Primary Environmental Indicators

Air quality

Air quality in Canada and the United States presents the most accurate and consistent data available and shows the clearest trend of improvement among all environmental categories during the last 25 years. This section examines the six air pollutants that regulations target: sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO), total suspended particulates (TSPs) and lead (Pb). (See table 6 at the end of this section for a summary of the discussion of each pollutant.) The primary synthetic sources of these pollutants are automobiles and industrial activity such as smelting, mining, fossil fuel production, pulp and paper production, chemical production, and manufacturing.

Air quality is measured in two ways: by considering *ambient levels* and *emissions*. Ambient levels are the actual concentration of a pollutant in the air. They are usually reported in parts per million (ppm), parts per billion (ppb) or micrograms per cubic metre ($\mu g/m^3$). Air-monitoring stations are maintained in most cities with populations greater than 100,000 where air pollution presents a potential problem. The Canadian National Air Pollution Surveillance network (NAPS) began a comprehensive national program of tracking common air contaminants in the mid-1970s. By 1995, the network consisted of 140 monitoring stations using over 400 instruments in 52 urban centres across Canada.[13] In the United States, 600 sampling stations provide ambient data.[14]

Statistics for emissions are less reliable than ambient concentrations because they are *estimates* rather than actual measures. The EPA and Environment Canada use models to estimate emissions. These estimates measure the pollution that human activities generate; they do not include releases of the pollutant from natural sources. Emissions are usually reported in kilograms or tonnes. Frequent revisions in the calculation methods used to estimate emissions make comparisons between years less meaningful than comparisons of annual ambient levels.

Each pollutant in this section is described and then compared to Canada's National Air Quality Objectives for the protection of human health and the environment.[15] When pollution levels are within the "good" to "fair" range, there is adequate protection for the most sensitive persons and parts of the environment.[16] These requirements describe a broad range of environmental effects and are comparable to the requirements in the United States and other parts of the world.[17] The objectives established by the World Health Organization (WHO) are cited in the footnotes for comparison.

The data show that there is not a simple or predictable correlation between emissions caused by human activities and ambient air quality. For instance, the United States has about 10 times the

13 Environment Canada, *CEPA Annual Report*, 1996b, p. 8.

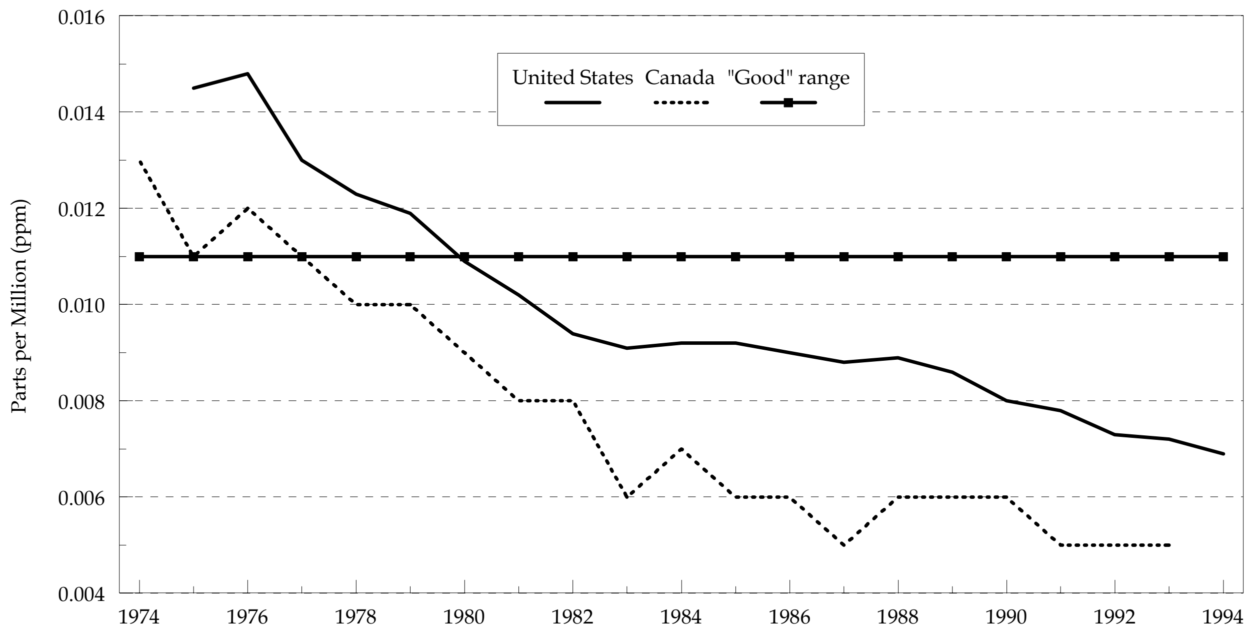
14 US EPA, *National Air Quality 1992*, 1993a.

15 Canada has a unique three-tiered system of objectives defining maximum desirable, maximum acceptable and maximum tolerable air pollution levels over periods of one year, 24 hours, eight hours and one hour. Each table in this section gives the corresponding levels explicitly in parts per million (ppm) or micrograms per cubic metre ($\mu g/m^3$). "Good" means an ambient pollution level lower than the maximum desirable objective, "Fair" lies between the maximum desirable and maximum acceptable objectives, "Poor" lies between the maximum acceptable and maximum tolerable objectives, and "Very Poor" means an ambient pollution level higher than the maximum tolerable objective.

16 Environment Canada, *The State of Canada's Environment*, 1991, p. 26.

17 Environment Canada, "Effects of Air Pollution," 1990, p. 26.

Figure 1: Sulphur Dioxide (Ambient Levels)



Sources: Environment Canada, 1996e; U.S. EPA, 1995c.

population, industry, and pollution emissions of Canada and yet do not always have *higher ambient levels*, because natural sources and meteorological factors such as temperature, sunlight, air pressure, humidity, wind, and rain affect ambient air quality. Hot summers, for example, cause higher ozone levels. The EPA is currently developing models that will adjust for such meteorological conditions.

Sulphur dioxide

Sulphur dioxide (SO_2) is a colourless gas that in sufficient concentrations has a pungent odour. The largest contributors to SO_2 emissions are industrial and manufacturing processes, particularly the generation of electric power. Environmental factors such as temperature inversion, wind speed, and wind concentration affect measured levels.

SO_2 is a precursor to acid rain.[18] Acid rain in large enough concentrations can cause the acidification of lakes and streams, accelerate the corrosion of buildings and monuments, and impair visibility. It was originally thought to damage forests and crops as well as endanger wildlife and human health. However, the decade-long US National Acid Precipitation Assessment Program (NAPAP) concluded that acid rain has had no significant effects on wildlife, forests, crops, or human health.[19] In fact, there have been cases in which acid rain has had a positive effect on soil and lakes as it can enhance vital nutrients and reduce pH levels where alkalinity is a problem.

Table 1 shows some of the effects of SO_2 on the environment and human health at different concentration levels. Figure 1 shows that the ambient level of SO_2 decreased by 50.3 percent in the United States and 54.5 percent in Canada between 1975 and 1993. The United States has met annual “good” objectives since 1981. Canada has met annual “good” objectives since 1978.[20]

In the case of emissions, figure 2 shows that levels in the United States fell 32.2 percent between 1970

18 SO_2 converts to sulphuric acid when it combines with oxygen and water in intense sunlight.

19 Bast, Hill, and Rue, *Eco-Sanity*, 1994, pp. 74–81.

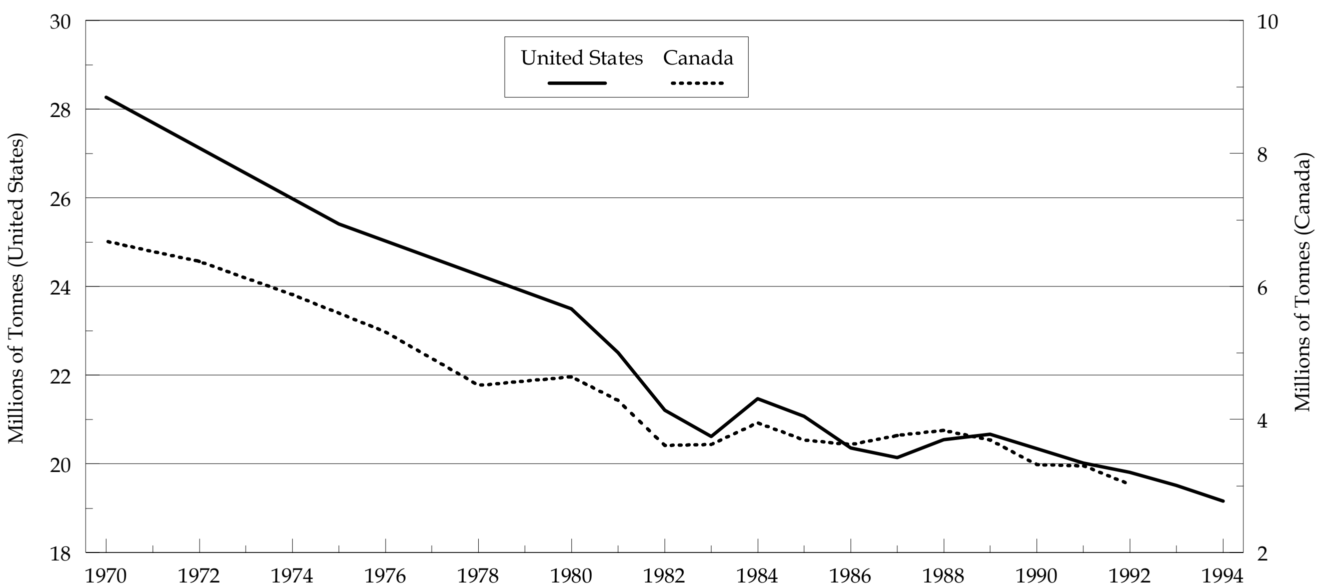
20 Individual stations may exceed these objectives; a 1990 Canadian study showed, however, that 98 percent of stations met annual “fair” objectives, 88 percent met 24-hr “fair” objectives and 82 percent met 1-hr “fair” objectives. See Environment Canada, *National Urban Air Quality*, 1994, pp. 12–17.

Table 1: Sulphur Dioxide (Ambient Levels)[A]

	Good	Fair	Poor	Very poor
Annual objectives	0–.011 ppm	.011–.023 ppm	>.023 ppm	NA
24-hour objectives	0–.057 ppm	.057–.115 ppm	.115–.306 ppm	>.306
1-hour objectives	0–.172 ppm	.172–.344 ppm	>.344 ppm	NA
Effects on human health and the environment	no effects	increasing damage to sensitive species of vegetation	odorous, increasing vegetation damage and sensitivity	increasing sensitivity of patients with asthma and bronchitis

[A] World Health Organization (WHO) guidelines (as reported in USEPA, 1995c, p. 7–4): Annual: .015–.023 ppm; 24hr: .038–.058 ppm, 1hr: .130 ppm; 10 min: .190 ppm.
Source: Environment Canada, *The State of Canada's Environment*, 1991, p. (2)11

Figure 2: Sulphur Dioxide (Emissions Estimates)



Sources: U.S. EPA, 1995b; Environment Canada, 1986; OECD, 1995.
Note: Environment Canada changed its calculation methodology in 1980.

and 1994. Canadian emissions fell 54.6 percent from 1970 to 1992. The largest factor contributing to the decline in emissions has been the increased use of control devices by industry. Process improvements, smelter closures, acid plant adoption, the use of low sulphur coal, the adoption of coal blending and washing procedures, and the conversion to cleaner fuels (e.g., natural gas and light oil) have also contributed to the decline. Federal environmental policy that mandates the use of scrubbers rather than permitting power generators to switch to low-sulphur coal may have impeded more dramatic emission improvements in the United States.[21]

In spite of this record, the US Clean Air Act Amendments (1990), which Canada is committed in principle to parallel,[22] mandates a further 9.1 million metric tonne reduction in SO_2 emissions

21 For a more complete analysis see Ackerman and Hassler, *Clean Coal, Dirty Air*, 1981. This regulation carries with it an enormous cost as well. Scrubbers on coal-fired plants can cost as much as US$200 million to install. See Portney, "Air Quality Policy," 1990, p. 76.

22 Environment Canada, 1996b, p. 33.

by the year 2000.[23] These reductions, warranted or not, may be achieved more cost effectively with methods other than increased regulation. For example, the 1990 US Clean Air Act has allowed the introduction of tradeable emissions permits. The Chicago Board of Trade now trades sulphur-dioxide pollution credits on the open market. Environmental groups can now further reduce emissions levels by purchasing these credits and retiring them.[24]

Nitrogen oxides

Nitrogen and oxygen combine naturally through bacterial action in soil, lightning, volcanic activity, and forest fires to form a variety of compounds referred to as nitrogen oxides (NO_x). The combustion of fossil fuels by automobiles, power plants, industry, and household activities also contribute to NO_x emissions. A reddish-brown gas called nitrogen dioxide (NO_2), a member of the NO_x family, is regularly tracked by environmental agencies since it combines with volatile organic compounds (VOCs) in the presence of sunlight to form ground-level ozone, which contributes to the formation of urban smog.

Table 2 lists the environmental and health effects of the subgroup NO_2. The ambient level of NO_2 shows a 33.8 percent decrease in the United States and a 38.7 percent decrease in Canada between 1977 and 1993 (figure 3). Both Canada and the United States have met annual "good" objectives since monitoring began in 1975 and 1977, respectively.[25]

Emissions data for NO_2 are unavailable. American emissions of the broader NO_x category, however, show an increase of 14.5 percent from 1970 to 1994, and Canadian emissions increased 45.9 percent from 1970 to 1992 (figure 4). In both nations, emissions increased throughout the 1970s and remained fairly stable after 1980. The emission increases of NO_x are puzzling in light of the reduction in ambient NO_2. It may be the case that either the estimates are inaccurate or the increase in other nitrogen oxide emissions exceeded the reduction in nitrogen dioxide emissions.

Hydrocarbons and volatile organic compounds (VOCs)

Volatile organic compounds (VOCs) are a subgroup of hydrocarbons (HCs) that enter the atmosphere

Table 2: Nitrogen Dioxide (Ambient Levels)[A]

	Good	Fair	Poor	Very poor
Annual objectives	0–.032 ppm	.032–.053 ppm	>.053 ppm	NA
24-hour objectives	NA	0–.106 ppm	.106–.160 ppm	>.160 ppm
1-hour objectives	NA	0–.213 ppm	.213–.532 ppm	>.532 ppm
Effects on human health and the environment	no effects	odorous	odour and atmospheric discoloration; increasing reactivity in asthmatics	increasing sensitivity of patients with asthma and bronchitis

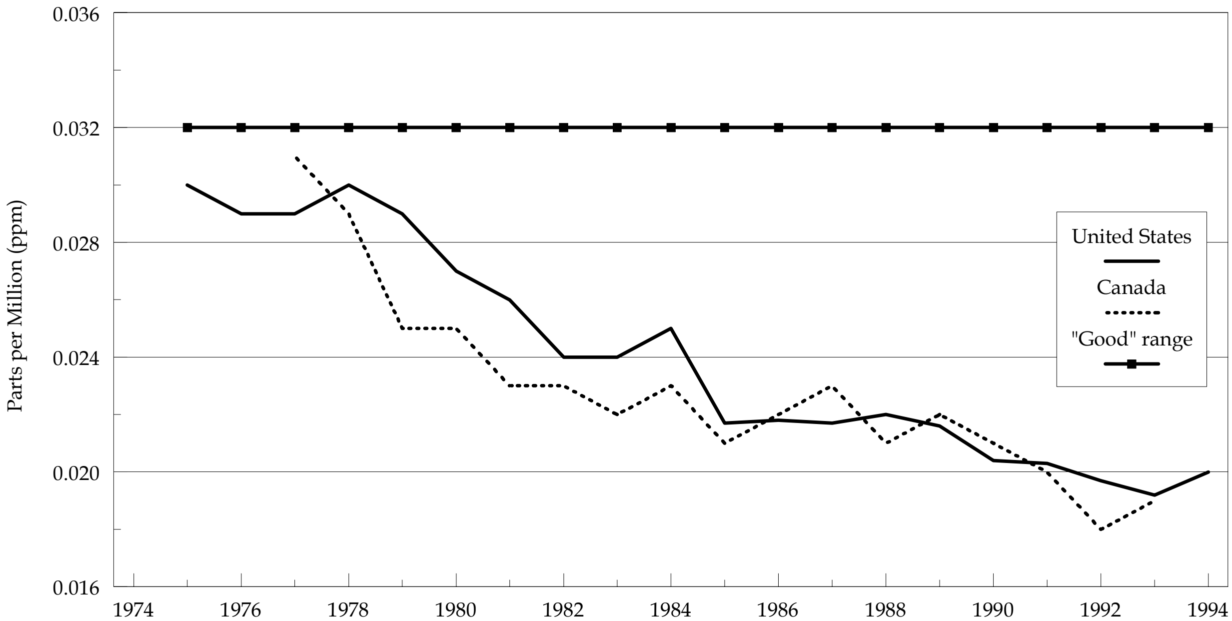
[A] WHO guidelines: 24hr: .080 ppm, 1hr: .210 ppm.
Source: Environment Canada, *The State of Canada's Environment*, 1991, p. (2)11.

23 US EPA, *National Annual Industrial Sulfur Dioxide Emission Trends*, 1995d, p. ES–1.

24 Working Assets Long Distance, a San Francisco-based long distance phone company, bought and retired US$74,000 worth of permits in 1992; this represents 336 metric tonnes of emissions.

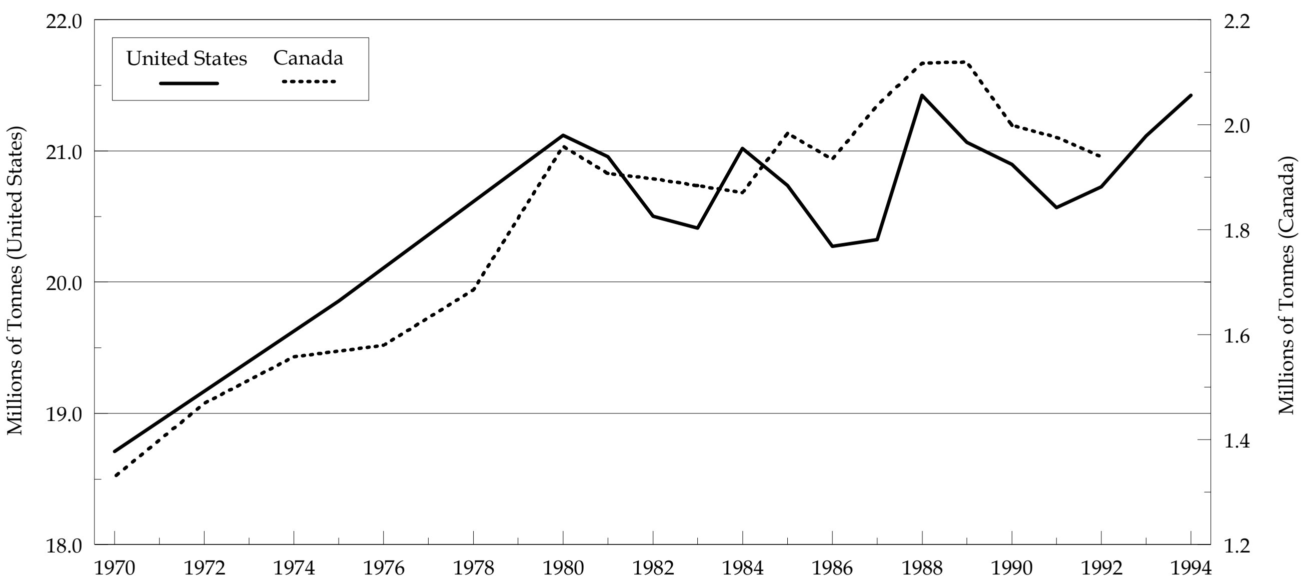
25 In the 1990 survey of individual stations, 100 percent of stations met annual, 24–hr and 1–hr "fair" objectives. Environment Canada, *National Urban Air Quality Trends 1981–1990*, 1994, pp. 18–22.

Figure 3: Nitrogen Dioxide (Ambient Levels)



Sources: Environment Canada, 1996e; U.S. EPA, 1995c.

Figure 4: Nitrogen Oxides (Emissions Estimates)



Sources: U.S. EPA ,1995b; Environment Canada, 1986; OECD, 1995.
Note: Environment Canada changed its calculation methodology in 1980.

through evaporation from auto fuel tanks, paints, coatings, solvents, and consumer products, such as lighter fluid and perfume. VOCs also occur naturally as a result of photosynthesis. They are an important subgroup of HCs because under the right conditions they combine with NO_2 to form ground level ozone, which contributes to urban smog. Regulators target VOC emissions to combat the secondary pollutant ozone. The ambient level of ozone and the emission levels for VOCs and hydrocarbons are presented in this section. Table 3 shows the effects of ozone on human health and the environment.

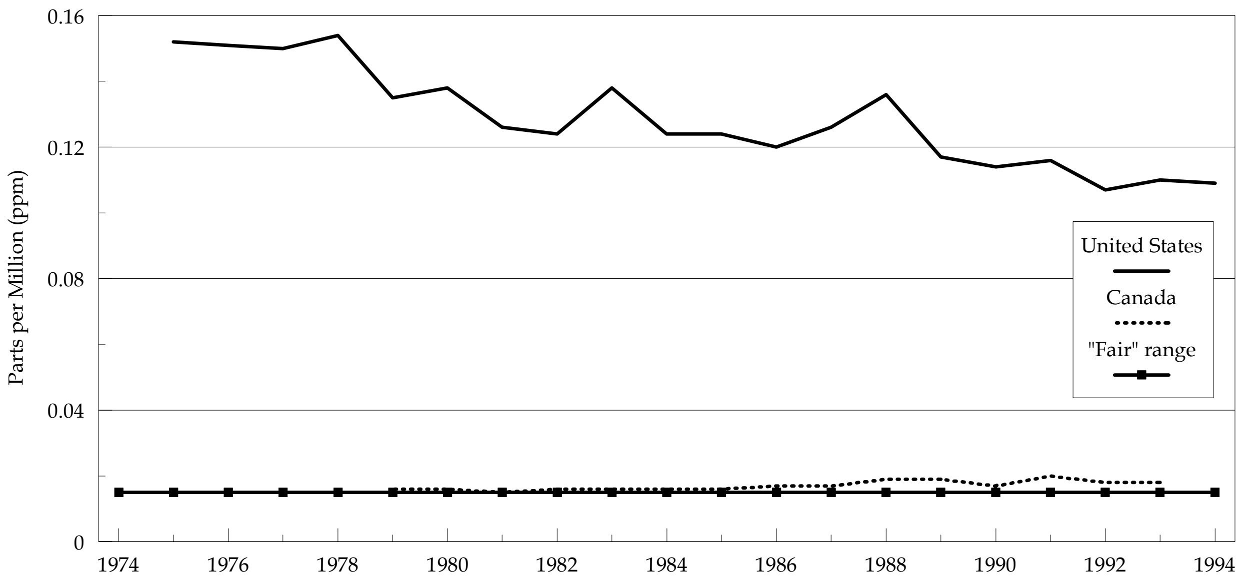
The level of ambient ozone decreased 18.5 percent in the United States but increased 12.5 percent in Canada between 1979 and 1993 (figure 5). Although

Table 3: Ozone (Ambient Levels)[A]

Objectives	Good	Fair	Poor	Very poor
Annual objectives	NA	0–.015 ppm	>.015 ppm	NA
1–hour objectives	0–.050 ppm	.050–.082 ppm	.082–.150 ppm	>.150 ppm
Effects on human health and the environment	no effects	increasing injury to some species of vegetation	decreasing performance by some athletes exercising heavily	light exercise produces effect in some patients with chronic pulmonary disease

[A] WHO guidelines: 8hr: .050–.060 ppm, 1hr: .050–.100 ppm.
Source: Environment Canada, *The State of Canada's Environment*, 1991, p. (2)11.

Figure 5: Ozone (Ambient Levels)



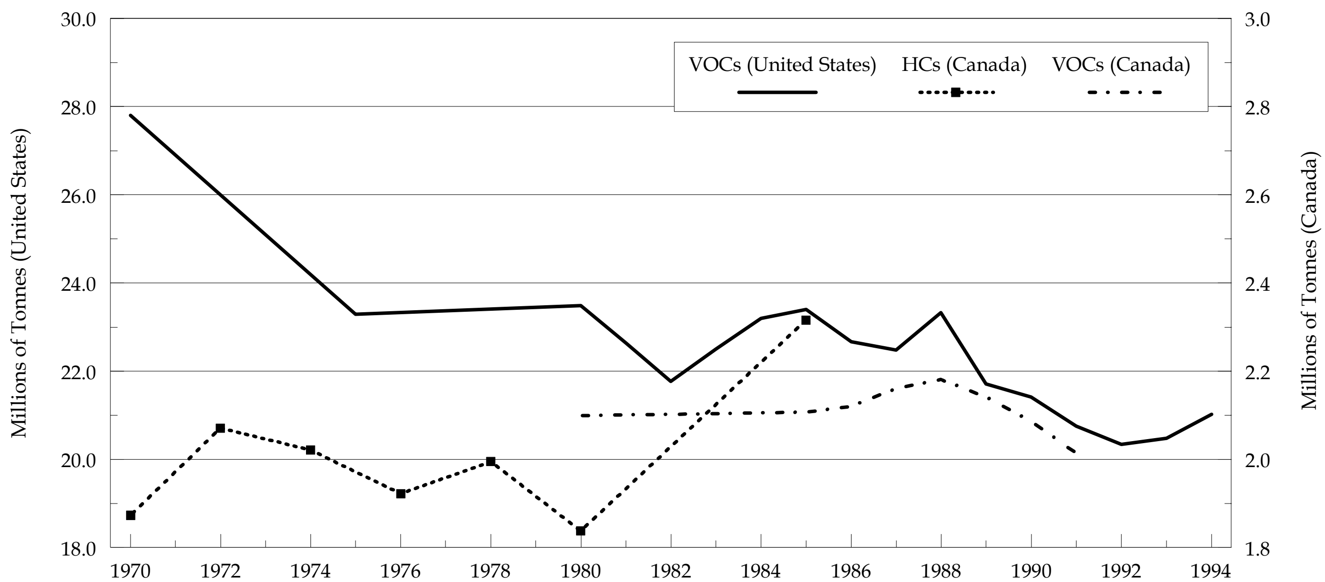
Sources: Environment Canada, 1996e; U.S. EPA, 1995c.
Note: There is no annual guideline for "Good" range. Measures above "Fair" are considered "Poor."

ozone levels in Canada have increased, Canada is still much better off than the United States in this area. For example, American ozone levels have consistently been much higher than those of Canada. However, the current level in Canada still exceeds annual "fair" objectives.[26] The ozone levels in the United States may be due to a difference in naturally occurring VOC emissions but may also be due to differences in data collection. Since ozone does not form in cold weather, Canadian data is collected from May to September, while American data is compiled year round. In addition, ozone concentrations vary considerably with meteorological factors such as temperature, wind speed, height of the inversion layer, cloudiness, and precipitation.

Ambient ozone levels do not directly or predictably reflect emissions. A 1991 National Academy Sciences report, *Rethinking the Ozone Problem in Urban and Regional Air Pollution*, concludes that current ozone reduction strategies may be misguided, partly because they do not account for naturally occurring VOCs. In the United States, VOC emissions declined 24.4 percent from 1970 to 1994 (figure 6). Canada

26 In 1990, 38 percent of stations met annual "Fair" objectives and 31 percent met 1–hr "Fair" objectives, although no station exceeded the "Poor" 1–hr level. Environment Canada, 1994, pp. 28–34.

Figure 6: Hydrocarbons and Volatile Organic Compounds (Emissions Estimates)



Source: U.S. EPA, 1995b; Environment Canada, 1986 and 1991a; OECD, 1995.
Note: Environment Canada changed its calculation methodology in 1980 and 1985.

estimated HC emissions until 1980, when they began to estimate the specific subgroup, VOC emissions. Total Canadian HC emissions increased 23.7 percent between 1970 and 1985 but VOC emissions fell 4.0 percent between 1980 and 1991. VOC emissions have decreased primarily because of the reformulation of petroleum-based products (especially paints and industrial coatings) and better containment and storage procedures that reduce evaporation.

The overlapping years for VOC and HC emissions in Canada highlight the problems with emissions estimates. VOCs are a *subgroup* of total hydrocarbons (HCs) and by definition must be smaller in abundance than HCs. Yet in 1980 VOC estimates *exceed* estimates for total HCs due to the different calculation methods employed.

Carbon monoxide

When fuel and other substances containing carbon burn without sufficient oxygen, carbon monoxide (CO), a colourless, odourless gas, is produced. Trace amounts of CO occur naturally in the atmosphere, but most emissions come from automobiles.

Table 4 shows the effects of CO on human health and the environment. 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 typically do not include annual recommendations for ambient CO levels. Ambient levels of CO have improved significantly. In the United States, annual ambient CO concentrations in 1993 were 60.5 percent lower than in 1975 while Canadian levels declined 61.6 percent over the same period (figure 7).[27]

CO emissions declined 14.9 percent in the United States between 1975 and 1994. There was a 13.6 percent decline in Canadian CO emissions between 1970 and 1990 (figure 8). These reductions can be attributed to cleaner automobiles (catalytic converters oxidize CO into non-poisonous CO_2) and more fuel-efficient industrial processes. To meet strict motor-vehicle regulations adopted in the early 1970s, exhaust gas recycling systems (EGRs) were installed and some older vehicles were retired. This has led to vastly reduced emissions per vehicle. For example, North American cars built in 1993 emitted 90 percent less NO_x, 97 percent less hydrocarbon, and 96 percent less carbon monox-

27 Although there are no annual objectives, in the 1990 study of Canadian stations, 98 percent of stations met the 8–hr and 1–hr Fair objectives. Environment Canada, 1994, pp. 23–27.

Table 4: Carbon Monoxide (Ambient Levels)[A]

	Good	Fair	Poor	Very poor
8-hour objectives	0–5 ppm	5–13 ppm	13–17 ppm	>17 ppm
1–hour objectives	0–13 ppm	13–31 ppm	>31 ppm	NA
Effects on human health and the environment	no effects	no detectable impairment but blood chemistry is changing	increasing cardiovascular symptoms in smokers with heart disease	increasing cardiovascular symptoms in non-smokers with heart disease, some visual and coordination impairment

[A]WHO guidelines: 8hr: 9 ppm; 1hr: 26 ppm.
Source: Environment Canada, *The State of Canada's Environment*, 1991, p. (2)11.

Table 5: Suspended Particulates (Ambient Levels)[A]

	Good	Fair	Poor	Very poor
Annual objectives	0–60 $\mu g/m^3$	60–70 $\mu g/m^3$	>70 $\mu g/m^3$	NA
24-hour objectives	NA	0–120 $\mu g/m^3$	120–400 $\mu g/m^3$	>400 $\mu g/m^3$
Effects on Human Health and the Environment	no effects	decreasing visibility	visibility decreased, soiling through deposition	increasing sensitivity of patients with asthma and bronchitis

[A] WHO guidelines: Total Particulates, Annual: 60–90 $\mu g/m^3$; 24hr: 150–230 $\mu g/m^3$; PM–10 24hr: 70 $\mu g/m^3$.
Source: Environment Canada, *The State of Canada's Environment*, 1991, p. (2)11.

ide than cars built two decades earlier.[28] These reductions in emissions are expected to continue as more old cars are retired. The most cost-efficient way to continue reducing emissions may be to target poorly tuned, polluting vehicles for repair or replacement.[29]

Total suspended particulates and PM–10

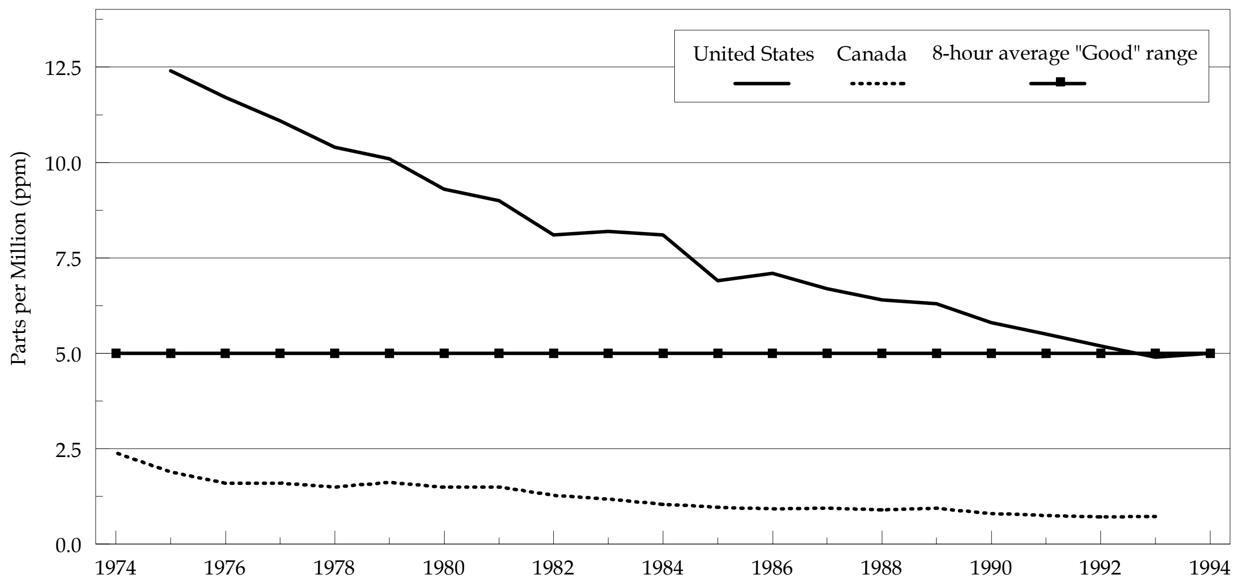
Suspended particulates are small pieces of dust, soot, dirt, ash, smoke, liquid vapour, or other matter in the atmosphere. Sources may include forest fires and volcanic ash as well as emissions from power plants, motor vehicles and waste incineration, and dust from mining.

Table 5 details the health and environmental effects of particulates. 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. Data from 1975 to 1991 show, in Canada, a 42.2 percent reduction, and, in the United States, a 23.6 percent reduction in the ambient levels of total suspended particulates

28 See Bast, Hill, and Rue, 1994, p. 111.

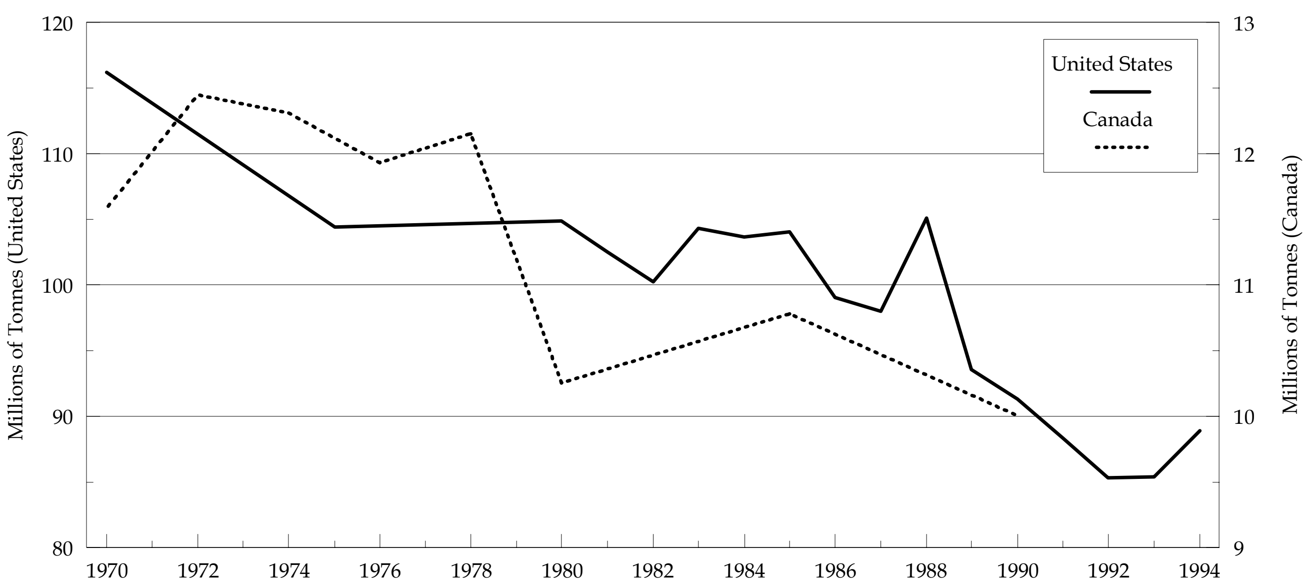
29 Dr. Donald Stedman, a chemistry professor at the University of Denver, has developed a device that can measure and test the exhaust of *moving* vehicles, thus isolating the heaviest polluters. For more on this see Bast, Hill, and Rue, *Eco-Sanity*, 1994, pp. 115–6. Also, if power plants were to add chemical or isometric "labels" to their emissions, lasimetric technology could map chemical concentrations from orbit. See Fred Smith, "Epilogue: Reappraising Humanity's Challenges, Humanity's Opportunities," p. 390.

Figure 7: Carbon Monoxide (Ambient Levels)



Sources: Environment Canada, 1996e; U.S. EPA, 1995c.
Note: There is no annual guideline for "Good" range. See text for explanation.

Figure 8: Carbon Monoxide (Emissions Estimates)



Sources: U.S. EPA, 1995b; Environment Canada, 1986, 1991a, 1995.
Note: Environment Canada changed its calculation methodology in 1985 and 1990.

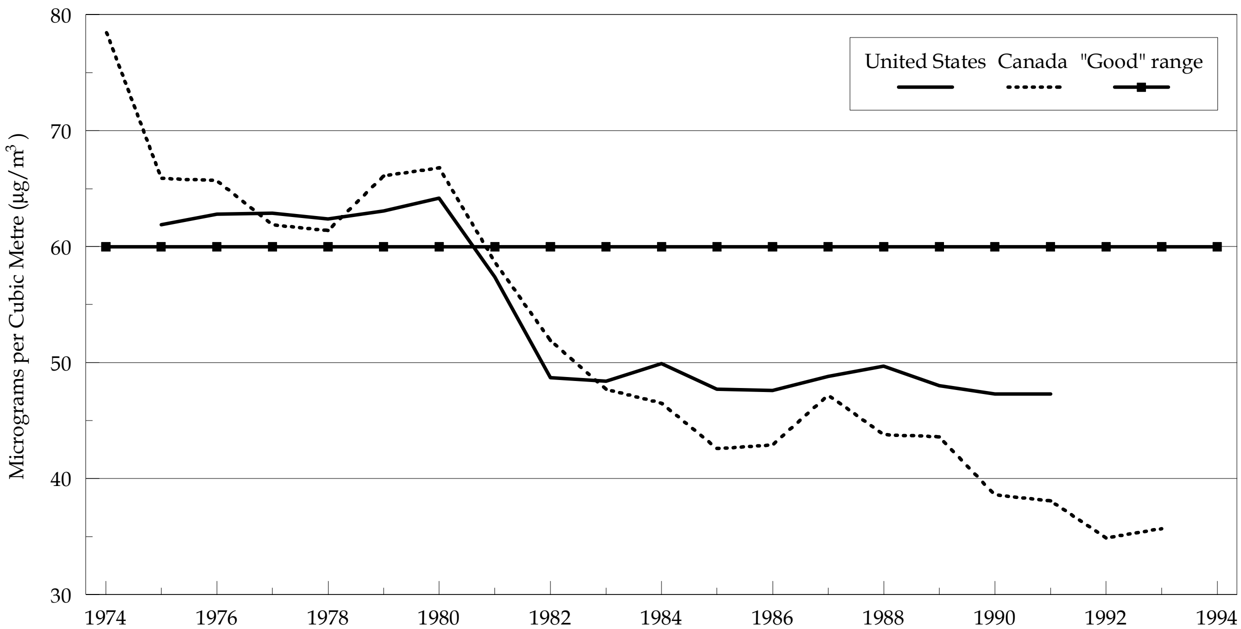
(TSPs) (figure 9). Both countries have met annual "good" objectives since 1981.[30]

The smallest particulates pose the greatest threat to human health because they are able to reach the tiniest passages of the lungs. As a result, recent emissions estimates focus on TSPs that are 10 micrometres or smaller (PM–10). The EPA changed its regulatory focus from total suspended particles to PM–10 in 1987.[31] Environment Canada,

30 In addition, the 1990 Canadian study shows that 100 percent of individual stations met annual "fair" objectives. Environment Canada, *National Urban Air Quality Trends*, 1994, pp. 35–42.

31 USEPA, *National Air Quality 1994*, 1995c, pp. 2–16.

Figure 9: Suspended Particulates (Ambient Levels)



Sources: Environment Canada, 1996e; U.S. EPA, 1995c.

however, continues to use the broader category of total suspended particulates. These regulatory differences make direct comparison of current particulate emissions difficult. TSP emissions in the United States fell 69.9 percent from 1970 to 1987 and PM–10 emissions declined 22.0 percent from 1988 to 1994 (figure 10). In Canada, TSP levels declined 8.5 percent from 1970 to 1990. The switch from coal to cleaner burning fuels such as oil and natural gas, as well as more frequent street cleaning, are responsible for most of the reductions in emission levels.

Lead

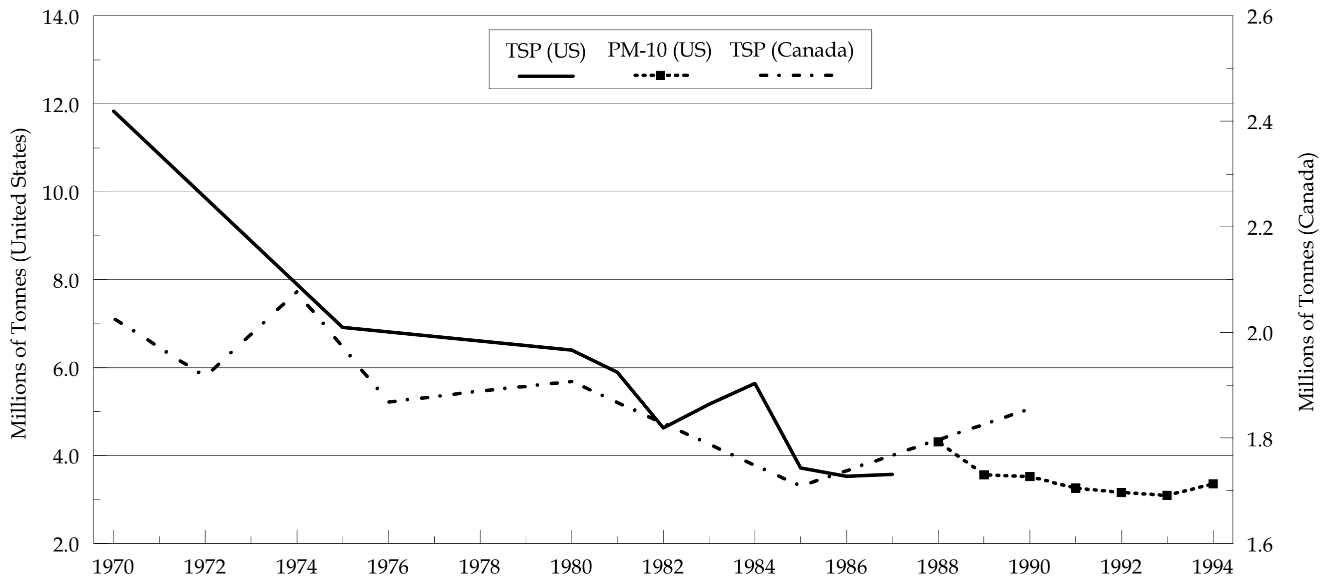
Lead is a soft, dense, bluish-gray metal. Its high density, softness, low melting point, and resistance to corrosion make it a valuable industrial resource. It is used in the production of piping, batteries, weights, gunshot, and crystal. Until recently, automobiles were the source of most lead emissions although small quantities of lead are naturally present in the environment. Lead is the most toxic of the main air pollutants. When it is ingested, it accumulates in the body's tissues. In high concentrations it can cause damage to the nervous system, seizures, behavioural disorders, and brain damage. In addition, recent evidence suggests that lead exposure may be associated with hypertension and heart disease.[32] Since lead is the most toxic of the main air pollutants, environmental and health guidelines for lead are stricter than the guidelines for other air pollutants. Canada and the United States are committed to reducing levels as low as technologically feasible, although no explicit objectives have been set. The WHO maximum for the protection of human health is shown in figure 11.

The decline in lead emissions and ambient lead concentration is the greatest success story in the efforts to reduce air pollution. Ambient lead concentration fell 97.1 percent in the United States and 96.9 percent in Canada between 1975 and 1992 (figure 11). The United States has met WHO's health objectives since 1981 and Canada has met them since monitoring began in 1974.

Lead emissions in the United States fell 97.7 percent between 1970 and 1994 (figure 12). In Canada, total emissions fell 54.5 percent from 1978 to

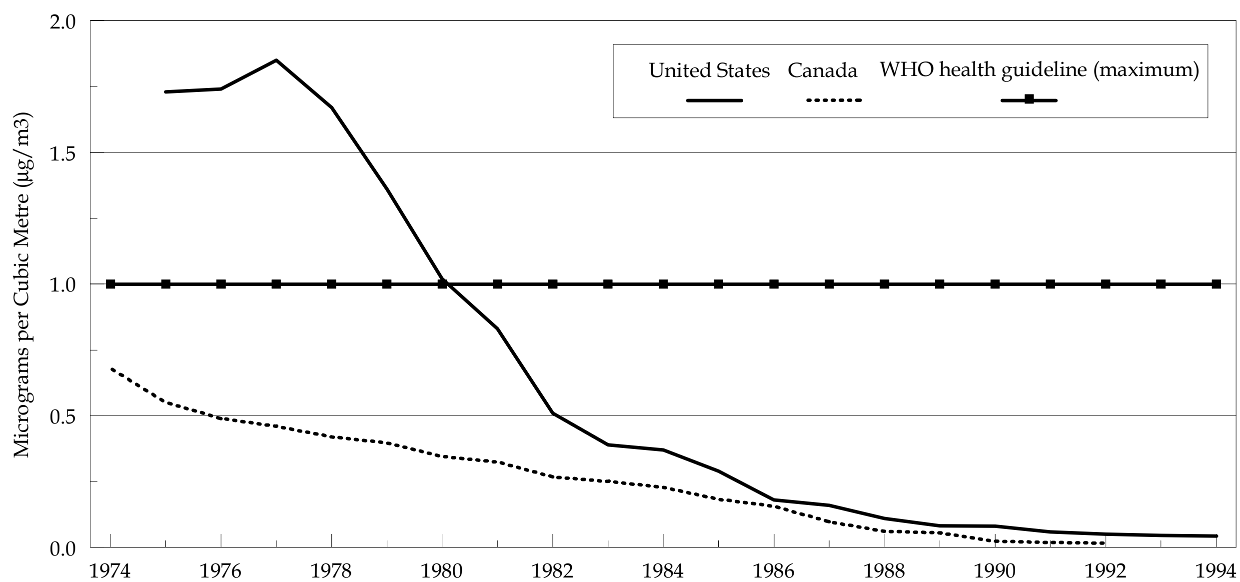
32 USEPA, *National Air Quality 1994*, 1995c, pp. 2–6.

Figure 10: Suspended Particulates (Emissions Estimates)



Sources: U.S. EPA, 1995b; Environment Canada, 1986; OECD, 1995.
Note: Environment Canada changed its calculation methodology in 1980.

Figure 11: Lead (Ambient Levels)



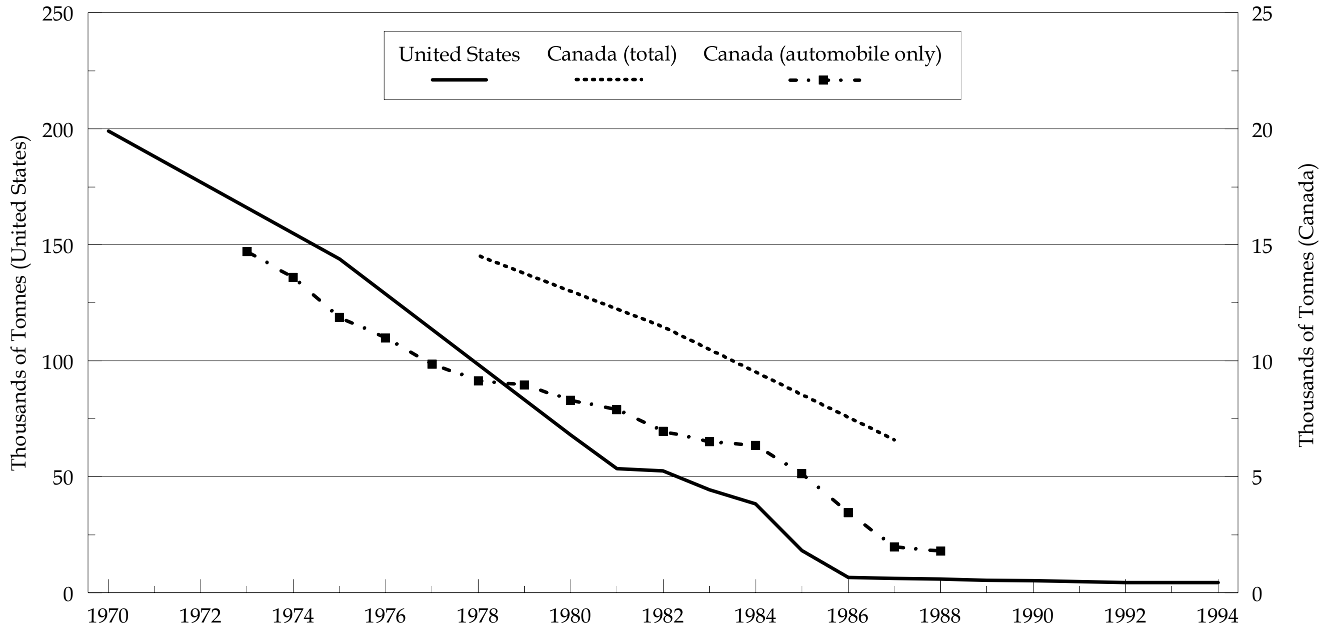
Sources: Environment Canada, 1996e; U.S. EPA, 1995c.
Note: There are no Environment Canada guidelines for lead. See text for explanation.

1987, and automobile emissions fell 87.8 percent from 1973 to 1988. Most of this dramatic reduction was due to the introduction of unleaded gasoline and the elimination of lead compounds in paints and coatings.

Air quality in selected cities: number of days exceeding the ozone standard

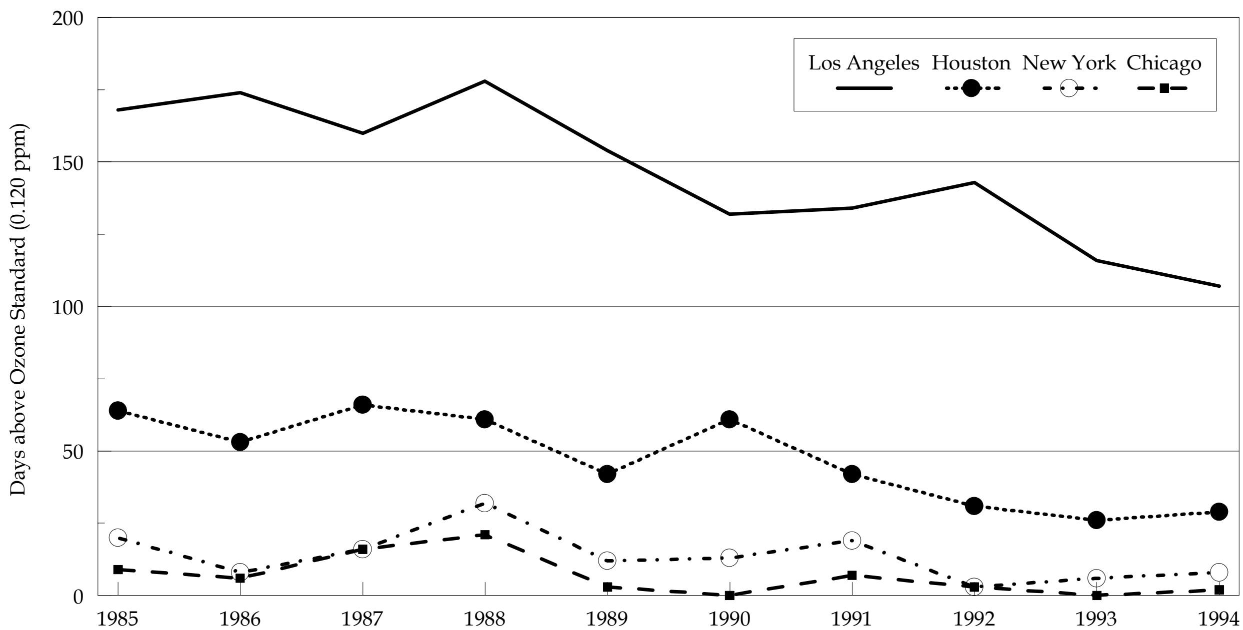
Sulphur, nitrogen, carbon, and fine particulate matter as well as ground-level ozone contribute to the formation of urban smog. Since ozone measures are

Figure 12: Lead (Emissions Estimates)



Sources: U.S. EPA, 1995b; Environment Canada, 1991a.

Figure 13: Urban Air Quality in Selected American Cities



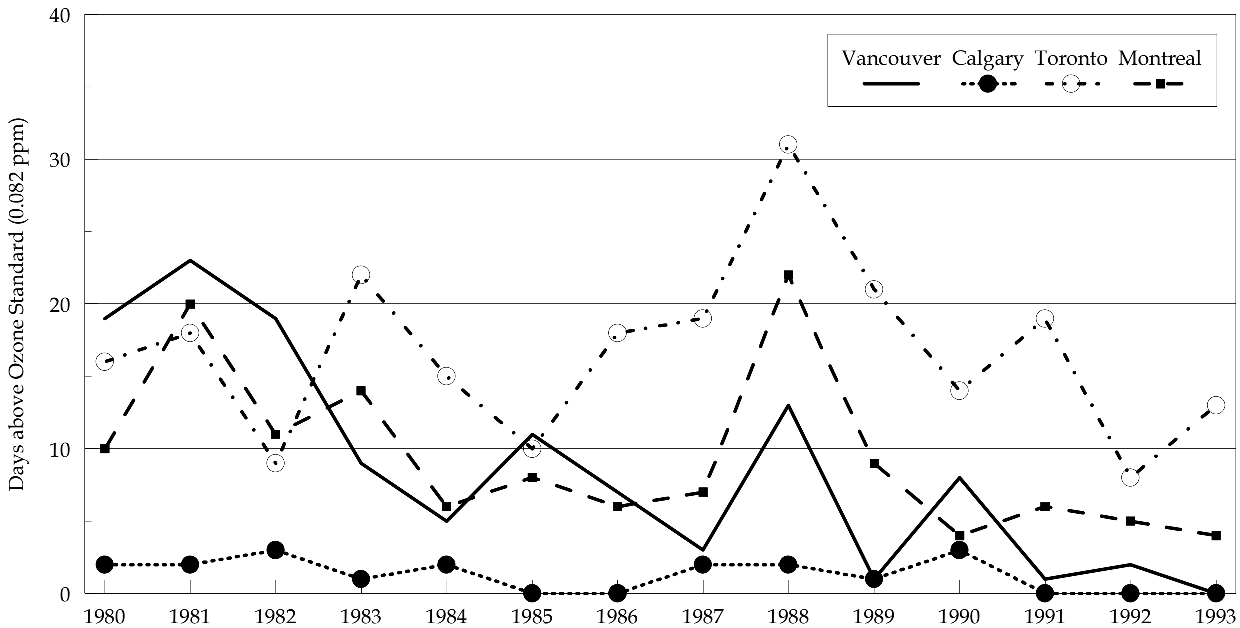
Source: U.S. EPA, 1994c.

relatively constant over large areas, it is often used as an indicator of overall urban air quality.[33]

Ozone problems occur most often on warm, clear, windless afternoons. Figures 13 and 14 show that the number of days when ozone objectives were exceeded in different cities tend to peak and decline in the same years. This strongly suggests meteorological influences. When analyzing this measure, it is important to understand that when a

33 USEPA, *National Air Quality and Emission Trends Report 1994*, 1995, p. 6–1.

Figure 14: Urban Air Quality in Selected Canadian Cities



Source: Environment Canada, 1996e.

single monitoring station registers one one-hour episode above the hourly standard this is considered a *day* above the ozone standard. It does not mean, however, that the standard was exceeded for the entire 24-hour period.

In many cities, days when ozone objectives are exceeded have become infrequent although in some areas, and especially in Los Angeles, smog remains a problem. Even in Los Angeles, ozone levels are improving (figure 13): between 1985 and 1994, the number of days exceeding the ozone standard fell 36.3 percent. In Houston, which, after Los Angeles, had the worst record of the large American cities, the number of days when ozone objectives were exceeded fell 54.7 percent between 1985 and 1994.

In Canadian cities, the number of days when ozone standards are exceeded have not matched the worst American cases. This is largely due to Canada's colder climate. Ozone pollution is recorded almost exclusively in the summer months from May to September. Data show that ozone levels in Toronto and Montreal are low but variable; Calgary's levels are consistently low, and Vancouver's ozone levels are low and show a decreasing trend. Vancouver did not exceed the ozone standard at all in 1993 (figure 14).[34] The data show that the number of days when ozone levels are exceeded in Canadian cities is not increasing despite the overall growth in ambient ozone concentrations in Canada. While the major urban centres demonstrate relatively few ozone episodes, southwestern rural Ontario records the highest number of days exceeding the ozone standard.[35]

Water quality

Assessing water quality

Water quality is among those environmental problems most difficult to assess on a nationwide basis. The data used in this section do not represent complete ambient water-quality information due to the lack of available data and the magnitude and

34 It should be noted that the Canadian ozone standard (.082 ppm) is stricter than that of the United States (.120 ppm).

35 Even measures at Canada's worst sites are relatively low. A recent study shows that the lakeshore sites around the Great Lakes record an average of 150 hours (20 days) annually that exceed the .082 ozone standard. Recorded levels greater than .120 ppm are rare in most regions and very infrequent in southern Ontario with only 0.14 percent of measures exceeding this level. See Dann, *Data Analysis Workgroup Report*, 1996, 2.3., pp. 1–27.

Table 6: Summary of Air Quality as Environmental Indicator

General comments	Performance record: US	Performance record: Canada
General comments on air quality		
• Ambient level refers to the actual concentration of a pollutant in the air. • Emissions are estimates of pollution caused by human activity. • There is not a simple or predictable correlation between emissions caused by human activities and ambient air quality. • Natural sources and meteorological factors such as temperature, sunlight, air pressure, humidity, wind, and rain greatly affect measurable levels. • Pollution levels within the good to fair range provide adequate protection for people and the environment.	• Ambient pollution in all categories has declined since the 1970s.	• Ambient pollution decreased in all but one of the categories.
Sulphur dioxide (SO_2)		
• SO_2 is a component of acid rain. • Acid rain has not damaged forests or crops in either the US or Canada and has had no observable effect on human health. • Ambient levels are affected by meteorological factors.	• Has met annual "Good" objectives since 1981. • Ambient level decreased 50.3% from 1975 to 1993.	• Has met annual "Good" objectives since 1978. • Ambient level decreased 54.5% from 1975 to 1993.
Nitrogen dioxide (NO_2)		
• NO_2 is a component of acid rain. • NO_2 combines with VOCs to form ground-level ozone (main component of urban smog); ozone levels vary considerably, however, with natural and meteorological factors.	• Has met annual "Good" objectives since monitoring began in 1975. • Ambient level decreased 32.7% from 1977 to 1993.	• Has met annual "Good" objectives since monitoring began in 1977. • Ambient level decreased 38.9% from 1977 to 1993.
Ozone		
• VOCs and NO_2 combine to form ground-level ozone. • Regulations target VOC emissions as the primary means to combat ozone. • Ambient ozone levels do not directly or predictably reflect emissions because of their failure to account for naturally occurring VOCs and meteorological factors.	• Exceeds annual "Fair" objectives. • Ambient level decreased 18.5% from 1979 to 1993.	• Exceeds annual "Fair" objectives. • Ambient level increased 12.5% from 1979 to 1993.
Carbon monoxide (CO_2)		
• North American cars built in 1993 emit 90% less NO_x, 97% less hydrocarbons and 96% less carbon monoxide than cars built two decades earlier.	• Ambient level decreased 60.5% from 1975 to 1993.	• Ambient level decreased 61.6% from 1975 to 1993.
Particulates		
• Particulates come from a variety of natural sources.	• Has met annual "Good" objectives since 1981. • Ambient level decreased 23.6% from 1975 to 1991.	• Has met annual "Good" objectives since 1981. • Ambient level decreased 42.2% from 1975 to 1991.
Lead		
• Natural sources contribute small quantities. • Leaded gasoline was phased out once the adverse health effects of lead were discovered.	• Has met WHO health guidelines since 1981. • Ambient level decreased 97.1% from 1975 to 1992.	• Has met WHO health guidelines since monitoring began in 1974. • Ambient level decreased 96.9% from 1975 to 1992.

complexity of measuring water quality. For example, American estimates indicate that taxpayers and the private sector have spent over US$500 billion on water pollution control since the enactment of the Federal Water Pollution Control Act (1972). Despite this expenditure, there is still no adequate national database of water quality to evaluate the results of such efforts.

To illustrate the complexity of measuring water quality, consider the province of Nova Scotia, which has 23 geological formations and 75 river basins. The effects of natural and human contaminants on water quality vary with water conditions (source, velocity, volume, depth, salinity, pH level), photosynthetic activity, and variations within a day as well as from season to season. To get an accurate picture of ambient water quality in Nova Scotia alone would require some 225 monitoring sites measured on a quarterly basis.[36] In addition, inconsistencies in data collection occur due to overlapping jurisdictions and budget considerations. As a result, crisis management and site-specific studies often take priority over systematic, consistent monitoring.

Water pollutants

There are two sources of water pollution: *point* and *non-point*.[37] Point sources refer to industrial discharge pipes and municipal sewer outlets that discharge pollutants directly into the aquatic ecosystem. Non-point sources refer to indirect sources of pollution such as runoff from agriculture, forestry, urban, and industrial activities, as well as landfill leachates and airborne matter. Water quality also varies naturally. Some bodies of water are of poor quality due to inherent chemical, physical, and biological characteristics. Water pollution from human activities includes nutrients, heavy metals, persistent pesticides, and other toxics.

Nutrients like phosphorus and nitrogen can cause significant degradation of water quality by accelerating eutrophication,[38] which depletes levels of dissolved oxygen. Phosphorus and nitrogen are found in fertilizers and livestock manure.[39] Government regulation stipulates a reduction of the amount of phosphate in detergents in an effort to improve water quality. Lower phosphate levels in lakes and streams, however, do not always result in higher levels of dissolved oxygen and improved water quality as plants continually recycle phosphorus from sediments.

Heavy metals occur in water from the weathering of rocks. They also reach the water system directly from industrial and mining activity. The most severe cases of metal contamination are caused by abandoned mines. Non-point sources such as urban storm-water and agricultural runoff also contribute to metal contamination. 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).[40]

Pesticides and toxics like polychlorinated synthetic compounds (DDT and PCBs) can also accumulate in biological organisms. The effects of these compounds on animals, such as birds, include growth retardation, reduced reproductive capacity, diminished resistance to disease, and birth deformities.

Water treatment

Industrial and municipal sewage is usually treated before being released into rivers, lakes, streams, and oceans. Primary wastewater treatment removes

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36 Cameron, personal communication, 1996.

37 Point versus non-point sources of water pollution could be compared to stationary versus mobile sources of air pollution.

38 Eutrophication, or nutrient enrichment, is the oversupply of inorganic nutrients that cause algae and plants to multiply rapidly; when they die and decompose, the water's dissolved oxygen content is depleted. Dissolved oxygen, which is derived from photosynthesis by aquatic plants and atmospheric exchange, is essential to ensure the maintenance of aquatic life and self-purification processes in natural water systems.

39 Environment Canada, *State of Canada's Environment*, 1991, p. (9)26.

40 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 tissues.

solid waste mechanically. Secondary treatment employs biological processes to break down dissolved organic material. Tertiary treatment removes additional contaminants, including heavy metals and dissolved solids.

As of 1992, "all sewage generated in the US is treated before discharge."[41] Wastewater treatment has reduced the release of organic wastes by 46 percent, of toxic organics by 99 percent, and of toxic metals by 98 percent. Although some individual firms and facilities exceed regulated discharge levels, most serious point-source discharges have been eliminated. Non-point sources, however, continue to be a problem. The EPA notes that non-point sources "are clearly the leading reason for impediment in surface waters."[42] Efforts to reduce non-point sources increased in 1987 when amendments were made to the Clean Water Act. These amendments encourage states to develop plans to reduce pollution from non-point sources.

In Canada, the proportion of waste water receiving treatment increased from 72 percent in 1983 to 85 percent in 1991.[43] Canada's Wastewater Technology Centre recently shifted its focus from industrial research to end-of-pipe pollution-prevention technologies.[44] For example, the Centre is developing technology to reduce phosphorus and ammonia in waste water, to control and manage sewer overflows and storm-water discharges, as well as to improve contaminated sites.

National water quality

Because Canada and the United States monitor water quality differently, this report considers each nation separately. Information on water quality and wildlife indicators for the Great Lakes are also presented to provide a case study of North America's internationally important freshwater resources.

The United States

The EPA instituted a National Water Quality Inventory (NWQI) in 1973. The NWQI assesses rivers, lakes, estuaries, and ocean shorelines based on "swimmable" and "fishable" criteria. The inventory provides a "snapshot" of water quality. According to the NWQI, 17 percent of rivers, 42 percent of lakes, ponds and reservoirs, and 78 percent of estuaries have been assessed to date.[45] Table 7 reports the results for 1990, the latest year available.

There are several problems with the NWQI data. For example, meaningful time-series analysis of the data is not possible due to annual changes in the water bodies being assessed, differing methodologies and reporting techniques and incomplete data. In addition, the percentages reported in table 7 may actually underestimate good water quality since states have a bureaucratic incentive to assess those waters where problems are most likely to be found. The EPA itself notes that "it is likely that unassessed waters are not as polluted as assessed waters."[46]

Several efforts are underway to improve the data on water quality. The National Water Quality Surveillance System (NWQSS) and the US Geological Survey's National Stream Quality Accounting Network (NASQAN) provide limited but consistent data. The 420 monitoring stations in this network are located on major American rivers, and are useful in tracking the progress of prominent point source controls, especially municipal sewage treatment plants. This network, it must be emphasized, is *not* designed to provide a statistical sample of the water quality of streams throughout the nation.

Figure 15 shows that the percent of readings exceeding the local clean-water standard for both phosphorus and fecal coliform have declined from their peaks in 1975. This seems to indicate a clear success for wastewater treatment. There has not,

41 Easterbrook, *A Moment on the Earth*, 1995, p. 682.

42 USEPA, *National Water Quality Inventory 1992*, 1993b.

43 Environment Canada, "Municipal Water Use Database" and "Municipal Water Pricing Database," Water Program from *1996 Environmental Indicators*, 1996.

44 Environment Canada, *Canadian Environmental Protection Act Annual Report, 1994 to 1995*. 1996, p. 10.

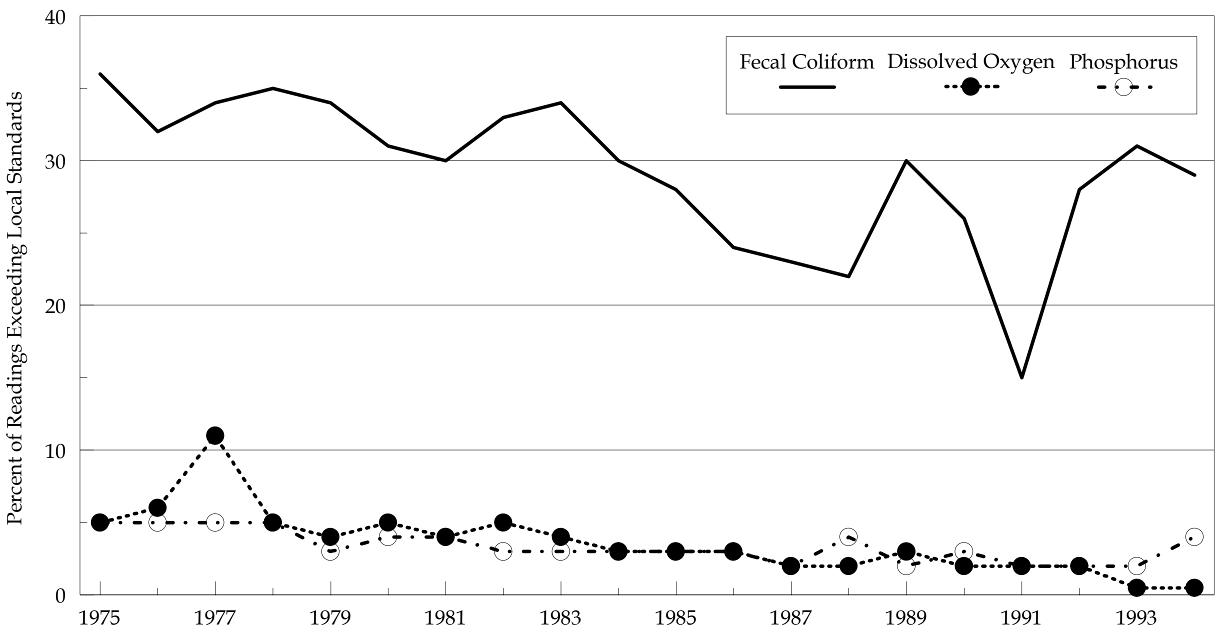
45 USEPA, *National Water Quality Inventory 1994 Report to Congress*, 1995.

46 USEPA, *National Water Quality Inventory 1988 Report to Congress*, 1989, p. xi.

Table 7: United States National Water Quality Inventory (1990)

	Swimmable objective			Fishable objective		
	Meeting	Partially meeting	Not meeting	Meeting	Partially meeting	Not meeting
Rivers/Streams (647,000 miles)	75%	8%	17%	80%	15%	5%
Lakes (17.6 million acres)	82%	10%	8%	70%	10%	20%
Estuaries (22,000 square miles)	87%	8%	5%	76%	16%	8%

Figure 15: Water Quality in the United States



Source: U.S. Geological Survey cited in U.S. Bureau of the Census, 1995.

however, been a significant increase in the dissolved oxygen content of water. In fact, "the most noteworthy finding from national-level monitoring is that heavy investment in point-source pollution control has produced no statistically discernible pattern of increases in the water's dissolved oxygen content during the last 15 years." [47]

Canada

The Canadian Council of Environment Ministers (CCME) established the Canadian Water Quality Guidelines in 1985 to provide a basis for designing site-specific water quality objectives. The guidelines outline concentrations recommended to support and maintain the use of water in several categories including aquatic life, drinking, recreational, agricultural, and industrial use. Water must meet requirements for biological (bacteria, viruses, protozoans), radiological (radioactive isotopes), physical (taste, odour, temperature, turbidity, colour), and chemical factors.

In Canada, provincial governments legislate standards and regulations for water quality although

47 Knopman and Smith, "*20 Years of the Clean Water Act*," 1993. See also Smith, Alexander, and Wolman, "Water Quality Trends in the Nation's Rivers," 1987.

the federal government has a leadership and advisory role. Municipalities are responsible for testing drinking water for coliforms and residual chlorine.

Detailed site-specific reports on water quality provide "snapshot" evidence that Canadian drinking water is generally good. Most Canadian municipalities treat drinking water through chlorination, ozone treatment or ultraviolet radiation. Environment Canada conducted a four-year study on the quality of drinking water in the Atlantic provinces, which revealed that of the 150 substances tested, none was present in levels that exceeded the maximum acceptable guidelines.[48] A 1986 study by the Canadian Public Health Association showed that levels of very few of the 161 substances measured in treated tapwater from the Great Lakes exceeded the guidelines.[49] Further, a 1990 study of the Great Lakes by The Toronto Board of Health could detect only 42 of the substances for which they were testing; none was present in levels that exceeded the guidelines.[50]

Although raw data on Canadian water quality exist in a federal database, the information is not in a format that can be used to evaluate water quality on a national level. The provinces, however, are taking a greater role in monitoring water quality. British Columbia, Alberta, Saskatchewan, Manitoba, and New Brunswick have developed site-specific objectives and maintain a record of goal attainment. These data provide only a snapshot of Canada's water quality.

Canada, like the United States, tests water at sites located upstream or downstream from urban centres and industrial facilities, on transboundary rivers and streams, and on bodies of water that are used for recreation. Figure 16 illustrates the success of British Columbia, Alberta, Saskatchewan and Manitoba in attaining water quality objectives. New Brunswick's record shows a considerable decrease in the percentage of sites exceeding objectives. It should be noted that the number and type of bodies of water tested, and of pollutants examined varies from province to province. Details of provincial reporting are described below.

British Columbia British Columbia has published objectives and attainment records for water quality since 1987. Objectives are based on *British Columbia Surface Water Quality Objectives*. The recently released *British Columbia Water Quality Status Report* (1996) provides an extensive review of some 124 bodies of water. This review develops a detailed index from objectives and attainment records (including the number, frequency, and magnitude of objectives exceeded) with category descriptions: poor, borderline, fair, good, and excellent. It details the source of threats to water quality with recommendations for maintenance and restoration of British Columbia's bodies of water. British Columbia has developed the most comprehensive monitoring and reporting program.[51]

Alberta Alberta monitors 19 stations that examine 7 major rivers in the province. Most stations are permanent and visited monthly. Nineteen different pollutants are tested against the stated objectives; more pollutants and objectives are being added over time. The *Alberta Ambient Surface Water Quality Guidelines* for recreation, agriculture, and the sustainability of aquatic life determine how quality objectives are set. The stated goal is to have water quality downstream of developed areas equal to upstream measures. Alberta has developed an arbitrary category description for objectives met: "not recommended" (70 percent and below); "poor" (71 to 85 percent); "fair" (86 to 95 percent); and "good" (96 to 100 percent).[52]

Saskatchewan Saskatchewan collects data from 14, regularly monitored, stations that test for 32 pollutants. Sites are monitored monthly for nutrients, salts, and bacteria, quarterly for metals and three times per year for some pesticides. *Saskatchewan*

48 Environment Canada, *Atlantic Region Federal-Provincial Toxic Chemical Survey*, 1990.

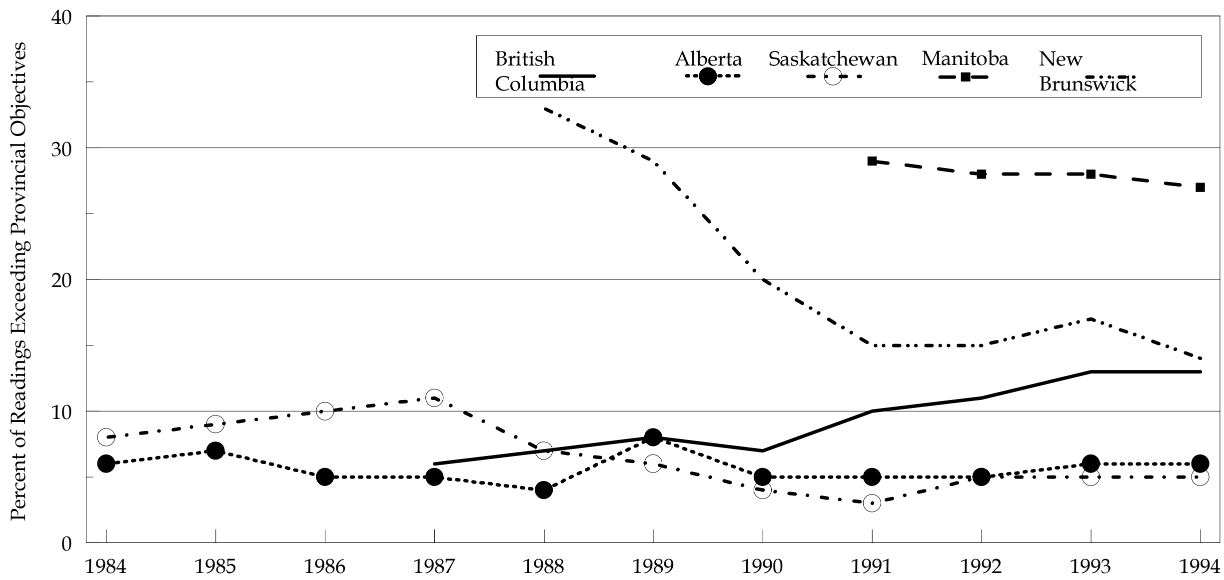
49 Canadian Public Health Association, *Comprehensive Survey*, 1986.

50 Kendall, *Quality of Drinking Water in Toronto*, 1990.

51 British Columbia Ministry of Environment, *Water Quality in British Columbia: Objectives/Attainment in 1992*, 1993, pp. 2–45; and Rocchini, personal communication, 1996.

52 Saffran, personal communications, 1996.; and Government of Alberta, *Second Annual Report on the Performance of the Government of Alberta: 1995–96 Results*, 1996, pp. 78–80.

Figure 16: Water Quality in Canada



Sources: Environment Departments for Alberta, 1996; British Columbia, 1996; Manitoba, 1996; New Brunswick, 1996; Saskatchewan, 1996.

Note: Data from other Canadian provinces are not available. each province measures between 15 and 20 pollutants.

Surface Water Quality Objectives for aquatic life, irrigation, and livestock watering are cross-referenced with the data. Priority is given to rivers affected by populated centres and locations where water quality might be threatened.[53]

Manitoba Manitoba monitors up to 70 water-quality variables at 35 sites located on 28 rivers and lakes. The goal of the monitoring is to identify changes between upstream and downstream locations and to develop focused maintenance and protection programs. The results are cross-referenced with *Canadian Water Quality Guidelines* and *Manitoba Water Quality Objectives*. Manitoba uses, with minor modifications, a water quality index developed by British Columbia; as applied by Manitoba, this index considers 25 key variables. Using the subjective category descriptors, "poor," "marginal," "fair," "good," and "excellent," it assigns a ranking based on the number of objectives met, and the magnitude and frequency of exceedances, i.e., incidents when pollution exceeds objectives.[54]

Ontario Ontario has performed periodic water-quality assessments at specific sites; the Toronto waterfront is one example. There is no federal-provincial agreement on water quality, although there is cross-border cooperation between federal governments through the International Joint Commission (IJC) on water quality in the Great Lakes. Ontario has 250,000 bodies of water and measures water quality at thousands of sites for from 10 to 200 variables. Four databases contain raw data: Great Lakes, Inland Rivers and Streams, Drinking Water Surveillance, and Inland Lakes. The databases are not set up to be cross-referenced with site-specific objectives.[55]

Quebec Quebec maintains a large database consisting of information on thousands of sites and dating back to the mid-70s. Primary consideration is granted to interprovincial sites and broad testing has been performed for tracking mercury levels.[56]

New Brunswick New Brunswick examines 17 variables in various lakes and rivers throughout

53 Hallord, personal communication, 1996.

54 Willamson, personal communication,1996

55 Willamson, personal communication,1996

56 Gouin, personal communication, 1996.

the province. Data is cross-referenced with the *Canadian Water Quality Guidelines* for aquatic life. Several instances of "objectives not met" are a result of naturally high levels of aluminum, copper, and acidity. New Brunswick is currently working on establishing its own site-specific objectives.[57]

Newfoundland No regular water quality monitoring program exists at the provincial level. Newfoundland follows the *Canada Water Quality Guidelines* and has worked in conjunction with the federal government on various initiatives.[58]

Nova Scotia Nova Scotia follows the *Canada Water Quality Guidelines* but has not set site-specific objectives. They do not perform ambient monitoring but run short-term projects to monitor and improve the water in problem areas. Residents rely equally on surface and groundwater for drinking. Nova Scotia's drinking water is generally good. Concerns specific to certain areas arise primarily due to mining and industrial activity.[59]

Prince Edward Island Residents of Prince Edward Island rely exclusively on groundwater for drinking water. Although pesticide contamination is potentially a problem, extensive surveys to date have revealed no cause for concern. In January 1996, Prince Edward Island signed an agreement with the federal government to establish a Watershed Inventory Project that will examine 12 watersheds consisting of 26 rivers.[60]

Yukon The federal government monitors river sites throughout the Yukon; they focus on *preventing* pollution, as most water bodies are considered to be in pristine condition. Only two communities discharge waste into surface water.[61]

Northwest Territories The federal government has collected data on 30 to 60 variables from about 100 stations reporting on 80 bodies of water in the Northwest Territories. Site-specific objectives have been established in some locations to account for unique natural occurrences and human activity. Several individual reports have been generated from the data.[62]

The Great Lakes

The Great Lakes contain one-fifth of the world's freshwater. They are exposed to many sources of point and non-point pollution. For many years it was thought that the Great Lakes were too big to have serious pollution problems. By the 1960s, however, 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, over the last 20 years Canada and the United States have spent over $9 billion to clean up Lake Erie.[63] These efforts have improved water quality.

Despite the improvements, however, the International Joint Commission (IJC), an advisory group of Americans and Canadians, remains pessimistic about water quality in the Great Lakes. They recently recommended an extreme measure: a ban throughout North American on the production of products using chlorine chemicals. The data, however, reveal several encouraging trends in water quality in the Great Lakes, particularly for harmful chlorine compounds. Nitrogen levels have increased, but are still well below the 10 milligrams per litre threshold for safe drinking water (figure 17). Phosphorus levels have declined by one-third in Lake Ontario, and have remained stable in Lake Huron and Lake Superior (figure 18). Phosphorus targets have been met in Lake Michigan since 1981, Lake Superior since 1984, Lake Huron since 1986, Lake Erie since 1987 and Lake Ontario since 1988 (figure 19).[64]

57 Choate, personal communication, 1996

58 Ullah, personal communication,1996.

59 Cameron, personal communication, 1996.

60 Murphey, personal communication, 1996.

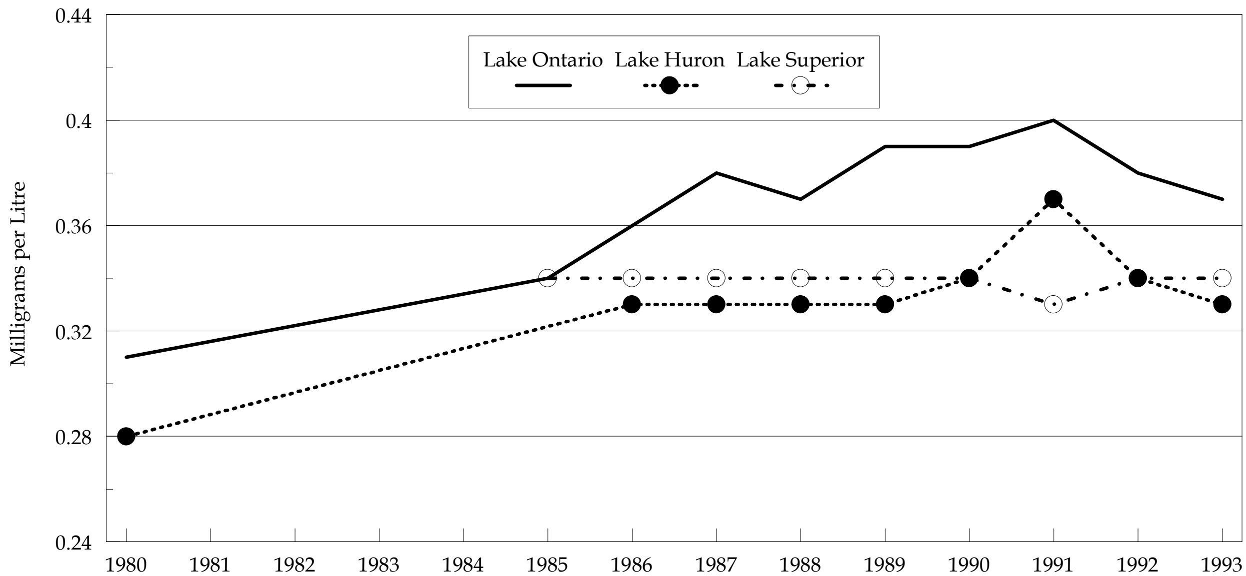
61 Whitley, Personal communication, 1996.

62 Haliwell, personal communication, 1996.

63 Hayward, *The Index of Leading Environmental Indicators*, 1994 p. 23.

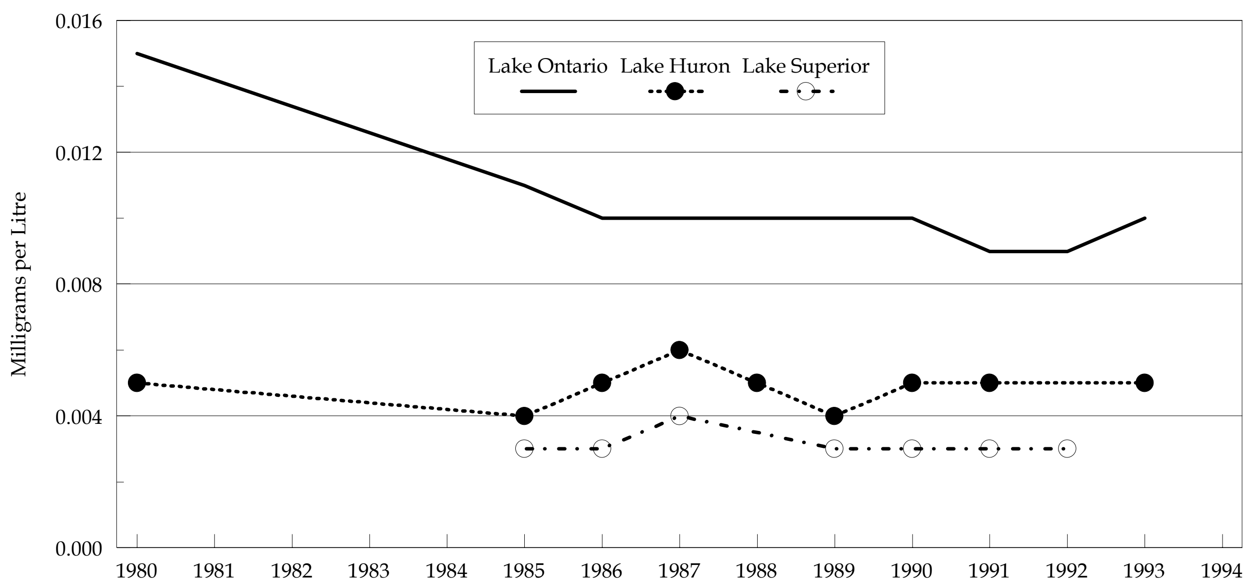
64 Phosphorus targets: Lake Michigan, 5,600 tonnes; Lake Superior, 3,400 tonnes; Lake Huron, 4,360 tonnes; Lake Erie, 11,000 tonnes; Lake Ontario, 7,000 tonnes.

Figure 17: Water Quality in the Great Lakes (Nitrogen)



Source: OECD, 1995.
Note: Data are not available for Lake Erie and Lake Michigan.

Figure 18: Water Quality in the Great Lakes (Phosphorus)

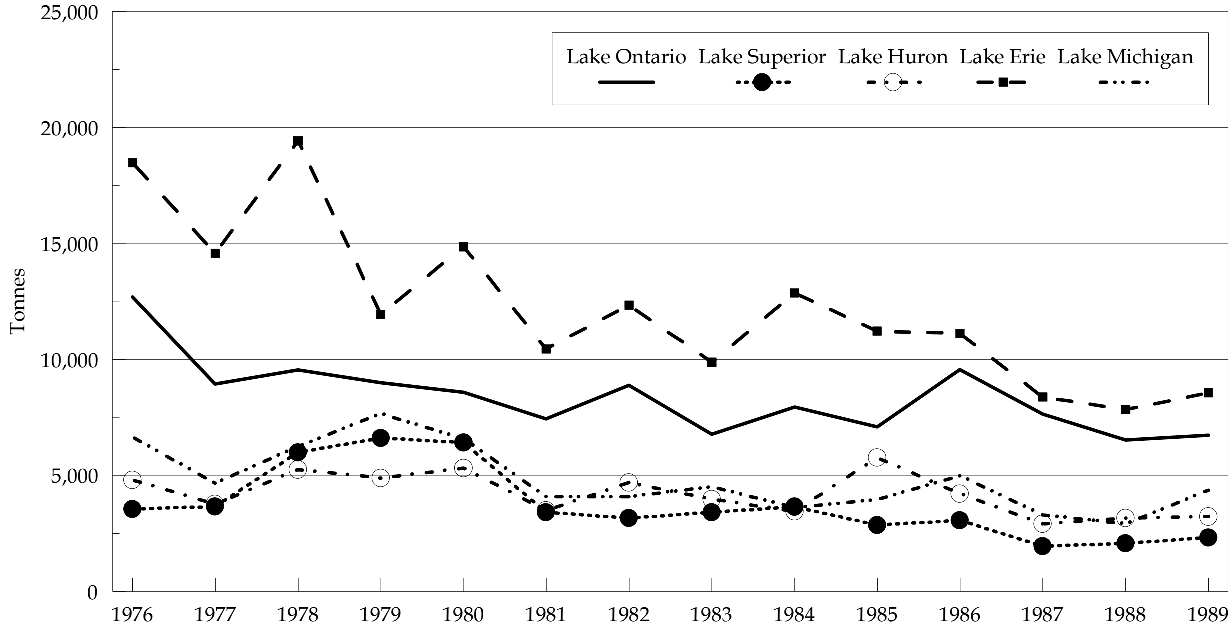


Source: OECD, 1995.
Note: Data are not available for Lake Erie and Lake Michigan.

Another important indicator of water quality in the Great Lakes is the pesticide contamination of bird eggs. The contamination of herring gull eggs fell considerably between 1974 and 1991. Dichloro-diphenyl-dichloro-ethylene (DDE) fell almost 85 percent in both Lake Ontario and Lake Superior from peak levels in 1975 (figure 20).[65] Available data also indicate a decrease in the already low lev-

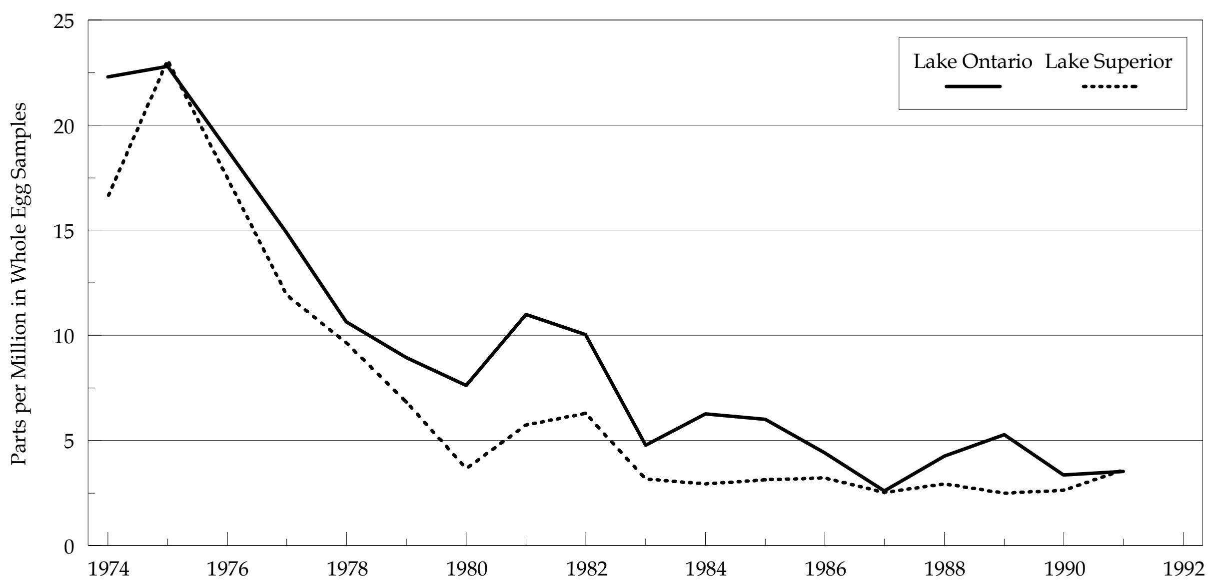
65 DDT (dichloro-diphenyl-trichloro-ethane) is a persistent, bioaccumulative, synthetic insecticide. Its use was heavily restricted in the 1970s and prohibited after 1990. The breakdown product, DDE (dichloro-diphenyl-dichloro-ethylene), is most easily measured in the fat of animals or in the eggs of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

Figure 19: Industrial Discharge of Phosphorus into the Great Lakes



Source: Council on Environmental Quality, 1994.

Figure 20: DDE Levels in Herring Gull Eggs in the Great Lakes

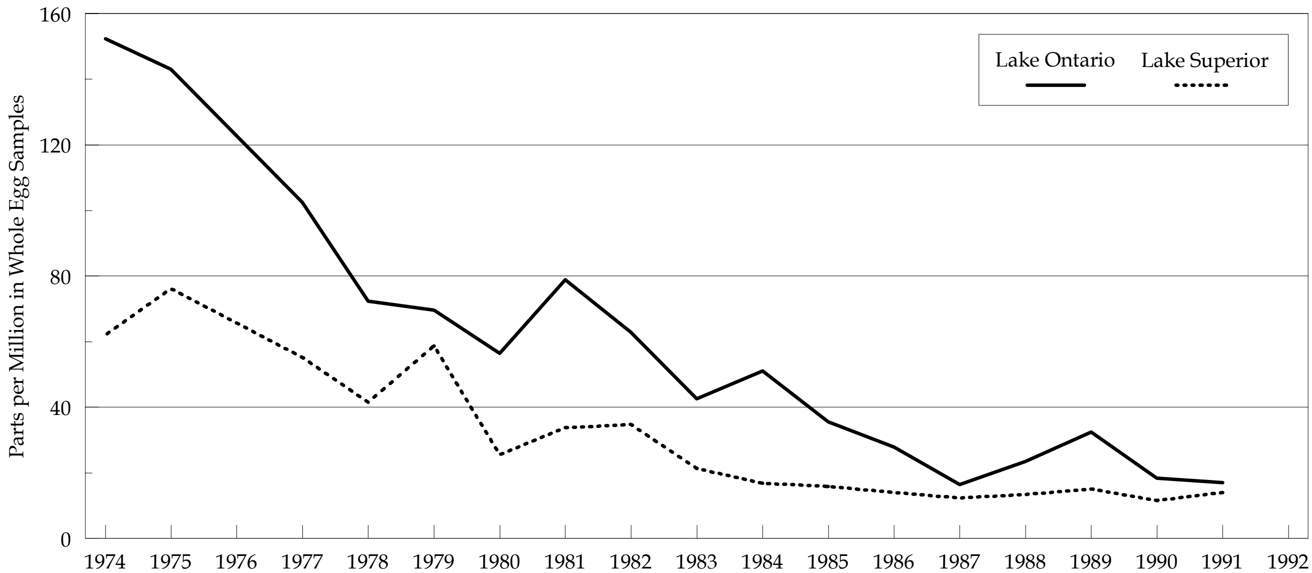


Source: Council on Environmental Quality, 1993.
Note: No data is available for Lake Huron, Lake Erie and Lake Michigan. DDE = dichloro-diphenyl-dichloro- ethylene.

els of the pesticides Dieldrin and Mirex in herring gull eggs. Polychlorinated biphenyls (PCBs) fell 88.8 percent in Lake Ontario and 81.5 percent from their highest levels in Lake Superior (figure 21).[66]

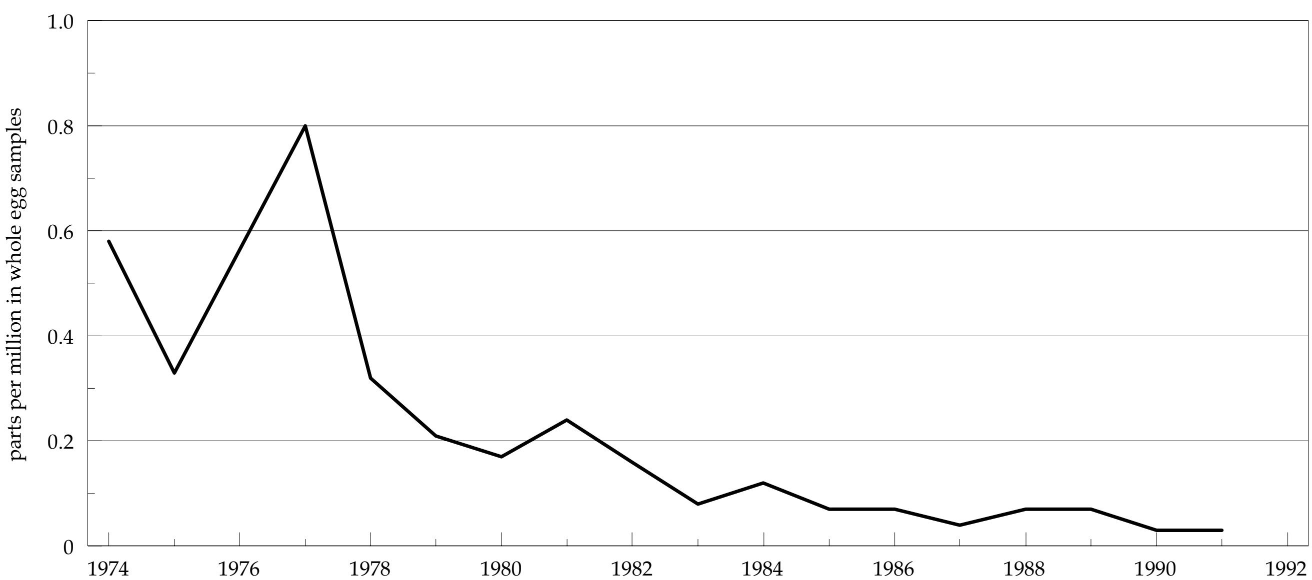
66 PCBs were once used extensively in many parts of the electrical and transmission industry, in flame retardants, water-proofing agents, printing inks, adhesives; they were also spread on roads to prevent airborne dust. In the 1980s, tight restrictions allowed PCBs to be used only in closed electrical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

Figure 21: PCB Levels in Herring Gull Eggs in the Great Lakes



Source: Council on Environmental Quality, 1993.
Note: No data is available for Lake Huron, Lake Erie and Lake Michigan. PCB = polychlorinated-biphenyl.

Figure 22: HCB Levels in Herring Gull Eggs in Lake Ontario



Source: Council on Environmental Quality, 1993.
Note: No data is available for other Great Lakes. HCB = hexachloro-benzene.

The level of hexachloro-benzenes (HCBs) peaked in 1977 and fell 96.3 percent by 1991 (figure 22).[67] These favourable trends can be observed in others of the Great Lakes as well.[68]

67 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.

68 CEQ, *1993 Report*, 1994, pp. 484–6.

Table 8: Summary of Water Quality as Environmental Indicator

General Comments	Performance Record: US	Performance Record: Canada
National water quality		
• National water quality is difficult to assess due to inconsistent, incomplete data. • Water pollutants include nutrients, heavy metals, persistent pesticides, and other toxic substances. • Industrial and municipal sewage normally undergo some treatment to remove these substances. • The US and Canada target different aspects of water quality as priorities.	• Measures of phosphorus, fecal coliform, and dissolved oxygen exceeding local standards (in rivers and streams only) decreased between 1974 to 1995 • In 1990, 70 to 87% of rivers, streams, lakes and estuaries met "swimmable" and "fishable" objectives.	• Objective-attainment records are only available for British Columbia, Alberta, Saskatchewan, Manitoba and New Brunswick. • In 1994, Alberta and Saskatchewan met their goals over 90% of the time. British Columbia and New Brunswick met their goals over 85% of the time. Manitoba met its goals over 70% of the time.
Water in the Great Lakes		
• The Great Lakes contain one-fifth of the world's water. • Nitrogen and phosphorus are given priority when water quality is evaluated.	• Measures of nitrogen have increased, but are well below the 10 mg per litre threshold for safe drinking water. • Phosphorus levels have declined by one-third in Lake Ontario and remained stable in Lake Huron and Lake Superior. • Targets for phosphorus discharges have been met in Lake Michigan since 1981; in Lake Superior since 1984; in Lake Huron since 1986; in Lake Erie since 1987; in Lake Ontario since 1988.	• Measures of nitrogen have increased, but are well below the 10 mg per litre threshold for safe drinking water. • Phosphorus levels have declined by one-third in Lake Ontario and remained stable in Lake Huron and Lake Superior. • Targets for phosphorus discharges have been met in Lake Michigan since 1981, in Lake Superior since 1984, in Lake Huron since 1986, in Lake Erie since 1987 and in Lake Ontario since 1988.
Wildlife in and around the Great Lakes		
• Bioaccumulation occurs when persistent, fat soluble, contaminants are ingested by an organism and accumulate over time in tissue. • Levels of DDE, PCBs and HCBs are monitored in herring gull eggs. • The use of DDT has been banned and PCBs are severely restricted.	• The levels of these contaminants in herring gull eggs fell considerably between 1974 and 1991. • DDE fell almost 85% in both Lake Ontario and Lake Superior from peak levels in 1975. • PCBs fell 88.8% in Lake Ontario. • The level of HCBs peaked in 1977 and fell 96.3% by 1991.	• The levels of these contaminants in Great Lakes herring gull eggs fell considerably between 1974 and 1991. • DDE fell almost 85% in both Lake Ontario and Lake Superior from peak levels in 1975. • PCBs fell 88.8% in Lake Ontario. • The level of HCBs peaked in 1977 and fell 96.3% by 1991.

Natural resource use

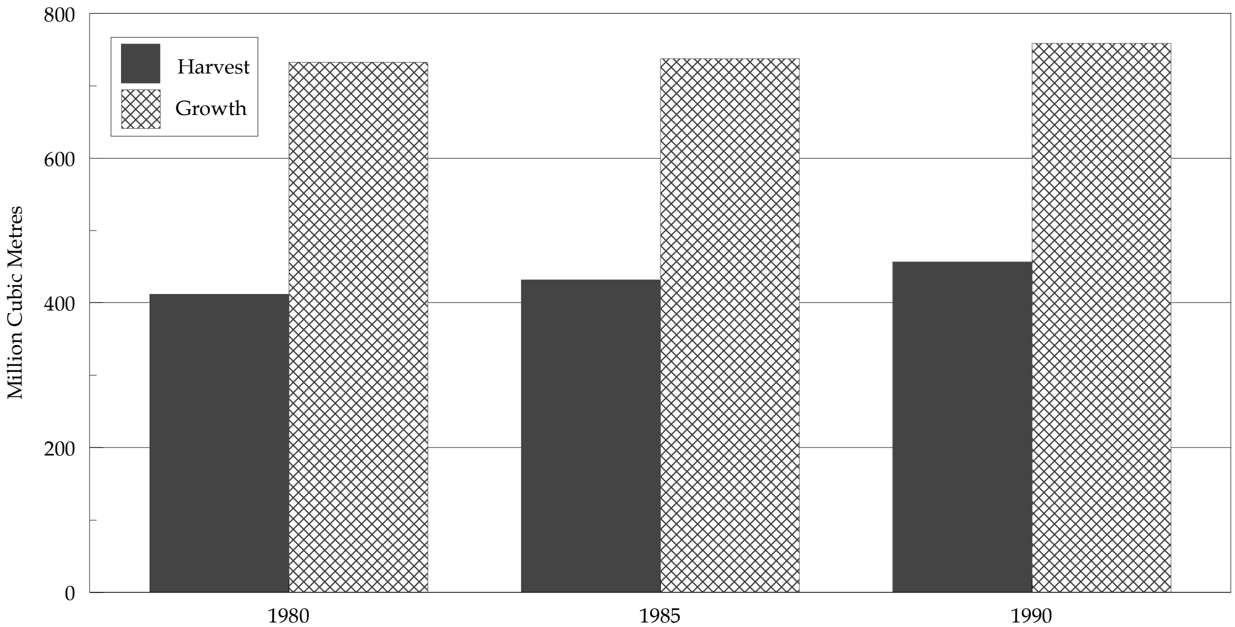
Forests

North America's forests are the subject of some of the most emotionally charged environmental controversies. The fear that we might run out of trees dates back more than a century in the United States. In his address to Congress in 1905, President Theodore Roosevelt warned that "a timber famine is inevitable," and the *New York Times* ran headlines in 1908 proclaiming, "The End of the Lumber Supply" and "Supply of Wood Nears End—Much Wasted and There's No Substitute."

North America's diverse forest resources include over 130 species of trees and sustain a wide variety of plants and animals.[69] Forests provide habitat,

69 Environment Canada, *State of Canada's Environment*, 1991, p. (10)4.

Figure 23: Forest Harvest and Growth in the United States



Source: OECD, 1995.

purify air, prevent run-off and inhibit erosion by anchoring topsoil. Forests release water vapour into the air and play a critical role in the carbon cycle by absorbing CO_2, storing the carbon, and releasing the oxygen.

Canada and the United States play a significant role in world timber-markets. In 1993, American and Canadian production provided over 50 percent of global wood pulp, over 35 percent of paper and cardboard, almost 30 percent of wood-based panels, and over one-third of other wood products.[70] The market demand for North American forest products is strong and is likely to remain so. The industry contributes significantly to regional economies.

Despite this strong commercial reliance, only a small portion of total forest resources are harvested each year. For example, in 1992, 933,177 hectares of timber were harvested in Canada, representing only 0.4 percent of total forest land.[71] Further, the Organisation for Economic Cooperation and Development (OECD) survey shows that the United States consistently harvests less than the amount of annual new growth (figure 23). The United States harvested 56 percent of the annual new growth in 1980, 59 percent in 1985 and 60 percent in early 1990s.

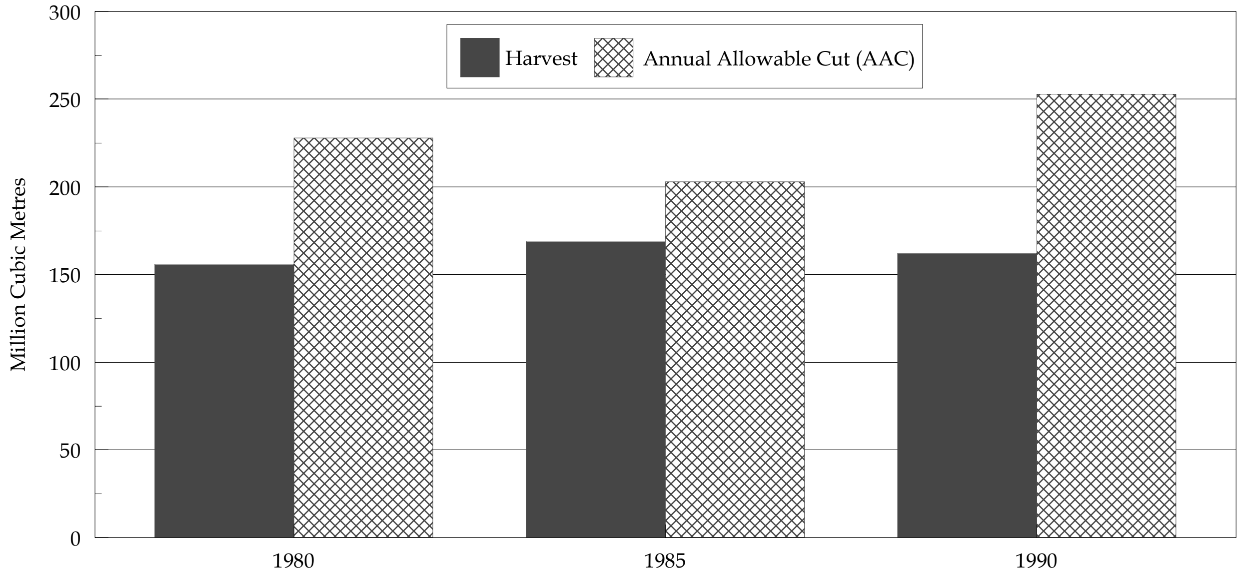
In Canada, various levels of governments own and control over 90 percent of forested land. Governments decide how much can be harvested based on the annual allowable cut (AAC), which is calculated by considering the quantity and quality of species, accessibility of the trees, growth rates, site sensitivity, and competing uses. The AAC calculation is not a measure of total new growth: it is a measure of growth *available for commercial harvesting*. The proportion of the AAC harvested was 68 percent in 1980; it climbed to 83 percent in 1985 and fell to 64 percent in the early 1990s (figure 24).

Historically, forest land was cleared primarily for agricultural use. Some land, however, has proven unsuitable for farming and is now reverting back to forest cover. In southern Ontario, forest land cover has actually increased from 25 percent to 29

70 Organisation for Economic Cooperation and Development (OECD), *Environmental Data Compendium*, 1995, p. 117. Production for each nation as a percentage of global production: wood pulp—US, 38.28%; Can., 15.53%; sawnwood and sleepers—US, 24.55%; Can., 13.82%; industrial roundwood—US, 26.33%; Can., 11.33%; paper and cardboard—US, 30.46%; Can., 6.92%; wood-based panels—US, 23.73%; Can., 5.63%.

71 Environment Canada, *Environmental Indicators*, 1996.

Figure 24: Forest Harvest and Growth in Canada



Source: OECD, 1995.
Note: For Canada, the OECD uses Annual Allowable Cut (AAC) instead of total growth. See text for explanation.

percent since the mid-1960s.[72] Reforestation efforts in Maine have increased wooded areas from 74 percent to over 90 percent of the state.[73]

The serious environmental debates surrounding forests and harvesting practices tend to be local in nature; examples of such debates are those about the preservation of old-growth stands and the practice of clear-cutting.

Old-growth forests are those stands that are over 140 years old, have over a specified number of trees, and have experienced minimal human disturbance. They have considerable commercial and environmental value. Today's commercial cutting cycle of 50 to 80 years means that once they are harvested, old-growth ecosystems will not be re-established. Second-growth forests, however, also provide commercial and environmental benefits.

> Even forests that have been clear-cut and replanted support diverse wildlife populations and contain trees of various ages, sizes and species. . . . The beautiful wilderness scenes in the popular movie *Last of the Mohicans*, for example, were filmed in a formerly clear-cut commercial forest, not a natural forest.[74]

Clear-cutting remains a popular method of harvesting. In Canada, almost 90 percent of trees logged are harvested by this means. There are two reasons for this. First, it is economically viable; second, clear-cutting simplifies reforestation. It allows easy preparation of the site for the re-establishment and tending of a new forest, and the open area provides the heat and sunlight needed for the new trees to grow. In addition, dead stumps support an extraordinary number of species, including fungi, spiders, beetles, and centipedes. Finally, leaves and branches contain plant nutrients and are often left to replenish the soil. When clear-cutting is not performed properly, however, it can damage sensitive watersheds and the ecosystems of rivers.

Fresh water

Only 2.7 percent of the Earth's water is fresh water.[75] Sources of fresh water include: snow, glaciers,

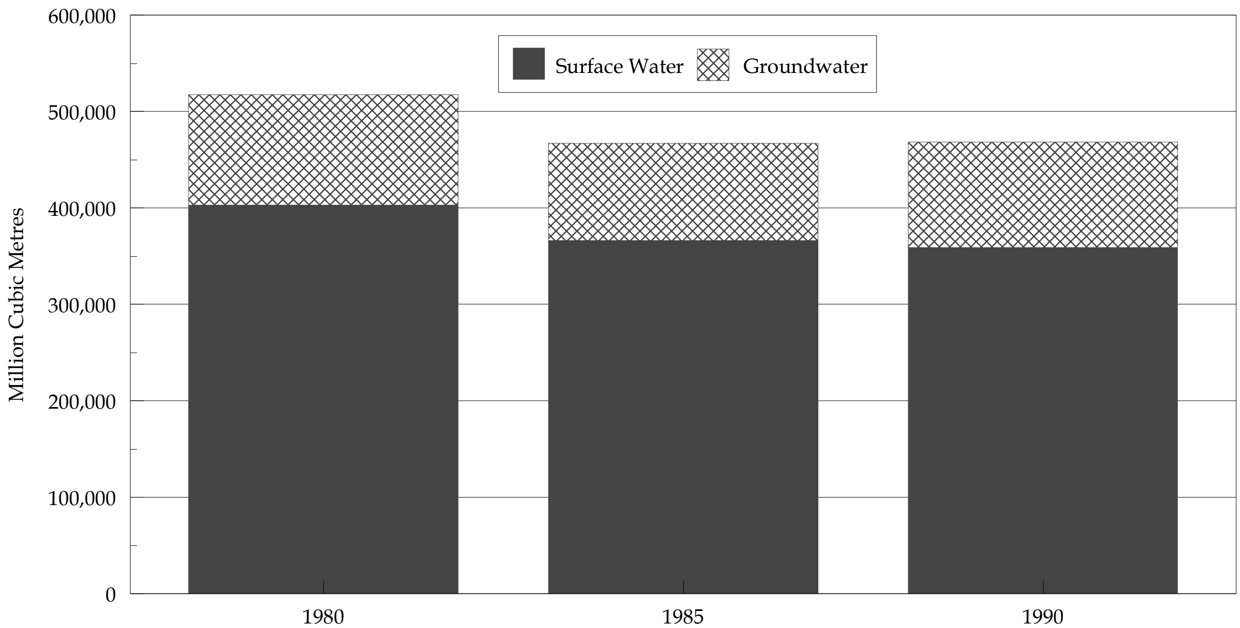
72 Armson, "People and Forests," 1989.

73 Ray, *Environmental Overkill*, 1993, p. 113; Sedjo, "Forests," 1995, pp. 178–209.

74 Bast, Hill and Rue, *Eco-Sanity*, 1994, p. 24.

75 Environment Canada, *State of Canada's Environment*, 1991, p. (3)5.

Figure 25: Freshwater Withdrawals in the United States



Source: OECD,1995.
Note: Freshwater withdrawals refer to the use of ground water (water below the surface) and surface water (rivers, lakes, streams and estuaries).

and polar ice (77 percent); underground (22 percent); lakes and wetlands (0.35 percent); atmosphere (0.04 percent); and streams (0.001 percent).[76] Only about 0.01 percent of water sources are both fresh and accessible in lakes, rivers, soil, and the atmosphere.

Water is used to provide a source of power, for drinking, for irrigation, and for diluting waste. The cooling of power-generating plants uses the most freshwater resources, accounting for 38.6 percent in the United States and 59.7 percent in Canada.[77] Industry uses 7.9 percent of freshwater resources in Canada and 5.7 percent in the United States.[78] The public uses 11 percent of freshwater resources in each nation. Irrigation accounts for 40.2 percent of freshwater use in the United States due to its large agricultural base; in Canada, irrigation uses only 7.1 percent of the total.[79] Approximately 90 percent of the water withdrawn is returned to its source after use or treatment.[80] Only about one-quarter of agricultural water is returned to its source.

North American water prices are relatively low. The cost per thousand litres is $0.35 in the United States and $0.30 in Canada. Prices can be up to three times higher in European nations. For example, the price per thousand litres is $0.56 in the United Kingdom, $0.66 in Sweden, $0.73 in France and $1.12 in Germany. It is interesting to note that, on average, bottled water costs about $425 per thousand litres.[81] As expected, lower prices tend to lead to higher levels of freshwater consumption. North Americans are the largest consumers of fresh water in the world. The average daily household use is about 420 litres in the United States and

76 White, "Water Resource Adequacy: Illusion and Reality," 1984, p. 252.

77 OECD, *Environmental Data Compendium*, 1995, p. 66.

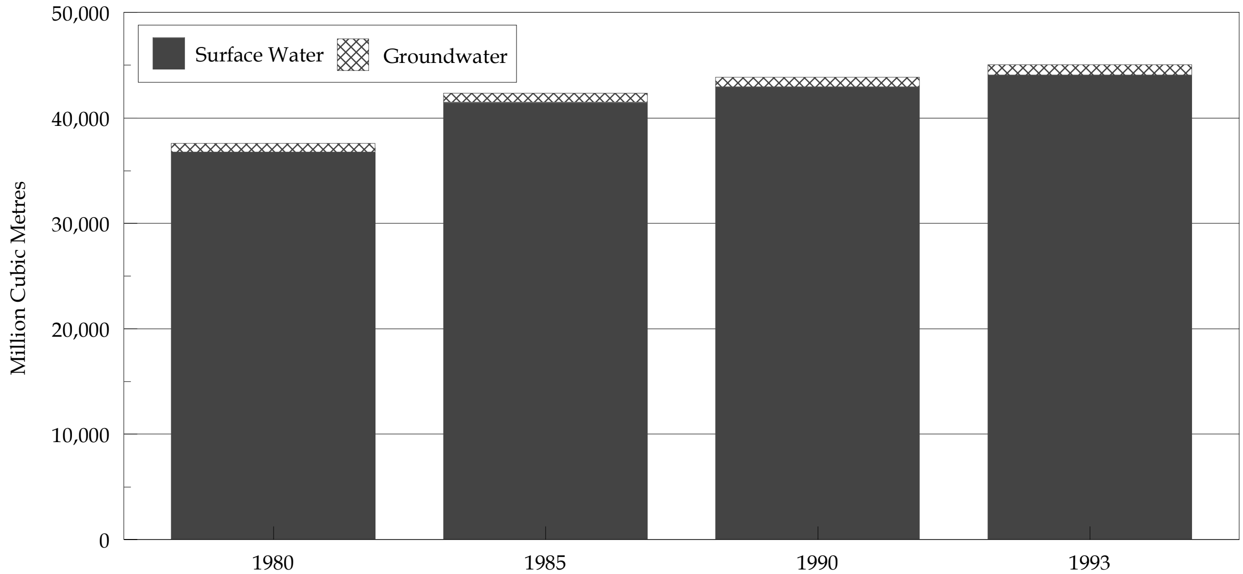
78 Ibid.

79 Ibid.

80 Environment Canada, *A Report on Canada's Progress toward a National Set of Indicators*, 1991, p. 82.

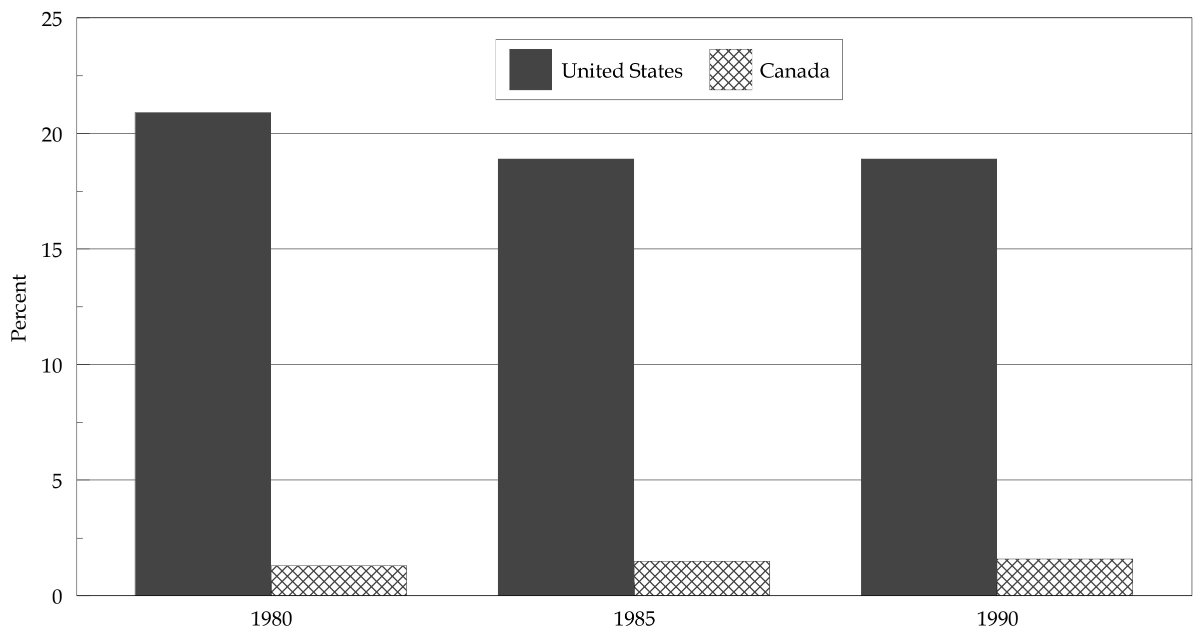
81 Environment Canada, *Technical Supplement*, 1991, p. 74. Conversion based on 1989 exchange rate of CDN$1.184 per US$1, from Statistics Canada, *Canadian Economic Observer*, 1995, p. 89. Prices are quoted in US dollars.

Figure 26: Freshwater Withdrawals in Canada



Source: OECD, 1995.
Note: Freshwater withdrawals refer to the use of ground water (water below the surface) and surface water (rivers, lakes, streams and estuaries).

Figure 27: Withdrawals as a Percentage of Renewable Freshwater Resources



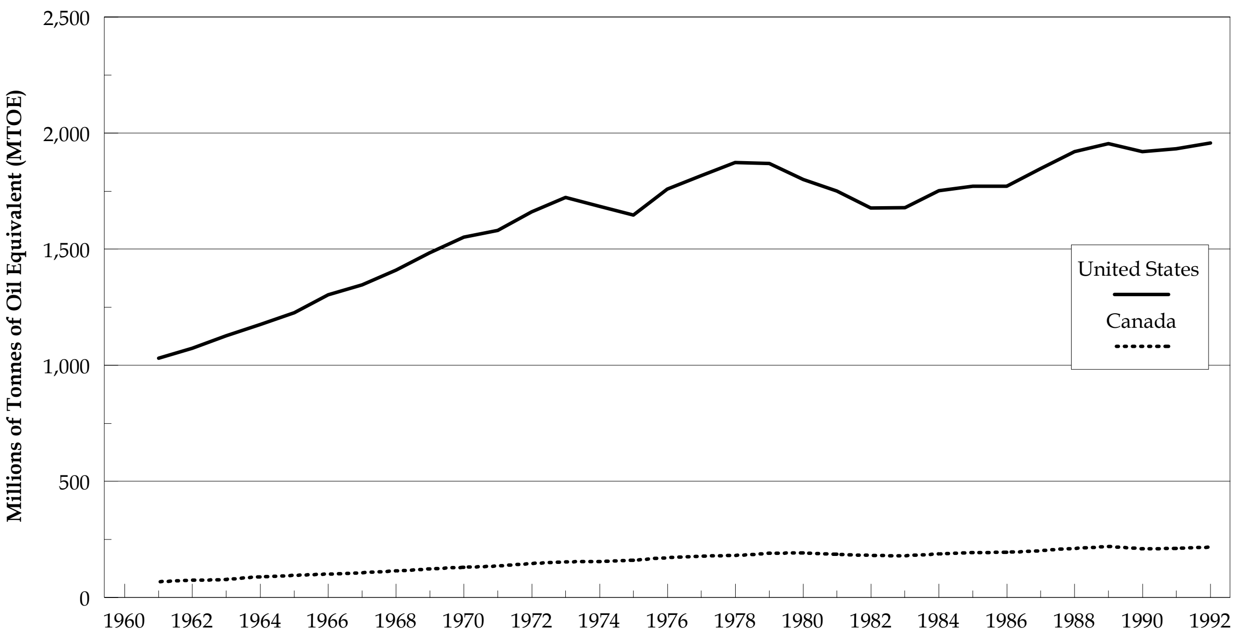
Source: OECD, 1995.

360 litres in Canada. This is more than double the rate of water use in many European countries.[82]

The OECD survey indicates that total water use decreased 9.5 percent in the United States between 1980 and 1990 (figure 25) but increased 20.0 percent in Canada between 1980 and 1993 (figure 26). The United States has 2.5 trillion cubic metres of renewable freshwater resources and used 20.9 percent in 1980 and 18.9 percent in both 1985 and 1990

82 Environment Canada, *State of Canada's Environment*, 1991, p. (3)8.

Figure 28: Total Annual Consumption of Energy



Sources: U.S. Department of Agriculture, 1994; World Bank, 1993.

(figure 27).[83] Canada has approximately 2.8 trillion cubic metres of renewable freshwater resources and used 1.3 percent in 1980, 1.5 percent in 1985 and 1.6 percent in both 1990 and 1993.

While this abundance contributes to lower prices, government subsidies also artificially suppress prices. Several municipalities charge a flat rate for water use and governments subsidize irrigation. In Canada, the provinces pay an average of 85 percent of the total cost of water use.[84] Subsidization policies eliminate the incentive for efficient use of water resources. Subsidies lead to inefficient agricultural use, less water recycling, and a greater need for wastewater treatment facilities. This places further pressure on water sources and increases the demand for new dam construction and water diversion projects.

Although Americans and Canadians use only a small portion of renewable freshwater resources, regional water shortages continue to be a problem. In parts of the United States where water is scarce, farmers have responded by changing irrigation technology and cropping practices, and by using recycled municipal waste water for agricultural purposes.[85]

Energy resources

Canada and the United States are among the world's most intensive users of energy due to their highly industrialized economies, widely dispersed populations, and large land masses. Nevertheless, this section shows that energy resources are not being depleted and that less energy is being used per capita in both Canada and the United States today than in previous years.

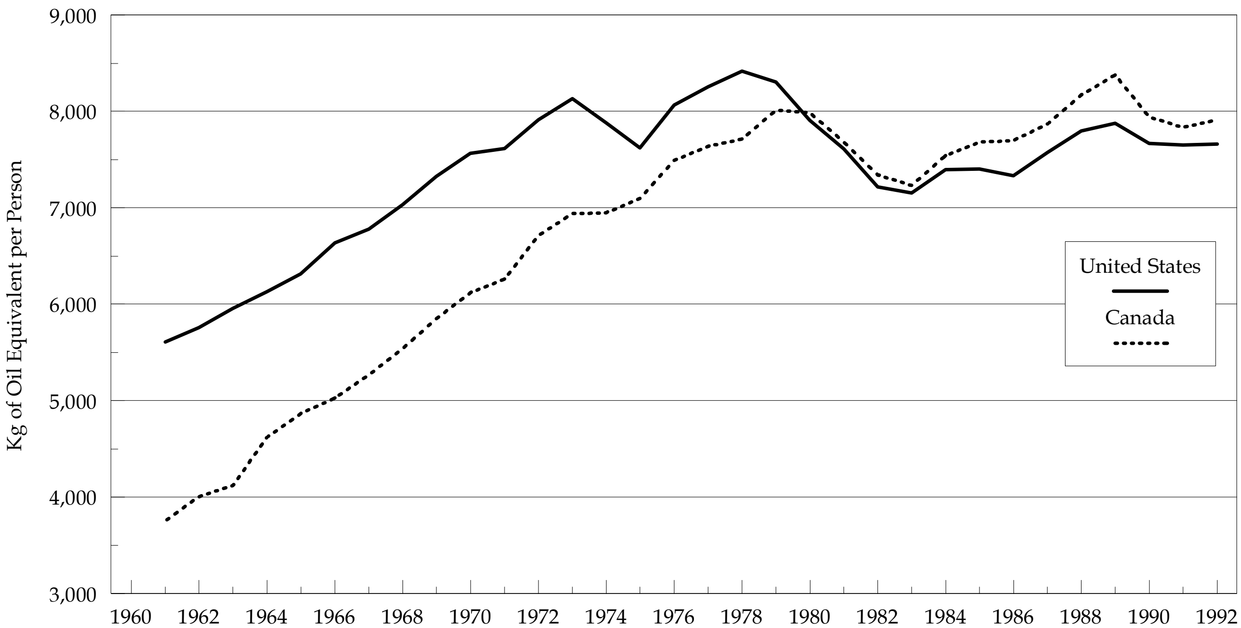
Figure 28 shows that total energy consumption is rising in Canada and the United States. A better measure of energy use, however, is per-capita consumption (figure 29). While per-capita energy use rose steadily before the end of the 1970s, it has since leveled off. For example, in 1992, Canada and the United States both used less energy per capita than they did in 1979. The reduction in per-

83 Calculations of Canadian and American figures are based on data from OECD, *Environmental Data Compendium*, 1995, pp. 63–65.

84 OECD, *Environmental Data Compendium*, 1995, p. (3)10.

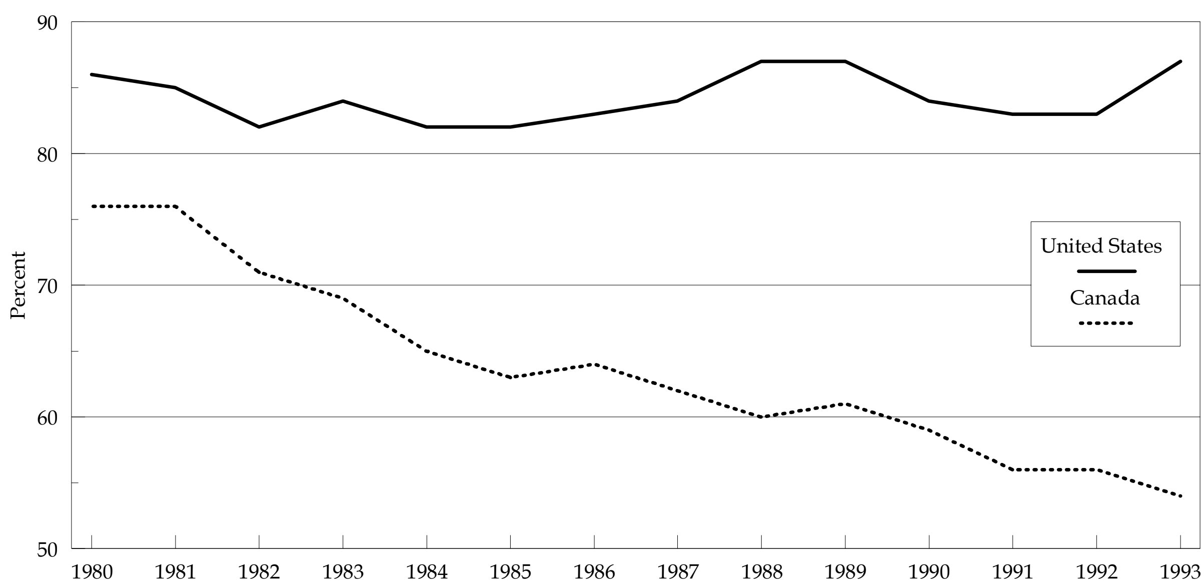
85 Avery, "Saving the Planet with Pesticides," 1995, pp. 68–9.

Figure 29: Per Capita Annual Consumption of Energy



Sources: U.S. Department of Agriculture, 1994; World Bank, 1993.

Figure 30: Consumption of Energy as a Percentage of Production



Source: OECD, 1995. Note: Energy includes petroleum, coal and electricity.

capita energy use reflects improvements in energy efficiency.[86]

If the world were close to running out of energy, as some believe, one would expect to see a decline in production and an increase in prices in recent years. Instead, the opposite is true. Although total consumption in the United States increased between 1980 and 1993, consumption as a percentage of production has been fairly stable (about 85 percent). In Canada, consumption as a percentage of production decreased from 76 percent in 1980 to 54 percent

86 One measure of energy efficiency is the ratio of energy use to the size of the national economy. See OECD, *Environmental Data Compendium*, 1995, p. 205.

Table 9: Summary of Use of Natural Resources as Environmental Indicator

General comments	Performance record: US	Performance record: Canada
Forests		
• Forest resources have remained relatively stable for the past fifty years. • Forests replanted after clear-cutting support diverse wildlife populations and contain trees of various ages, sizes, and species. • Forestry companies have taken increasing responsibility for forest management, including reforestation.	• Each year the US harvests less than total new growth. • Only about 60% of new growth is harvested.	• Each year Canadian forestry companies harvest less commercial growth than governments allow. • Only 64% of Annual Allowable Cut (AAC) was harvested in the early 1990s.
Fresh water		
• North American water prices are relatively low; prices in Europe are up to three times higher. • While abundant supplies contribute to lower prices, government subsidies artificially suppress prices. • Lower prices lead to higher levels of freshwater consumption.	• The US consumes only about 20% of total available renewable freshwater resources.	• Canada consumes about 1.5% of total available renewable freshwater resources.
Energy resources		
• Energy supplies are abundant. • There have been great improvements in energy efficiency. • Higher energy prices encourage conservation, technological innovations and increased	• The US consistently consumes only about 85% of the energy it produces.	• Canada's consumption of energy as percentage of production declined from 76% to 54% in between 1980 and 1993.

in 1993. Both countries are producing more energy than they are consuming. Figure 30 shows that Canada and the United States are net *exporters* of energy.

Land use and condition

Land cover in Canada and the United States is illustrated in figures 31 and 32. This section discusses land use and condition in each country. Wetlands, urban sprawl, and soil erosion are the three concerns examined.

Wetlands

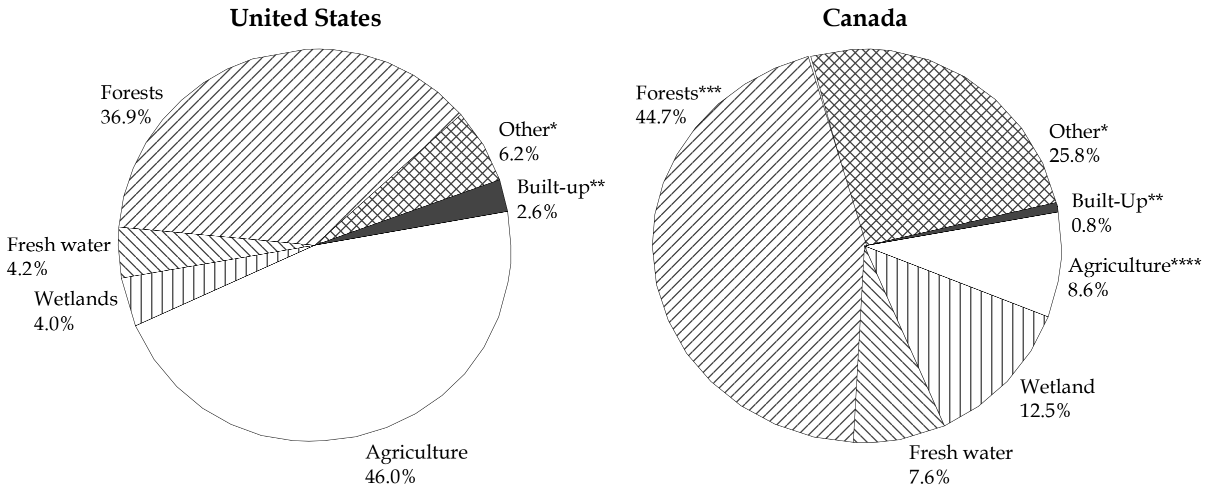
Wetlands are areas of land that are sufficiently saturated with water to promote aquatic processes. They include marshes, swamps, and bogs. Wetlands protect land from flooding and shorelines from erosion, and act as filtration systems by breaking down nutrients and neutralizing disease-causing pathogens. They also provide habitat for a wide range of species. Canadian prairie wetland, for instance, provides habitat for 50 percent of North America's waterfowl.[87]

In the past, wetlands were considered waste areas to be drained and converted to economically productive uses. Farming subsidies contributed to the destruction of this sensitive habitat. In the United States, over 80 percent of natural wetlands were converted to agricultural use.[88] The Canadian Wheat Board Act determines grain delivery quotas based on the total area seeded and left fallow. This encourages farmers to cultivate marginal land

87 Environment Canada, *State of Canada's Environment*, 1991, p. (17)10.

88 USEPA, *Wetlands*, 1988, p. 6.

Figures 31 & 32: Land Cover in the United States (1987) and in Canada (1989)



Source: U.S. Department of Agriculture, 1994.
*Other includes designated military areas.
**Built-up includes urban and non-urban industrial areas.

Source: Environment Canada, 1991a.
*Other includes tundra, ice and snow.
**Built-up includes urban and industrial land.
***Forests include taiga.
****Agriculture includes cropland and rangeland.

rather than leave it in its natural form.[89] In addition, the Maritime Marshland Rehabilitation Act (1943) was designed to discourage reversion of arable land to original wetland coverage.[90] This trend seems to be reversing, however, as recent studies show that wetland loss from agricultural conversion has dropped sharply.[91]

The human impact on wetlands is difficult to quantify as areas of wetland fluctuate dramatically in size and number between wet and dry years. In addition, estimates from different studies vary depending on survey techniques, time frame, region, and definition of wetland. For example, the estimates of prairie wetland loss in two Canadian studies range from 40 percent to 71 percent.[92] In the United States, the EPA is developing a national wetlands inventory but there are disagreements over basic definitions that have hindered its progress.[93]

Wetlands are more extensive in Canada than in the United States. According to the Ramsar Convention, Canada contains 13,030,200 hectares of internationally important wetlands compared to the 1,194,000 hectares that is found in the United States.[94] Nevertheless, this represents only a small share of total wetland area. For example, most recent estimates suggest that wetlands cover 14 percent or 127,000,000 hectares of Canada's land base; this is nearly 25 percent of the world's wetlands.[95] Since 1986, the OECD survey reports indicate that Canada has suffered no net loss of wetlands. American wetlands have also been stable since 1980 (figure 33).

As more is discovered about the function and value of wetlands, it is becoming clear that they can play a reinforcing, rather than a strictly competing, role in agriculture and urban development. For example, wetland preservation can help conserve and purify groundwater and protect against drought. In the United States, degraded or lost wetlands are now being restored as a means of treating municipal sewage.

89 Environment Canada, *State of Canada's Environment*, 1991, p. (26)6.

90 Environment Canada, 1991, p. (20)6.

91 Tolman, *Gaining More Ground*, 1994.

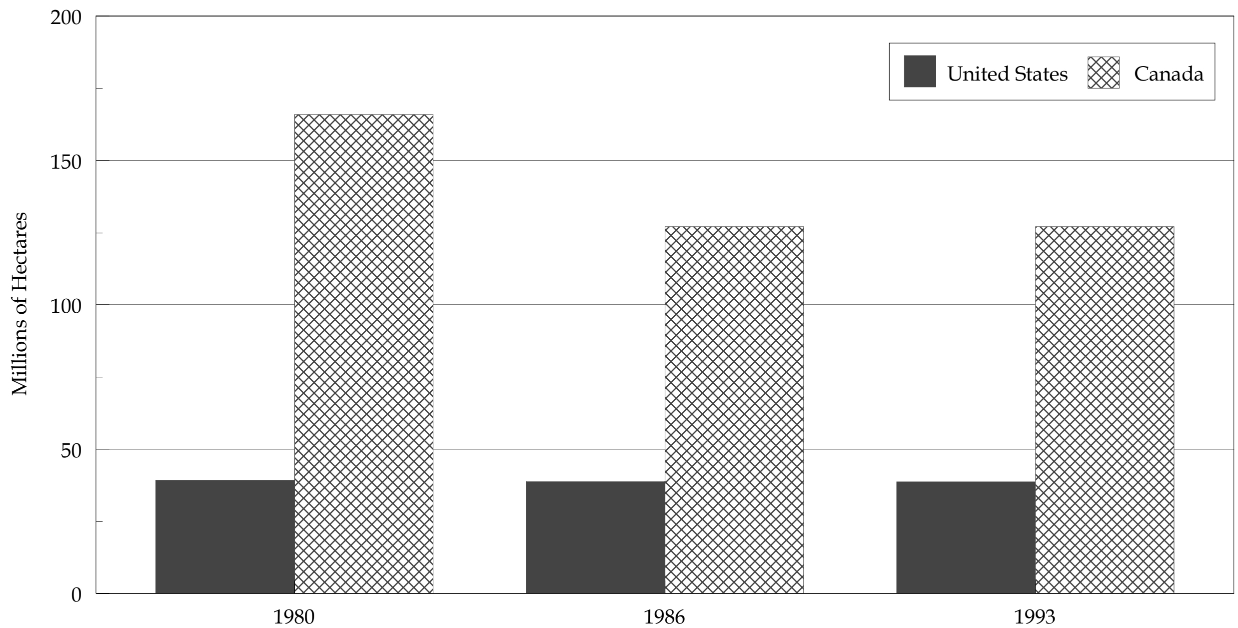
92 Ibid.

93 Easterbrook, *A Moment on the Earth*, 1995, pp. 438–39.

94 OECD, *Environmental Data Compendium*, 1995, p. 149.

95 Environment Canada, *State of Canada's Environment*, 1991, p. (26)7.

Figure 33: Area of Wetlands in the United States and Canada



Sources: OECD, 1993; Frayer et. al., 1983; Bailey, 1995.

In the United States, 75 percent of wetlands are on privately owned land.[96] Regulations for the protection of wetlands are usually imposed without compensation; this places a heavy burden on the landowners and causes controversy. It is interesting that there is a new approach to the protection of wetland habitat in both Canada and the United States. Private organizations such as Ducks Unlimited and the Nature Conservancy are the two largest private stewards of Canada's 1.1 million hectares of non-government conservation lands.[97]

Urban sprawl

The main problem associated with urban sprawl is the conflict over land use. Urban sprawl causes two kinds of land-use conflict: urban expansion into agricultural land, and human encroachment on wilderness areas. Urban centres were originally established close to prime agricultural land. As populations increased, urban development began to infringe upon farm land. Further, the spread both of urban and of agricultural land has meant that fewer areas were left in their natural state.

Changes in land use for urban, agricultural, and protected areas in Canada and the United States have occurred between the late 1950s and the late 1980s (figures 34 and 35).[98] Urban areas expanded steadily in both countries during the decades following World War II. In the United States, the agricultural landbase remained fairly stable despite urban expansion. In Canada, where large expanses of Crown land were available for conversion to designated uses, the growth of agricultural and protected lands kept pace with urban expansion. For example, in 1959, urban areas in Canada were equal to 5.5 percent of agricultural land; by 1986, this proportion had grown to only 7.2 percent.

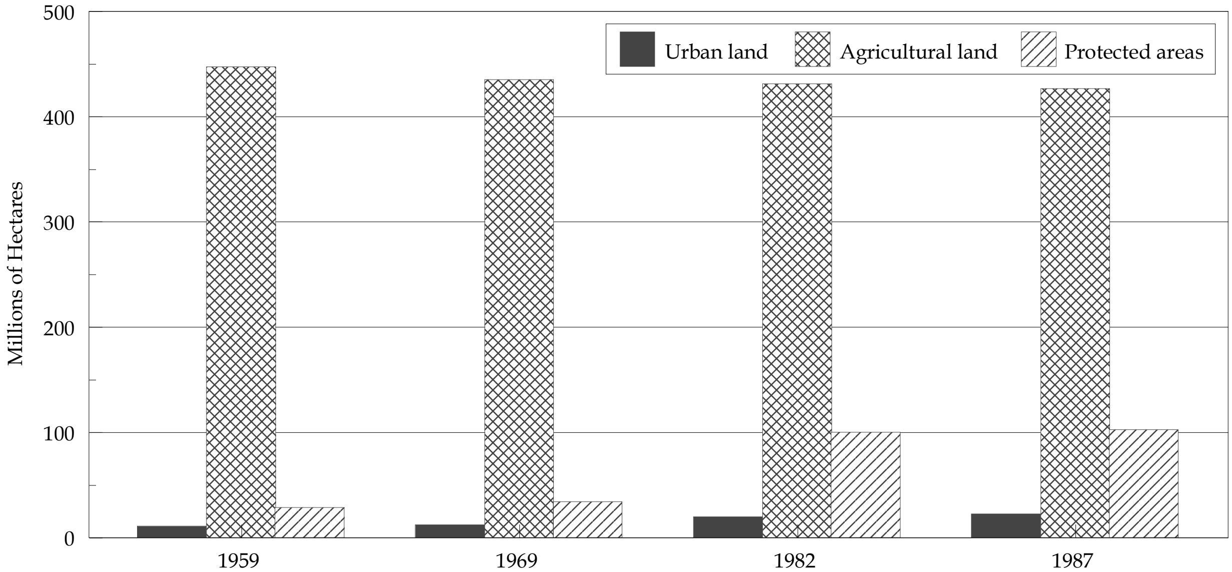
Agricultural lands are not in danger of being overrun by towns and cities. Agricultural land-bases are many times the size of urban areas. Further, the figures presented above do not reflect the increasing productivity of agricultural land. According to

96 Brookes, "The Strange Case of the Glancing Geese," 1991, pp. 104–112. This estimate excludes Alaska, which is 90 percent wetland area and 90 percent government owned.

97 Statistics Canada, *Human Activity and the Environment*, 1994, pp. 214–5.

98 Comparable data do not exist after this period because the Canada Land Use Monitoring Program ended in 1986. Statistics Canada is attempting to derive comparable data for 1991 (Trant, personal communication, 1996).

Figure 34: Land Uses in the United States



Sources: UN, 1993; U.S. Department of Agriculture, 1994.
Note: Graph only considers land with currently competing uses. It does not include entire land base.

Figure 35: Land Uses in Canada

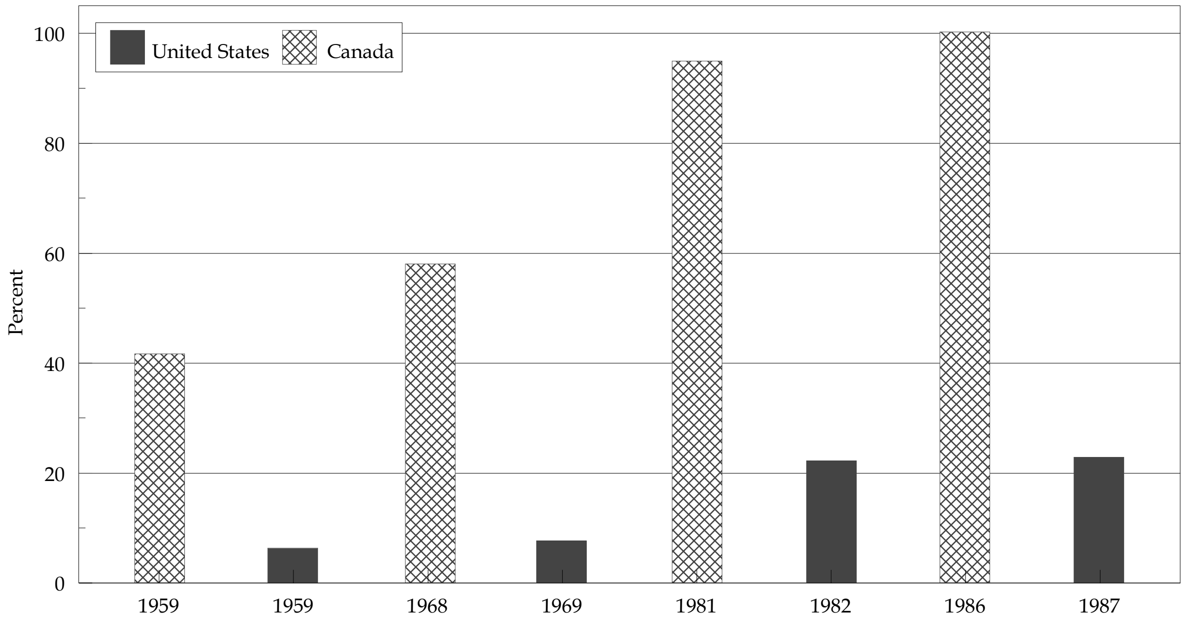
Sources: UN, 1993; U.S. Department of Agriculture, 1994; OECD, 1996b.
Note: Graph only considers land with currently competing uses. It does not include the entire land base.

the indices of the United States Department of Agriculture (USDA), the American agricultural sector was 158 percent more productive at the end of the 1980s than at the beginning of the 1960s; in Canada productivity grew by 206 percent.[99] This growth in output far outweighs any threat to farmlands posed by incremental urban expansion.

Similarly, wilderness areas are not in danger of disappearing. In both countries, protected areas have

99 USDA, *World Agriculture: Trends & Indicators, 1961–91: North America and Australia and New Zealand*, Electronic database, 1994.

Figure 36: Protected Areas as a Percentage of Urban and Agricultural Areas



Sources: UN, 1993; U.S. Department of Agriculture, 1994; OECD, 1996b.

increased since 1959. The ratio of protected areas to urban and agricultural lands had grown from 6.4 percent to 22.9 percent in the United States by 1987 (figure 36). In Canada, with its lower population density, this ratio is much higher. By 1986, Canadian protected areas were larger in total area than urban and agricultural lands combined. This trend appears to be continuing. Between 1986/87 and 1991/92, agricultural land bases remained fairly stable, decreasing by less than 1 percent in each country.[100] Protected areas increased in total size by 10.3 percent in Canada and 1.0 percent in the United States.[101] Claims about a "crisis" of urban sprawl are exaggerated. In the most recent years for which comparable data exist, urban areas occupied 2.6 percent of the land base in the United States and 0.8 percent of the land base in Canada (figures 34 and 35).

Soil erosion

Erosion is the most common soil-degradation problem. Erosion is a natural process that removes topsoil, reduces the level of organic matter, and breaks down soil structure.

Water erosion occurs when precipitation levels exceed the soil's capacity to absorb water. Water erosion varies widely depending on climate, ground slope, vegetation, and soil type and condition. Erosion from water causes the accumulation of silt, affects fish habitat, and pollutes water.

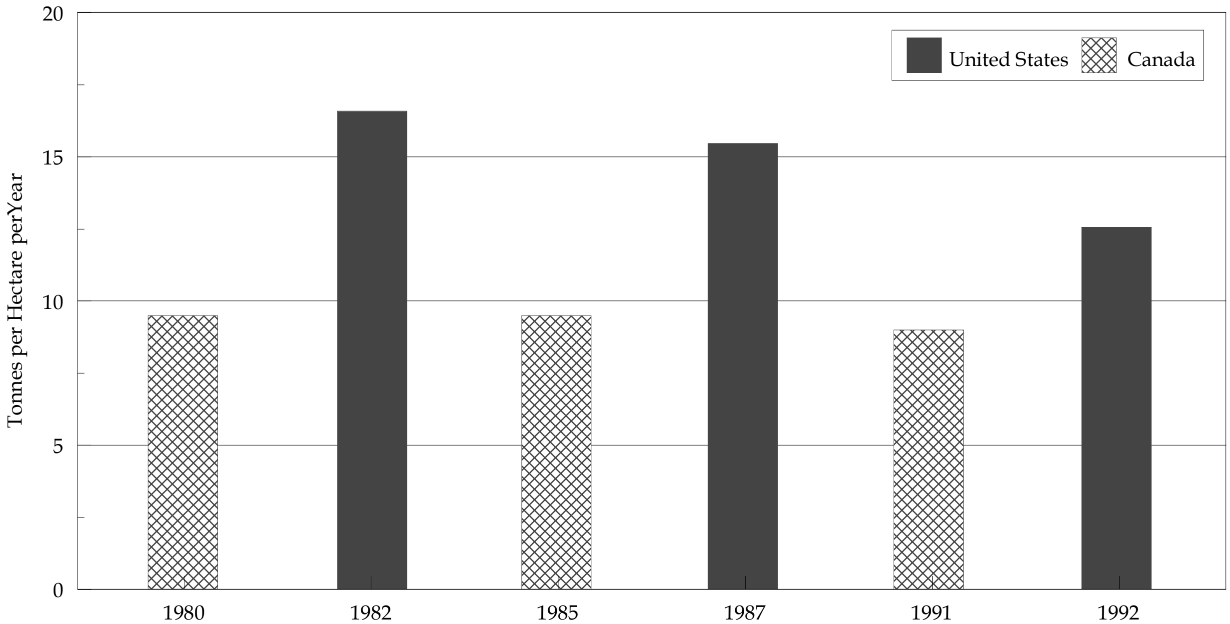
Wind erosion occurs as a result of high winds and dry surface conditions. Some farming practices contribute to erosion. Compacted soil and lost organic matter impede water absorption. Cropping practices like summer-fallowing that leave soil unprotected can make wind and water erosion worse. Other farming practices that encourage erosion include monoculture, improper tilling on slopes, fall ploughing, and wide-row cropping. Although wind erosion deposits sediments in water, it has a larger impact on air quality. Airborne soil is abrasive, and can damage buildings, machinery, vegetation, and human health.

Figure 37 shows the average rates of erosion from cropland in Canada and the United States since the early 1980s. Erosion from American croplands declined from 16.6 tonnes per hectare (t/ha) in 1982 to 12.6 t/ha in 1992. In Canada, these rates were

100 USDA 1994; USDA, *Major Land Uses (1945–1992)*, Electronic Database, 1996.

101 OECD 1995; *UN List of National Parks and Protected Areas*, Electronic Database, 1993.

Figure 37: Soil Erosion from Cropland



Sources: OECD, 1996b; U.S. Department of Agriculture, 1994.

lower than in the United States, declining from 9.5 to 9.0 t/ha between 1980 and 1991. This reduction has occurred as farmers continue to adopt sensible farming practices such as crop rotation, interseeding, and the planting of winter crops.

Soil erosion, however, does not mean soil loss. Studies show that only a small percentage of eroded soil is permanently removed from agricultural lands; most is merely moved from one field to another.[102] Further, soil is continuously being created by natural processes. The average rate of soil creation is about 0.5 to 1.0 tonne per hectare per year. This is equal to the rate of soil lost on lands with permanent cover.[103] Soil loss of less than 5 t/ha is difficult to see. Losses in excess of 5 to 10 t/ha can represent a potential for long-term damage to productivity.[104]

Solid waste

Solid waste has become a leading environmental issue in recent years. Occasionally it is even billed as a "crisis" because of the perceived lack of landfill space. The famous Mobro garbage barge episode in the mid-1980s, in which the wandering barge appeared night after night on the news, became the icon of the trash debate in the United States.[105]

The management of solid waste involves decreasing the amount of solid waste generated ("reduce and reuse") and disposed ("recycle and recover"). Canada and the United States have adopted ambitious targets—as much as 50 percent by the year 2000—for the reduction and recycling of solid waste.[106]

102 Easterbrook, *A Moment on the Earth*, 1995, p. 388.

103 Environment Canada, *State of Canada's Environment*, 1991, p. (9)10.

104 Ibid.

105 Whatever happened to the Mobro garbage barge? After wandering up and down the Atlantic seaboard for several weeks, the trash it carried was placed in a landfill in New York, just a few miles from where it had started its journey.

106 The Canadian Council of Ministers of the Environment (CCME) has set a nation-wide goal of 50 percent reduction per capita from 1988 level, by the year 2000. A second initiative, the National Packaging Protocol (NAPP), targets the 35 to 40 percent of solid waste that is composed of discarded packaging, and aims to reduce the level of discarded packaging to 50 percent of the 1988 level by the year 2000. See Environment Canada, *State of Canada's Environment*, 1991, p. (25)4, 14.

Table 10: Summary of Land Use and Condition as Environmental Indicator

General Comments	Performance Record: US	Performance Record: Canada
Wetlands		
• Government farming subsidies have contributed to wetland loss. • Wetlands fluctuate dramatically in size and number with wet and dry years. • Wetlands can help to conserve and purify groundwater sources and protect against drought.	• The US has 1,194,000 ha of wetlands rated as internationally important waterfowl habitat. • American wetlands have been relatively stable since 1980.	• Canada has 13,030,200 ha of wetlands rated as internationally important waterfowl habitat. • Canada has suffered no net wetland loss since 1986.
Urban sprawl		
• Claims about a "crisis" of urban sprawl are exaggerated. • Agricultural lands are not in danger of being overrun by towns and cities. • Wilderness areas are not in danger of disappearing.	• In the US, urban areas comprise only 2.6% of the landbase. • Urban areas relative to agricultural land increased from 2.5% to 5.4% between 1959 and 1987. • The ratio of protected areas to urban and agricultural lands grew from 6.4% to 22.9% between 1959 and 1987.	• In Canada, urban areas comprise only 0.8% of the landbase. • Urban areas relative to agricultural land increased from 5.5% to 7.2% between 1959 and 1986. • By 1986, Canadian protected areas were larger in total area than urban and agricultural areas combined.
Soil erosion		
• Erosion is the most common soil degradation problem. • Erosion is a natural process that removes topsoil. • Most eroded soil is merely moved from one field to another. • Soil is continuously being created by natural processes. • Farmers have adopted farming practices aimed at reducing erosion.	• Erosion from American croplands declined from 16.6 to 12.6 t/ha between 1982 and 1992.	• Erosion from Canadian croplands declined from 9.5 to 9.0 t/ha between 1980 and 1991.

Reduction and reuse

The composition of municipal waste in the United States is (by weight) 38 percent paper and cardboard, 23 percent food and garden refuse, 9 percent plastics, 7 percent glass, 8 percent metals, and 16 percent textiles and other.[107] In Canada, the percentages are (by weight) 28 percent paper and cardboard, 34 percent food and garden refuse, 11 percent plastics, 7 percent glass, 8 percent metals, and 13 percent textiles and other.[108] A comprehensive study in the United States and a report by the Ontario Ministry of the Environment both show that discarded packaging accounts for about one third of waste.[109]

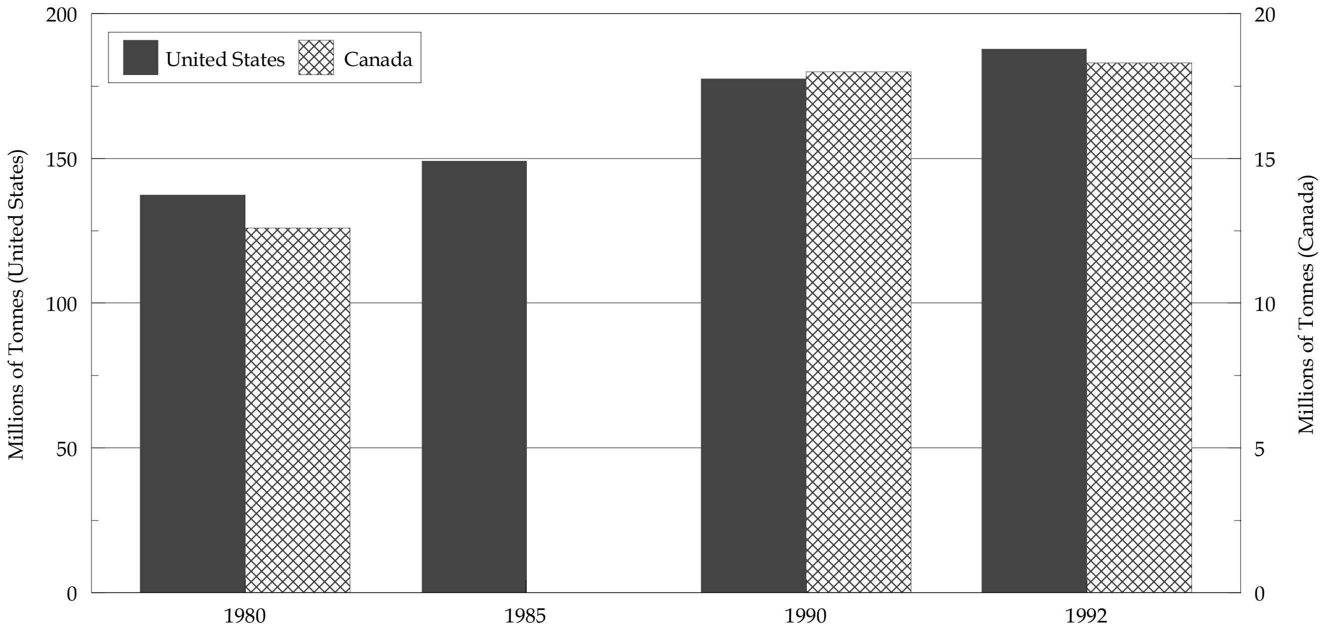
There are several reasons to expect that the generation of solid waste will increase as a country's wealth increases. The first and most obvious is that rising incomes lead to rising consumption. The increase in single-person households and in the number of women in the workplace also may increase the amount of solid waste generated because both increase the consumption of small packaged items.

107 OECD, *Environmental Data Compendium*, 1995, p. 160.

108 Ibid.

109 Franklin Associates, *Characterization of Municipal Solid Waste*, 1992; Environment Canada, *State of Canada's Environment*, 1991, p. (25)7.

Figure 38: Total Municipal Solid Waste Generated in the United States and Canada



Source: OECD, 1995.

An OECD survey tracks total and per-capita solid waste from municipalities.[110] Overall municipal waste increased 36.7 percent in the United States and 49.2 percent in Canada between 1980 and 1992 (figure 38). Per-capita waste increased 21.6 percent in the United States from the early to late 1980s. In Canada, per-capita solid waste increased 31.4 percent over the same period. A slight decline of 1.5 percent was observed between 1990 and 1992 in Canada (figure 39).

Most solid waste is buried in landfill sites. The United States disposes of 62.5 percent of its solid waste in landfills and incinerates 15.9 percent.[111] Canada disposes of 67.2 percent of its solid waste in landfills but only incinerates 3.0 percent.[112] The heavy reliance on landfills has caused the fear that North America is running out of space for landfills. This popular concern about solid waste is unfounded; North America is not running out of space for landfills. Although many landfills are close to capacity, this is because they are designed to have a short life span. Thus, they are always scheduled to reach capacity and close within a few years of opening. There is no shortage of room for landfills. A single square of land, 114 km on each side and about 37 metres deep, could accommodate all of the garbage generated in the United States for 1000 years.[113] Canada would require about one-tenth of this area. It is not a scarcity of land that inhibits the siting of landfills and incinerators, but rather the high price of land close to urban areas and political pressure. When a site is chosen for garbage disposal, it becomes unavailable for other uses, and communities worry about odour, dust, litter, and scavenging animals that have been associated with landfills in the past. New sanitary landfill technology now being used greatly reduces these problems.

Concerns about running out of space for landfills have made recycling an increasingly popular alternative to disposal. In the 1970s, most municipalities

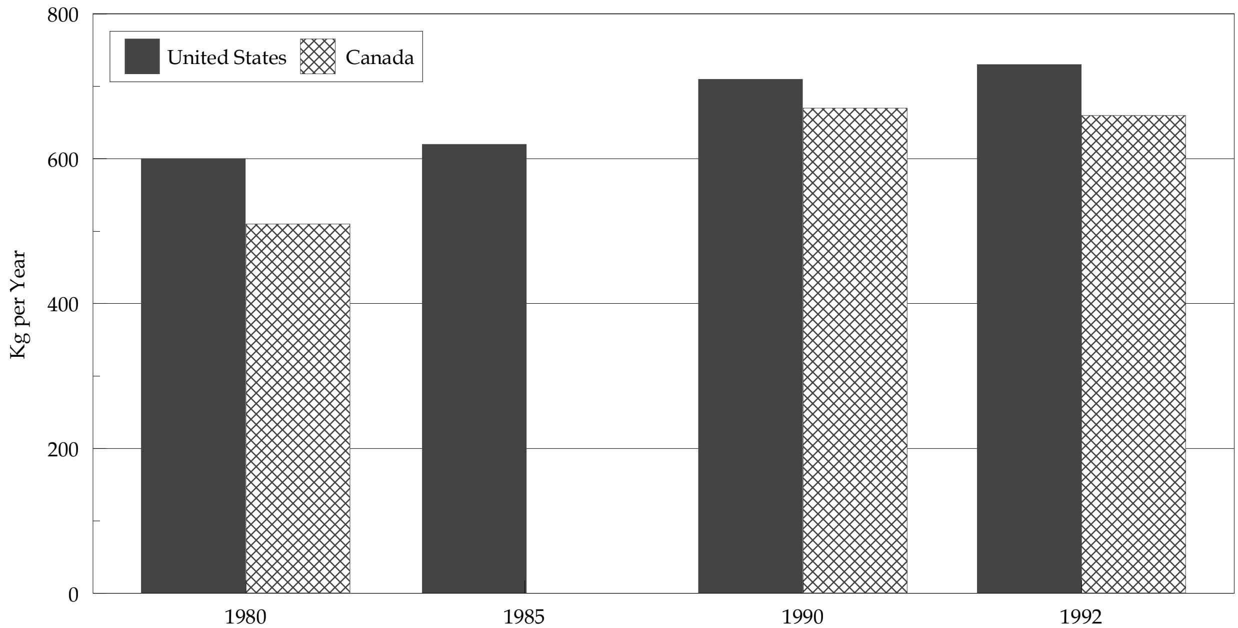
110 In the United States, *municipal waste* is waste collected by, or on the order of, municipalities. It includes waste originating in households, commercial activities, office buildings, institutions like schools and government buildings, and small businesses that dispose of waste at the same facilities used for municipally collected wastes. In Canada, municipal waste is all waste that is not construction and demolition debris. See OECD, *Environmental Data Compendium*, 1995, p. 161.

111 United States Bureau of Census, *Statistical Abstract*, 1995, table 360.

112 Christenson, personal communication, 1996.

113 Imperial measures are 44 square miles and 120 feet deep. See Wiseman, "US Wastepaper Recycling Policies," 1990.

Figure 39: Per-Capita Municipal Solid Waste Generated in the United States and Canada



Source: OECD, 1995.

opened community recycling depots. Municipalities, provincial governments, grocery stores, newspaper publishers, and the plastics, packaging, and soft-drink industries jointly fund the Blue Box program. Under this program, household newspapers, bottles, and cans are collected on a designated day. Some municipalities have expanded collection to include cardboard and rigid plastic containers.

Recycling and recovery

Recycling, composting, and resource recovery all affect the total amount of waste disposed but recycling is not always economically feasible. In many cases, manufacturing products from recycled materials requires more resources and energy, and produces more pollution, than it does to produce the same products from primary raw materials. In addition, recycling is not always environmentally desirable.[114] For instance, McDonald's decision to discontinue the use of polystyrene hamburger packaging has several unfortunate resource tradeoffs. A polystyrene package requires 30 percent less energy to produce. This means 46 percent less air pollution and 42 percent less water pollution than the current paperboard alternative.[115] Finally, recycling is not possible for all products. For example, it is impossible at current prices and with current technology to recycle burned out light bulbs, since these contain glass, interior coatings, adhesive cement, and two or three different metals.[116]

According to the OECD, paper and cardboard recycling in the United States was 22 percent of consumption in 1980, but increased to 34 percent by 1993.[117] Glass recycling climbed from 5 percent to 22 percent of consumption over the same period (figure 40). In Canada, paper and cardboard recycling rose from 20 percent in 1980 to 32 percent in 1992. Glass recycling was 69 percent of consumption in 1990, and rose to 75 percent in 1992 (figure 41).[118]

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114 Wiseman, "Government and Recycling," 1992.

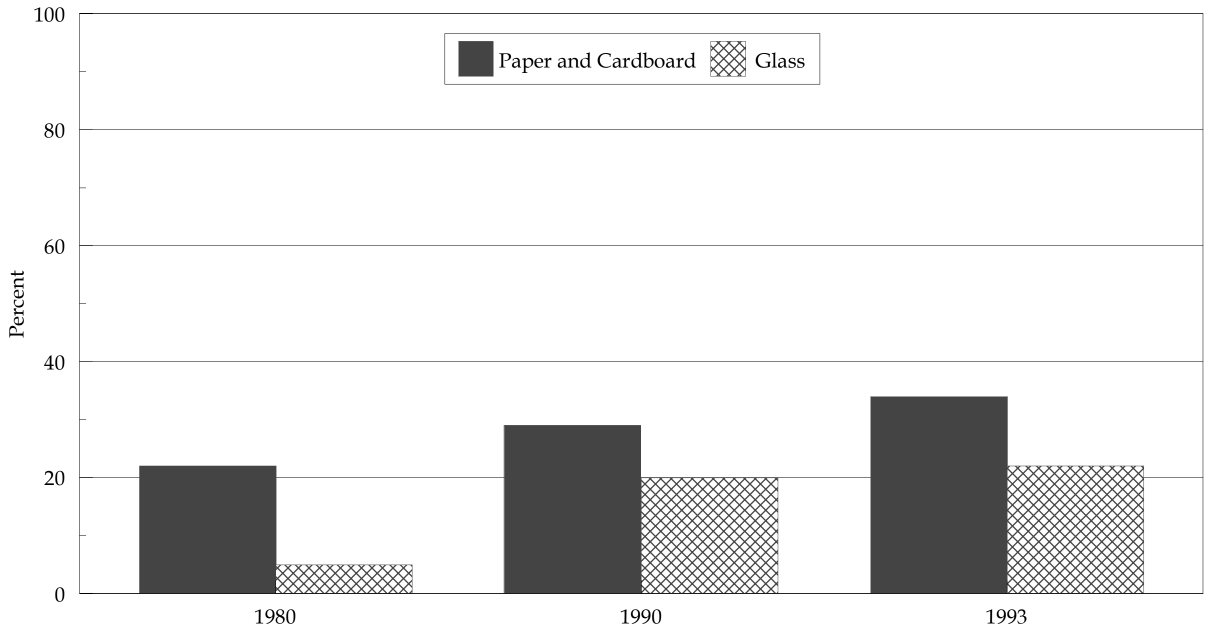
115 Scarlett, "Make Your Environment Dirtier—Recycle," 1991.

116 Environment Canada, *State of Canada's Environment*, 1991, p. (25)7.

117 Canadian data are based on *apparent* consumption (a proxy for waste generated derived from consumption) using figures from domestic consumption of the respective product + imports - exports. American data are based on amounts of waste generated. OECD, *Environmental Data Compendium*, 1995, p. 170–71.

118 Canada's glass recycling figure includes the reuse of refillable money-back bottles. OECD, *Environmental Data Compendium*, 1995, p. 171.

Figure 40: Recycling Rates in the United States

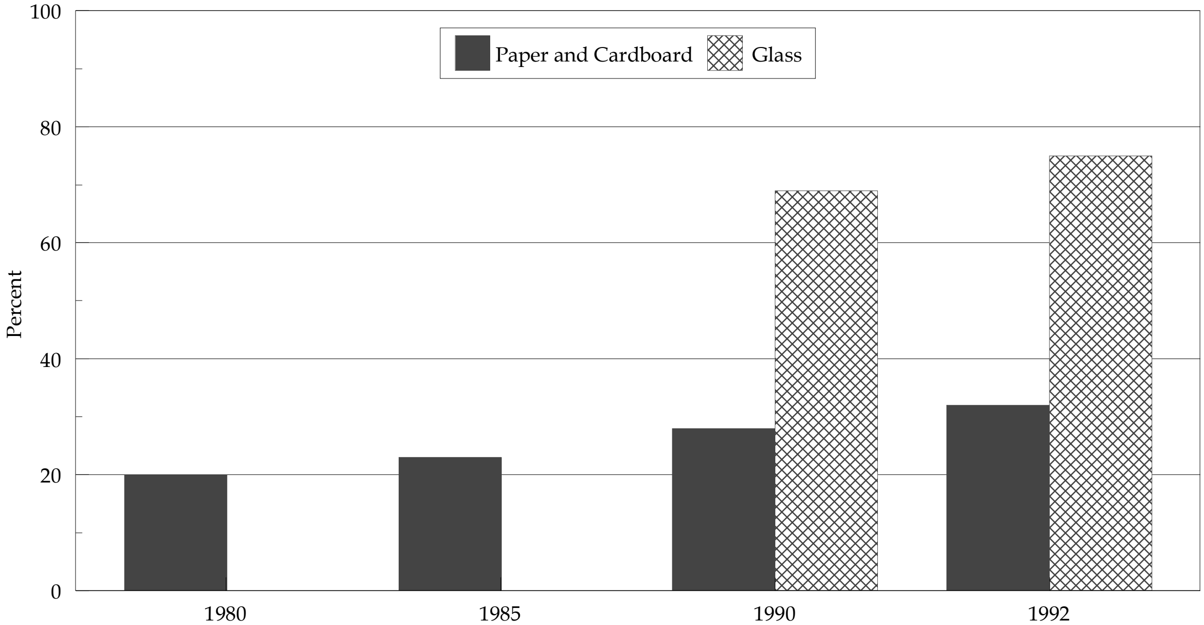


Source: OECD, 1995.

Table 11: Summary of Solid Waste as Environmental Indicator

General comments	Performance record: US	Performance record: Canada
Reduction and re-use		
• Solid waste can be managed through decreasing the amount generated and decreasing the amount disposed. • Both the US and Canada have adopted ambitious solid-waste reduction targets and recycling programs. • Most solid waste is buried in landfill sites. • Waste disposal sites are designed to impose minimal burden on communities. • There is no shortage of room for landfills. • Recycling has become an increasingly popular alternative to disposal.	• Overall municipal waste generation increased 36.7 percent in the US between 1980 and 1992. • Per-capita waste generation increased 21.6 percent in the US through the 1980s.	• Overall municipal waste generation increased 49.2 percent in Canada between 1980 and 1992. • Per-capita waste generation increased 31.4 percent in Canada in the 1980s declined slightly between 1990 and 1992.
Recycling and recovery		
• Recycling is sometimes more polluting than producing new materials.	• Paper and cardboard recycling increased from 22 percent of consumption to 34 percent between 1980 and 1993. • Glass recycling climbed from 5 percent of consumption to 22 percent over the same period.	• Paper and cardboard recycling increased from 20 percent in 1980 to 32 percent in 1992. • Glass recycling was 69 percent in 1990 and rose to 75 percent in 1992.

Figure 41: Recycling Rates in Canada



Source: OECD, 1995.