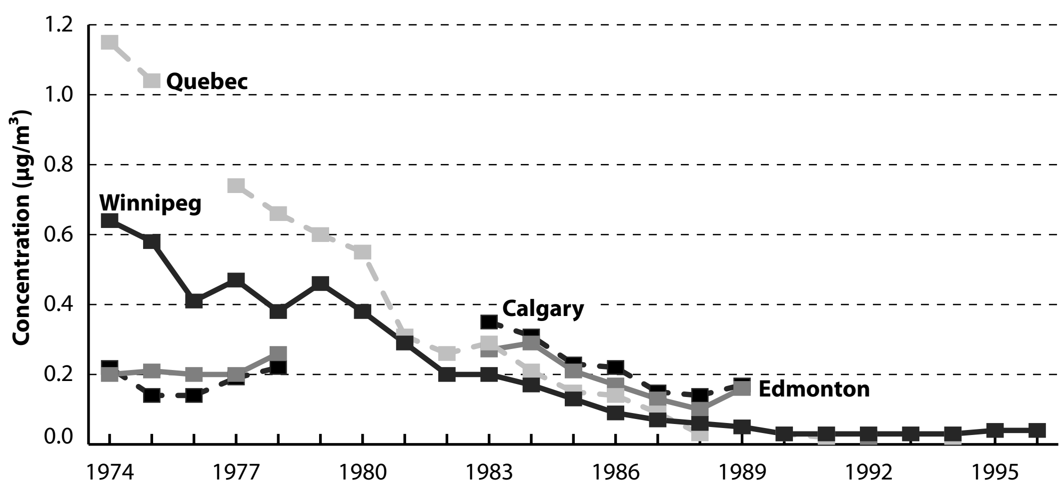
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.52: Lead—small cities, 1974–1999



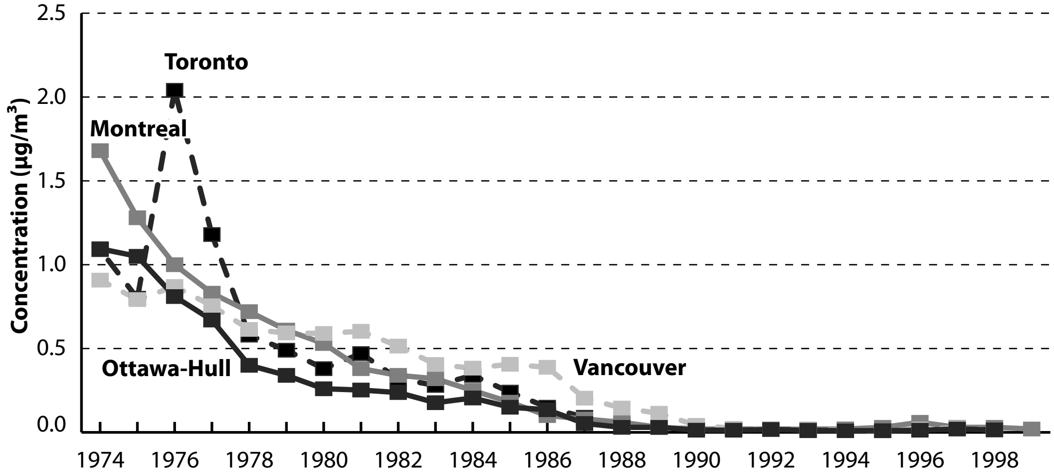
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.53: Lead—medium cities, 1974–1999



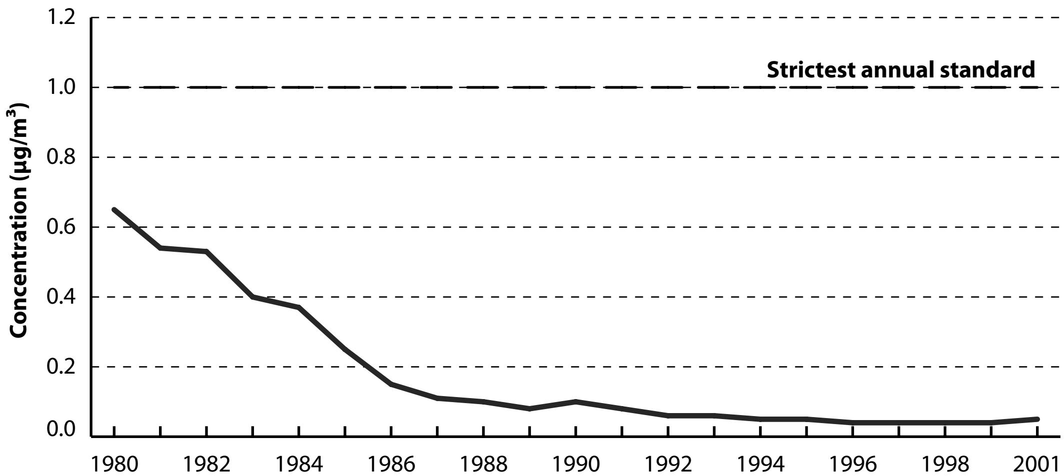
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.54: Lead—large cities, 1974–2001



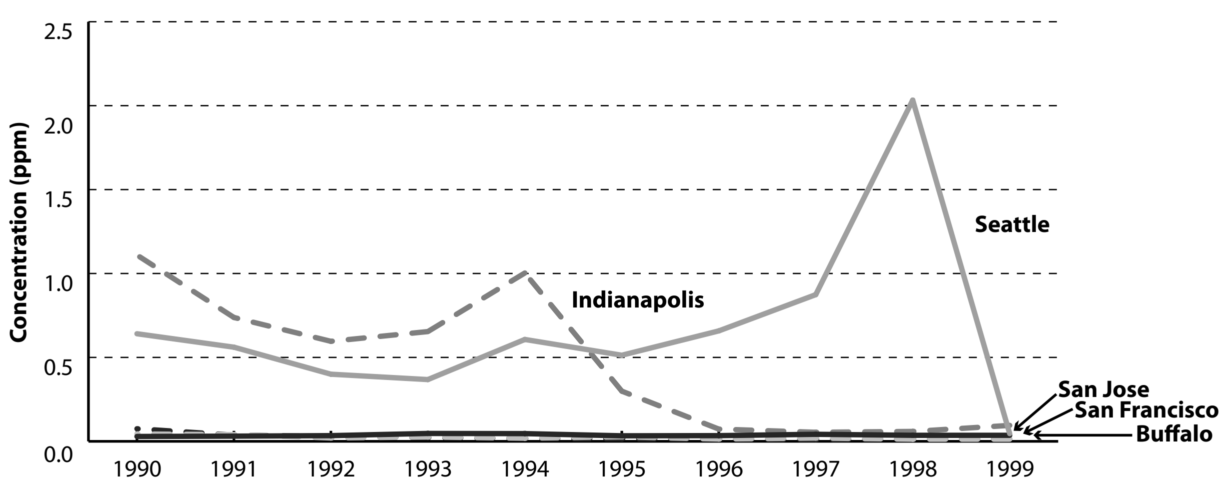
Source: Environment Canada (2003), *National Air Pollution Surveillance Network 2002 Annual Data*.

Figure 1.55: US ambient levels of lead



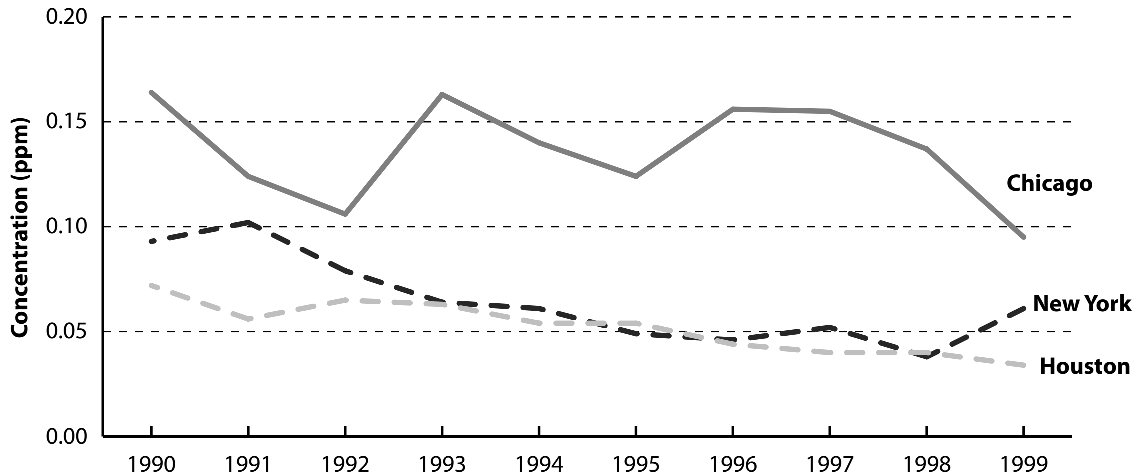
Source: *EPA National Air Quality and Emissions Trend Report 1999*; *EPA National Air Quality: 2001 Status and Trends Report* (used to derive the 2001 values).

Figure 1.56: US lead ambient concentrations—select medium cities



Source: *EPA National Air Quality and Emissions Trend Report 1999.*

Figure 1.57: US lead ambient concentrations—select medium cities



Source: *EPA National Air Quality and Emissions Trend Report 1999.*

2 Water Quality

Water pollution

Point and non-point sources

There are two general sources of water pollution: point and non-point sources. Point sources refer to industrial discharge pipes and municipal sewer outlets that discharge pollutants directly into an aquatic ecosystem. Non-point sources refer to indirect sources of pollution such as run-off from agriculture, forestry, urban and industrial activities as well as landfill leachates and air-borne matter. Water quality also varies as a result of naturally occurring chemical, physical, and biological characteristics. Water pollution from human activities includes nutrients, heavy metals, persistent pesticides, and other toxins.

Pollutants

Nutrients like phosphorus and nitrogen, found in fertilizers, livestock manure, and washing detergents, can cause significant degradation of water quality by depleting levels of dissolved oxygen. Government regulation has stipulated reductions of the amount of phosphate in detergents to try to improve water quality.

Heavy metals are found in water as a result of the weathering of rocks. They may also reach the water system directly from industrial and mining activity. Non-point sources such as urban storm-water and agricultural run-off also contribute to contamination by heavy metals. High concentrations of heavy metals can affect the quality of drinking water and harm aquatic life as the metals accumulate in organs and tissues (bioaccumulation).

Other substances—pesticides like dichlorodiphenyltrichloroethane (DDT) and toxins like polychlorinated synthetic compounds (PCBs)—can also accumulate in biological organisms. The effects of these compounds on animals such as birds include growth retardation, reduced reproductive capacity, lowered resistance to disease, and birth deformities.

Assessing water quality

Clean water is essential for good health and is also an important factor in economic and social activities. North America possesses some of the largest freshwater resources in the world but they are still vulnerable to pollution. Although in recent years there have been several high-profile incidents affecting the quality of drinking water in Canada, we restrict our analysis of water quality in this report to the quality of surface water, which is not to be confused with the quality of drinking water. This distinction is important as the quality of drinking water has become largely a function of infrastructure, technology, and policy decisions; therefore, it fails to provide an accurate indication of environmental quality.[1] Moreover, it is important to recognize a distinction between quality standards for surface and for drinking water, as many naturally occurring substances in surface water may be deemed unsuitable for drinking water.

The quality of water is very difficult to summarize on a national basis because there are no nation-wide indices or standards. The Canadian Council of Ministers of the Environment (CCME) devised the Canadian Water Quality Guidelines (CWQG) in 1987 (and the Canadian Environmental Quality Guidelines in 1999) as a basis for the provincial and territorial governments to design site-specific water-quality objectives. Although many provinces compare sample results to the CWQG—and some provinces have even developed their own objectives and standards based on the CWQC—these guidelines are voluntarily adopted and can be ignored by the provincial and territorial governments.

Other obstacles in assessing Canada's water quality are the lack of uniform monitoring and the magnitude and complexity of measuring water quality. The effects of both natural and manufactured contaminants upon water quality fluctuate with water conditions (source, velocity, volume, depth, pH level), photosynthetic activity, and daily and seasonal variations.

What to measure

Water quality is typically assessed according to chemical, physical, and microbiological parameters. Each parameter includes a comprehensive list of water-quality measures. Some of the most common include nitrates, phosphorous, dissolved oxygen, fecal coliform, DDT, PCBs, and sedimentation.[2] These pollutants are also characterized as to whether they are persistent[3] or non-persistent.[4] For the purpose of this report, indicators and pollutants have been chosen that provide a broad measure of water quality. A brief description of the pollutants and a rationale for the associated indicators is provided below.

Excess nutrient levels

Concentrations of nutrient levels, such as phosphorous and nitrogen, provide an important set of indicators because they often cause the degradation of water quality by accelerating eutrophication.[5] In excess concentrations, nitrogen promotes the rapid growth of algae, thereby reducing the oxygen levels in the water. Over-abundance of algae can thus lead to dramatically reduced oxygen levels, creating an environment unsuitable to fish and shellfish, which may lead to "dead zones" where nothing is capable of surviving (USGS. 2003).

Phosphorus and nitrates are typically found in fertilizers, livestock manure, and detergents. As a preventative measure, Canadian regulations impose caps on the amount of phosphate in detergents; however, it should be noted that lower phosphate levels in lakes and streams do not always result in higher levels of dissolved oxygen and improved water quality, because plants continually recycle phosphorus from sediments.[6]

Toxic substances

High concentrations of toxic substances affect the quality of drinking water and harm aquatic life as these substances concentrate in the organs and tissues of biological organisms, a process known as bioaccumulation.7 Concentrations of pesticides and toxins in biological organisms offer good indicators of water quality as they are known to bioaccumulate. Commonly monitored examples of these pollutants include polychlorinated synthetic compounds (DDT and PCBs). The effects of these compounds on animals such as birds and fish include growth retardation, reduced reproductive capacity, lowered resistance to disease, and birth deformities.

Heavy metals are found in water as the result of the weathering of rocks. They may also reach the water system directly from industrial and mining activity. Aggregate sources such as urban storm-water and agricultural runoff also contribute to metal contamination.

Wastewater treatment

Wastewater is often one of the largest single sources of pollution into freshwater systems, where it has dramatic effects on water quality. As a result, assessing societal access to water treatment at the primary and advanced levels provides a valuable indicator of water quality.

Water quality in Canada and North America has improved significantly over the past three decades. In order to illustrate this trend, this section assesses and demonstrates improvements in water quality across Canada. For comparative purposes, we will also briefly assess water quality relative to quality and improvements made in both the United States and Mexico.

Limitations to measurement

Although many provinces compare sample results to the CWQG devised by the Canadian Council of Ministers of the Environment, these guidelines are only voluntarily adopted by the provincial and territorial governments and may not be fully adhered to. As a result, several provinces have developed their own objectives and standards based on the CWQG and may not be strictly comparable.

Further obstacles to assessing Canada's water quality include a lack of uniform monitoring procedures and the technical complexity of measuring water quality. Differing sampling intensity, intervals, and methodology make direct comparison of provincial jurisdictions difficult. Additionally, the effects of both natural and manufactured contaminants upon water quality fluctuate with water conditions (source, velocity, volume, depth, pH level), photosynthetic activity, and daily and seasonal variations. Cross-country variation in conditions associated with these factors may also introduce some degree of sampling error.

In order to overcome the aforementioned obstacles, we will examine the best available information from each province and territory individually. In some cases, trend data for these indicators were unavailable. This is unfortunate, as the snapshot data that is available provides little information as to whether water quality is improving or deteriorating. However, some provinces are now trying to create indices of water quality that could be compared over time. In the provincial sections, current regulations are discussed; however, it is important to remember that regulation gives little indication about actual environmental quality since regulations may be enforced differently.

To complement analyses of individual provinces, we have included an analysis of indicators that provide insight into water quality on both a regional and national scale.

This includes a national indicator based upon wastewater treatment and, because their size and importance, indicators of the state of the Great Lakes.

Performance Analysis

Atlantic Canada

Fishing and maritime recreation continue to be important aspects of the economy and culture in Atlantic Canada. The ocean is home to uncounted species and ecosystems and, although it has experienced degradation in the past, restoring and maintaining the quality and purity of its waters is considered vitally important. Water quality on the eastern coast of Canada is monitored in several ways including testing levels of toxic contaminants in birds' eggs and contaminants in fish and tracking shellfish closures.

Trends

Toxic contaminants have decreased significantly over the past 25 years on Canada's eastern coast: samples taken from the eggs of double-breasted cormorants in the Bay of Fundy show significant declines in the level of both DDE and PCBs. Between 1972 and 2000, the amount of DDE found in the seabirds' eggs decreased by 94.7%, while the amount of PCBs found decreased by 76.7% (figure 2.1) (Environment Canada, 2002). These pollutants are discussed further in the Quebec, Great Lakes, and US National comparative sections of this report.

Analysis of shellfish closures on Canada's eastern coast also supports the theory that pollutants levels are declining and water quality improving. The Atlantic coast of Canada is a major shellfish harvesting area. Shellfish that feed by filtering water, such as oysters, clams, and mussels, can become contaminated by bacteriological pollution (such as sewage) and natural biotoxins and cause illness if eaten. The Shellfish Water Quality Protection Program,[8] operated by Environment Canada, monitors water quality in shellfish-growing areas and subsequently classifies these areas as approved, conditionally approved, or closed. The percent of surveyed area that is approved for harvesting has risen over time, increasing from 61.4% in 1989 to 65.1% in 2002 (figure 2.2) (Environment Canada, 2003).

Analysis for contaminants along the Atlantic coast of the United States is addressed in the United States performance section of this report.

Newfoundland

Newfoundland has an abundance of clean water from its many lakes, rivers, streams, and groundwater. Despite this abundance, management of the resource is complicated by a very large number of small, dispersed coastal communities along an extensive coastline. This settlement pattern presents several challenges for the development of water supply infrastructure and distribution systems.

Approximately 83% of Newfoundlanders receive water from public sources while 17% obtain water from private sources. Of the public supplies, 88% come from surface water and 12% from groundwater (CCME, 2001).

Trends

Newfoundland has taken several progressive measures to protect a large degree of its surface and groundwater. Under Newfoundland's Environment Act (1995), the area surrounding a source of public water can be designated as a Protected Water Supply Area, which prohibits activities in that watershed that would impair water quality. As a result, during the period from 1974 to 2002, the number of protected areas has risen from five to 262. All major water supply areas, encompassing 350,000 hectares, have now been designated. The majority of the population (70%) receives water from these protected areas. Moreover, wellhead source protection has recently been provided for, and this is expected to result in an increase in the number of wellhead-protected areas over the next several years (Goebel, 2003).

The treatment of wastewater remains an area of difficulty for Newfoundland. Although many inland communities have wastewater treatment facilities, many coastal communities remain without treatment; therefore, sewage from these communities is pumped untreated into the ocean (Goebel, 2002). Several positive steps, however, have been taken. In St. John's Harbour, for example, where the level of fecal coliform density has increased significantly since 1981, the city devised the St. John's Harbour Clean-Up plan and has since completed the first phase. This plan is intended to provide primary treatment and disinfection of all wastewater in its earlier phases and ultimately provide secondary treatment (Goebel, 2003).

Nova Scotia

Nova Scotia has the benefit of abundant water resources including over 6,700 lakes, 100 rivers, and abundant supplies of groundwater. Forty-six percent of people obtain their drinking water from private wells, while 54% receive treated drinking water from central groundwater or surface supplies. Despite this abundance, however, Nova Scotia maintains several challenges associated with protecting its valuable resource such as source protection and ensuring adequate treatment levels (NSEL, 2002).

Trends

There have been steady improvements in Nova Scotia's drinking water due to significant investment in new municipal treatment facilities and improvements in surface water due to more municipal sewage treatment plants. Overall water quality has also been improving through better controls and treatment facilities at pulp and paper mills. Effluents from mills have dramatically decreased since 1995 as a result of improved regulation and investment in pollution control. In 1998, compliance with regulation levels reached 99% (Wilson, 2000).

Nova Scotia is making improvements in protecting the sources of its drinking water, which has been designated as the number-one challenge to the province. The Ministry of Environment and Labour has initiated a consensus-based, community-level source protection program. Currently, 24 of 77, or 31%, of all water supplies are designated as protected. The number of municipal water supplies with protected water area designation has been steadily increasing in number since 1965.

Prince Edward Island

Prince Edward Island is a province rich in groundwater. The island does not contain large surface-water bodies; therefore, it is estimated that 60% to 70% of the surface water flows originate from groundwater discharges (PEI Environment, 1999). Because all human water needs are satisfied from groundwater sources, groundwater is assessed according to the GCDWQ. Surface waters are compared to the CWQG for the protection of aquatic life.

Trends

Prince Edward Island and Environment Canada cooperatively monitor a network of water-quality stations under the Canada-PEI Memorandum of Agreement on Water. A total of 28 stations, including 14 on rivers and streams, five monitoring groundwater wells, and nine in estuaries, are tested six to eight times a year (Raymond, 2001). Most recently, according to a three-part Environmental Bulletin from the Department of Fisheries, Aquaculture, and Environment, nitrogen in the form of nitrates was found at low levels in most groundwater, with average levels in the range of 3 to 4 mg/L. In some agricultural areas, however, more than 15% of the domestic wells exceeded the guideline of 10 mg/L identified in the Guidelines for Canadian Drinking Water Quality (GCDWG) (PEI, 2003). The majority of these exceedances have been attributed to runoff from agricultural land, often laden with fertilizers.

A *PEI Water Quality Interpretive Report*, published in 1999, describes the quality of the groundwater supplies, fresh surface waters, and estuary waters as generally high. The province's groundwater is considered "excellent" with only isolated test results exceeding water-quality guidelines. Its waters are considered susceptible to human influence, however, particularly in areas of intensive agriculture, and a trend of increasing nitrogen concentrations has been observed at several stations along rivers with longer observation records. Although only 1% to 2% of all wells tested on Prince Edward Island exceed recommended levels for nitrogen, 6% to 7% in some areas of intensive cultivation do not meet the guideline. Fecal bacteria are another measure that occasionally exceeds guidelines for shellfish and recreation in surface and estuarine waters (Environment Canada, 1999).

New Brunswick

Approximately 40% of New Brunswick's population obtains water from surface watersheds, while the remainder relies upon groundwater. In order to ensure the safety of these water supplies, New Brunswick legislation protects both watersheds for surface water (since 1990) and wellheads (since 2000) as well as the recharge area for groundwater through its Watershed Protection Program.

Although New Brunswick compares its surface-water quality monitoring data to the CWQG, there is no move at present to develop provincial standards. Data are collected from baseline stations for examining long-term trends, stations providing background information for specific projects in the short term, and downstream stations measuring the effects of point and non-point sources of pollution.

Trends

Major pollution abatement (industrial and municipal) and remedial efforts took place in New Brunswick in the 1970s and 1980s. Today, new developments are more strictly controlled than in the past. This has resulted in significant improvements in water quality in some areas. While efforts are continuing, present effects on water quality are not as obvious as some of the more dramatic improvements of the past (Choate, 2002).

Natural waters in many areas of New Brunswick tend to be poor in nutrients (especially phosphorous) and acidic—some natural pH values fall below the CWQG of pH 6.5. In some areas, naturally high levels of aluminum and iron often exceed the guidelines (Choate, 2000). Generally, however, the province's surface waters are considered high in quality and suitable for recreation and the support of aquatic life (Choate, 2002).

One long-term concern in New Brunswick has been the impact of acid rain on surface water. A recent study examined trends in the amount of acid in precipitation and the quality of lakes in southwestern New Brunswick. It found that reduced sulphate emissions have resulted in less acid deposition and that some acidified lakes may be in the early stages of recovery (Pilgrim, 2001). Future monitoring is required to determine if recovery is actually in progress (Choate, 2002).

Quebec

The Quebec Ministry of the Environment and Wildlife operates 386 monitoring stations located in 40 watersheds to measure nitrogen, phosphorus, fecal coliforms, pH, turbidity, and suspended solids. These readings, as well as biological surveys and measurements of toxic chemicals in fish, artificial substrates, and water are conducted on a monthly basis. The province does not set water-quality objectives but instead studies point sources to determine the nature of local or regional use of the water body and how it must be preserved or restored. Goals can vary from one site to the next on the same river as the use of that river changes.

Trends

Quebec is one of the first provinces to carry out a comprehensive overview of the status and trends of the water quality of its rivers. Over $7 billion has been spent over the last 20 years to restore Quebec's waterways. Two water cleanup programs, the Programme d'Assainissement des Eaux du Québec (PAEQ), and the Programme d'Assainissement des Eaux Municipales du Québec (PADEM), have led to 98% of the municipal population being served with wastewater treatment. This has resulted in declining levels of contaminants, including nitrite-nitrates, phosphorus, turbidity, and fecal coliforms, in Quebec rivers since 1979 (Ministère de l'Environnement du Québec and Environment Canada, 2001). Moreover, improvements to the treatment of mill effluents in the province's pulp and paper industry have also contributed to an improvement in water quality, leading to a 75% decrease in loading by suspended particles from 1980 to 1994 (Painchaud, 1997).

The Saint Lawrence River is one of the major waterways in Quebec that has shown significant improvements in water quality. Historically, the river has served as a dumping point for industrial, human, and toxic waste; however, recent remedial efforts have now begun to show signs of success. Samples taken from the eggs of double-breasted cormorants living in the Saint Lawrence estuary indicate that between 1972 and 1996, DDE decreased by 85.5%, and PCB levels by 51.4%. (Environment Canada, 2002) (figure 2.3). Quebec has also made impressive improvements in its wastewater treatment.

Ontario

Ontario is home to a significant portion of the Great Lakes Basin, the largest freshwater system in the world. About 8.9 million people in Ontario—82% of the population—get their drinking water from municipal waterworks; the remainder are served by individual wells or private waterworks. Of some 627 municipal waterworks, 399 rely on ground water, 225 use surface water, and three use combined sources. The Ontario Ministry of the Environment runs the Drinking Water Surveillance Program that monitors 175 of these waterworks regularly for 200 chemical and physical parameters (Fleischer, 2001).

Trends

From 1993 to 1999, the Drinking Water Surveillance Program performed 963,382 tests on source water, treated drinking water, and water in the distribution systems. Of almost a million tests, only 192 exceeded parameters: 99.98% of water samples passed all health-related standards. International comparisons have shown that some of the parameters exceeded on those rare occasions—lead, nitrates, THMs, and turbidity—are common problems for all jurisdictions. In fact, because of Ontario's stringent standards, more exceedances may have been recorded than if the tests were performed in other jurisdictions. For example, if the American drinking-water standard for fluoride was applied, no violations would have been reported in Ontario (Ontario Ministry of Environment, 2000a).

The government of Ontario announced new regulations for drinking water in August 2000, just a few months after the Walkerton crisis erupted in the national media. The new regulations replace the Ontario Drinking Water Objectives with the Ontario Drinking Water Standards and include 84 new, revised, or reaffirmed parameters for assessing drinking water. Under the new regulations, water works in Ontario are responsible for monitoring their supplies of drinking water to ensure they satisfy provincial standards, and are responsible for notifying both the Ministry of Environment and the local Medical Officer of Health if any health parameters are exceeded. Ontario is currently looking at regulations to protect sources of drinking water. The new regulations, which are currently in the development stage, will be designed to safeguard the recharge area for groundwater near wells (Fleischer, 2001). Though the need for such regulations had been discussed prior to Walkerton, that calamity reinforced the issue.

Another result of Walkerton was a change in the frequency of waterworks inspections: previously, they were only inspected every four years but are now inspected annually. From June to November 2000, almost 600 water-treatment plants were scrutinized and more than 250 orders were issued resulting from various deficiencies or infractions (Ontario Ministry of Environment, 2000b).

Manitoba

Manitoba has over 900 trillion liters of surface water covering 16% of the province. Manitoba Conservation's Water Quality Management Section monitors ambient water quality at over 50 sites throughout the province. Up to 100 water-quality variables are measured throughout the year (Manitoba Conservation, 2003); these results are regularly assessed against the Manitoba Surface Water Quality Objectives (MSWQO) and Manitoba Water Quality Standards, Objectives, and Guidelines. These objectives are used as a baseline for developing legally enforceable limits that are specified in licenses issued under the Environment Act to control pollution from point sources (Manitoba Conservation, 2003).

Trends

Nutrient levels in surface water are a concern in Manitoba due to naturally high background levels of nitrogen and phosphorus and intensive agricultural practices. A comprehensive analysis of nutrient loading in Manitoba shows that total phosphorous and nitrogen levels in surface water have been highly variable over time. Although many streams showed no increasing trend in phosphorous and nitrogen, several streams in the southern parts of the province were documented as demonstrating increasing levels. This problem has been largely associated with high population density and intensive agricultural use. To combat this, Manitoba Conservation has already drafted a Nutrient Management Strategy that it plans to implement in the near future (Manitoba Conservation, 2001).

Several proactive initiatives are being undertaken in order to improve water quality in Manitoba. These include, but are not limited to, significant revisions to the MWQSOG to reflect national science guidelines, implementation of a nutrient management strategy, detailed scientific studies on water quality in Lake Winnipeg, and the development of a Watershed Management Plan for Shoal Lake, the source of Winnipeg's water supply.

Saskatchewan

Although Saskatchewan is often thought of only as an agricultural area, growing endless acres of wheat, its geography is very diverse and includes large volumes of surface water. The northern half of the province is located in the boreal shield ecozone and has been called a "land of lakes and forests" (SERM, 2000). Twelve percent of Saskatchewan's surface area is covered by water in the form of streams, rivers, ponds, lakes, and man-made reservoirs.

The province currently employs the Saskatchewan Surface Water Quality Objectives (1997) as a guide for assessing water quality. Monitoring stations are currently located on 15 major rivers testing for 70 pollutants. However, this data cannot be considered reflective of overall water quality but gives instead a "snap shot" of water quality in the major rivers of southern and central Saskatchewan (Hallard, 1997). In general, the quality of surface water varies considerably by region. In the north, the water is low in nutrients and can be described as "clean, deep, and cold." Waters in southern areas occasionally show elevated nitrate and phosphorous levels (possibly as a result of intense agriculture) but they do not generally exceed standards (Ferris, 2001).

Trends

A recent study of groundwater examined the contamination of well-water by pesticides. This is of concern because 45% of Saskatchewan's residents rely on private wells for drinking water. The study determined that although one or more pesticides were detected in all but two of the tested wells, all concentrations were significantly lower than the maximum acceptable under the GCDWQ (McKee, 1999).

The outbreak of water-borne illness in North Battleford during the spring of 2001 was caused by a parasite, *cryptosporidium*, which infected the town's water supply. The cause of the outbreak is believed to have been a malfunctioning filtration device. Tests for *cryptosporidium* are not regularly performed on public water systems in Canada due to technological limits. Generally, the presence of the parasite is only brought to the public's attention after a diagnosis of illness resulting from the organism (Fleischer, 2001). However, the situation in North Battleford was complicated by a week-long delay from the time of diagnosis of a case of illness until action was taken by the local health authorities. In general, a well-operated and monitored multi-barrier system is critical in preventing and removing these parasites.

Alberta

The majority of Alberta's water is generated in the Peace River system and flows northward through the Slave River. Water quality is assessed for hundreds of variables at more than 300 locations on lakes and rivers throughout Alberta each year. Water quality is determined by comparing samples to the Surface Water Quality Guidelines for Use in Alberta, which replaced previous interim guidelines in 1999.

Alberta does not have any specific regulations protecting source water. The province ensures the quality of its drinking water through surface-water treatment plants, of which it has 210, far more than any other province, though this option is generally more expensive than regulation (Lang, 2001).

Due to the complex nature of water quality assessment, the Alberta Water Quality Index was developed in order to summarize complex chemical, biological, and physical data into a composite descriptor of water quality. This index provides a simple "snap-shot" of yearly water quality conditions in various areas of the province (Alberta Environment, 2003).

Alberta's Water Quality index is modeled after the Canadian Council of Ministers of the Environment Water Quality Index. The index incorporates the number of variables not meeting objectives, the number of times objectives are not met, and the amount by which objectives are not met. The overall index value is based on four sub-indices that are calculated for metals, nutrients, bacteria, and pesticides (Saffran, 2001). Because of missing data, the overall index has only been calculated since 1996 (table 2.1) Three of the sub-indices, however, have data going back to 1991 (table 2.2).

Trends

Analysis of Alberta's Water Quality Index reveals that water quality of Alberta's major rivers in 2000/2001 was "good" to "excellent." General observation reveals that water quality tends to be better upstream from urban centers, and industrial or agricultural development than downstream (table 2.1, 2.2). Based upon both the metals and bacteria sub-indices, index values were recorded as consistent or increasing (improving quality) at all six rivers, some by as much as nine points. The bacteria sub-indices have shown a similar trend, although it is noted that, the Upstream Edmonton station decreased in 2001 by 0.6 (Alberta Environment, 2003).

Investment in infrastructure has helped improve water quality in many of Alberta's larger urban centers. Thanks to upgraded municipal wastewater treatment facilities in Calgary (1997), Edmonton (1998), and Lethbridge (1999), water quality downstream of these cities has improved (Alberta Finance, 2001).

British Columbia

British Columbia is blessed with some of the cleanest and most abundant water supplies in the world (BCMELP, 1999). Associated with its broad range of landscapes is an equally broad diversity of lakes, rivers, and other freshwater assets.

Table 2.1: Alberta Surface Water Quality Index—overall

	Athabasca River		Smoky / Peace River		North Saskatchewan River	
	at Athabasca	at Old Fort	at Watino	at Fort Vermilion	upstream from Edmonton	downstream from Edmonton
1995 / 1996	94.3		91.5		96.2	69.3
1996 / 1997	90.8	90.0	84.5	85.7	91.1	65.6
1997 / 1998	92.5	90.3	83.3	88.5	97.1	70.7
1998 / 1999	90.4	95.2	91.1	93.6	93.2	80.3
1999 / 2000	90.9	90.5	90.2	85.9	86.3	81.1
2000 / 2001	91.1	91.5	87.3	88.4	91.9	74.4

	Red Deer River		Bow River		Oldman River	
	upstream from Red Deer	downstream from Red Deer	upstream from Calgary	downstream from Calgary	upstream from Lethbridge	downstream from Lethbridge
1995 / 1996	92.9	88.1	100.0	71.4	61.6	67.4
1996 / 1997	75.7	83.7	96.0	75.5	77.7	83.0
1997 / 1998			100.0	86.7	82.9	84.2
1998 / 1999	83.0	80.8	97.5	82.3	89.0	79.6
1999 / 2000	86.7	75.3	97.4	83.9	97.2	86.1
2000 / 2001	81.8	79.9	97.7	82.1	86.7	83.2

Source: Alberta Finance (2002), *Measuring Up: 2001-02 Annual Report*.

Table 2.2a: Alberta Surface Water Quality Index — subindices

	Athabasca River		Smoky/Peace River		North Saskatchewan River	
	at Athabasca	at Old Fort	at Watino	at Fort Vermilion	upsteam from Edmonton	downstream from Edmonton
NUTRIENTS						
1990/1991	74.6	74	68.4	55.8	84	53.4
1991/1992	75.7	85.2	70.9	68.4	87.4	69.2
1992/1993	88.3	80.1	73.5	73.2	87.2	70.2
1993/1994	76.2	89.3	72.5	68.3	88.4	70.3
1994/1995	77.5	73.4	54	54.2	100	56.5
1995/1996	86.3	84.4	70.3	60.1	88.3	71.4
1996/1997	75.4	72.6	71.7	64.4	87.5	66.8
1997/1998	73.6	68	63.5	65.7	88.2	69.1
1998/1999	79.5	87.7	76.1	88.3	80.4	74.2
1999/2000	80.2	77.2	75.3	78.8	76.5	72.8
2000/2001	90	87	78	83	90	79
BACTERIA						
1990/1991	85.4	100	100	90.1	100	37.8
1991/1992	92.7	100	100	100	100	32.2
1992/1993	100	100	100	100	100	37.6
1993/1994	100	100	100	100	100	28.1
1994/1995	100	100	78.4	100	100	32.7
1995/1996	100	100	100	87.7	100	31.7
1996/1997	100	100	91.3	100	95.9	29.6
1997/1998	100	100	93.7	100	100	45.4
1998/1999	93.2	100	100	93.7	100	94.9
1999/2000	100	100	100	100	93.6	89.2
2000/2001	100	100	100	100	93	94
METALS						
1990/1991	92.4	100	81.9	69	100	84.5
1991/1992	100	96.4	100	80.3	96.3	100
1992/1993	100	96.5	100	86.2	100	100
1993/1994	92.9	95.9	100	84.1	100	100
1994/1995	96.7	93.2	96.1	89.9	86.9	85.6
1995/1996	91	95.7	95.8	86.4	96.5	93
1996/1997	87.6	87.3	74.9	78.5	95.7	95.8
1997/1998	100	93.3	79.6	92	100	96.5
1998/1999	96.7	96.5	88.3	92.5	96.1	81.3
1999/2000	83.5	84.8	89	88	82.4	76.8
2000/2001	97	97	92	89	92	95
PESTICIDES						
2000/2001	100	93	100	100	81	71

Source: Alberta Finance (2002), *Measuring Up: 2001-02 Annual Report.*

Table 2.2b: Alberta Surface Water Quality Index — subindices

	Red Deer River		Bow River		Oldman River	
	upstream from Red Deer	downstream from Red Deer	upstream from Calgary	downstream from Calgary	upstream from Lethbridge	downstream from Lethbridge
NUTRIENTS						
1990/1991	76.4	74	100	73.4	87.9	64.2
1991/1992	75.1	70.8	100	72.1	88	73.9
1992/1993	76.3	70.8	75.5	71.3	76.1	73
1993/1994	75.7	68.7	88.4	73.3	72.6	61.6
1994/1995	76.3	45.6	88.4	72.9	88.4	86.3
1995/1996	76.1	75.2	100	73.5	67.6	65.3
1996/1997	75.6	58.2	88.4	73.7	74.6	64.6
1997/1998	88.3	41.4	100	73.4	65.9	71.1
1998/1999	76.7	64.6	100	66.4	87.4	78.7
1999/2000	79.8	75.9	89.6	68.6	100	90.2
2000/2001	90	80	100	79	100	100
BACTERIA						
1990/1991	81.4	62.1	93.8	29.4	90.4	78.3
1991/1992	93	78.9	100	21.8	82.3	87.6
1992/1993	92.9	55.4	94	20.7	68.6	77
1993/1994	100	49	100	10.6	49.6	52.3
1994/1995	96.5	89.5	100	51.4	83.9	88.4
1995/1996	100	86.1	100	33.4	37	39.7
1996/1997	85.6	88.6	100	44	51.9	89
1997/1998	74.3	95.9	100	88.9	69.1	69.1
1998/1999	89.5	90.7	100	90.4	92.5	85.6
1999/2000	90.7	78.1	100	88.5	100	82.6
2000/2001	100	100	100	100	100	100
METALS						
1990/1991	100	100	100	100	96.3	100
1991/1992	100	100	100	100	100	100
1992/1993	100	92.3	100	100	96.2	100
1993/1994	100	96.3	100	100	100	100
1994/1995	96.2	92.2	95.7	95.7	100	100
1995/1996	95.7	95.4	100	96	93	89.1
1996/1997	93.2	95.7	95.7	96	96.4	100
1997/1998	92.1	96	100	100	96.5	96.5
1998/1999	86.1	100	90	90.6	88.4	80.9
1999/2000	91.5	76.6	100	97.3	97.2	93.9
2000/2001	95	90	100	97	97	100
PESTICIDES						
2000/2001	75	77	96	80	82	65

Source: Alberta Finance (2002), *Measuring Up: 2001-02 Annual Report*.

The provincial Ministry of Environment, Land, and Parks (MELP) monitors the quality of surface water in British Columbia based upon the British Columbia Surface Water Quality Objectives. About 150 streams, rivers, and lakes have specific objectives set for their quality, depending on the use of the water (drinking, agriculture, recreation, etc.), and depending on the natural state of the water's quality (Swain, 2001).

British Columbia is unique in that it is one of the few provinces that maintains a clearly documented freshwater strategy and produces regular status and trend reports on water quality. In addition to outlining the problems and difficulties that British Columbia faces, it identifies three broad goals—healthy aquatic ecosystems, assured human health and safety, and sustainable social, economic, and recreational benefits of water (BCMELP, 1999)—and an associated strategy to achieve these goals.

Trends

An assessment of water quality in British Columbia reveals that the water quality in British Columbia is excellent. According to the provincial Water Quality Index, which monitors 33 water bodies against the Water Quality Objectives, 94% of the water bodies were in Fair to Excellent condition, while over 50% of the bodies were in Good or Excellent condition. Only two water bodies rated as Borderline, and none rated as Poor (figure 2.4).

Moreover, according to a BCMELP report entitled *Water Quality Trends in Selected British Columbia Waterbodies* (2000), British Columbia's water quality also shows steady signs of improvement. Data from 133 monitoring stations on 49 rivers or creeks, 14 lakes or reservoirs and five groundwater aquifers has been collected over the last 10 to 20 years. The report revealed that for surface water, 59% of the stations had no observed change, 31% had improving trends, and 10% had deteriorating trends (figure 2.5, left). For groundwater, 53% of the stations had no observed change, 27% had improving trends, and 20% had deteriorating trends (figure 2.5, right). The report makes it clear, however, that these trends are not to be considered representative of the water quality trends in the province as a whole because monitoring is primarily done in areas where people are active. Thus, "this report gives a view of water quality in developed areas rather than of undeveloped watersheds where water is still in a largely natural state" (Ministry of Environment, Lands and Parks, 2000).

Levels of toxic contaminants have been decreasing over the past 20 years in British Columbia. Samples taken from the eggs of a Great Blue Heron colony located near the University of British Columbia show a marked decline in levels of PCBs, DDE, dioxins and furans (figure 2.6). Between 1977 and 2000, PCBs decreased by 85% and DDE by 83% (PCBs and DDE are discussed in greater detail in the discussion of the Great Lakes later in this section).

Yukon, Northwest Territories, and Nunavut

Until recently, the federal Department of Indian Affairs and Northern Development (DIAND) managed water resources for the Yukon, Northwest Territories, and Nunavut, often in cooperation with the territorial governments and Environment Canada.[9] In the Yukon, however, on April 1, 2003 all responsibilities of the DIAND Land and Resource Management Program were devolved to the provincial level and passed to the Government of Yukon.

In order to manage, protect, and conserve water quality in the shared Mackenzie Basin, the Yukon and Northwest Territories (NWT) signed the Yukon-NWT Transboundary Water Management Agreement. This agreement helps manage and address transboundary water-management issues while also protecting the aquatic ecosystem for generations to come. Furthermore, the agreement sets out specific water quantity and quality objectives and requires each jurisdiction to provide early notification and consultation opportunities on any developments or activities that may have an impact upon the aquatic ecosystem of the other jurisdiction (DIAND, 2003).

Because most water bodies in the Yukon are considered largely pristine, water quality objectives have not been set in the territory and contamination is prevented through enforcement of water-use licenses. The Northwest Territories employ water-quality objectives that comply with the CWQG and some site-specific objectives have been established to track unique natural occurrences and human activity.

Point sources, runoff from surrounding areas, and deposition from the atmosphere serve as the primary source of heavy metals in lakes and rivers in the arctic. A major concern for aquatic ecosystems is local pollution from metal industries and old mines. Despite select problems in the Canadian north, lead, cadmium, and mercury generally occur at levels below one microgram per liter in all Arctic freshwater, similar to levels in unpolluted areas outside the Arctic (AMAP, 2002).

Albeit in small quantities, persistent organic pollutants are present throughout the marine Arctic environment. As early as 1970, when it was detected in the blubber of ringed seals, it was evident that DDT was present in the Arctic. By the mid-1970s, researchers had documented the presence of DDT and other pesticides in beluga, polar bear, and fish. Moreover, birds of prey declined in northern areas that were thought to be uncontaminated. In addition to pesticides, most analyses in animals also found traces of an industrial oil made of compounds known as PCBs (AMAP, 2002).

Trends

Evidence suggests that many pollutants in the arctic are decreasing quite rapidly. For example, a study of seabird and migratory bird eggs in the Canadian high arctic, during the period of 1975 and 1998, revealed that levels of PCBs, DDTs, and hexachlorobenzene[10] (HCB) decreased in all bird species studied. This trend is also echoed in the analysis of several other arctic species, such as seals and polar bears.

Analysis of water quality for the Slave River, the largest tributary of the Mackenzie River, reveals that many pollutants are present at extremely low levels or were not detected at all even with state of the art analytical techniques (DIAND 1998). Of the compounds that were found in low levels, some are the result of natural weathering of rocks, some indicate atmospheric transport, and some could be the result of being flushed downstream from Alberta, British Columbia, or Saskatchewan.

Despite improvements in the arctic, not all pollutants have shown decreasing trends. In particular, levels of hexachlorocyclohexane[11] (HCH) and polybrominated diphenyl ether (PBDE) have increased somewhat over the past few decades. These increases are attributed to several factors, including legacy emissions from old military sites and the result of oceanic transport (currents) across the arctic from countries where these contaminants are more prevalent (AMAP, 2002).

The Great Lakes

The Great Lakes Basin (GLB), which straddles the border between Canada and the United States, comprises the largest system of fresh surface water on earth, containing roughly 23,000 km^3 of water or 18% of the world's supply (GC & USEPA, 1995). The lakes, including Lakes Superior, Michigan, Huron, Erie and Ontario, provide tremendous economic and ecological benefits to the surrounding area, the Great Lakes basin, which includes the lakes and the more than 76,000,000 hectares of land that drain into them. The GLB contains a large concentration of industrial capacity, housing one quarter of American industry and almost 70% of American and Canadian steel mills (USEPA, 1995: 496). It also supports a large agricultural base: nearly 25% of Canadian and 7% of American agricultural production is in the basin (GC & USEPA, 1995). In addition to economic benefits, the lakes provide drinking water for more than 23 million people and support recreational activities and other uses for one-tenth of the United States' population and one-quarter of Canada's population who live in the basin (GC & USEPA, 1995).

Although for many years it was believed that the Great Lakes were too big to develop serious pollution problems, modern settlement did cause deterioration in water quality. Agricultural development increased the amount of silt and nutrients in streams and along shorelines, and growing urbanization and industrialization produced large amounts of wastewater and toxic contaminants that were discharged directly into the lakes. Consequently, by the 1960s, sewage, fertilizer run-off, and chemical wastes had caused serious degradation to Lake Erie and the other lakes showed signs of similar trouble.

As a result of the water degradation, a variety of pollution abatement initiatives have been formulated at both the regional and international levels over the past 30 years. In 1972, the Great Lakes Water Quality Agreement (GLWQA) between the United States and Canada set a management framework for controlling pollution, researching problems, and measuring progress. The purpose of this agreement is "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem" (Environment Canada, 1989). Since 1994, a biennial conference—the State of the Lakes Ecosystem Conference (SOLEC)—has been evaluating trends using a variety of indicators. The findings from these conferences are summarized through the *State of the Great Lakes* reports, most recently published for 2001 (Environment Canada and United States Environmental Protection Agency, 2001).

In order to establish a strategic direction toward rehabilitation, two primary programs were established as planning tools: Lakewide Management Plans (LaMPs) and Remedial Action Plans (RAPs). Lakewide Management Plans were created to address the most critical pollutants that affect whole lakes or large portions of them. Remedial Action Plans are more regionally focused and were originally designed to rehabilitate the 43 Areas of Concern (AOCs). AOCs are designated geographical areas where several beneficial uses, such as fishing or swimming, are impaired. As of 2003, there remain 42 (of 43 original) AOCs; 11 are located in Canada, 26 in the United States, and five in connecting channels (EPA, 2003a).

Monitoring and continual improvement are essential tasks that must be included when managing a remediation project of this nature. As a result, a set of 80 basin-wide indicators were developed to signify progress under the GLWQA. These indicators are grouped into seven environmental compartments: air, water, land, sediments, biota, fish, and humans. However, the 2001 report determined that only 33 of these indicators are collectable. Because the majority of these indicators extend beyond water quality assessment, we will evaluate only the few indicators that measure water quality,[12] including toxic contaminants and excess nutrients.

Trends for toxic contaminants

The 2001 *State of the Great Lakes Report* depicts a steady improvement in the water quality of the Great Lakes. Evidence of this improvement can be found in the continual downward trend in toxic contaminants in herring gull eggs and a large increase in the population of most bird species. Moreover, there have been note-worthy reductions in levels of phosphorous, organic material, and solids.

The levels of toxic contamination found in herring gull eggs throughout the GLB have exhibited a steadily decreasing trend. During the period from 1974 to 2002, monitoring and analysis by the Canadian Wildlife Service found that levels of DDE[13] fell by 86% in Lake Ontario, 89% in Lake Erie, 85% in Lake Michigan, 91% in Lake Superior, and 93% in Lake Huron (figure 2.7) (Pekarik and Weseloh, 1998).

Levels of polychlorinated biphenyls (PCBs)[14] and hexachloro-benzenes (HCBs)[15] also showed drastic reductions during the same periods. PCBs fell 89% in Lake Ontario, 82% in Lake Erie, and 80% in Lake Michigan relative to their levels in the mid 1970s (figure 2.8). PCBs fell 87% in Lake Superior and 92% in Lake Huron (Pekarik and Weseloh, 1998).

Despite these dramatic improvements, there are still concerns about the level of toxic contaminants in the Great Lakes. PCB concentrations in fish in various areas of the basin continue to exceed the International Joint Commission's objective of 0.1 μg of PCBs per gram of fish tissue. Restrictions on the consumption of fish also remain and the IJC recommends that advisories on the consumption of sport fish should state plainly that eating Great Lakes sport fish may lead to birth anomalies (IJC, 2000). There is also concern about the presence of other toxic contaminants. Including the pollutants already discussed, scientists have detected 362 contaminants in the Great Lakes (32 metals, 68 pesticides, and 262 other chemicals). Eleven chemical pollutants are of special concern because of their toxicity, persistence in the environment, and tendency to bioaccumulate (Statistics Canada, 2000). As a result of these concerns, many regulatory agencies recommend further reductions in contaminant concentration and further remediation of contaminated sediment.

Trends for nutrient levels

Annual total phosphorous loadings in the Great Lakes have shown significant improvements over the past three decades (figure 2.10). Phosphorous loadings decreased in Lake Erie by 67% from 1967 to 1995 and by 65% in Lake Michigan from 1974 to 1995. Lakes Superior, Huron, and Ontario also saw declines of 43%, 33%, and 5%, respectively from 1974 to 1991 (Dolan, 2001). Lakes Michigan, Superior, and Huron met have their target load levels to prevent excessive algal growth since 1981, 1985, and 1986, respectively. Lake Ontario met its target in 1988 and 1989 but exceeded it in 1990 and 1991. Lake Erie met its goal in 1987, experienced increases in the early 1990s and met its target again in 1994 and 1995.[16]

These reductions in nutrient concentrations are largely attributed to reductions in municipal phosphorous loading (figure 2.11). Municipal phosphorous discharges decreased by 80% in Lake Erie between 1974 and 1995, 72% in Lake Michigan between 1976 and 1991, and 42%, 38% and 41% in Lakes Huron and Ontario between 1974 and 1991, and 46% between 1978 and 1991 in Lake Superior (Dolan, 2001). Limits placed on phosphorous concentrations in detergents in 1972 were effective in reducing loadings because 70% of total inputs of phosphorous are from detergents from municipal wastes (Environment Canada & USEPA, 1995a:3). Other reductions can be attributed to better control practices in industrial processes and agriculture.

Annual loadings of nitrogen in the GLB have been increasing since 1971 (figure 2.9). During the period from 1971 to 1993, nitrogen levels increased 49.8% in Lake Ontario. Despite these increases, levels remain well below the threshold of 10 milligrams per litre for safe drinking water.

Further evidence supporting improvement in water quality within the GLB has been the elimination of the Area of Concern (AOC) located in the harbor of Collingwood, Ontario. In general, approximately one third of the beneficial uses in AOCs have been reinstated and more than 60% of the action necessary to restore AOCs fully have been implemented. Furthermore, all the recommended remedial action at the Spanish Harbor AOC in Ontario has taken place and it is now in a stage of natural recovery (Environment Canada, 2000b).

Despite these improvements, most environmental groups and regulatory bodies continue to call for further action to improve water quality in the Great Lakes. The International Joint Commission (IJC), an advisory group of Canadians and Americans, states in their Eleventh Biennial Report on Great Lakes Water Quality (2002) that decisive action and increased funding is needed to address the issues of sediment contaminated with persistent toxic substances, humans consuming contaminated sport fish, and alien invasive species. The 2001 *State of the Great Lakes Report* also illustrates that many indicators are showing either mixed (undeterminable) or mixed with deteriorating results. Clearly, there is still much room for improvement.

Treatment of wastewater (national)

Municipal Wastewater Effluents (MWWE) are the largest source of human-related pollution, by volume, entering Canadian Waters (Environment Canada, 2001). MWWE, comprising both sanitary sewage and storm water, contains debris, suspended solids, disease-causing microorganisms, organic wastes, nutrients, and chemicals. These substances can cause unhealthy increases in nutrient levels, depletion of dissolved oxygen, habitat alteration, and the bioaccumulation of toxics. Furthermore, they may also lead to the contamination of drinking water via the introduction of bacteria and protozoans such as *Giardia* and *Cryptosporidium*.

The implementation of municipal water treatment infrastructure is one of the most effective ways to combat pollution from MWWE. Three levels of treatment are possible. Primary wastewater treatment removes solid waste mechanically with screens and filters, and finer sediment in settling chambers; secondary treatment employs microorganisms to break down dissolved organic material biologically, and uses settling to remove suspended solids; and tertiary treatment removes additional contaminants, including heavy metals and dissolved solids, through a variety of physical, chemical, and biological treatment processes. Tertiary treatment is most important for wastewater being discharged into sensitive environments or situations where the water will be reused (Environment Canada, 2001.

Trends

The amount of pollution being discharged into Canadian waters via MWWE has decreased dramatically over the last two decades. Raw sewage treatment is conducted through either septic tanks or municipal wastewater treatment plants (MWTPs). In Canada, 26% of the population, mostly living in rural areas, is served by septic systems, while the remaining 74%, living in municipalities, rely upon treatment from municipal sewers (MWTPs). Of this population on sewer systems, some level of sewage treatment served 97% of the people.

During the period from 1983 to 1999, the proportion of the population served by wastewater treatment increased from 72.7% to 96.7%. (figure 2.12) (Environment Canada, 1999). Over this same period, the percentage of populations receiving both secondary and tertiary treatment rose from 56% to 78%. MWTP coverage in Canada compares favorably to coverage in the United States and Mexico, reported at 71.4% and 23.8%, respectively (OECD, 2001).

Figures 2.13 to 2.17 show the changes in access to municipal wastewater treatment by region between 1983 and 1999. With a dramatic increase from 11.8% to 97.3% of the proportion of the municipal population served by some form of wastewater treatment, Quebec showed the greatest improvement in general access. The Prairies now provide 59% of the municipal population with tertiary, or highest, level of treatment, as opposed to 8.8% in 1983. British Columbia improved the level of treatment to secondary or tertiary levels by 1999 for 36.3% of the population who had been receiving the minimum primary level in 1983 (Environment Canada, 2000).

Water quality in the United States (national)

The *Clean Water Act* sets, as a national goal, the protection of the biological, chemical, and physical integrity of the waters of the United States (EPA, 2002).

Ground water is the principal source of freshwater reserve in the United States and represents a large source of the future water supply. Groundwater accounts for as much as 40% of stream and river flow in the eastern United States. Moreover, it is estimated that groundwater supplies drinking water to approximately 46% of the whole American population and to 99% of those living in rural areas (EPA, 2000).

Given the scale and geographic diversity of the United States, an equally diverse set of programs has been established to monitor water-quality issues. These include, but are not limited to, the US Geological Survey's (USGS) National Water Quality Assessment (NAWQA) Program, the EPA's Environmental Monitoring and Assessment Program (EMAP), the National Oceanic and Atmospheric Administration (NOAA) and the Natural Resources Conservation Services (NRCS) Natural Resources Inventory (NRI).

Performance Analysis

Contaminant levels in fish and wildlife

Contaminant levels in shellfish, fish, and wildlife in the United States provide a good comparison for water quality in Canada. The US federal government began monitoring the levels of pesticides and other contaminants in all segments of the environment through a multi-agency program in the 1960s using methodologies similar to those used in Canada, (see section above on Atlantic Canada). Currently, under the US Fish and Wildlife Service and the USGS, the National Contaminant Biomonitoring Program (NCBP) monitors such trends over time.

Trends

Coastal water quality in the United States is improving as it is in Canada. Shellfish contaminant levels on the coast of the United States have followed a rapidly declining trend. Monitored through the Mussel Watch Project 14, DDT levels on America's Atlantic coast fell 36% while PCB levels fell 48% during the period from 1986 to 1994 (NOAA, 1988).

Analysis of the freshwater fish and the European starling in the United States support the same declining trend in contaminants found in Canada. The European starling was selected for monitoring contaminant levels in terrestrial habitats because of its varied diet and wide geographic distribution while freshwater fish were chosen due to their susceptibility to pesticides and bioaccumulation (Schmidt, 2003). Among freshwater fish during the period from 1969 to 1986, levels of DDE dropped 82% while levels of PCBs fell 83% (NCBP, 2003). Similarly, among European starlings, levels of DDT and PCBs fell 86% and 68%, respectively (NCBP, 2003). Other species showing the same trend are the mallard and the black duck (Schmitt, 2003).

Nutrient levels

Since 1991, USGS scientists with the National Water-Quality Assessment (NAWQA) program have been collecting and analyzing data and information in more than 50 major river basins and aquifers across the United States. The goal is to develop long-term consistent and comparable information on streams, ground water, and aquatic ecosystems to support sound management and policy decisions. The NAWQA Program has successfully achieved three of its primary goals. First, it has assessed the condition of American streams and rivers. Second, it has progressed toward its second goal of assessing long- term trends by establishing baseline conditions that will allow for meaningful comparison in the future. This includes baselines for persistent contaminants such as DDT, PCBs, and lead. Finally, it has made progress in establishing how natural features and human activity affect stream and river conditions (USGS, 1999).

Phosphorous loadings are derived primarily from fertilizers, manure, other non-point sources, and wastewater treatment. In order to control excessive algae growth, the US Environmental Protection Agency (USEPA) has established a recommended limit of 0.05 mg/L for total phosphates in streams that enter lakes and 0.1 mg/L for total phosphorus for flowing waters (USGS, 1999).

Trends

Targeted point-source controls have been very effective in reducing phosphorous loads to the environment in the United States. The use of phosphorous in detergents, for example, estimated at 220,000 metric tons in 1987, was reduced to less than 15,000 tons by 1998, due in large part to enactment of phosphate bans and the manufacturers' voluntary elimination of phosphates in detergents. Moreover, limits on effluents from wastewater plants were successful at reducing phosphrous concentrations in effluents from approximately 11 mg/L in 1970 to approximately 5 mg/L today. This reduction is largely attributed to the shift in type of treatment plants operating in the United States. During the period from 1962 to 1996, the proportion of plants with primary treatment or less was reduced from 50% to almost zero, while the number of plants using tertiary treatment increased from zero to 25% over the same period. Due to the success of these programs, attention has now shifted toward non-point sources of pollutants (USGS, 1999).

Despite the significant gains made through source controls, problems still remain surrounding non-point sources such as agriculture. During the period from 1950 to 1998, the use of phosphorous in fertilizers more than doubled while phosphorous inputs from manure also increased dramatically. About half of all river sites tested had phosphorus concentration levels of 100 ppb or higher. About one fourth of the tested sites had concentrations below 50 ppb. Since some areas have higher natural levels of phosphorus than others, interpreting this indicator will become much easier when trend information is available (Litke, 1999).

Mexico

There is limited data available on general water quality in Mexico. Figure 2.18 shows the level of nitrates in four major rivers in Mexico, between 1980 and 1998. Except for a sudden spike in the Panuco River in 1997, the Grijalva, Panuco, and Bravo rivers have had low concentrations of nitrates. In the Lerma River, nitrate concentrations have varied widely but are showing a general downward trend. Figure 2.19 shows the phosphorus concentrations in the same rivers between 1980 and 1998. The Grijalva and Panuco rivers have had low concentrations of phosphates. The Lerma River is showing an increasing trend in phosphate concentration levels.

Notes

1 Water sources of very poor quality may be adequately treated to produce high-quality drinking water.

2 For a complete list of water pollutants, please refer to the Guidelines for Canadian Drinking Water Quality, located at <http://www.ec.gc.ca/CEQG-RCQE/English/Ceqg/Water/default.cfm>.

3 Persistent (degrade slowly): this is the most rapidly growing type of pollution and includes substances that degrade very slowly or cannot be broken down at all; they may remain in the aquatic environment for years. The damage they cause is either irreversible or reparable only over decades or centuries. These pollutants include PCBs, DDT, heavy metals, dioxins, and petroleum products.

4 Non-persistent (degradable): these compounds can be broken down by chemical reactions or by natural bacteria into simple, non-polluting substances such as carbon dioxide and nitrogen. The process can lead to low oxygen levels and eutrophication if the pollution load is high but this damage is reversible.

5 Eutrophication is the process that, over time, turns a lake into a bog. This process is tremendously accelerated by high concentrations of phosphorus and nitrogen (from fertilizer, for example), which enrich the water with nutrients, causing the aquatic plants to bloom. As the plant growth explodes, it chokes off the oxygen supply normally shared with other organisms living in the water. When the plants die, their decomposition uses up even more oxygen. As a result, fish suffocate and die and bacterial activity decreases (Environment Canada, 2003).

6 Phosphate levels have been regulated twice in Canada: 8.7% limit in 1970, followed by a 2.2% limit in 1972.

7 Bioaccumulation in aquatic organisms occurs when a persistent, fat-soluble, contaminant enters the organism's body through the skin or by ingestion. If consumption exceeds the organism's ability to metabolize or eliminate the contaminant, over time it accumulates in the tissues.

8 For more information, please refer to <http://www.ns.ec.gc.ca/epb/factsheets/sfish_wq.html>.

9 Further information may be obtained at <http://www.ainc-inac.gc.ca/nt/wrd/wres_e.html>.

10 HCB is a white crystalline solid that was commonly used as a pesticide until 1965. In the past, HCB was also used as a fungicide to protect seeds of wheat and for a variety of industrial purposes. HCB is a persistent, bioaccumulative, and toxic (PBT) pollutant targeted by the EPA. HCB damages bones, kidneys, and blood cells, can harm the immune system, can cause abnormal fetal development, and cause cancer <http://www.epa.gov/opptintr/pbt/hexa.htm> (USEPA, 2003b).

11 Hexachlorocyclohexane, gamma-, also known as HCH gamma- or lindane, is a white solid that turns into a vapour when released into the air. Once released, it is colourless but has a musty odor. HCH gamma- is a man-made chemical and it exists in eight different forms. HCH gamma- was mostly used on fruit and vegetable crops to kill insects. Today it is used as an ingredient in ointments that help cure head lice, body lice, and scabies. HCH gamma- has not been made in the United States since 1977 but it is still brought into the country (imported) and formulated. The US Environmental Protection Agency (EPA) has placed limits on what it can be used for in the United States. Only individuals who are certified can use it. Workers exposed to HCH gamma- while making pesticides showed signs of lung irritation, heart disorders, blood disorders, headache, convulsions, and changes in sex hormones. Humans and animals exposed to large amounts of HCH gamma- died (USEPA, 2003c).

12 For a complete assessment of all 33 indicators, please refer to State of the Great Lakes 2001, (Environment Canada and United States Environmental Protection Agency, 2001)

13 DDE is a product of the breakdown of DDT (dichloro-diphenyl-trichloro-ethane), which is a persistent, bioaccumulative, synthetic insecticide. Its use was heavily restricted in the 1970s and prohibited after 1990. DDE is most easily measured in the fat of animals or in the eggs of birds. Most pesticides in use today are not as persistent and hence not transported to the same degree as DDT.

14 PCBs were once used extensively in many parts of the electrical and transmission industry, in flame retardants, water-proofing agents, printing inks, and adhesives. They were also spread on roads to prevent airborne dust. In the 1980s, tight restrictions allowed PCBs to be used only in closed electrical equipment. Safe incineration technologies now are used to destroy those currently in storage. They have been associated with declining fish populations in some locations.

15 HCBs are used in fungicides, dye manufacturing, and wood preservatives. They are also produced as a waste by-product of chemical manufacturing. The Great Lakes region is at risk from HCB contamination since numerous chlorine plants are located near the Lakes on both sides of the border.

16 Target loads for phosphorous (in metric tonnes per year) set in the 1978 Great Lakes Water Quality Agreements: Lake Superior, 3,400; Lake Michigan, 5,600; Lake Huron, 4,300; Lake Erie, 11,000; Lake Ontario, 7,000.

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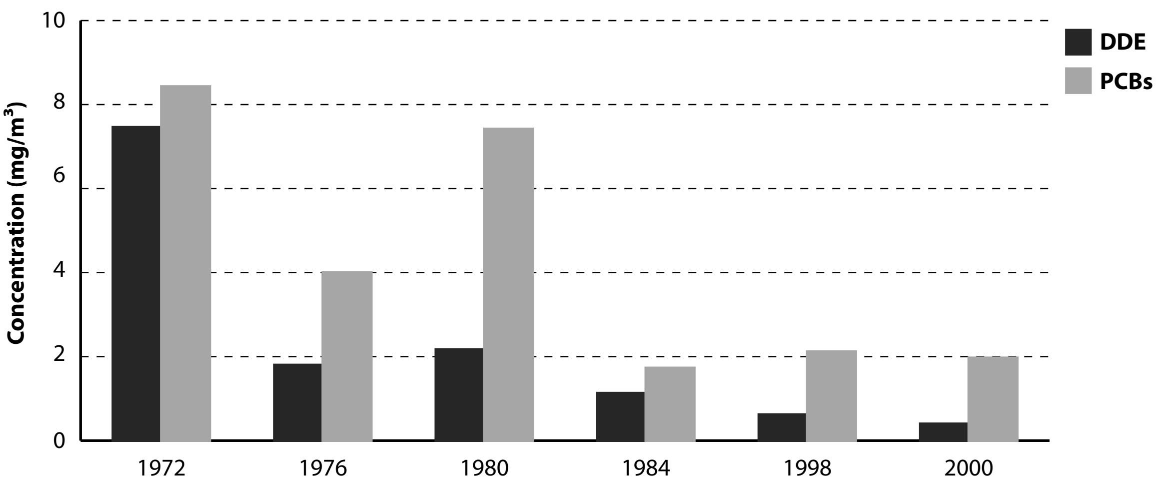
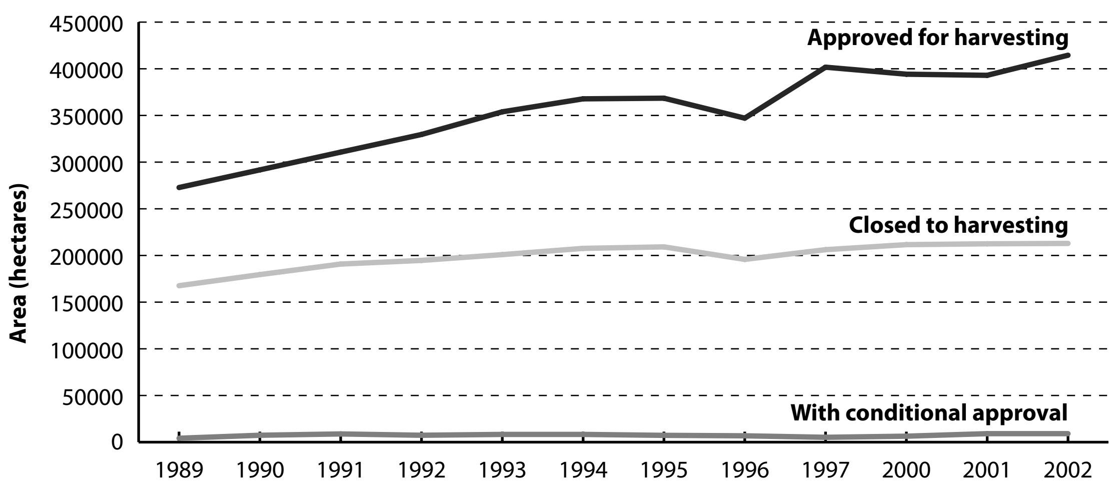
Figure 2.1: Levels of PCBs and DDE in the eggs of double-breasted cormorants in Bay of Fundy



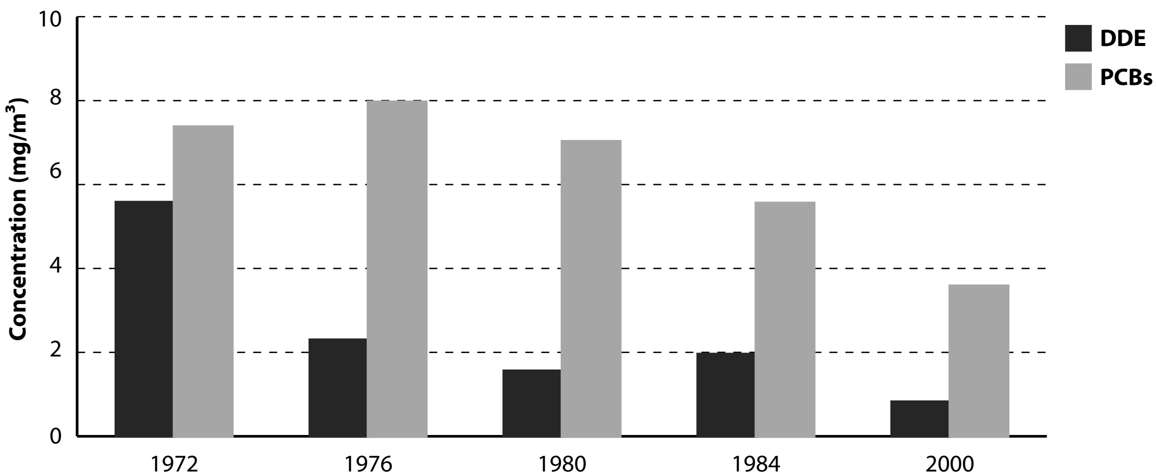
Canada: Environment Canada (2003), *Canada's National Environmental Indicator Series 2003.*

Figure 2.2: Shellfish areas under management



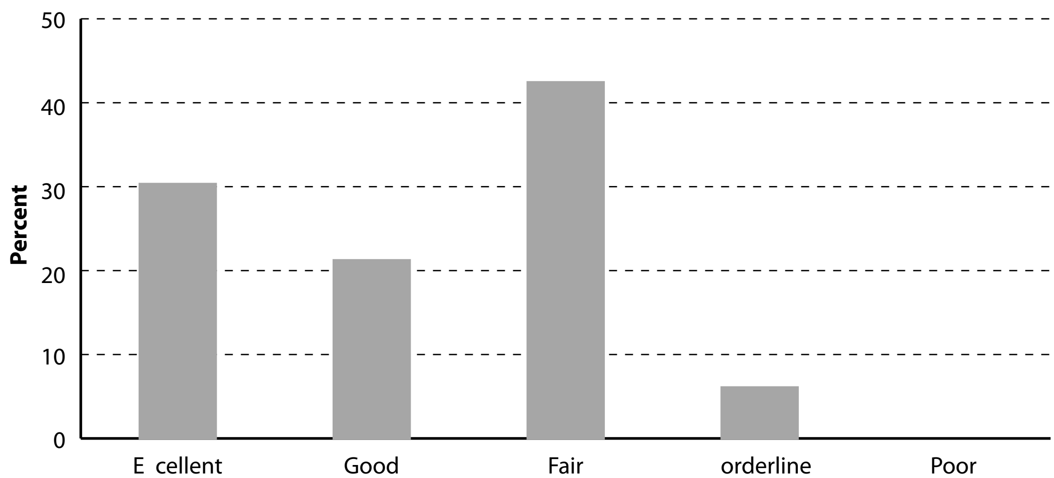
Source: Statistics Canada (2000), *Human Activity and the Environment 2000*; personal communication with Amar Menon, Shellfish Water Quality Protection Program, Environment Canada.

Figure 2.3: Levels of toxic contaminants in the eggs of double-breasted cormorants in the St. Lawrence estuary



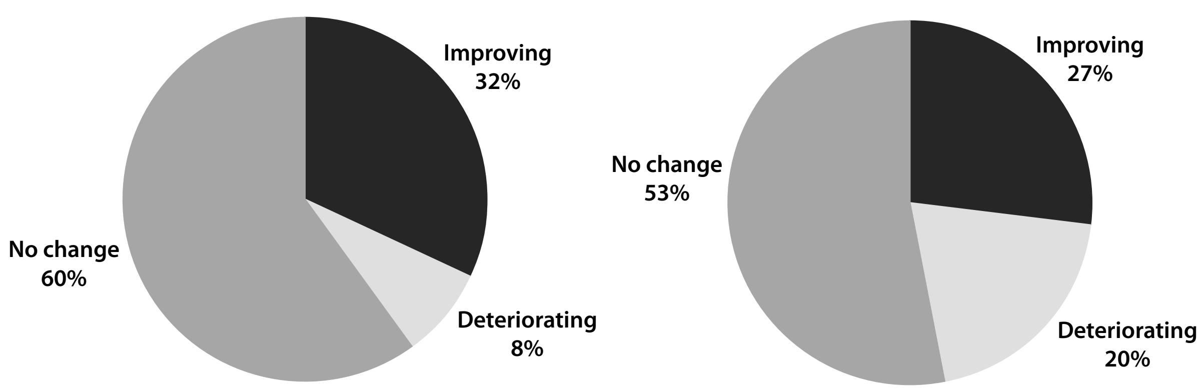
Source: Environment Canada (2003), *Canada's National Environmental Indicator Series 2003*.

Figure 2.4: Percent of selected British Columbian water bodies rated as excellent, good, fair, borderline or poor, 2000



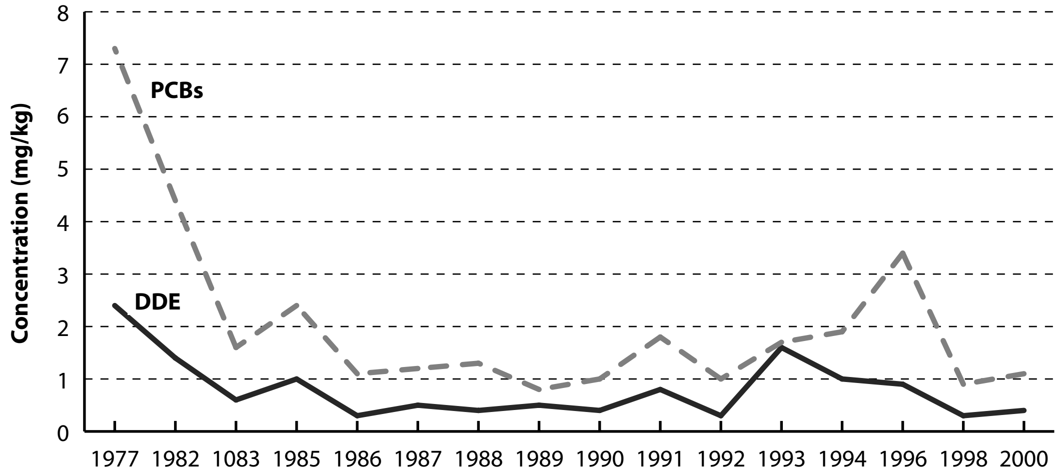
Source: BC Ministry of Water, Land, and Air Protection (2002), *Status of Water Quality*.

Figure 2.5: Trends in water quality in British Columbia, surface water (left) and ground water (right)



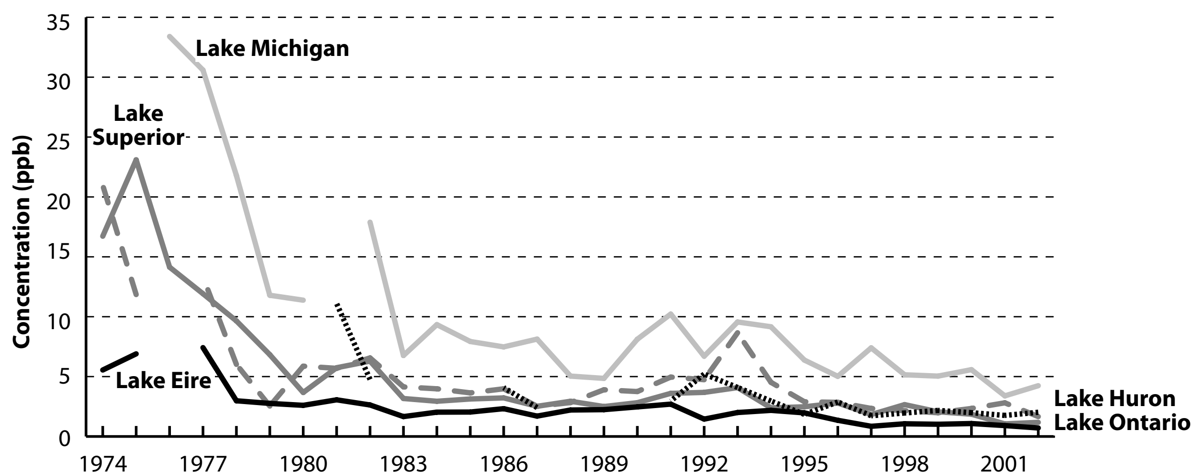
Source: BC Ministry of Water, Land, and Air Protection (2002), *Status of Water Quality*.

Figure 2.6: Trends in contaminants in eggs of blue herons at the University of British Columbia



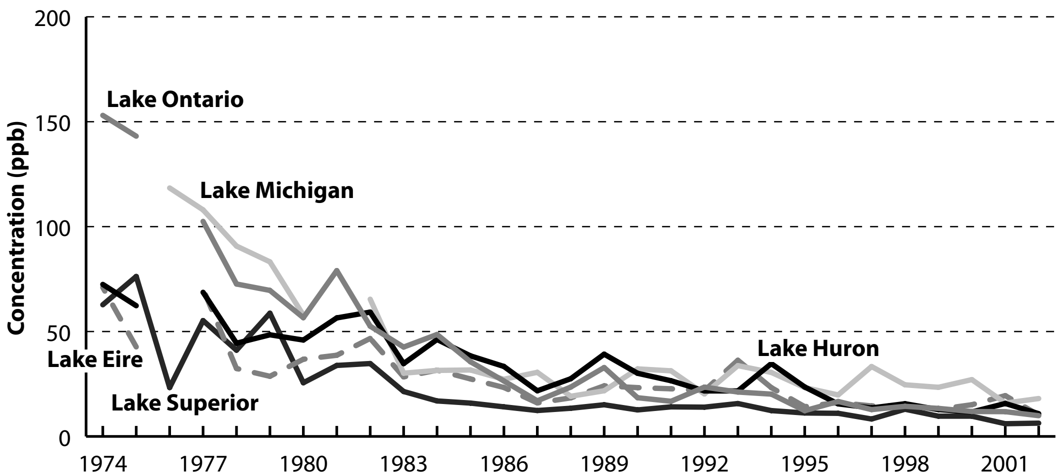
Source: BC Ministry of Water, Land, and Air Protection (2002), *Persistant* [sic] *Chemical in Wildlife in British Columbia, Contaminants in Great Blue Heron Eggs*.

Figure 2.7: DDE levels in herring gulls of the Great Lakes



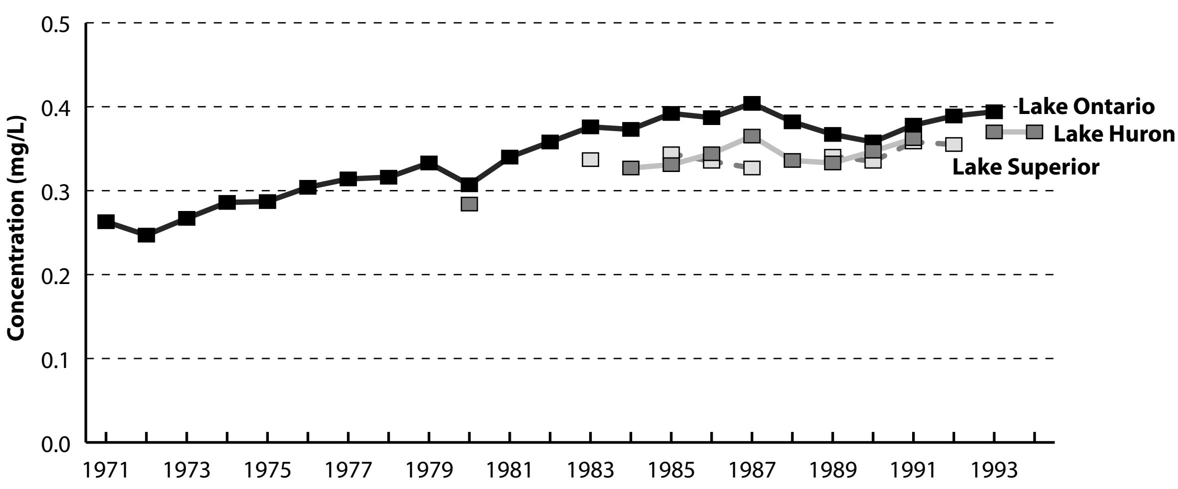
Source: Environment Canada (2003), *Contaminants in Herring Gull Eggs from the Great Lakes: 25 Years of Monitoring Levels and Effects* (January 31), <http://www.on.ec.gc.ca/wildlife/factsheets/fs_herring_gulls-e.html>; Council on Environmental Quality (1996), *Environmental Quality along the American River: The 1996 Report of the Council on Environmental Quality*.

Figure 2.8: PCB levels in herring gull eggs in the Great Lakes



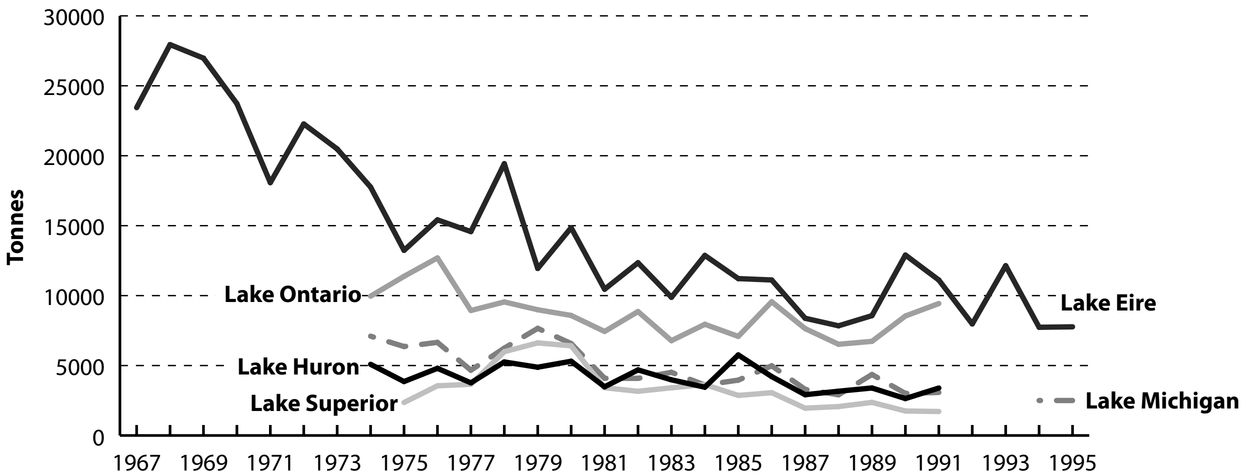
Source: Environment Canada (2003), *Contaminants in Herring Gull Eggs from the Great Lakes: 25 Years of Monitoring Levels and Effects* (January 31), <http://www.on.ec.gc.ca/wildlife/factsheets/fs_herring_gulls-e.html>; Council on Environmental Quality (1996), *Environmental Quality along the American River: The 1996 Report of the Council on Environmental Quality*.

Figure 2.9: Nitrate concentrations—Great Lakes, 1971–1994



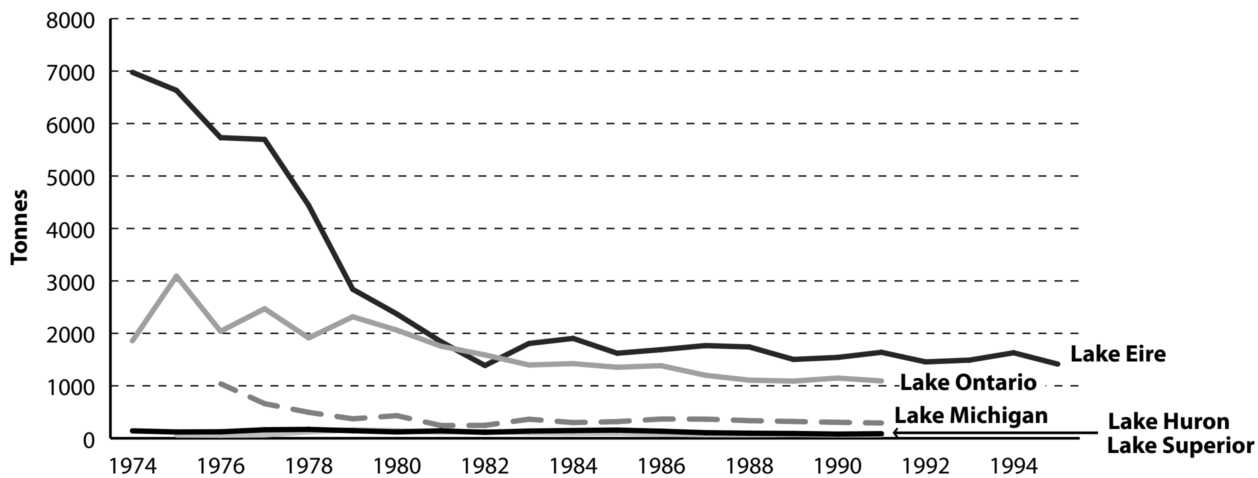
Source: Environment Canada (1999), *Environmental Conservation*.

Figure 2.10: Total phosphorous loadings in the Great Lakes



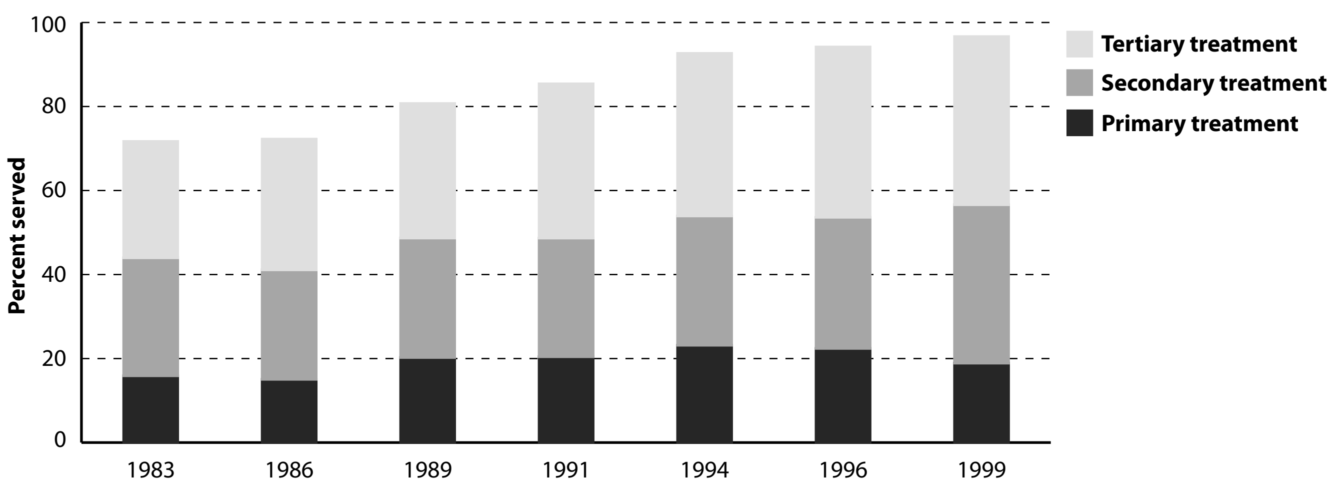
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report.*

Figure 2.11: Phosphorous loading from municipal sources in the Great Lakes



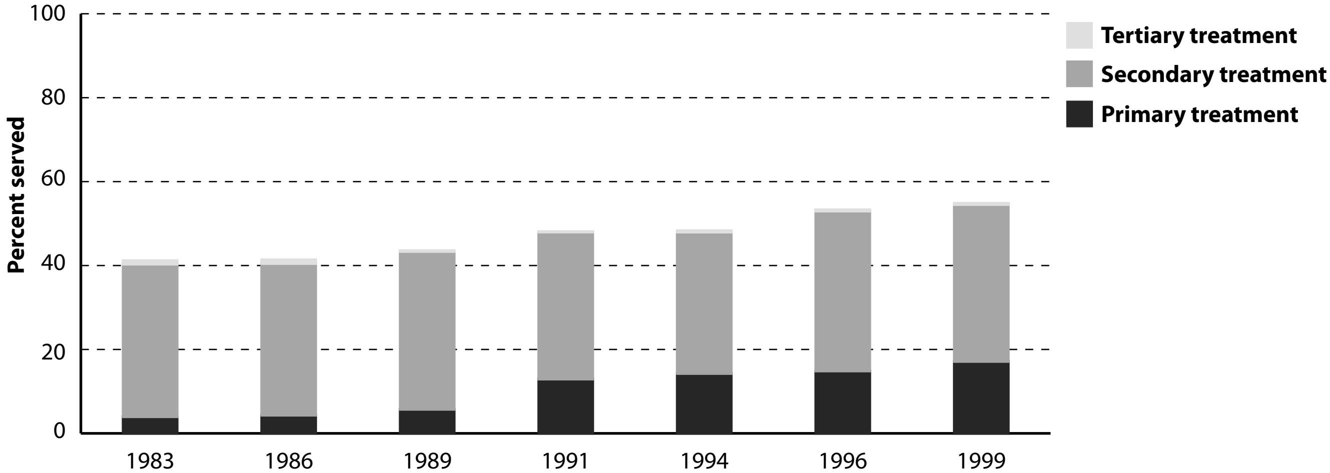
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report.*

Figure 2.12: Percentage of Canada's municipal populations served by wastewater treatment



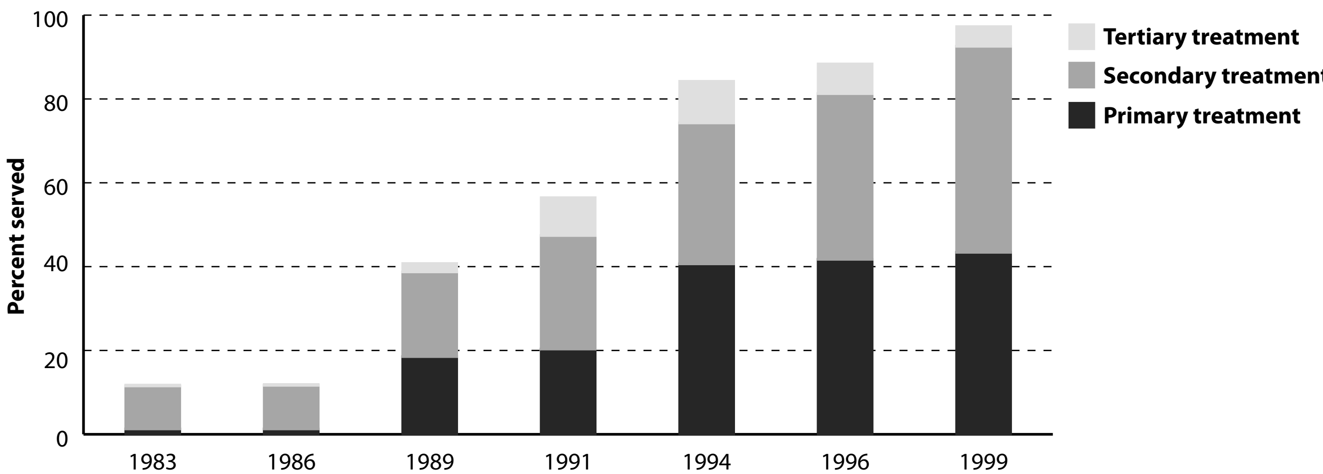
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report.*

Figure 2.13: Percentage of the Atlantic provinces' municipal populations served by wastewater treatment



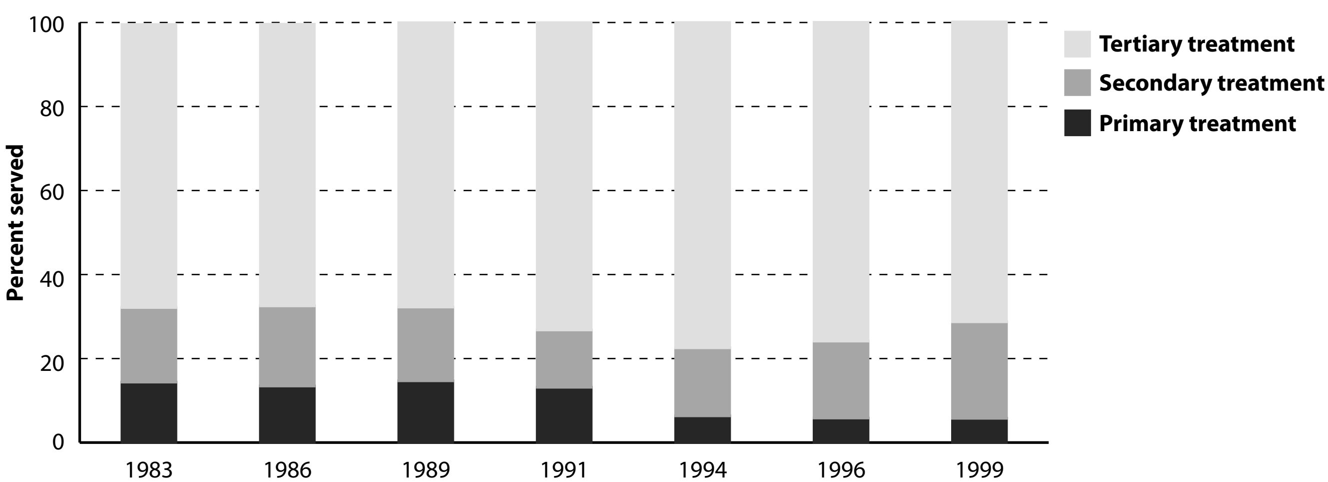
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report*.

Figure 2.14: Percentage of Quebec's municipal populations served by wastewater treatment



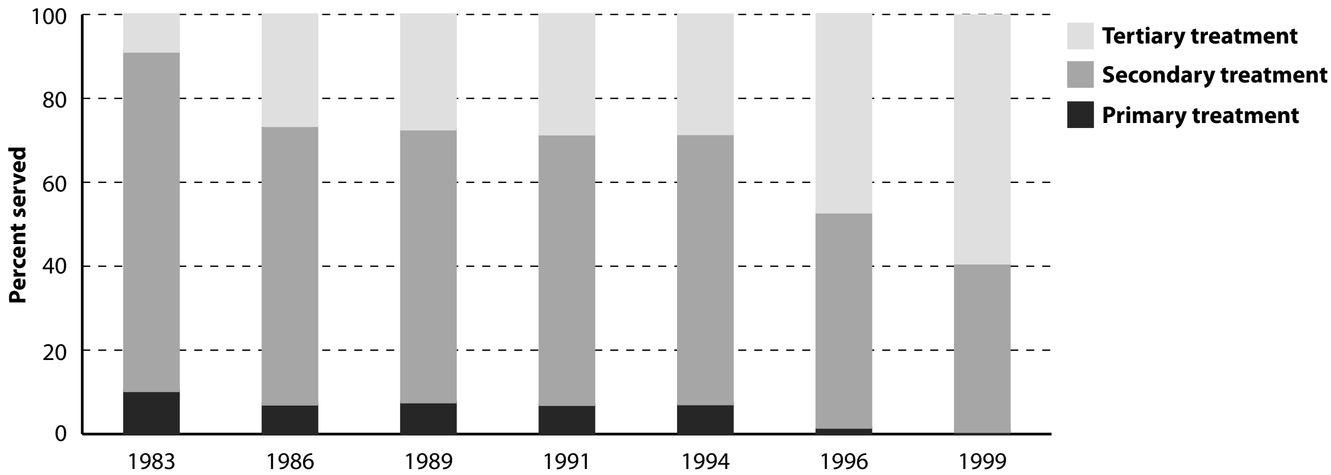
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report*.

Figure 2.15: Percentage of Ontario's municipal populations served by wastewater treatment



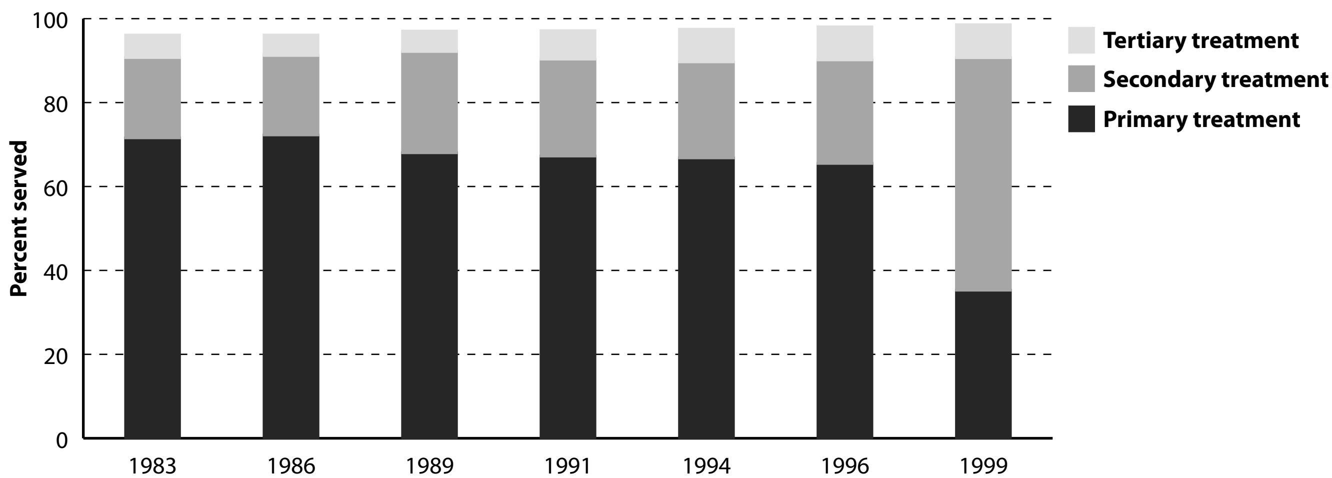
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report*.

Figure 2.16: Percentage of the Prairie provinces' municipal populations served by wastewater treatment



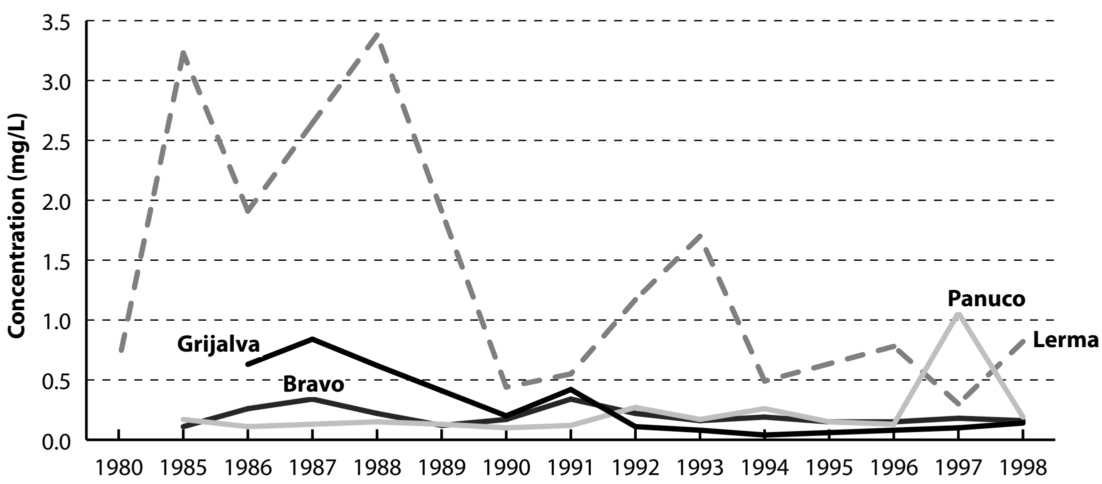
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report.*

Figure 2.17: Percentage of British Columbia's municipal populations served by wastewater treatment



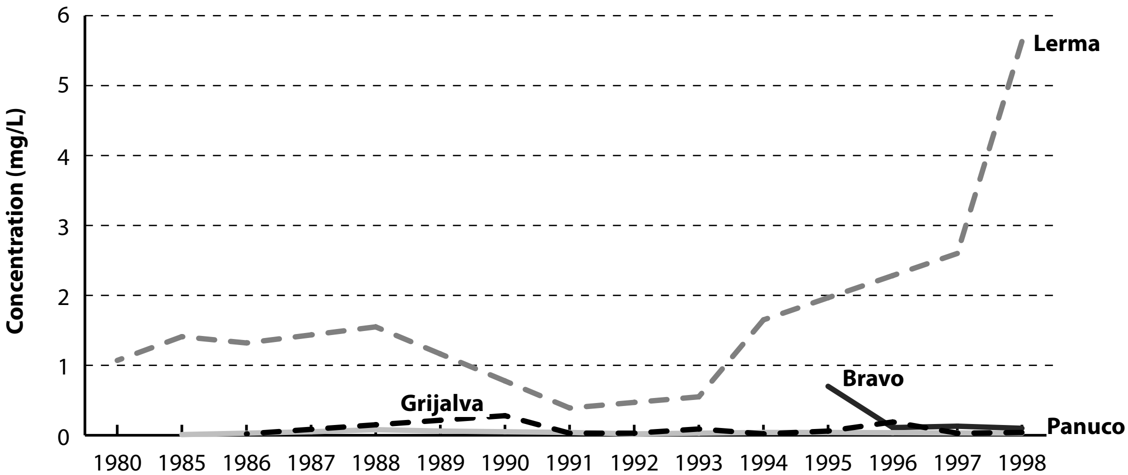
Source: Environment Canada (2001), *The State of Municipal Wastewater Effluents in Canada. State of the Environment Report.*

Figure 2.18: Nitrate levels in selected rivers in Mexico, 1980–1998



Source: Organisation for Economic Cooperation and Development (2002), *Environmental Data Compendium 2002.*

Figure 2.19: Total phosphorous levels in selected rivers in Mexico, 1980–1998



Source: Organisation for Economic Cooperation and Development (2002), *Environmental Data Compendium 2002*.

3 Solid Waste

Several controversial events surrounding waste management have been publicly debated in recent years. Events like the proposed landfill for Toronto's waste at the Adams Lake mine have been entwined with competing special-interest arguments, often to the general confusion of the public. As a result, a many questions and concerns about waste management have arisen; these deserve proper analysis.

People have become increasingly aware and concerned about waste generation and management in the last decade, partly due to widespread campaigns such as "reduce, reuse, and recycle." The result has been a corresponding reduction in the amount of waste going into landfills and an increase in the amount of waste diverted to recycling.[1]

What is waste management?

Waste management extends beyond the disposal of daily trash to include the "collection and transportation of waste and materials destined for recycling or reuse, the operation of non-hazardous and hazardous waste disposal facilities, the operation of transfer stations, the operation of recycling facilities and the treatment of hazardous waste" (Statistics Canada, 2000).

Who is involved?

Canadian waste management involves a two-tiered structure of services, including both public and private operators. Institutions such as local governments, regional boards and commissions represent public-sector involvement while private contractors, often on contract with the government, make up the private sector. Expenditures by public bodies targeted toward waste management totaled $1.4 billion in 2000, representing an increase of 10% over 1998 spending levels. Although public spending has been increasing, evidence shows that an increasingly large portion of waste services are being contracted out to private firms, reaching 59% in 2000. Employment for the entire industry, including both public and private operators, totalled 30,980 people in 2000. (Statistics Canada, 2002).

Objectives

Because so much solid waste is the result of discarded packaging, the Canadian Council of Environment Ministers (CCME) founded the National Packaging Protocol (NaPP) with the aim of reducing the amount of packaging sent for disposal to 50% of the 1988 level by the year 2000. This goal was achieved in 1996, four years ahead of schedule. Selected cities have also established waste reduction and diversion objectives. Toronto, for example, has established a 100% diversion goal by the year 2010 (Railcycle North, 2003).

Trends

How much is produced?

The total amount of waste generated[2] in Canada each year has exhibited a rising trend over time; however, the per-capita level of generation has been falling in several provinces in recent years. As depicted in figure 3.1, per-capita levels of garbage generation fell in four of the 9 provinces that reported data in a national survey.

In 2000, just over 31 million tonnes of waste were produced by Canadians, 1,019 kilograms (kg) per person. At the provincial level, Ontario and Quebec combined to produce over 65% of all waste in the country in 2000, proportional to the population in these two provinces and consistent with previous years. The lowest per-capita generation was observed in Nova Scotia (613 kg per capita) followed by New Brunswick (749 kg per capita).

Where does it come from?

Most of the waste[3] disposed of in Canada is generated by industrial, commercial and institutional sources, which generated approximately 52% of the total annual waste generated in 2000. Comparatively, residential waste accounted for 36%, while construction and demolition generated 12% (figure 3.2). These proportions have remained consistent over the past five years, although there has been a marginal increase (2%) in the proportion of waste disposed by the residential sector.

Where does it go?

Most of Canada's solid waste is either buried in landfill sites (67%) or incinerated (6%). This heavy reliance on landfills has perpetuated the fear that North America is running out of space for landfills and is facing a garbage crisis; however, this popular belief is unfounded. A single square of land, about 71 km (44 miles) on each side and about 37 m (120 feet) deep, could accommodate all the waste generated in the United States for 1,000 years (Wiseman, 1990). Given the rate of waste generation in Canada, it would require one tenth of this area. It should be noted, however, that not all land is equal when it comes to landfills. Even given modern engineering techniques like landfill liners and leachate-capture systems, some types of land are clearly more economical or practical for us as landfills: one would want a site with clay sub-soil, distant from major water supplies, and located away from major population centers but still close enough for cost-efficient transportation of waste. Given Canada's geographical expanse, there is no lack of such landfill space; therefore, if landfills are managed properly, Canada should not be concerned about a looming garbage crisis.

The impression that there is a lack of space for landfills may be the result of many current landfills nearing their capacity. However, most landfills are designed to have a short life span and are scheduled to close within a few years of opening. It is not the scarcity of land that inhibits the construction of new landfills and incinerators but rather the high price of land close to urban areas combined with political pressure. Within the Greater Toronto Area, for example, there have been no newly approved landfill or incinerators proposals during the period of 1990 to 2002. When a site eventually does get chosen for waste disposal, communities worry about environmental damage, odour, dust, litter, and scavenging animals that have been associated with landfills in the past. Such has been the source of heated controversy surrounding the proposed use of the Adams Lake mine as a disposal site for Toronto's waste. Fortunately, new sanitary technology now being used greatly reduces these problems.

How much waste is there?

Though Canada clearly does not have a lack of landfill space, a reduction in waste disposal is generally viewed as a positive environmental indicator. In 1994, Statistics Canada started its biennial Waste Management Industry Survey that monitors both public and private providers of waste management services. The survey's inception marked Canada's first real effort in measuring its solid waste in a comprehensive way.

Until 2000, Canadians had been decreasing the total annual amount of garbage disposed in landfills and incinerators (figure 3.3). During the period of from 1994 to 1998, the total amount of trash disposed fell 2.9%, from 21.5 to 20.8 million tonnes. In 2000, however, levels jumped 10.2%.

Possible causes of the increase

The province of Quebec conducts its own survey to collect information on disposal and recycling. Given that it uses a different methodology to collect data, caution should be exercised when comparing Quebec's data to that of other provinces. This is particularly notable in that 64% of the increase in waste recorded in 2000 is derived from Quebec.

Similarly, per-capita disposal rates were reduced steadily from 1994 to 1998 but climbed back to pre-1994 levels in 2000 (figure 3.4). Although several provinces showed increases, because the population of Quebec is so large, this increase may be partially explained by the Quebec's data.

Some provinces clearly dispose of more waste than their neighbours (figure 3.5). Nova Scotia has the lowest per-capita disposal rate—459 kg per person—and has shown the most improvement—a reduction in the per-capita disposal rate of almost 40% since 1994. Nova Scotia is not alone in its efforts to reduce the amount of waste disposed: of the nine provinces for which data is available, seven recorded reductions in the amount of waste disposed. Only Alberta and Quebec showed increases in the amount of waste disposed, recording 6% and 32%, respectively.

These reductions in per-capita disposed waste are encouraging because they occurred during a period of tremendous economic growth in Canada. As a country's wealth increases, generation of solid waste also generally increases for several reasons. The most prominent is that rising incomes lead to rising consumption. Thus, as Canadians become more prosperous, they go through more houses, clothes, and newspapers, among other things.

The composition of municipal waste in Canada is (by weight) 28% paper and cardboard, 34% food and garden refuse, 11% plastics, 7% glass, 8% metals, and 13% textiles and other (OECD 1999: 166). These proportions have shifted slightly over time; paper products have decreased from 37% of waste in 1985 to 28% in 2000, while levels of plastics, glass and metals all rose, most notably plastics, which rose from 5% to 11%. A report by the Ontario Ministry of the Environment and a comprehensive study in the United States both show that discarded packaging accounts for about one third of waste (Environment Canada, 1991; Franklin Associates, 1992)

One of the ways in which communities could further reduce garbage disposal is to implement user fees for waste collection. Communities in the United States that charge "pay-as-you-throw" rates for garbage collection in conjunction with recycling programs have routinely reported between 25% and 45% reduction in tonnage going to disposal facilities (Skumatz, 1993).

Recycling

In the 1970s, many local governments in Canada and the United States opened community recycling depots and started curbside recycling programs. For example, in Ontario, municipal governments, grocery stores, newspaper publishers, and the plastics, packaging and soft-drink industries jointly funded the Blue Box program through which household recyclables are collected on a designated day. Since the advent of these recycling programs, recycling rates have continued to climb and some municipalities have expanded collection to include cardboard and rigid plastic containers.

In 2000, Canada generated 31.4 million tones of non-hazardous solid waste, 7.5 million tones of which was recycled, accounting for approximately 24% of total production. This level represents an 11.4% increase from the 6.7 million tones recycled in 1996. Ferrous metals and mixed paper dominated this content, accounting for almost 50% of all materials recycled (figure 3.6). The proportion of these two components has been notably growing in the recycling mix, along with organics, all showing increases over the past 5 years.

On a provincial level, British Columbia recorded the highest rate of recycling, with 32% of all waste generated being recycled. Quebec and Nova Scotia tied for second with 30%. British Columbia also managed to maintain the highest recycling rate of waste from solely residential sources at 415, followed closely by Nova Scotia at 39%.

Although an increase in recycling rates is often considered a positive indicator, it is not always economically feasible or environmentally desirable to recycle waste. In some cases, manufacturing products from recycled materials requires more resources and energy and causes more pollution than does manufacturing the same products from primary raw materials.[4]

In other cases, changing the material a product is made from to a seemingly more environmentally friendly one involves unseen trade-off's. For instance, McDonald's decision to discontinue the use of polystyrene hamburger packaging has had several unfortunate consequences. The polystyrene shell used 30% less energy to produce than the paperboard alternative and resulted in 46% less air pollution and 42% less water pollution (Scarlett 1991). McDonald's decision to switch from polystyrene to paperboard also unfortunately caused the closure of the National Polystyrene Recycling Company, which had been newly formed by Dow Chemical and seven other plastic manufacturers to recycle polystyrene from 450 McDonald's restaurants (Blast et al., 1994).

Hazardous waste

The transboundary shipment of hazardous waste between Canada and the United States has become a hotly debated issue in recent years. Citizens often think that to import hazardous waste is to promote Canada as a dumping ground, while exporting is thought immoral because in doing so we shirk our responsibility to treat it properly at home. Unfortunately, what is left out of this debate is the ability of each country to transport, treat, and store such waste properly. It is important to recognize that waste exchange between countries provides an efficient matching service between the waste generator and potential user of the waste product. Transboundary movement provides a wider selection of treatment facilities, helping to reduce long-distance transportation between facilities or to give access to more specialized treatment for a specific type of waste. This can reduce the total volume and cost of waste disposal while promoting the efficient use of the nations' resources. For example, waste fuel for energy recovery, catalysts destined for precious metal recovery and spent caustic from the pulp and paper industry are often exported to the United States because the capacity for disposal or recycling does not exist in Canada (Environment Canada, 2003). Similarly, facilities for disposing of hazardous wastes are not always readily accessible in the United

States; therefore, waste is imported into Canada for treatment and storage. Despite these fundamental advantages to waste exchange, it should be noted that pre-treatment requirements are much more stringent in the United States than in Canada, thereby placing an increased burden on American producers.

Characteristics

In Canada, the responsibility for managing hazardous wastes is shared between the provincial and federal governments. The federal government is responsible for the regulation of all international movements while provincial and territorial governments monitor and regulate the generators, waste-management facilities, and transportation within their jurisdictions.

In 1992, the Government of Canada introduced *Export and Import of Hazardous Wastes Regulations* under the *Canadian Environmental Protection Act*. The Transboundary Movement Branch (TMB) of Environment Canada is responsible for implementing and monitoring these regulations in addition to implementing international agreements aimed at controlling the transboundary movement of hazardous waste.

Canada is currently working with Mexico and the United States through the North American Free Trade Agreement (NAFTA) Commission on Environmental Cooperation (CEC) to develop a North American approach to environmentally sound management of hazardous waste.

Trends

The total volume of transboundary hazardous waste crossing between Canada and the United States has risen over the last decade (figure 3.7). Despite this increase, however, imported hazardous waste accounts for less than 10% of domestic hazardous waste production. Notably, the total volume of transboundary movement fell in 2000 as imports fell almost 11% from 560,000 tonnes to 500,000 tonnes.

The volume of hazardous waste undergoing proper pre-treatment after import is rising. This is supported by examining the quantity of waste *not* receiving pre-treatment. Untreated waste levels fell in 2001, down 34% from 160,000 tonnes in 2000, and down 55% from 1999 levels, when they peaked at 235,000 tonnes. In total, approximately 1 million tones of hazardous waste were treated and disposed of in 2000 in Canada (Statistics Canada, 2003).

Imports of hazardous waste for recycling went to six provinces but Ontario and Quebec continue to receive nearly all hazardous waste imports into Canada. More than 99.7% of all imports for final disposal were destined for Ontario and Quebec, with very small quantities imported into British Columbia, Alberta, and Manitoba. Canadian exports of hazardous waste between 2000 and 2001 decreased from 323,000 to 313,000 tonnes.

Notes

1 Recycling is commonly referred to as "diversion."
2 Total generation is the sum of total residential and non-residential solid waste disposed of PLUS the total amount of materials processed for recycling.
3 If not otherwise indicated, in this chapter "waste" will refer to non-hazardous waste.
4 There are some situations, notably with aluminum and steel, where recycling is clearly the most cost-effective and environmentally friendly method to use. However, it is unnecessary to have a government program for recycling these materials since companies are willing to pay for the return of them. For example, the largest steel company in the United States, TXI Chaparral Steel, uses recycled steel entirely.

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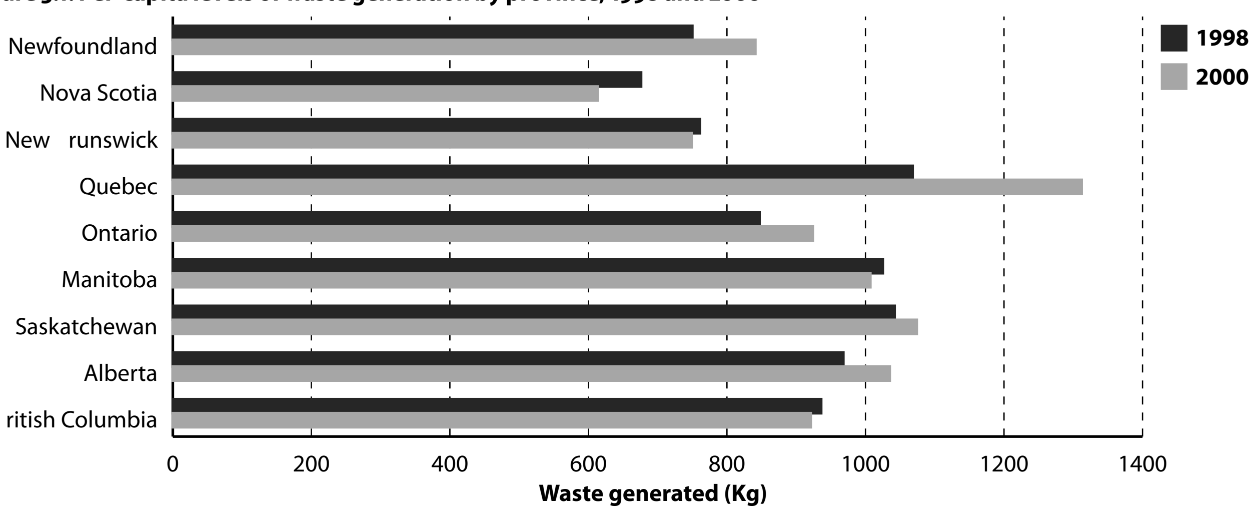
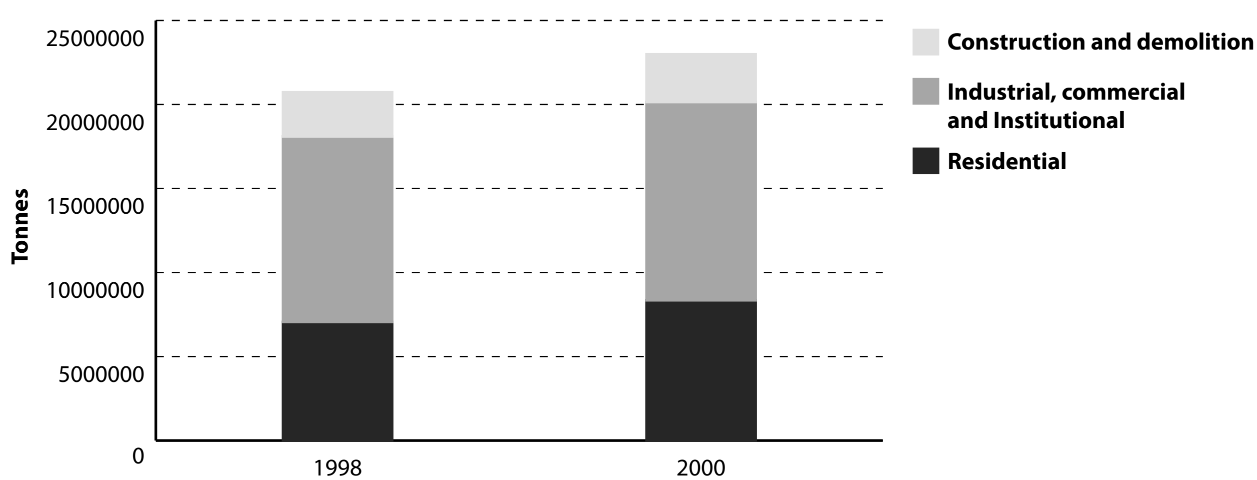
Figure 3.1: Per-capita levels of waste generation by province, 1998 and 2000



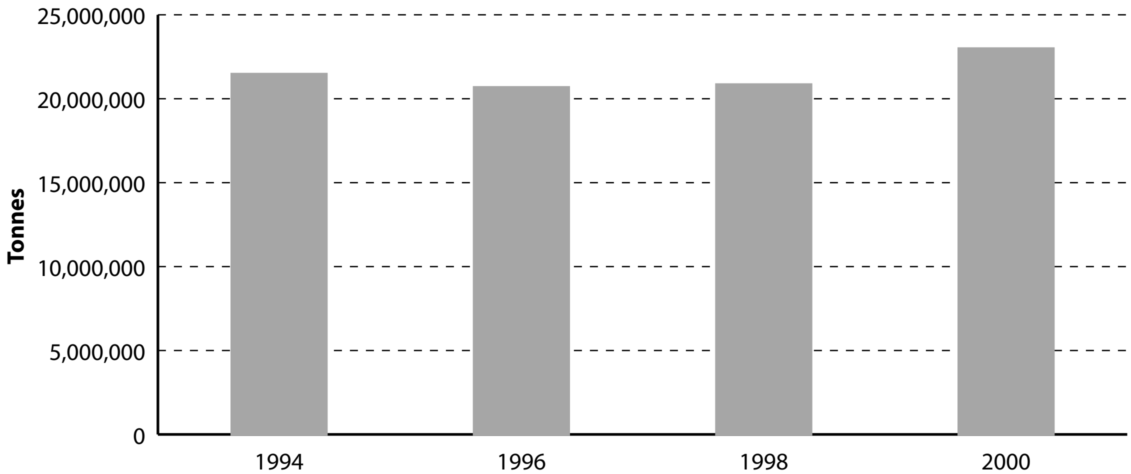
Source: Statistics Canada (2000), *Waste Management Industry Survey: Business and Government Sectors*.

Figure 3.2: Disposal of waste by source, 1998 and 2000



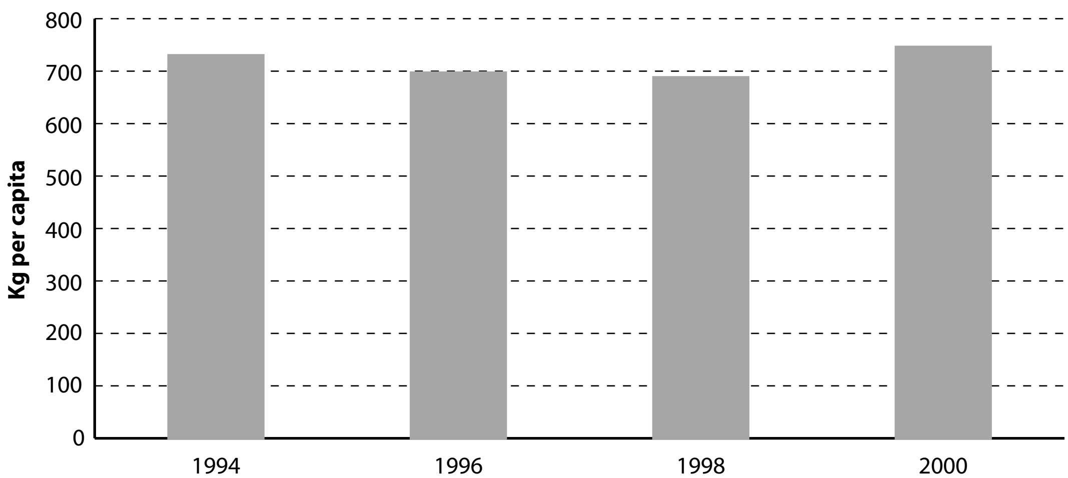
Source: Statistics Canada (2000), *Waste Management Industry Survey: Business and Government Sectors*.

Figure 3.3: Total quantity of waste disposed in landfills or incinerators



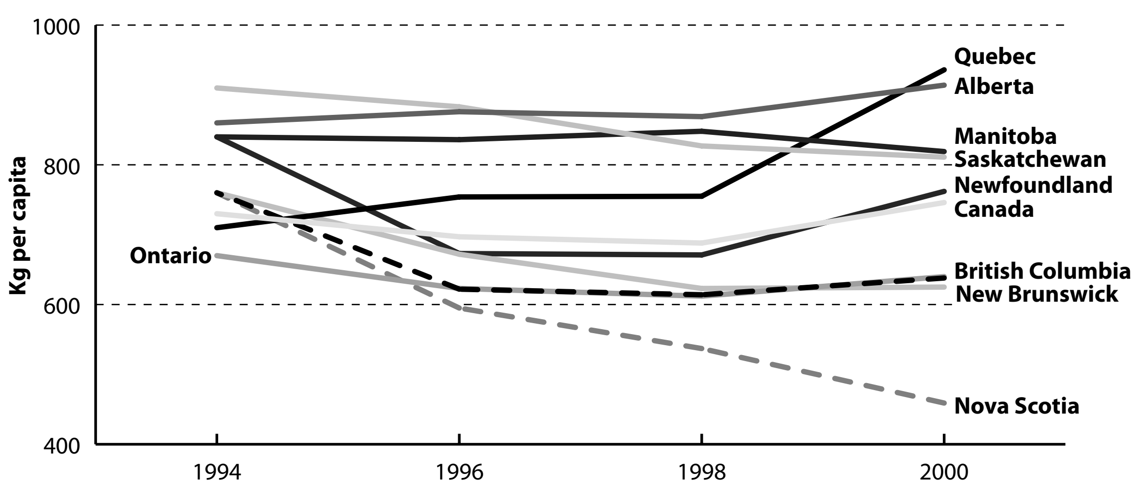
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 3.4: Canadian disposal trends—kg per capita disposal



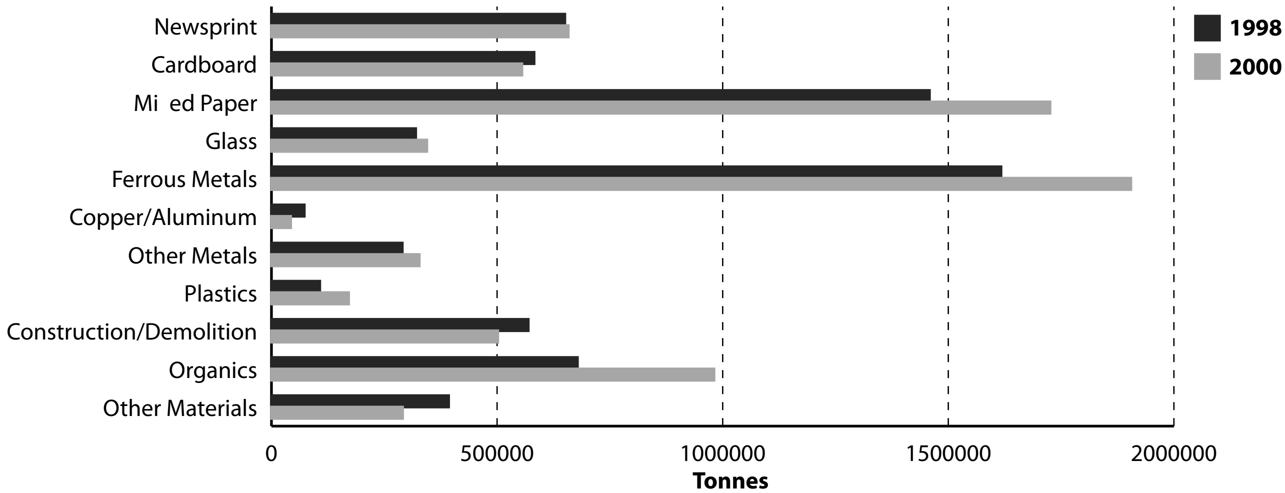
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 3.5: Canadian provincial waste disposal per capita



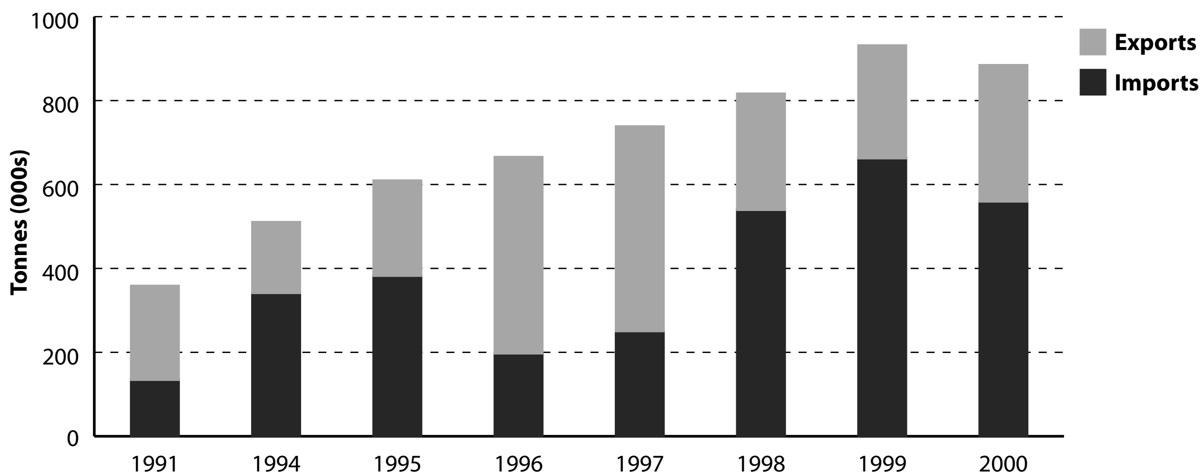
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 3.6: Materials prepared for recycling, by source



Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 3.7: Transboundary movement of hazardous wastes



Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

4 Land Use

Canada is the second largest country in the world, spanning 998,467,000 hectares. Of this area, 89,116,300 hectares (7.6%) is covered by freshwater and the remaining 909,350,700 hectares is land of various types (table 4.1) (Statistics Canada, 2003). Forests account for the largest portion of the land base (45%), while tundra—treeless, level or rolling ground in the arctic—covers 23%. Urban space represents the smallest land cover, accounting for less than 1% of all land in Canada (figure 4.1).

Despite Canada's size, only a small portion of it is suitable for agriculture and other economic activities. As a result, there is conflict over the use of this relatively small area. A primary area of conflict is human encroachment upon wilderness areas, particularly ecologically sensitive areas such as wetlands. Other concerns include urban expansion into agricultural areas, the sustainability of agricultural practices, and the environmental impact of biotechnology.

This section will first examine agricultural trends, with a special focus on biotech (BT) foods grown in Canada, followed by an assessment of protected lands in Canada, with a special emphasis on wetlands.

Agriculture

It has been estimated that 11% of Canada's land is capable of supporting some form of agriculture and 5% is suitable for crops (Environment Canada, 1996a). Almost all land that is suitable for agriculture is either in use today or has been developed for other uses.

Canada's agricultural sector, which includes farmers, suppliers, processors, transporters, grocers, and restaurant workers, is the third largest employer in Canada with approximately two million workers, representing 14% of total employment (Canadian Federation of Agriculture, 1997). The agri-food industry generated 8.5% of the Canadian GDP in 1998 and over $95 billion in domestic retail and food service sales (Agriculture Canada, 2000).

Over the past few decades, several factors have been responsible for driving change throughout the agricultural industry. These include, but are not limited to, domestic and global economic pressures, rapid technological change, disease scares, and unpredictable weather and environmental issues.

Trends

Although the total land used for agriculture has increased, the number of farms in Canada has been falling for over half a century. The most rapid decline in the number of farms occurred between 1956 and 1961, when the total fell by 16.5%, followed by an additional 15% decline between 1966 and 1971. The following decades showed similar declines, although at reduced rates (figure 4.2). Most recently, the 2001 Census of Agriculture recorded 246,923 farms lost, down 10.7% over the period from 1996 to 2001 (Statistics Canada, 2001). This rate is considerably higher than the rate of 5.6% experienced in the previous decade. Provincially, farm numbers fell a minimum 10% in all provinces, except in Alberta and British Columbia, where rates showed slower decline. Prince Edward Island suffered the largest decrease, recording a 16.8% reduction. Despite this drop in the total number of farms, however, the remaining farms have been getting larger, largely through consolidation. Farms with receipts of greater than $250,000 have more than doubled since 1991, while almost half of the farms with receipts less than $25,000 were lost over the same period. In terms of area, the average farm size rose 11.2%, increasing from 608 acres to 676 acres. Total land area devoted to agriculture in Canada has remained relatively constant since the mid-1980s (figure 4.3).

Large gains in Canadian farm productivity have been experienced through rapidly changing technology and land use practices. For example, cropland has increased 25.6% and the amount of land not worked for at least a year—summer fallow—has decreased by 42%.[1] According to a study by the United States Department of Agriculture, the Canadian agricultural sector was 206% more productive at the end of the 1980s than at the beginning of the 1960s (USDA, 1994). These gains have also been spurred by advances in biotechnology and the advent of crop varieties that are much more resilient to various environmental factors.

Although national levels of agricultural land have remained stable, provincial data reveals variation from region to region. The largest decrease in agricultural land during the census period was in Ontario (a decrease of 644,845 hectares or 10.3%), followed by Quebec (a decrease of 552,732 hectares or 13.8%) and New Brunswick (a decrease of 80,761 hectares or 17.3%) (Statistics Canada, 1997: 70). Since most of the agricultural land in Quebec and Ontario is located along the densely populated shores of Lake Erie, Lake Ontario, and the St. Lawrence River, some of this decrease can be attributed to urban development (table 4.1).

The major crops grown in Canada are wheat, canola, barley, oats, corn, and soybean. Evidence indicates, however, that there have been large shifts in the proportions of these crops. Although wheat and barley remain the dominant crops, the area planted in these crops fell 12.6% and 10%, respectively, in the 2001 census. Surveys show that these traditional crops are being replaced by specialty pulse crops, such as field peas, lentils, and beans.

Livestock production has become an increasingly important component of the agriculture sector. During the period 1996 to 2001, cattle and hog numbers reached record levels, increasing 4.4% and 26.4%, respectively, to include 15.6 million cattle and 13.9 million hogs (Statistics Canada, 2003). Cattle numbers have risen in every census since 1986. Hog numbers are nearing the number of cattle for the first time in history (*The Daily*, 2002).

Soil quality

One of the major issues in Canadian agriculture is the maintenance of soil quality and the reduction of erosion. Erosion is a natural process that removes topsoil and lowers the level of organic matter in the soil. When organic matter is lost, the soil structure breaks down and becomes less permeable to air, water, and nutrients. As soil fertility and productivity drops off, greater inputs (i.e. fertilizers) are needed to produce a crop. Eventually, the soil reaches an unproductive state. Many farming practices contribute to erosion including summer fallow, which leaves soil unprotected, and conventional tillage, which loosens the earth and makes it more susceptible to all types of erosion. Some results of erosion are poorer crop yield, more soil crusting, more runoff in the spring, higher soil pH, clogged drainage ditches, and the decline of water quality downstream due to the addition of nutrients, pesticides, and bacteria.

Trends

Between 1981 and 1996, the risk[2] of all three types of erosion—water, wind, and tillage—was significantly reduced in Canada (Agriculture Canada, 2000). The general trend of decreasing risk reflects the degree to which changes have been made in cropping systems and tillage practices. A combination of reduced tillage, decreased summer fallow, and the removal of marginal lands from production

Table 4.1: Total agricultural land in Canada, by province, 1976–2001

	1981	1986	1991	1996	2001
British Columbia	2,178,596	2,411,060	2,392,341	2,529,060	2,587,118
Alberta	19,108,513	20,655,340	20,811,002	21,029,228	21,067,486
Saskatchewan	25,947,086	26,599,354	26,865,488	26,569,062	26,265,645
Manitoba	7,615,926	7,740,226	7,724,990	7,732,138	7,601,779
Ontario	6,039,237	5,646,582	5,451,379	5,616,860	5,466,233
Quebec	3,779,169	3,638,801	3,429,610	3,456,213	3,417,026
Nova Scotia	466,023	416,507	397,031	427,324	407,046
New Brunswick	437,888	408,893	375,631	386,019	388,053
Prince Edward Island	283,024	272,433	258,875	265,217	261,482
Newfoundland	33,454	36,561	47,353	43,836	40,578
Canada	65,888,916	67,825,757	67,753,700	68,054,956	67,502,447

Source: Statistics Canada (2002), *2001 Census of Agricultural*.

all contributed to lower erosion rates. The Prairies, where two-thirds of the land is at moderate to severe risk of wind erosion, saw a 30% decline in the risk of wind erosion during this time.

Tillage erosion is caused when plows, discers, and other implements loosen soil and move it downslope with the help of gravity. The result over time is large losses of topsoil from the tops of hills and knolls and the accumulation of soil downslope, often mixed with less-productive subsoil. From 1981 to 1996, the overall risk of tillage erosion dropped by 24% in Canada. In 1996, almost half the cultivated land in Canada was under some type of reduced tillage and about 15% was under no-till or direct seeding methods. Conservation tillage and no-till practices have been made possible by the development of direct-seeding equipment and a wide array of herbicides that control weeds on untilled fields.

Other indicators also demonstrate improvements in soil quality. For example, whereas the levels of organic matter in Canada's uneroded agricultural soils had declined by 15% to 30% since cultivation began, they are now being maintained or improved in many Canadian croplands (Acton & Gregorich, 1995: 40, 45).

Genetically modified foods

Canadians enjoy a safe, inexpensive, and plentiful food supply. In the past few years, however, concern over the environmental and health ramifications of genetically modified foods—otherwise known as biotechnology foods or transgenic foods—have become a major issue in Canada.

Biotechnology is defined by the Canadian Environmental Protection Act as "the application of science and engineering in the direct or indirect use of living organisms, or parts or products of living organisms, in their natural or modified forms" (FBCN 2000).

Biotechnology has been used to create new food products with many different traits. Many of the crops currently approved were developed to be herbicide-resistant, allowing farmers to take advantage of no-till soil conservation practices to control weeds. With herbicide-resistant crops, farmers can control a wider range of weeds in a single application of herbicide, which benefits the environment and lowers the farmers' costs. Similarly, some types of potatoes have been modified to be resistant to insects, particularly the Colorado potato beetle. By greatly reducing the amount of pesticides used, consumers, farmers, and the environment benefit.

Trends

The total area planted in genetically modified (GM) foods has grown dramatically over the past eight years (figure 4.4). During the period from 1996 to 2002, the estimated area planted in GM crops grew from 1.7 to 58.7 million hectares worldwide, representing a 3,352% increase over this period. A sustained rate of annual growth of more than 10% per year has been achieved every year for the last six years, since their introduction in 1996 (ISAAA, 2003). In Canada, the total area grew from 0.1 to 3.5 million hectares, a 3,400% increase. Despite these increases, however, Canada's share of the GM market, as high as 11.8% in 1997, has slipped considerably, to 6% in 2002.

Despite large increases in several developing countries, Biotech (BT) crop production remains dominated by developed countries. According to international statistics, four countries were responsible for 99% of the area planted in BT crops in 2002: the United States (66%), Argentina (23%), Canada (6%) and China (4%). All four of these countries experienced increases in their 2002 production area (ISAA, 2003b). Developing countries that have recently adopted the production of biotech crops include India, Honduras, and Columbia.

Protected areas

Canada's first national park, Banff, was created in 1885. Today, in Canada there are over 60 different types of protected areas such as parks, wildlife areas, ecological reserves, and migratory bird sanctuaries, covering over 100 million hectares of land. Parks Canada, the Canadian Wildlife Service, and provincial environment ministries are the main government managers of Canada's protected areas. Non-governmental organizations such as Ducks Unlimited Canada, the Wildlife Habitat Foundation Canada and the Nature Conservancy of Canada also play an important role. Between 1987 and 1996, groups such as these were responsible for creating over 70% of the protected sites in the Atlantic provinces (Statistics Canada, 2000).

Trends

Canada's total protected land grew dramatically between 1876 and 2001 in all provinces and territories. Vast tracts of protected land are located in the Northwest Territories and Nunavut. (figure 4.5)

The first comprehensive effort to compile a database of all of Canada's protected lands under all the various designations is currently being undertaken by a division of

Statistics Canada. The Canadian Conservation Area Database attempts to capture all lands managed by federal, provincial, and non-governmental agencies, by size, category, latitude and longitude, and year of establishment. As this database is continuing to be developed, its usefulness as an indicator of Canada's protected lands will increase.

Recently, Canada has begun to turn its attention to protecting its marine environments through several initiatives. In 1998, the governments of Canada and Quebec jointly created the Saguenay-St. Lawrence Marine Park. Canada has also been working towards establishing a national park in each of the 39 natural regions defined by the *National Park System Plan* (1990) and marine conservation areas in each of the 29 marine regions defined by *Sea to Sea to Sea, Canada's National Marine Conservation Areas System Plan* (1995) (Federal Provincial Parks Council, 2000).

Significant progress has been made by Canada in protecting its most fragile marine environments. As of July 2002, just over 1000 sites representing 4.2 million hectares had been designated as marine conservation areas. Furthermore, in March 2003, Canada announced the establishment of Canada's first Marine Protected Area (MPA),[3] the Endeavour Hydrothermal Vents Area, located southwest of Vancouver Island, British Columbia. Establishing MPAs has become a key activity of Canada's newly implemented Oceans Strategy (DFO, 2003).

Wetlands

Wetlands are areas where water and land meet and are wet for an ecologically significant part of the year. Environment Canada defines wetlands to include bog, fens, swamps, marshes, and shallow open water. Wetlands may be temporarily flooded each day as with tidal marshes or be filled seasonally with water from melting snow.

In the past, wetlands were considered waste areas and were drained and converted to agriculture and other economically productive activities. It is estimated that about one-seventh (about 20 million hectares) of Canada's pre-settlement wetlands were drained (Rubec, 2001). In some areas, wetland conversion to agriculture has been considerable: 70% in southern Ontario, 71% in the prairie provinces and 80% of the Fraser River Delta in British Columbia (Natural Resources Canada, 2003).

Farming subsidies and other government policies, such as the Maritime Marshland Rehabilitation Act (1943), contributed to the destruction of wetlands. Until recently, the Canadian Wheat Board Act determined grain delivery quotas based on the total areas seeded and left fallow. This encouraged farmers to cultivate marginal land rather than leave it in its natural form (Environment Canada, 1991c.

As more is discovered about the function and value of wetlands, it is becoming clear that they play a reinforcing, rather than strictly competing, role in agriculture and urban development. For example, wetland preservation can help conserve and purify ground water and protect against drought and soil erosion. Wetlands in southern Canada also have direct economic benefits, producing wild rice, forest products, fresh water, cranberries, horticultural peat, and sphagnum mosses and support many socioeconomic functions such as hunting, trapping, fishing, tourism, and recreation.

The function of wetlands

Wetlands have often been described as the kidneys of the landscape because of the role they play in water cycles. They act as filtration systems, breaking down nutrients and neutralizing disease-causing pathogens. Wetlands also protect the land from flooding and shorelines from erosion as well as provide habitat for a wide range of species. Canadian prairie wetland, for instance, provides habitat for 50% of North America's waterfowl (Environment Canada, 1991c: [17]10).

Trends

Canada contains nearly 25% of the world's wetlands (Environment Canada, 1991c: [26]7), covering approximately 148 million hectares or 16% of our country's land base (Rubec, 2001). Although they are located across the country, they are primarily concentrated in northern Ontario, northern Alberta, the Northwest Territories, and Manitoba.

Canada has adopted and supported many conservation programs over the last two decades in recognition of the ecological and economic importance of wetlands. In 1981, Canada became a contracting party to the Ramsar Convention, an intergovernmental treaty to preserve wetlands. In 1990, the Canadian government established the North American Wetlands Conservation Council and, in 1991, Canada adopted the Federal Policy on Wetland Conservation, making it the first nation to formalize wetland policy on a national level.

A *List of Wetlands of International Importance*, developed through the Ramsar Convention, covers more than 1,000 sites around the world. It lists 36 sites in Canada, which make up just over 16% of the total wetland area designated world-wide under the convention to date, though only about 9% of the wetlands in Canada (Rubec, 2001).

These sites cover a surface area of more than 13 million hectares and are diverse in type and size, ranging from 244 hectares to over 6 million hectares.

The main conservation efforts, however, have been through the North American Waterfowl Management Plan (NAWMP), which Canada and the United States created in 1986 and Mexico joined in 1994. Through joint ventures between public and private agencies, this billion-dollar-plus program has identified the key habitats necessary to protect waterfowl populations and has developed plans for the restoration and protection of these areas. Of the 2 million hectares targeted in Canada under the NAWMP, 800,000 hectares have been protected thus far, which includes both wetlands and upland habitat associated with waterfowl (Rubec, 2001). Though some of this land belongs to the Crown, the majority of it is protected through programs with private landowners.

Private conservation organizations have made a significant contribution to wetland protection efforts. The two largest stewards of Canada's non-governmental conservation lands include Ducks Unlimited Canada and the Nature Conservancy of Canada. Ducks Unlimited Canada directly manages 1.5 million hectares and has conserved over 6 million hectares through agreements with governments and individuals (Cicierski, 2001). The Nature Conservancy has conserved 675,800 hectares on over 1,000 properties, largely through deals with private landowners (Rehman, 2001).

Industry has also been an active player in protecting key areas. Shell Oil gave a large holding in British Columbia to the Nature Conservancy in 1992; MacMillan Bloedel donated Cathedral Grove in the 1940s; and New Brunswick's Bowater-Mersey Forest Products Limited has entrusted areas of ecological importance, including wetlands, to governmental and non-governmental conservation groups (Environment Canada, 1996b).

Recent changes to the federal tax code, through the Ecological Gifts Program, have given individuals and companies increased incentive to give land to governmental or private organizations. Over 200 gifts of land have been made since 1995: 50 of these gifts donated in 2000 alone and 60% have been wetlands (Rubec, 2001).

Summing up the land covered under the NAWMP, Parks Canada, National Wildlife Areas, Migratory Bird Sanctuaries, private organizations and other initiatives, it is estimated that 15 million hectares of wetlands in Canada are protected. That means that roughly 10% of Canadian wetlands are under some status secured for conservation efforts. The major thrust of conservation efforts currently focus on working with private landowners in southern Ontario, the Prairies, and some coastal areas where wetlands are most vulnerable.

A recent conservation effort has been Natural Legacy 2000, a program administered by the federal government's Canada Millennium Partnership Program, which involved the World Wildlife Fund Canada, the Nature Conservancy of Canada Ducks Unlimited Canada, and the Canadian Nature Federation. Ducks Unlimited Canada secured 182,000 hectares under various conservation programs while the Nature Conservancy preserved 24,400 hectares under conservation easements, land donations, and planned gifts.

Notes

1 Since lands left in summer fallow are more likely to sustain erosion and to promote salinization, this decrease is a positive one. The decline in erosion rates is partly attributed to this trend in summer fallow.

2 Risk is calculated by Agriculture and Agri-food Canada as an indirect measure of changes in soil quality. They assess soil, climate, management factors, prevailing land use, and tillage practices when calculating the indicator.

3 An MPA is an area of the ocean that is designated for special management measures under the *Oceans Act*. This designation puts in place enforceable regulations to protect the area and its marine organisms, while encouraging continued scientific study and research of this unique eco-system.

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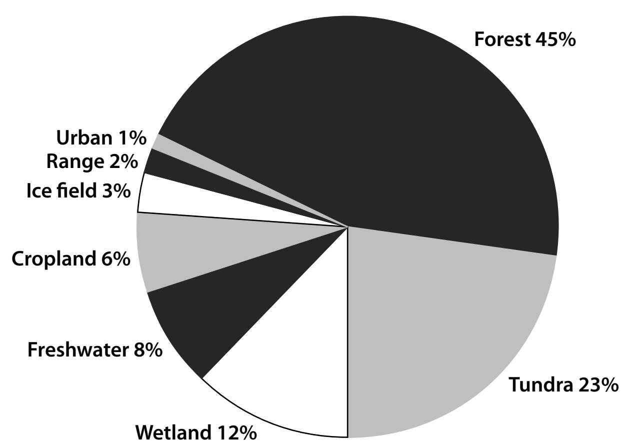
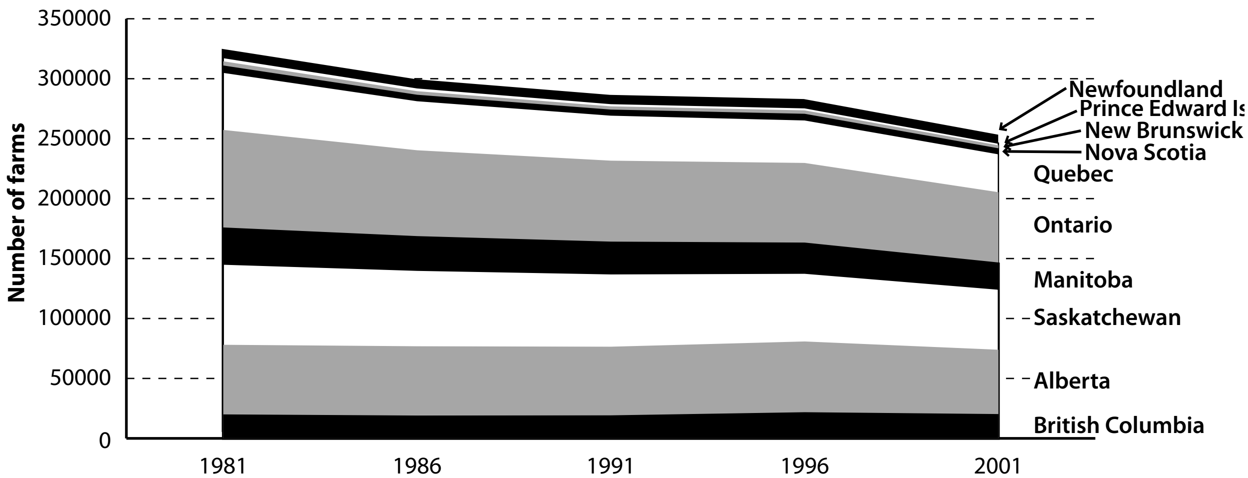
Figure 4.1: Land cover in Canada



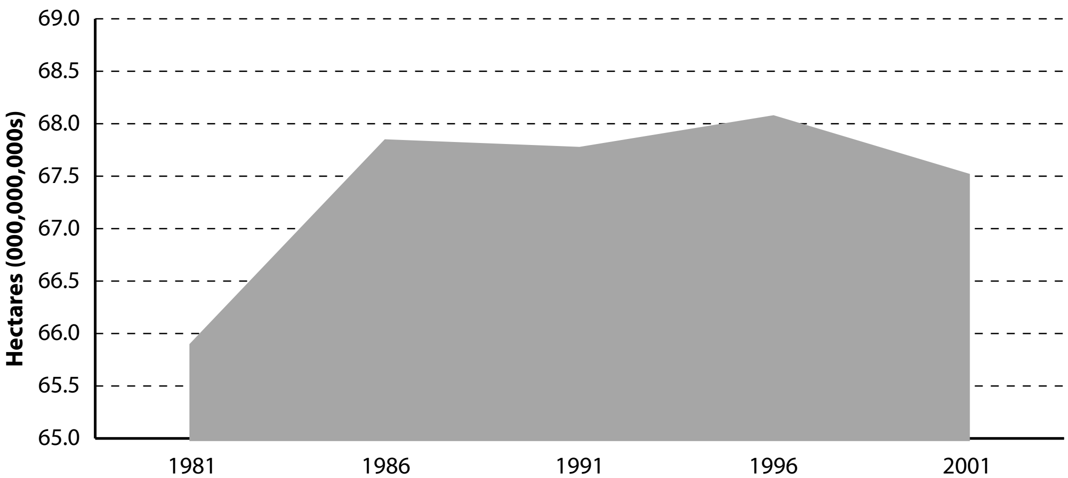
Source: Statistics Canada (2003), *Canadian Statistics, Geography, Land Area and Resources*.

Figure 4.2: Total number of farms by province, 1981–2001



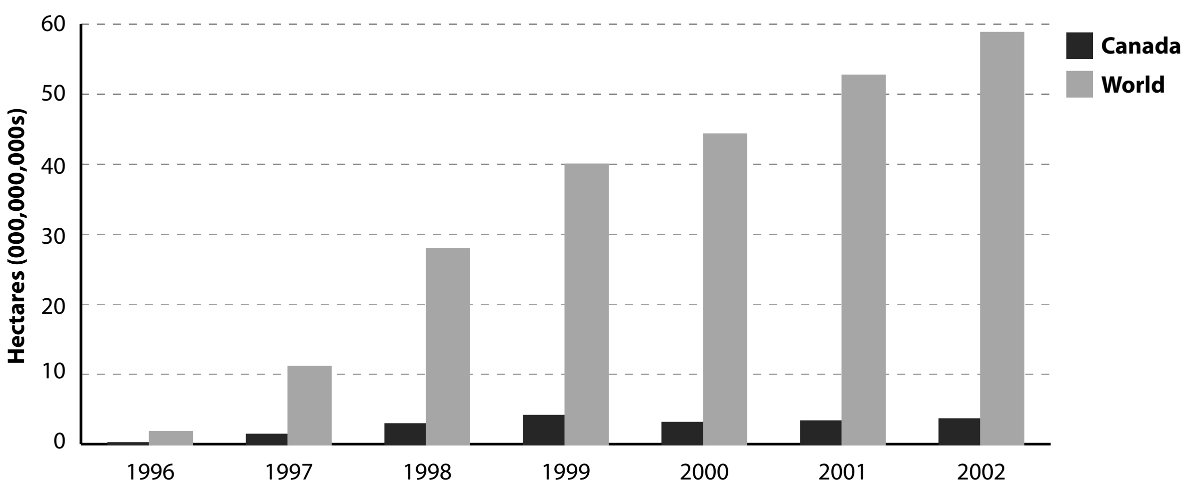
Source: Statistics Canada (2002), *2001 Census of Agriculture*.

Figure 4.3: Total agricultural land in Canada



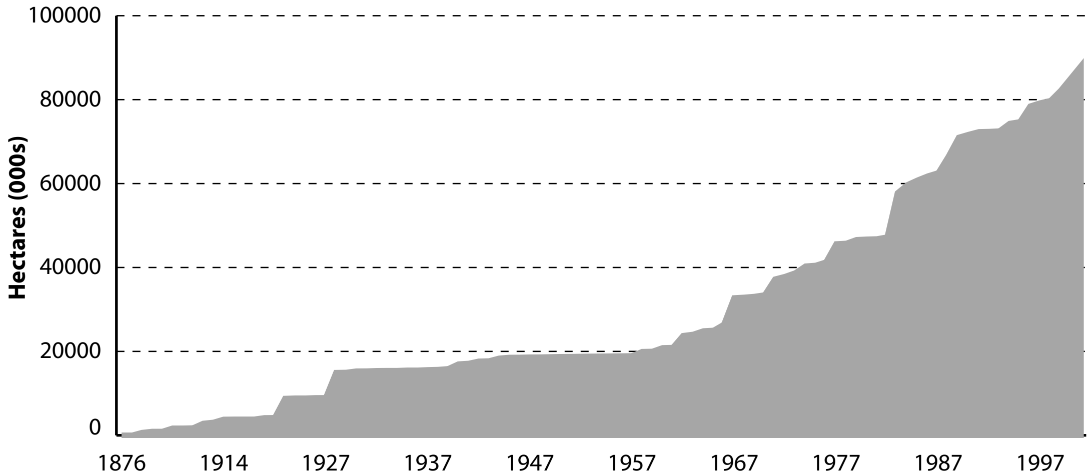
Source: Statistics Canada (2002), *2001 Census of Agriculture*.

Figure 4.4: Area planted in genetically modified (GM) crops



Source: International Service for the Acquisition of Agri-Biotech Applications (2000), *Global Review of Commercialized Transgenic Crops: 2000*.

Figure 4.5: Total protected area (hectares), 1876–2001



Source: Canadian Conservation Area Database (2002), <http://geogratis.cgdi.gc.ca/ccea/ccea_e.html>.

5 Natural Resources

Fresh Water

Canada is naturally endowed with nearly half of North America's renewable fresh water resources. On a per-capita basis, Canada has more than nine times the renewable water resources of the United States and 20 times more than Mexico (WRI et al., 2003) (figure 5.1). Annually, Canada's rivers discharge 7% of the world's renewable water supply—105 000 cubic meters per second (Environment Canada, 2003). Sixty percent of Canada's water resources drain north to the Arctic Ocean, leaving roughly 40% readily available to most of Canada's population, about 84% of whom live within 300 km of the southern border (Environment Canada, 2001b: 1).

In accord with its bountiful supply, Canada has become one of the largest users of fresh water in the world, relying upon it for nearly all of its economic and social activities. Economic activities include, but are not limited to, hydroelectric power generation, manufacturing, irrigation, transportation, and mineral extraction, while social activities include recreation, art, and municipal uses. As of 1991, economic activities accounted for the majority of Canada's water use, with power generation accounting for 63% of total withdrawals, manufacturing 16%, municipal 11.3%, agricultural 8.9%, and mineral extraction 0.8% (Environment Canada, 2003).

Despite the abundance of fresh water in Canada, genuine concern remains about its availability due to frequent regional shortages across the country. These shortages are largely prompted by three factors: semi-arid conditions during summer months, regional dependence upon groundwater, and strains on existing infrastructure. Between 1994 and 1999, approximately 26% of municipalities with water distribution systems reported water shortages (Environment Canada, 2003).

Significant concern has also been raised in Canada about the perceived waste of water. Canada's per-capita demands on municipal water resources are the second highest in the world, estimated at 638 litres per person per day (Environment Canada, 2001: 19). Notably, less than 3% of municipally treated water used in households is used for drinking, while 65% is used in bathrooms and, during the summer, approximately three-quarters of the treated water used domestically is sprayed onto lawns (Environment Canada, 1996c: record 16441). Low investment in municipal delivery and treatment systems has led to 14% of municipal water being lost through leaks in pipes (Environment Canada, 1999).

Canada's extensive use of water has been directly linked to the minimal cost to the average consumer. Based upon an analysis of the 1999 Municipal Water Pricing Survey, the average water user in Canada pays $1.14 for every 1000 litres used, with rates varying by city and region (figure 5.2). In five of the six Canadian cities for which data were available between 1996 and 1998, rates were recorded as falling. Ottawa had the largest decline as rates fell almost 80%, while Winnipeg and Edmonton had modest declines of less than 5%. Because most provincial and municipal offices levy their fees according to the administrative cost of water management, rather than the actual volume of water consumed (per customer), there is little or no incentive for consumers to conserve water. As a result, the government subsidizes the majority of the cost of water use. For example, water charges for irrigation supplies only recover about 10% of the actual cost of the services; municipalities charge a flat rate for the use of water, regardless of the volume drawn. The result has been that consumers make decisions on how much water to use without considering the true cost. This situation, however, may begin to change as more people are now installing water meters. The percentage of Canada's municipal population using metered water increased by about 8% between 1991 and 1999 (Environment Canada, 2001b: 4).

Studies show that people are more inclined to conserve water when they are required to pay the full cost of water they use. In a study conducted in Denton, Texas between 1981 and 1985, economists found that holding all other factors constant, every 10% increase in price resulted in a 16% decrease in demand (Palda, 1998: 63). Similarly, in 1999, Canadian households paying for water by volume used 33% less than households paying a flat rate (Environment Canada, 2001b: 4).

To evaluate trends in the use of fresh water, this section considers water use by sector from 1981 to 1996 (1996 is the most current year in which Environment Canada has estimated water withdrawals by source). Water use is measured by two different indicators: (1) total water withdrawals, recording the total amount of water extracted, and (2) withdrawals as a percent of total renewable resources. This section examines data for both indicators.

Trends

(1) Total withdrawals

Freshwater use in Canada has demonstrated an increasing trend over the past two decades; however, recent evidence suggests that this trend is reversing. Between 1981 and 1991, total water withdrawals in Canada increased by 25.3% (figure 5.3). Withdrawals between 1991 and 1996, however, fell by approximately 1%, the first five-year period in the past two decades during which there was a decline. This change can be attributed to a significant reduction in the amount of withdrawals by the manufacturing sector, where consumption fell by over one billion cubic metres during the five-year period. The sector that had the greatest increase in withdrawals was electric-power generation, where water withdrawals increased 58% to account for 71% of total water withdrawals. Agricultural use increased 31.1% to account for 10% of total consumption, largely due to the water required for irrigation. In comparison, manufacturing use decreased by 37% to account for 15.8% of total use. This decrease is due to more efficient water use via technical advancement and recycling efforts. For example, an initiative at a steel plant located in Quebec was able to reduce total volume of water used by 36% through water recirculation (Environment Canada, 1998d). This conservation of water not only benefits the environment but also lowers operating costs because of the energy saved by pumping less water.

In the United States, evidence indicates that total freshwater withdrawals have been falling since the early 1980s (figure 5.4) During the period from 1950 to 1980, total water withdrawals increased rapidly, reaching a peak consumption of 614 billion cubic metres per day in 1980. Consumption has since decreased, falling 16% between 1980 and 1995, when consumption was 463 billion cubic metres per day. On a sectoral basis, irrigation is now the largest single drawer of freshwater resources in the United States, accounting for 40% of total withdrawals. Although it remains the largest user, it is important to recognize that its proportion of total withdrawals has fallen considerably from 48.5% in 1950. Electricity production has experienced a significant rise in total use, from 21.8% to 39.4% of total withdrawals over the same period. Although currently the second largest user, this is a recent phenomenon, as electricity was the primary use between 1965 and 1990. Other sources, including industry, public supply, and rural accounted for 7%, 12% and 2% of withdrawals, respectively, during the same period. Unfortunately, No data was available for Mexico's annual freshwater withdrawals.

Bulk Water Exports

Canadian bulk water exports have become a hotly debated issue in recent years. Canadian regional shortages combined with severe shortages throughout much of the United States (US), has lead to multiple proposals to commoditize water in Canada. Many believe that Canada's abundance of water could produce wealth for Canada, much like oil reserves have produced wealth for Alberta and the OPEC nations. The opposing argument, however, highlights the potential environmental impacts of bulk water exports, including the introduction of non-native species, the alteration of natural ecosystems, and changes in water levels and groundwater tables. In addition, this concern has been strengthened by NAFTA Chapter 11 investment provisions that are designed to help protect potential (water) investors. Many believe that such provisions will be detrimental to Canada because it is believed that investment protection (through Chapter 11) will always supersede any domestic water conservation efforts should a conflict of interest arise, thus limiting Canada's ability to manage its own water supply. One such case, involving Canada versus The Sun Belt Corporation, is currently underway and will challenge this very assertion.[1]

Given the controversial debate surrounding bulk water exports, several regulatory steps have been taken to address the issue. In 1999, the Canadian Council of Ministers of the Environment (CCME) generally agreed to the prohibition of bulk water removals from major drainage basins in Canada. Although most provinces were in agreement on the banning of water export, some jurisdictions felt that more discussion and clarification of points were necessary before they would sign onto a proposed Canada-wide accord on bulk water removals. In response to this hesitation, and Newfoundland's entrepreneurial proposal to export water from Gisborne Lake to the US, the federal government intervened by introducing amendments to the International Boundary Waters Treaty Act (1911) to prohibit bulk removal from Canadian portions of boundary waters, particularly from boundary water bodies and the Great Lakes (Environment Canada 2001: Background information on bulk water removal and export). These changes, which came into effect in December 2002, require that any water-related projects in Canada that affect the level or flow of waters on the US side of the border must acquire licenses from the federal government.

(2) Withdrawals as a percentage of available freshwater resources

Despite an increased use of freshwater resources in recent decades, Canadians only withdraw 1.7% of their renewable fresh water supply annually (figure 5.5). Moreover, due to the predominant types of water use in Canada, only a small portion of this withdrawn water is actually consumed[2] and much of the water is returned to the natural hydrological cycle. In 1991, Canadians withdrew 45,095 million cubic metres of water, of which only 1.9% was not returned to the natural system after use (Statistics Canada, 1998).

Mexico and the United States both use much larger proportions—16.2% and 19.7%, respectively—of their annual available freshwater resources than Canada. Although the American and Mexican levels are more than eight times larger than Canada's, they still have an abundant amount of renewable freshwater that remains unused. As a basis for international comparison, the average European Union (EU) country utilizes 19.4% of its renewable freshwater resources while the average OECD country utilizes 13.9%.

Concentrations of urban population across Canada have resulted in skewed patterns of water use. Figure 5.6 illustrates total water withdrawals in 1996 by region. Ontario is the largest user, accounting for 63.4% of total withdrawals. This high usage is a result of the large urban population, a heavy reliance on electric power generation, and the proximity to the Great Lakes.

Forests

Canada's forests cover 45% of the nation's land mass and account for 417.6 million hectares, or 10% of the world's total forested area (CFS, 2001: 6). There are eight forest regions in Canada, ranging from the northern Boreal Forest Region, which stretches from British Columbia to New Brunswick, to the small deciduous forest region located just north of Lake Erie and Lake Ontario. Of Canada's forests, 67% are softwoods, 15% are hardwoods, and 18% are mixed woods (CFS, 2001: 7). Approximately 234 million hectares are deemed commercial although only 119 million hectares are actively managed. Total growing stock in Canada is estimated at 25 billion cubic metres (COFI, 2000).

In Canada, the majority of forests are owned by the Canadian public: 71% is owned by the provinces, 23% is under federal jurisdiction, while 6% remains private, held by an estimated 425,000 landowners (figure 5.7). Ownership varies by province and it is interesting to note that 80% of privately owned forests are located east of Manitoba (table 5.1) (CFS, 2001: 7). The percentage of privately owned forests is particularly high in the Maritime Provinces due to historical patterns of colonization: early settlers were given large areas of land as an incentive to come to Canada. On the other hand, ownership remains largely in the hands of the Crown in the western provinces, which were settled later (CFS, 1998: 41).

Table 5.1: Forest ownership in Canada

	Total Area (millions of hectares)	Federal (%)	Provincial (%)	Private (%)
Newfoundland	22.5	0	99	1
Prince Edward Island	0.2	1	7	92
Nova Scotia	3.9	3	28	69
New Brunswick	6.1	1	48	51
Quebec	83.9	0	89	11
Ontario	58.0	1	88	11
Manitoba	26.3	1	94	5
Saskatchewan	28.8	2	97	1
Alberta	38.2	9	87	4
British Columbia	60.6	1	95	4
Yukon	27.5	100	0	0
Northwest Territories	61.4	100	0	0
Nunavut	n/a	n/a	n/a	n/a
Canada	417.6	23	71	6

Source: Natural Resources Canada, Canadian Forest Service (2003), *The State of Canada's Forests 2001–2002*.

Forests play a vital role in Canada's economy. As the world's largest exporter of forest products, the Canadian forest industry contributed $28.5 billion to the Canadian economy (GDP) in 2001, or 2.9% of GDP, while also contributing $34.4 billion to the country's net balance of trade (NRC, 2002). In addition, the forest industry provided 246,000 direct and 738,000 indirect jobs in Canada during the same period. Provincial and federal government revenues from the industry and its employees were reported at $8.1 billion (PWC, 2001).

Provincial governments are responsible for the management of Crown forest resources. This responsibility includes, but is not limited to, awarding licenses and tenures for harvesting, developing operating standards and regulations, establishing harvest levels, monitoring forest practices, and ensuring adequate regeneration in harvested areas. To fulfill this responsibility, each province allocates operating licenses or specific rights to harvest timber on Crown land in return for payments to the Crown, typically referred to as stumpage. Licenses vary in length, typically ranging between 10 and 25 years, and usually carry with them the downloaded responsibility of ensuring successful stand regeneration. To satisfy growing public criticism regarding forest practices, licensees are also now encouraged to pursue independent third-party verification (certification) of their practices according to national standards for Sustainable Forest Management. Compliance with these standards, however, is voluntary and many firms have chosen to pursue certification according to other national standards that match the demands of their American customers more closely.

Harvest activity is heavily dominated by three Canadian provinces. Nearly 70% of all harvesting activity (by area) is concentrated in British Columbia, Ontario, and Quebec (figure 5.8). As of 2001, 30.5% of the total area harvested in Canada was located in Quebec; 18.8% was in Ontario; 19.5 % was in the Atlantic provinces; 20.6% in British Columbia; 10.7% in the Prairie provinces, and less than 1% in the North.

Despite increasing harvest levels, only a small portion of Canada's forest resources are harvested each year. Of Canada's 418 million hectares of forestland, 56% (234.5 million hectares) are classified as commercially viable. Of these 234.5 million hectares, however, only 28%, or 119 million hectares, are actively managed for timber purposes. As a result, given that only 993,000 hectares were actually harvested in 2001, harvest area accounted for less than 1% (0.83%) of commercial forests and 0.25% of total forests—less than the amount of forest lost to natural events[3] each year.

In order to evaluate the state of Canada's forests the following section will examine trends relating to harvest levels, regeneration, conservation, and the sustainability of forest practices.

Trends

(1) Canadian harvest versus annual allowable cut (AAC)

Harvest levels in Canada continue to remain well within defined sustainable limits.[4] During the period from 1970 to 1999, total harvest volume in Canada rose by 65.3%; however, not once during this increase did the harvest level exceed the annual defined annual allowable cut (AAC).[5] In fact, there have been only two years during this period, 1989 and 1999, where the harvested volume exceeded 80% of the AAC. Given that these AACs are determined based upon the principle of long-term sustainable yield, it is clear that Canadian harvest levels constitute sustainable forest practices (NFDB, 2003).

Canadian forests are being replenished at a rate equivalent to, or greater than, that the rate they are being harvested. Figure 5.10 illustrates this point by monitoring the status for each year of cumulative harvest since 1956. As the graph depicts, the total area of "understocked" forest has remained stable over the past 25 years, showing a slight decline in the past decade. It is important to note that understocked area does not refer to areas devoid of trees but rather to areas that have yet to achieve predetermined target densities custom to each specific area harvested. Because new areas are harvested each year, there will always be new areas to the graph that are understocked; however, it is clear based upon the above trend that these areas are quickly (typically in 3 years) re-established as stocked forest area.

Annual Allowable Cut

Although Canada has one of the largest annual harvests (by volume) within the OECD, it is important that this volume be put into context according to the scale, species diversity, growth rates, zoning objectives, and protected areas within Canada's forest resources. To accomplish this task, provinces use these factors, as well as many others, to model and forecast forest trends into future so that they can thereby calculate an AAC volume that ensures the long-term sustainability of the resource. This volume is subsequently allocated to forest operators within designated areas of each province. Although this volume is all allotted, the actual harvest volume harvested each year rarely reaches the annual AAC (figure 5.9). This variance is largely attributed to unforeseen operating factors, such as poor market conditions, shutdowns due to extended fire and snow seasons, and labour disputes.

Efforts to protect critical forest habitat within Canada's commercial ecozones have been very successful to date. Given the emphasis on deriving economic value from Canada's forests, it has become equally important to recognize and protect unique ecological values, where deemed necessary. Canada's commercial forests are largely found within four ecozones: the Boreal Shield, Atlantic Maritime, Pacific Maritime, and Montane Cordillera. Evidence indicates that the amount of protected area in each of these ecozones has been increasing steadily (figure 5.11). During the period from 1970 to 2001, the amount of protected area has increased by over 90% in all four ecozones. The largest increases in protection took place in the Atlantic and Pacific Maritime ecozones, where increases were recorded at 328.6% and 292% respectively, while the Boreal Shield and Montane Cordillera recorded significant gains of 183% and 95%.

Over the past five years, efforts to verify sustainable forest practices in Canada independently have resulted in a dramatic increase in certified forest area. Despite multiple systems worldwide, three certification systems that have evolved as options in Canada, including the Canadian Standards Association (CSA), the Sustainable Forest Initiative (SFI) and the Forest Stewardship Council (FSC). Despite almost no hectares being certified in 1998, the total area certified under each system has skyrocketed to include 217.4 million hectares under CSA, 2.8 million under SFI, and 1.0 million under FSC. Now totaling 126 million hectares, certified timber lands represent an AAC of almost 110 million cubic metres per year. This dramatic increase in certified forests through independent third parties has facilitated a non-biased opinion regarding the sustainable nature of forest management in Canada. Given the success made to date, in conjunction with even larger tracts of certified land intended for 2006, it is apparent that the Canadian forests are being managed in a suitable manner.

Energy

Canada is fortunate to have large reserves of diverse energy resources such as petroleum, natural gas, coal, and hydroelectric potential. By drawing on these resources, Canada's energy sector plays an important role in the global energy market. Canada is the world's second largest producer of hydro-electric power (NRC, 2000: 1), third largest producer of natural gas, and the thirteenth largest producer of crude oil (CAPP, 2003). Canada is a leader in the nuclear sector, producing about one-third of the world's uranium, operating 22 CANDU reactors domestically and exporting technology around the world (NRC, 2000: 1, 13).

Canada's energy sector contributes substantially to the Canadian domestic economy. In 1998, approximately 7% of the gross domestic product and 8% of total merchandise exports were attributed to the energy industry (NEB, 1999). Industry payments to government have averaged $7 billion annually over the past 10 years, with contributions in 2001 nearing $15.6 billion, including all royalty payments, bonus payments, and taxes. Investment spending within the industry totaled $28 billion in 2001, while total industry employment is estimated at over 500,000 Canadians (CAPP, 2003).

Jurisdiction over the valuable energy sector is divided between the federal and provincial governments. Provincial governments have jurisdiction over resource management within their borders while the federal government maintains ownership of resources on frontier lands (north and offshore), controls nuclear power and uranium, and monitors international and trans-boundary environmental impacts. Because federal ownership of offshore oil resources has been disputed by the provinces, the Nova Scotia and Newfoundland oil and gas industry is jointly managed (NRC, 2000: 8). On the west coast, a federal moratorium on off-shore drilling is in place but, because of the extensive reserves believed to exist in the Hecate Straight, the provincial government of British Columbia is currently lobbying the federal government and performing a cost-benefit analysis on the impacts of lifting this moratorium.

Two significant policy-related issues have been debated in the energy industry in recent years. First, there has been a progressive move by government to liberalize and deregulate the energy markets in Canada, which have traditionally been very heavily regulated. Significant progress has been made in the oil and gas sectors, with large restructuring taking place, but the electricity sector has been much slower to evolve. This tardiness is largely due to the provincial control and regulation of the electricity sector, which has resulted in an uneven movement towards deregulation. Several provinces, such as Alberta, British Columbia, and until recently Ontario, are moving more quickly than others on deregulation, although the pressure and backlash from the public has been significant (Energy Trends, 2002). Driving factors behind the move to deregulate in Canada include potentially lucrative export markets in the United States, as well as a growing need to stimulate future investment to meet power shortages in various Canadian regions. In response to public pressures, however, Ontario recently abandoned a planned initial public offering of its largest energy producer Hydro-One. Second, given the scale and industrial processes associated with energy production, the recent signing of the international Kyoto Protocol has vaulted the energy production issue to the front of policy development. This agreement, which commits Canada to reduce its carbon dioxide and greenhouse gas emissions by 6% from 1990 levels by 2008 to 2012, has been the source of heated debate given that several of Canada's largest trading partners, most notably the United States, have opted out of the agreement (Energy Trends, 2003).

Canadians are among the world's most intensive users of energy. Due to a high standard of living, cold climate, energy-intensive industrial base, large geographic area, and widely dispersed population, Canada ranks as the world's sixth largest user of primary energy (Environment Canada, 1997; 1996). Within Canada, there is a great deal of regional variance in the production and consumption of energy. Alberta is the largest producer of energy in Canada due its vast oil reserves while Ontario remains the largest energy consumer in Canada due to its large population and extensive industrial base (NRC, 2000: 18).

The purpose of this section is to examine trends related to energy consumption, production, and future reserve availability. Consumption trends are interesting since they illustrate changes in energy use and efficiency over time. Production trends address concerns about Canada running out of energy reserves.

Trends in consumption

Total energy consumption in North America has been gradually increasing. During the period from 1980 to 2000, total energy consumption for the continent rose 15.6% (figure 5.12). On a national basis, consumption in Canada, the United States, and Mexico rose 23.5%, 13.6% and 35.2%, respectively.

Despite increases in total energy consumption, the consumption per capita across North America has decreased slightly (figure 5.13). During the period from 1980 to 2000, energy consumption per capita fell by nearly 8%. Notably, energy consumption relative to GDP also fell by 37.6% (figure 5.14). In Canada, rates fell by 1.6% per capita and 28.4% relative to GDP, while rates in the United States fell 6.1% and 39.6%, and in Mexico, 3.2% and 19.9%. These reductions are attributed to a combination of factors, including improvements in energy efficiency and structural changes in the economy away from activities that require the use of more energy. One report that studied the decline in energy demand between 1971 and 1988 attributed 65% of the decline to energy efficiency and the remaining 35% to structural changes in the economy (Environment Canada, 1996c: record 6052). More recently, according to the Canadian Office of Energy Efficiency and its Energy Efficiency Index, energy efficiency in Canada has improved by 9.4% between 1990 and 2000, resulting in $8.7 billion in savings in energy costs (NRC, 2002).

Figure 5.15 illustrates total domestic energy consumption by end use in Canada. During the period from 1980 to 2000, the largest user of power remained industry, rising by almost 2% to account for 36.8% of all use by 2000. Over the same period, both transport and non-energy uses (waxes, lubricants, etc.) declined in consumption, falling 3.6% and 7%, respectively.

In the United States, transportation has emerged as the sector consuming the most energy (figure 5.16). On a par with industry in 1980, at 32.8%, consumption by the transportation sector has since increased by 24.1% to account for 40.7% of total consumption, while consumption by the industry sector has fallen 27%, now accounting for 24% of the total.

In Mexico, consumption has developed with sector weightings that are different from those in the United States (figure 5.17). In 1980, industry was the lead consumer of energy at 32.8%. From 1980 to 2000, however, industry's consumption fell by nearly 6% while that of transportation increased by 12.8%, making it the top consumer of energy in 2000. Both non-energy and other uses also fell over this period.

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

Although energy use in Canada increased by 12.2% between 1990 and 1999, energy efficiency improved by 8.0%. These improvements have translated into direct savings of nearly $5 billion for Canadians (Natural Resources Canada 2000: 4). The greatest improvements in energy intensity were in transportation with freight, which improved 15.4%.

This change is due primarily to increases in activity, energy efficiency, and structure. More freight was moved by trucks, which improved efficiency in turn through measures such as consolidating loads and reducing the number of kilometers traveled without freight. Residential energy intensity decreased 13.0% as a result of the introduction of more efficient space heaters and appliances. Industrial energy intensity increased 9.1% over this period. Commercial energy intensity was flat, largely due to a slowdown in new building starts.

Trends in production

Energy production in North America has been on a steady rise over the past 25 years. During the period from 1980 to 2000, total production of primary energy in North America increased by 19.4% (figure 5.18). Canada has recorded the largest increases in North American production, increasing its output by 80.7% to account for 16.4% of total production. The United States increased production by 7.9% and still has the largest share of North American production at 73.5%. Finally, Mexico increased production by 53.8% to produce 10% of total energy production.

Sources of energy production have shifted significantly over the past two decades (figure 5.19). Although crude oil accounted for 36.5% of total energy production in 1980, it accounted for only 29.3% by the year 2000. During this same period, the proportion of natural gas production also fell, dropping from 28.3% to 27.4%. The largest increases (by percentage) in production were recorded in the alternative source category, particularly geothermal and solar energy, where production increased by 276%. Despite this increase, however, these sources still account for less than 1% of North American production. Nuclear power also increased significantly as a source, rising 187% to account for 10% of total production.

High rates of production and export, coupled with the fact that oil and natural gas are non-renewable resources, have led many to predict that Canada will run out of oil and natural gas resources in the near future. With the exception of 1983 and 1997, annual net production has exceeded annual gross reserve additions of crude oil (CAPP, 2001). Similarly, natural gas additions have generally been below production levels since 1985 (CAPP, 2001). For oil, this negative net change in reserves can be partially attributed to decreasing oil prices that have encouraged producers to switch from drilling oil wells to drilling for natural gas (NEB, 1999c: 1). More recently increases in both oil and gas prices has prompted rapid increases in exploration and development, which is expected to yield considerable gains in established reserves.

While examining figures 5.20 and 5.21, it is important to note that they display only data on established reserves. For crude oil, it has been estimated that an additional 4,615 million cubic metres of crude oil are undiscovered and another 1,031 cubic metres can be extracted from existing reserves because of technological advances (NEB, 1999b). As a result, at the end of 1997 Canadians had extracted only 7.2% of their total estimated recoverable crude oil and bitumen resources. Similarly, there is a large amount of undiscovered natural gas: it is estimated that Canadians have produced between 14% and 17% of their economically recoverable natural gas resources (NEB, 1999c).

Non-conventional energy sources are quickly becoming a much larger proportion of established energy reserves. For example, Canada's oil sands (also referred to as bitumen) spread across northern Alberta and British Columbia and are estimated to contain as much as 397 billion m^3 of bitumen, 48 billion m^3 of which is recoverable with today's technology. This makes Canada's oil sands a larger hydrocarbon deposit than Saudi Arabia's proven oil reserves and, if fully recovered, alone could meet the world's oil demand for the next 100 years (Natural Resources Canada, 2000: 42; Energy in Canada, 2000). However, extracting oil from oil sands not only tends to disturb more land per unit of oil produced than conventional projects but also to produce large amounts of contaminated sludge. There will be greater ecological and economic costs as more oil is extracted from oil sands. The process of extracting oil from the sands is also more energy intensive, requiring approximately 9 to 12 cubic metres of oil sands to produce 1 cubic metre of bitumen (Environment Canada, 1999b). To be upgraded, this bitumen then needs to be processed.

Notes

1 Following a provincial move to ban all bulk water exports from British Columbia, the Sun Belt corporation of California subsequently launched a $10.5 billion dollar suit against the Government of Canada, claiming a violation of Chapter 11 under NAFTA.

2 Water consumption refers to water use that prevents the water from re-entering the system.

3 Approximately 0.5% of Canada's total forests are lost to outbreaks of fire or infestation by insects each year (CFS, 1998: 5; NFDP, 2001).

4 See Text Box, "Annual Allowable Cut."

5 Individual Softwood and hardwood AACs have been combined for the purpose of this exercise to generate a national figure.

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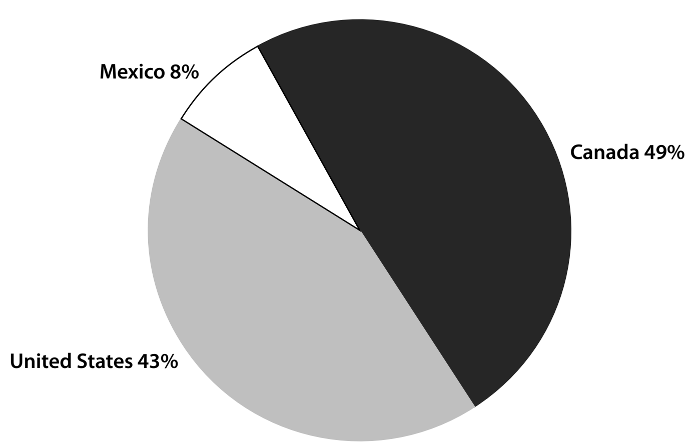
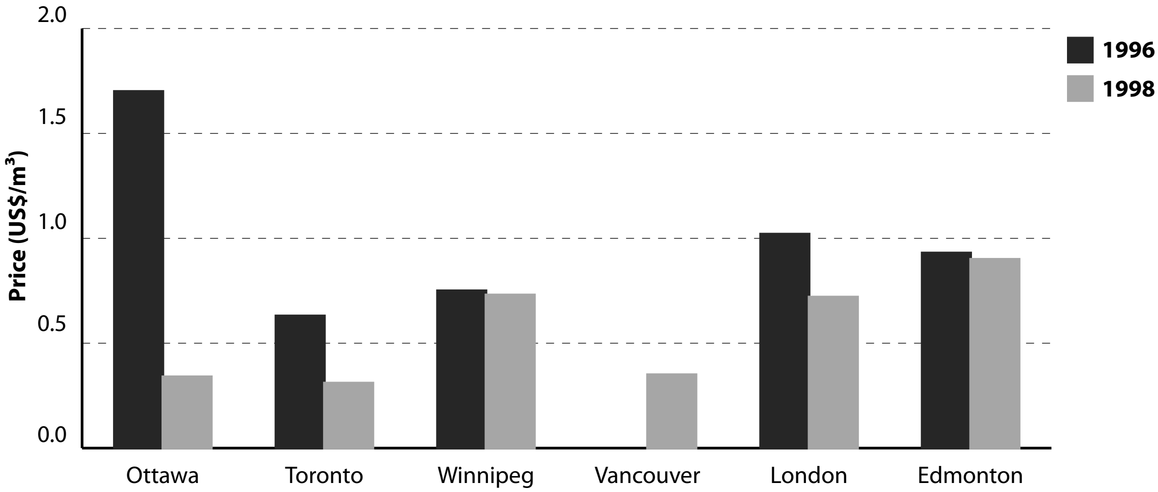
Figure 5.1: Total water resources, by country



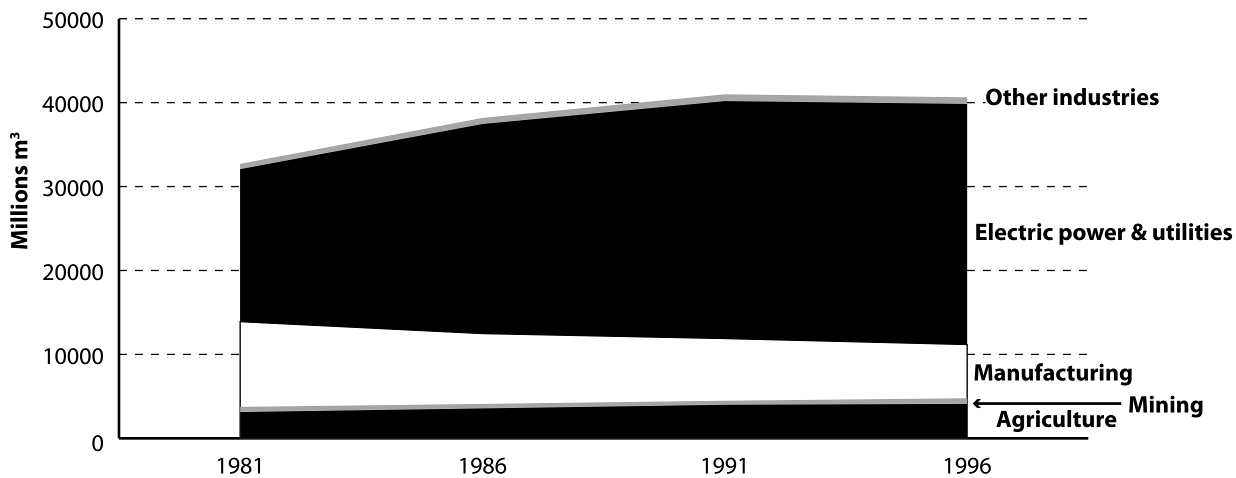
Source: OECD (2001), *OECD Environmental Data Compendium 2001*.

Figure 5.2: Canadian water pricing in select cities, 1996, 1998



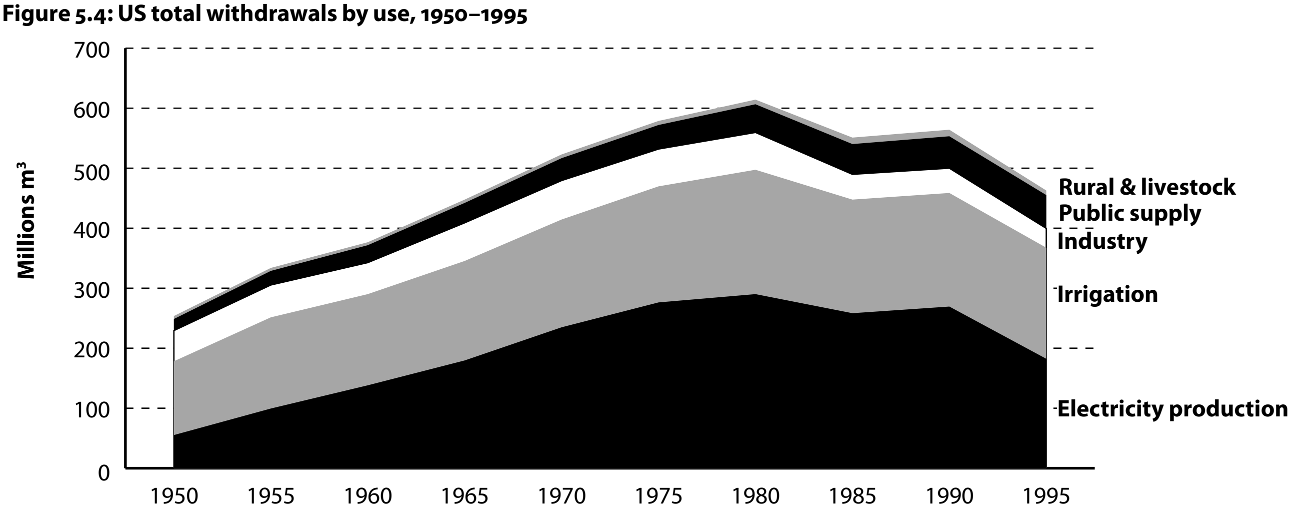
Source: OECD (2001), *OECD Environmental Data Compendium 2001*.

Figure 5.3: Canadian total fresh water withdrawals by use, 1981–1996



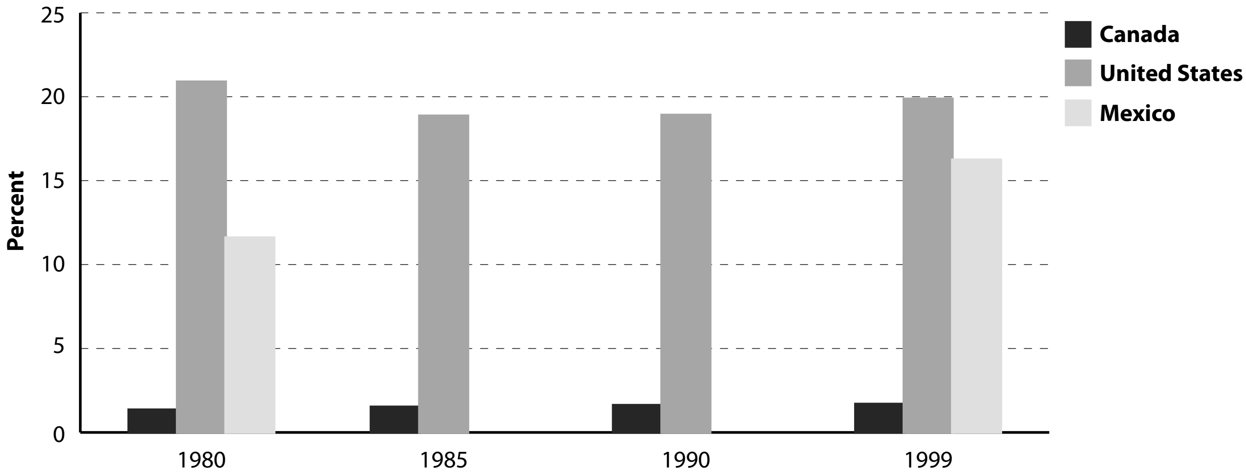
Source: Environment Canada (2002), *Municipal Water Use Database* (MUD).

Figure 5.4: US total withdrawals by use, 1950–1995



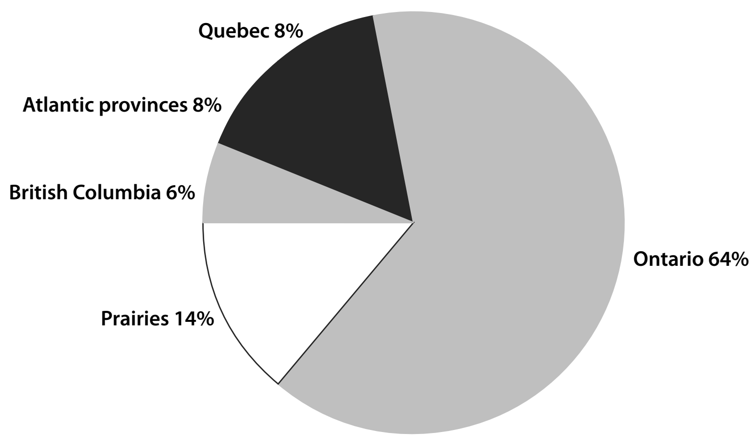
Source: United States Geological Service (2001), *Estimated Use of Water in the United States in 2000*.

Figure 5.5: Annual freshwater withdrawals as a percent of resource available



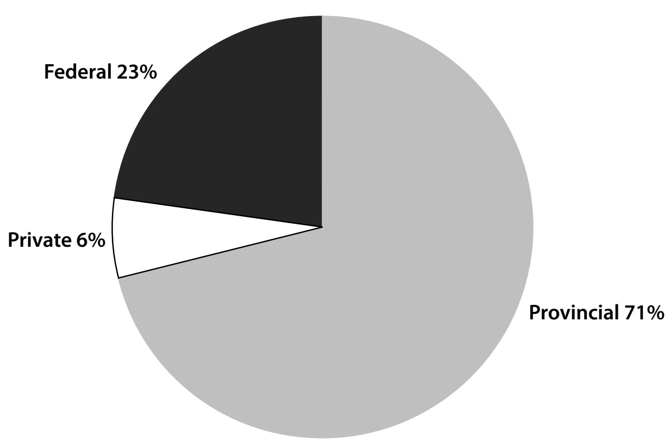
Source: OECD (2001), *OECD Environmental Data Compendium 2001*.

Figure 5.6: Total water withdrawals by region, 1996



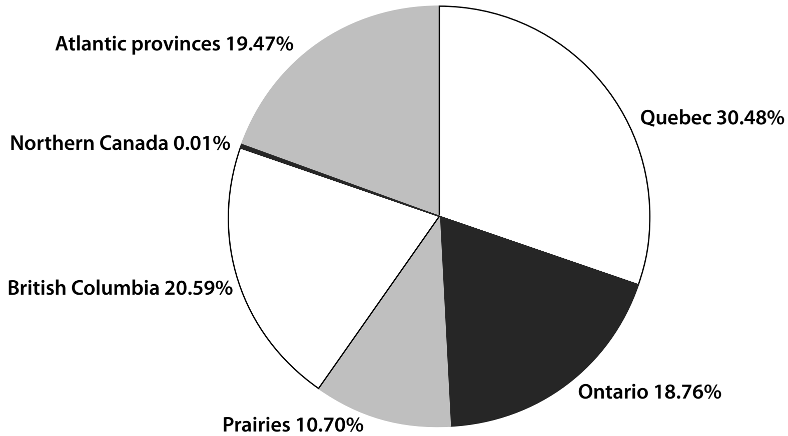
Source: Environment Canada (2003), *The Management of Water, Water Use Data*.

Figure 5.7: Forest ownership in Canada, 2001



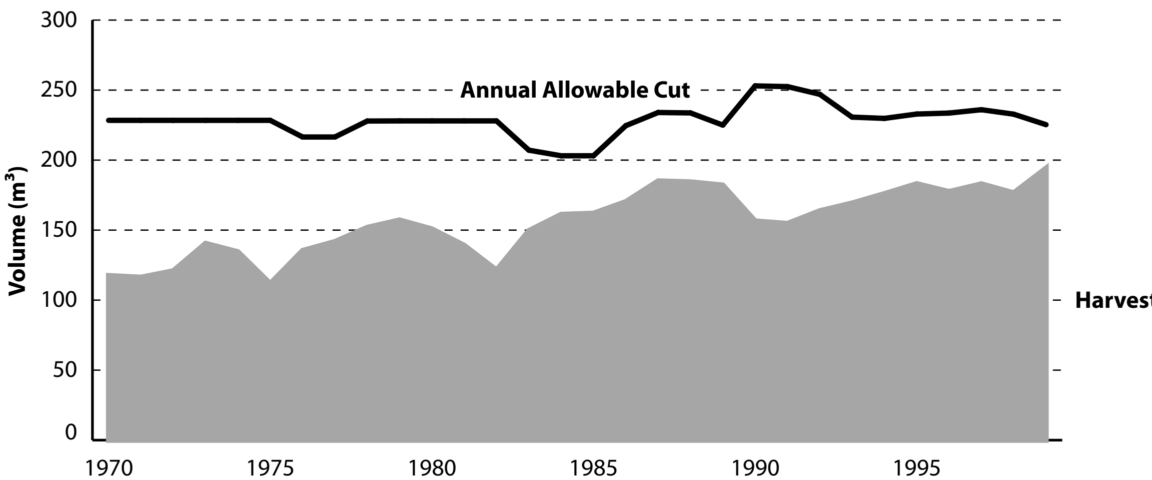
Source: Natural Resources Canada, Canadian Forest Service (2003), *The State of Canada's Forests 2001–2002*.

Figure 5.8: Regional share of national harvest by area



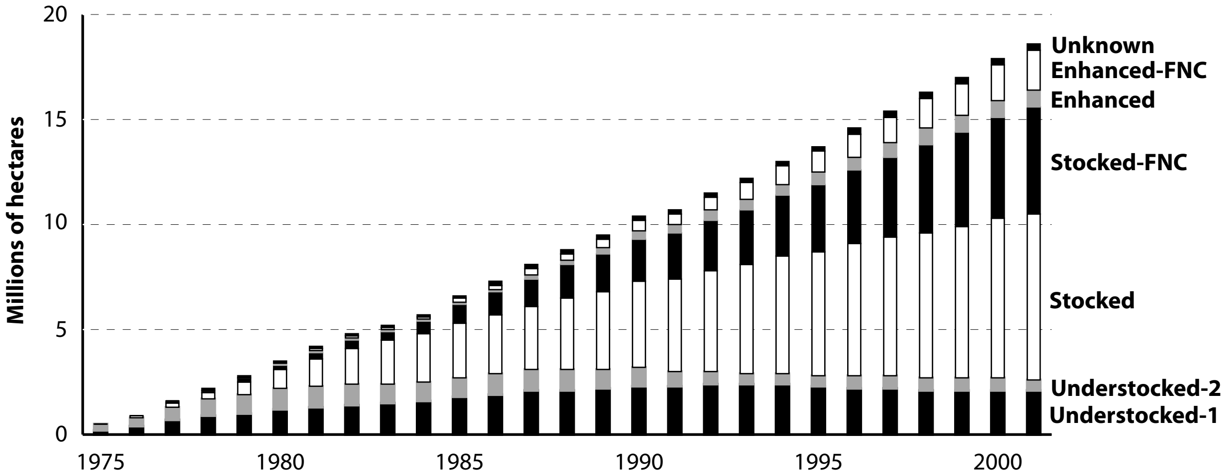
Source: Natural Resources Canada, Canadian Forest Service (2003), *The State of Canada's Forests 2001–2002*.

Figure 5.9: Canadian harvest volume and annual allowable cut (AAC)



Source: Natural Resources Canada, Canadian Forest Service (2003), *The State of Canada's Forests 2001–2002*.

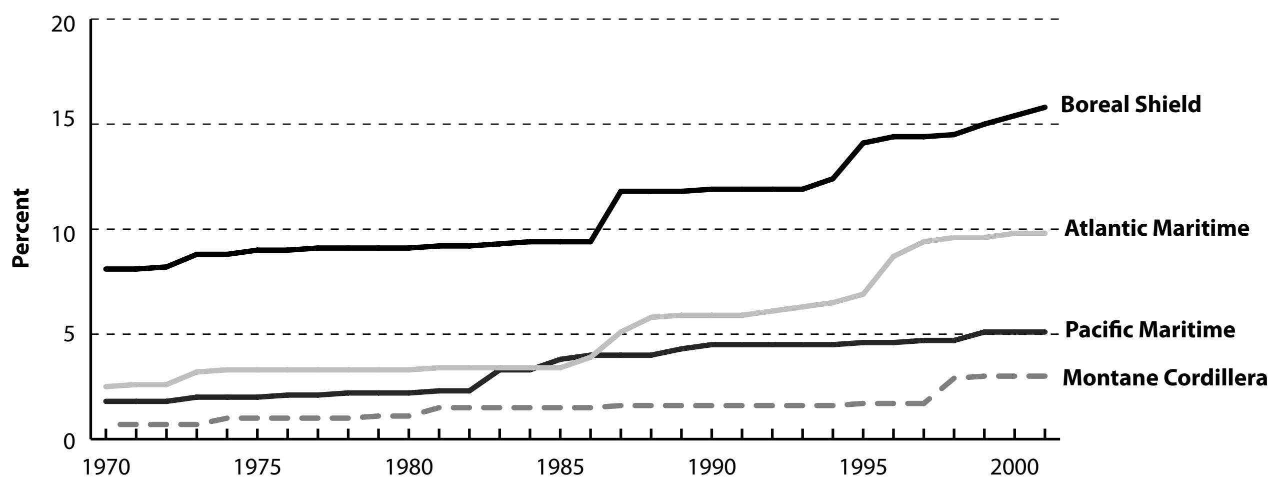
Figure 5.10: Canada, Crown land, regeneration status at one-year intervals



Notes: ***Understocked***—disturbed productive area that does not meet stocking standards; ***Understocked-1*** requires silvicultural treatment to reach stocking objectives; ***Understocked-2*** will achieve stocking objectives through natural recruitment. ***Stocked***—area where stocking standards have been met. ***Enhanced***—stocked area where density control standards have been met. ***FNC*** = free from non-crop competition—stocked or enhanced area where competition control objectives have been met.

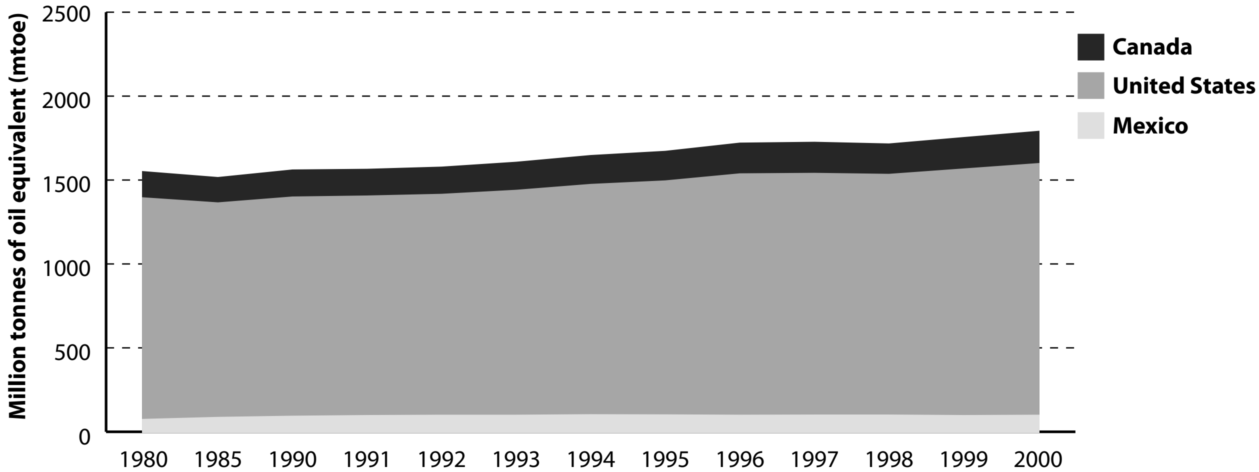
Source: Natural Resources Canada, Canadian Forest Service (2003), *The State of Canada's Forests 2001–2002*.

Figure 5.11: Percent of forest area protected, by ecozone, 1970–2001



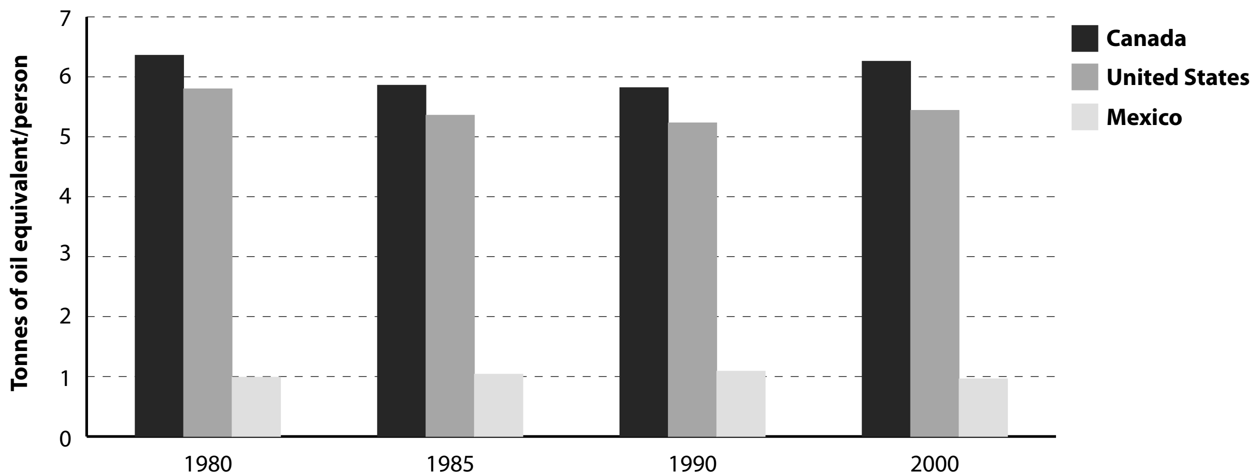
Source: Environment Canada, Canadian Wildlife Service (2002), *Canadian Council on Ecological Areas Database*..

Figure 5.12: Total energy consumption in North America, 1980–2000



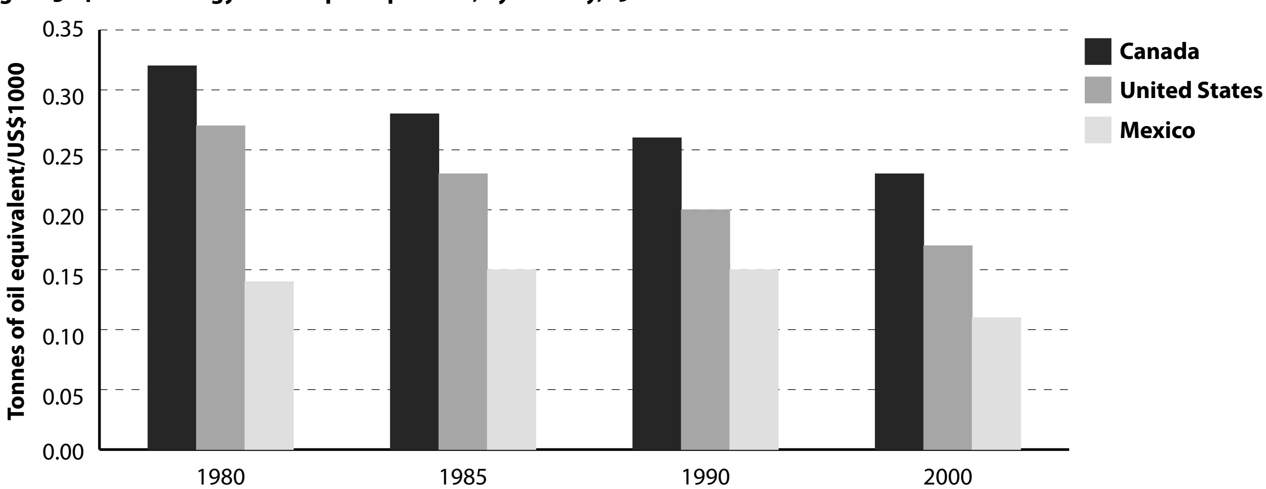
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 5.13: Total energy consumption per capita, by country, 1980–2000



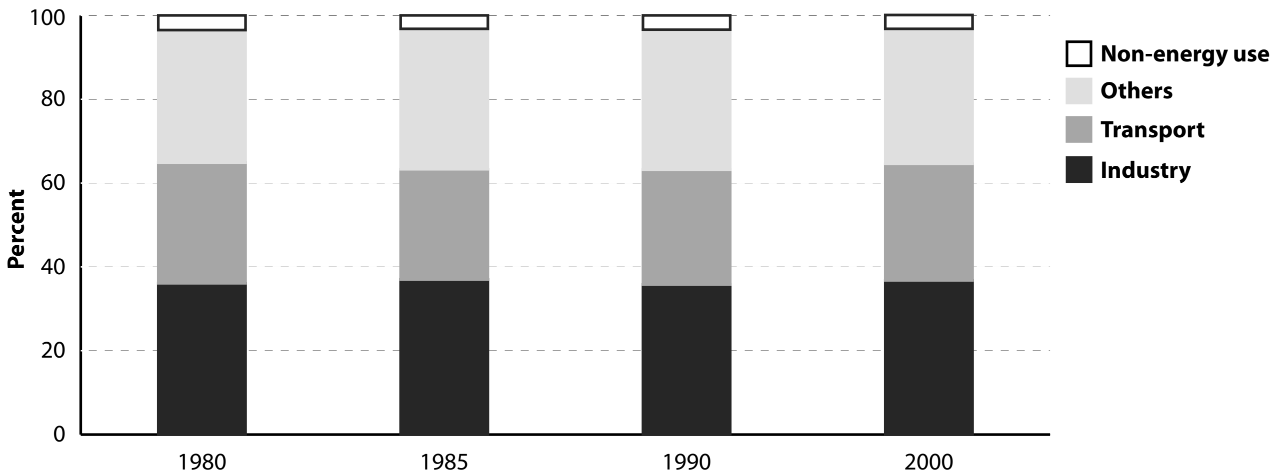
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 5.14: Total energy consumption per GDP, by country, 1980–2000



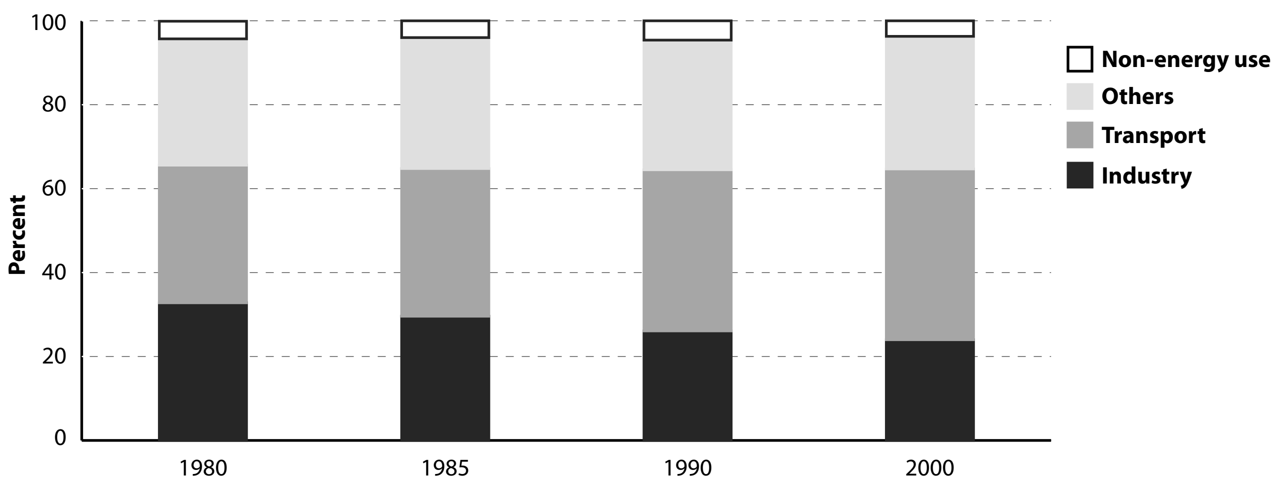
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 5.15: Canadian total energy consumption, by sector, 1980–2000



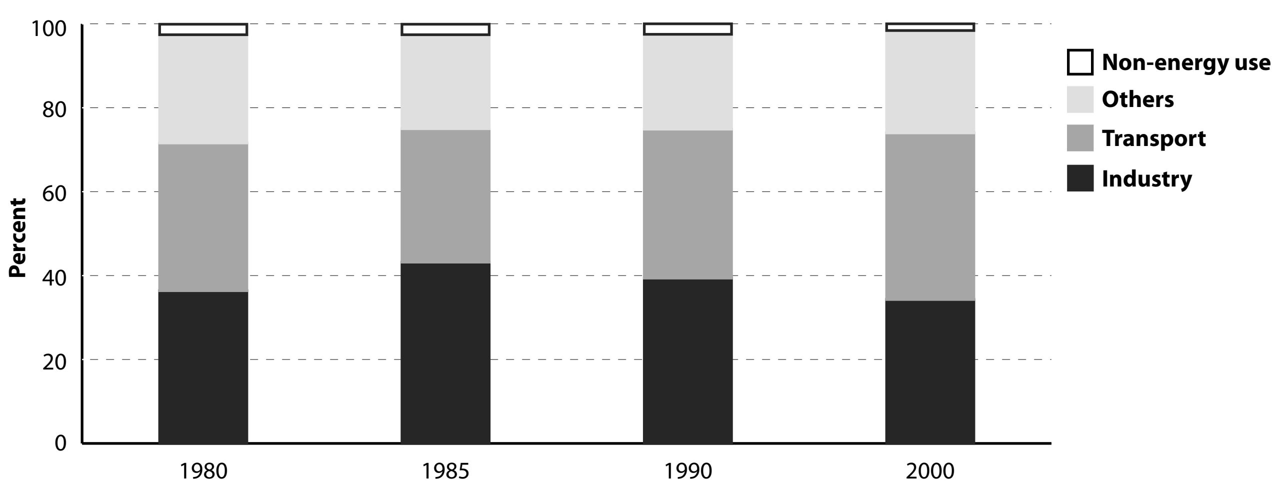
Source: OECD (2002), *OECD Environmental Data Compendium 2002*. The OECD includes in its data for the total final consumption of energy non-energy uses of gas, coal, oil, and oil derivatives.

Figure 5.16: US total energy consumption, by sector, 1980–2000



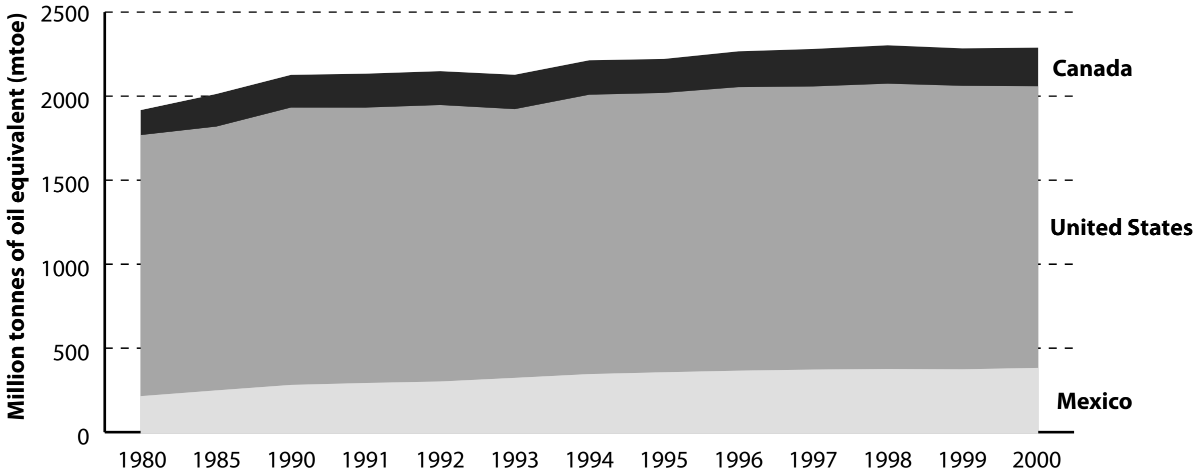
Source: OECD (2002), *OECD Environmental Data Compendium 2002*. The OECD includes in its data for the total final consumption of energy non-energy uses of gas, coal, oil, and oil derivatives.

Figure 5.17: Mexican total energy consumption, by sector, 1980–2000



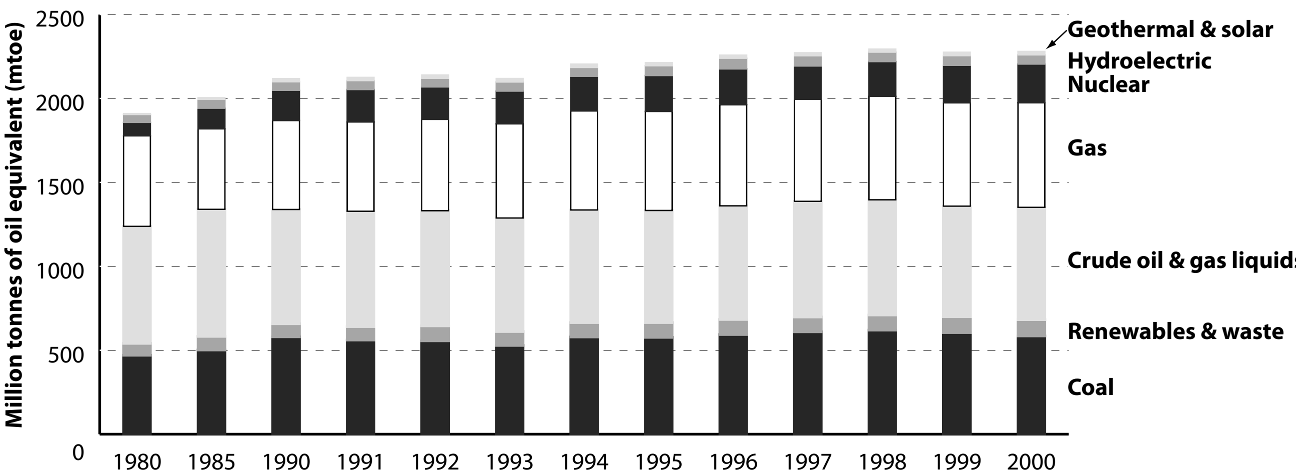
Source: OECD (2002), *OECD Environmental Data Compendium 2002*. The OECD includes in its data for the total final consumption of energy non-energy uses of gas, coal, oil, and oil derivatives.

Figure 5.18: Total energy production in North America, 1980–2000



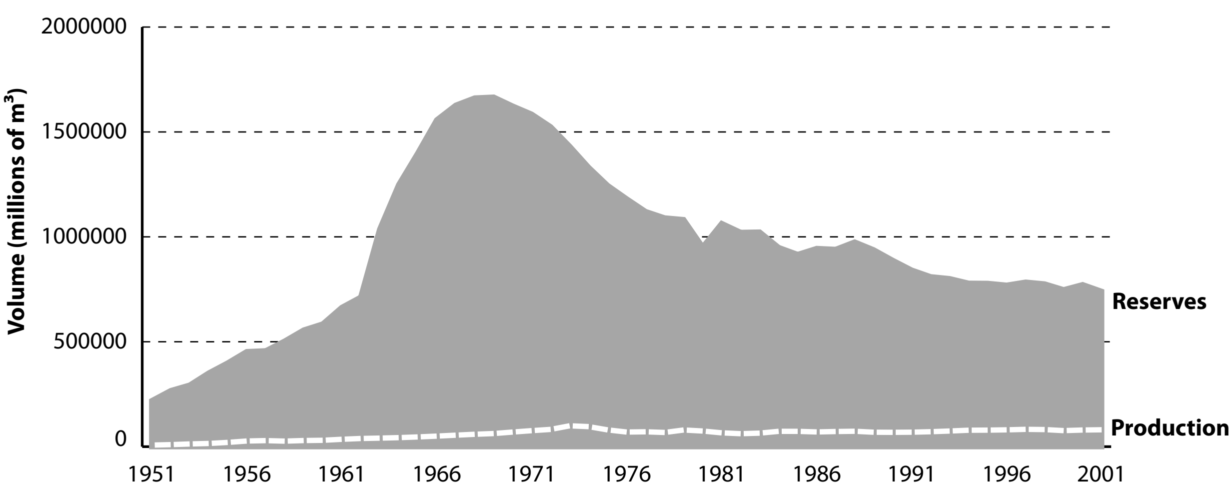
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 5.19: Total energy prodution in North America, by source, 1980–2000



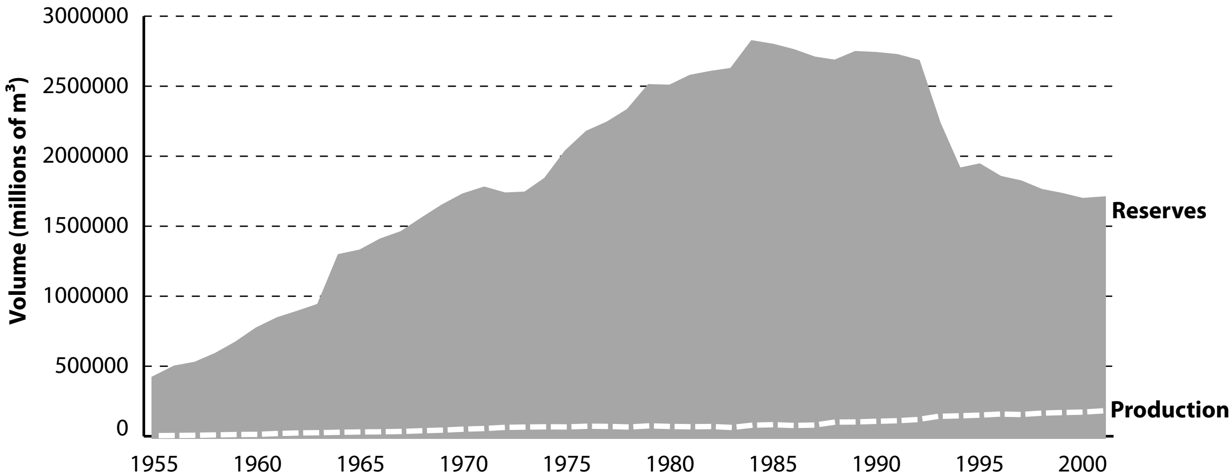
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 5.20: Established crude reserves and production, 1951–2001



Source: Canadian Association of Petroleum Producers (2003), *Industry Facts and Information*.

Figure 5.21: Established natural gas reserves and production, 1955–2001



Source: Canadian Association of Petroleum Producers (2003), *Industry Facts and Information*.

Secondary environmental indicators

6 Carbon Dioxide Emissions

Carbon dioxide (CO_2) is a vital nutrient for plants. Oceans absorb and produce CO_2 in great quantities through a complex cycle and store about 50 times more carbon than does the atmosphere.[1] The combustion of fossil fuels by humans also generates CO_2.

It has been suggested that CO_2 emissions arising from human activity are linked to global warming. As a result, controlling CO_2 emissions has been the subject of many recent policy debates. In order to understand fully the popular debate about global warming, one must appreciate the distinction between the greenhouse effect and the enhanced greenhouse effect. Scientists agree that there is a greenhouse effect that causes the earth to be warm. This effect occurs because greenhouse gases such as carbon dioxide, water vapour, nitrous oxide, and methane are transparent to the short wavelength radiation from the sun but opaque to the longer wavelength radiation emitted from the earth. In simple terms, greenhouse gases trap the heat from the sun and this warms the earth.

The popular debate revolves around the question whether humans, through their additions of greenhouse gases to the atmosphere,[2] enhance the greenhouse effect that occurs naturally and, thus, contribute to global warming. The theory of enhanced greenhouse effect gained many advocates in the 1950s but lost popularity in the 1960s and 1970s when average temperatures fell. During the 1970s, many who now promote the theory of the enhanced greenhouse effect supported the idea that pollution was causing global cooling by reflecting sunlight away from the earth's surface.

Although some now claim that the increase in CO_2 levels in the atmosphere will cause a catastrophic warming, there are many credible challenges to this theory. In the face of the uncertainty within the scientific community about the link between human additions of CO_2 to the atmosphere and global warming and in the absence of a proven link to global warming, CO_2 cannot be considered a pollutant but, at most, a secondary indicator of environmental quality.

The scientists who criticize the notion of impending catastrophic global warming possess three powerful lines of attack on the apocalyptic theories: the inadequacy of the computer models being used to forecast future temperatures, the evidence from actual temperature records, and the strength of competing hypotheses (currently under-reported and insufficiently considered by policy makers) to explain warming.

(1) The inadequacy of computer models

It is important to realize that current projections of global warming and policy recommendations for dealing with the predicted crisis are based on computer models that try to forecast future temperatures based on a number of assumptions. At the present time, these computer models are incapable of modeling the atmospheric system completely. Large gaps in understanding about the way important variables such as oceans and clouds affect climate and how the effects of these variables change with additions of CO_2 make the predictions of these models unreliable.

(2) Evidence from temperature records

The second major criticism of the theory that temperatures are likely to rise as a result of increasing CO_2 emissions and cause dramatic damage to the environment is that temperature records do not support a strong link between CO_2 emissions and warming. According to ground-level temperature records, there has indeed been an increase in temperature over the past 100 years. Most of this increase, however, occurred before 1940; in other words, most of the increase in temperature occurred before the main input of CO_2 emissions arising from human activity. In addition, records from the satellites that have been measuring temperatures in space since 1979 do not support the hypothesis that the earth is warming. While the climate models produced by computers predict that there should have been some warming over the past 20 years, the satellite data show little warming. The evidence does not support the predictions of the models. It is considered a problem in any scientific discipline when the evidence contradicts a theory and such a discrepancy should lead to a re-evaluation of the models.

(3) Other explanations for temperature change

There are other viable explanations that do not rely upon CO_2 emissions to explain changes in atmospheric temperature. Unfortunately, these explanations have not received widespread media attention. Some scientists hypothesize, for example, that much of the temperature fluctuation can be explained by changes in the brightness of the sun—something that is obviously beyond human control. Sallie Baliunas, a scientist at the Harvard Center for Astrophysics, explains:

> Most of the warming early in this century, then, must have been due to natural causes of climatic change, and these natural causes must be understood in order to make an accurate assessment of the effect upon climate of any human activities that may have been added to the natural changes. One possible natural cause of climatic change is variation in the brightness of the sun. (Baliunas and Soon: 81)

> The processes of "fingerprinting" various mechanisms of climatic change and projecting climatic change requires knowing all the relevant factors, both those that are natural and those that are the result of human activity. And, these factors must be considered simultaneously in a model. Once such a model is verified, then only can each mechanism be identified. Since the mechanisms of climatic change are not fully known—as we have shown, the question how the sun affects the climate is unresolved—and the models have not been verified, fingerprinting is not yet possible. (Baliunas and Soon: 86–7)

It is clear that a great deal of uncertainty surrounds the issue of climate change and many important questions remain unanswered. Are we experiencing a trend towards global warming? Do humans contribute to the trend through the emission of greenhouse gases? How significant is the human contribution? Would global warming cause widespread problems?

Some argue that we must take drastic regulatory action to control greenhouse gases without delay. However, because of the uncertainty and the unanswered questions, this is a simplistic approach to policy. In fact, we cannot afford to take action until we are reasonably certain that we have a problem because taking drastic measures to control greenhouse gases will come at the expense of other social objectives.

Despite these problems associated with estimating the emissions and impacts of CO_2 and GHG emissions, we will examine trends based upon the best available data, provided by the OECD.

Performance

Emissions of CO_2 have been shown to correlate with fluctuations in Gross Domestic Product (GDP). In Canada, emissions of CO_2 have risen by 14.1% during the period from 1980 to 1999. Following a rise in emissions with economic growth in the 1970s, emissions then levelled off before declining in the early 1980s. More recently, emissions have risen again (figure 6.1), rising 18.5% during the period from 1991 to 1999.

In the United States, CO_2 emissions have exhibited a trend similar to that seen in Canada, albeit at much higher levels (figure 6.2). During the period from 1980 to 1999, total CO_2 emissions rose by 17.2%. Emissions fell through the early 1980s, followed by a rise in the latter half of the decade to surpass previous highs. After a brief decline in the early 1990s, CO_2 emissions once again began to increase steadily, showing a 15.7% increase during the period from 1991 to 1999.

In Mexico, CO_2 emissions have exhibited a much more consistent rising trend over the past three decades (figure 6.3). During the period from 1980 to 1999, total CO_2 emissions rose by 46.6%. Although there were brief periods of decline in the mid-1980s and 1990s, levels have been largely increasing for much of the period.

Notes

1 The atmosphere contains 750 billion tonnes of carbon dioxide; living plants contain 560 billion tonnes; soils, 1,400 billion tonnes; ocean sediments, 11,000 billion tonnes; and the oceans themselves, 38,000 billion tonnes (Environment Canada, 1991 c:(22)7)

2 Scientists do not dispute that the increase in equivalent CO_2 has occurred. Since the Industrial Revolution, equivalent CO_2 levels have risen from approximately 290 ppm to nearly 440 ppm in 1994 (Bailey, 1995: 87). Humans do not, however, contribute to the main absorbers of infrared light in the atmosphere. Water vapour and clouds are responsible for 98% of the current greenhouse effect (Lindzen, 1992: 2).

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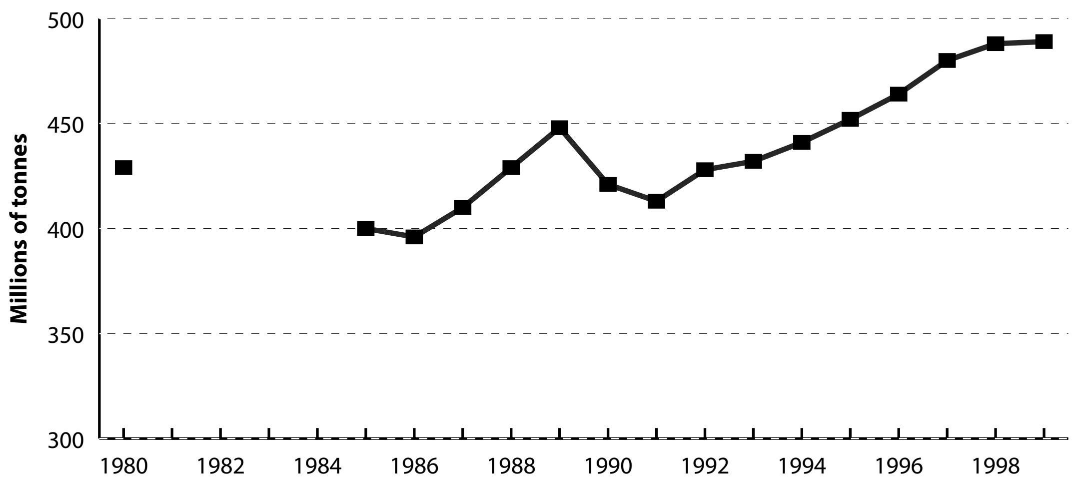
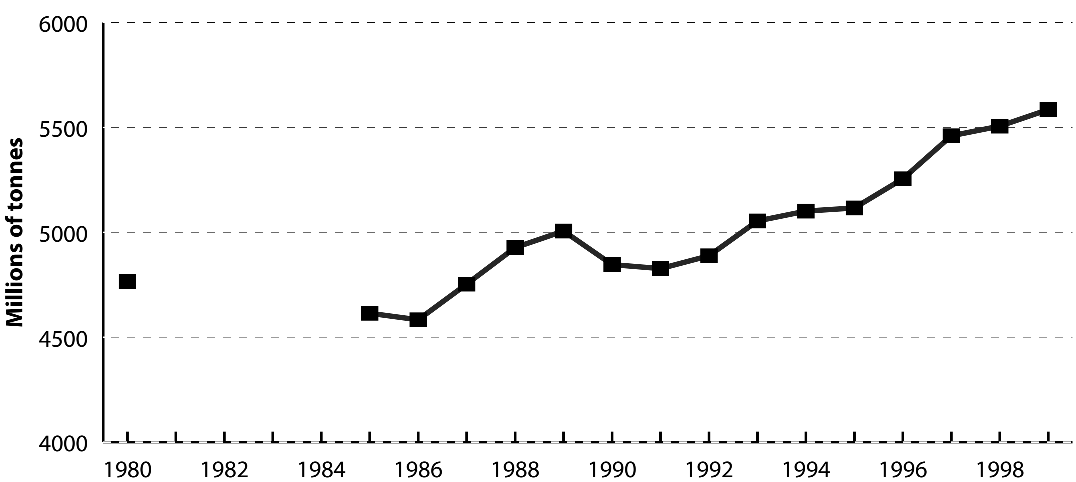
Figure 6.1: Canadian CO_2 emissions, 1980–1999



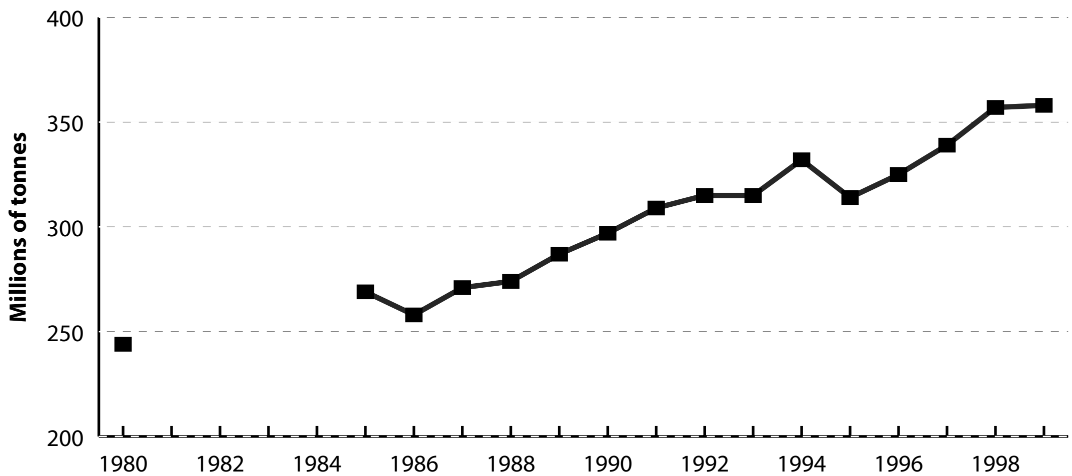
Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 6.2: US CO_2 emissions, 1980–1999



Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

Figure 6.3: Mexican CO_2 emissions, 1980–1999



Source: OECD (2002), *OECD Environmental Data Compendium 2002*.

7 Oil Spills

Oil spills such as the Exxon Valdez spill off Alaska in 1989, and the Odyssey spill off Nova Scotia in 1988 receive intense media coverage. Images of oil-soaked seabirds and distressed wildlife remain as clear memories. Unfortunately, this coverage and its lasting impressions have lead to a public perception that the number of oil spills and the severity of those spills are increasing. This is clearly not the case, however, as significant measures have been taken both in North America and internationally to reduce the risk of future oil spills.

Environment Canada estimates that Canada can expect a catastrophic spill (over 10,000 tonnes) only once every 15 years based on current levels of tanker traffic. According to the US Coast Guard, tanker accidents are only a minor source of water pollution, contributing approximately 5% of the 2.3 million tons of petroleum hydrocarbons entering the marine environment each year (Environment Canada, 2001). On the other hand, it is estimated that American households pour 1.3 billion litres of oil and oil-based products down the drain every year (Allen, 1993). The last two spills that affected North America were the Exxon Valdez in 1989 in Prince William Sound, Alaska, which spilled 40,000 tonnes, and the Odyssey in 1988, 700 nautical miles off Nova Scotia, which spilled 132,000 tonnes (ITOPF, 2001: 5).

Given the potential damage associated with oil spills, they are never a desirable event; however, it is important to recognize nature's ability to deal effectively with spilled oil when accidents do occur. Since oil is a natural substance produced by the decomposition of microorganisms, it degrades naturally in the environment. The eight main processes that lead to the natural weathering of oil are spreading, evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation, and biodegradation (ITOPF, 2002). Within 48 hours of an accident, 40% of spilled oil evaporates. Bacteria and other marine species break down and consume over 90% of the remaining oil over time (Bast, Hill, and Rue 1994: 148–53). According to *Science News*, about 50% of the oil from the Exxon Valdez incident was degraded naturally (Environment Canada, 2001). In some cases, active cleanup can actually cause more harm than good. For example, the steam used to clean rocks kills many tiny organisms, including those that would otherwise ingest and decompose spilled oil.

Continual efforts are being made to ensure that oil is shipped safely. Since 1993, double hulls are a requirement for all new tankers. Although ships are getting larger (250,000 deadweight tonnes today compared to 30,000 deadweight tonnes in the 1950s), limits have been placed on the size of individual tanks within the ships. Moreover, technological advances are leading to the development of more precise charting, radar, and navigation equipment and, in Canada, the "polluter pays" principle applies. This means that the party responsible for causing the pollution is responsible for paying the costs of clean-up (Environment Canada, 2001).

In response to the need for more accurate monitoring of spills in Canadian waters, the Environmental Response division of the Canadian Coast Guard implemented the Marine Pollution Incident Reporting System (MPIRS) in June 2001. Prior to this, data was not stored in a consistent or accessible manner. The MPIRS standardizes reporting for each of the five Canadian Coast Guard regions and ensures that reports include pollutant spilled (chemical, petroleum, other), region, and an estimate of quantity. Between June 2001 and January 2002, 1,374 incidents had been reported, 878 of which were reported to have been petroleum spills (Armstrong, 2002).

Performance

The comprehensive measures introduced in order to reduce the incidence of oil spills around the globe have resulted in a significant decline in both the number and volume of spills. As of 2002 (figure 7.1), the total number of spills between seven and 700 tonnes has declined by 86.8% since its peak in 1974, while the number of spills over 700 tonnes declined by 91.8% since its peak in 1979 (IOTPF, 2003). Moreover, the total quantity of oil spilled internationally has also declined, falling 86% since a peak spill year in 1979. This is likely a reflection of improved technology and precautionary safety measures such as double-hulled tankers.

The United States Coast Guard monitors oil spills in and around American waters and their data also reflect this trend. Although the total number of spills varies somewhat, it has decreased by 29% since its peak in 1978 and, more importantly, the total volume of oil spilled in American waters decreased 96% since its peak in 1975 (figure 7.2).

Similar data for Mexico are not available at this time.

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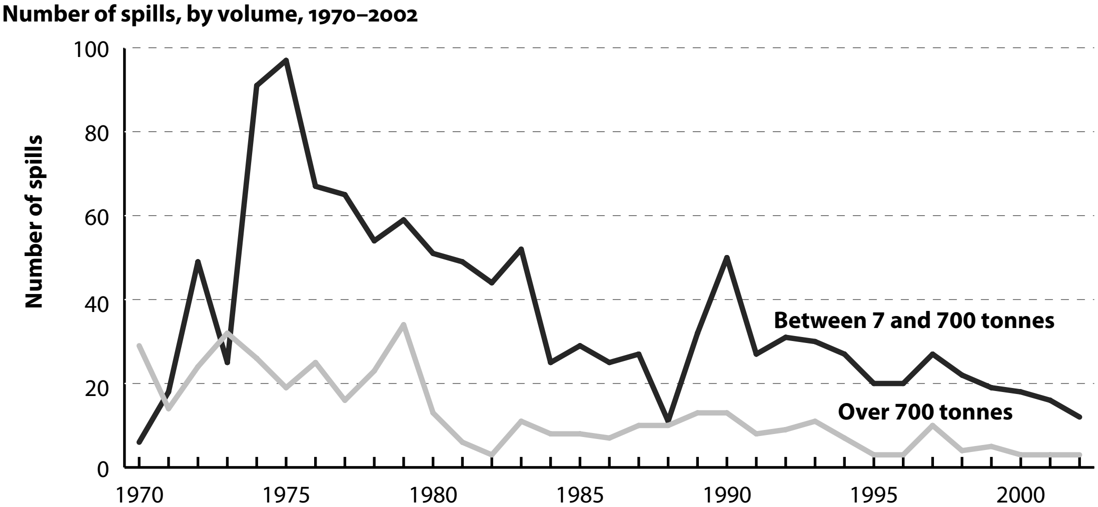
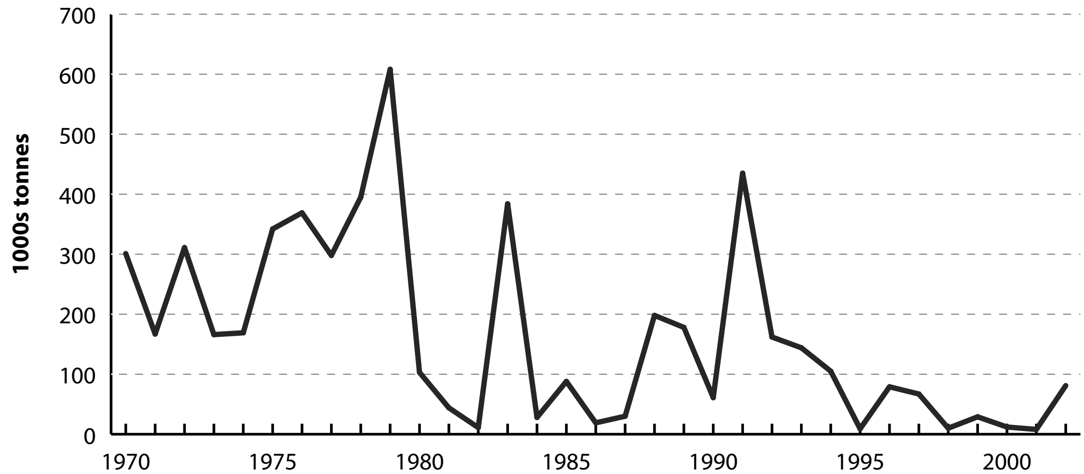
Figure 7.1: Number of spills, by volume, 1970–2002



Source: International Tanker Owners Pollution Federation Ltd (2003), *Fate of Marine Oil Spills*.

Figure 7.2: Total quantity of oil spilled, 1970–2002



Note on data for 2002: For the purposes of this publication, the amount spilt by the Prestige includes all oil lost to the environment and that which remains in the sunken tanker sections, i.e. 77,000 tonnes. This figure will be updated pending further information. This is consistent with the approach adopted in previous incidents.

Source: International Tanker Owners Pollution Federation Ltd (2003), *Fate of Marine Oil Spills*.

8 Pollutant Releases

The release of pollutants into the environment has become an issue of growing concern over the past several decades. Given the potential impact of pollutants upon the environment and human health, local governments and community groups have become increasingly active in their attempts to gain access to data on both the types and the quantities of pollutants being released in their areas. As a result, there have been several federal initiatives across North America to track pollutant releases and increase the amount of information available to the general public.

In Canada, the National Pollutant Release Inventory (NPRI) was established in 1992 under the Canadian Environmental Protection Act (Jackson 2000). The NPRI is a database managed by Environment Canada that maintains data on annual pollutant releases to air, water and land, as well as off-site transfers (Environment Canada, 2002).

In the United States, the Toxic Release Inventory (TRI) is a database managed by the Environmental Protection Agency (EPA) that maintains data on pollutant releases. Established under the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and further expanded under the Pollution Prevention Act of 1990, the TRI database is intended to inform communities and citizens of chemical hazards in their areas and to hold both companies and governments accountable for how chemical pollutants are handled (EPA, 2002).

In Mexico, the Pollution Release and Transfer Registry (PRTR) is a database managed by Secretaria del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP) that monitors and maintains data on pollutant releases. Established as part of the National Environmental Information System under the Right-to-Know clause in the General Law of Ecological Equilibrium and Environmental Protection (LGEEPA), it is designed to provide the public with information on generation, emissions, and discharges of listed contaminants (Pulse Point, 2000). Although reporting still remains voluntary at this time, legislation was passed in 2001 that represents a significant step towards mandatory reporting in the future (CEC, 2002). Unfortunately, however, little comparable data from Mexico is available for valid comparisons with the NPRI and TRI of Canada and the United States.

Increased access to information about pollutants provides several benefits. First, it provides valuable incentives for companies to pursue pollution-reduction strategies so that they will not be deemed a heavy polluter and unfriendly to the environment. Second, it assists in monitoring pollutant releases over time, thereby enabling the identification and prioritization of areas of concern and the development of plans to remedy the problems.

Performance

The total amount of pollutant released and transferred across North America have exhibited a slightly decreasing trend in recent years:[1] during the period from 1995 to 2000, total releases and transfers for North America fell by 4% (figure 8.1) Data indicate, however, that this trend was not the same in Canada and the United States (CEC, 2002). The total amount of pollutant released and transferred in Canada has exhibited a decreasing trend. During the period from 1995 to 2000, total pollutants and transfers increased by 27%. Total on-site releases were recorded as falling 3% while off-site releases decreased 7% and transfers increased by 49%.

Total pollutant releases and transfers in the United States have exhibited a slightly decreasing trend. During the period from 1995 to 2000, total pollutants and transfers fell by 6%. While total on-site releases fell by 19% and total off-site releases increased by 50%, total transfers increased by 13%.

Note

1 Comparable data only available for Canada and the United States.

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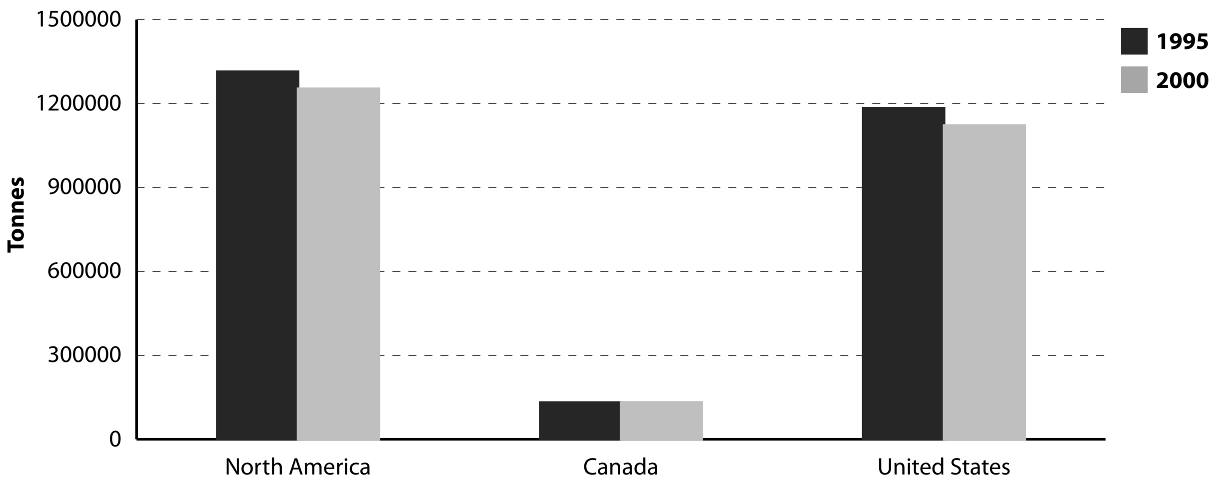
Figure 8.1: Total pollutant releases and transfers



Source: Environment Canada (2002), *2001 National Pollutant Release Inventory (NPRI) National Overview*.

9 Wildlife

Concern about preserving global biodiversity is growing among environmentalists, governments, and the public. This concern, however, has lead to some confusion about the status of wildlife within national borders. This confusion can be attributed to a lack of distinction between national endangered species lists and the state of global biodiversity.

Canada

In order to assess the true state of the Canada's wildlife, Environment Canada established the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1978. COSEWIC comprises government wildlife representatives in each province and territory as well as representatives from the Canadian Wildlife Service, Parks Canada, Fisheries and Oceans, the Canadian Nature Federation, and World Wildlife Fund Canada. Each year, COSEWIC publishes *Canadian Species at Risk*, which lists species that fall within one of the following five categories: "extinct," "extirpated," "endangered," "threatened," and "special concern" (table 9.1).

Performance

In Canada, the number of species designated by COSEWIC as "at risk" has increased from 17 species in 1978 to 431 in 2003. Although the growth in this list would appear to indicate a serious environmental problem, it is important to understand that much of this increase is simply reflects the increasing number of species that COSEWIC has studied. It is anticipated that this list will continue to grow as COSEWIC continues to further study new species not previously assessed. According to COSEWIC, "any use of the mere numbers of species currently in any of COSEWIC's categories to show there is, or is not, a trend in the rate at which species are becoming endangered is not correct and not justified." (COSEWIC, 2002).

Due to several methodologies used to categorize species as "at risk," the final number of species listed by COSEWIC has become inflated. Firstly, COSEWIC assesses isolated subpopulations of a species separately without taking into account whether other viable populations of the species exist. For example, the grizzly bear appears twice on the list of 431 species. While the prairie populations of grizzly bears is listed as extirpated, other populations in Alberta, British Columbia, the Northwest Territories, Nunavut, and the Yukon are listed as of "special concern." This clearly results in the double counting of a single species. Furthermore, because COSEWIC's mandate is to examine wildlife species in Canada exclusively, little recognition is given to species whose range spans well across the American border. As a result, COSEWIC's list includes several

Table 9.1: COSEWIC definitions of "At Risk" categories

Category	Definition
Extinct	species no longer exists
Extirpated	species no longer exists in the wild in Canada but is found elsewhere
Endangered	species faces imminent extirpation or extinction
Threatened	species likely to become endangered if limiting factors are not reversed
Special Concern	species is particularly sensitive to human activities or natural events but is not endangered or threatened
Data Deficient	there is inadequate information to make a direct, or indirect, assessment of species' risk of extinction

Source: Committee on the Status of Endangered Wildlife in Canada, 2003.

species that are naturally rare in Canada simply because Canada represents the northernmost extent of their range. Consequently, it can be concluded that the COSEWIC cannot be considered a reliable indicator of the actual number of species at risk of extinction in Canada.

While the number of species considered “at risk” is growing, the number within the most serious category, “extinct,” is not. To date, only 12 of the 431 species on the list are actually “extinct” and only 2 of the 12 species are mammals, the Sea Mink and the Queen Charlotte Island Caribou. Table 9.2 lists the species that have become extinct in Canada, the date of the extinction, and the probable cause of the extinction. Although extinctions can be considered a natural phenomenon, most of the extinctions on the Canadian list were a result of over-exploitation—hunting, trapping, and fishing. As unfortunate as these extinctions have been, there is no reason to expect that they will continue. The problem of over-hunting, with the exception of the fisheries, has largely been resolved. According to Environment Canada, “extinctions and extirpations from harvesting wildlife have declined because of changing policies and legislation combined with better management and enforcement” (Environment Canada, 1996). Moreover, one third of the species are in the least serious category, “special concern,” while 24% fall within the next least serious category, “threatened” (figure 9.1). It is important to note that species classified as of “special concern” are not endangered or threatened but rather sensitive to human activities and natural events.

Despite environmental campaigns and public attention toward large, charismatic, mega-fauna such as baby seals and the Kermode “Spirit” bear, analysis of Canada’s species “at risk” reveals that plants and fish constitute the largest proportion of species, representing 31.6% and 18.6%, respectively (figure 9.2). This is interesting in that it indicates that those species in the greatest need of awareness and protection are not receiving it by their self-proclaimed champions in the conservation movement.

United States

The Endangered Species Act (ESA) of 1973 gives the Secretary of the Interior the authority—delegated to the Director of the US Fish and Wildlife Service (FWS)—to determine whether individual plants and animals should be included on the federal list of endangered and threatened species. Candidates may be chosen as the result of either the petition process, or the candidate assessment process. By either route, the species must undergo a series of scientific examinations and public consultations before it can be listed. Under the ESA, a species should be listed as threatened or endangered if the species’ habitat or range is at risk of present or threatened destruction or modification; it is being overharvested for any purpose (including commercial or educational); it is at risk of disease or predation; or other factors are threatening the species’ survival (Nicholopoulos, 1999).

Table 9.2: Species extinction in Canada

Common Name	Latin Name	Category	Date of Extinction	Probable Cause of Extinction
Caribou dawsoni subspecies	*Rangifer tarandus dawsoni*	Mammal	1920s	Past unregulated hunting
Mink, Sea ()	*Mustela macrodon*	Mammal	1894	Past unregulated hunting
Auk, Great	*Pinguinus impennis*	Bird	1844	Past unregulated hunting
Duck, Labrador	*Camptorhynchus labradorius*	Bird	1875	Past unregulated hunting, habitat alteration
Pigeon, Passenger	*Ectopistes migratorius*	Bird	1914	Past unregulated hunting, habitat alteration
Cisco, Deepwater	*Coregonus johannae*	Fish	1952	Commercial fishing, predation by Introduced species
Dace, Banff Longnose	*Rhinichthys cataractae smithi*	Fish	1986	Commercial fishing, predation by Introduced species
Stickleback, Hadley Lake (benthic)	Gasterosteus sp.	Fish	1999	Predation by introduced species
Stickleback, Hadley Lake (limnetic)	Gasterosteus sp.	Fish	1999	Predation by introduced species
Walleye, Blue	*Stizostedion vitreum glaucum*	Fish	1965	Commercial fishing, habitat alteration
Limpet, Eelgrass	*Lottia alveus alveus*	Mollusca	1929	Natural causes
Moss, Macoun’s Shining	*Neomacounia nitida*	Mosses	not observed since 1864	Natural causes

Source: Committee on the Status of Endangered Wildlife in Canada, 2003.

Performance

In the United States, the number of species on the federal list of endangered and threatened species has increased from 281 species in 1980 to 1,263 in 2002 (FWS, 2002). Again, although the growth in this list would appear to be cause for concern, it is important to remember that the list will continue to grow as previously unexamined species are assessed. Further, although over half of the species listed as endangered or threatened are plants (figure 9.3), it is spectacular species such as the bald eagle that American conservation groups champion, despite the fact that, across the border in Canada, the bald eagle is not at risk.

Mexico

While there are recent data available on the number of species considered endangered in Mexico (figure 9.4), there is little information available on the procedures by which a species is determined to be endangered. However, the snapshot data does reveal similar that, like Canada and the United States, Mexico is concerned about its biodiversity and has delegated authority for monitoring it. Further, the Conservation Program of Wildlife and Rural Sector Production Diversification has determined that plants make up the largest single group at risk.

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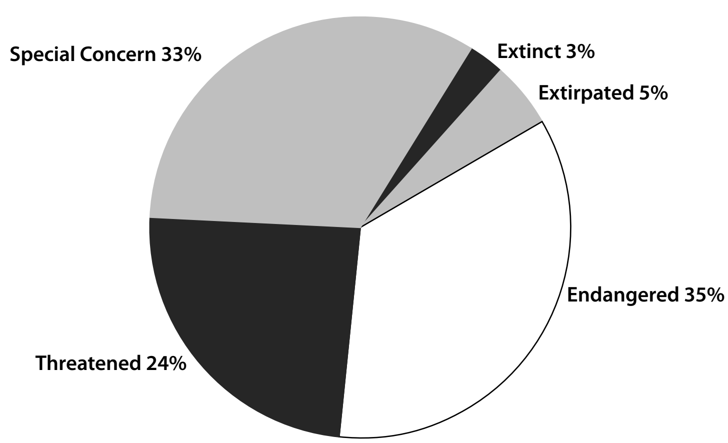
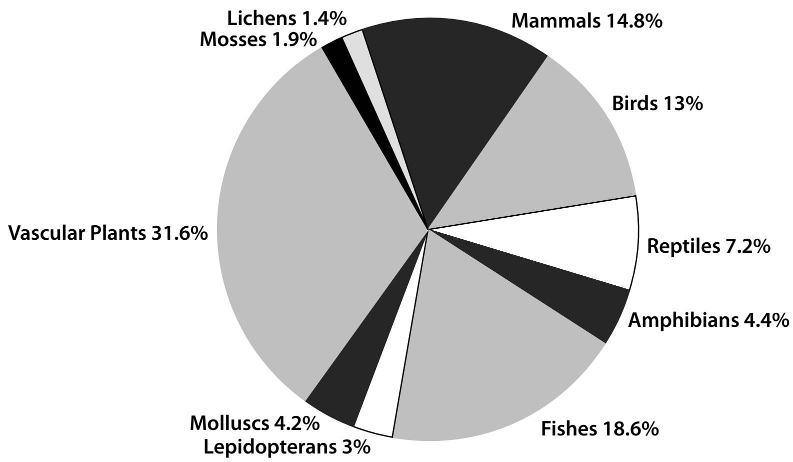
Figure 9.1: Status of species at risk in Canada



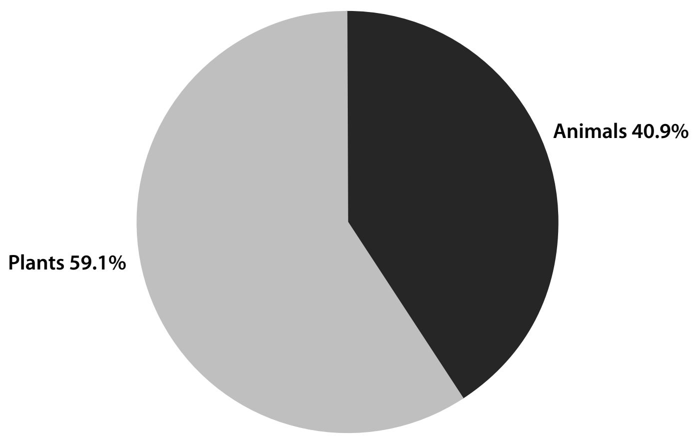
Source: Committee on the Status of Endangered Wildlife in Canada (2003).

Figure 9.2: Species at risk, by category



Source: Committee on the Status of Endangered Wildlife in Canada, 2003.

Figure 9.3: US endangered species distribution



Source: United States Fish and Wildlife Service, 2002, *US Listed Species per Calendar Year (from 1980 to 2002)*.