# Secondary Environmental Indicators

The secondary environmental indicators discussed in this section are carbon dioxide, oil spills, pesticides, toxic releases, and wildlife. These often cited measures of the state of the environment are classed as secondary indicators in this report because, at best, they provide indirect information about environmental quality. In some cases, such as carbon dioxide, it is unclear whether the indicator contributes to an environmental problem (global warming). In other cases, wildlife for example, the questionable data makes it difficult to draw reliable conclusions.

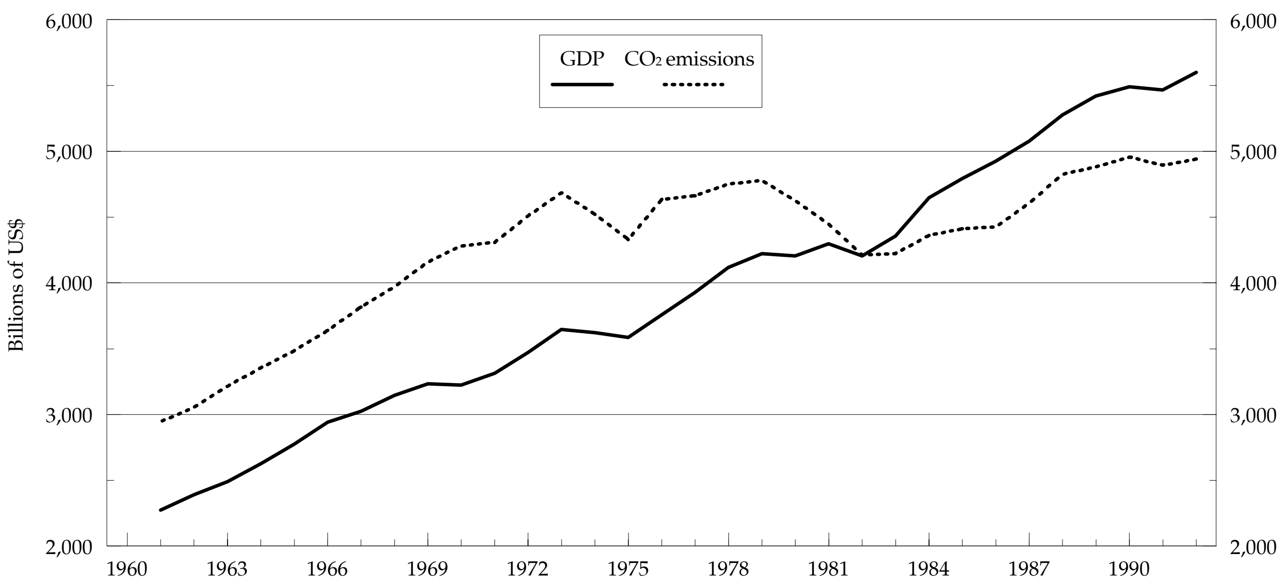
## Carbon dioxide emissions

Carbon dioxide ($CO_2$) is a vital nutrient for plants. Oceans absorb and produce $CO_2$ in great quantities through a complex cycle, and store about 50 times more carbon than does the atmosphere.[119] The combustion of fossil fuels by humans also generates $CO_2$.

Since the 1950s, $CO_2$ has been monitored because of its role in producing the "greenhouse effect." $CO_2$ has the propensity to trap heat in the atmosphere and so may contribute to global warming. Temperature records, however, do not support the theory that catastrophic global warming is underway. In addition, the sophisticated computer climate models, upon which the global warming theory is partly based, have been heavily criticized within the scientific community. It is unclear, therefore, whether $CO_2$ emissions are a dangerous pollutant.

Figures 42 and 43 show that American and Canadian $CO_2$ emissions rose with economic growth until the 1970s. Emissions then leveled off before declining in the early 1980s. Recently, emissions

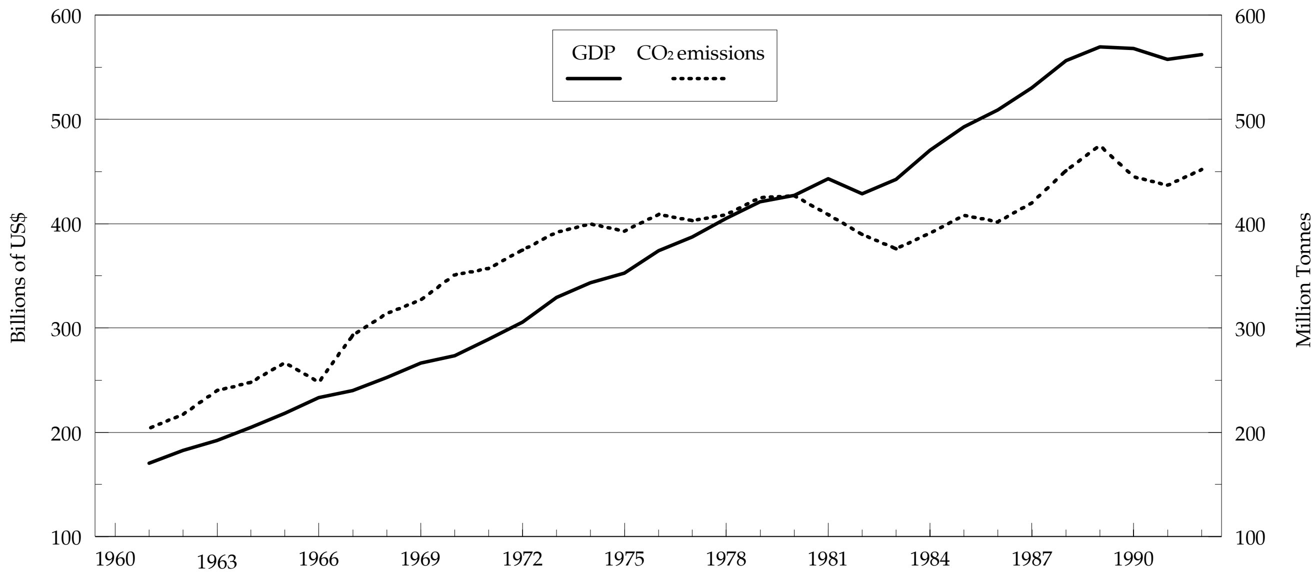
**Figure 42: GDP Compared to $CO_2$ Emissions: Trends in the United States**




Source: U.S. EPA, 1994; OECD 1996a.
Note: GDP is in constant (1990) dollars.

119 The atmosphere contains 750 billion tonnes of carbon dioxide compared with living plants (560 billion tonnes), soils (1,400 billion tonnes), ocean sediments (11,000 billion tonnes) and oceans (38,000 billion tonnes). See Environment Canada, *State of Canada's Environment*, 1991, p. (22)7.

**Figure 43: GDP Compared to $CO_2$ Emissions: Trends in Canada**




Source: Environment Canada, 1996a; OECD 1996a.
Note: GDP is in constant (1990) dollars.

have increased. These figures show that $CO_2$ output closely follows changes in GDP.

## Oil Spills

Oil spills are high profile events. Incidents such as the Santa Barbara oil spill of 1969 and the *Exxon Valdez* spill in 1989 receive intense media coverage. Despite the public perception that the number of oil spills and the severity of those spills has increased, figure 44 shows that there has been a declining trend in the amount of oil spilled in American waters over the last 20 years. As a source of water pollution, oil spills from the petroleum industry are a minor source of pollution when compared to oil waste generated by households. It is estimated that American households pour 1.3 billion litres of oil and oil-based products down the drain every year.[120] In comparison, the *Exxon Valdez* spilled just over 41 million litres of crude oil into Prince William Sound.

While oil spills are never desirable, and the immediate damage can be quite alarming, in time nature will effectively deal with spilled oil. Since oil is a natural substance produced by the decomposition of micro-organisms, it degrades naturally in the environment. Within 48 hours of an accident, 40 percent of spilled oil evaporates. Bacteria and other marine species break down and consume over 90 percent of the remaining oil.[121] In some cases, active cleanup can actually cause more harm than good. For example, the steam used to clean rocks kills many tiny organisms, including those that would otherwise ingest and decompose spilled oil.

Canadian data track total marine spills from petroleum, industrial waste, and other chemicals. Data are only available for the 10-year period from 1976 to 1987 (figure 45). Both the number of events and the volumes of oil spilled fluctuate widely during this period. This fluctuation can be attributed primarily to differences in the numbers of vessel collisions, groundings, and sinkings. It is also due to changes in the number of accidents occurring when oil is being transferred from one vessel to another.

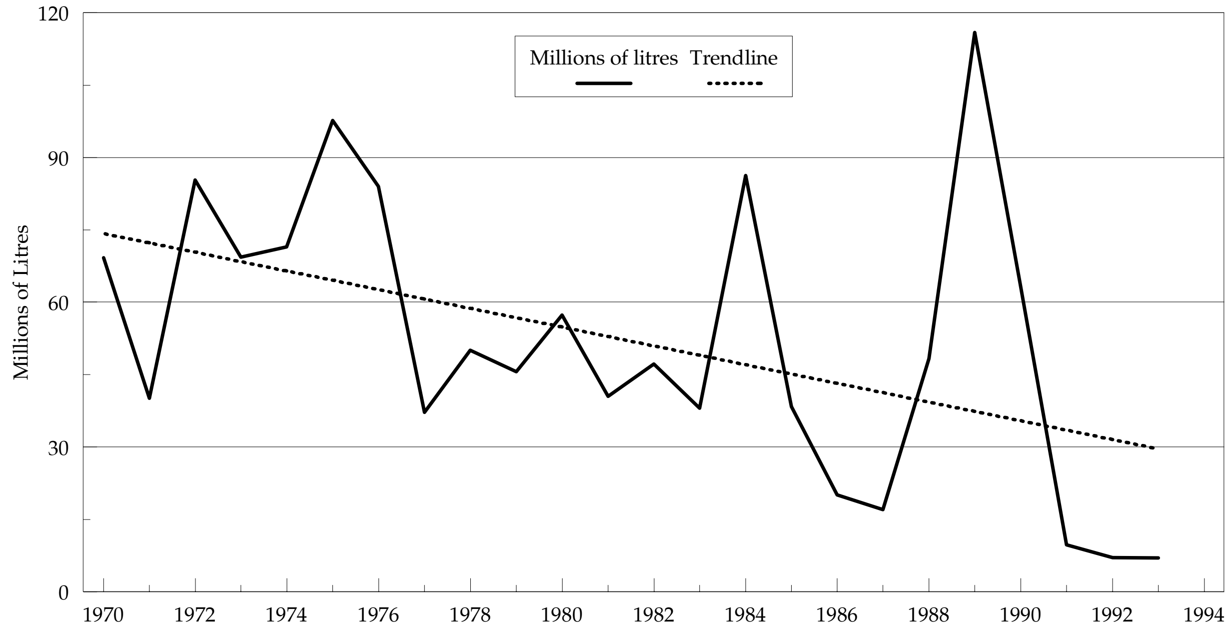
## Pesticides

Pesticides are a family of substances including herbicides, insecticides, fungicides, and fumigants. Although DDT and several other notorious pesticides have been discontinued, pesticide use re-

120 Allen, "Who Else Pollutes?" 1993.

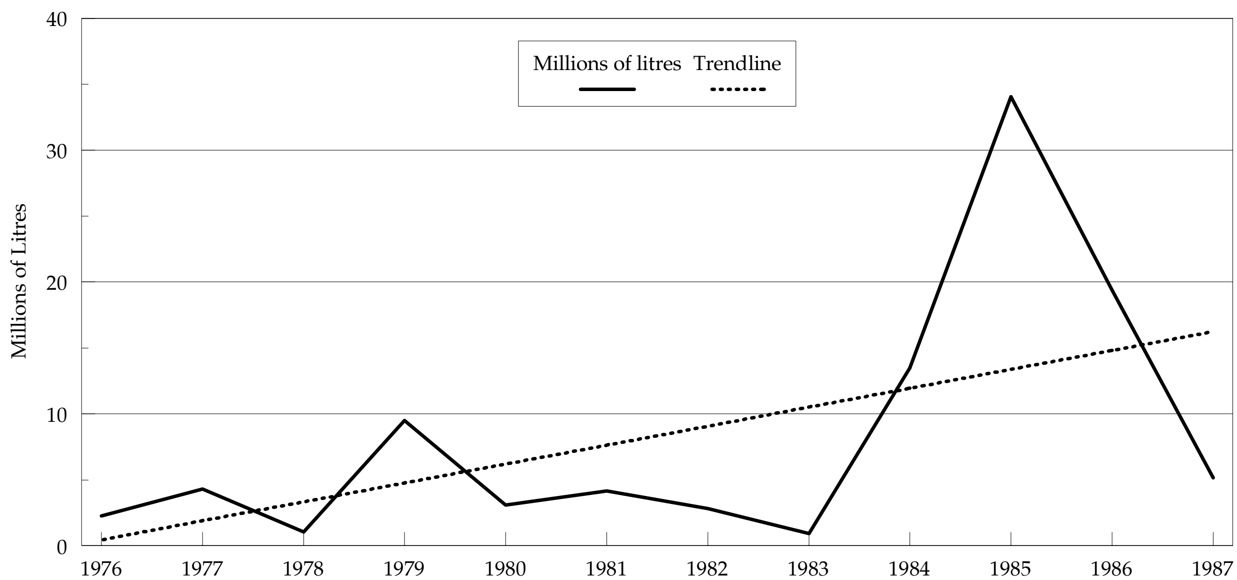
121 Bast, Hill and Rue, *Eco-Sanity*, 1994, pp. 148–53.

**Figure 44: Oil Spills in and around American Waters (by volume)**




Source: U.S. Coast Guard cited in U.S. Bureau of the Census, 1995.

**Figure 45: Significant Spills in and around Canadian Waters (by volume)**




Source: Environment Canada, 1991.
Note: Canadian data does not include spills in the Arctic ocean. Significant spills are those that exceed 1,000 litres.
From 1976 to 1987: Petroleum 32.1%; Industrial Waste 60.5%; Other 7.4%

mains controversial. Figure 46 shows the use of pesticides per square kilometre of arable land in the United States and Canada. The limited data available show that, in the United States, the use of pesticides fell from 204 $kg/km^2$ in 1980 to 195 $kg/km^2$ in 1991. In Canada, use of pesticides fell from 94 $kg/km^2$ to 81 $kg/km^2$ between 1985 and 1990. While these declines are not dramatic, they illustrate that fears of greatly increased pesticide use have not materialized.[122]

122 For a summary, see Easterbrook, *A Moment on the Earth*, 1995, pp. 79 ff.

**Table 12: Summary of $CO_2$ Emissions and Oil Spills as Environmental Indicators**

| General comments | Performance record: United States. | Performance record: Canada |
|---|---|---|
| **Carbon dioxide ($CO_2$) emissions** | | |
| • $CO_2$ is a vital nutrient for plants and oceans absorb and produce it in massive quantities.<br>• $CO_2$ is believed to contribute to global warming but the temperature record does not support this theory.<br>• The sophisticated computer climate models, upon which the global warming theory is partly based, have come under heavy criticism.<br>• Industrialized economies produce great amounts of $CO_2$.<br>• A massive economic downturn would be needed to reduce $CO_2$ emissions radically. | • American $CO_2$ emissions rose with economic growth until the 1970s, before leveling, and then fell in the early 1980s.<br>• In recent years, emissions have begun rising again, although not as steeply as in the decades before the "energy crisis" of the 1970s. | • Canadian $CO_2$ emissions rose with economic growth until the 1970s, before leveling, and then fell in the early 1980s.<br>• In recent years, emissions have begun rising again, although not as steeply as in the decades before the "energy crisis" of the 1970s. |
| **Oil spills** | | |
| • Oil Spills from the petroleum industry are minor compared to oil waste generated by households.<br>• Since oil is a natural substance, it degrades naturally in the environment.<br>• Within 48 hours of an accident, 40% of spilled oil evaporates, then bacteria and other marine species break down and consume over 90% of the remaining oil.<br>• In some cases, active cleanup can actually cause more harm than good. | • There has been a downward trend in the amount of oil spilled over the last 20 years.<br>• The *Exxon Valdez* spilled 41 million litres whereas American households pour 1.3 billion litres of oil and oil-based products down the drain every year. | • Petroleum, industrial waste, and other chemical spills vary considerably from year to year. From 1976 to 1987, the volume of spills varied from 34.1 million litres to only 0.9 million litres. |

Pesticides today are substantially changed from what they were when first introduced. Research has produced pesticides that have a much shorter half-life and are, therefore, less dangerous to human and animal health. In the 1960s, about one-half of all pesticides were chlorinated hydrocarbons such as Aldrin, Dieldrin, and DDT. These are persistent in the environment and tend to accumulate in animal tissue. Today, chlorinated hydrocarbons account for only about 5 percent of all pesticides.[123] They have been replaced by a new class of pesticides that are effective in lower doses, less persistent, and have fewer environmental side-effects.

Although pesticides are hazardous chemicals that should be handled carefully, their use yields enormous benefits and the risk from residues is minor. Pesticides stimulate crop production so that less land is converted from wilderness to agricultural uses, and food costs are lower. Banning pesticides and other agricultural chemicals could increase the average household's food bill by as much as 12 percent per year.[124] The EPA's most conservative risk-assessment models attribute a maximum of about 0.00008 percent of all cancer cases per year to pesticide residues.[125] In fact, the risk from carcinogenic compounds that occur naturally in food is much greater than the risk from pesticide residues.[126]

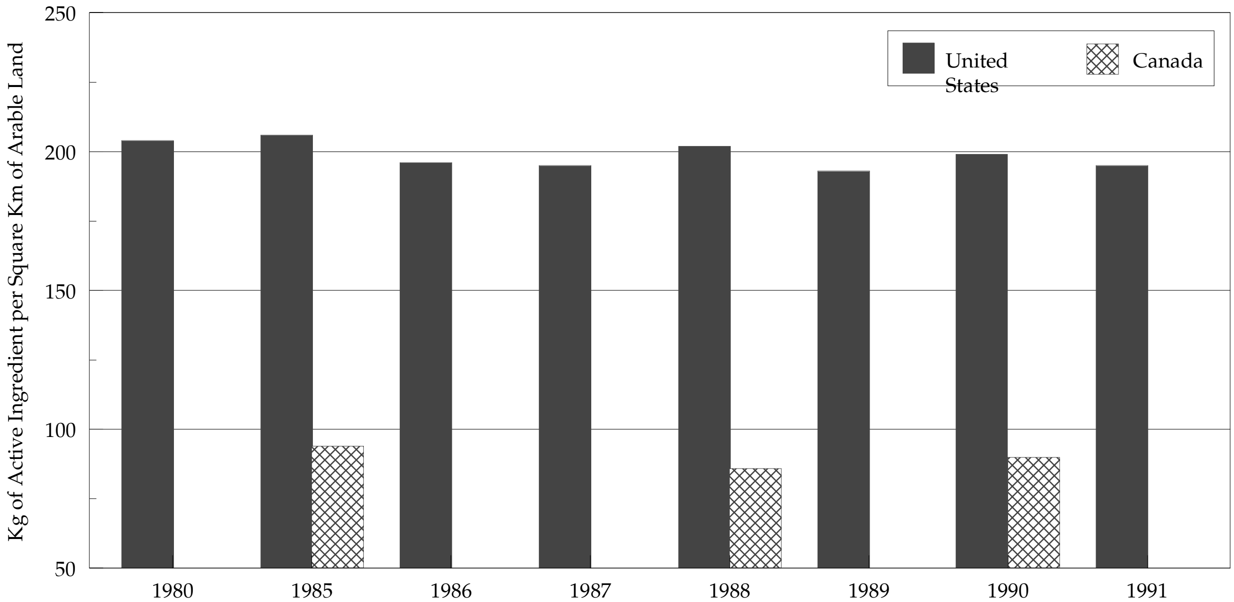
123 Hayward, *The Index of Leading Environmental Indicators*.

124 Knutson et al., *Economic Impacts of Reduced Chemical Use, 1990*.

125 Utt, "The Divergence Between the Perceived and Real Risk of Pesticide Use," 1991.

126 See Ames, *Risks, Costs, and Lives Saved*, 1996, chapter 2.

**Figure 46: Pesticide Use**




Source: OECD, 1994.

## Toxic releases

The US Congress passed the Emergency Planning and Community Right-to-Know Act in 1986 after the toxic catastrophe in Bhopal, India and a near disaster in West Virginia shortly after. This act mandated the EPA to compile the Toxic Release Inventory (TRI), which requires industrial facilities to report a broad range of toxic emissions. In 1993, the latest year for which data are available, the TRI program required the reporting of 316 chemical releases in 20 different categories. In Canada, time-series data do not exist over the same period, although the National Pollutant Release Inventory (NPRI) began a similar program in 1993. Figure 47 shows the data available for the United States and Canada.

In the United States, toxic releases declined sharply over the brief period for which data are available. Though this trend suggests an improvement in environmental quality, toxic releases are a problematic environmental indicator. Broad definitions apply to toxic wastes and the TRI does not distinguish between releases that pose environmental problems and those that do not. As the EPA points out: "TRI data alone cannot indicate the risk that chemical releases pose to human health and the environment. . . . A determination of risk depends on many factors, including the toxicity of the chemical, the extent of exposure, the type of release, and the conditions of the environment. For example, small releases of highly toxic chemicals may present a greater risk than large releases of less toxic chemicals."[127]

Further, the TRI definition of "releases" makes no distinction between releases into the environment and instances where toxic wastes are disposed of in well contained enclosures. For example, though some chemical wastes are stored in secure underground facilities, the TRI program counts these underground disposals as toxic releases.[128] In light of these problems with the data, the decline in releases may be a positive sign of environmental improvement, but the magnitude of this improvement is difficult to measure.

## Wildlife

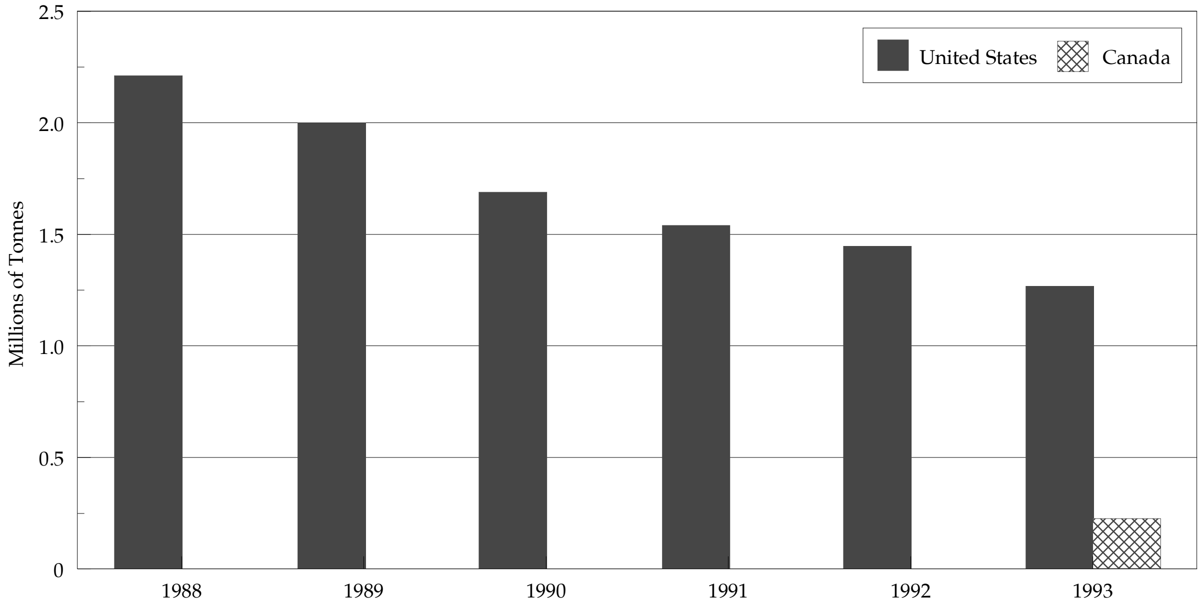
The North American wildlife population consists of at least 1,950 species of vertebrates, 4,200 species of vascular plants, approximately 95,000 species of invertebrates, and 34,000 species of insects.[129] Many more unrecorded species may exist.

127 USEPA, *Executive Summary: 1993 TRI Data Release*, 1995.

128 Ibid.

129 Environment Canada, *State of Canada's Environment*, 1991, p. (6)4.

## Figure 47: Toxic Waste Releases




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

## Table 13: Summary of Pesticide Use and Toxic Release as Environmental Indicators

| General comments | Performance Record: US | Performance record: Canada |
|---|---|---|
| **Pesticides** | | |
| • Use of DDT and several other harmful pesticides has been discontinued.<br>• Today's new class of pesticides are less persistent and have fewer environmental side-effects.<br>• Pesticide use increases crop production, which means that less land is converted from wilderness to agricultural use.<br>• Naturally occurring carcinogenic compounds pose a much greater risk than pesticide residues. | • In the US, pesticide use fell from 204 kg/km$^2$ in 1980 to 195 kg/km$^2$ in 1991. | • In Canada, pesticide use fell from 94 kg/km$^2$ in 1985 to 81 kg/km$^2$ in 1990. |
| **Toxic releases** | | |
| • The US TRI requires the reporting of 316 chemical releases in 20 different categories.<br>• The Toxic Release Inventory (TRI) does not distinguish between releases that pose an environmental problem and those that do not.<br>• Determining risk depends on the toxicity of the chemical, the extent of exposure, the type of release and environmental conditions.<br>• The TRI makes no distinction between toxic wastes released into the environment and those that are put into special, long-term storage facilities. | • There has been a significant reduction in releases from 1988 to 1993. | • Canada's National Pollutant Release Inventory (NPRI) program, modeled after the TRI program in the US, was started in 1993. |

**Table 14: Summary of Wildlife as Environmental Indicator**

| General comments | Performance record: US | Performance Record: Canada |
|---|---|---|
| • The North American wildlife population is diverse.<br>• There is no standard by which to determine the threats human activity actually poses to ecosystems.<br>• The rate of species extinction, the practice of relating species decline to habitat destruction, and even the total number of species that exist are all hotly disputed issues in the scientific community. | • The number of species officially designated as threatened or endangered by the US Fish and Wildlife Service has tripled from 283 in 1980 to 836 in 1994.<br>• More than half of the species listed are plants.<br>• The US Fish and Wildlife Service has identified another 3,500 species as candidates for listing. | • In Canada the number of species categorized by the Committee on the Status of Wildlife as extinct, extirpated, endangered, threatened, and vulnerable has increased from a total of 17 in 1978 to 264 in 1995.<br>• Plants have been the largest category of listed species since 1986. |

The number of species officially designated as threatened or endangered by the United States Fish and Wildlife Service has tripled from 283 in 1980 to 836 in 1994 (figure 48). In Canada, the number of species designated by the Committee on the Status of Wildlife (COSEWIC) as extinct, extirpated, endangered, threatened, or vulnerable[130] has increased from a total of 17 in 1978 to 264 in 1995 (figure 49).

Although the number of endangered species in the United States appears to exceed those in Canada greatly, it is unclear whether this reflects any actual differences in the number of endangered species. The numbers may reflect differences between the countries' definitions of what constitutes an endangered species. In addition, definitions within countries have changed to include more species over time. In the United States, for example, species are listed according to a process established by the Endangered Species Act (1973). The public originally supported the act on the grounds that it would protect animals such as the bald eagle and the grizzly bear. Today, however, more than half of the species listed are plants (figure 50). The Fish and Wildlife Service has identified an additional 3,500 species as candidates for listing. [131]

In Canada, over 120 government and private programs address wildlife issues.[132] The Committee on the Status of Wildlife is composed of federal, provincial, and territorial management agencies, the Canadian Nature Federation, the Canadian Wildlife Federation, and the World Wildlife Fund of Canada. Figure 51 shows the trends in species listings. Since 1986, plants have been the largest category of the species listed.

There are many problems with using wildlife as an indicator when assessing environmental quality. For example, the practice of relating the number of species becoming extinct to the amount of habitat destruction is a hotly disputed topic in the scientific community.[133] In addition, there is uncertainty associated with which species should be classified as endangered and the distinction between a species and a subspecies.[134] Regardless of the answers to these scientific questions, private landowners are being forced to bear almost the entire burden of protecting listed species and habitat. In the United States, "critical" habitat is heavily regulated without compensation for the landowners, a practice that has already begun to erode political support for species and habitat protection.

130 *Extinct*: a species no longer existing; *extirpated*: a species no longer existing in the wild in Canada but existing elsewhere; *endangered*: a species facing imminent extirpation or extinction; *threatened*: a species likely to become endangered if limiting factors are not reversed; *vulnerable*: a species of special concern because it has characteristics that make it particularly sensitive to human activities or natural events. From COSEWIC, *Canadian Species at Risk*, 1995, p. 1.

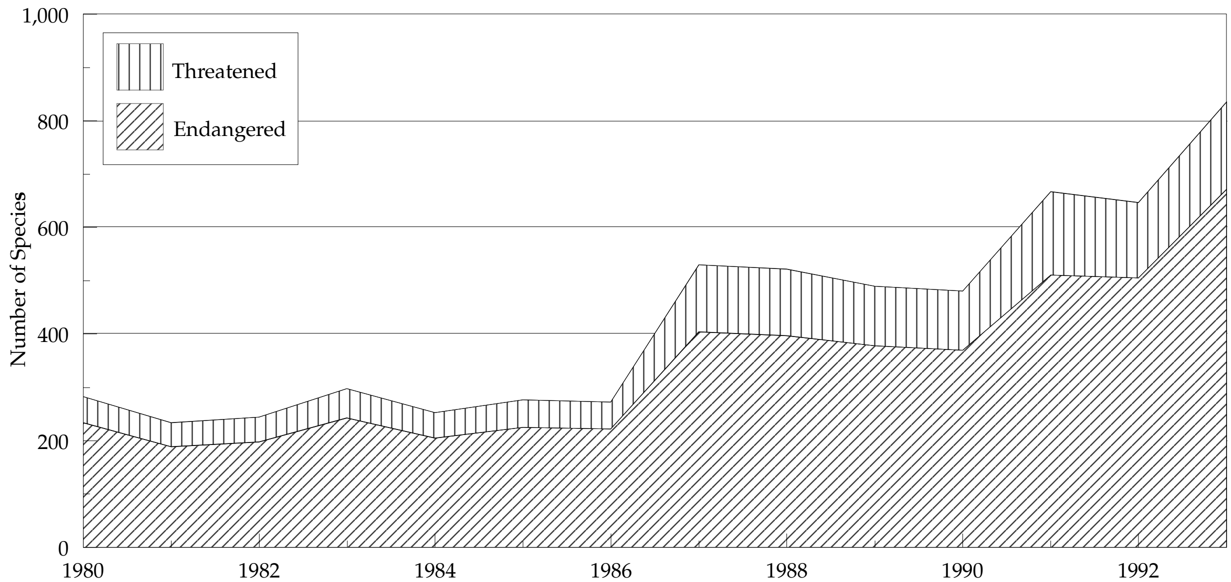
131 Mann and Plummer, "The Butterfly Problem," 1992, p. 52.

132 Environment Canada, *State of Canada's Environment*, 1991, pp. (6)20–3.

133 Edwards, "Conserving Biodiversity," 1995, pp. 211–65.

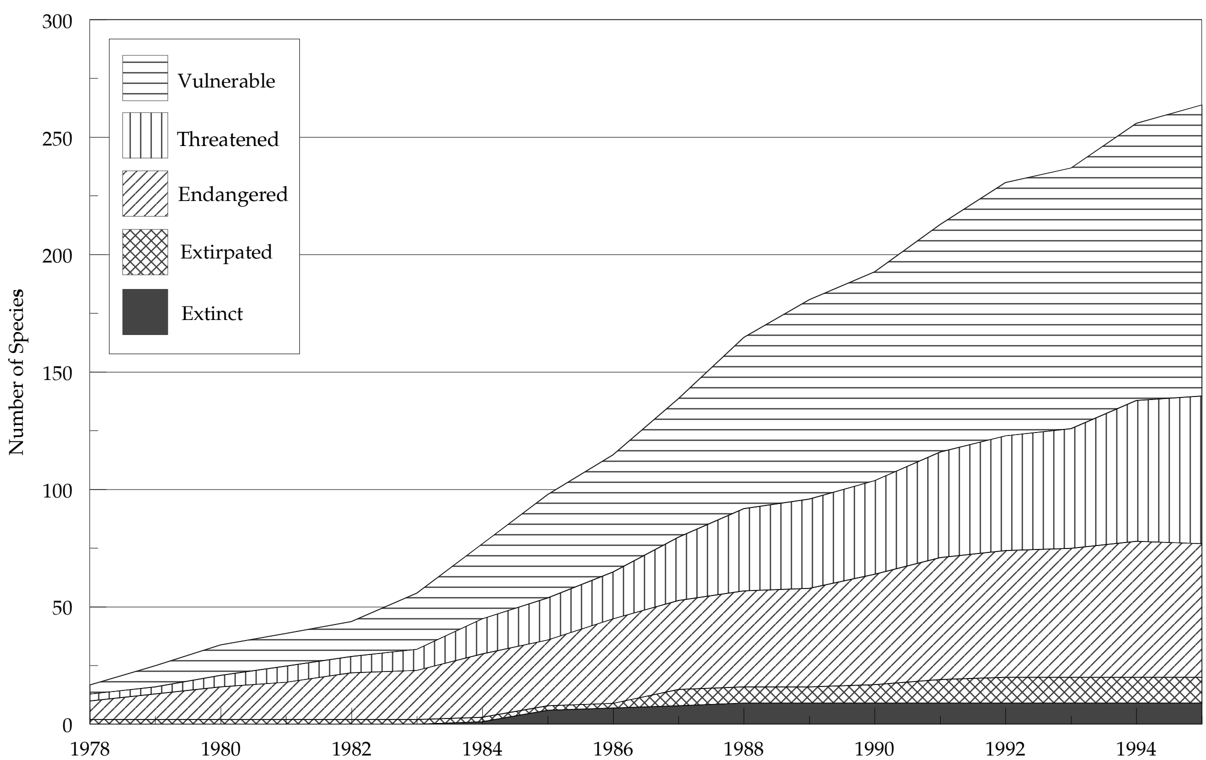
134 Easterbrook, "The Birds," 1994. Easterbrook argues that the number of spotted owls has been badly underestimated, that it does not differ genetically from the spotted owl populations in California, that it thrives in more kinds of habitat than is claimed, and, therefore, that it is not endangered.

## Figure 48: Wildlife at Risk in the United States



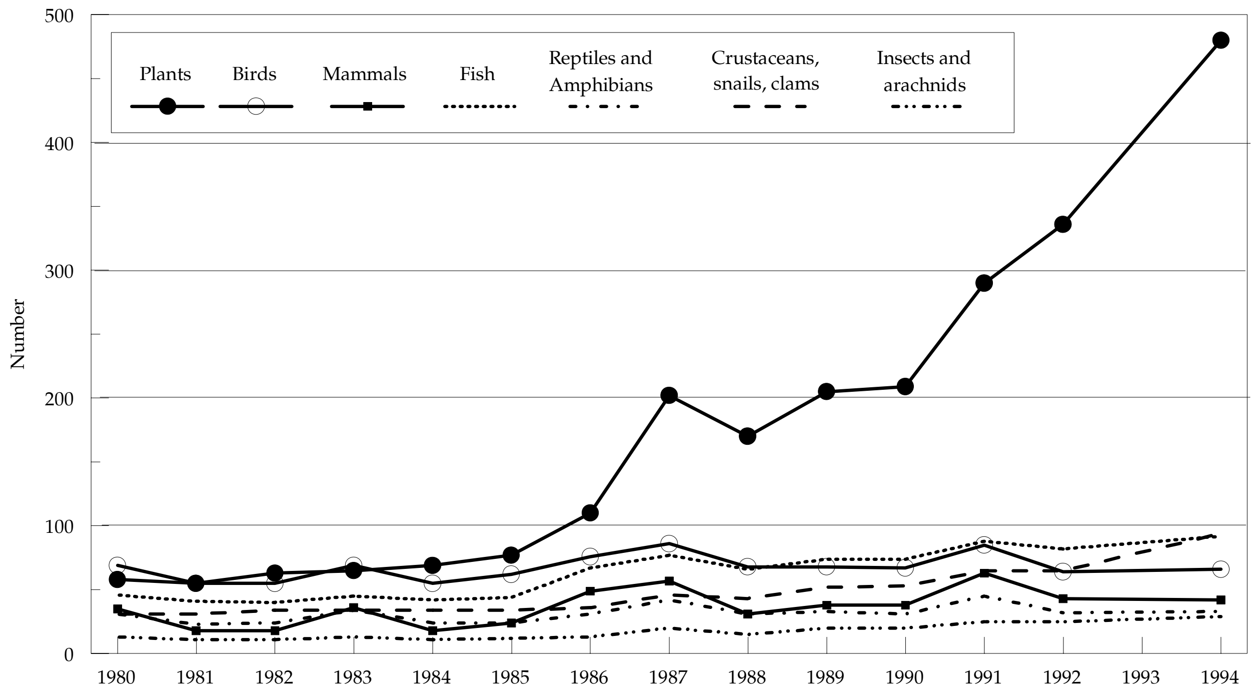

Source: U.S. Fish and Wildlife, 1994.
Note: Data is unavailable for 1993. Designated wildlife includes plants; birds; mammals; fish; reptiles and amphibians; crustaceans, snails, and clams; insects and arachnids.

## Figure 49: Wildlife at Risk in Canada



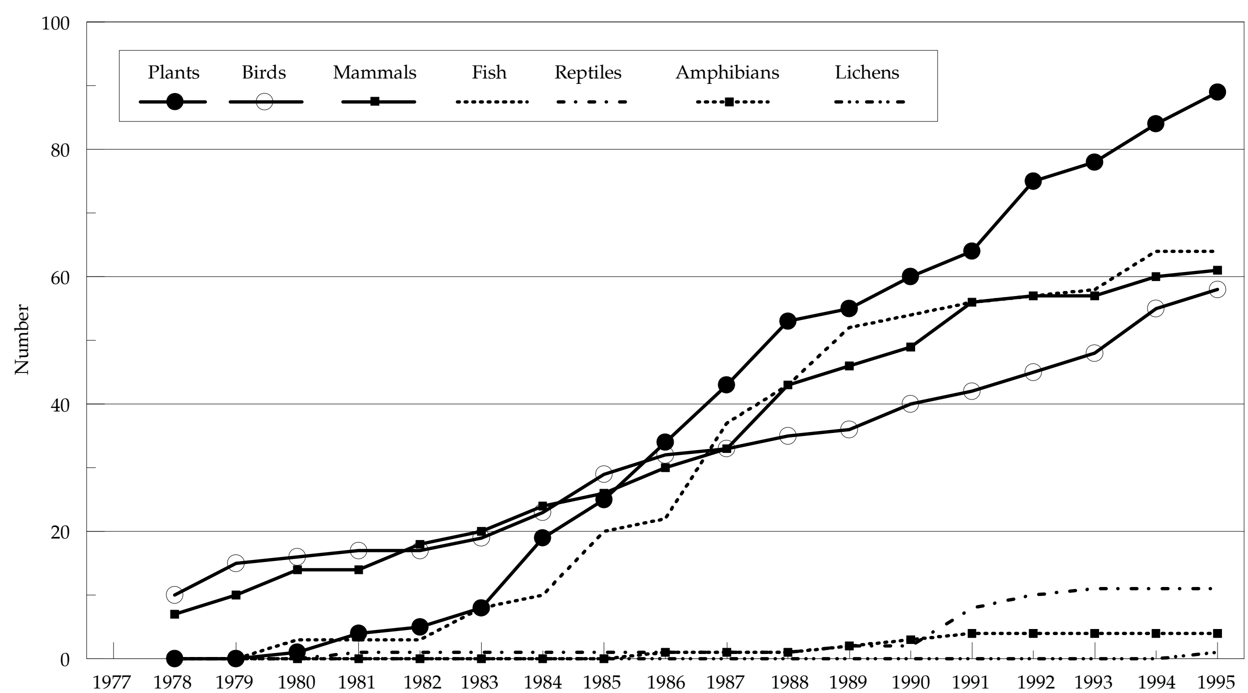

Source: Committee on the Status of Wildlife in Canada, 1995.
Note: Designated wildlife includes plants, birds, mammals, fish, reptiles, amphibians, and lichens.

## Figure 50: Species at Risk in the United States




Source: U.S. Fish and Wildlife, 1994.
Note: Designated wildlife includes endangered and threatened categories. Data is unavailable for 1993.

## Figure 51: Species at Risk in Canada




Source: Committee on the Status of Wildlife in Canada, 1995.
Note: Designated wildlife includes all categories: extinct, extirpated, endangered, threatened and vulnerable.

# Index of Environmental Indicators

The indicators in this report show improvements in many areas of environmental concern including air and water quality, natural resource use, and solid waste management. This section develops an index that measures improvements or reductions in overall environmental quality for the United States and Canada. The index shows that the relative severity of environmental problems is decreasing and that environmental quality in most categories is improving relative to the quality in 1980. It also shows that *overall* environmental quality has improved relative to 1980 levels for both countries.

## Methodology

To aggregate individual environmental indicators such as lead, phosphorus, and soil erosion into a single measure of environmental quality, a common unit of measure is required. To create the index of environmental indicators, annual values within each of the four main categories (air quality, water quality, natural resources, and solid waste) are converted to the base year 1980. This makes it possible to compare environmental quality in later years to the base year. It is important to note that this approach allows a comparison of relative values only. The base-80 values do not provide any information about the absolute level of environmental quality. This is unavoidable as assessments of absolute environmental quality are value judgments, beliefs about the "state of nature" that are social constructs varying among societies and over time.[135]

Base-80 values are comparable across categories because they are measured in the same units. For the same reason, these values can be averaged. A second technical issue arises when determining the weight assigned to each indicator. For example, it is difficult to quantify the respective weights to be given to air and, say, water pollution. For this reason, no attempt is made to give relative weights to each indicator. For each year, base-80 values are averaged within each of the four environmental categories (air quality, water quality, natural resources, solid waste). The category averages are then weighted equally to arrive at an overall average for each year.[136] The resulting time series represents the general trend in environmental quality for the United States and Canada.

It was necessary to account for missing data in many categories because the available time-series environmental data are often incomplete. Straightforward linear regression techniques are used to estimate missing values. In cases where trends are improving, however, the law of diminishing marginal returns may begin to have a significant effect. This means that future improvements may be more difficult to achieve than past ones. In such cases, linear projections would overestimate the rate of environmental improvement. For this reason, linear projections are used only to interpolate, that is, to fill gaps between known data points and years without data. Forward projections are conservatively estimated: they use the last known data point as an estimator for later years with missing data. This technique ensures that no additional environmental improvement is assumed where data are missing. In cases where backward projections are necessary, missing data are also conservatively estimated. As a result, the index of environmental indicators likely *underestimates* the actual improvement in environmental quality relative to 1980.

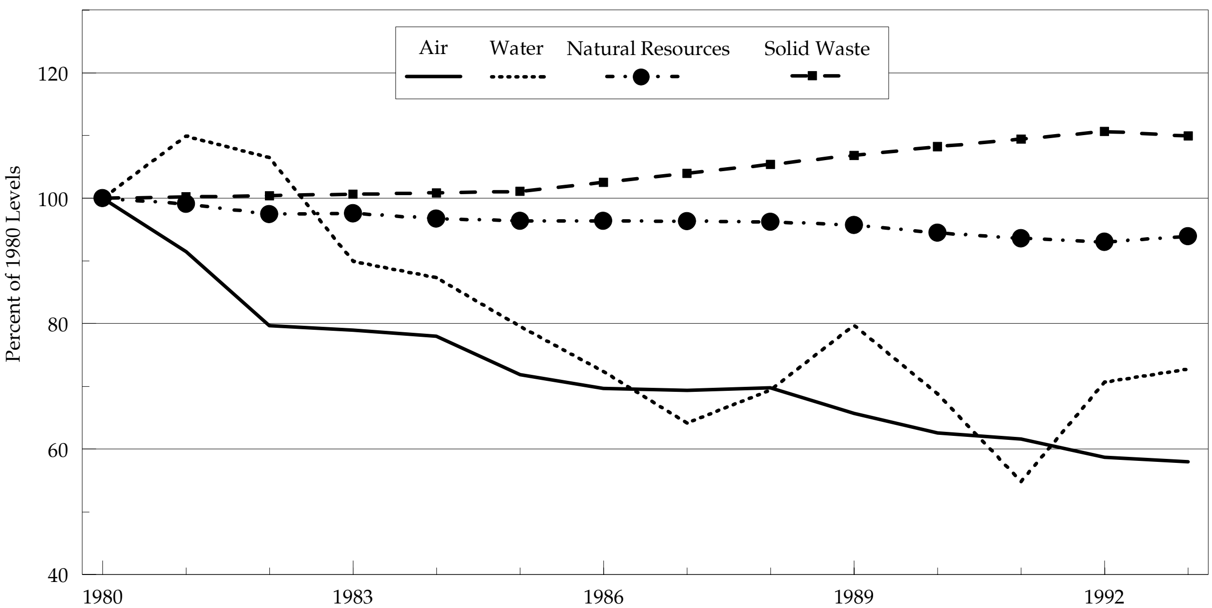
## Results

Tables 15 and 16 show the base-80 values for each environmental indicator as well as category and

135 For a comprehensive discussion of the wide variety of beliefs about nature in this century alone, see Bramwell, *Ecology in the 20th Century*, 1989.

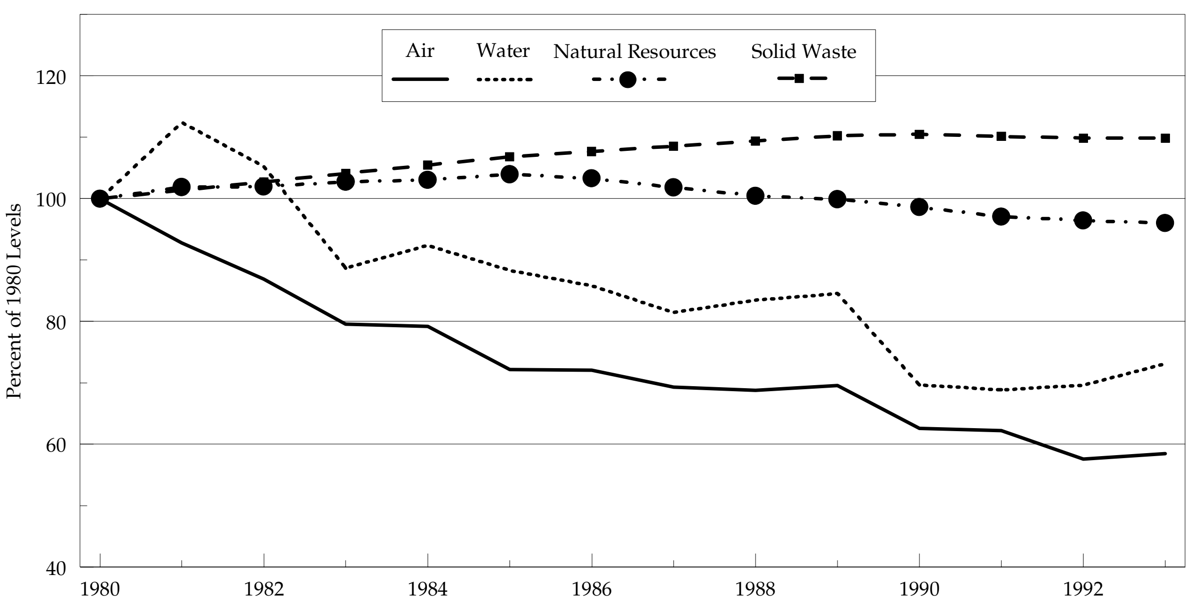
136 This two-stage averaging process is necessary to avoid giving exaggerated weight to categories that include a larger number of sub-categories.

**Figure 52: Relative Severity of Environmental Problems in the United States**




Note: Annual values are calculated by averaging "base-80" values within each environmental category.

**Figure 53: Relative Severity of Environmental Problems in Canada**

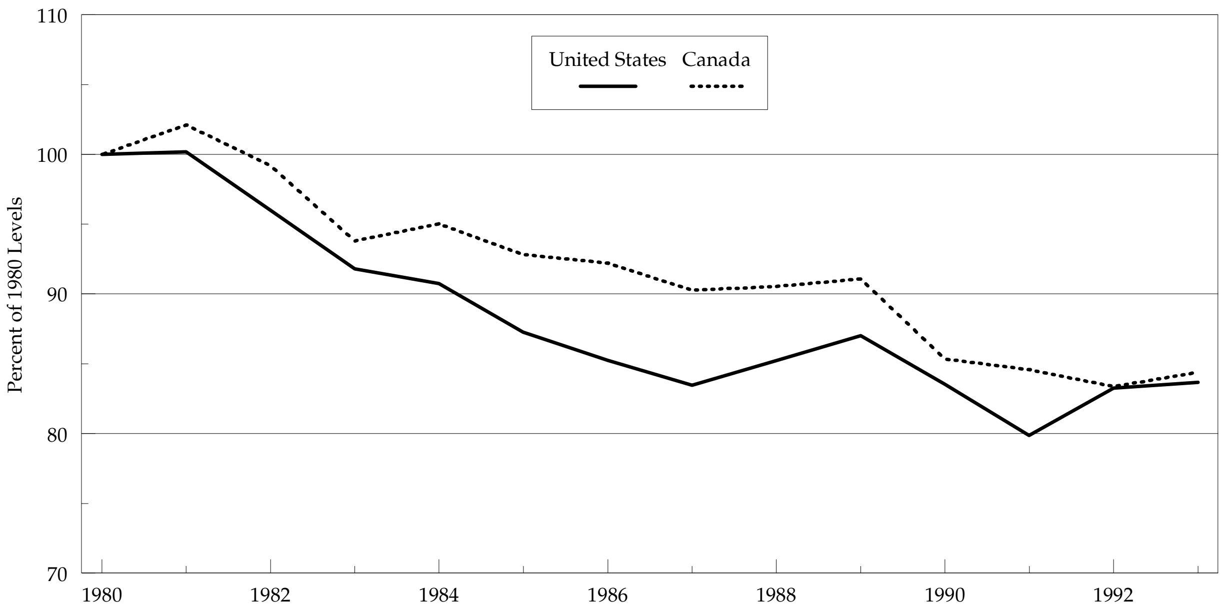



Note: Annual values are calculated by averaging "base-80" values within each environmental category.

overall averages for the United States and Canada from 1980 to 1993.[137] The category averages are presented graphically in figures 52 and 53. The trend in each country is clear: relative to the situation in 1980, environmental pollution is declining in severity in the categories of air quality, water quality, natural resources, and solid waste. On average, overall environmental problems in the United States in these categories were 16.3% less severe in 1993 than in 1980, and 15.6% less severe in Canada (figure 54).

137 This is the time period for which the data are most complete across all categories.

**Figure 54: Relative Severity of Environmental Problems in the United States and Canada**




Note: Slopes are calculated by averaging the "base-80" values of all four environmental categories.

The greatest improvements in the environment in both countries were in air and water quality. In Canada, overall ambient air quality improved by 41.5% while water quality improved by 26.9% between 1980 and 1993. During the same period, American ambient air quality showed an 42.0% improvement, while water quality improved by 27.2%. The improvement in water quality, however, should be taken with a note of caution as the available data represent only a small fraction of the number of rivers, lakes and streams in each country.

While these trends are encouraging, a few indicators showed a decrease in environmental quality. For example, ground-level ozone levels deteriorated in Canada in the 1980s. Because ground-level ozone is the result of many factors, its reduction remains a particularly difficult regulatory problem. In addition, freshwater consumption in Canada increased relative to renewable freshwater resources. However, since Canada has abundant water resources and since freshwater consumption could be drastically reduced by allowing it to be sold at market value, this trend may not be of great concern.

In the United States and Canada, municipal waste generation has increased substantially since 1980; recycling rates, however, have increased as well. While Americans and Canadians produced increasing amounts of refuse, fewer economically valuable resources were being sent to landfills and incinerators. In addition, using the total amount of waste generated as an indicator of environmental quality may overstate the waste problem, as there is no shortage of landfill space in either the United States or Canada.

## Conclusion

The Fraser Institute-Pacific Research Institute index of environmental indicators shows that fears about increasing environmental degradation in Canada and the United States are unfounded. In both countries, environmental quality is getting better, not worse. While it is impossible to determine the exact magnitude of the improvement in the environment due to the difficulty in determining how overall environmental quality should be measured as well as the lack of data for some important categories, the direction of the change in quality is clear. While there are still some serious environmental problems that need to be addressed, overall environmental quality is improving.

## Table 15: Relative Severity of Environmental Problems in the United States (base year 1980)[A]

Values >1 represent an increase in environmental degradation; values <1 represent a decrease.

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Net change[B] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Air quality[C]** | | | | | | | | | | | | | | | |
| **$SO_2$** | 1.00 | 0.94 | 0.86 | 0.83 | 0.84 | 0.84 | 0.83 | 0.81 | 0.82 | 0.79 | 0.73 | 0.72 | 0.67 | 0.66 | –0.339 |
| **$NO_2$** | 1.00 | 0.96 | 0.89 | 0.89 | 0.93 | 0.80 | 0.81 | 0.80 | 0.81 | 0.80 | 0.76 | 0.75 | 0.73 | 0.71 | –0.289 |
| **Ozone** | 1.00 | 0.91 | 0.90 | 1.00 | 0.90 | 0.90 | 0.87 | 0.91 | 0.99 | 0.85 | 0.83 | 0.84 | 0.78 | 0.80 | –0.203 |
| **CO** | 1.00 | 0.97 | 0.87 | 0.88 | 0.87 | 0.74 | 0.76 | 0.72 | 0.69 | 0.68 | 0.62 | 0.59 | 0.56 | 0.53 | –0.473 |
| **TSP** | 1.00 | 0.89 | 0.76 | 0.75 | 0.78 | 0.74 | 0.74 | 0.76 | 0.77 | 0.75 | 0.74 | 0.74 | 0.74 | 0.74 | –0.263 |
| **Pb** | 1.00 | 0.81 | 0.50 | 0.38 | 0.36 | 0.28 | 0.18 | 0.16 | 0.11 | 0.08 | 0.08 | 0.06 | 0.05 | 0.05 | –0.955 |
| **Average** | 1.00 | 0.91 | 0.80 | 0.79 | 0.78 | 0.72 | 0.70 | 0.69 | 0.70 | 0.66 | 0.63 | 0.62 | 0.59 | 0.58 | –0.420 |
| **Water quality** | | | | | | | | | | | | | | | |
| **"Exceedances"[D]** | 1.00 | 0.95 | 1.03 | 1.03 | 0.90 | 0.85 | 0.75 | 0.68 | 0.70 | 0.88 | 0.78 | 0.48 | 0.80 | 0.84 | –0.163 |
| **Phosphorus (Gr. Lakes)** | 1.00 | 0.96 | 0.91 | 0.87 | 0.83 | 0.78 | 0.78 | 0.87 | 0.83 | 0.78 | 0.78 | 0.74 | 0.74 | 0.78 | –0.217 |
| **Nitrogen (Gr. Lakes)** | 1.00 | 1.02 | 1.03 | 1.05 | 1.06 | 1.08 | 1.11 | 1.13 | 1.12 | 1.14 | 1.15 | 1.18 | 1.14 | 1.12 | 0.118 |
| **DDE (Gr. Lakes)** | 1.00 | 1.48 | 1.45 | 0.70 | 0.81 | 0.81 | 0.68 | 0.45 | 0.64 | 0.69 | 0.53 | 0.63 | 0.63 | 0.63 | –0.368 |
| **PCB (Gr. Lakes)** | 1.00 | 1.37 | 1.19 | 0.78 | 0.83 | 0.63 | 0.51 | 0.35 | 0.45 | 0.58 | 0.37 | 0.38 | 0.38 | 0.38 | –0.620 |
| **HCB (Gr. Lakes)** | 1.00 | 1.41 | 0.94 | 0.47 | 0.71 | 0.41 | 0.41 | 0.24 | 0.41 | 0.41 | 0.18 | 0.18 | 0.18 | 0.18 | –0.824 |
| **Average (Great Lakes)[E]** | 1.00 | 1.25 | 1.10 | 0.77 | 0.85 | 0.74 | 0.70 | 0.61 | 0.69 | 0.72 | 0.60 | 0.62 | 0.61 | 0.62 | –0.382 |
| **Average[F]** | 1.00 | 1.10 | 1.06 | 0.90 | 0.87 | 0.80 | 0.72 | 0.64 | 0.69 | 0.80 | 0.69 | 0.55 | 0.71 | 0.73 | –0.272 |
| **Natural resources** | | | | | | | | | | | | | | | |
| **Forests[G]** | 1.00 | 1.01 | 1.02 | 1.03 | 1.04 | 1.05 | 1.06 | 1.06 | 1.06 | 1.06 | 1.07 | 1.07 | 1.07 | 1.07 | 0.071 |
| **Water[H]** | 1.00 | 0.98 | 0.96 | 0.94 | 0.92 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.91 | 0.91 | 0.91 | 0.91 | –0.095 |
| **Energy[I]** | 1.00 | 0.99 | 0.95 | 0.98 | 0.95 | 0.96 | 0.96 | 0.98 | 1.00 | 1.01 | 0.98 | 0.96 | 0.97 | 1.01 | 0.010 |
| **Development sprawl[J]** | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 0.006 |
| **Soil erosion** | 1.00 | 0.98 | 0.93 | 0.92 | 0.91 | 0.89 | 0.88 | 0.87 | 0.84 | 0.80 | 0.77 | 0.74 | 0.71 | 0.71 | –0.295 |
| **Average** | 1.00 | 0.99 | 0.97 | 0.98 | 0.97 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.94 | 0.94 | 0.93 | 0.94 | –0.061 |
| **Solid waste** | | | | | | | | | | | | | | | |
| **Waste generation** | 1.00 | 1.02 | 1.03 | 1.05 | 1.07 | 1.09 | 1.13 | 1.17 | 1.21 | 1.25 | 1.29 | 1.33 | 1.37 | 1.37 | 0.367 |
| **Recycling rate[K]** | 1.00 | 0.99 | 0.97 | 0.96 | 0.95 | 0.94 | 0.92 | 0.91 | 0.90 | 0.89 | 0.87 | 0.86 | 0.85 | 0.83 | –0.168 |
| **Average** | 1.00 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.03 | 1.04 | 1.05 | 1.07 | 1.08 | 1.09 | 1.11 | 1.10 | 0.100 |
| **Overall average[L]** | | | | | | | | | | | | | | | |
| | **1.00** | **1.00** | **0.96** | **0.92** | **0.91** | **0.87** | **0.85** | **0.83** | **0.85** | **0.87** | **0.84** | **0.80** | **0.83** | **0.84** | **–0.163** |

## Table 16: Relative Severity of Environmental Problems in Canada (base year 1980)[A]

Values >1 represent an increase in environmental degradation; values <1 represent a decrease.

| | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | Net change[B] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Air quality[C]** | | | | | | | | | | | | | | | |
| $SO_2$ | 1.00 | 0.89 | 0.89 | 0.67 | 0.78 | 0.67 | 0.67 | 0.56 | 0.67 | 0.67 | 0.67 | 0.56 | 0.56 | 0.56 | –0.444 |
| $NO_2$ | 1.00 | 0.92 | 0.92 | 0.88 | 0.92 | 0.84 | 0.88 | 0.92 | 0.84 | 0.88 | 0.84 | 0.80 | 0.72 | 0.76 | –0.240 |
| Ozone | 1.00 | 0.94 | 1.00 | 1.00 | 1.00 | 1.00 | 1.06 | 1.06 | 1.19 | 1.19 | 1.06 | 1.25 | 1.13 | 1.13 | 0.125 |
| CO | 1.00 | 1.01 | 0.86 | 0.79 | 0.70 | 0.65 | 0.62 | 0.63 | 0.60 | 0.63 | 0.54 | 0.50 | 0.48 | 0.49 | –0.512 |
| TSP | 1.00 | 0.88 | 0.78 | 0.71 | 0.70 | 0.64 | 0.64 | 0.71 | 0.66 | 0.65 | 0.58 | 0.57 | 0.52 | 0.53 | –0.466 |
| Pb | 1.00 | 0.94 | 0.77 | 0.73 | 0.66 | 0.53 | 0.45 | 0.28 | 0.18 | 0.16 | 0.07 | 0.05 | 0.05 | 0.05 | –0.951 |
| Average | 1.00 | 0.93 | 0.87 | 0.80 | 0.79 | 0.72 | 0.72 | 0.69 | 0.69 | 0.70 | 0.63 | 0.62 | 0.58 | 0.59 | –0.415 |
| **Water quality** | | | | | | | | | | | | | | | |
| "Exceedances"[D] | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.02 | 1.02 | 1.02 | 0.98 | 0.97 | 0.79 | 0.76 | 0.78 | 0.84 | –0.155 |
| Phosphorus (Gr. Lakes) | 1.00 | 0.96 | 0.91 | 0.87 | 0.83 | 0.78 | 0.78 | 0.87 | 0.83 | 0.78 | 0.78 | 0.74 | 0.74 | 0.78 | –0.217 |
| Nitrogen (Gr. Lakes) | 1.00 | 1.02 | 1.03 | 1.05 | 1.06 | 1.08 | 1.11 | 1.13 | 1.12 | 1.14 | 1.15 | 1.18 | 1.14 | 1.12 | 0.118 |
| DDE (Gr. Lakes) | 1.00 | 1.48 | 1.45 | 0.70 | 0.81 | 0.81 | 0.68 | 0.45 | 0.64 | 0.69 | 0.53 | 0.63 | 0.63 | 0.63 | –0.368 |
| PCB (Gr. Lakes) | 1.00 | 1.37 | 1.19 | 0.78 | 0.83 | 0.63 | 0.51 | 0.35 | 0.45 | 0.58 | 0.37 | 0.38 | 0.38 | 0.38 | –0.620 |
| HCB (Gr. Lakes) | 1.00 | 1.41 | 0.94 | 0.47 | 0.71 | 0.41 | 0.41 | 0.24 | 0.41 | 0.41 | 0.18 | 0.18 | 0.18 | 0.18 | –0.824 |
| Average (Great Lakes)[E] | 1.00 | 1.25 | 1.10 | 0.77 | 0.85 | 0.74 | 0.70 | 0.61 | 0.69 | 0.72 | 0.60 | 0.62 | 0.61 | 0.62 | –0.382 |
| Average[F] | 1.00 | 1.12 | 1.05 | 0.89 | 0.92 | 0.88 | 0.86 | 0.81 | 0.83 | 0.85 | 0.70 | 0.69 | 0.70 | 0.73 | –0.269 |
| **Natural resources** | | | | | | | | | | | | | | | |
| Forests[G] | 1.00 | 1.04 | 1.09 | 1.13 | 1.18 | 1.22 | 1.18 | 1.14 | 1.10 | 1.06 | 1.02 | 0.98 | 0.94 | 0.94 | –0.059 |
| Water[H] | 1.00 | 1.03 | 1.05 | 1.08 | 1.10 | 1.13 | 1.14 | 1.14 | 1.15 | 1.16 | 1.17 | 1.18 | 1.19 | 1.20 | 0.200 |
| Energy[I] | 1.00 | 1.00 | 0.94 | 0.91 | 0.86 | 0.84 | 0.84 | 0.81 | 0.79 | 0.80 | 0.78 | 0.74 | 0.74 | 0.71 | –0.294 |
| Development sprawl[J] | 1.00 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 0.006 |
| Soil erosion | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.98 | 0.97 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 | –0.053 |
| Average | 1.00 | 1.02 | 1.02 | 1.03 | 1.03 | 1.04 | 1.03 | 1.02 | 1.00 | 1.00 | 0.99 | 0.97 | 0.96 | 0.96 | –0.040 |
| **Solid waste** | | | | | | | | | | | | | | | |
| Waste generation | 1.00 | 1.04 | 1.09 | 1.13 | 1.17 | 1.21 | 1.26 | 1.30 | 1.34 | 1.39 | 1.43 | 1.46 | 1.49 | 1.49 | 0.492 |
| Recycling rate[K] | 1.00 | 0.98 | 0.97 | 0.95 | 0.94 | 0.92 | 0.90 | 0.87 | 0.85 | 0.82 | 0.78 | 0.74 | 0.70 | 0.70 | –0.295 |
| Average | 1.00 | 1.01 | 1.03 | 1.04 | 1.05 | 1.07 | 1.08 | 1.09 | 1.09 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 0.098 |
| **Overall average[L]** | | | | | | | | | | | | | | | |
| | **1.00** | **1.02** | **0.99** | **0.94** | **0.95** | **0.93** | **0.92** | **0.90** | **0.91** | **0.91** | **0.85** | **0.85** | **0.83** | **0.84** | **–0.156** |

## Notes to Tables 15 and 16

[A] Except where otherwise noted, missing data were either extrapolated backward using the earliest available data point or extrapolated forward using the last available data point. See text for explanation.

[B] Net change equals the 1993 base-80 value minus the 1980 base-80 value; multiply by 100 to obtain a percentage change. Any slight discrepancies between the net change column and the difference between the 1993 and 1980 columns are due to rounding-off.

[C] Ambient levels.

[D] An "exceedance" is an instance of a reported failure to comply with a standard. This line shows the percentage of readings failing to meet local standards. In table 15, this is an average of fecal coliform, dissolved oxygen, and phosphorus; in table 16, this is an average of responses from British Columbia, Alberta, Saskatchewan, Manitoba, and New Brunswick.

[E] Average of phosphorus, nitrogen, DDE, PCB, and HCB.

[F] Average of the line "Exceedances" and the line "Average (Great Lakes)."

[G] In table 15, this is the ratio of harvest to growth; in table 16 this is the ratio of annual allowable cut (AAC) to growth.

[H] Ratio of withdrawals to renewable resources.

[I] Ratio of consumption to production.

[J] Developed land (urban + agricultural) as a proportion of total land base.

[K] Recycling rate is an average of the rate of recycling of paper and cardboard and of glass. The rates are inverted to express the proportion of waste *not* recycled. Canadian glass recycling figures (table 16) were unavailable before 1990, so figures for 1980 to 1989 were derived using the average ratio of paper and cardboard to glass for years where data is available.

[L] Overall average is the average of the lines "Average (air quality)," "Average (water quality)," "Average (natural resources)," and "Average (solid waste)."

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