Primary Environmental Indicators

Air quality

This section examines air quality trends in North America and the United Kingdom for 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). 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 in Canada, Mexico, the United Kingdom, and the United States shows the clearest trend of improvement among all environmental categories during the last two decades. The continuing improvement in the quality of the air in North America proves that reports predicting there would be a sharp decline in air quality after the signing of the North America Free Trade Agreement (NAFTA) were incorrect. For example, *The Environmental Implications of Trade Agreements*, released by the Ontario Ministry of Environment and Energy in 1993, predicted that pollutants such as sulphur dioxide would increase by more than 4.5 percent annually in North America as a direct result of NAFTA. However, data from Environment Canada, the United States, and the Organisation for Economic Cooperation and Development (OECD) show that sulphur dioxide levels in North America are continuing to fall.

Measuring Air Quality

Air quality can be measured in two ways: by considering either *ambient levels* or *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 ($\mu g/m^3$). In Mexico, ambient air quality is reported to the public using a national pollution index, Índice Metropolitano de la Calidad del Aire (IMECA; Metropolitan Index of Air Quality). Pollution levels exceeding 100 points on the IMECA scale are considered a threat to human health (OECD 1998: 81).

Ambient Air Quality

In order to evaluate ambient air quality in Canada, the United States, and the United Kingdom, monitoring stations are maintained in most cities with populations greater than 100,000 where air pollution can be a problem. In Canada, 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 the country (Environment Canada 1996b: h 8). In the United States, 4800 monitoring sites report air-quality data for one or more of the six National Ambient Air Quality System pollutants to the Aerometric Information Retrieval System (USEPA 1996a). In the United Kingdom, there are 107 automatic monitoring sites organized in three networks: urban, rural, and hydrocarbon. Data from the sites are processed by the National Environmental Technology Centre (NETCEN), a private company contracted by the department of the Environment (NETCEN 1998: 18).

In Mexico, monitoring of air quality began later and is less comprehensive than it is in Canada, the United States, or the United Kingdom. Although there was limited monitoring of air pollution as early as 1986, efforts to create a comprehensive air-quality monitoring system in Mexico did not begin until after the General Law of Ecological Balance and Environmental Protection (LGEEPA) was passed in 1988. The law prohibits emissions of pollutants that might cause ecological damage and provides guidelines for ambient air quality and emission limits for fixed and mobile sources of pollution. Although it does not designate national objectives for air management, it does provide for the setting of state and local quantitative environmental goals or targets (OECD 1998: 85). Although no national ambient time-series data are available for Mexico, such data from 1988 are available for Mexico City. There are also data available from the early 1990s for Guadalajara and Monterrey.

Monitoring of air quality in Mexico has recently been expanded. As of early 1997, networks measuring trends for SO_2, NO_x, CO, ozone, PM-10, VOCs and lead were operating in Mexico City, Guadalajara, Monterey, Ciudad Juarez, Tijuana, Queretaro, Mexicali, Tula, Aguascalientes, Minatitlan, and Toluca. As well, about 20 other cities have installed measuring equipment that is not yet operational (OECD 1998: 80–1).

Emissions

In addition to records of ambient air quality, Canada, the United States, and the United Kingdom also record emission statistics. Mexico only recently began recording emission estimates and has no reliable, comprehensive emission data (OECD 1998: 88). Although emission statistics provide some useful information regarding air quality trends, they are less reliable indicators than ambient concentrations because they are *estimates* generated by models rather than actual measures. In addition, frequent revisions in the calculation methods used to estimate emissions make comparisons between years less meaningful than comparisons of annual ambient levels.

The models used to generate emission estimates are based on many factors, including the level of industrial activity, changes in technology, fuel consumption rates, vehicle miles travelled (VMT), and other activities that cause air pollution.[1] These models estimate 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.

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 population, industry, and pollution emissions of Canada and yet does not always have higher ambient pollution levels, because natural sources and meteorological factors such as temperature, sunlight, air pressure, humidity, wind, rain, and topography 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.

In this section

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.[2] Canada's standards are used because they include a broad range of environmental effects and are comparable to the requirements in the United States and other parts of the industrialized world (Environment Canada 1990b: 26). When pollution levels are within the range from "good" to "fair," there is adequate protection for the most sensitive persons and parts of the environment (Environment Canada 1991c: 26). The objectives established by the World Health Organisation (WHO) are cited in the endnotes for comparison. Mexico's IMECA standards for health, which are more lenient than Canadian objectives, are included with Canadian standards when referring to Mexican data.

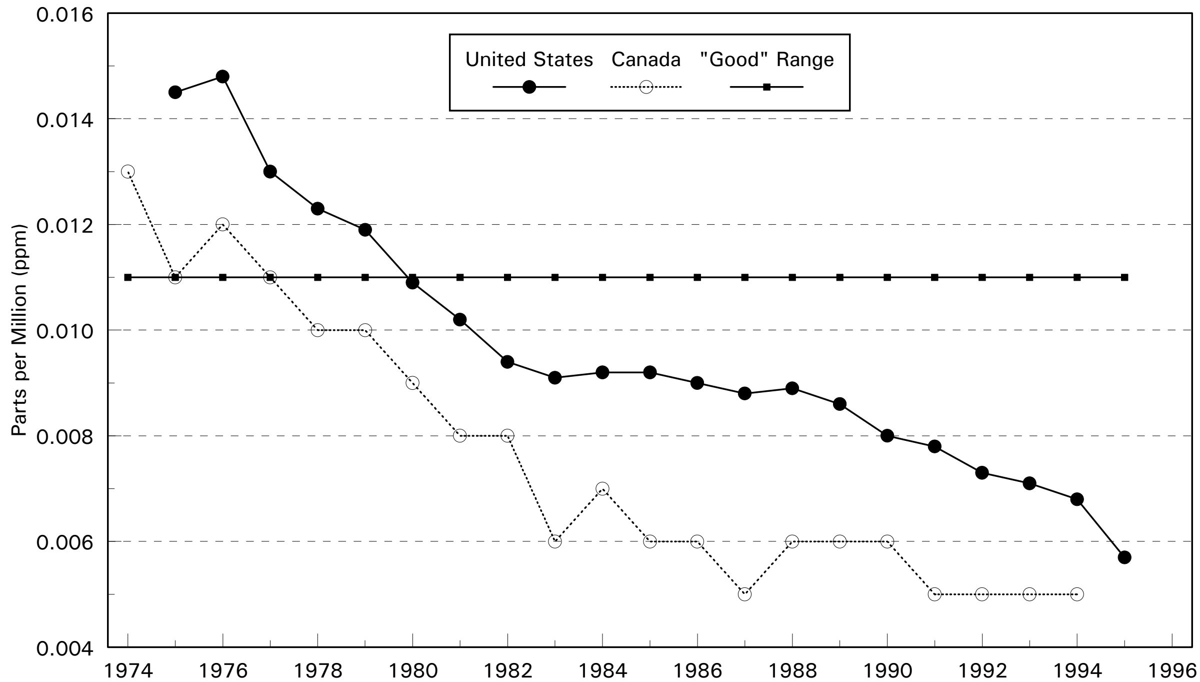
Sulphur dioxide

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

SO_2 is a precursor to acid rain.[3] 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. After ten years of study, however, the United States National Acid Precipitation Assessment Program (NAPAP) concluded that acid rain has had no significant effects on wildlife, forests, crops, or human health (Bast, Hill and Rue 1994: 74–81). 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.

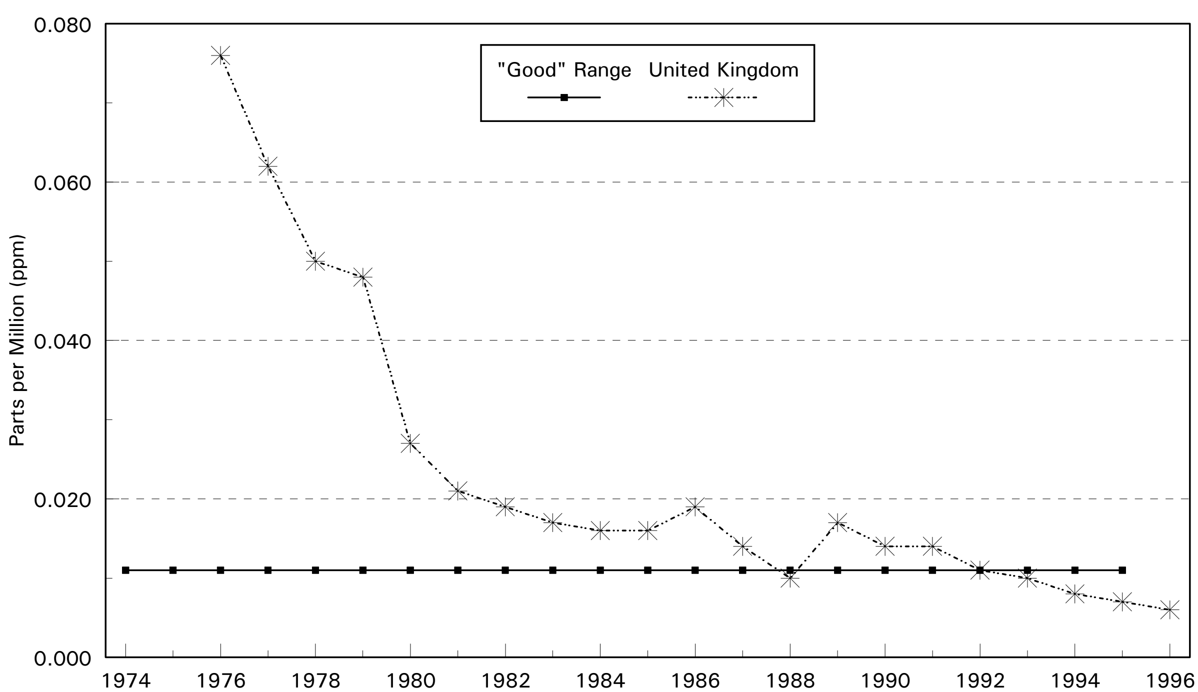
Table 1 shows some of the effects of SO2 on the environment and on human health at different levels of concentration. Figure 1 shows that the ambient level of SO_2 decreased by 60.7 percent in the United States between 1974 and 1995 and 61.5 percent in Canada between 1975 and 1994. In the United Kingdom, SO_2 levels declined by 92 percent between 1976 and 1996. The United States has met annual "good" objectives since 1981; Canada has met annual "good" objectives since 1978;[4] the United Kingdom has met annual "good" objectives since 1992.

Figure 1a: Sulphur Dioxide (ambient levels) in the United States and Canada



Sources: Environment Canada 1996c; US Environmental Protection Agency (USEPA) 1996a.

Figure 1b: Sulphur Dioxide (ambient levels) in the United Kingdom



Sources: Website of the United Kingdom's Department of Environment, Transportation and Regions (UKDETR). Data calculated as a mean of UKDETR sites. SO_2 measured at Central London, Cromwell Road, and Glasgow Hope Street only.

Table 1: Sulphur Dioxide (Ambient Levels)

	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

Source: Environment Canada 1991c: (2)11. World Health Organization (WHO) guidelines (as reported in US EPA 1995c: 7–4): Annual: .015–.023 ppm; 24hr: .038–.058 ppm, 1hr: .130 ppm; 10 min: .190 ppm.

Figure 2 shows ambient concentrations of SO_2 in three Mexican cities. In Mexico City, SO_2 levels fell 50 percent between 1988, when measurements were first recorded, and 1996. In Guadalajara, SO_2 levels fell 30 percent between 1994 and 1996. In Monterrey, SO_2 levels increased 18 percent between 1993 and 1996. While all three cities currently meet the Mexico's IMECA standard as well as Canada's 24 hour "good" health standard, none of the cities meet Canada's annual "good" health standard, which allows less than one-tenth the IMECA level of pollution.

In the case of emissions, figure 3 shows that levels in the United States fell 41.2 percent between 1970 and 1995; Canadian emissions fell 60 percent between 1970 and 1994; emissions in the United Kingdom fell 68 percent between 1970 and 1996. The largest factor contributing to the decline in emissions has been the increased use of control devices by industry. Improvements in the processes used, 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 (USEPA 1996a: 29). 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.[5] In the United Kingdom, the European Community's ban on the burning of natural gas kept sulphur dioxide emissions higher than necessary until the ban was lifted in 1990.

In spite of this record of reducing emissions and meeting the strictest health standards, in 1991 Canada signed the Canada/United States Air Quality Agreement for the reduction of SO_2 and NO_x emissions. Canada's obligations under this agreement include the establishment of a permanent national limit on SO_2 of 3.2 million tonnes by the year 2000 (USEPA 1995d: ES-1). In the United Kingdom emission reduction goals are 50 percent by the year 2000, 70 percent by 2005 and 80 percent by 2010 from a 1980 baseline. As of 1996 the United Kingdom was ahead of schedule in meeting these targets. (United Kingdom, Dep't of Environment, Transportation and Regions [UKDETR] 1998a: 23).[6]

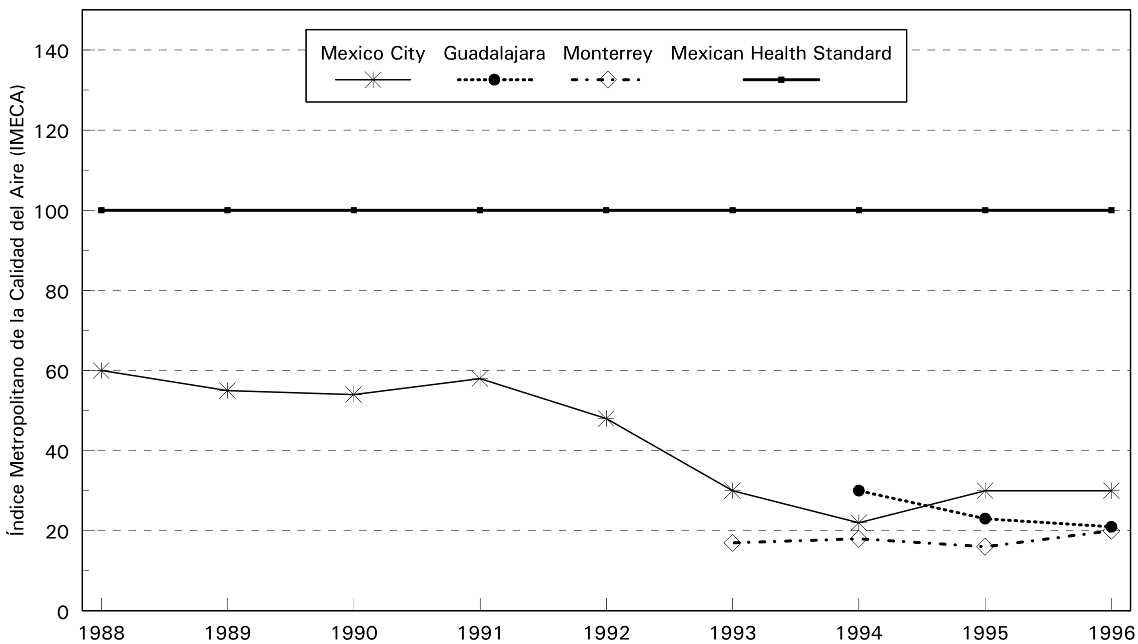
These reductions, warranted or not, may be achieved more cost effectively with methods other than increased regulation. For example, the 1990 United States Clean Air Act has allowed the introduction of tradeable emissions permits. The Chicago Board of Trade now trades sulphur-dioxide pollution credits on the open market. Environmental groups can now further reduce emissions levels by purchasing these credits and retiring them.[7] Mexico is also experimenting with pollution credits for SO_x and NO_x under the "Mexican Pollutant Release and Transfer Register."

Nitrogen oxides

Nitrogen and oxygen combine naturally through lightning, volcanic activity, bacterial action in soil, 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.

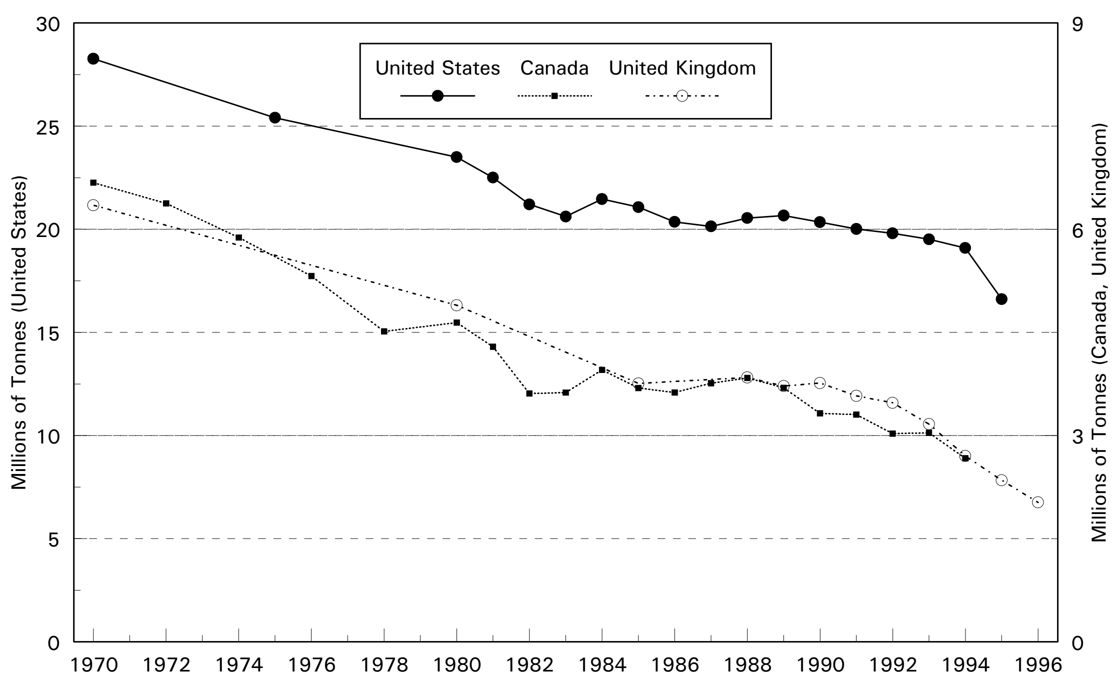
Table 2 lists the effects of the subgroup NO_2 upon the environment and health. The ambient level of NO_2 shows a 37.3 percent decrease in the United States between 1975 and 1995, a 41.9 percent decrease in Canada

Figure 2: Sulphur Dioxide (ambient levels) in Mexico



Source: Mexico, Ministry of the Environment, Natural Resources and Fisheries 1997
Note: The Mexican Health Standard of 100 on the Índice Metropolitano de la Calidad del Aire (IMECA; Metropolitan Index of Air Quality) is equal to .13 ppm; the Canadian annual "good" standard is .011 ppm.

Figure 3: Sulphur Dioxide (emissions estimates) in Canada, the United Kingdom and the United States



Sources: USEPA 1995c, 1996a; Environment Canada 1986, 1996c; OECD 1997; UKDETR 1998a: 38
Notes: Data available only for points shown on graph. Environment Canada changed its calculation methodology in 1980.

Table 2: Nitrogen Dioxide (Ambient Levels)

	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
Source: Environment Canada 1991c: (2)11. WHO guidelines: 24hr: .080 ppm, 1hr: .210 ppm.				

between 1977 and 1994, and a 37.8 percent decrease in the United Kingdom between 1977 and 1996 (figure 4). Canada and the United States have met annual "good" objectives since monitoring began in 1975 and 1977, respectively.[8] In the United Kingdom, annual "good" objectives have been met since 1986.

In Mexico City, concentrations of NO_2 have increased 25 percent between 1988 and 1996. In Guadalajara NO_2 levels increased by 11 percent between 1994 and 1996. In Monterrey, NO_2 levels declined about 4 percent between 1993 and 1996 (figure 5). All three cities have met Mexico's IMECA standard since monitoring began in 1988. None of the cities meet the Canadian annual "good" standard.

Emissions data for NO_2 are unavailable. American emissions in the broader NO_x category, however, show an increase of 5.6 percent from 1970 to 1995; Canadian emissions increased 50 percent from 1970 to 1994; British emissions declined 3.4 percent from 1970 to 1995 (figure 6). The increases in the emission of NO_x in Canada are puzzling in light of the reduction in ambient NO_2; the estimates may be inaccurate or the increase in other nitrogen oxide emissions may have exceeded the reduction in nitrogen-dioxide emissions.

Volatile Organic Compounds (VOCs)

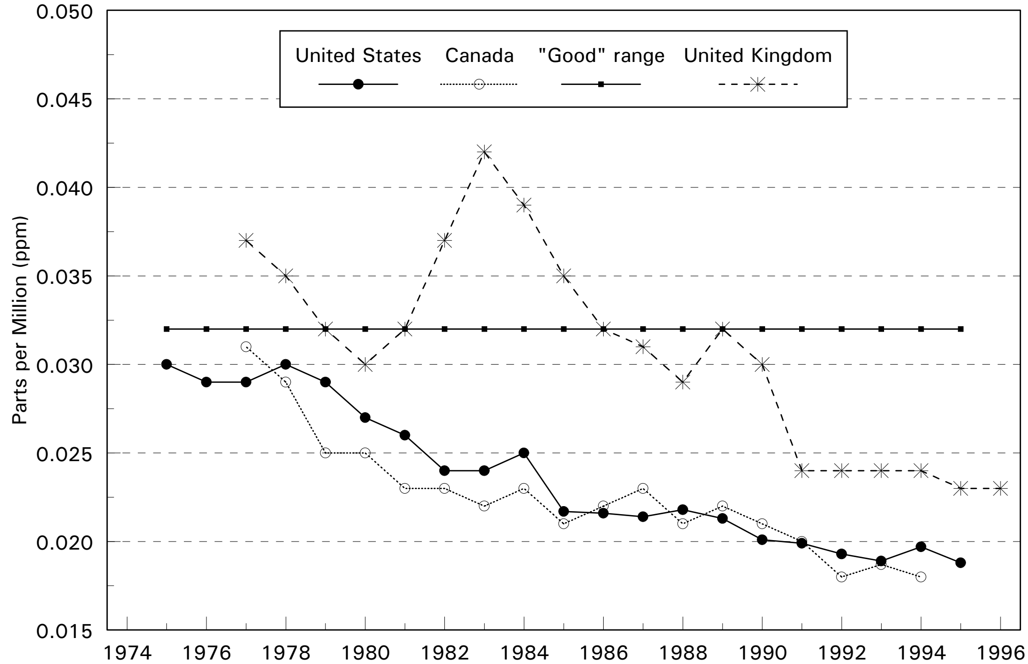
Volatile organic compounds (VOCs) are a subgroup of hydrocarbons (HCs); they enter the atmosphere through evaporation of automotive fuel (from the fuel tanks of automobiles), paints, coatings, solvents, and consumer products, such as lighter fluid and perfume. VOCs also occur naturally as a result of photosynthesis. They are important because under the right conditions they combine with NO_2 to form ground-level ozone, which contributes to urban smog. Regulators target emissions of VOCs 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 25.7 percent in the United States between 1976 and 1995 but increased 31.3 percent in Canada between 1979 and 1994 (figure 7). Although ozone levels in Canada have increased, Canada is still much better off than the United States as American ozone levels have consistently been much higher than those in Canada. However, the current level in Canada still exceeds annual "fair" objectives.[9]

Table 3: Ozone (Ambient Levels)

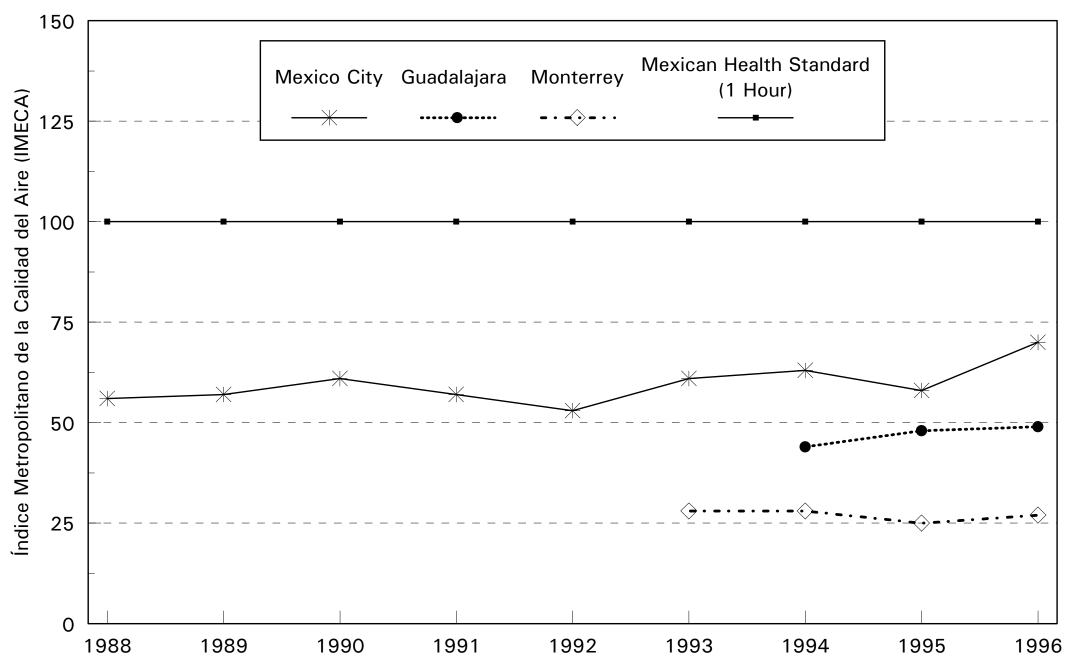
Objectives	Good	Fair	Poor	Very poor
Annual objectives	NA	0–.015 ppm	>.015 ppm	NA
1–hour objectives	0–.050 ppm	.050–.082 ppm	.082–.150 ppm	>.150 ppm
Effects on human health and the environment	• no effects	• increasing injury to some species of vegetation	• decreasing performance by some athletes exercising heavily	• light exercise produces effect in some patients with chronic pulmonary disease
Source: Environment Canada 1991c: (2)11. WHO guidelines: 8hr: .050–.060 ppm, 1hr: .050–.100 ppm.				

Figure 4: Nitrogen Dioxide (ambient levels) in Canada, the United Kingdom and the United States



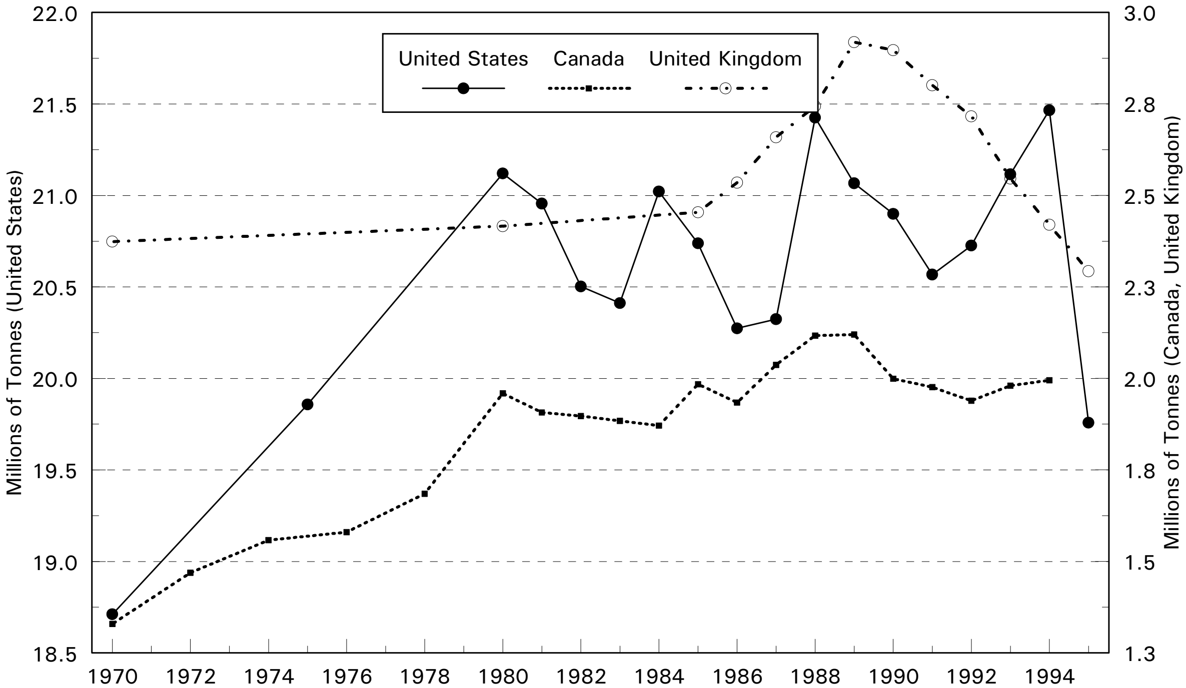
Sources: Environment Canada 1996c; USEPA 1995c, 1996a; UKDETR 1998a.
Notes: In 1986, the US EPA increased its monitoring sites from 48 to 216. UK figures before 1987 are an average of three sites (central London, Cromwell Road, and Stevenage) only.

Figure 5: Nitrogen Dioxide (ambient levels) in Mexico



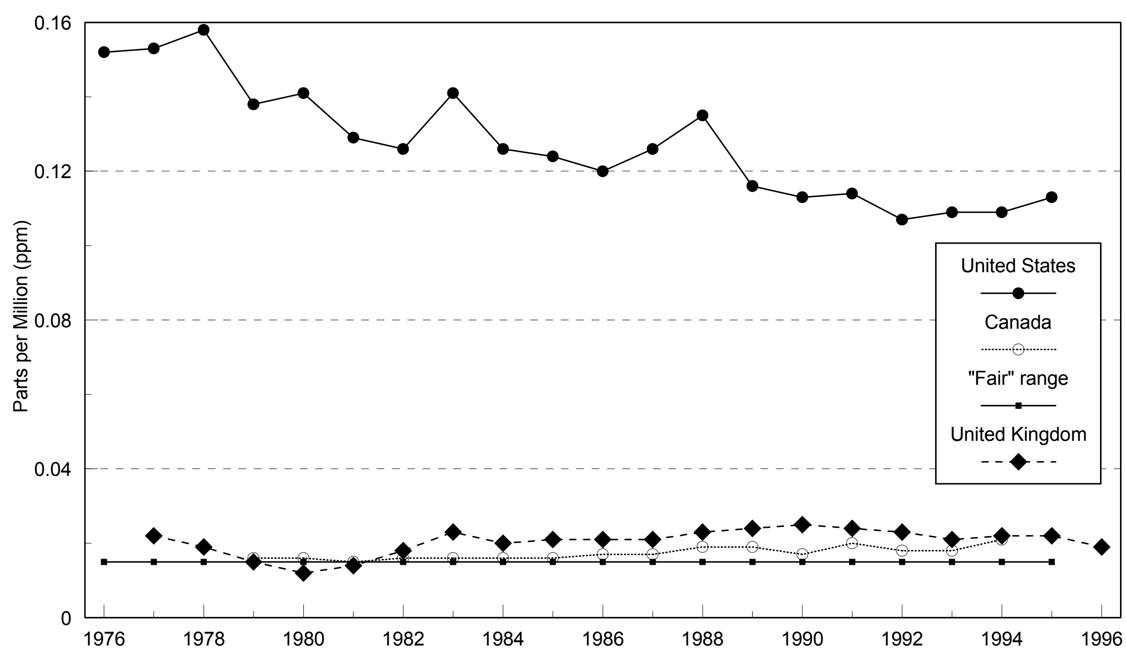
Source: Mexico, Ministry of the Environment, Natural Resources and Fisheries, 1997.
Note: The Mexican Health Standard of 100 on the IMECA Scale is equal to .21 ppm
This is also the Canadian “Fair” 1-hour objective.

Figure 6: Nitrogen Dioxide (emissions estimates) in Canada, the United Kingdom and the United States



Sources: USEPA 1996a; Environment Canada 1986; OECD 1997; UKDETR 1998a: 46
Note: No UK data 1971–1979, 1981–1984. Environment Canada changed its calculation methodology in 1980.

Figure 7: Ozone (ambient levels) in Canada, the United Kingdom and the United States



Sources: Environment Canada, 1996a; US EPA, 1995c, 1996a; UKDETR 1997 and UKDETR Website.
Notes: There is no annual guideline for “Good” range. Measures above “Fair” range are considered “Poor.” More sites were added to UK data in 1986.

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 the year round. In addition, ozone concentrations vary considerably with meteorological factors such as temperature, wind speed, cloudiness, and precipitation, and physical factors such as terrestrial relief. In the United Kingdom, ozone levels declined 14 percent between 1977 and 1996. Most of the observed decreases in ozone levels are the result of cuts in VOC emissions from industries and other combustion sources as well as from automobiles.

Mexico measures ambient ozone levels in three cities. In Mexico City ozone levels increased slightly between 1988 and 1996; ozone levels in Toluca increased 43 percent between 1994 and 1996; Monterrey's ozone levels declined 9 percent between 1993 and 1996. Mexico City and Toluca exceed Mexico's IMECA one hour standard of .11 ppm. Monterrey meets Mexico's standard (figure 8).

Ambient ozone levels do not directly or predictably reflect emissions. A 1991 National Academy of 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 9.5 percent from 1980 to 1995; Canadian VOC emissions increased 28.7 percent between 1980 and 1994; in the United Kingdom, VOC emissions decreased 3.3 percent between 1980 and 1995 (figure 9). VOC emissions have decreased primarily through reformulation of petroleum-based products (especially paints and industrial coatings) and containment and storage procedures that reduce evaporation.

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 upon human health and upon 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 do not include annual recommendations for ambient CO levels.

Ambient levels of CO have improved significantly in all the countries examined. In the United States, annual ambient CO concentrations in 1995 were 63.7 percent lower than in 1975; Canadian levels declined 73.3 percent between 1974 and 1994; in the United Kingdom, ambient CO declined 86 percent between 1976 and 1996.[10] The United Kingdom and Canada have been in the "good" range since monitoring began. The United States has met "good" standards since 1993 (figure 10). In Mexico City, CO levels decreased 3.2 percent between 1988 and 1996. Guadalajara experienced a 9.8 percent decrease in CO between 1994 and 1996 and, in Monterrey, CO levels fell 16 percent between 1993 and 1996. All three Mexican cities are the "good" to "fair" range according to Canadian Standards. (figure 11).

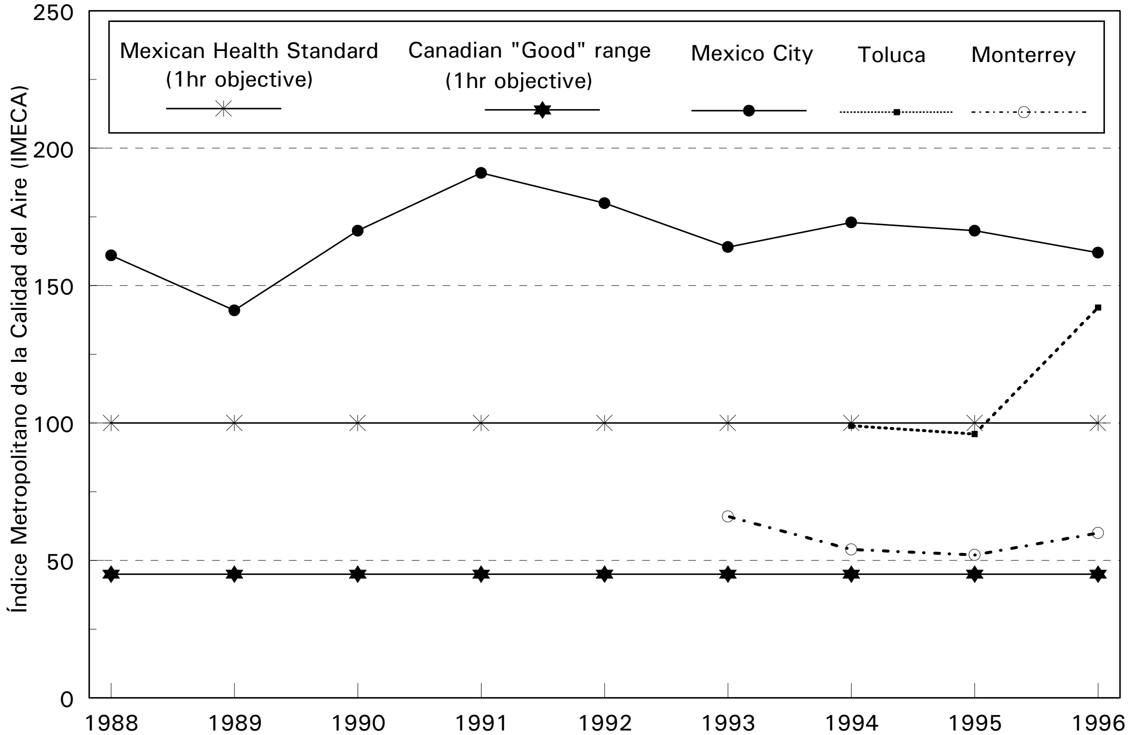
Carbon monoxide emissions declined 33 percent in the United States between 1970 and 1995. There was a 13 percent decline in Canadian CO emissions between 1970 and 1994 (figure 12). In the United Kingdom, there was a 28 percent decrease in emissions between 1970 and 1995. These reductions can be attributed to cleaner automobiles (catalytic converters oxidize CO into non-poisonous CO_2) and more fuel-efficient industrial processes, and in some countries fuel duties kept down

Table 4: Carbon Monoxide (Ambient Levels)

	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

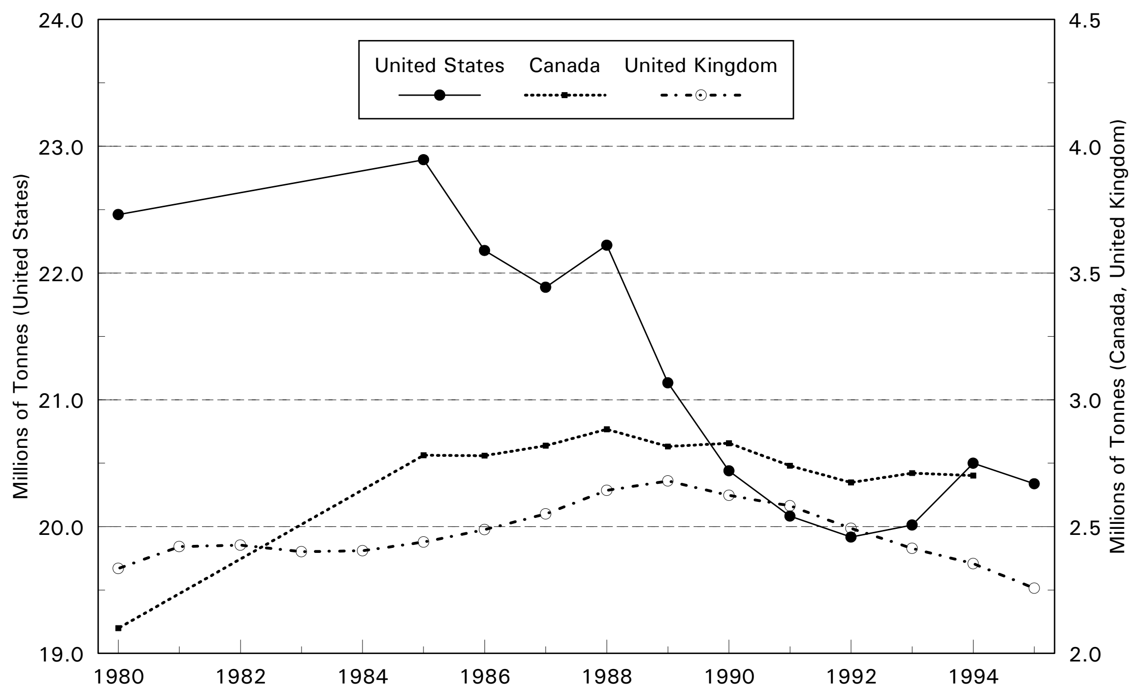
Source: Environment Canada 1991c: (2)11. WHO guidelines: 8hr: 9 ppm; 1hr: 26 ppm.

Figure 8: Ozone (ambient levels) in Mexico



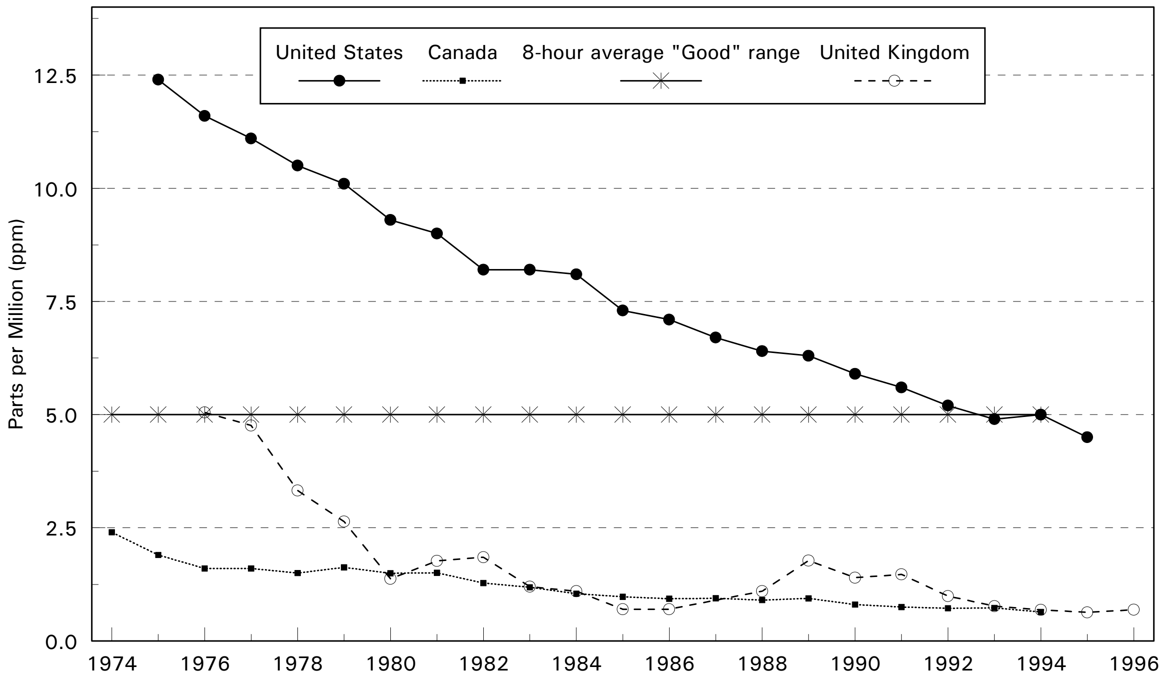
Source: Ministry of the Environment, Natural Resources and Fisheries, 1997.
Note: 100 IMECA = .11 ppm.

Figure 9: Volatile Organic Compounds (emissions estimates) in Canada, the United Kingdom and the United States



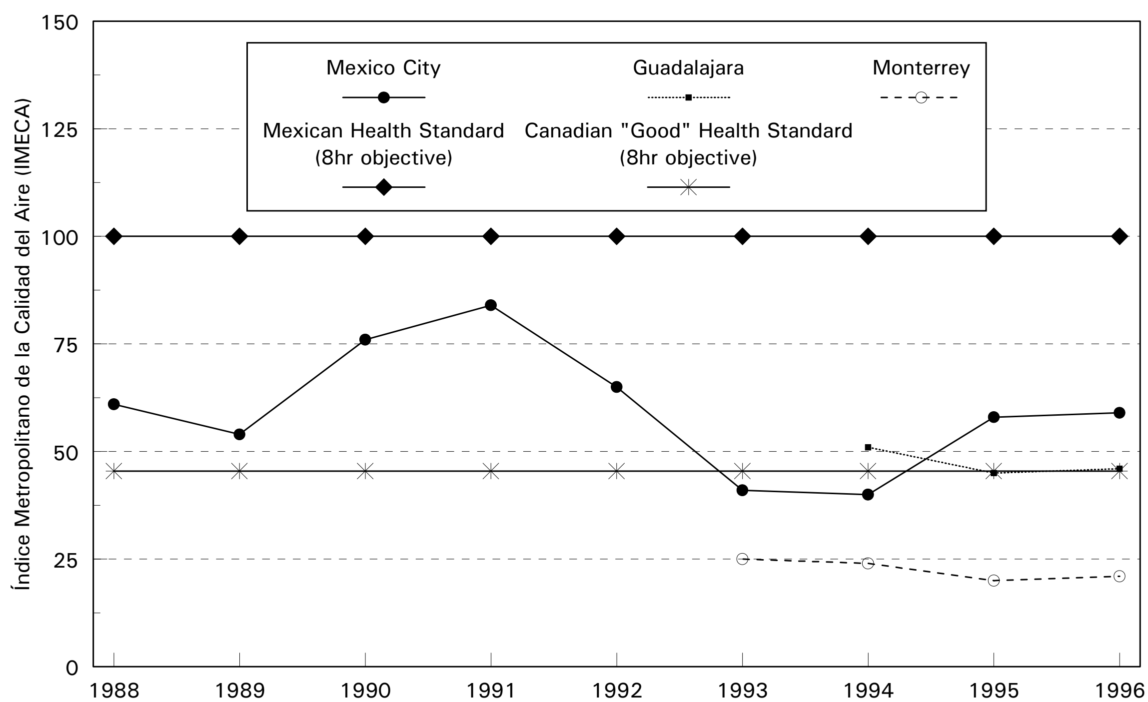
Sources: OECD 1997; United Kingdom, Department of the Environment (UKDE) 1994.
Note: No data for Canada or the United States, 1981–1984.

Figure 10: Carbon Monoxide (ambient levels) in Canada, the United Kingdom and the United States



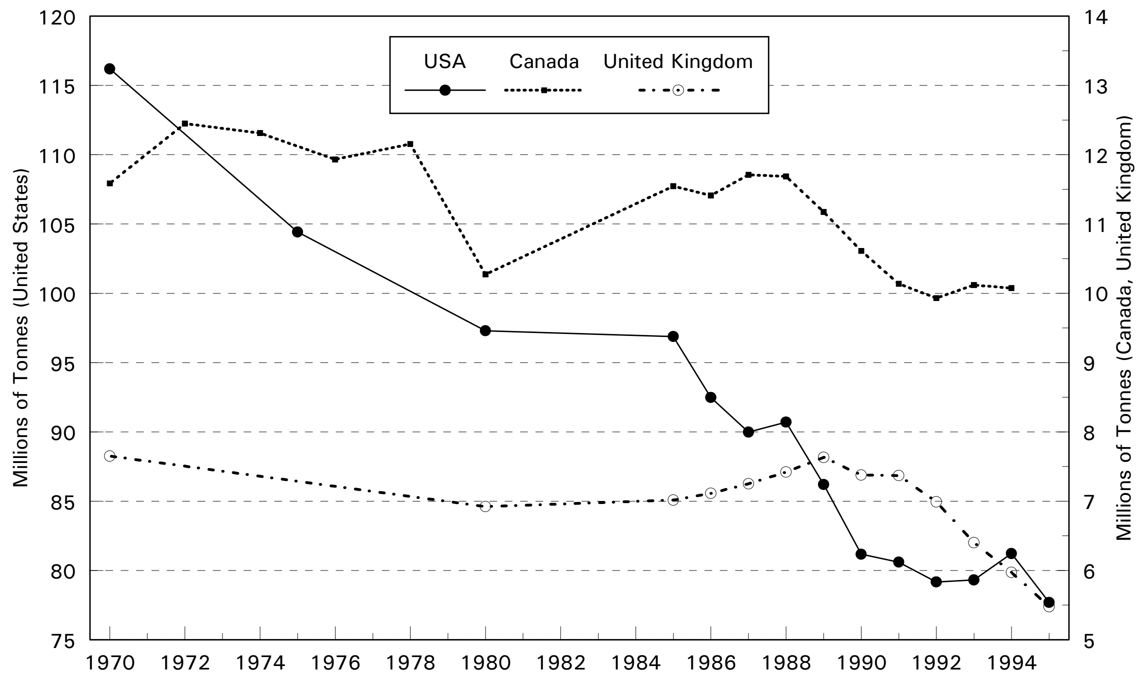
Sources: Environment Canada 1996a; USEPA 1995c, 1996a; UKDETR 1997 and UKDETR Website.
Notes: The United Kingdom started to add more sites in 1989. There are no UK data for 1987. There is no annual guideline for the "good" range. See text for explanation.

Figure 11: Carbon Monoxide (ambient levels) in Mexico



Source: Mexico, Ministry of the Environment, Natural Resources and Fisheries, 1997.
Note: 100 IMECA = 11 ppm.

Figure 12: Carbon Monoxide (emissions estimates) in Canada, the United Kingdom and the United States



Sources: USEPA 1995b; Environment Canada 1986, 1991c, 1995; OECD 1997.
Note: Data available only for points shown on the graph. Environment Canada changed its calculation methodology in 1985 and 1990.

consumption. 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 CO than cars built two decades earlier (Bast, Hill, and Rue 1994: 111). These reductions in emissions are expected to continue as older cars continue to be retired. The most cost-efficient way to continue reducing emissions may be to target poorly tuned, polluting vehicles for repair or replacement.[11]

Total suspended particulates and PM–10s

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. 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, in 1987 the United States Environmental Protection Agency changed its regulatory focus from total suspended particulates (TSPs) to suspended particulates that are 10 micrometers or smaller (PM-10s) (USEPA 1995c: 2–16). Canada, Mexico, and the United Kingdom continue to measure TSPs. These regulatory differences make direct comparison of current particulate emissions difficult.

Table 5 gives details of the effects of particulates upon health and the environment. 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 1980 to 1993 show, in Canada, a 46.2 percent reduction in the ambient levels of total suspended particulates (TSPs). In the United Kingdom, TSP levels fell 48 percent between 1980 and 1994. A 22 percent reduction in ambient PM-10 levels has been observed between 1988 and 1995 in the United States (figure 13). Since 1982, all three countries have achieved a rating in the “good” range. In Mexico City, TSP levels fell 1 percent between 1988 and 1996; in Guadalajara, TSP

Table 5: Suspended Particulates (Ambient Levels)

	Good	Fair	Poor	Very poor
Annual objectives	0–60 μg/m³	60–70 μg/m³	>70 μg/m³	NA
24-hour objectives	NA	0–120 μg/m³	120–400 μg/m³	>400 μg/m³
Effects on human health and the environment	• no effects	• decreasing visibility	• visibility decreased, soiling through deposition	• increasing sensitivity of patients with asthma and bronchitis
Source: Environment Canada 1991c: (2)11. WHO guidelines: Total Particulates, Annual: 60–90 μg/m³; 24hr: 150–230 μg/m³; PM–10 24hr: 70 mg/m³.				

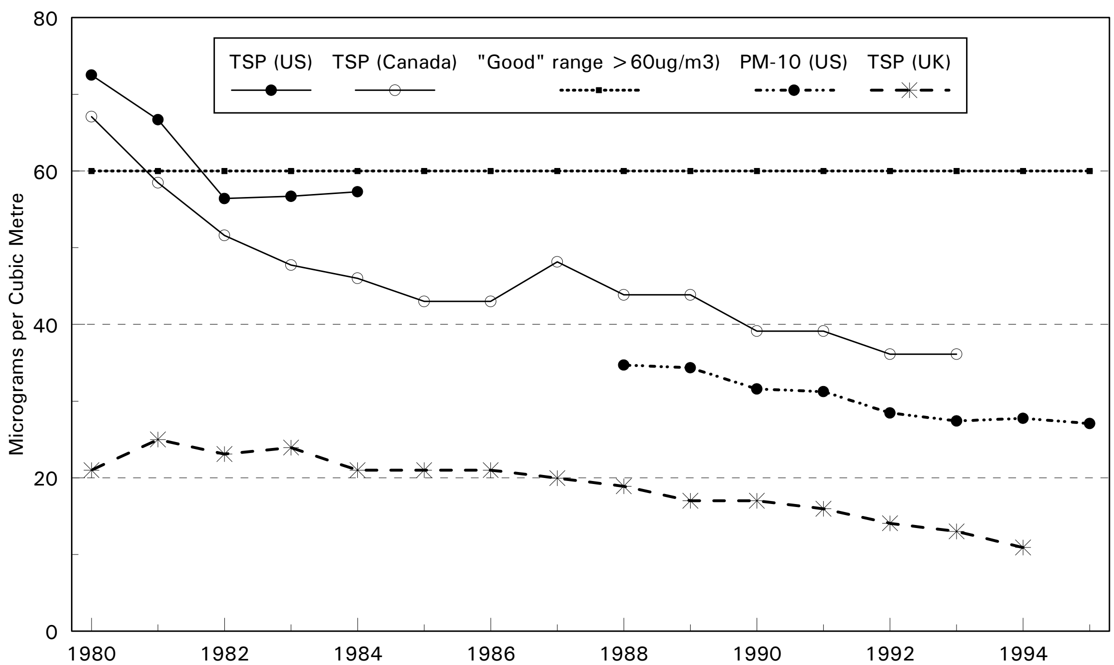
levels fell 17 percent between 1994 and 1996; and in Monterrey, TSP levels fell 11.6 percent between 1993 and 1996 (figure 14). All three cities exceed Canadian 24-hour "fair" standards and are in the "poor" range.

PM-10 emissions in the United States fell 51.9 percent from 1980 to 1995 (figure 15). In Canada, TSP emissions levels declined 13.5 percent from 1980 to 1994. The United Kingdom saw a 31.6 percent decrease in PM-10 emission between 1980 and 1995. The switch from coal to fuels such as oil and natural gas that burn more cleanly and more frequent street cleaning are responsible for most of the reductions in emission levels.

Lead

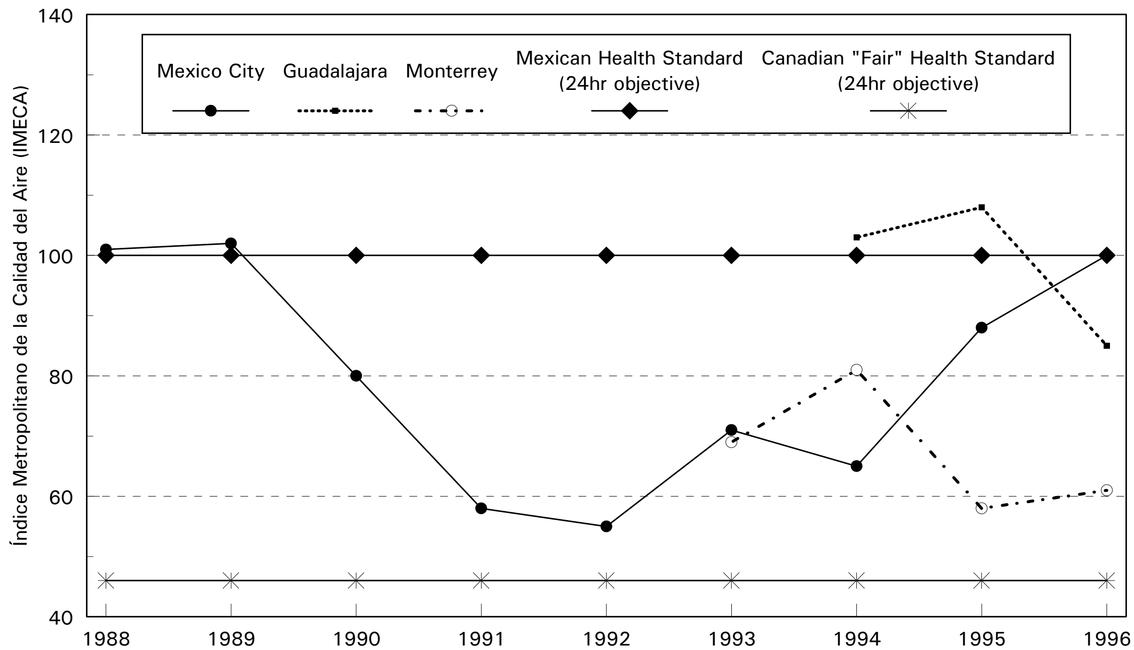
Lead is a soft, dense, bluish-gray metal. Its high density, softness, low melting point, and resistance to corrosion make it of value in the production of piping, batteries, weights, gunshot, and crystal. Until recently, automobiles were the source of most lead emissions although small quantities of 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

Figure 13: Suspended Particulates (ambient levels) in Canada, the United Kingdom and the United States



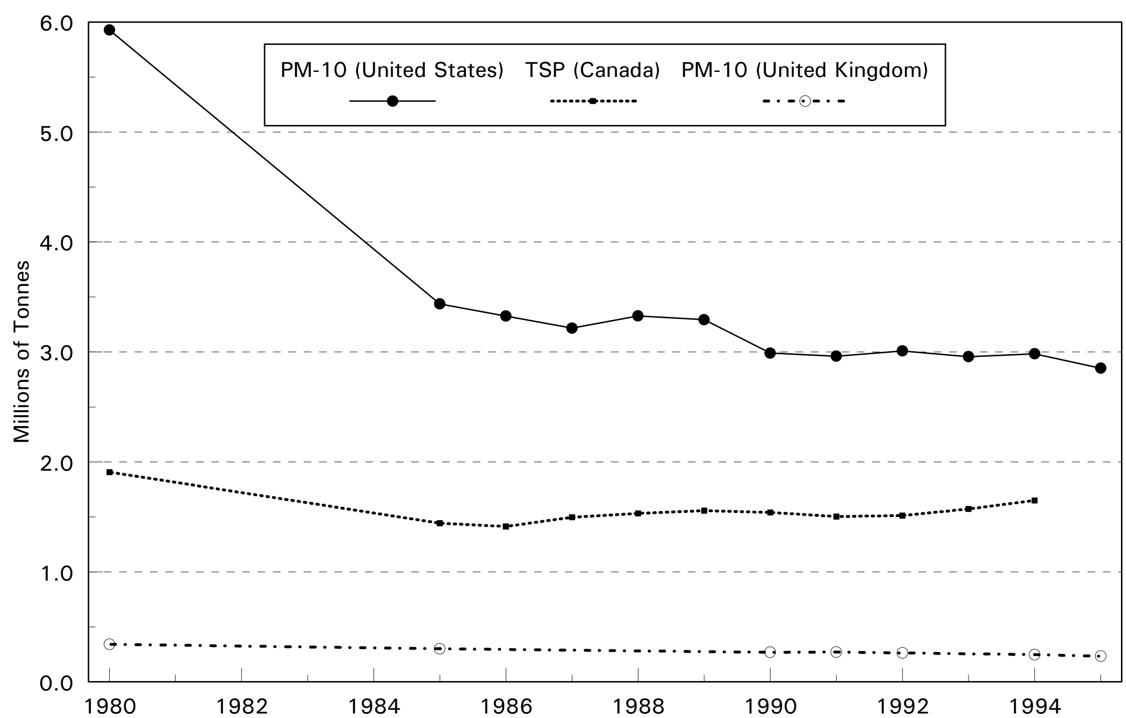
Sources: USEPA 1995c; OECD 1997.
Notes: TSP = total suspended particulates; PM-10 = suspended particulates 10 micrometers or smaller; EPA no longer measures TSPs, but rather the narrower category of PM-10s.

Figure 14: Suspended Particulates (ambient levels) in Mexico



Source: Mexico, Ministry of the Environment, Natural Resources and Fisheries 1997.
Note: Mexico measures PM-10. 100 IMECA points = 150 μg/m3.

Figure 15: Suspended Particulates (emissions estimates) in Canada, the United Kingdom and the United States



Source: OECD, 1997.
Notes: TSP = total suspended particulates; PM-10 = suspended particulates 10 micrometers or smaller; data available only for points shown on graph.

damage. In addition, recent evidence suggests that exposure to lead may be associated with hypertension and heart disease (USEPA 1995c: 2–6). Since lead is the most toxic of the main air pollutants, environmental and health guidelines for lead are stricter than 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 16.

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 97.2 percent in the United States between 1976 and 1995, 90.6 percent in the United Kingdom between 1980 and 1995, and 97 percent in Canada between 1974 and 1994 (figure 16). Mexico's ambient lead concentration fell 82.5 percent between 1990 and 1995. All four countries meet WHO health guidelines.

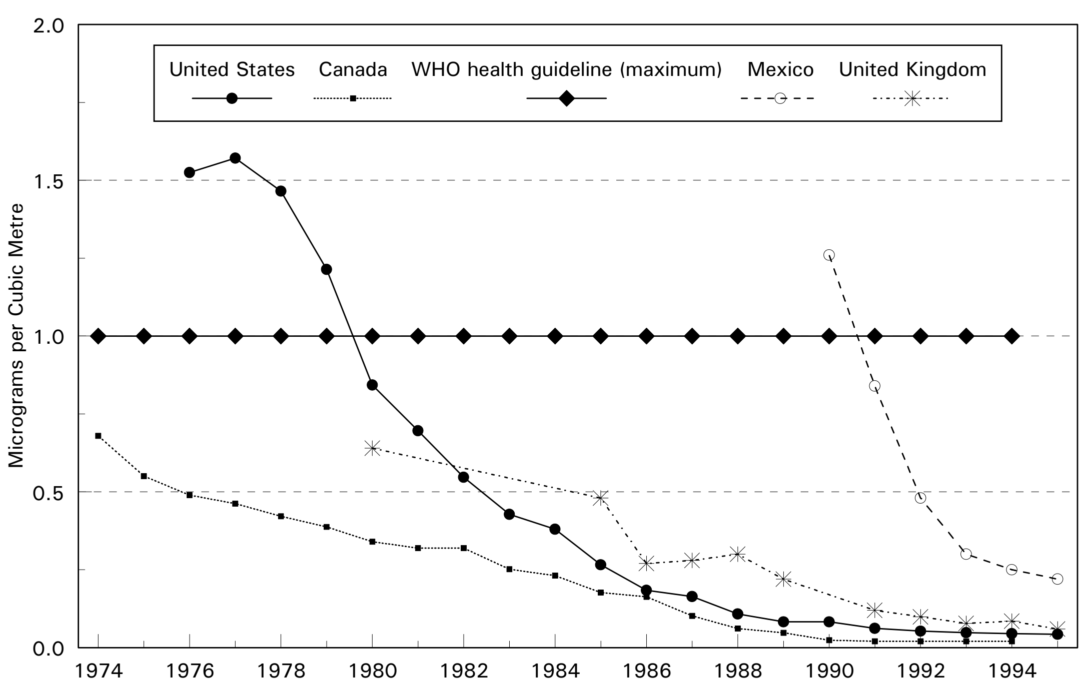
Lead emissions in the United States fell 97.7 percent between 1970 and 1995. In the United Kingdom, lead emissions declined by 75.6 percent between 1970 to 1994. In Canada, emissions fell 73.9 percent from 1978 to 1995, and automobile emissions fell 87.8 percent from 1973 to 1988 (figure 17). Most of this dramatic reduction was due to the introduction of unleaded gasoline and the elimination of lead compounds in paints and coatings. For example, in Mexico unleaded gasoline was introduced in 1990 and the lead content of leaded gasoline was reduced in 1993 (OECD 1998: 90-91).[12] Reductions in Mexico's lead emissions will continue as older cars continue to be retired and when leaded gasoline is banned in Mexico City in the year 2000.

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 relatively constant over large areas, it is often used as an indicator of overall urban air quality (USEPA 1995c: 6–1).

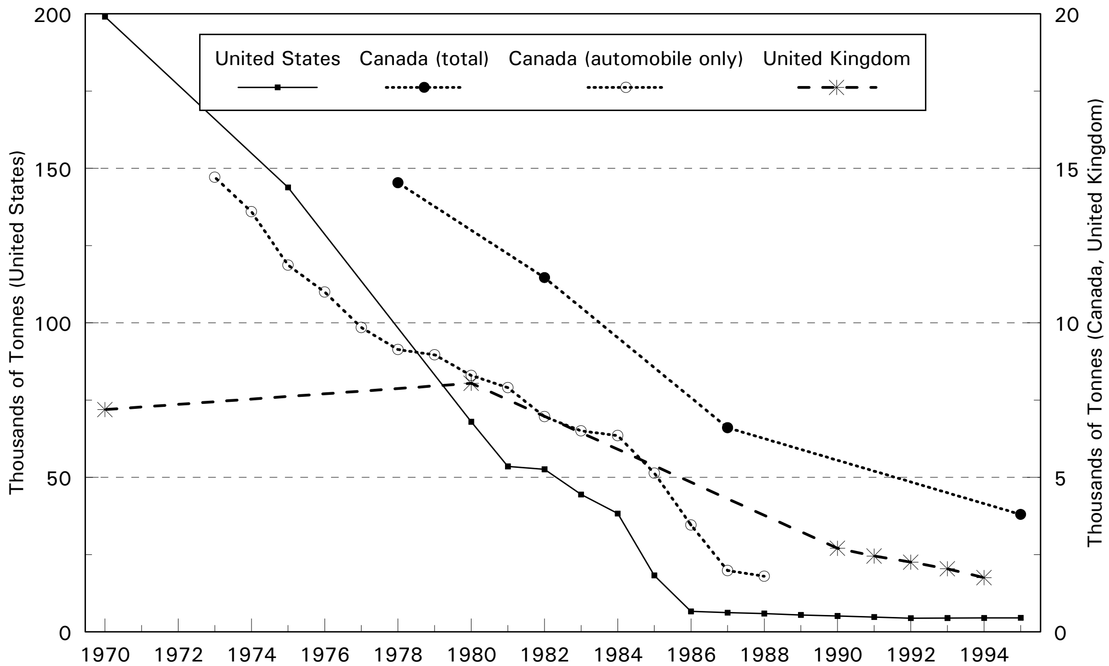
Ozone problems occur most often on warm, clear, windless afternoons. Figures 18 through 21 show that the number of days when ozone objectives were exceeded in different cities in the same geographical region tended to peak and decline in the same years. This strongly suggests meteorological influences. When analyzing this

Figure 16: Lead (ambient levels) in Canada, the United Kingdom and the United States



Sources: Environment Canada 1996a; USEPA 1995c, 1996a; OECD 1997.
Note: There are no Environment Canada guidelines for lead. See text for explanation.

Figure 17: Lead (emissions estimates) in Canada, the United Kingdom and the United States



Sources: USEPA 1995b, 1996a; Environment Canada 1997; UKDETR 1996.
Note: Data available only for points shown on graph.

measure, it is important to understand that when a 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.

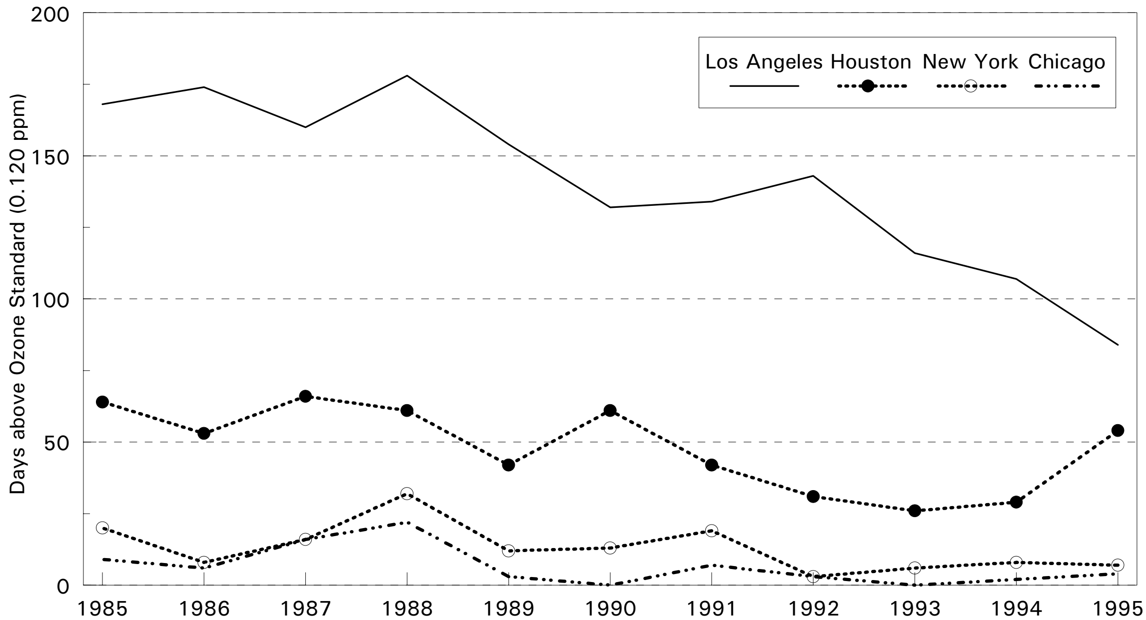
In many Canadian and American cities, days when ozone objectives are exceeded have become infrequent, although in some areas, especially Los Angeles, smog remains a problem. Even in Los Angeles, ozone levels are improving (figure 18): between 1985 and 1995, the number of days exceeding the ozone standard fell 50 percent. New York also saw a major reduction during the same period when exceedances fell 65 percent between 1985 and 1995.

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 19).[13] 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.[14]

Cities in the United Kingdom have variable ozone exceedences. In 1996, the most recent year for which data are available, London had 7 days above the standard, Cardiff had 19 days above the standard, Birmingham had 15 days above the standard, Belfast had 6 days above the standard, and Edinburgh had 3 days above the standard (figure 20). It must be noted, however, that the standard of .050 ppm is stricter than the United States standard (.12 ppm) or the Canadian standard (.082 ppm).

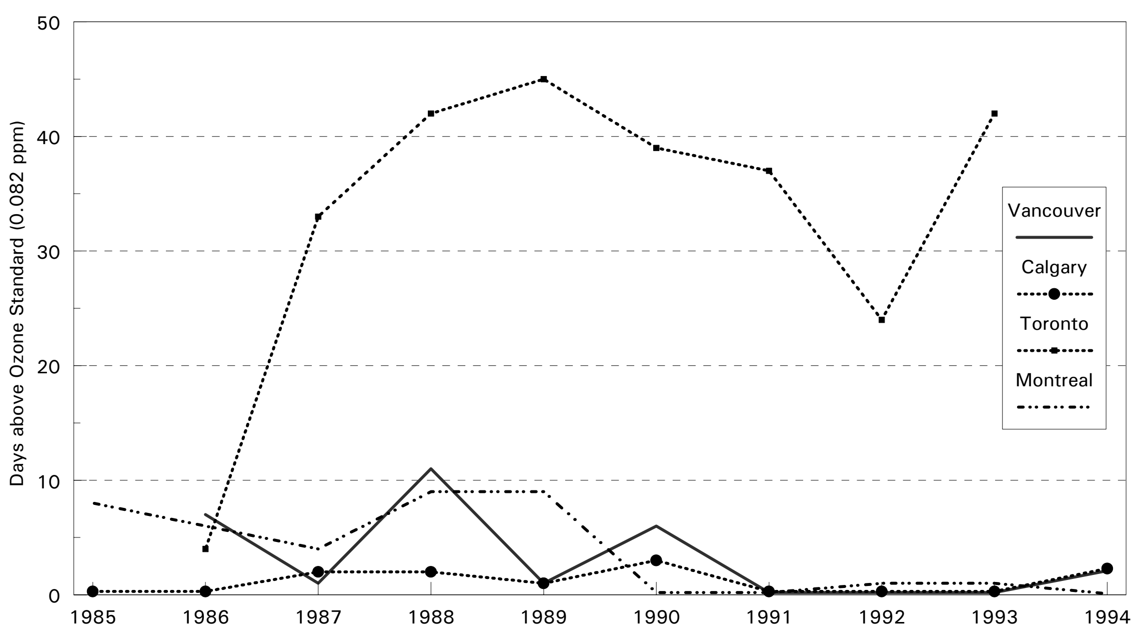
Cities in Mexico have shown moderate to extreme cases of overly high ozone levels (figure 21). In Mexico City, almost nine days out of every ten show ozone levels above the acceptable standard. There are three contributing factors. First, Mexico City is 2,200 meters above sea level and the higher above sea level, the faster petrochemicals react to produce ozone. Second, because there is little wind to blow pollution away, it lingers over the city rather than being dispersed over a large area. Finally, Mexico has long hours of sun light and this helps to trap smog. Smaller cities such as Toluca still exceed standards on average about one out of every four days, an improvement over 1994 when they exceeded standards just over 50 percent of all days.

Figure 18: Urban Air Quality in Selected American Cities



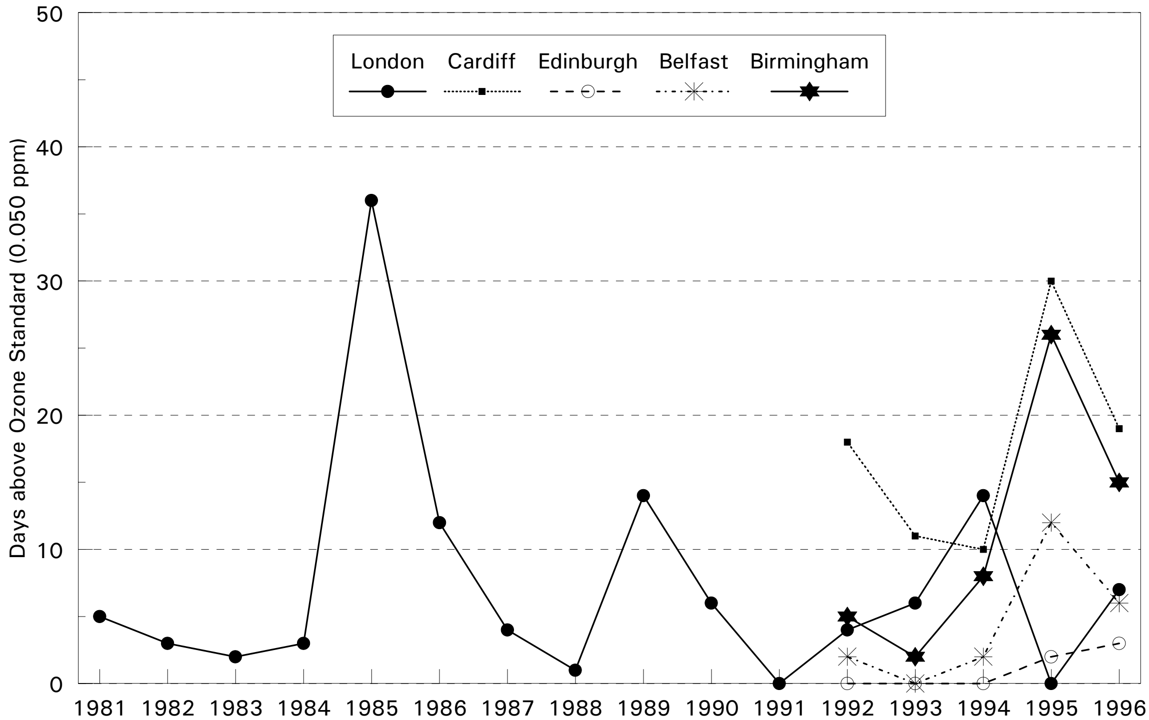
Source: USEPA 1996a.

Figure 19: Urban Air Quality in Selected Canadian Cities



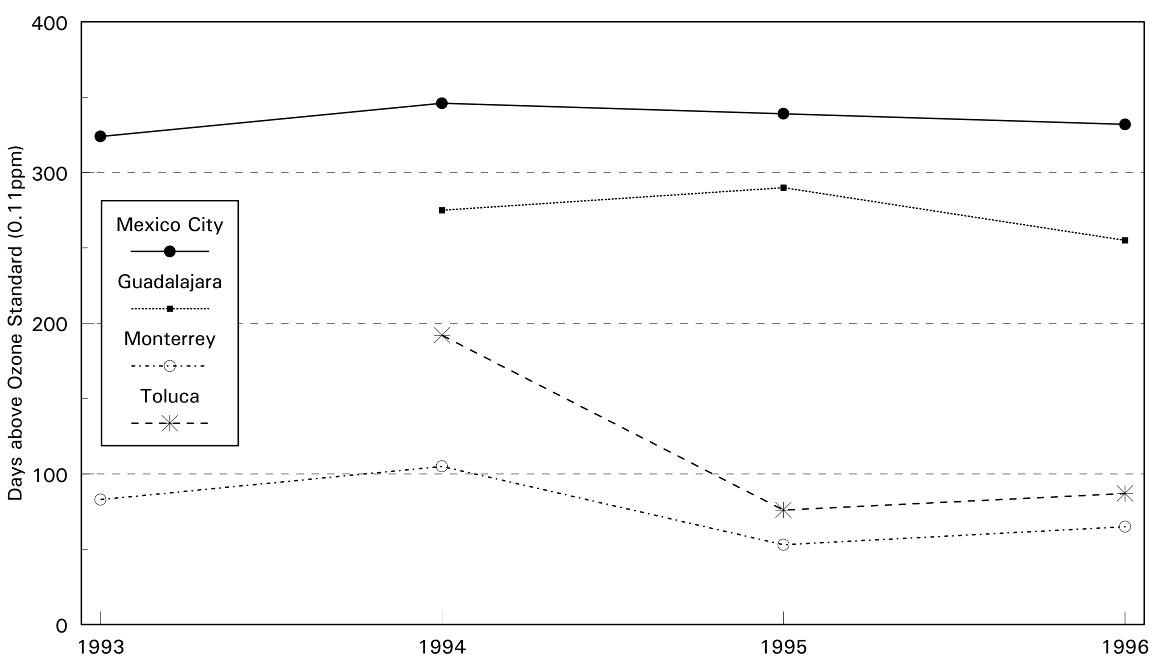
Source: Tom Dann, Environment Canada, Environment Protection, Technology Development Branch, Pollution Measurement Division, Air Toxics, personal communication 1997.

Figure 20: Urban Air Quality in Selected Cities in the United Kingdom



Source: UKDETR Website
Note: The UK National Air Quality Strategy has set a provisional standard of 50 ppb measured as a running 8-hour mean.

Figure 21: Urban Air Quality in Selected Mexican Cities



Source: Mexico, Ministry of Environment, Natural Resources and Fisheries, 1997.

Water quality

Assessing water quality

Water quality is among those environmental problems most difficult to assess on a nation-wide basis. The data used in this section do not represent complete information about ambient water quality due to the lack of available data and the magnitude and complexity of measuring water quality. For example, American estimates indicate that taxpayers and the private sector have spent over US$500 billion controlling water pollution 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.

The effects of both natural and manufactured contaminants upon water quality vary with water conditions (source, velocity, volume, depth, pH level), photosynthetic activity, and variations within a day as well as from season to season. In addition, inconsistencies in data collection are apt to occur due to overlapping jurisdictions and budget considerations.

There appears to be an unfortunate trend occurring in this age of fiscal restraint. Those in the field of data collection and analysis have begun to feel a constant pressure to produce results that justify the budgetary expense of their department. This, coupled with dwindling resources, has resulted in a concentration upon crisis management and site-specific studies are, thus, often given priority over systematic and consistent monitoring. Data analysis becomes very difficult without a solid database from monitoring stations. One technician articulates clearly the problem that occurs when scientific research is strangled by bureaucracy: “If you are not monitoring, you are not managing.”

Currently, there are attempts in both Canada and the United States to start national indexes of water quality; some regional representatives, however, are resisting the setting of national standards by a central planning committee. Due to the enormous geographic size of both countries, water quality cannot be quantified effectively with one or two general measures because there are different parameters for different regions. For example, in Canada the Canadian Council of Ministers of the Environment (CCME) has decided that a Water Quality Index should be constructed by technical subgroups, one from each province and one from the federal government. In discussion, the CCME established general parameters for developing a national index of water quality in Canada.

Water pollutants

There are two sources of water pollution: point and non-point sources.[15] 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 run-off from agriculture, forestry, urban and industrial activities, as well as landfill leachates, and airborne matter. Water quality also varies due to natural causes: 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 toxins.

Nutrients like phosphorus and nitrogen can cause significant degradation of water quality by accelerating eutrophication,[16] which depletes levels of dissolved oxygen. Phosphorus and nitrogen are found in fertilizers and livestock manure (Environment Canada 1991c: [9] 26). 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 run-off 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).[17]

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, or oceans. Primary waste-water treatment removes 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.

Since 1992, "all sewage generated in the United States [has been] treated before discharge" (Easterbrook 1995: 682). Waste-water 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" (USEPA 1993: 18). 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 the United Kingdom about 87 percent of waste is treated before being released into waterways. Between 1987 and 1997 (UKDETR 1998a: 10), the percent of waste-water emission complying with government water-quality standards increased from 79 percent to 96 percent. Politicians in the United Kingdom have indicated they would like to increase this to 100 percent.

In Canada, the proportion of waste water receiving treatment increased from 72 percent in 1983 to 93 percent in 1994 (Environment Canada 1996d, 1996e). Canada's Wastewater Technology Centre recently shifted its focus from industrial research to end-of-pipe, pollution-prevention technologies (Environment Canada 1996b: 10). 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, and to improve contaminated sites.

In Mexico, water programs focus on providing households with access to sanitation (sewage networks and septic tanks). Since 1990, 1.9 million people per year on average have been given access. As of 1997, 67 percent of the population is connected to a sewer network. (OECD 1997: 74) The population served by waste-water treatment plants remains low, 22 percent, but this is likely to improve soon as the construction of new waste-water facilities continues.

National water quality

Because Canada, the United Kingdom, Mexico and the United States monitor water quality differently, *Environmental Indicators* 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

In 1972, the EPA instituted a *National Water Quality Inventory* (NWQI) under the Clean Water Act. The EPA, in conjunction with the United States Geological Survey, reports to Congress upon the criteria for water quality and pollution. Each state must meet the minimum federal criteria and may set additional objectives to address problems particular to its region. Each must also submit biennial "305b" reports to a regional EPA office (there are ten regions) stating whether they met or exceeded the minimum federal levels. The regional EPA offices amalgamate the "305b" reports to produce the biennial USEPA Report to Congress on Water Quality.

The NWQI assesses rivers, lakes, and estuaries based on water-quality standards for beneficial uses, and numeric, and narrative criteria for allowing each use. Designated beneficial uses are the desirable uses that water quality should support. There are 9 categories: support of aquatic life, fish consumption, shellfish harvesting, supply of drinking water, primary contact (swimming), secondary contact (recreation), agriculture, recharge of the supply of ground-water, and wildlife habitat. These designated uses replace the 1990 NWQI "swimmable" and "fishable" objectives.

Table 6: United States National Water Quality Inventory (1994) Showing Levels for Overall Use

	Good		Fair	Poor	
	Fully Supporting	Threatened	Partially Supporting	Not Supporting	Not Attainable
Rivers (615,806 miles)	57%	7%	22%	14%	<1%
Lakes (17.1 million acres)	50%	13%	28%	9%	<1%
Estuaries (34,388 miles^2)	2%	1%	34%	63%	0%

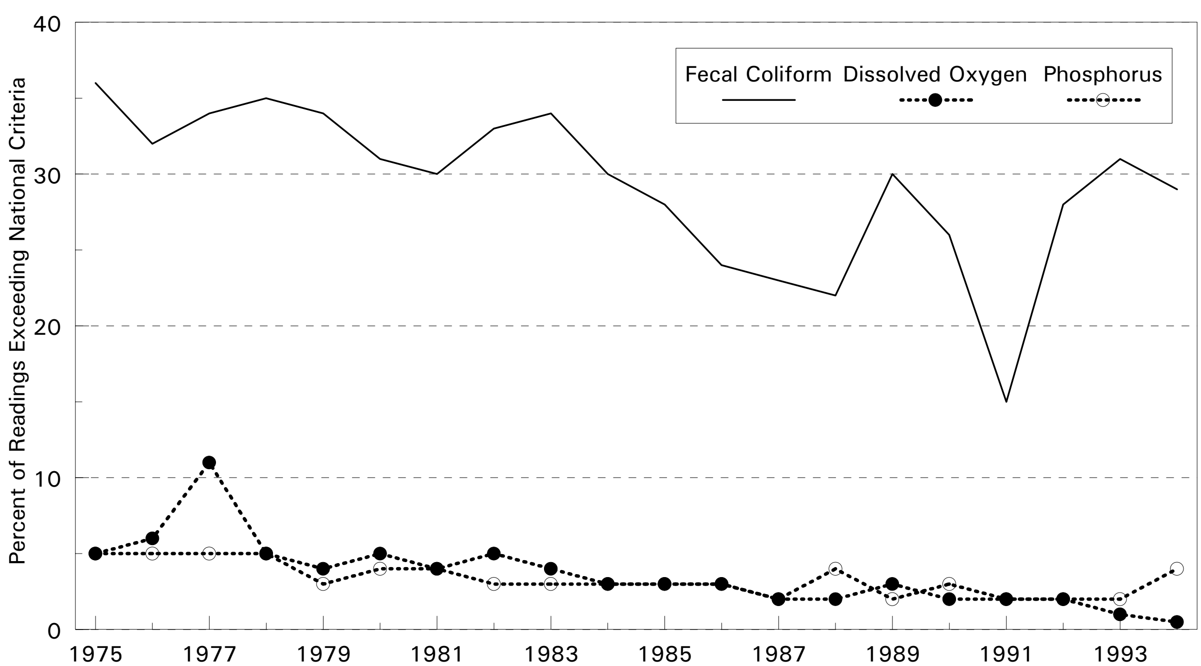
The inventory provides a "snapshot" of water quality. According to the NWQI, 17 percent of rivers, 42 percent of lakes, ponds, and reservoirs, and 78 percent of estuaries have been assessed to date (USEPA 1995e: Executive Summary). Table 6 reports the results for 1994.

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 6 may actually under-estimate 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" (USEPA 1989: xi).

Several efforts are underway to improve the data on water quality. The National Water Quality Surveillance System (NWQSS) and the United States Geological Survey's National Stream Quality Accounting Network (NASQAN) provide limited but consistent data. The 420 monitoring stations in this network, located on major American rivers, 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 22 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, however, been a signifi-

Figure 22: Water Quality in the United States



Source: US Geological Survey cited in US Bureau of the Census, 1997.

cant 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" (Knopman and Smith 1993; Smith, Alexander, and Wolman 1987). The United States has ten EPA water-quality regions:

1 Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont

2 New Jersey, New York, Puerto Rico, and the United States Virgin Islands

3 Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia

4 Alabama, Florida, Georgia, Kentucky, Mississippi, North and South Carolina, and Tennessee

5 Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin

6 Arkansas, Louisiana, New Mexico, Oklahoma, and Texas

7 Iowa, Kansas, Missouri, and Nebraska

8 Colorado, Montana, North and South Dakota, Utah, and Wyoming

9 Arizona, California, Hawaii, Nevada, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands

10 Alaska, Idaho, Oregon and Washington (Alaska did not submit a 305(b) report for 1994)

The EPA's NWQI 1994 Report to Congress compiles assessments of data on minimum-requirement water quality collected during 1992 and 1993 by 61 states, American Indian tribes, territories, Interstate Water Commissions, and the District of Columbia. The list of EPA regions above indicate how immense is the task of writing the Report: data from many varied geographies administered by multiple layers of bureaucracy must be collected and analyzed. Furthermore, the process of compiling "305(b)" reports is flexible in that states, tribes, and other jurisdictions do not use identical survey methods and criteria to rate their water quality. The EPA admits that caution must be the rule in attempting to compare data submitted by different states and jurisdictions in one reporting period, or by the same jurisdictions over more than one reporting period because survey methodology is neither spatially nor temporally standardized (USEPA 1995e: ES-2).

Canada

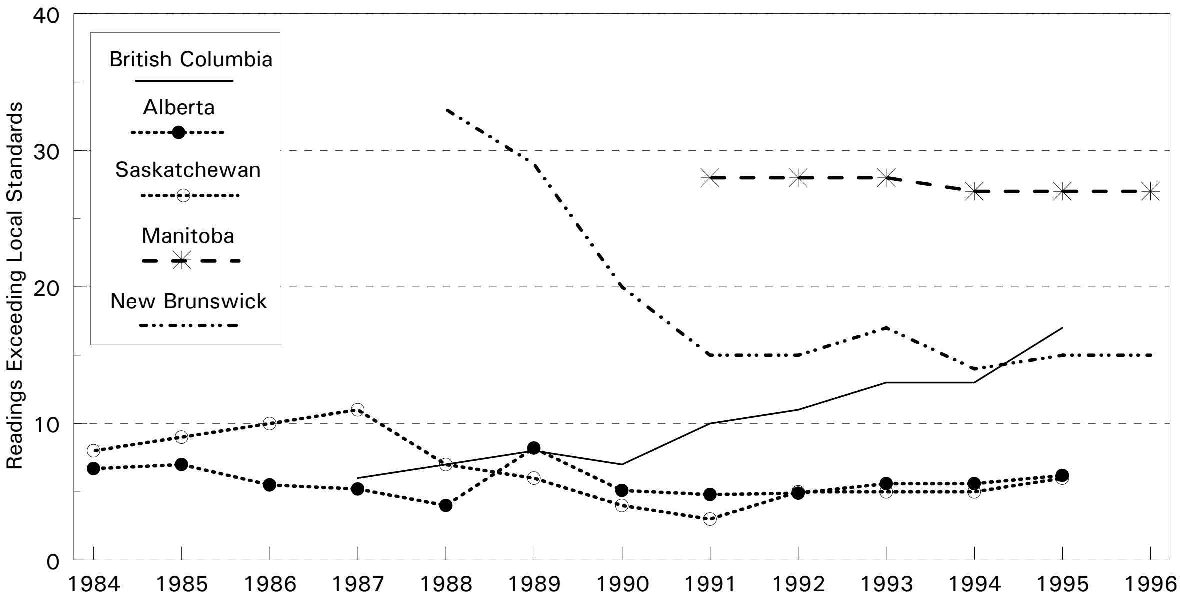
Canada does not have legislated water-quality objectives. The Canadian Council of Ministers of the Environment (CCME) established the Canadian Water Quality Guidelines in 1985 to provide a basis for designing site-specific water-quality objectives. The guidelines recommend concentrations for supporting and maintaining several categories of water use including aquatic life, drinking, recreational, agricultural, and industrial use. Water must meet requirements for biological (bacteria, viruses, protozoan), radiological (radioactive isotopes), physical (taste, odour, temperature, turbidity, colour), and chemical factors.

In Canada, provincial governments legislate standards and regulations for water quality although the federal government offers advice and leadership. 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 (Environment Canada 1990). A study carried out in 1986 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 (Canadian Public Health Association 1986). Further, a study of the Great Lakes by the Toronto Board of Health in 1990 could detect only 42 of the substances for which they were testing; none was present in levels that exceeded the guidelines (Kendall 1990).

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.

Figure 23: Water Quality in Canada



Sources: Personal communications with L.G. Swain (BC), Karen Saffran (AB), Kim Hallard (SK), Dwight Williamson (MB), and Jerry Choate (NB), 1997.
Note: Data from other Canadian provinces are not available.

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 23 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

Criteria are based on the *British Columbia Surface Water Quality Objectives*. The province of British Columbia has published objectives and attainment records for water quality since 1987. Since 1985, the province has jointly operated federal-provincial monitoring stations in partnership with Environment Canada under the Canada-British Columbia Water Quality Monitoring Agreement. These monitoring stations, operated to assess trends in water quality, are situated on rivers over which both the federal and the provincial governments have jurisdiction or in which both have an interest. By 1997, Environment Canada and British Columbia's Ministry of Environment were to be operating about 30 sites, including ten new sites. In addition to these sites established under the joint agreement, since 1975 Environment Canada has operated six sites monitoring long-term ambient water quality on rivers of interest to the federal government. The *British Columbia Water Quality Status Report* (1996) provides an extensive review of some 124 bodies of water. This report provides a detailed index developed from objectives and attainment records (including the number, frequency, and magnitude of objectives exceeded), rating bodies of water as poor, borderline, fair, good, or excellent. It describes the source of threats to water quality and recommends methods for maintaining and restoring British Columbia's bodies of water. Of all Canadian provinces, British Columbia has developed the most comprehensive monitoring and reporting program on water quality (British Columbia Ministry of Environment 1993: 2–45; Rocchini 1996).

Alberta

Parameters of the *Alberta Guidelines Index* are placed in different use categories according to information in the CC-

ME's Canadian Water Quality Guidelines. The stated goal is to have water downstream of developed areas equal in quality to water upstream. 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) (Saffran 1996; Government of Alberta 1996: 78–80). Assessment of water quality in lakes and rivers in Alberta covers the entire province. There are currently 18 permanent stations that are visited monthly. Data from 12 of these stations are currently used for the *Surface Water Quality Index*. Samples are collected on a monthly basis at two locations (one upstream and one downstream from the developed area) in each of the province's six major river systems (Saffran 1997). The water samples are tested for an extensive list of pollutants, 20 of which are evaluated against the *Alberta Ambient Surface Water Quality Interim Guidelines*. More pollutants and objectives are being added over time.

Saskatchewan

The *Saskatchewan Surface Water Quality Objectives* are used as a guide in assessing the quality of surface water in the province. Priority is given to rivers affected by populated centres and locations where water quality might be threatened. Saskatchewan collects data from 15 regularly monitored stations that test for 70 pollutants (there are numerical guidelines for some of these pollutants only). Sites are monitored on a monthly basis for nutrients, salts, and bacteria, on a quarterly basis for metals, and three times per year for certain pesticides. Saskatchewan continues to monitor for long-term trends, and admits that this data cannot be considered reflective of overall water quality, but gives instead a "snap shot" of water quality in the major rivers of southern and central Saskatchewan (Hallard 1997).

Manitoba

Manitoba's goal in monitoring water quality 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, the water quality index developed by British Columbia; as applied by Manitoba, this index considers 25 key variables. Manitoba monitors up to 70 water-quality variables at 35 sites located on 28 rivers and lakes. 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 (Williamson 1996). Manitoba is particularly concerned about the effects on water quality of the larger facilities for intensive production of livestock and value-added food processing facilities. Programs are underway to reduce the impact of food-processing waste and to assist the irrigating community in developing sustainable irrigation practices. Flooding of the Red River in 1997 slightly elevated fecal coliform levels and there were trace concentrations of several organics; nevertheless, bacterial levels remain relatively low at all sites (Williamson 1997).

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 from 10 to 200 variables of water quality at thousands of sites. 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 (Gemsa and Whitehead 1996).

Quebec

Quebec does not set water quality objectives. Instead, point sources are studied to determine the nature of local or regional use of a water body and how it must be preserved or restored. Goals can vary from one site to the next on the same river as the use of that river changes. Nearly 350 sites, measuring nitrogen, phosphorous, fecal coliforms, pH, turbidity, and suspended solids, are monitored once a month. As well, biological surveys and measurements of toxic chemicals in fish, artificial substrates, and water are conducted on a monthly basis. Quebec is currently revising the content of their reports pertaining to the principal rivers. Since 1978, Quebec has committed more than $5 billion towards improving waste-water treatment and, by 1998, about 98 percent of the population with access to a sewer system will have its waste water treated (Gouyin 1997).

New Brunswick

New Brunswick is currently writing its own site-specific objectives but, at the moment, data is cross-referenced with the *Canadian Water Quality Guidelines* for aquatic life. New Brunswick examines 32 variables in various lakes and rivers throughout the province. Data is collected from base-line stations providing data over the long term, stations providing background information for specific projects in the short term, and downstream stations measuring the effects of point and non-point sources of pollutants. Natural waters in many areas tend to be poor in nutrients (especially, phosphorous) and acidic—some natural pH values fall below the *Canadian Water Quality Guideline* of pH 6.5. Naturally high levels of aluminum and iron often exceed the guidelines (Choate 1997).

Newfoundland

Newfoundland monitors up to 35 water-quality variables at approximately 56 sites located on rivers and lakes throughout the province. The goals of the monitoring program include collecting data on background and ambient water quality of major rivers and basins, detecting and measuring trends in water quality, and assessing fresh-water aquatic health and the suitability of water for various beneficial uses. Newfoundland maintains its own water-quality database, which is updated every two to three years. A report, the *State of Water Quality in Newfoundland*, based on the water quality index developed by British Columbia, is currently under preparation (Goebel 1997).

Nova Scotia

Nova Scotia follows the *Canada Water Quality Guidelines* but has not set site-specific objectives. They do not perform ambient monitoring but use short-term projects to monitor and improve the water in problem areas. Residents rely equally on surface and ground water for drinking and Nova Scotia's drinking water is generally good. Concerns specific to certain areas arise primarily due to mining and industrial activity (Cameron 1996).

Prince Edward Island

Prince Edward Island has not established water-quality guidelines of its own but uses the national water-quality criteria as developed and maintained by CCME. Currently 26 sampling sites are located in six watersheds. Residents of Prince Edward Island rely exclusively on ground water for drinking water, which is judged according to national guidelines developed jointly by Health Canada and the provinces. In 1996, "Evaluation and Planning of Water Related Monitoring Networks on PEI" was incorporated into a new agreement, the *Canada-PEI Water Annex to the Federal/Provincial Framework Agreement for Environmental Cooperation in Atlantic Canada*, between Environment Canada and the province's department of Fisheries and Environment. In January 1996, Prince Edward Island signed an agreement with the federal government to establish a Watershed Inventory Project that will examine 12 watersheds incorporating 26 rivers. New initiatives include a new multi-year program to sample drinking water for pesticides according to several parameters, and the release of an educational booklet entitled *Water on PEI: Understanding the Resource, Knowing the Issues* (Raymond 1996).

Yukon

The federal department of Indian Affairs and Northern Development (DIAND) manages the water resources of the Yukon Territory. Water-quality objectives have not been set for any water bodies as most water bodies in the region are considered pristine. DIAND and Environment Canada jointly operated 19 monitoring stations in 1996. Baseline monitoring of rivers and streams was ended in September 1996 in preparation for the end of the Arctic Environmental Strategy of the Canadian government's *Green Plan*. Raw data is collected but due to budgetary constraints, it has not been correlated into readable information. Prevention of pollution through enforcement of water-use licenses is the sole strategy used to maintain water quality. Most communities treat sewage in lagoons, discharging it to ground or wetlands; two communities discharge treated sewage to surface water. There are two mines in operation; one of these, a tank-leach gold mine, has difficulty meeting licensed effluent conditions (Whitley 1997).

Northwest Territories

The water-quality objectives of the Northwest Territories comply with the CCME water-quality guidelines and site-specific water-quality objectives. The federal department of Indian Affairs and Northern Development and the Territory's Department of Environment currently co-operate in maintaining 50 active federal, federal-territorial, and territorial stations that monitor water quality. 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 (Haliwell 1997).

Effective April 1, 1999, the Northwest Territories will be divided into two separate territories. The eastern territory, Nunavut, will be 2,000 kilometres wide and 1,800 kilometres deep. Eighty-four percent of its population will be Inuit. How this political division will affect the collection of data is not yet clear.

The Great Lakes

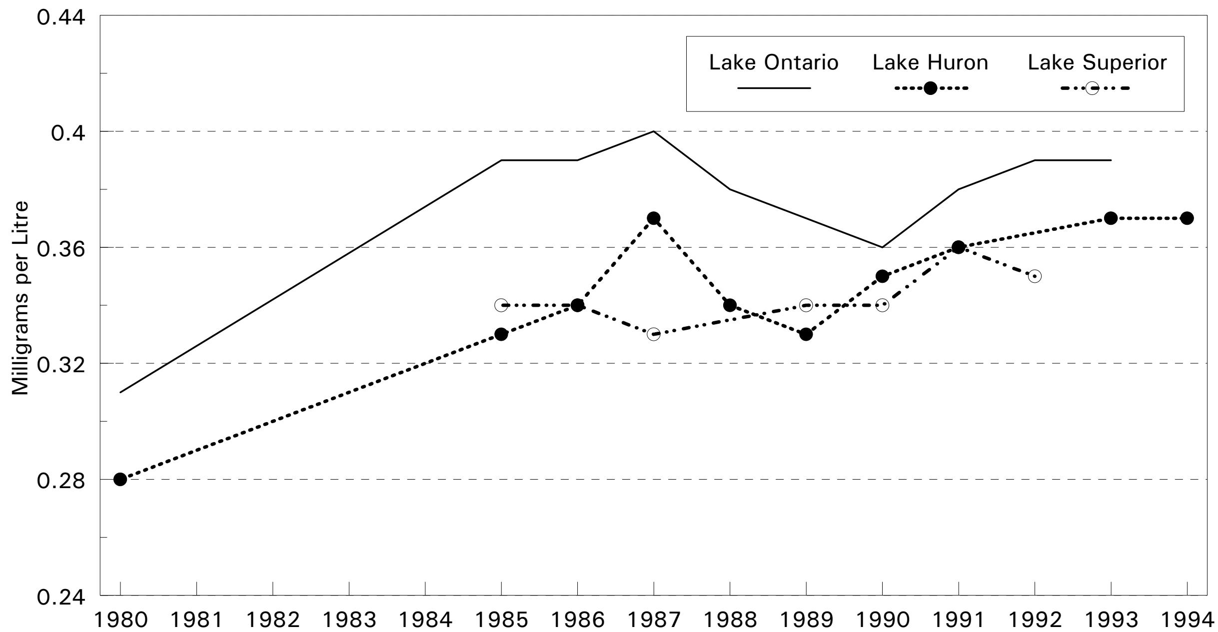
The Great Lakes (from west to east, Lakes Superior, Michigan, Huron, St. Clair, Erie and Ontario) contain one-fifth of the world's freshwater. Over 23 million people depend on the Great Lakes for drinking water, which provide tremendous economic and ecological benefits to the surrounding area. One quarter of all American industry and 70 percent of American and 69 percent of Canadian steel mills are located in the Great Lakes Basin (USEPA 1995e: 496). The Great Lakes are exposed to many sources of point and non-point pollution but it was thought for many years 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 (Hayward 1994: 23). These efforts have improved water quality. Although discharges from waste-water treatment plants have increased due to population growth and industrial development, levels of dissolved oxygen have steadily improved, resulting in cleaner discharge. There have been noteworthy reductions in organic material, solids, and phosphorus as well. Fish have returned to some harbours from which they had all but disappeared, and the number of double-crested cormorants, a water bird that all but vanished from the Great Lakes in the 1970s, has climbed to 12,000 nesting pairs (USEPA 1995e: 497).

The USEPA's *National Water Quality Inventory* states that "less visible problems continue to degrade the Great Lakes." Six of the eight American states bordering upon the Great Lakes surveyed 94 percent of the Great Lakes' shorelines in 1994. These states reported that most of the Great Lakes' nearshore waters were safe for swimming and other recreational activities, and could be used as a source of drinking water with normal treatment. However, about 97 percent of the surveyed Great Lakes shoreline is subject to fish-consumption advisories and shows unfavourable conditions for supporting aquatic life (USEPA 1995e: 497). The pollutants were "primarily PCBs," which impaired 98 percent of the shoreline. PCBs are a bioaccumulative pollutant and, since the 1980s, have only been allowed in closed electrical equipment. So, although PCBs are of concern as a pollutant, it is important to note that they are not coming from new sources.

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 America on the production of products using chlorine chemicals. The data, however, reveal several encouraging trends in the water quality of the Great Lakes, particularly for harmful chlorine compounds. Nitrogen levels have increased but are still well below the threshold of 10 milligrams per litre for safe drinking water (figure 24). Phosphorus levels have declined by one-third in Lake Ontario, 80 percent in Lake Huron, and have remained stable in Lake Superior (figure 25). Phosphorus targets have been met consistently in Lake Michigan since 1981 and in Lake Superior since 1985; for the most part Lakes Huron, Erie, and Ontario have also met their targets since 1986, 1987, and 1988 respectively (figure 26).[18]

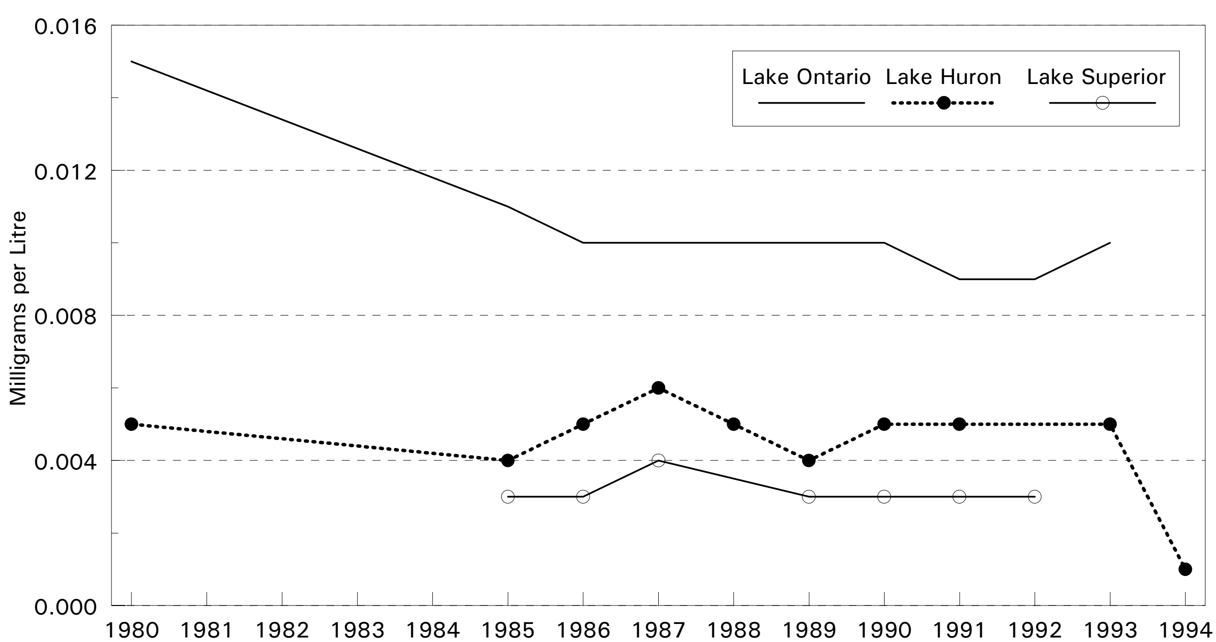
Another important indicator of water quality in the Great Lakes is the pesticide contamination found in birds' eggs. The contamination of herring gull eggs fell considerably between 1974 and 1991. Levels of Dichloro-diphenyl-dichloro-ethylene (DDE)[19] fell 90.2 percent in Lake Ontario and 89.2 percent in Lake Superior from peak levels in 1975 (figure 27). Available data also indicate a decrease in the already low levels of the pesticides Dieldrin and Mirex in herring gull eggs. Polychlorinated biphenyls (PCBs)[20] fell 91.1 percent in Lake Ontario, 87.4 percent in Lake Huron, 85.4 percent in Lake Superior, 80.3 percent in Lake Michigan, and 67.5 percent in Lake Erie from their highest recorded levels (figure 28). The level of hexachloro-benzenes (HCBs)[21] peaked in 1977 and fell 97.5 percent in Lake Ontario, 91.9 percent in Lake Erie, and 87.5 percent in Lake Michigan by 1995. Lakes Superior and Huron fell 92.3 percent and 92.1 percent respectively between 1974 and 1995 (figure 29). These favourable trends can be observed in others of the Great Lakes as well (Council on Environmental Quality 1996).

Figure 24: Water Quality in the Great Lakes (Nitrogen)



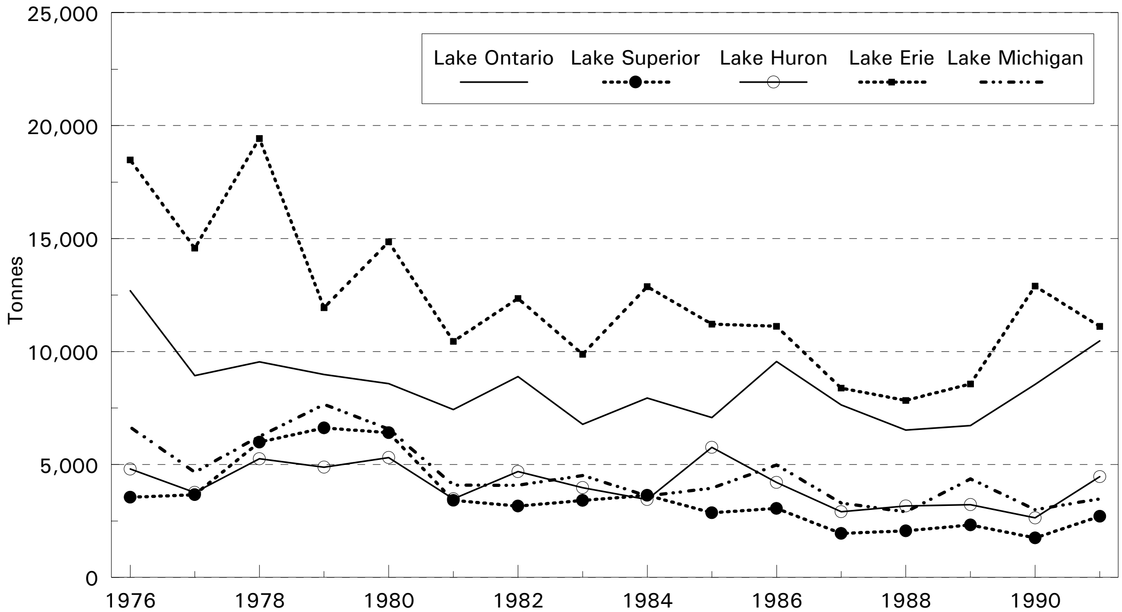
Source: OECD 1997.
Note: No data for 1981–1984. Data are not available for Lakes Erie and Michigan.

Figure 25: Water Quality in the Great Lakes (Phosphorus)



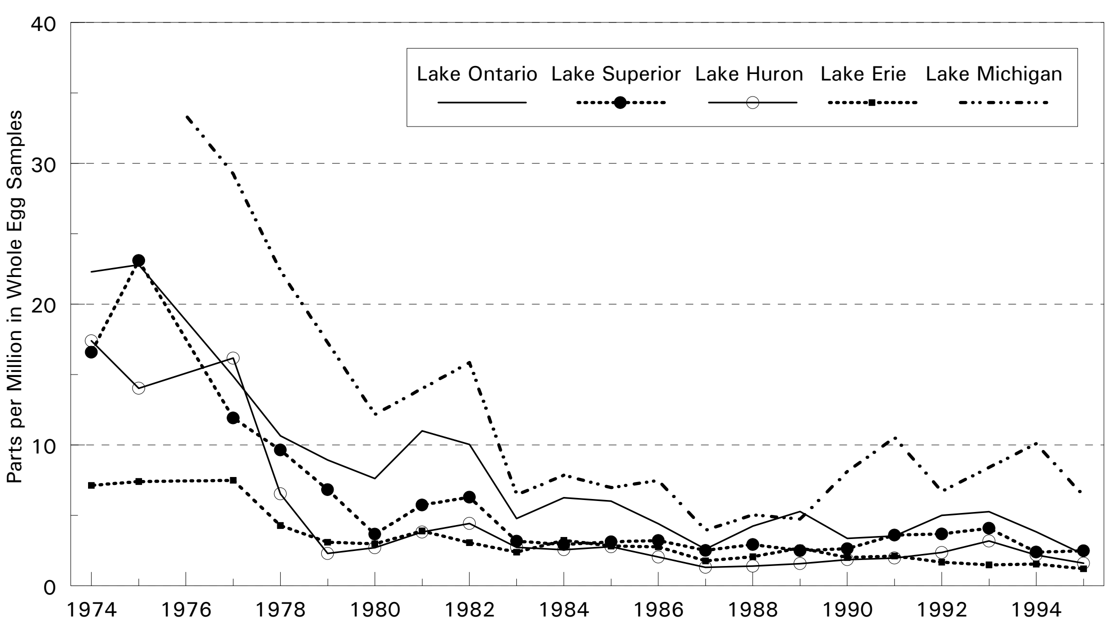
Source: OECD 1997.
Note: No data for 1981–1984. Data are not available for Lakes Erie and Michigan.

Figure 26: Industrial Discharge of Phosphorus into the Great Lakes



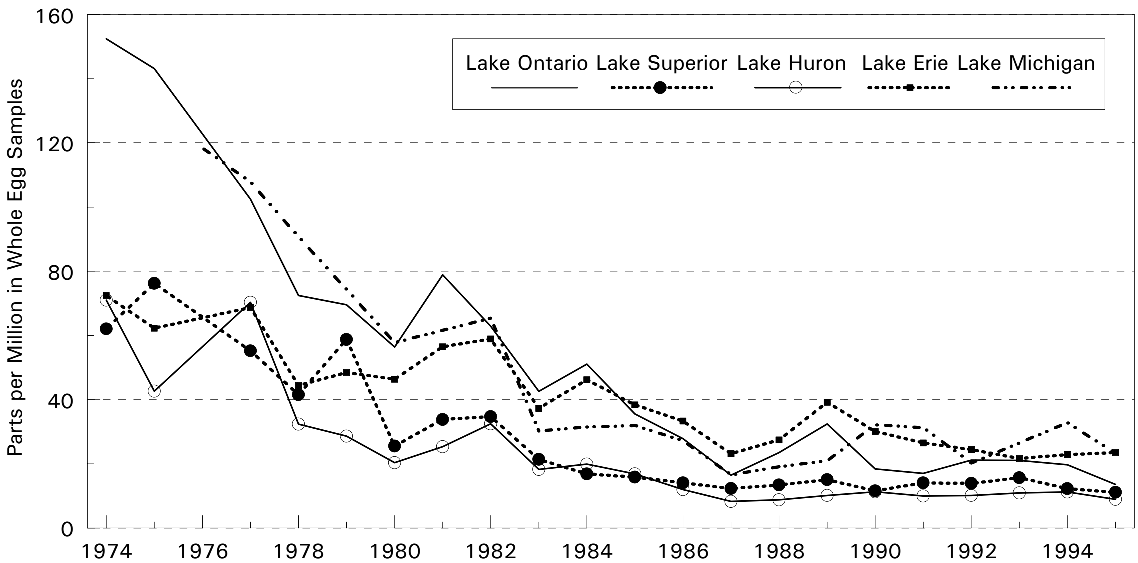
Source: Council on Environmental Quality 1996.

Figure 27: DDE Levels in Herring Gull Eggs in the Great Lakes



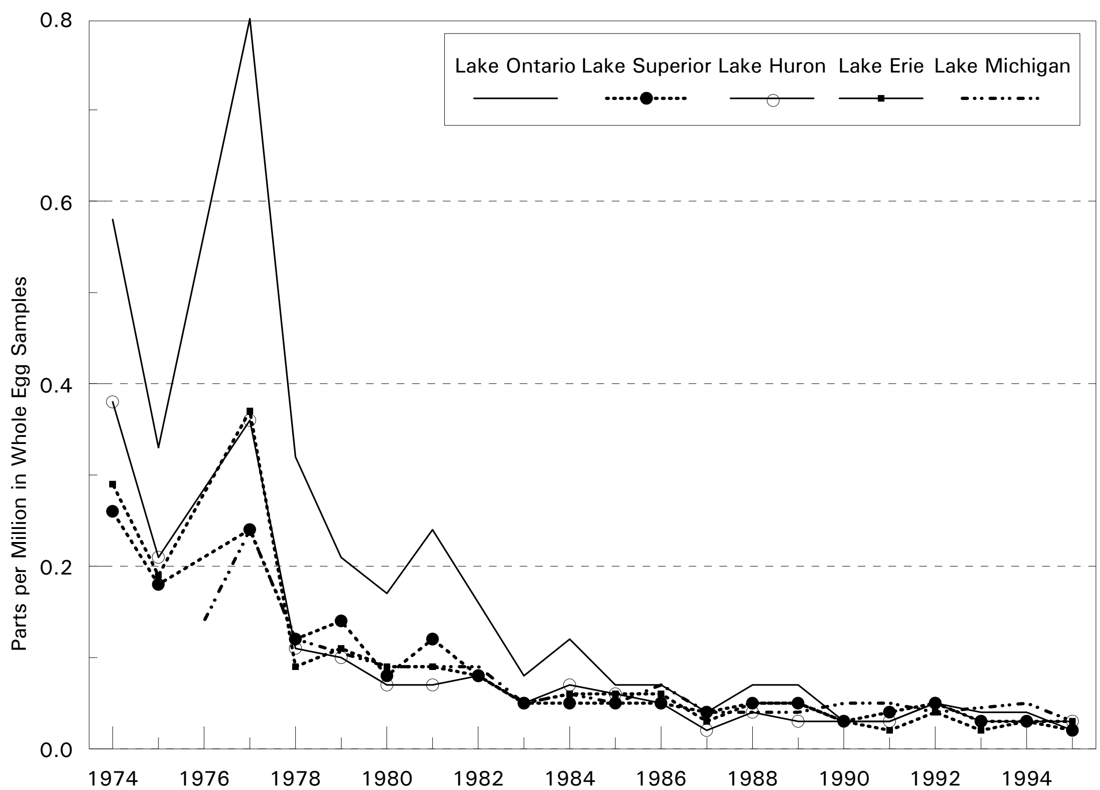
Source: Council on Environmental Quality 1996.
Note: DDE = dichloro-diphenyl-dichloro-ethylene

Figure 28: PCB Levels in Herring Gull Eggs in the Great Lakes



Source: Council on Environmental Quality 1996.
Note: PCBs = Polychlorinated biphenyls.

Figure 29: HCB Levels in Herring Gull Eggs in the Great Lakes



Source: Council on Environmental Quality 1996.
Note: HCB = hexachloro-benzene.

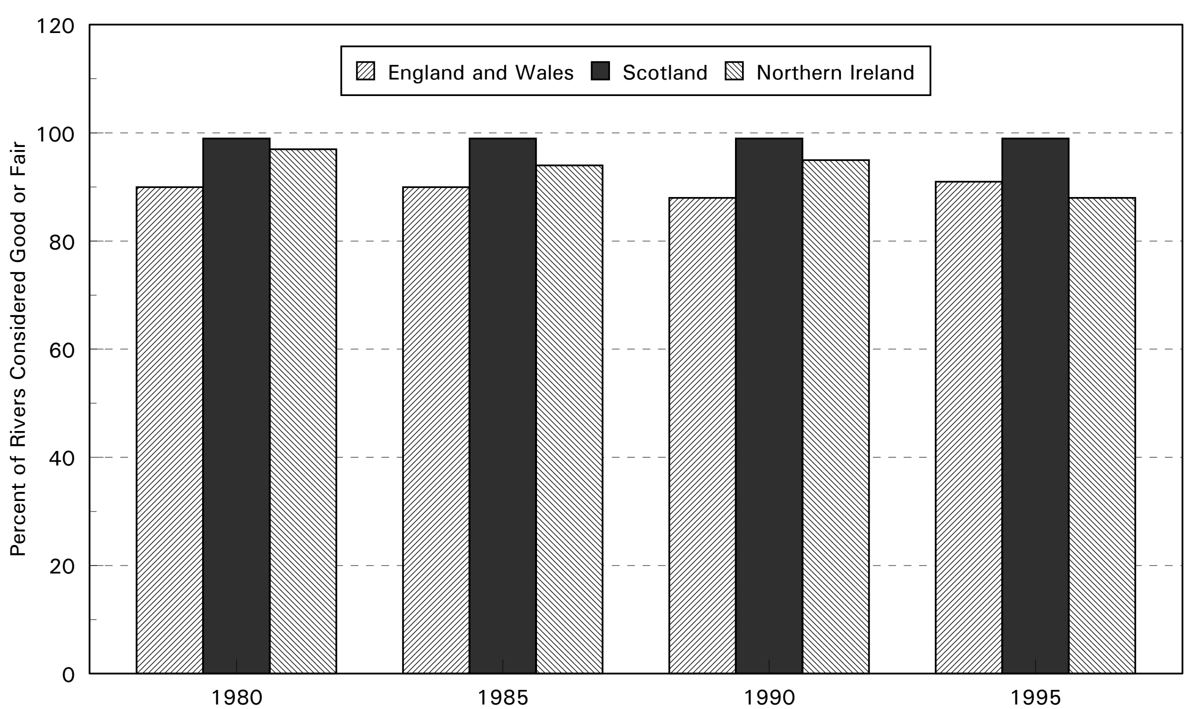
The United Kingdom

The United Kingdom's Department of Environment, of Transport and the Regions (UKDETR) routinely reports the results of a series of national surveys monitoring the quality of water in the rivers and canals of England, Wales, Scotland, and Northern Ireland. (UKDETR 1998d). A *General Quality Assessment* (GQA) system is used to classify water quality into categories based on chemical grade (biochemical oxygen demand, dissolved oxygen, and ammonia) from A (for the highest water quality) to F (for water quality which is of lowest quality). Assessments are also currently underway for biological grading (comparing the number of tiny animal species at sites against the range of those species that might be expected if the sites were in a pristine, unpolluted condition). Future indicators may include aesthetics and nutrients (UKDETR 1998d).

Regular monitoring of the chemical and biological composition of the water in rivers and canals provides general information about water quality. Three chemical characteristics are measured: dissolved oxygen, biochemical oxygen demand, and ammonia. Biological quality is assessed by comparing the number of tiny species (*i.e.* macro-invertebrates that live in or on the bed of the river) present in a body of water to how many species one would expect to find if there was no pollution (UKDETR 1998a: 65–66). Figure 30 shows the chemical quality of rivers and canals between 1980 and 1995. As of 1995, 91 percent of rivers and canals in England and Wales were considered of "good" or "fair" quality. In Scotland 99 percent and, in Northern Ireland, 88 percent of rivers and canals were assessed as "good" or "fair" (UKDETR 1998a). The biological quality of rivers and canals in the United Kingdom is also fairly high. In 1995, 93 percent of rivers and canals in England and Wales, 98 percent in Scotland, and 100 percent in Northern Ireland were considered "good" or "fair" quality (see figure 31).

Data from the Organisation for Economic Cooperation and Development are available for a variety of indicators of water quality for rivers and lakes in the United Kingdom (see figures 32–36). Cadmium levels fell 90 percent and 99 percent in the Thames and Severn rivers respectively between 1980 and 1995. In the Clyde river, cadmium levels increased 9 percent and, in Mersey river, 37 percent between 1980 and 1995. Chromium and copper levels have fallen dramatically in all four rivers. For example, copper levels in the Thames River fell 32 percent between 1980 and 1995.

Figure 30: Chemical Quality of Rivers and Canals, 1980–1995

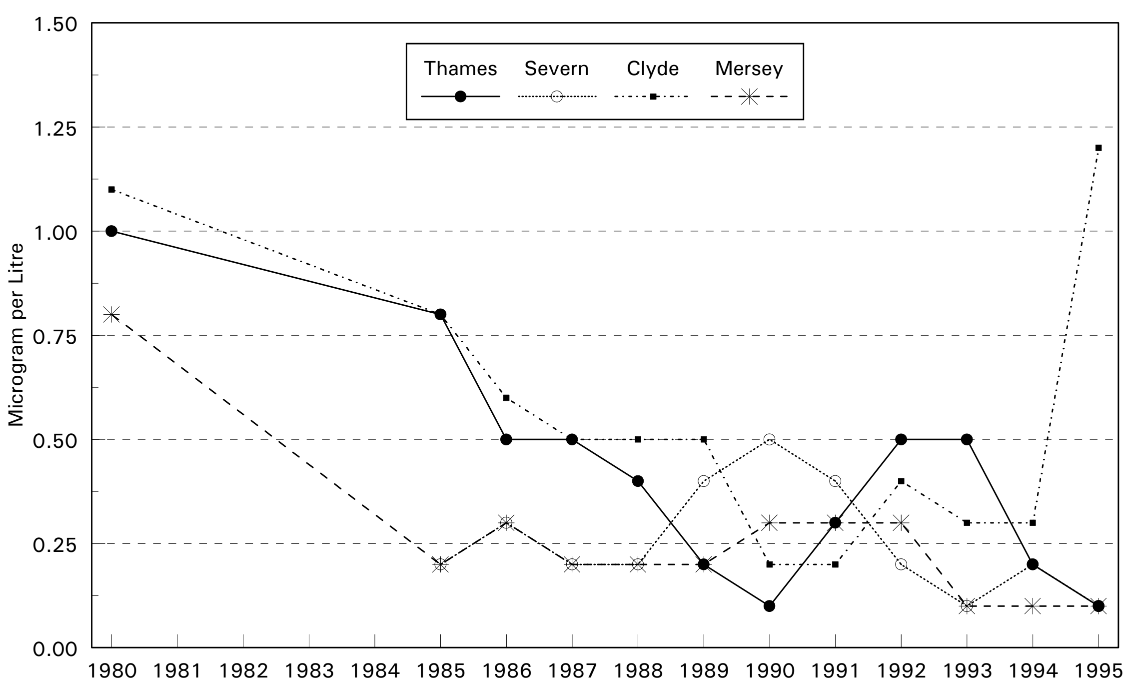


Source: UKDETR 1998a.

Figure 31: Biological Water Quality of Rivers and Canals, 1990–1996

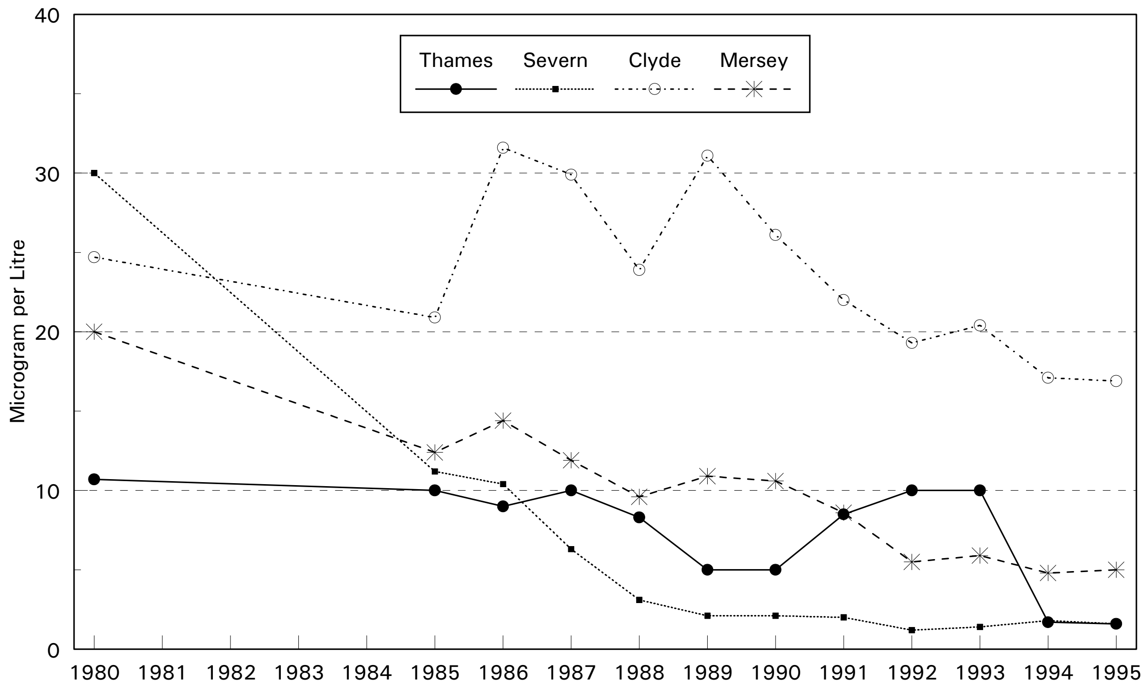
Source: UKDETR 1998a.

Figure 32: Water Quality of Selected Rivers in the United Kingdom (Cadmium)



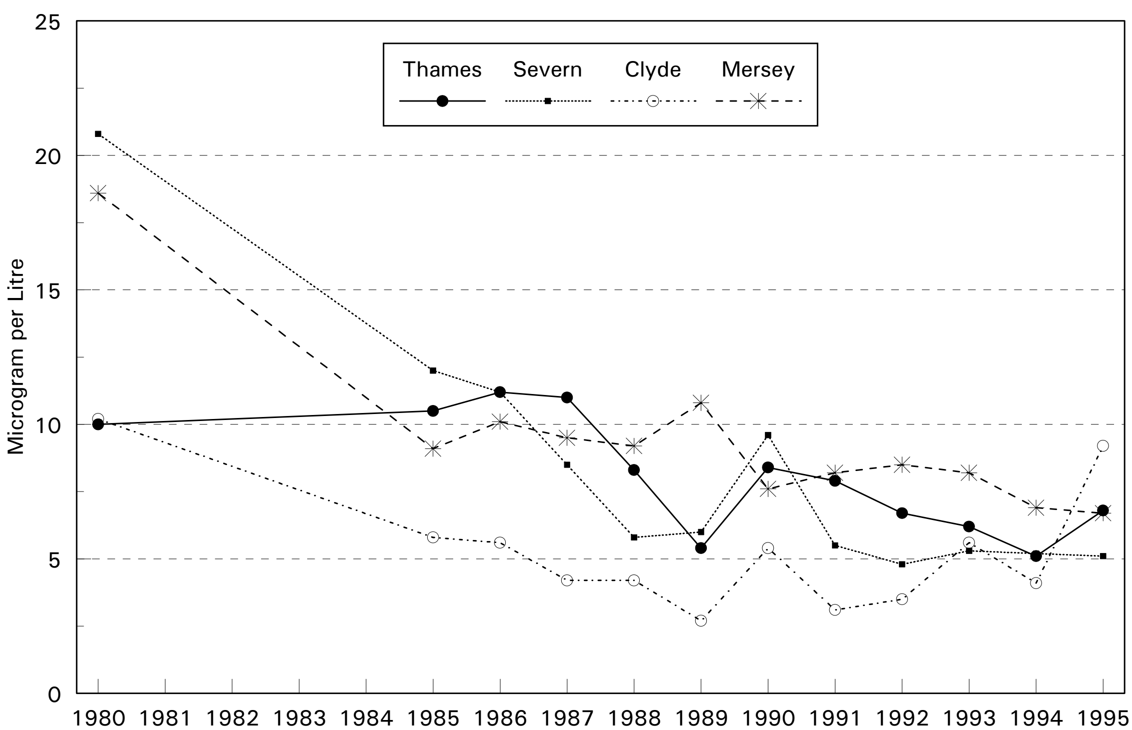
Source: OECD 1997. The OECD reports a reading of 10 μg/litre for the Severn in 1980.

Figure 33: Water Quality of Selected Rivers in the United Kingdom (Chromium)



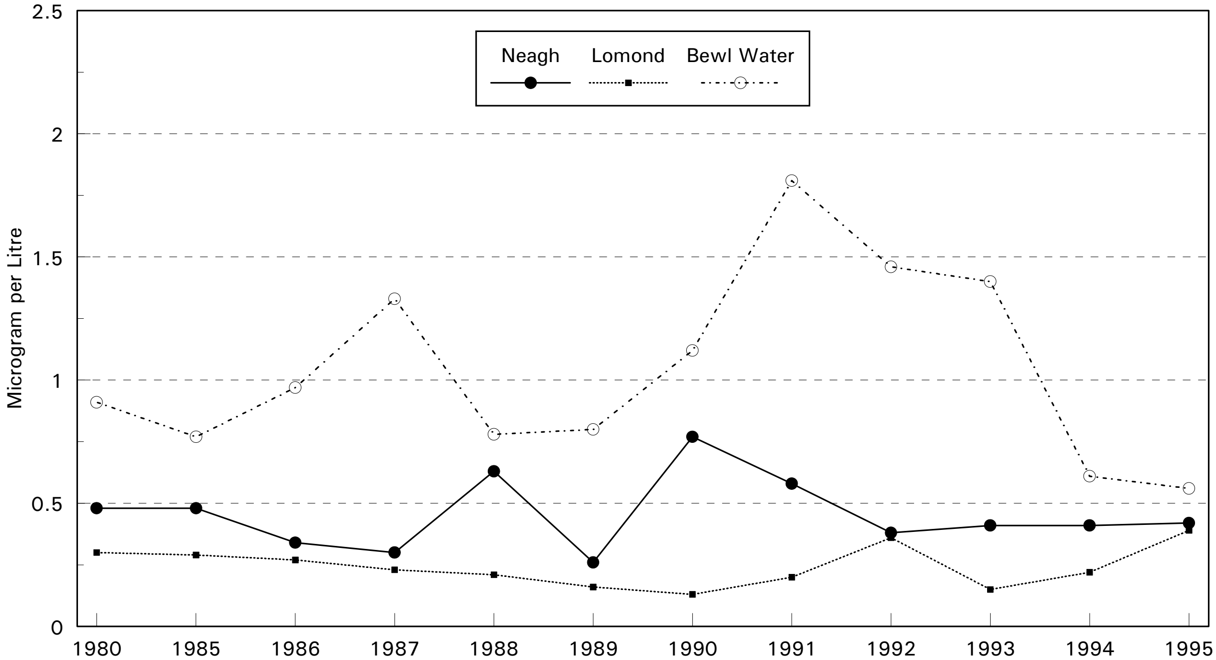
Source: OECD 1997.

Figure 34: Water Quality of Selected Rivers in the United Kingdom (Copper)



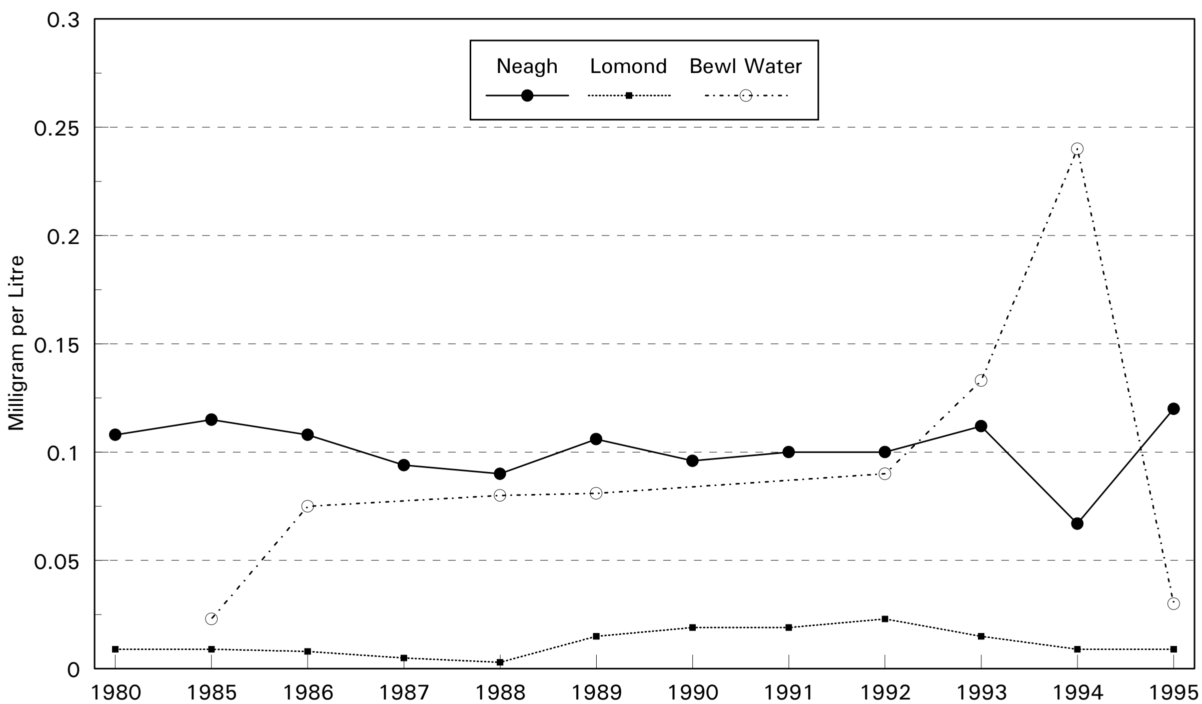
Source: OECD 1997.

Figure 35: Water Quality of Selected Lakes in the United Kingdom (Nitrogen)



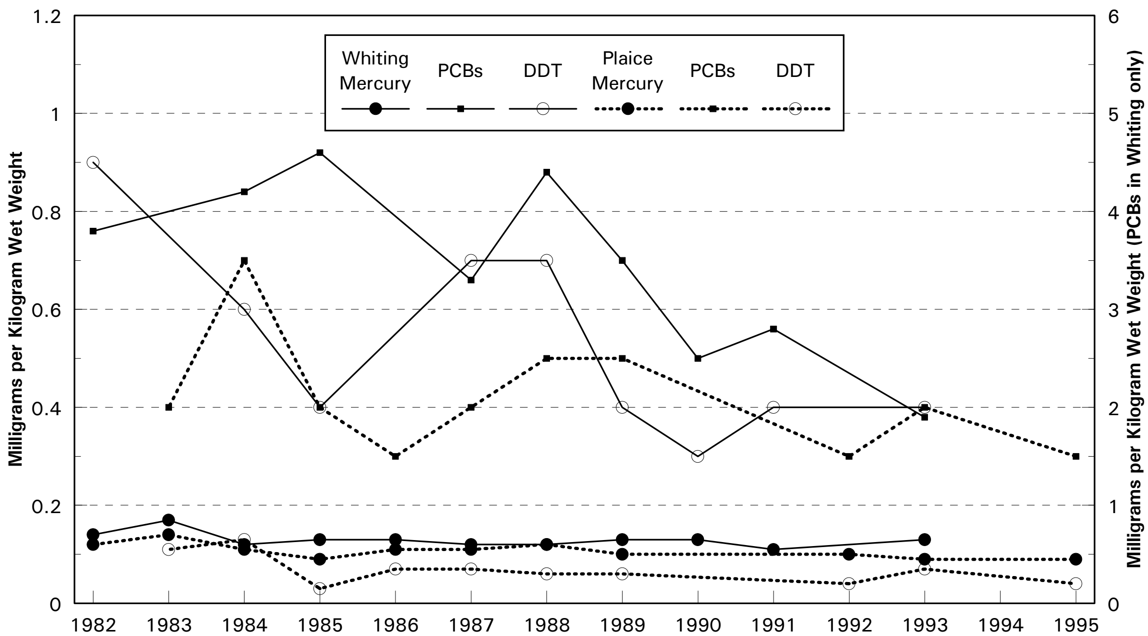
Source: OECD 1997.

Figure 36: Water Quality of Selected Lakes in the United Kingdom (Phosphorus)



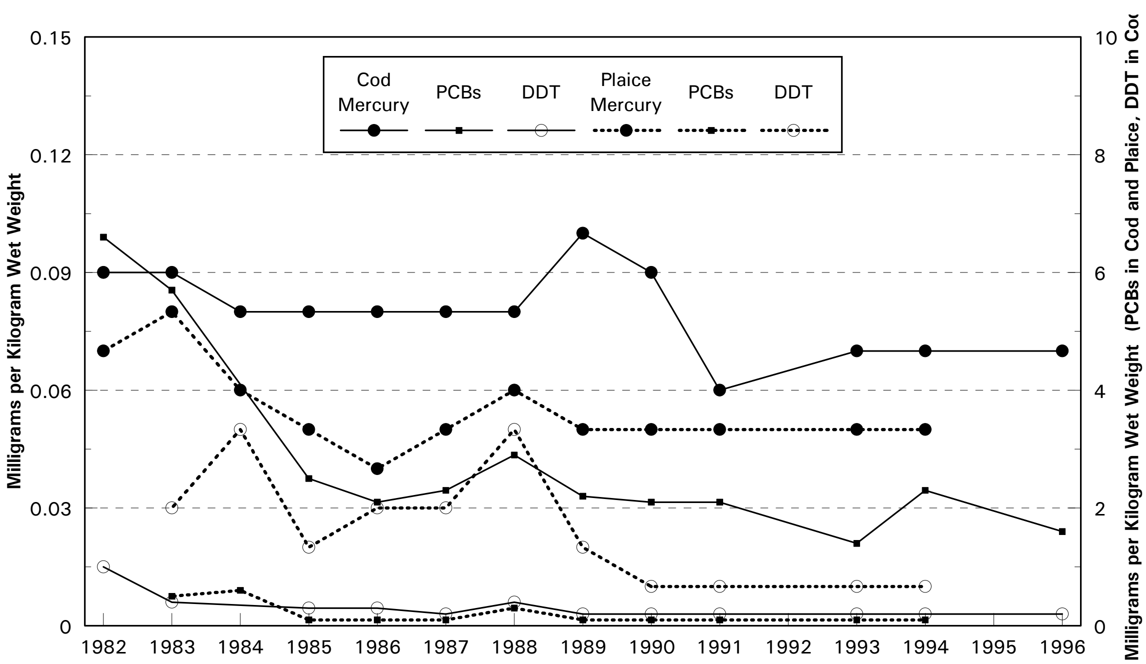
Source: OECD 1997.

Figure 37: Contaminants in Whiting and Plaice in the Irish Sea



Source: UKDETR 1998a.

Figure 38: Contaminants in Cod and Plaice in the North Sea



Source: UKDETR 1998a.

Water quality in the three lakes included in the OECD report show mixed trends. Nitrogen levels in Lake Neagh and Bewl Water have decreased. Nitrogen levels in Lomond have increased slightly. Phosphorus levels in Lake Neagh and Bewl Water have increased slightly while levels in Lomond lake have remained the same.

The statistics available show modest to significant declines in the amount of toxic chemicals in fish in the North Sea and Irish Sea. In the Irish Sea, for example, PCBs found in whiting declined 50 percent between 1982 and 1993 and mercury levels in plaice declined 25 percent between 1982 and 1995 (figure 37). In the North Sea, mercury levels in cod declined 22 percent and DDT levels in cod declined 80 percent between 1982 and 1996 (figure 38).

Twenty-nine private companies supply drinking water to residents in the United Kingdom. These private companies supply about 16,800 million litres of water drawn from rivers, reservoirs and wells. Water quality is monitored by a grid system to ensure that any contamination of the water system will remain in a contained area (Drinking Water Inspectorate: 1) The government has set up some 55 standards, which the water companies must follow to ensure that they pass government safety standards. A survey of British water companies shows that 99.7 percent of all drinking water in the United Kingdom meets government safety standards. This is a small increase over the results in 1992, when just over 98 percent were approved, and the government in the United Kingdom is aiming to have 100 percent of water tested meet the government standards. (UKDETR 1998c: 2)

Mexico

In Mexico, the National Water Commission (CNA), established in 1989, has authority over water management, including inspection and enforcement of regulations.

The quality of surface water and ground water is monitored and classified according to a water-quality index that considers 18 parameters such as oxygen-demanding substances, nutrients, and bacteria and defines six quality classes (OECD 1998: 58). Monitoring is carried on near developed areas in 24 of Mexico's 37 hydrological regions. Only a few areas monitored was the water rated excellent or acceptable, the upper two classes of water quality and waters in most regions were rated as polluted or strongly polluted (OECD 1998: 58). Recent evidence, however, indicates that water quality in Mexico is beginning to improve. For example, Lake Chapala, Mexico's largest lake, has seen a 65 percent reduction in pollution levels in recent years (OECD 1998: 58).

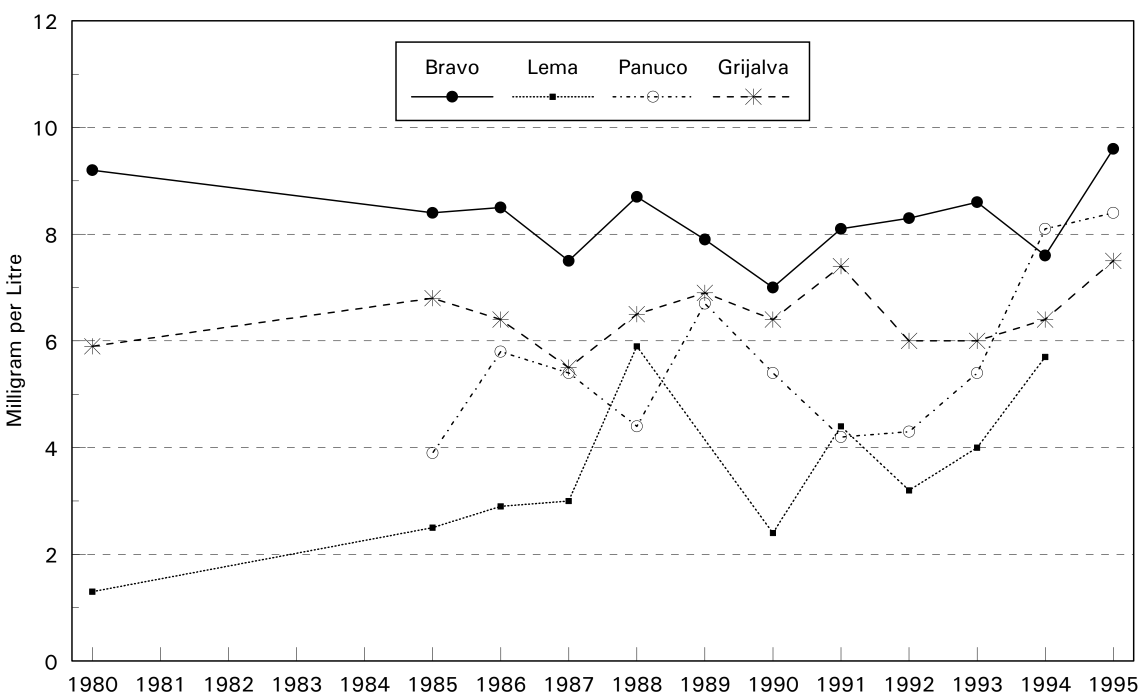
Data collected by the OECD on the water quality of Mexican rivers shows mixed trends. Nitrate levels in the Grijalva river fell 90 percent between 1986 and 1995. In the Lema river, nitrates fell 23 percent between 1980 and 1994. In the Panuco river, nitrates fell 12 percent between 1985 and 1995. In the Bravo river, however, nitrates increased 30 percent between 1985 and 1995 (see figure 39). Dissolved oxygen levels have improved in all four rivers (see figure 40). Phosphorus levels in the Lema, Punuco, and Grijalva rivers have increased while levels in the Balsas have decreased (see figure 41). Copper levels in the Panuco decreased 50 percent between 1989 and 1993 (see figure 42). Ammonium levels in the Bravo, Panuco, and Grijalva rivers declined while levels in the Panuco river increased (see figure 43).

The limited data available for lakes in Mexico show some improvement and some deterioration in quality. Nitrogen levels in the Chapala Lake increased 9 percent between 1980 and 1994 while nitrogen levels in the Catemaco decreased 88 percent between 1987 and 1995 (see figure 44). Phosphorus levels in Lake Chapala increased by 14 percent between 1980 and 1994 while phosphorus levels in Lake Patzcuaro and Lake Catemaco decreased between the late 1980s and mid-1990s (see figure 45).

Figure 39: Water Quality of Selected Rivers in Mexico (Nitrates)

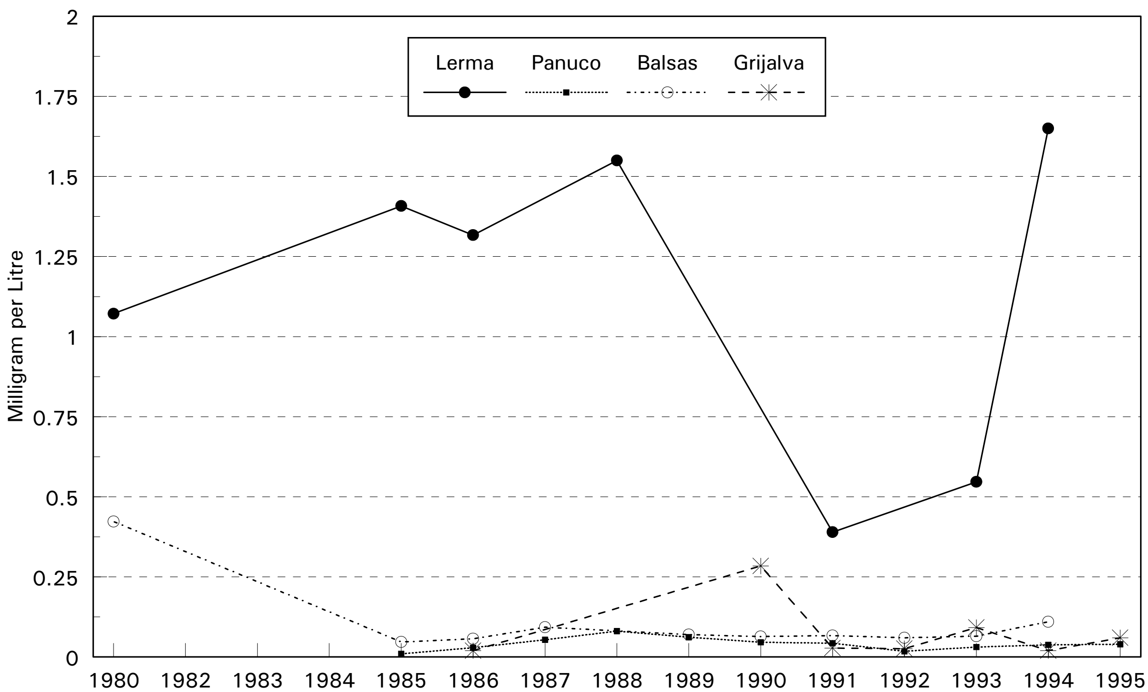
Source: OECD 1997.

Figure 40: Water Quality of Selected Rivers in Mexico (Dissolved Oxygen)



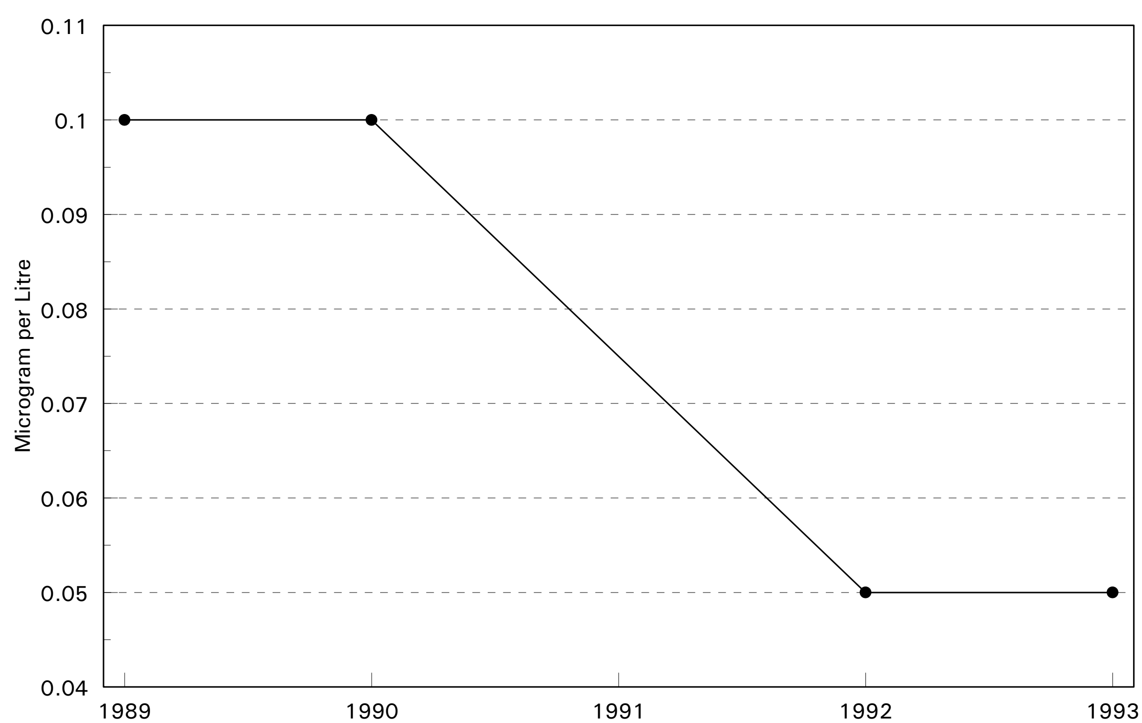
Source: OECD 1997. Data available only for points shown on graph.

Figure 41: Water Quality of Selected Rivers in Mexico (Phosphorus)



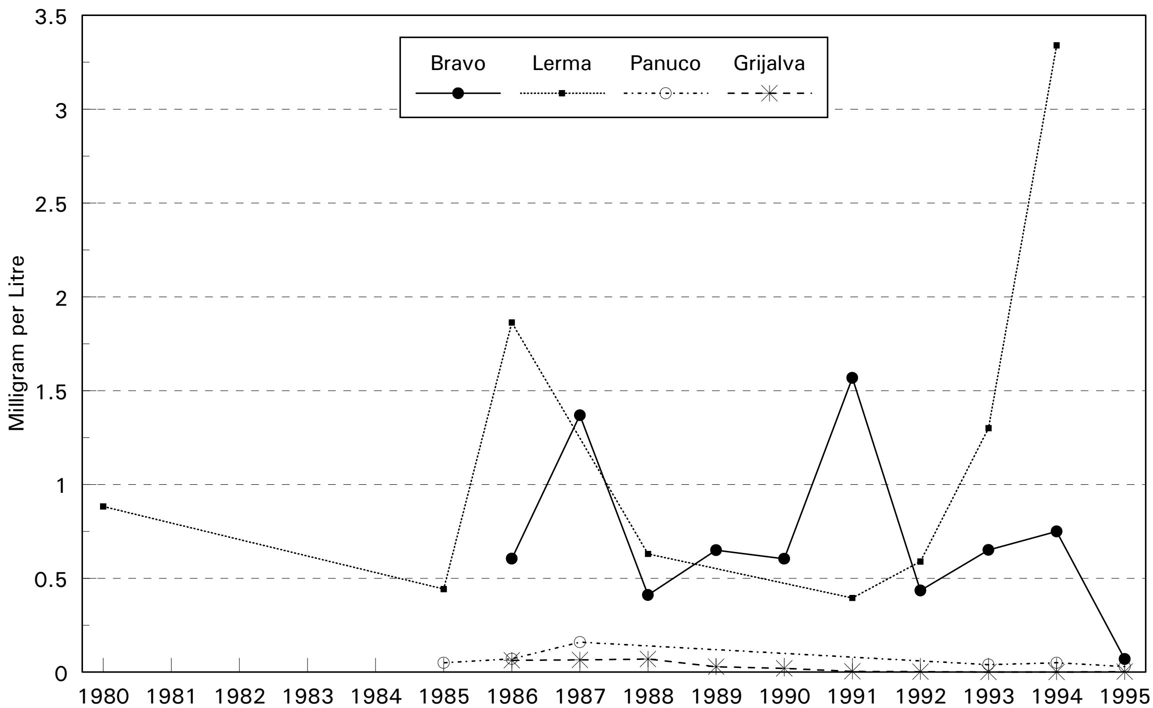
Source: OECD 1997; data available only for points shown on the graph.

Figure 42: Water Quality of the Panuco River in Mexico (Copper)



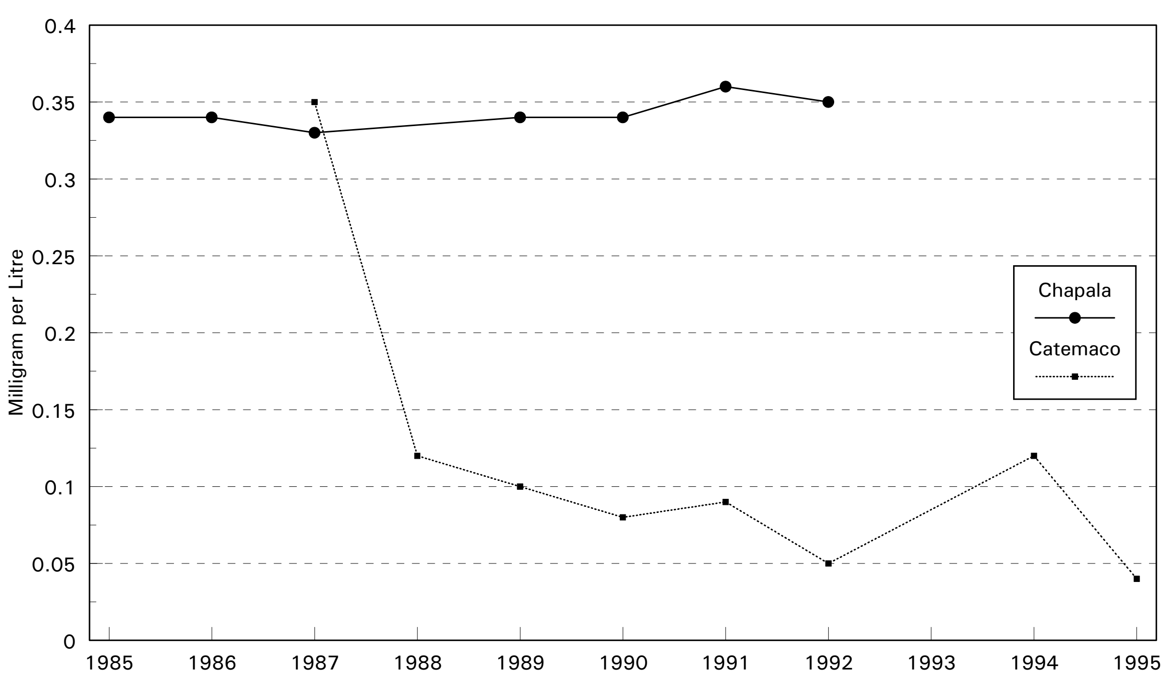
Source: OECD 1997.

Figure 43: Water Quality of Selected Rivers in Mexico (Ammonium)



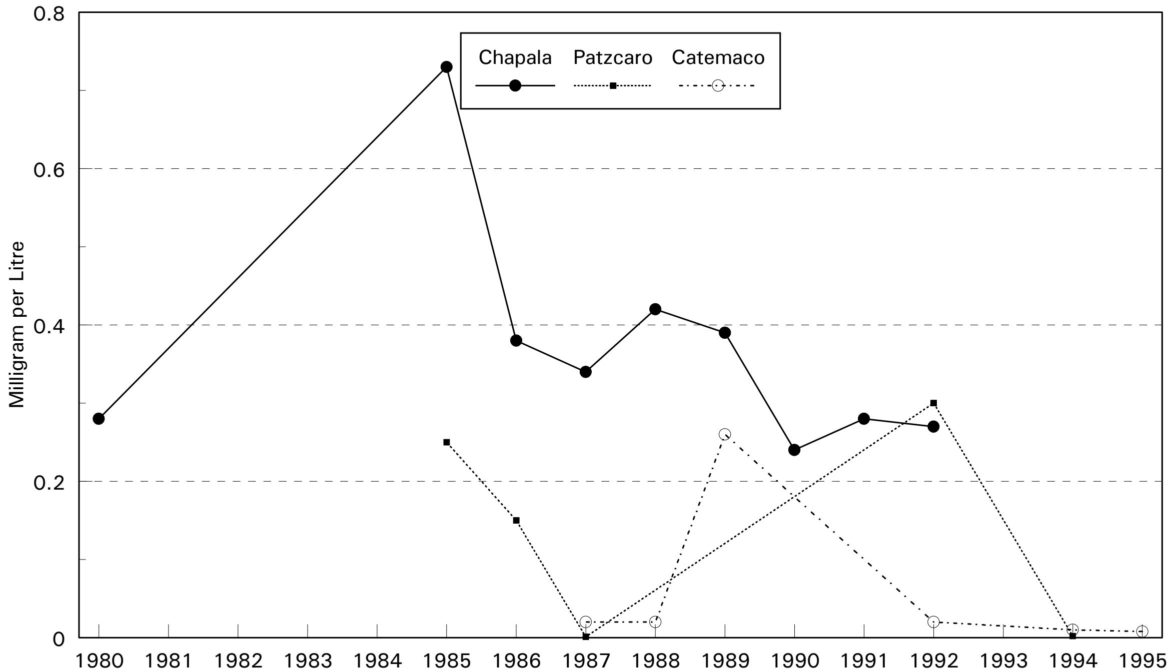
Source: OECD 1997.

Figure 44: Water Quality of Selected Lakes in Mexico (Nitrogen)



Source: OECD 1997.

Figure 45: Water Quality of Selected Lakes in Mexico (Phosphorus)



Source: OECD 1997.

Natural resource use

Forests

Forests are the subject of some of the most emotionally charged environmental controversies. The fear that we shall 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." Debate in Mexico surrounds the southern rain forests. The most diverse ecosystems on earth, rain forests are thought to contain many undiscovered medicines. Concern in Canada and the United Kingdom, as in many countries, focuses upon forestry's impact on ecology and landscape.

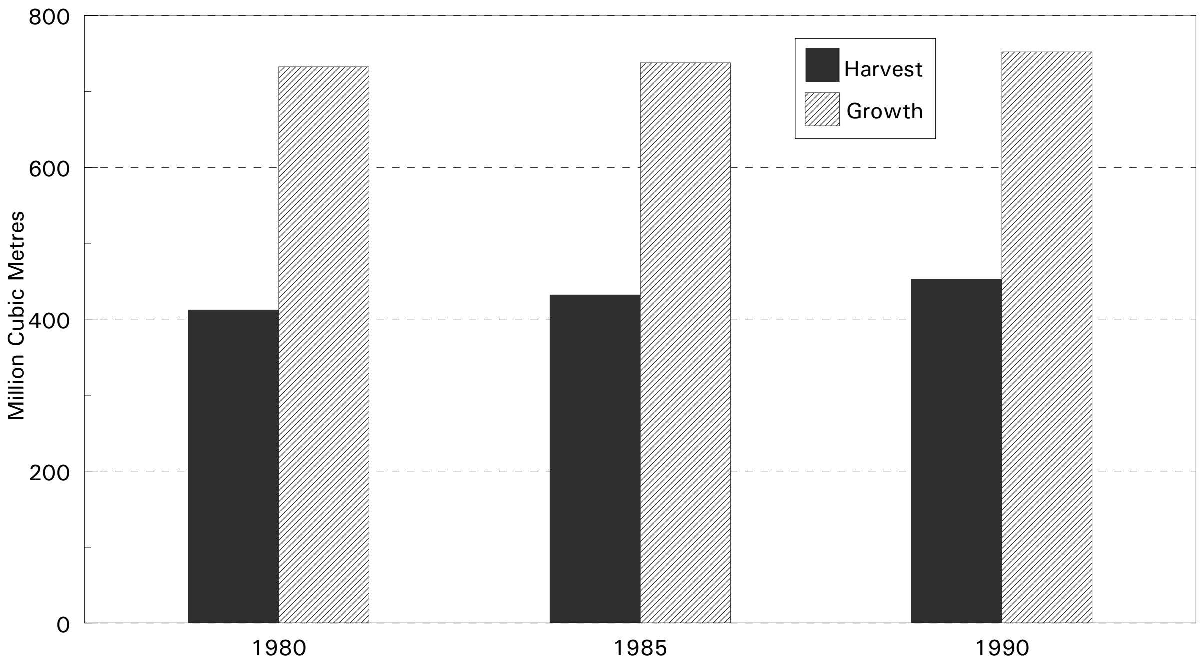
Forests provide habitat, purify air, prevent run-off, and inhibit erosion by anchoring topsoil. Forests release water vapour into the air and play a critical role in the carbon cycle by absorbing CO_2, storing the carbon, and releasing the oxygen. North America's diverse forest resources include over 130 species of trees and sustain a wide variety of plants and animals (Environment Canada 1991c: [10]4).

Canada and the United States play a significant role in world timber markets. In 1995, American and Canadian production provided over 50 percent of global wood pulp, over 25 percent of paper and paperboard, over 15 percent of wood-based panels, and almost 40 percent of other wood products.[22] Despite the Asian financial crisis, the global demand for North American forest products is large and likely to remain so. The industry is a primary contributor to regional economies: one in 15 workers in Canada is employed directly or indirectly by the forestry sector (Environment Canada 1996c).

Despite this strong commercial reliance upon the forests, only a small portion of total forest resources is harvested each year in Canada and the United States. Environment Canada reports that of the country's 418 million hectares of forestland, 119 million hectares are accessible and actively managed for timber production. A mere 0.8 percent of managed forests are harvested per year, averaging 165 million cubic metres of harvested timber, with each cubic metre contributing $95 to the Gross Domestic Product of Canada (Environment Canada 1996c). In Canada, 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, sensitivity of the site, 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 66.1 percent in 1980; it climbed to 79.8 percent in 1985 and fell to 73.4 percent in 1993 (figure 46). Data collected by the Organisation for Economic Cooperation and Development (OECD) show that the United States consistently harvests less than the amount of annual new growth (figure 47). The United States harvested 56 percent of the annual new growth in 1980, 59 percent in 1985, and 60 percent in the early 1990s. Forests in the United Kingdom have been expanding since the introduction of the forest expansion program after the World War I. In 1970, there was 1.8 million hectares of land covered by trees, increasing to 2.4 million by 1995 (Department of the Environment, 1996). Part of this increase is due to the introduction of Broad-leaved Woodland Grant Scheme and its successor, the Woodland Grant Scheme, which provide incentives for private forestry. This success has led the government to set new targets for increasing forest cover in the United Kingdom. According to its 1995 *Rural White Paper*, the government wants English woodland to double over the next 50 years. The government regulates the forest industry through complex Forest Design plans but the amount of land under private ownership has also increased, from 45,000 hectares in 1988/89 to 640,000 in 1994/95 (UKDETR 1996: 73) In the United Kingdom, annual harvests are about 65 percent of growth (Gillingham 1998; see figure 48).

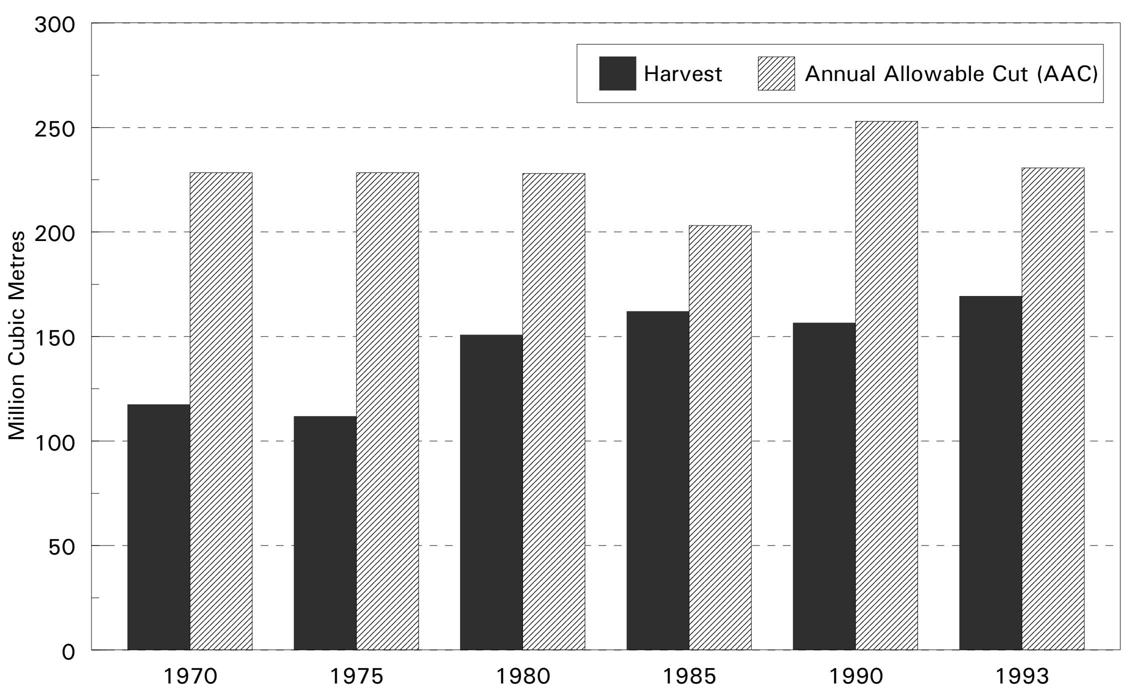
In Mexico, annual growth also exceeds harvests. The latest Mexican data available indicate that harvests are roughly 17 percent of growth (figure 49), down from 23 percent in 1980. Mexico, however, has lost about 15 percent of its forest land since 1970. This is primarily due to increases in agriculture and cattle grazing (OECD 1998: 99).

Figure 46: Forest Harvest and Growth in the United States



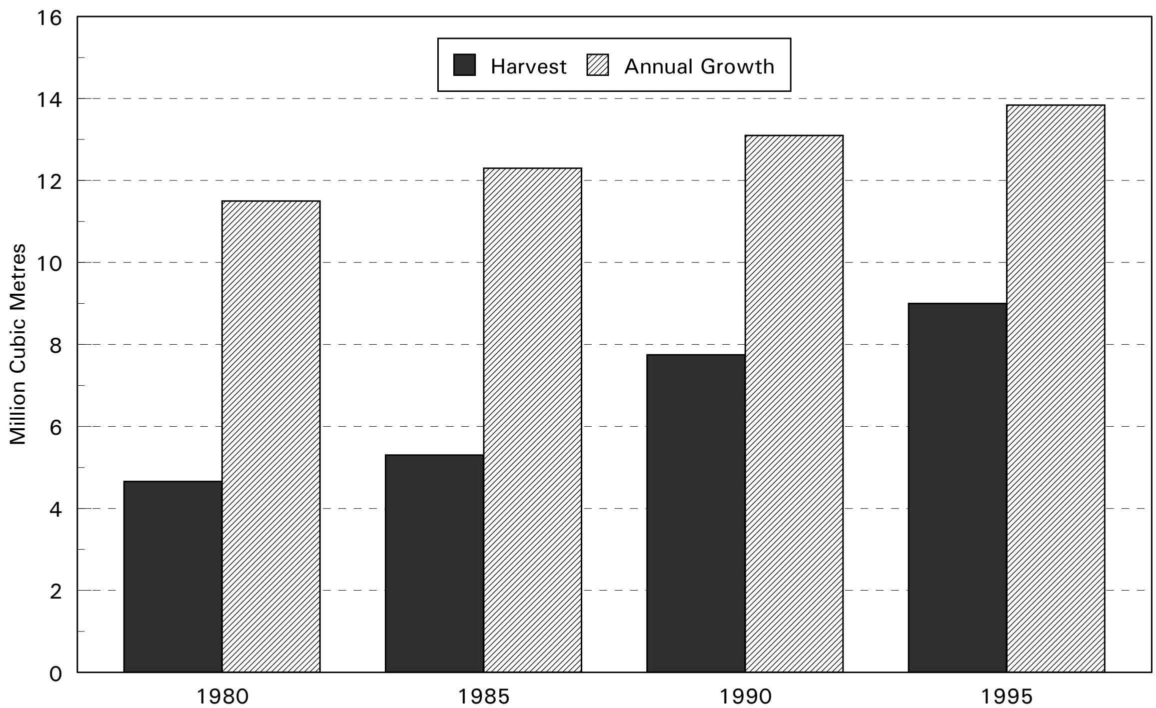
Source: OECD 1997.

Figure 47: Forest Harvest and Growth in Canada



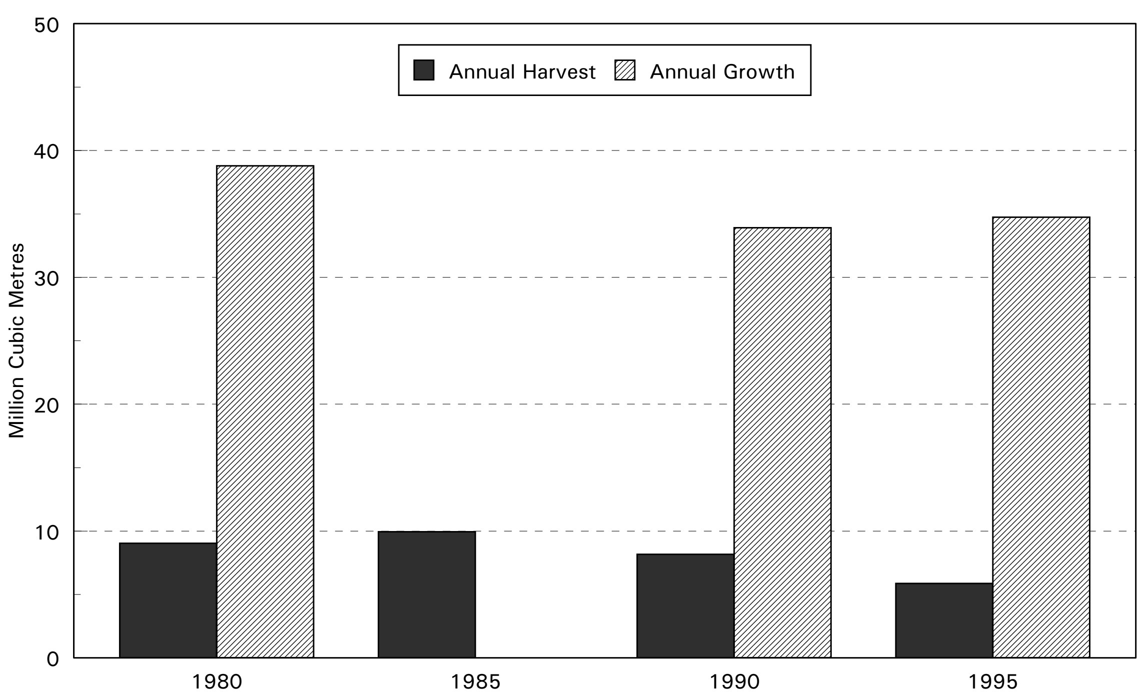
Source: National Forestry Database, Canadian Council of Forest Ministers, cited in Environment Canada, 1996c.
Note: see text for explanation of Annual Allowable Cut (AAC).

Figure 48: Forest Harvest and Growth in the United Kingdom



Source: Gillingham 1998.

Figure 49: Forest Harvest and Growth in Mexico



Source: OECD 1997.

In all countries, many of the serious environmental debates surrounding forests and harvesting practices are 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 (Bast, Hill, and Rue 1994: 24).

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 as humus to replenish the soil. When clear-cutting is not performed properly, however, it can damage sensitive watersheds and the ecosystems of rivers. Overall it is important to bear in mind that the area harvested nationally is minimal in comparison to the annual extent of natural disturbances (Environment Canada 1996c).

Fresh water

Only 2.7 percent of the Earth's water is fresh water (Environment Canada 1991c). Sources of fresh water include snow, glaciers, and polar ice (77 percent); underground (22 percent); lakes and wetlands (0.35 percent); atmosphere (0.04 percent); and streams (0.001 percent) (White 1984: 252). Only about 0.01 percent of water sources are both fresh and accessible in lakes, rivers, soil, and atmosphere. When discussing the withdrawal (use) of water, it is important to remember that water is neither gained nor lost; it is always returned to the earth in one form or another.

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 in the United States and Canada, accounting for 38.6 percent and 59.7 percent respectively. In the United Kingdom, this process accounts for only 2.8 percent of use, and in Mexico, only 0.2 percent. Industry (other than electrical cooling) uses 7.9 percent of freshwater resources in Canada, 5.7 percent in the United States, 5.5 percent in Britain, and 3.4 percent in Mexico. The public uses 11.3 percent of freshwater in Canada, 11.4 percent in the United States, and 11.5 percent in Mexico. In the United Kingdom the public water supply accounts for 65.4 percent of water use. Irrigation accounts for 40.2 percent of freshwater use in the United States and 83.1 percent in Mexico due to agriculture and climate. In Canada and the United Kingdom, irrigation is only 7.1 percent and 1.6 percent of the total respectively (OECD 1997: 68-71).

North American water prices are relatively low. The cost per thousand litres is $0.40 in the United States and $0.35 in Canada. Prices can be up to three times higher in European nations. For example, the price per thousand litres is $0.65 in the United Kingdom, $0.77 in Sweden, $0.85 in France and $1.30 in Germany. It is interesting to note that, on average, bottled water costs about $497 per thousand litres.[23] As one would expect, lower prices tend to lead to higher levels of freshwater consumption and 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 360 litres in Canada. This is more than double the amount of water used daily in many European countries (Environment Canada 1991c: [3]8).

Total water use, according to data from the OECD, has decreased in the United States and the United Kingdom but increased in Canada and Mexico. Use decreased 9.5 percent in the United States between 1980 and 1990, and 30 percent in Britain between 1980 and 1995. Between 1980 and 1995, water use increased 20 percent in Canada and 32 percent in Mexico (figures 50–53).

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 (figure 54).[24] Canada has about 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. The United Kingdom has about 76 billion cubic metres and used 18.3 percent in 1980 and 6.8 percent in 1995 (OECD 1995). Of its 414 billion cubic metres, Mexico used 13.8 percent in 1980 and 14.5 percent in 1995 (OECD 1995).

Figure 50: Freshwater Withdrawals in the United States

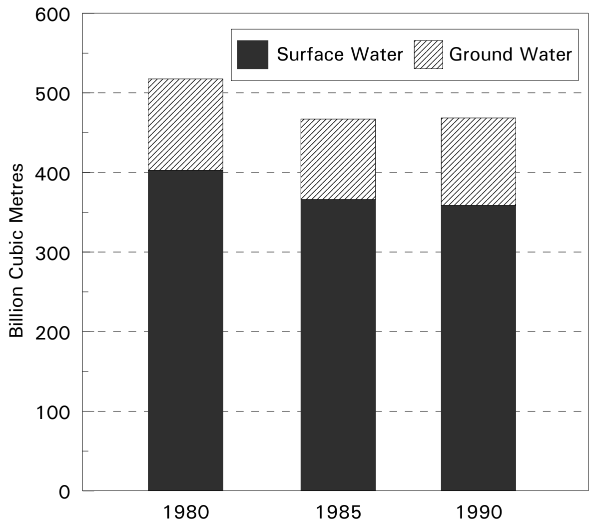
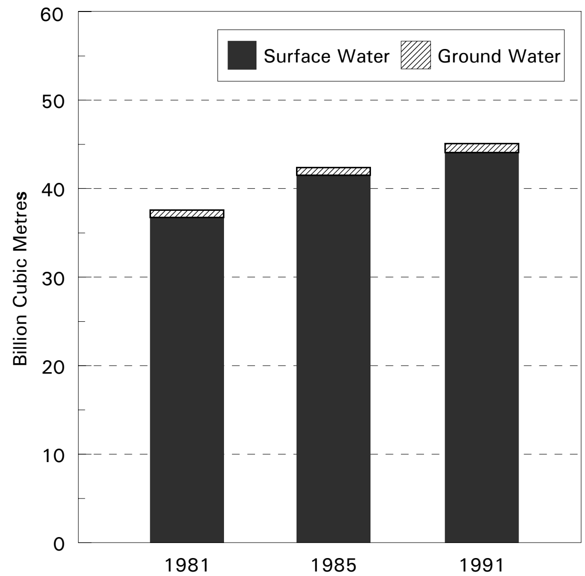


Figure 51: Freshwater Withdrawals in Canada



Source: OECD 1997.
Note: freshwater withdrawals refer to the use of ground water (water below the surface and supplying wells and spring) and of surface water (rivers, lakes, streams, and estuaries).

Figure 52: Freshwater Withdrawals in the United Kingdom

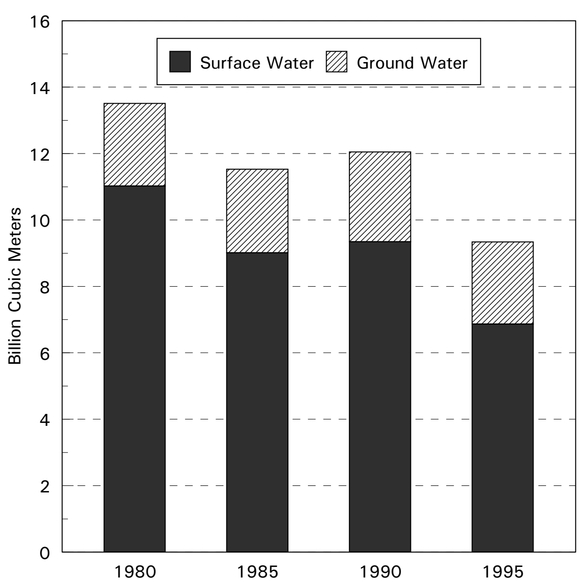
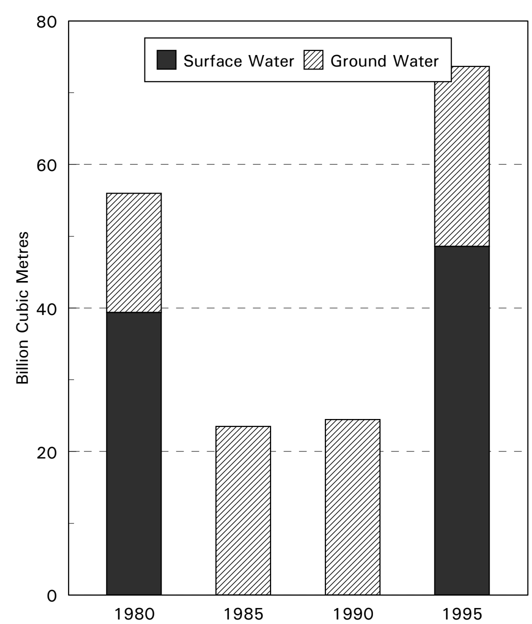
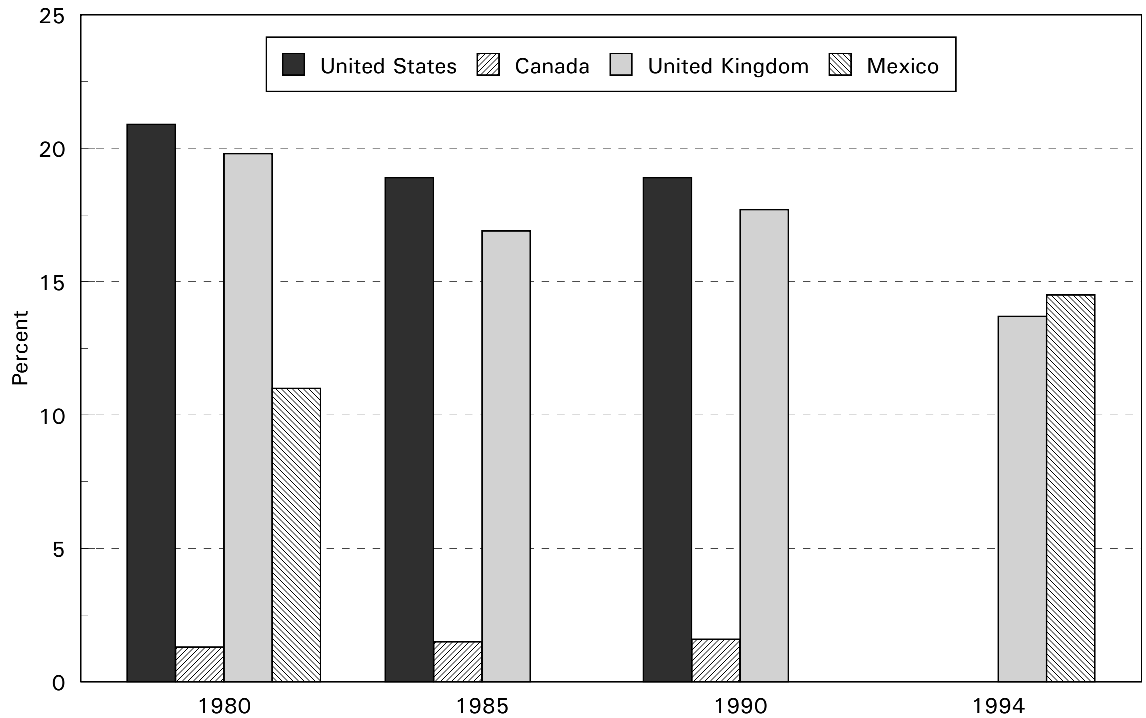


Figure 53: Freshwater Withdrawals in Mexico



Source: OECD 1997.
Note: data not available for surface water withdrawals in Mexico 1985, 1990.

Figure 54: Withdrawals as a Percentage of Renewable Fresh Water Resources



Source: OECD 1997.
Note: UK data refer to England and Wales only; 1980 and 1990 data for Canada are for 1981 and 1991.

While this abundance contributes to lower prices, government subsidies also depress prices artificially. In some cases, 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 (Environment Canada 1996c). 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 waste-water treatment facilities. This places further pressure on water sources and increases the demand for new dam construction and water diversion projects. To eliminate the difference between the real cost and the actual price of water, Environment Canada, in its *State of the Environment Report*, recommends that "we should pay a fair price that will recover the full cost of water delivered to the tap, one that is based on actual quantity used" (Environment Canada 1996c).

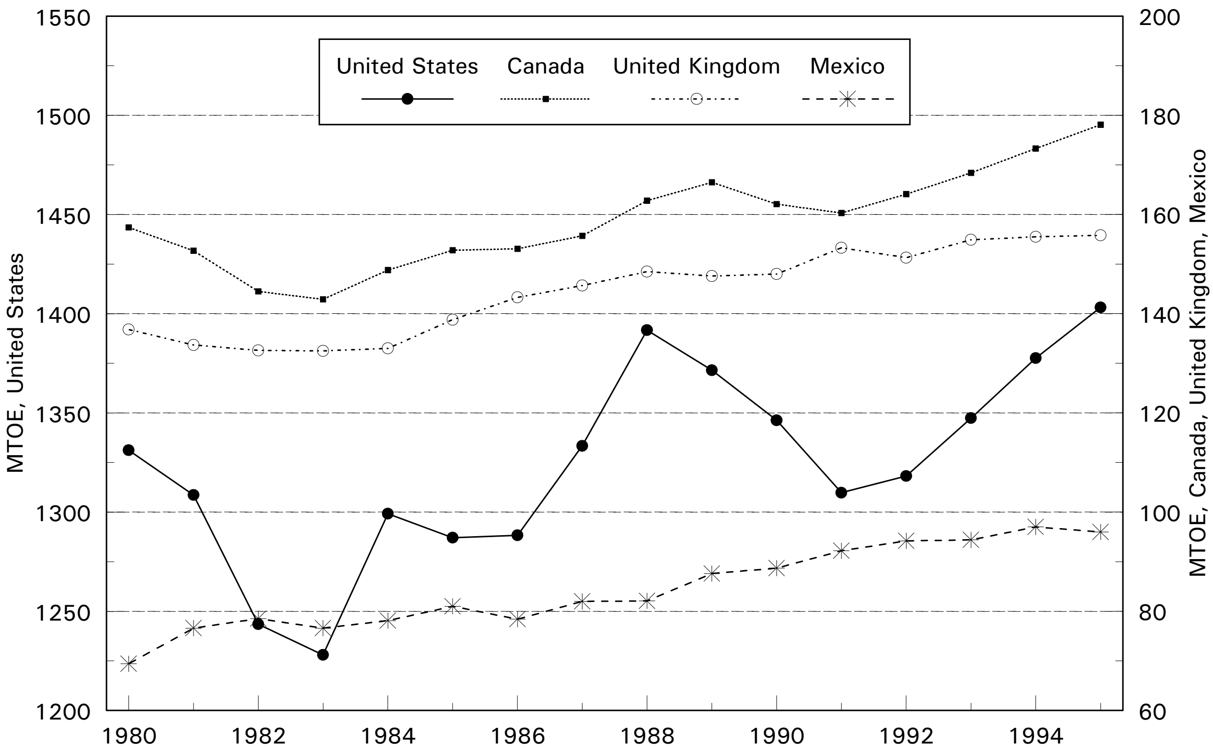
Although people in North America and the United Kingdom use only a small portion of renewable freshwater resources, regional water shortages continue to be a problem. In parts of the United States where water is scarce, farmers have responded by changing irrigation technology and cropping practices, and by using recycled municipal waste water for agricultural purposes (Avery 1995: 68–9).

Energy resources

Canada and the United States are among the world's most intensive users of energy. Environment Canada lists several reasons why Canada uses so much energy: the cold climate, an energy-intensive industrial base, a large land area, and a widely dispersed population. This section shows, however, that, despite the obstacles to energy efficiency that confront Canada, the United States, Mexico, and Britain, energy resources are not being depleted and that today the energy being used per capita is the same as, or less than, that used in previous years.

Figure 55 shows that total energy consumption is rising in North America and the United Kingdom. A better measure of energy use, however, is per-capita consumption. While per-capita energy use rose steadily before the

Figure 55: Total Annual Consumption of Energy

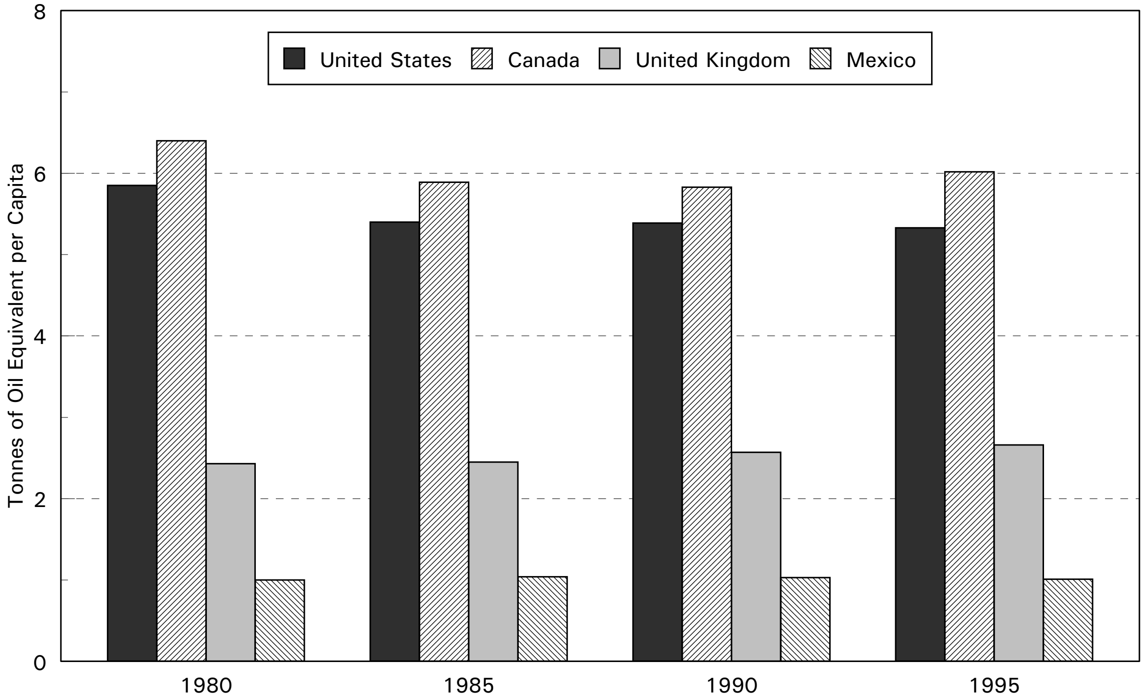


Source: OECD 1997.
Note: MTOE = millions of tons of oil equivalent.

end of the 1970s, it has since leveled off. For example, in 1995 Canada and the United States both used less energy per capita than they did in 1979. The reduction in the use of energy per capita reflects improvements in energy efficiency.[25] In Mexico and the United Kingdom, energy use per capita has remained roughly the same between 1980 and 1995 (figure 56).

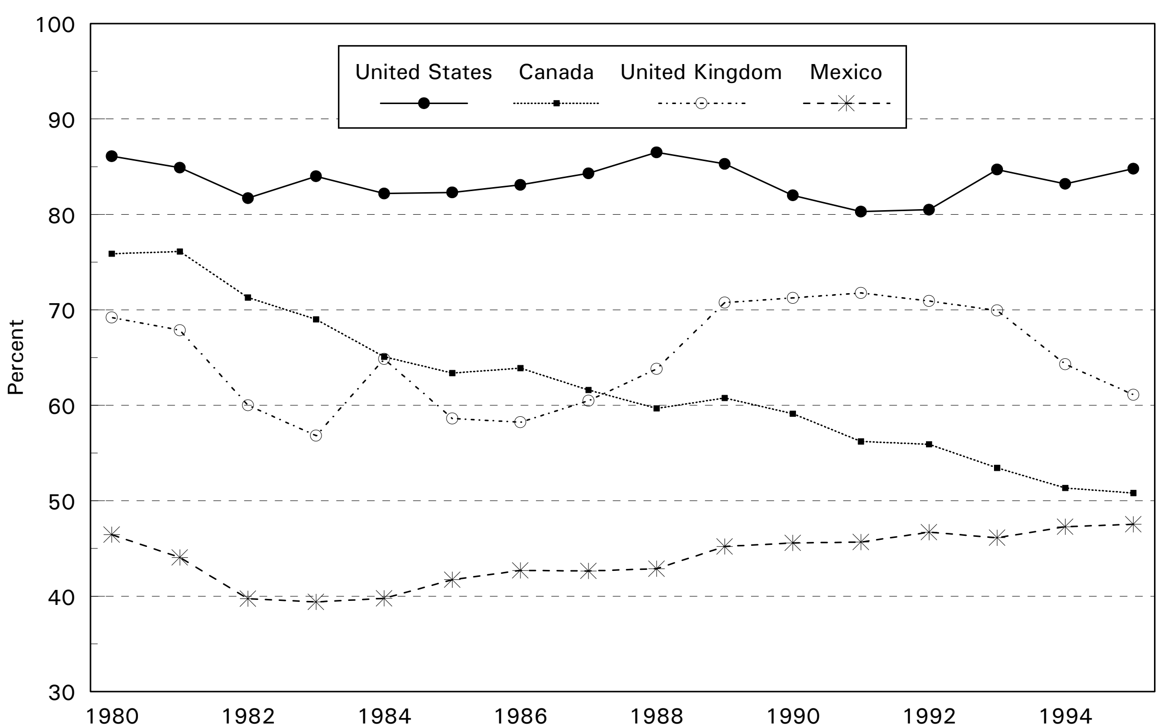
If the world were close to running out of energy, as some believe, one would expect to see a decline in the production of energy and an increase in prices in recent years. Instead, the opposite is true. In Canada, consumption as a percentage of production decreased from 76 percent in 1980 to 50.8 percent in 1995. The United Kingdom has seen a similar decline from 69.2 percent in 1980 to 61.1 percent in 1995. Although total consumption in the United States and Mexico increased between 1980 and 1995, consumption as a percentage of production has been fairly stable (about 85 percent and 47.5 percent respectively). All four countries are producing more energy than they are consuming. Figure 57 shows that Canada, the United States, Mexico, and the United Kingdom are net exporters of energy.

Figure 56: Per-capita Annual Consumption of Energy



Source: OECD 1997.

Figure 57: Consumption of Energy as a Percentage of Production

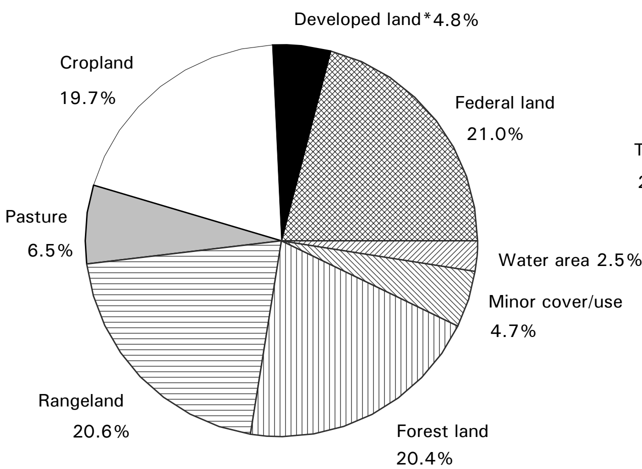


Sources: OECD 1997.
Note: Production of primary energy refers to petroleum, coal, and electricity.

Land use and condition

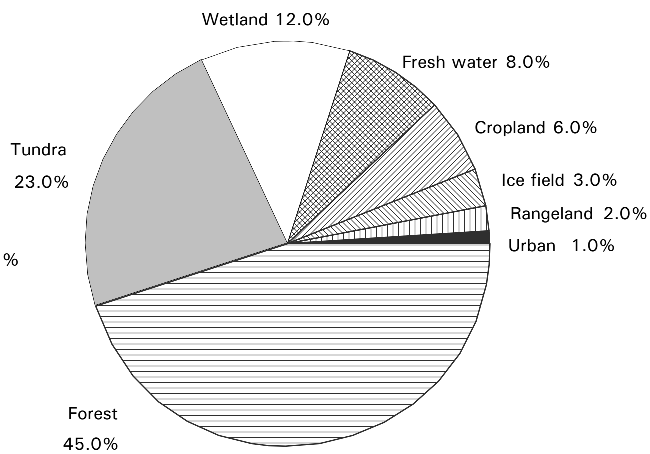
This section discusses land use and condition in Canada, the United States, Mexico, and the United Kingdom, examining at three areas of concern: wetlands, urban sprawl, and soil erosion. A general picture of land cover in the United States, Canada, the United Kingdom and Mexico can be seen in figures 58 through 61.

Figure 58: Land Cover in the United States



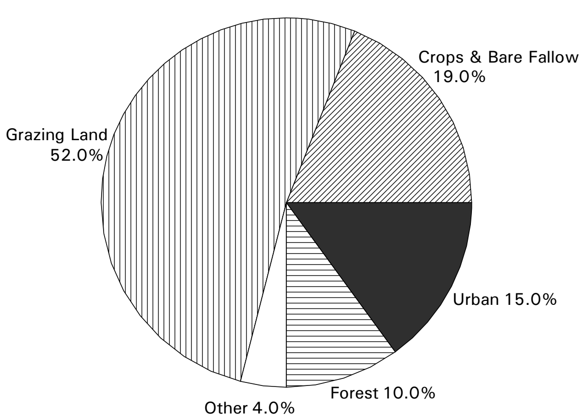
Source: United States Department of Agriculture, cited in US Bureau of the Census 1996.
* Note: developed land includes urban, built-up, and rural transport lands.

Figure 59: Land Cover in Canada



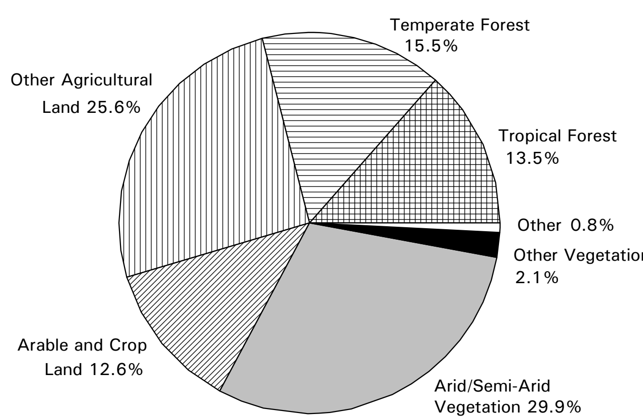
Source: Statistics Canada, 1996.

Figure 60: Land Cover in the United Kingdom



Source: Environmental Data Digest, 1998.

Figure 61: Land Cover in Mexico



Source: OECD Environmental Performance Reviews.

Wetlands

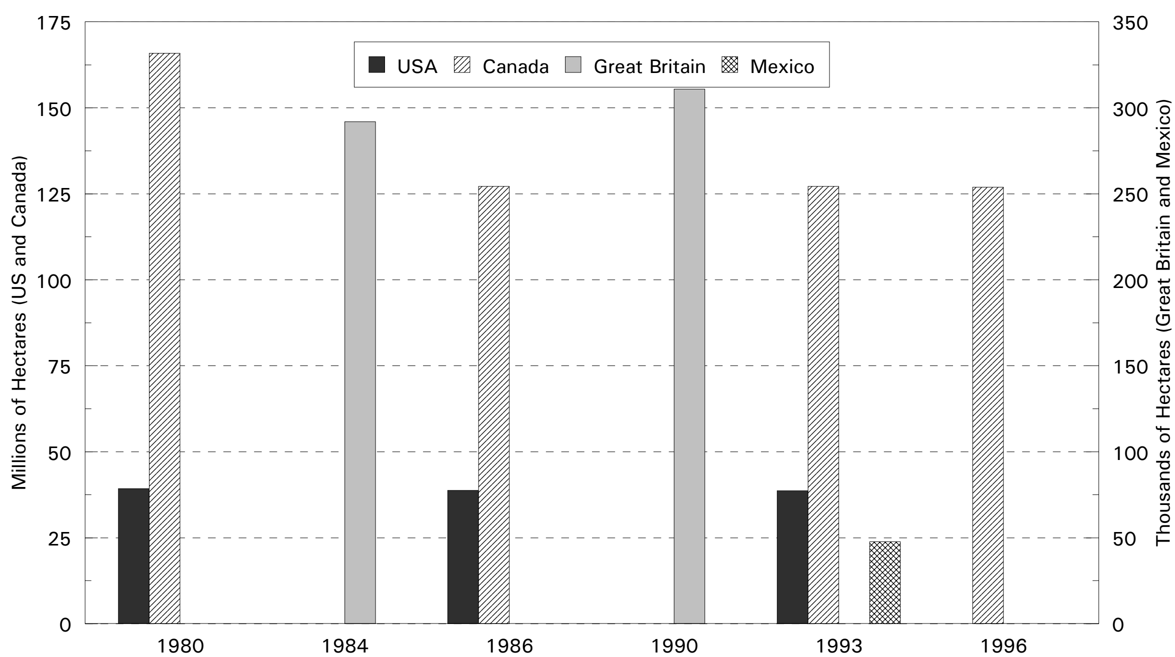
Wetlands are areas of land that are sufficiently saturated with water to promote aquatic processes. They include marshes, swamps, and bogs. Wetlands protect land from flooding and shorelines from erosion, and act as filtration systems by breaking down nutrients and neutralizing pathogens. They also provide habitat for a wide range of species. Canadian prairie wetland, for instance, provides habitat for 50 percent of North America's waterfowl (Environment Canada 1991c: [17]10).

In the past, wetlands were considered waste areas to be drained and made economically productive. In some cases, 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 (USEPA 1988: 6). Since the Canadian Wheat Board Act used to determine grain delivery quotas based on the total area seeded or left fallow, farmers were encouraged to cultivate marginal land rather than leave it in its natural state (Environment Canada 1991c: [26]6). In addition, the Maritime Marshland Rehabilitation Act (1943) was designed to discourage reversion of arable land to original wetland coverage (Environment Canada 1991c: [20]6). This trend now seems to be reversing, however, as recent studies show that wetland loss from agricultural conversion has dropped sharply (Tolman 1994).

The human impact on wetlands is difficult to quantify as areas of wetlands 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 wetlands. For example, estimates of the loss of prairie wetlands in two Canadian studies range from 40 percent to 71 percent (Tolman 1994).

Wetlands are more extensive in Canada than in the United States, the United Kingdom, and Mexico. According to the *Ramsar Convention*, Canada contains 13,030,200 hectares of internationally important wetlands compared to 1,194,000 hectares in the United States, 47,800 hectares in Mexico and 274,900 hectares in the United Kingdom (OECD 1995: 149). 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 (Environment Canada 1991c: [26]7). Since 1986, the OECD survey reports indicate that Canada has suffered no net loss of wetlands. American wetlands have also been stable since 1980. In the United Kingdom, wetlands increased by 6.5 percent between 1984 and 1990 (figure 62).

Figure 62: Area of Wetlands in the United States, Canada, Great Britain, and Mexico



Sources: OECD 1993; Frayer *et. al*. 1983; Bailey 1995; Environment Canada 1996a; UKDETR 1998a: 210; OECD 1995.

In 1996, Canada, the United States, and Mexico launched the North America Wetlands Management Program, a billion-dollar wildlife-conservation program that grew out of public concern in the mid-1980s over the loss of North American wetlands. The program is a partnership of federal, provincial, territorial, and state governments, non-governmental organizations, and the private sector. As of late 1994, Canada had secured 3,355 km^2 of wildlife habitat through the program's joint ventures (Environment Canada 1996c). Also in 1996, the US EPA's Water Program was implemented, wetlands management was added as a program priority, and it is currently implementing a 40-point plan to enhance wetlands protection, make the regulation of wetlands more fair and flexible, and move towards the goal of no net loss of wetlands (USEPA 1996b).

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

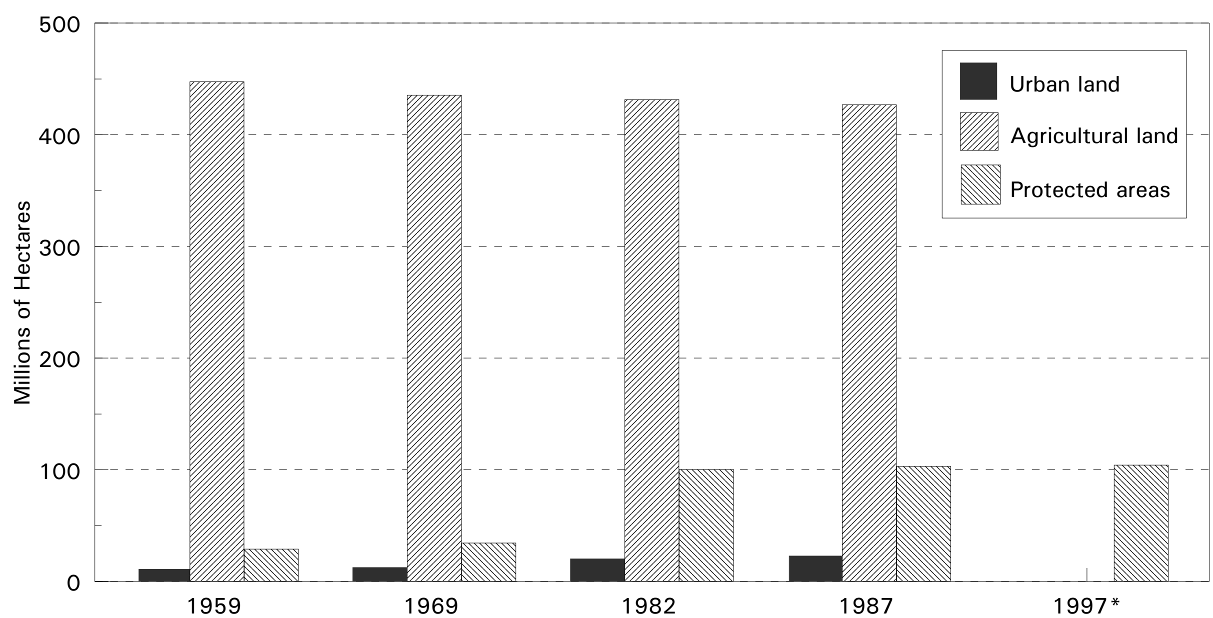
In the United States, 75 percent of wetlands are on privately owned land.[26] Regulations for the protection of wetlands are usually imposed without compensation; this places a heavy burden on the landowners and causes controversy. There is, however, a new approach to the protection of wetland habitat emerging. Private organizations such as Ducks Unlimited and the Nature Conservancy have become the two largest private stewards of Canada's 1.1 million hectares of non-government conservation lands (Statistics Canada 1994: 214–15). Ducks Unlimited also protects wetlands in the United States and Mexico.

Urban sprawl

Urban sprawl causes conflict over the use of land through urban expansion into agricultural land and human encroachment upon wilderness areas. Urban centres were originally established close to prime agricultural land and, as populations increased, urban development began to infringe upon farm land. Further, the spread both of urban and of agricultural land has meant fewer areas left in their natural state.

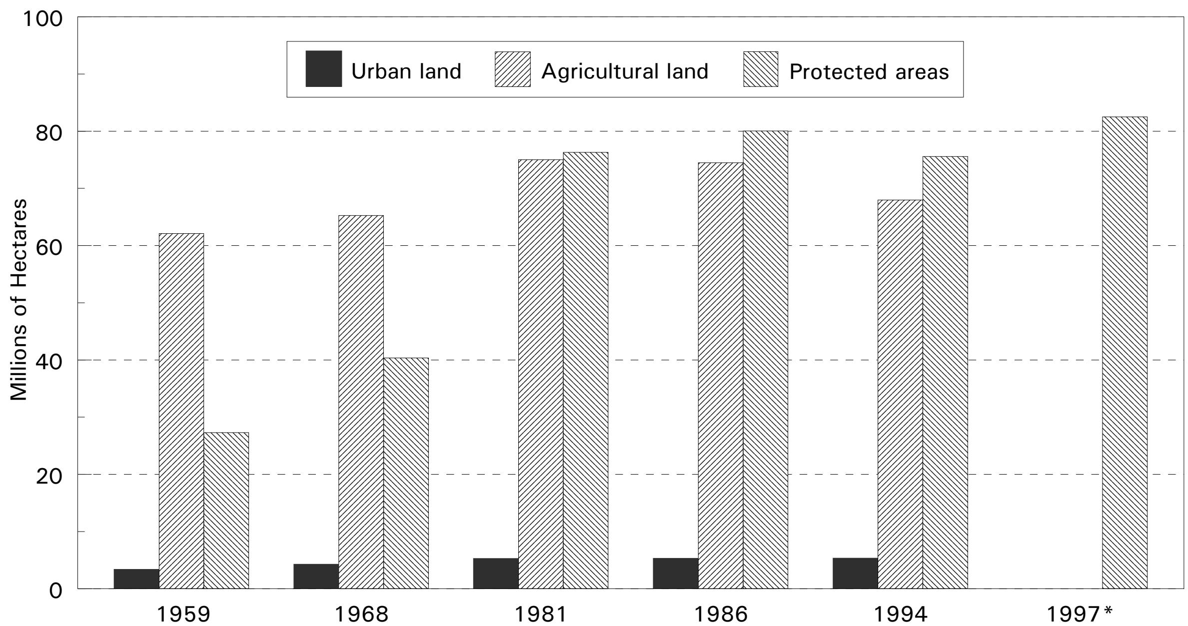
Changes in land use for urban, agricultural, and protected areas in Canada, the United States, Mexico, and the United Kingdom have occurred between the late 1950s and the mid-1990s (figures 63 through 66).[27] Urban

Figure 63: Land Use in the United States



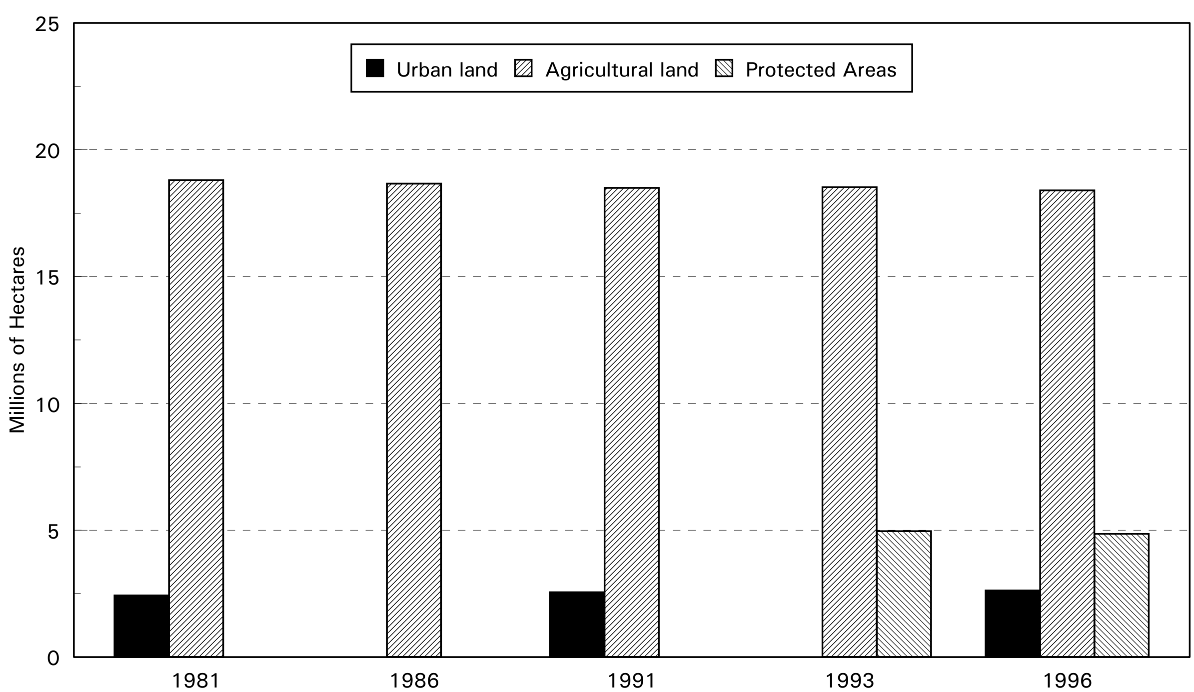
Sources: UN 1993; USDA 1994; World Conservation Monitoring Centre 1997.
Note: the graph only considers land with currently competing uses and does not include the entire land base.
*no data are available for either urban land or agricultural land for 1997.

Figure 64: Land Use in Canada



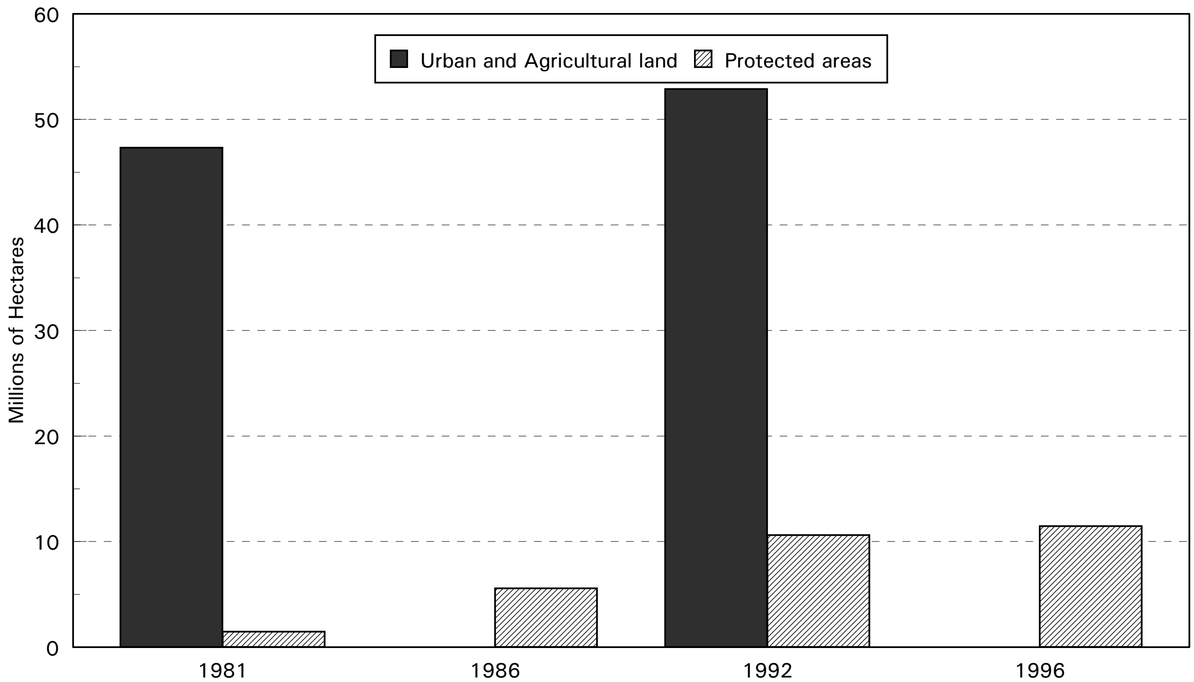
Sources: UN 1993; USDA 1994; OECD 1996b; World Conservation Monitoring Centre 1997.
Note: the graph only considers land with currently competing uses and does not include the entire land base.
*no data are available for either urban land or agricultural land for 1997.

Figure 65: Land Use in the United Kingdom



Sources: UKDETR 1998a; OECD 1997.

Figure 66: Land Use in Mexico



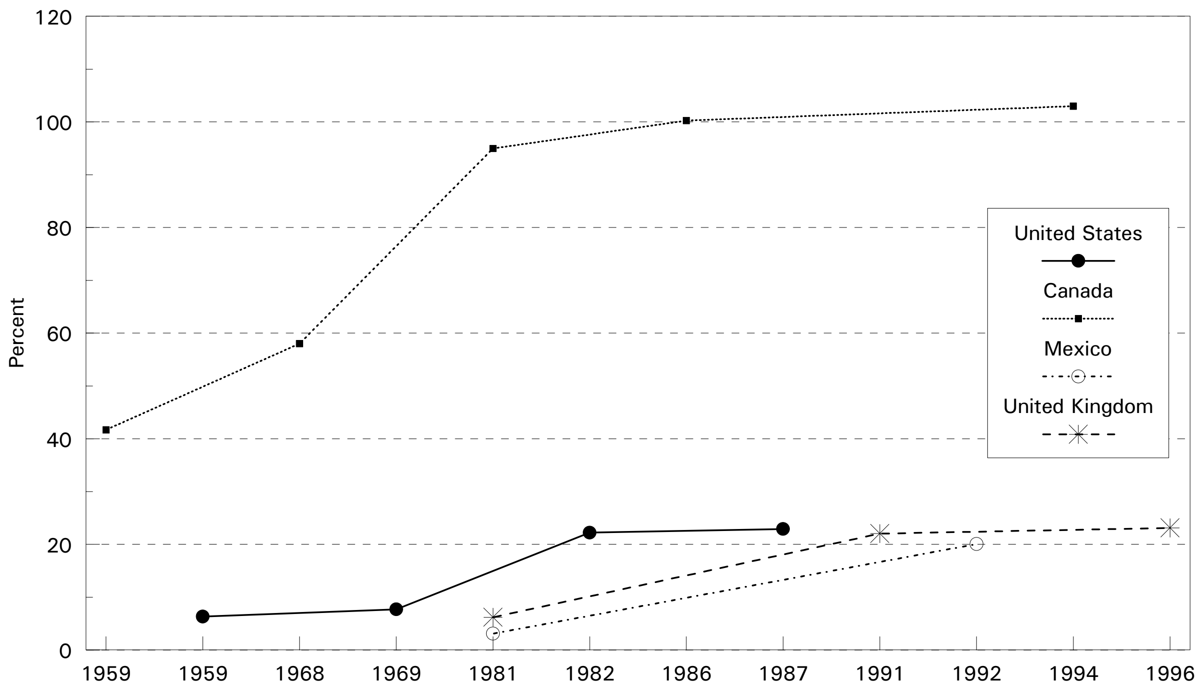
Sources: Website of the Instituto Nacional de Estadistica, Geografia e Informatica**; OECD 1997.**
Note: data for protected areas in 1981 refer to 1980–1985, in 1986 refer to 1986–1990, in 1992 refer to 1991–1995, and in 1996 to 1996–1997.

areas expanded steadily in Canada and the United States 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. Urban land occupies less than 1 percent of Canada's 9,215,430 km^2, and crop and range lands represent 8 percent of Canada's total land mass (United States Department of Agriculture 1994). In the United States, developed land occupies 4.9 percent of the total 7,850,945 km^2. Crop, pasture, and range lands account for another 48 percent of total land mass in the United States. In Mexico, urban and agricultural land account for 27.7 percent of the total 1,908,690 km^2 landbase. Urban and agricultural land increased 3 percent between 1981 and 1992. Protected areas in Mexico increased dramatically from 1.5 million hectares in 1981 to 11.5 million hectares in 1996. In the United Kingdom, urban and agricultural land remained fairly stable between 1980 and 1996 while protected areas increased dramatically (UKDETR 1998a: 206).

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 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 (United States Department of Agriculture 1994). This growth in output far outweighs any threat to farmlands posed by incremental urban expansion on farmlands.

Similarly, wilderness areas are not in danger of disappearing. In all four countries, protected areas have 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. 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 and this trend appears to be continuing. In Mexico, the ratio of protected areas to urban and agricultural lands increased from 3.1 percent in 1981 to 20 percent in 1992. In the

Figure 67: Protected Areas as a Percentage of Urban and Agricultural Areas



Sources: UN 1993; US Department of Agriculture 1994; OECD 1996b; World Conservation Monitoring Centre 1997, Website of the Instituto Nacional de Estadistica, Geografia e Informatica, UKDETR 1998a.
Note: UK 1981 includes 1980 data; UK 1991 includes 1990 data.

United Kingdom, the ratio of protected areas to urban and agricultural lands increased from 6 percent in 1981 to 23 percent in 1996 (figure 67). Protected areas increased in total size by 10.3 percent in Canada and 1.0 percent in the United States (OECD 1995; United Nations 1993). In Mexico, the number of protected areas almost doubled between 1993 and 1996 (OECD 1995, 1997). Claims about a "crisis" of urban sprawl are exaggerated.

Soil erosion

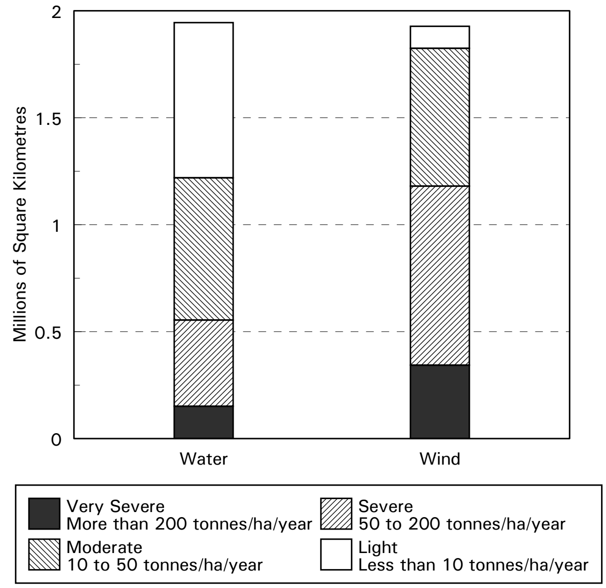
Erosion is the most common soil-degradation problem. It is a natural process that removes topsoil, reduces the level of organic matter, and breaks down soil structure. Erosion due to water occurs when precipitation levels exceed the soil's capacity to absorb water. Such erosion varies widely depending on climate, ground slope, vegetation, and soil type and condition, and causes the accumulation of silt, affects fish habitat, and pollutes water. Erosion due to wind 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 fallow) 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 68 shows the amount of land affected by wind and water erosion in Mexico. Figure 69 shows the average rates of erosion from cropland in Canada and the United States since the early 1980s. Erosion from croplands in the United States declined from 16.6 tonnes per hectare (t/ha) in 1982 to 12.6 t/ha in 1992. In Canada, rates were lower than in the United States: erosion from Canadian croplands declined 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.

In the United States, the USDA has initiated a Crop Replacement Program whereby it pays participants an annual rent per acre plus half the cost of establishing a permanent land cover in exchange for retiring for a period of 10 years cropland at high risk of erosion. Between 1986 and 1992 this voluntary program saw the enrolment of 36,422,722 acres, and thus a reduction of soil erosion by an average of 19 tonnes per acre per year (United States Bureau of the Census 1996). As well, the Natural Resources Conservation Service (NRCS) conserved a total of 41,619,019 acres, including 16,211,566 acres of cropland (Environment Canada 1991c: [9]10).

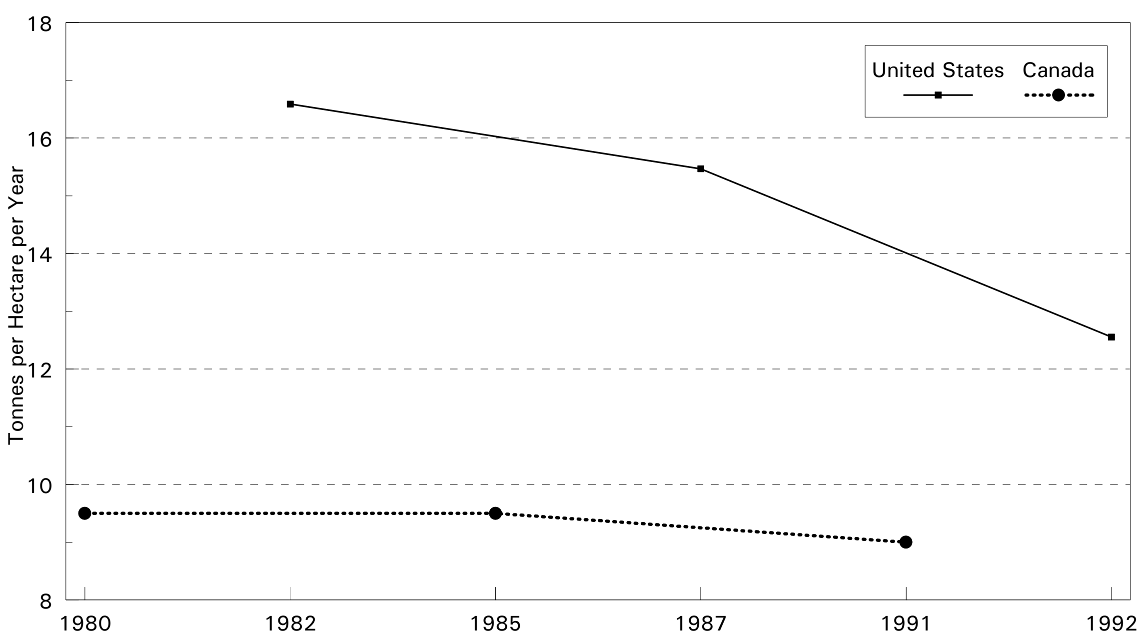
Soil erosion, however, does not mean soil loss. Studies show that only a small percentage of eroded soil is permanently removed from agricultural lands; most is merely moved from one field to another (Easterbrook 1995: 388). Further, soil is continuously being created by natural processes. The average 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 (Environment Canada 1991c: [9]10). 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 (Environment Canada 1991c: [9]10).

Figure 68: Erosion due to wind and water in Mexico, 1995



Source: Mexico, Estadicas del Medio Ambiente 1997: 181–83.

Figure 69: Soil Erosion from Cropland



Sources: OECD 1996b; US Department of Agriculture 1994.

Solid waste

Solid waste has become a leading environmental issue in recent years. Occasionally, it is even billed as a "crisis" because of the popular belief that there is a 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.[28]

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 reduction and recycling of solid waste[29] by the year 2000. The United Kingdom has set targets for the recovery of 40 percent of all waste generated in England and Wales by 2005 (UKDETR 1998a). Mexico does not have any recycling goals.

Reduction and reuse

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.

A survey by the OECD tracks the total solid waste and the amounts generated per capita by municipalities.[30] Overall municipal waste increased 38.1 percent in the United States between 1980 and 1994, 43.7 percent in Canada between 1980 and 1992, and 44.8 percent in Mexico between 1991 and 1995. In the United Kingdom, household waste increased 29 percent between 1980 and 1995 (figure 70). Solid waste generated per capita increased 21.7 percent in the United States from the 1980 to 1994; 180 percent in Mexico between 1975 and 1995; 23.5 percent in Canada from 1980 to 1992; and 21.4 percent in the United Kingdom between 1980 and 1995 (figure 71).

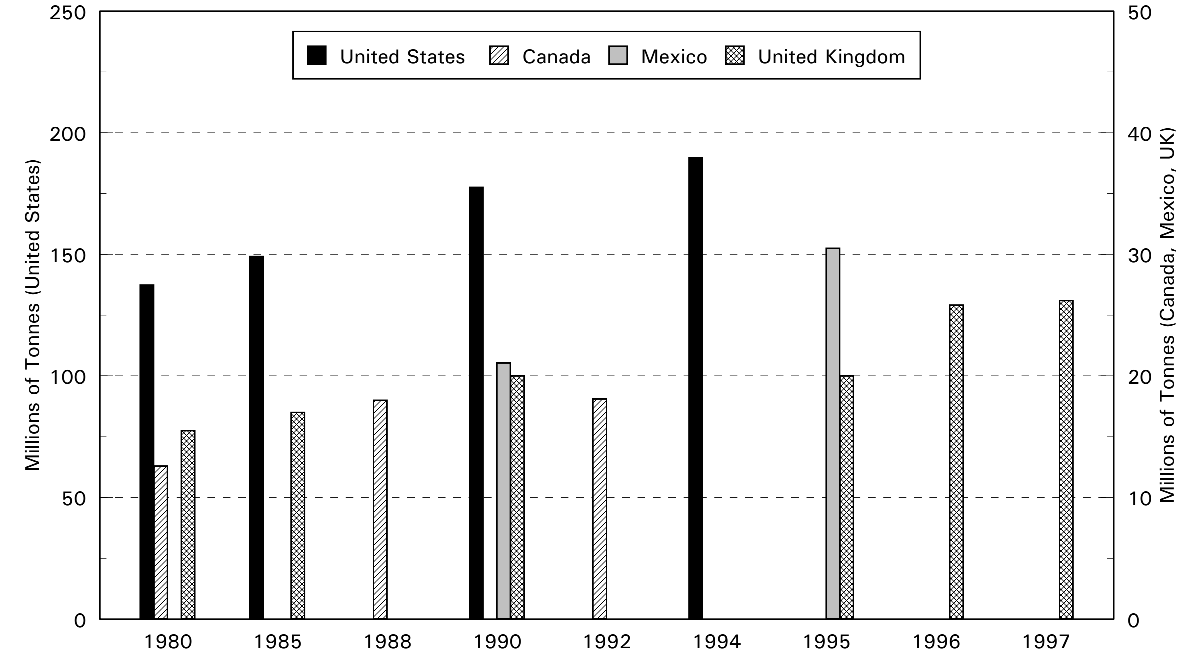
Most solid waste is buried in landfill sites. The United States disposes of 56.8 percent of its solid waste in landfills and incinerates 15.6 percent (United States Bureau of Census 1996: table 360). Canada disposes of 67.2 percent of its solid waste in landfills but only incinerates 3.0 percent (Christenson 1996). The United Kingdom disposes of over 70 percent of its waste in landfills.[31] Mexico buries almost all of its garbage (99 percent) in either landfill sites or open air dumping sites (OECD 1997).

The heavy reliance on landfills has caused the fear that countries are running out of space for landfills but this popular belief is unfounded. 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.[32] 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.

Recycling and recovery

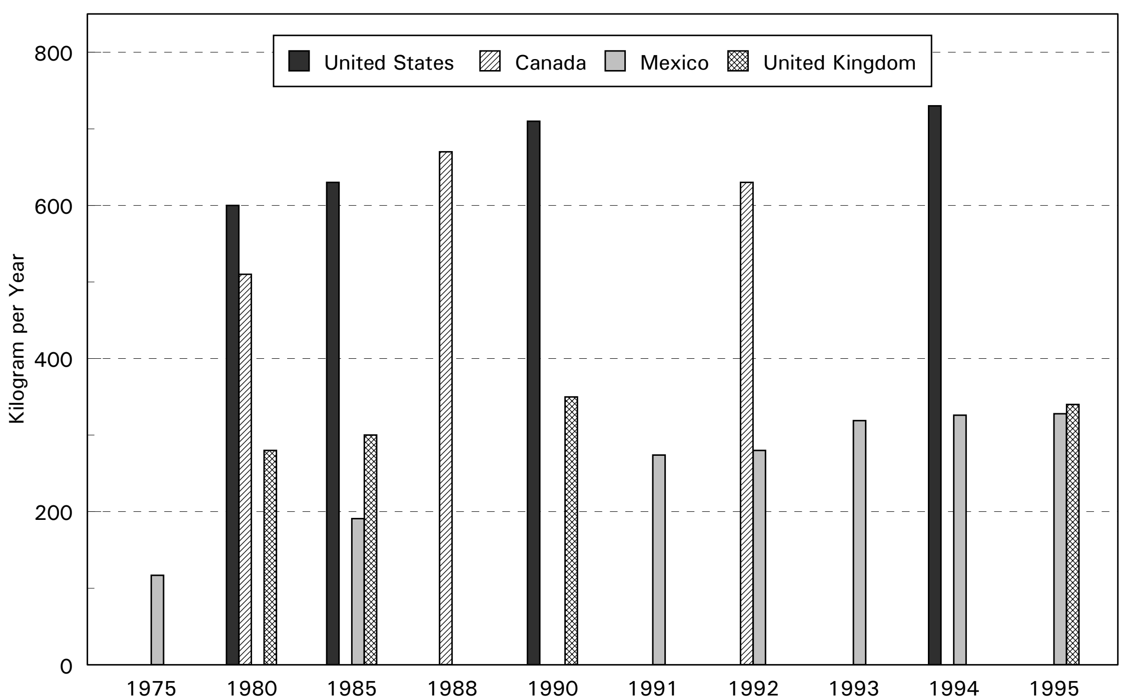
Concern about running out of space for landfills has made recycling an increasingly popular alternative to disposal. In the 1970s, many municipalities opened community recycling depots. Local governments, grocery stores, newspaper publishers, and the plastics, packaging, and soft-drink industries jointly fund programs such as the Blue Box program through which household newspapers, bottles, and cans are collected on a designated day. Some municipalities have expanded collection to include cardboard and rigid plastic containers.

Figure 70: Total Municipal Solid Waste Generated in the United States, Canada, Mexico and the United Kingdom



Sources: OECD 1997, UKDETR 1998a.
Note: OECD Data up to 1985 refer to England and Wales only. UK data up to 1995 refer to household waste. 1996/97 UKDETR data refer to municipal waste from England and Wales only.

Figure 71: Municipal Waste Generated Per Capita

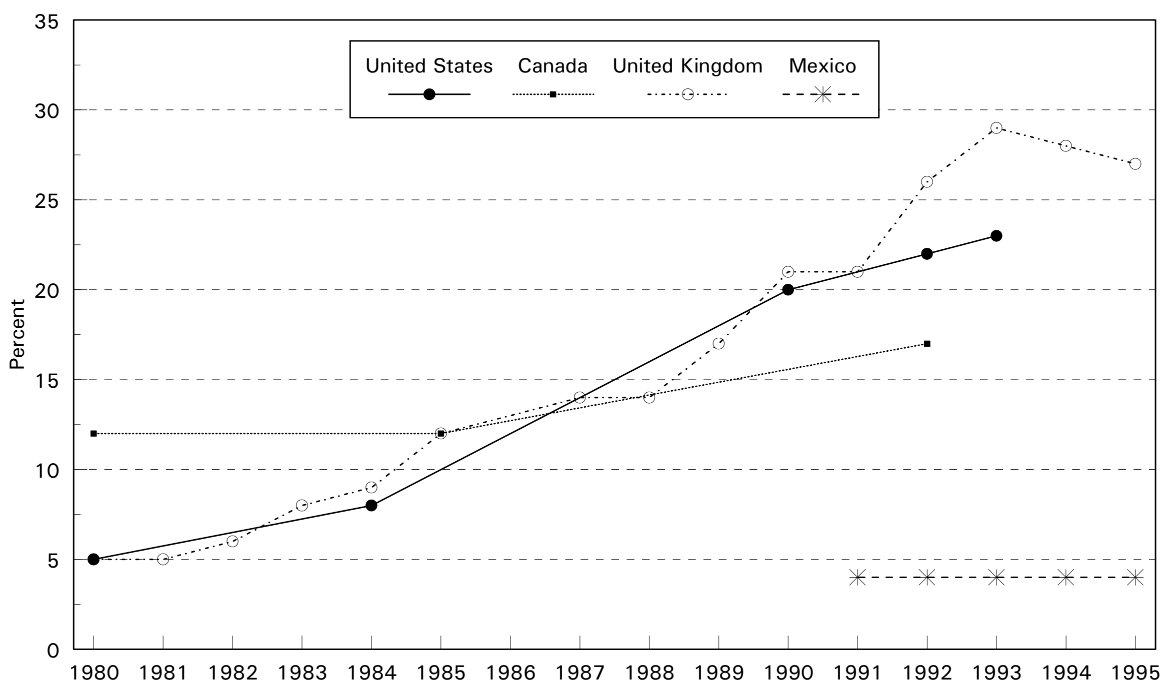


Sources: OECD 1997, Mexico, Instituto Nacional de Estadistica, Geografia e Informatica 1998.
Note: United Kingdom data up to 1985 refer to England and Wales only.

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 producing the same products from primary raw materials. In addition, recycling is not always environmentally desirable (Wiseman 1992). For instance, McDonald's decision to discontinue the use of polystyrene hamburger packaging has several unfortunate resource trade-offs. It requires 30 percent less energy to produce a polystyrene package than it does to produce the paperboard alternative; this means 46 percent less air pollution and 42 percent less water pollution (Scarlett 1991). 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 (Environment Canada 1991c: [25]7).

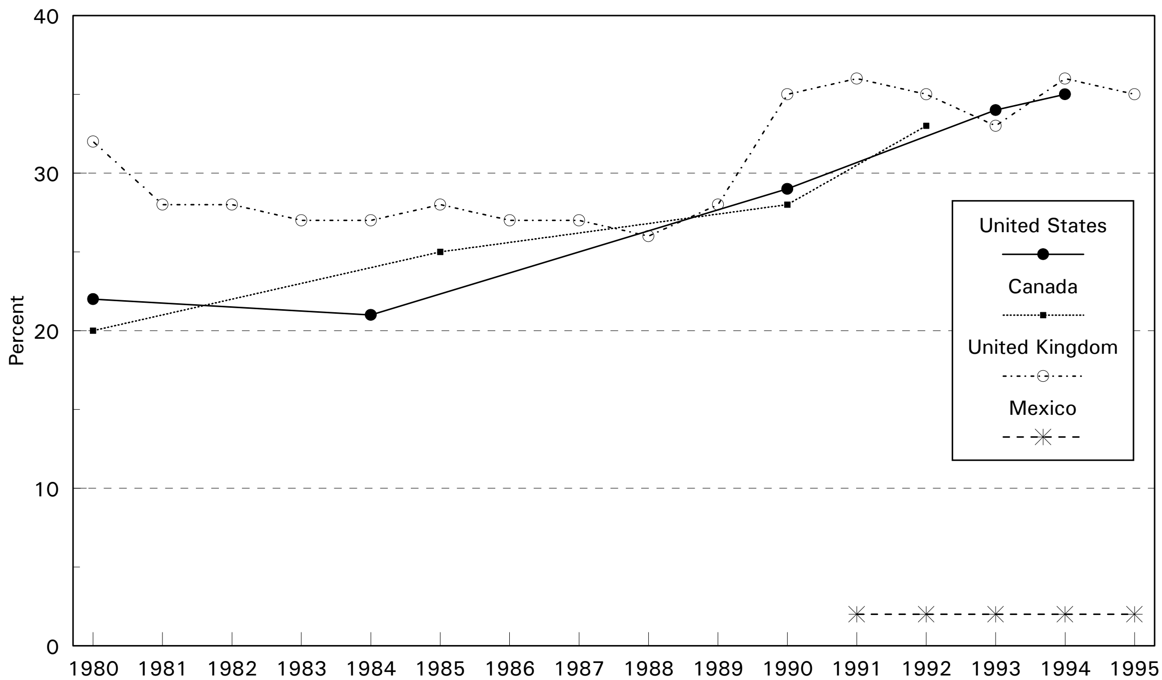
According to the OECD, paper and cardboard recycling in the United States was 22 percent of consumption in 1980 but increased to 35 percent by 1994.[33] Glass recycling climbed from 5 percent to 23 percent of consumption over the same period. In Canada, paper and cardboard recycling rose from 20 percent in 1980 to 32 percent in 1992. Glass recycling was 12 percent of consumption in 1980, and rose to 17 percent in 1992. In Mexico, glass and paper recycling remained constant at 4 percent and 2 percent of consumption respectively between 1991 and 1995. In the United Kingdom between 1980 and 1995, glass recycling increased from 5 percent to 27 percent of consumption and paper and cardboard recycling increased from 32 percent to 35 percent (figures 72 and 73).[34]

Figure 72: Recycling Rates for Glass in the United States, Canada, the United Kingdom and Mexico



Source: OECD 1997.
Note: UK data refer to Great Britain only.

Figure 73: Recycling Rates for Paper and Cardboard in the United States, Canada, the United Kingdom and Mexico



Source: OECD 1997.