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, such as global warming. In other cases, wildlife for example, the questionable data makes it difficult to draw reliable conclusions.

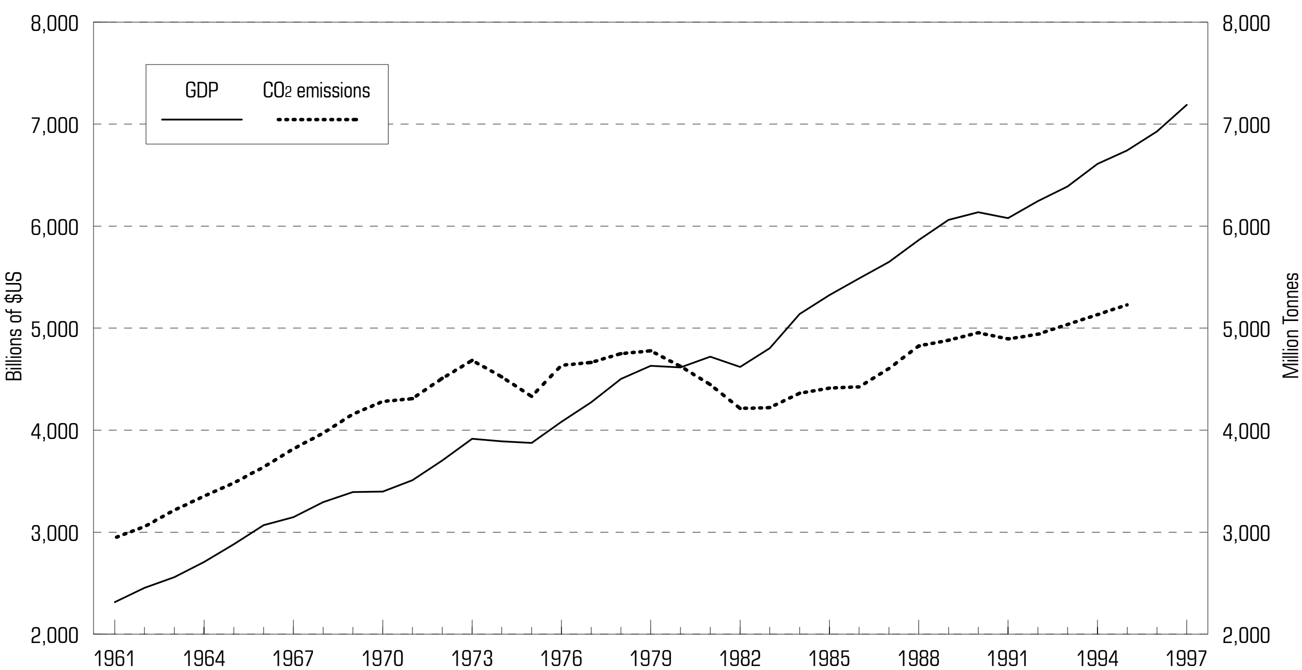
Carbon dioxide emissions

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.[1] The combustion of fossil fuels by humans also generates CO_2.

Figures 41 and 42 are a graphic indication of how CO_2 emissions correlate with fluctuations in Gross Domestic Product (GDP). 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 have increased.

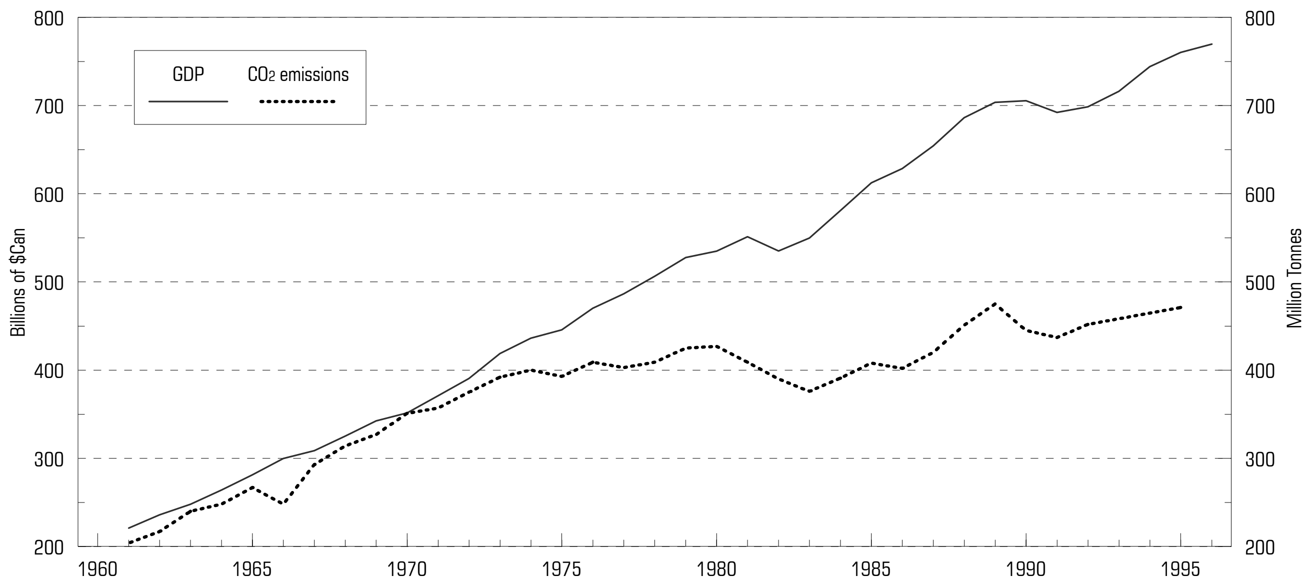
CO_2 emissions have been linked to a possible human-induced global warming. As a result, controlling CO_2 emissions has been the subject of many recent policy debates. In order fully to understand the popular global warming debate, one must appreciate the distinction between the greenhouse effect and the enhanced greenhouse effect. Scientists agree that there is a greenhouse effect that causes the earth to be warm. This effect occurs because greenhouse gases such as carbon dioxide, water vapour, nitrous

Figure 41: GDP Compared to CO_2 Emissions: Trends in the United States



Source: US EPA, 1994; IEA, 1997; Bureau of Economic Analysis, 1998. Note: GDP is in constant (1992) US dollars.

Figure 42: GDP Compared to CO_2 Emissions: Trends in Canada



Source: Environment Canada, 1996a; IEA, 1996; Canadian Economic Observer, 1998. Note: GDP is in constant (1992) Canadian dollars.

oxide, and methane are transparent to the short wavelength radiation from the sun but opaque to the longer wavelength radiation emitted from the earth. In simple terms, greenhouse gases trap the heat from the sun and this warms the earth.

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

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

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

The inadequacy of the computer models

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

In fact, the computer models cannot even replicate what has already happened to temperatures. For example, according to the model used by the Intergovernmental Panel on Climate Change (IPCC), the northern hemisphere should have warmed between 1.3° and 2.3° Celsius since the beginning of the century. It has not. For the northern hemisphere, the warming measured at ground-based stations is about 0.6 degrees Celsius—less than one-third the warming that was predicted to occur.

Evidence from temperature records

The second major criticism of the theory that temperatures are likely to rise as a result of increasing CO_2 emissions and cause dramatic damage to the environment is that temperature records do not support a strong link between CO_2 emissions and warming. According to ground-level temperature records, there has indeed been an increase in temperature over the past 100 years. Most of this increase, however, occurred before 1940; in other words, *most of the increase in temperature occurred before the main input of human-induced CO_2 emissions.* In addition, records from the satellites that have been measuring temperatures in space since 1979 do not support the hypothesis that the earth is warming. While the climate models produced by computers predict that there should have been some warming over the past 18 years, the satellite data show a slight global cooling. Thus, the evidence does not support the predictions of the models. It is considered a problem in any scientific discipline when the evidence contradicts a theory, and such a discrepancy should lead to a re-evaluation of the models.

Other explanations for temperature change

There are other viable explanations that do not rely upon CO_2 emissions to explain atmospheric temperature change. Unfortunately, these explanations have not received widespread media attention.

Some scientists hypothesize, for example, that much of the temperature fluctuation can be explained by changes in the brightness of the sun—something that is obviously beyond human control. Sallie Baliunas, a scientist at the Harvard Center for Astrophysics, explains:

> Most of the warming early in this century, then, must have been due to natural causes of climatic change, and these natural causes must be understood in order to make an accurate assessment of the effect upon climate of any human activities that may have been added to the natural changes.
>
> One possible natural cause of climatic change is variation in the brightness of the sun. (Baliunas and Soon: 81)
>
> The processes of "fingerprinting" various mechanisms of climatic change and projecting climatic change requires knowing *all* the relevant factors, both those that are natural and those that are the result of human activity. And, these factors must be considered *simultaneously* in a model. Once such a model is verified, then only can each mechanism be identified. Since the mechanisms of climatic change are not fully known—as we have shown, the question how the sun affects the climate is unresolved—and the models have not been verified, fingerprinting is not yet possible. (Baliunas and Soon: 86–7)

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

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

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 43 shows that there has been a declining trend in the amount of oil spilled in American waters over the last two decades. 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 (Allen 1993). 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 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 (Bast, Hill and Rue 1994: 148–53). In some cases, active cleanup can actually cause more harm

Figure 43: Oil Spills in and around American Waters (by volume)

Source: US Coast Guard, cited in US Bureau of the Census, 1996.

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 44). 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 vessels involved in 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 remains controversial. Figure 45 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 196 kg/km^2 in 1993. In Canada, use of pesticides fell from 94 kg/km^2 to 70.5 kg/km^2 between 1985 and 1994. While these declines are not dramatic, they illustrate that fears of greatly increased pesticide use have not materialized. (For a summary, see Easterbrook 1995: 79 ff.)

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 persist in the environment and tend to accumulate in animal tissue. Today, chlorinated hydrocarbons account for only about 5 percent of all pesticides (Hayward 1994). 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 (Knutson et al. 1990). The EPA's most conservative risk-assessment models attribute a maximum of about

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. • CO_2 is believed to contribute to global warming but the temperature record does not support this theory. • The sophisticated computer climate models, upon which the global warming theory is partly based, have come under heavy criticism. • Industrialized economies produce great amounts of CO_2. • A massive economic downturn would be needed to reduce CO_2 emissions radically.	• CO_2 emissions in the United States have risen and fallen with GDP fluctuations over the last two decades. • In recent years, emissions have begun rising again, although not as steeply as in the decades before the "energy crisis" of the 1970s.	• CO_2 emissions in Canada have risen and fallen GDP fluctuations over the last two decades. • 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. • Since oil is a natural substance, it degrades naturally in the environment. • 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. • 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. • 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.

0.00008 percent of all cancer cases per year to pesticide residues (Utt 1991). In fact, the risk from carcinogenic compounds that occur naturally in food is much greater than the risk from pesticide residues (Ames and Gold 1996).

Toxic releases

The Congress of the United States 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 stipulated that the 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 46 shows the data available for the United States and Canada.

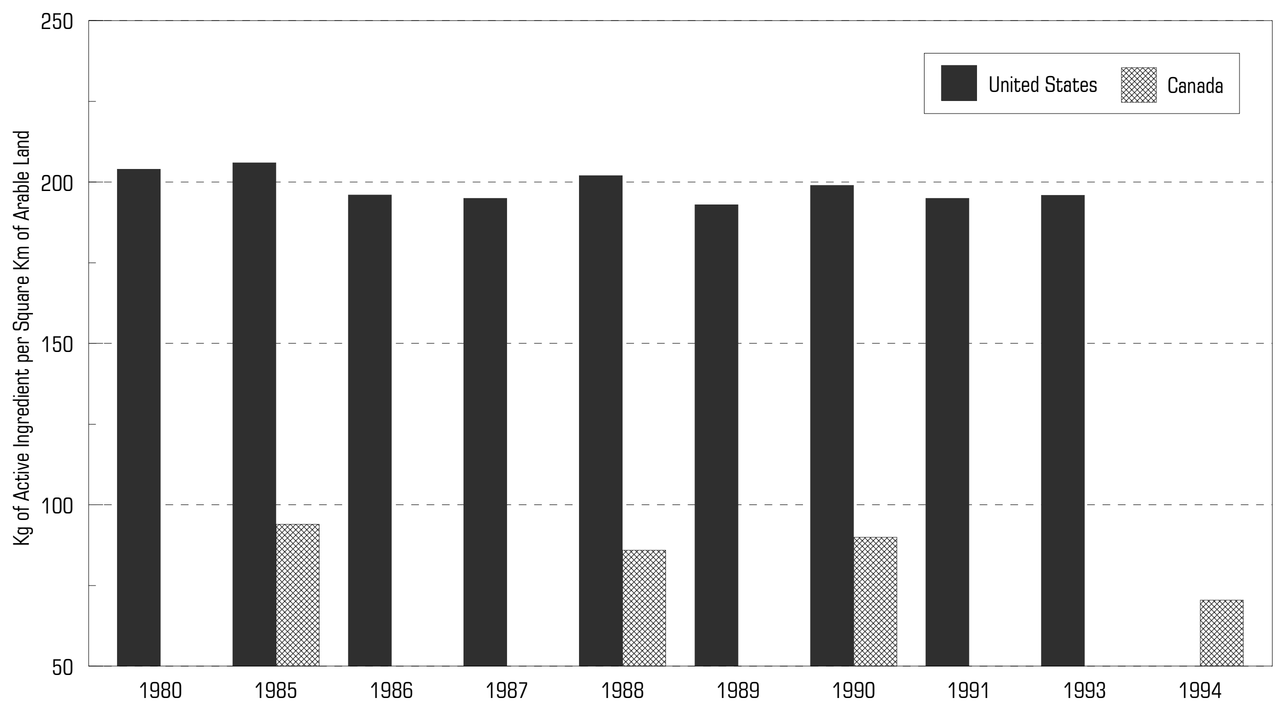
In the United States, toxic releases declined sharply over the brief period for which data are available. Though this trend suggests an improvement in environmental quality, toxic releases are a problematic environmental indicator. Broad definitions apply to toxic wastes and the TRI does not distinguish 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. (USEPA 1995a)

Figure 44: Significant Spills in and around Canadian Waters (by volume)

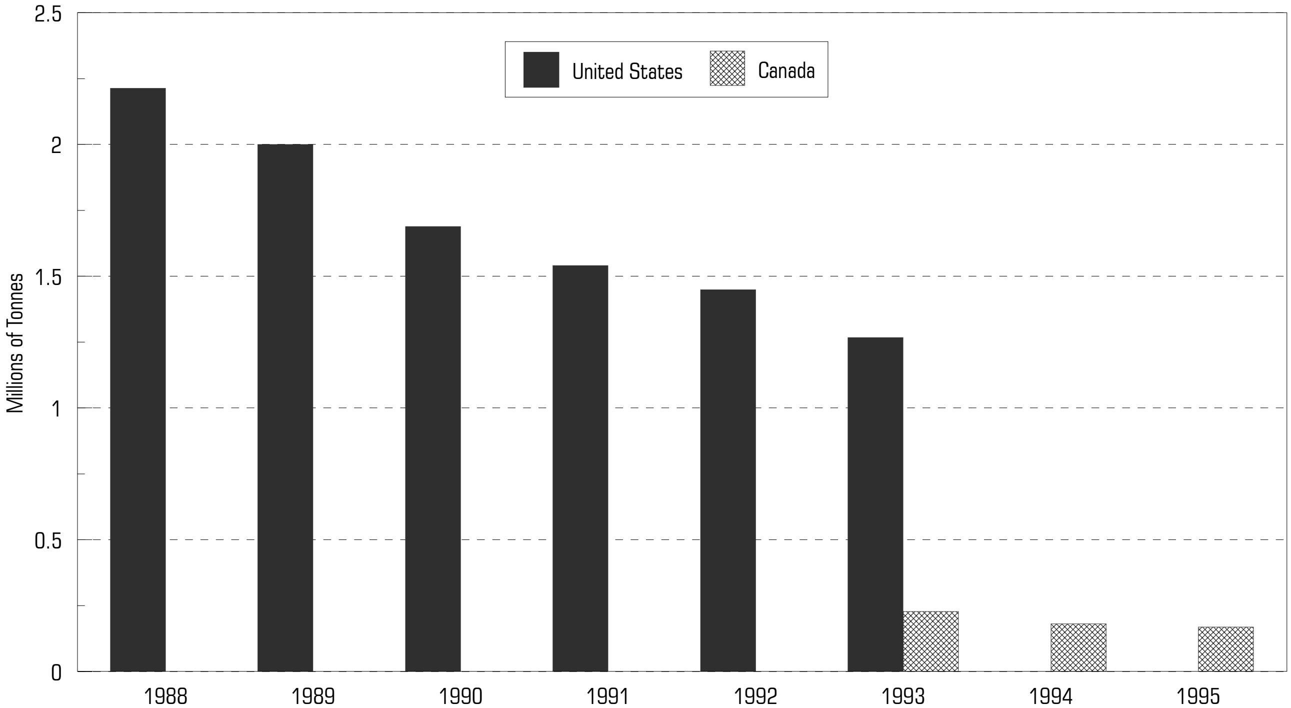
Source: Environment Canada, 1991c. Note that the Canadian data includes all spills in the Pacific and Atlantic oceans.
From 1976 to 1987, petroleum = 32.1%; industrial waste = 60.5%; other = 7.4%.

Figure 45: Pesticide Use



Source: OECD, 1994,1997. American data are unavailable after 1993; Canadian data available only for the years shown.

Figure 46: Toxic Waste Releases



Sources: U.S. EPA, 1995a; Environment Canada, 1995, 1997. American data are unavailable after 1993; Canadian data unavailable before 1993.

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. • Today's new class of pesticides are less persistent and have fewer environmental side-effects. • Pesticide use increases crop production, which means that less land is converted from wilderness to agricultural use. • 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 196 kg/km^2 in 1993.	• In Canada, pesticide use fell from 94 kg/km^2 in 1985 to 70.5 kg/km^2 in 1994.
Toxic releases		
• The US TRI requires the reporting of 316 chemical releases in 20 different categories. • The Toxic Release Inventory (TRI) does not distinguish between releases that pose an environmental problem and those that do not. • Determining risk depends on the toxicity of the chemical, the extent of exposure, the type of release and environmental conditions. • 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, modelled after the TRI program in the US, was started in 1993. • There has been a 26 percent decrease in toxic releases between 1993 and 1995.

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 (Bast, Hill and Rue 1994: 148–53). 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

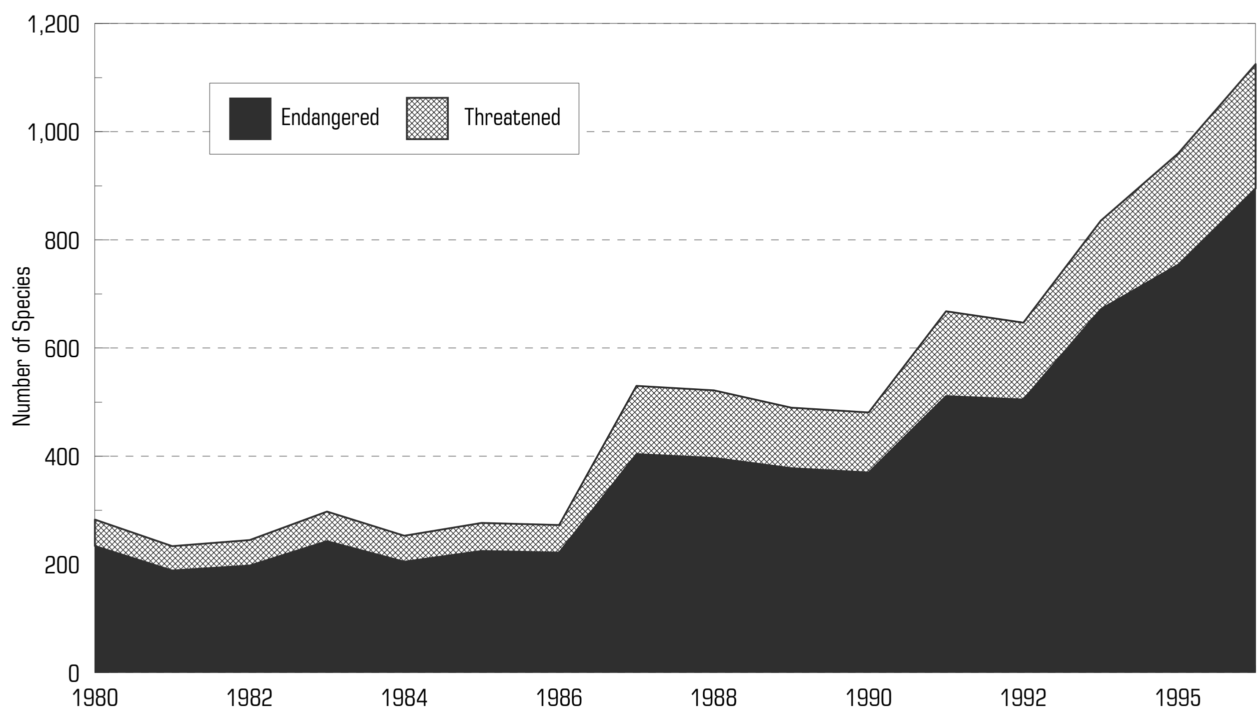
The North American wildlife population consists of at least 1,950 species of vertebrates, 4,200 species of vascular plants, approximately 95,000 species of invertebrates, and 34,000 species of insects (Environment Canada 1991c: (6)4). Many more unrecorded species may exist.

The number of species officially designated as threatened or endangered by the United States Fish and Wildlife Service has almost quadrupled from 283 species in 1980 to 1125 in 1997 (figure 47). In Canada, the number of species designated by the Committee on the Status of Wildlife (COSEWIC) as extinct, extirpated, endangered, threatened, or vulnerable[3] has increased from a total of 17 species in 1978 to 280 in 1996 (figure 48).

Although the number of species identified as endangered in the United States exceeds greatly the number identified in Canada, it is unclear whether this reflects any actual differences in the number of endangered species. These numbers may only reflect differences between the definitions in one country or the other of what constitutes an endangered species. In addition, definitions within each country have changed over time and now include more species. 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 one-half of the species listed are plants (figure 49), and the Fish and Wildlife Service has identified an additional 3,500 species as candidates for listing (Mann and Plummer 1992: 52).

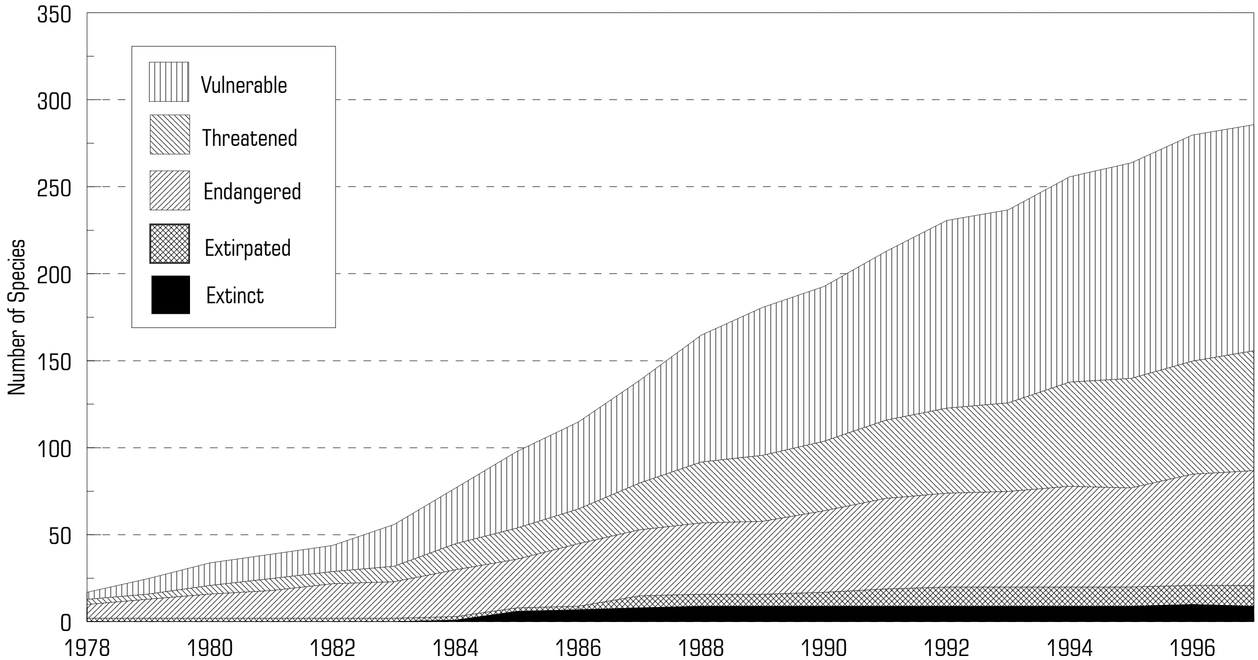
In Canada, there are over 120 government and private programs that address wildlife issues (Environment

Figure 47: Wildlife Thought to Be at Risk in the United States



Source: U.S. Fish and Wildlife cited in Council on Environmental Quality, 1996. Note that data is unavailable for 1993 and 1996. Designated wildlife includes plants; birds; mammals; fish; reptiles and amphibians; crustaceans, snails, and clams; insects and arachnids.

Figure 48: Wildlife Thought to Be at Risk in Canada



Source: Committee on the Status of Wildlife in Canada, 1995; COSEWIC in Environment Canada, 1996c; COSEWIC in WWF, 1997.
Note that designated wildlife includes plants, birds, mammals, fish, reptiles, amphibians and lichens.

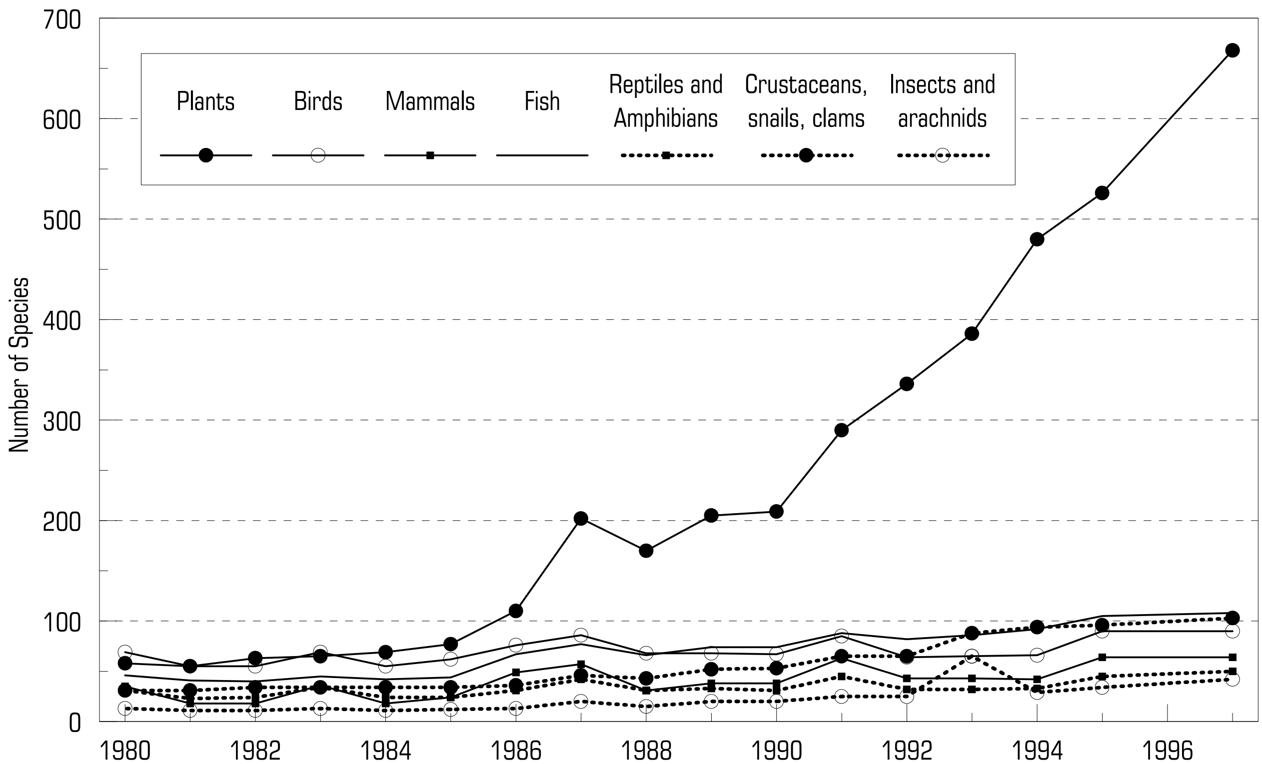
Canada 1991c: (6)20–3). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is composed of federal, provincial, and territorial management agencies, the Canadian Nature Federation, the Canadian Wildlife Federation, and the World Wildlife Fund of Canada. Figure 50 shows the trends in species listings. Since 1986, plants have been the largest category of the species listed.

There are many problems in using wildlife as an indicator when assessing environmental quality. For example, the practice of relating the number of species that are becoming extinct to the amount of habitat destruction is a topic that is hotly disputed in the scientific community (Edwards 1995: 211–65). In addition, there is uncertainty associated with the classification of species as endangered and with the distinction between a species and a subspecies.[4] 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.

Table 14: Summary of Wildlife as Environmental Indicator

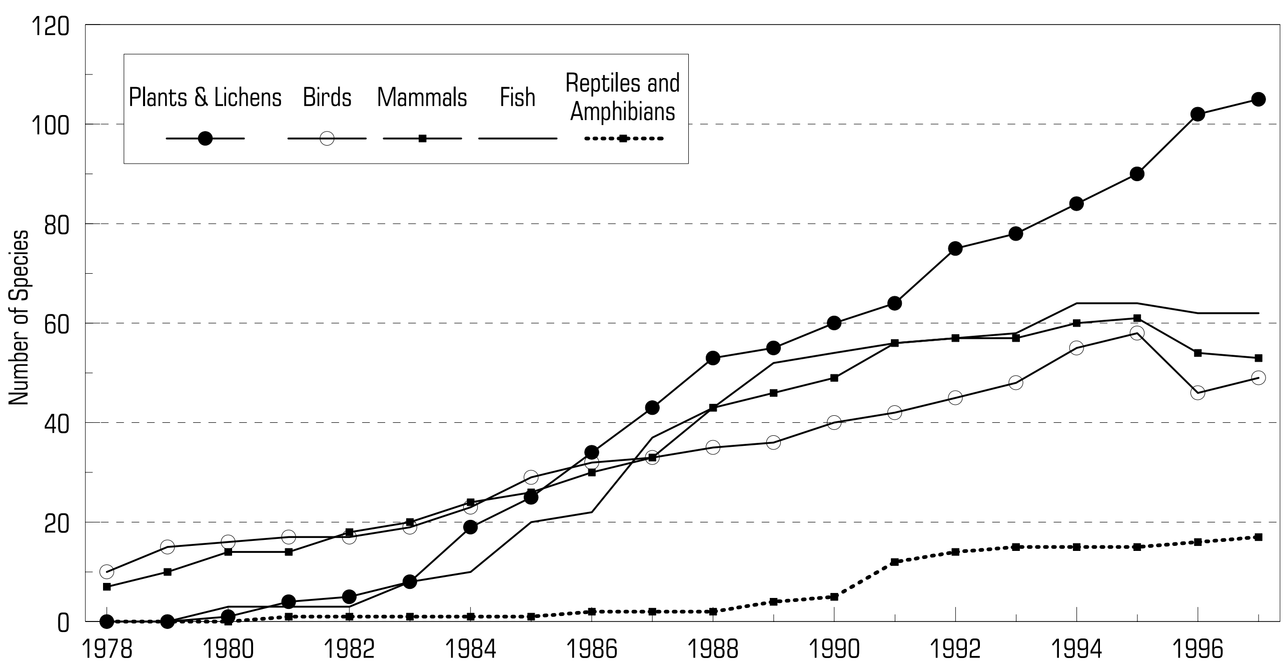
General comments	Performance record: US	Performance Record: Canada
• The North American wildlife population is diverse. • There is no standard by which to determine the threats human activity actually poses to ecosystems. • The rate of species extinction, the practice of relating species decline to habitat 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 1125 in 1997. • More than half of the species listed are plants. • 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 286 in 1997. • Plants have been the largest category of listed species since 1986.

Figure 49: Species Thought to Be at Risk in the United States



Source: U.S. Fish and Wildlife, 1994; Council on Environmental Quality, 1996. Note: Designated wildlife includes endangered and threatened categories. Data is unavailable for 1996.

Figure 50: Species Thought to Be at Risk in Canada



Source: COSEWIC, 1995; COSEWIC cited in Environment Canada, 1996c; COSEWIC cited in WWF, 1997. Wildlife includes extinct, extirpated, endangered, threatened, and vulnerable.

Index of Environmental Indicators

The indicators in this report show improvements in many areas that are of environmental concern including the quality of air and water, the use of natural resources, and the management of solid wastes. 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, both in the United States and in Canada, *overall* environmental quality has improved relative to 1980 levels.

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.[1]

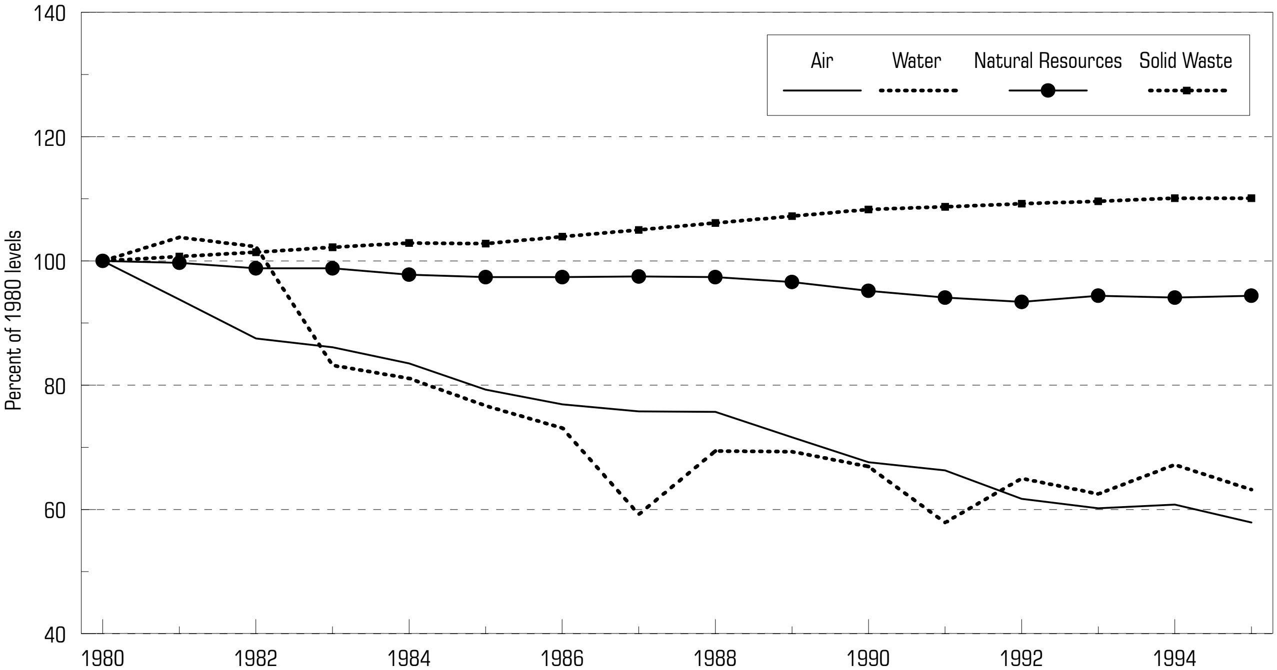
Base-80 values are comparable across categories because they are measured in the same units. For the same reason, these values can be averaged. A second technical issue arises when determining the weight assigned to each indicator. For example, it is difficult to quantify the respective weights to be given to air pollution and 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, and solid waste). The category averages are then weighted equally to arrive at an overall average for each year.[2] 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

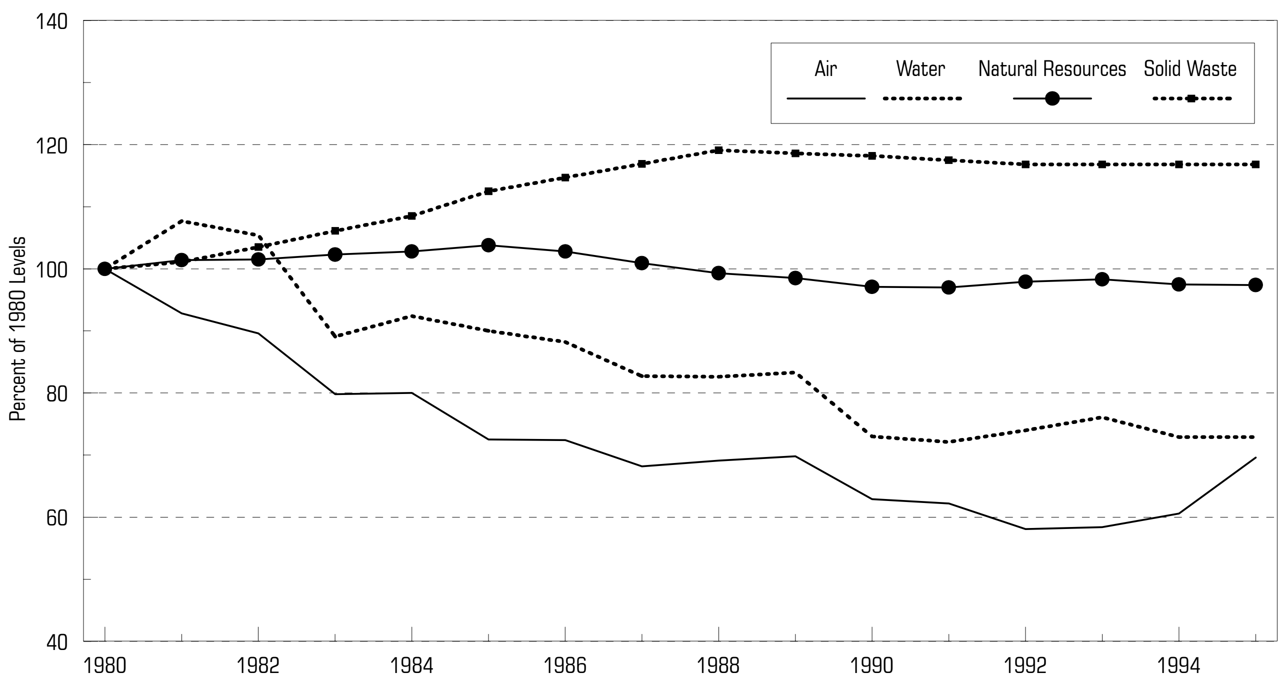
Tables 15 and 16 show the base-80 values for each environmental indicator as well as category and overall averages for the United States and Canada from 1980 to 1995.3 The category averages are presented graphically in figures 51 and 52. The trend in each country is clear: relative to the situation in 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 19.2 percent less severe in 1995 than in 1980, and 13 percent less severe in Canada (figure 53).

Figure 51: Relative Severity of Environmental Problems in the United States



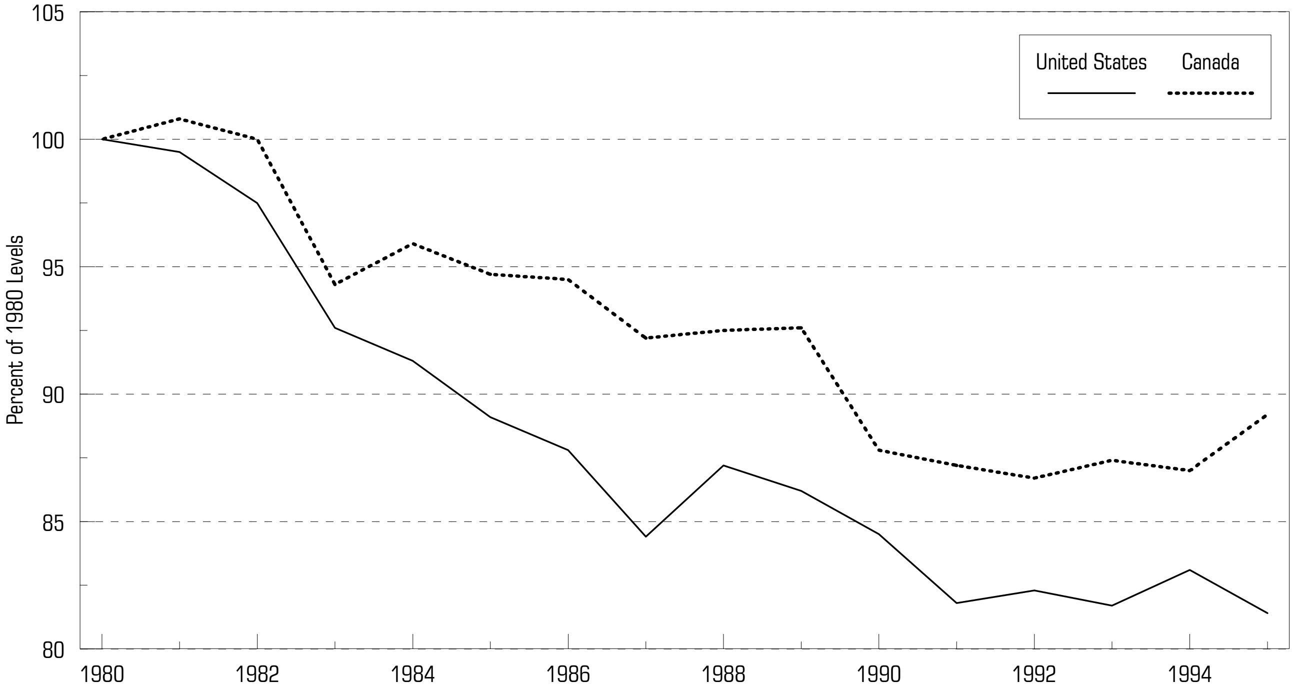
Note: Annual values are calculated by averaging "base-80" values of the four primary indicator categories.

Figure 52: Relative Severity of Environmental Problems in Canada



Note: Annual values are calculated by averaging "base-80" values of the four primary indicator categories.

Figure 53: Relative Severity of Environmental Problems in the United States and Canada



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

The greatest improvements in the environment in both countries were in air quality and water quality. In Canada, overall ambient air quality improved by 39.3 percent while water quality improved by 27.1 percent between 1980 and 1995. During the same period, American ambient air quality showed an 44.4 percent improvement, while water quality improved by 36.8 percent. 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 index of environmental indicators for Canada and the United States 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, the overall trend in environmental quality continues to improve.

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	1994	1995	Net change[B]
Air quality[C]																	
SO_2	1.00	0.94	0.86	0.84	0.84	0.84	0.83	0.81	0.82	0.79	0.73	0.72	0.67	0.65	0.62	0.52	–0.477
NO_2	1.00	0.98	0.96	0.94	0.95	0.94	0.95	0.94	0.95	0.92	0.88	0.88	0.83	0.81	0.86	0.83	–0.168
Ozone	1.00	0.92	0.89	1.00	0.89	0.88	0.85	0.89	0.96	0.82	0.80	0.81	0.76	0.77	0.77	0.80	–0.199
CO	1.00	0.97	0.88	0.88	0.87	0.79	0.76	0.72	0.69	0.68	0.63	0.60	0.56	0.53	0.54	0.48	–0.516
PM-10s[D]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.91	0.90	0.82	0.79	0.80	0.78	–0.220
Pb	1.00	0.83	0.65	0.51	0.45	0.32	0.22	0.20	0.13	0.10	0.10	0.07	0.06	0.06	0.05	0.05	–0.949
Average	1.00	0.94	0.88	0.86	0.84	0.80	0.77	0.76	0.76	0.72	0.68	0.66	0.62	0.60	0.61	0.58	–0.421
Water quality																	
“Exceedances”[E]	1.00	0.92	0.94	0.88	0.77	0.75	0.71	0.55	0.70	0.69	0.66	0.46	0.60	0.57	0.68	0.68	–0.322
Phosphorus (Gr. Lakes)	1.00	0.96	0.91	0.87	0.83	0.78	0.78	0.87	0.80	0.74	0.78	0.74	0.74	0.78	0.61	0.61	–0.391
Nitrogen (Gr. Lakes)	1.00	1.03	1.06	1.08	1.11	1.14	1.15	1.18	1.13	1.12	1.13	1.18	1.19	1.19	1.19	1.19	0.194
DDE (Gr. Lakes)	1.00	1.32	1.36	0.67	0.78	0.75	0.68	0.42	0.54	0.58	0.62	0.75	0.67	0.77	0.69	0.48	–0.523
PCB (Gr. Lakes)	1.00	1.24	1.23	0.73	0.80	0.67	0.55	0.37	0.45	0.57	0.50	0.48	0.44	0.34	0.48	0.39	–0.610
HCB (Gr. Lakes)	1.00	1.22	0.98	0.56	0.72	0.58	0.60	0.34	0.50	0.48	0.34	0.34	0.46	0.33	0.36	0.26	–0.740
Average (Great Lakes)[F]	1.00	1.15	1.11	0.78	0.85	0.78	0.75	0.64	0.69	0.70	0.67	0.70	0.70	0.68	0.67	0.59	–0.414
Average[G]	1.00	1.04	1.02	0.83	0.81	0.77	0.73	0.59	0.69	0.69	0.70	0.58	0.65	0.63	0.67	0.63	–0.368
Natural resources																	
Forests[H]	1.00	1.01	1.02	1.02	1.03	1.04	1.05	1.05	1.06	1.06	1.07	1.07	1.07	1.07	1.07	1.07	0.071
Water[I]	1.00	0.98	0.96	0.94	0.92	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	–0.100
Energy[J]	1.00	1.00	0.96	0.99	0.97	0.97	0.98	0.99	1.02	1.00	0.96	0.94	0.95	1.00	0.98	1.00	0.000
Development sprawl[K]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.004
Soil erosion	1.00	1.00	1.00	0.99	0.97	0.96	0.95	0.93	0.90	0.86	0.83	0.79	0.76	0.76	0.76	0.76	–0.243
Average	1.00	1.00	0.99	0.99	0.98	0.97	0.97	0.98	0.97	0.97	0.95	0.94	0.93	0.94	0.94	0.94	–0.056
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	1.32	1.34	1.36	1.38	1.38	0.381
Recycling rate[L]	1.00	1.00	0.99	0.99	0.99	0.97	0.95	0.93	0.91	0.89	0.87	0.86	0.85	0.83	0.82	0.82	–0.179
Average	1.00	1.01	1.01	1.02	1.03	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.09	1.10	1.10	1.10	0.101
Overall average[M]	**1.00**	**1.00**	**0.98**	**0.93**	**0.91**	**0.89**	**0.88**	**0.84**	**0.87**	**0.86**	**0.85**	**0.82**	**0.82**	**0.82**	**0.83**	**0.81**	**–0.186**

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	1994	1995	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	0.56	0.56	–0.444
NO_2	1.00	0.92	0.92	0.88	0.96	0.87	0.87	0.83	0.85	0.91	0.85	0.78	0.72	0.74	0.74	0.74	–0.261
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	1.31	1.31	0.313
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	0.43	0.43	–0.572
TSP[D]	1.00	0.87	0.77	0.71	0.69	0.64	0.64	0.72	0.65	0.65	0.58	0.58	0.54	0.54	0.54	0.54	–0.462
Pb	1.00	0.94	0.94	0.74	0.68	0.52	0.48	0.30	0.18	0.14	0.07	0.06	0.06	0.06	0.06	0.06	–0.940
Average	1.00	0.93	0.90	0.80	0.80	0.73	0.72	0.68	0.69	0.70	0.63	0.62	0.58	0.58	0.61	0.61	–0.393
Water quality																	
"Exceedances"[E]	1.00	1.00	1.00	1.00	1.00	1.02	1.01	1.02	0.97	0.97	0.79	0.74	0.78	0.84	0.79	0.87	–0.129
Phosphorus (Gr. Lakes)	1.00	0.96	0.91	0.87	0.83	0.78	0.78	0.87	0.80	0.74	0.78	0.74	0.74	0.78	0.61	0.61	–0.391
Nitrogen (Gr. Lakes)	1.00	1.03	1.06	1.08	1.11	1.14	1.15	1.18	1.13	1.12	1.13	1.18	1.19	1.19	1.19	1.19	0.194
DDE (Gr. Lakes)	1.00	1.32	1.36	0.67	0.78	0.75	0.68	0.42	0.54	0.58	0.62	0.75	0.67	0.77	0.69	0.48	–0.523
PCB (Gr. Lakes)	1.00	1.24	1.23	0.73	0.80	0.67	0.55	0.37	0.45	0.57	0.50	0.48	0.44	0.34	0.48	0.39	–0.610
HCB (Gr. Lakes)	1.00	1.22	0.98	0.56	0.72	0.58	0.60	0.34	0.50	0.48	0.34	0.34	0.46	0.33	0.36	0.26	–0.740
Average (Great Lakes)[F]	1.00	1.15	1.11	0.78	0.85	0.78	0.75	0.64	0.69	0.70	0.67	0.70	0.70	0.68	0.67	0.59	–0.414
Average[G]	1.00	1.08	1.05	0.89	0.92	0.90	0.88	0.83	0.83	0.83	0.73	0.72	0.74	0.76	0.73	0.73	–0.271
Natural resources																	
Forests[H]	1.00	1.04	1.08	1.12	1.16	1.21	1.14	1.08	1.03	0.98	0.94	0.99	1.05	1.11	1.11	1.11	0.110
Water[I]	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.19	1.20	1.22	1.23	1.23	1.23	1.23	1.23	1.23	0.231
Energy[J]	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	0.70	0.68	0.67	–0.331
Development sprawl[K]	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.91	–0.087
Soil erosion	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.97	0.97	0.96	0.95	0.95	0.95	0.95	0.95	–0.053
Average	1.00	1.01	1.02	1.02	1.03	1.04	1.03	1.01	0.99	0.99	0.97	0.97	0.98	0.98	0.98	0.97	–0.026
Solid waste																	
Waste generation	1.00	1.05	1.11	1.16	1.21	1.27	1.32	1.38	1.43	1.43	1.43	1.44	1.44	1.44	1.44	1.44	0.437
Recycling rate[L]	1.00	0.97	0.96	0.96	0.96	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.90	0.90	0.90	0.90	–0.101
Average	1.00	1.01	1.04	1.06	1.09	1.13	1.15	1.17	1.19	1.19	1.18	1.18	1.17	1.17	1.17	1.17	0.168
Overall average[M]	**1.00**	**1.01**	**1.00**	**0.94**	**0.96**	**0.95**	**0.95**	**0.92**	**0.93**	**0.93**	**0.88**	**0.87**	**0.87**	**0.87**	**0.87**	**0.89**	**– 0.108**

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 1995 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 1995 and 1980 columns are due to rounding-off.

[C] Ambient levels.

[D] For Canada the TSP measure was used; for the United States, however, the narrower category of PM-10 is monitored and has thus been included in the study.

[E] 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.

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

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

[H] 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.

[I] Ratio of withdrawals to renewable resources.

[J] Ratio of consumption to production.

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

[L] 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.

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

Notes

Primary Indicators

1 USEPA 1996a: 1. Cities from 50,000–100,000 have a class-two station and cities with populations over 250 000 are required to have a class-one monitoring station according to the NAPS.

2 Canada has a unique three-tiered system of objectives defining maximum desirable, maximum acceptable and maximum tolerable air pollution levels over periods of one year, 24 hours, eight hours and one hour. Each table in this section gives the corresponding levels explicitly in parts per million (ppm) or micrograms per cubic metre (μg/m3). “Good” means an ambient pollution level lower than the maximum desirable objective, “Fair” lies between the maximum desirable and maximum acceptable objectives, “Poor” lies between the maximum acceptable and maximum tolerable objectives, and “Very Poor” means an ambient pollution level higher than the maximum tolerable objective.

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

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

5 For a more complete analysis, see Ackerman and Hassler 1981. This regulation carries with it an enormous cost as well. Scrubbers on coal-fired plants can cost as much as US$200 million to install. See Portney 1990: 76.

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

7 In the 1990 survey of individual stations, 100 percent of stations met annual, 24–hr and 1–hr “fair” objectives. Environment Canada 1994: 18–22.

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

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

10 Dr. Donald Stedman, a chemistry professor at the University of Denver, has developed a device that can measure and test the exhaust of moving vehicles, thus isolating the heaviest polluters. For more on this see Bast, Hill, and Rue 1994: 115–6. Also, if power plants were to add chemical or isometric “labels” to their emissions, lasimetric technology could map chemical concentrations from orbit. See Smith 1995: 390.

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

12 Even measures at Canada’s worst sites are relatively low. A recent study shows that the lake-shore sites around the Great Lakes record an average of 150 hours (20 days) annually that exceed the .082 ozone standard. Recorded levels greater than .120 ppm are rare in most regions and very infrequent in southern Ontario with only 0.14 percent of measures exceeding this level. See Dann 1996: 1–27.

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

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

15 Bioaccumulation in aquatic organisms occurs when a persistent, fat-soluble, contaminant enters the organism’s body through the skin or by ingestion. If consumption exceeds the organism’s ability to metabolize or eliminate

the contaminant, over time it accumulates in tissues.

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

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

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

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

20 Organisation for Economic Cooperation and Development (OECD), Environmental Data Compendium, 1997, p. 120. Production for each nation as a percentage of global production: wood pulp—US, 19.8%; Can., 34.7%; sawnwood and sleepers—US, 10.2%; Can., 33.0%; industrial roundwood—US, 26.3%; Can., 2.0%; paper and cardboard—US, 10.2%; Can., 15.6%; wood-based panels—US, 5.96%; Can., 9.2%.

21 Environment Canada 1991b: 74. Conversion based on 1989 exchange rate of CDN$1.184 per US$1, from Statistics Canada 1995: 89. Prices are quoted in US dollars.

22 Calculations of Canadian and American figures are based on data from OECD 1997: 67–70.

23 One measure of energy efficiency is the ratio of energy use to the size of the national economy. See OECD 1995: 205.

24 Brookes 1991: 104–112. This estimate excludes Alaska, which is 90 percent wetland area and 90 percent government owned.

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

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

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

28 In the United States, municipal waste is waste collected by, or on the order of, municipalities. It includes waste originating in households, commercial activities, office buildings, institutions like schools and government buildings, and small businesses that dispose of waste at the same facilities used for municipally collected wastes. In Canada, municipal waste is all waste that is not construction and demolition debris. See OECD 1997: 153.

29 Imperial measures are 44 square miles and 120 feet deep. See Wiseman 1990.

30 Canadian data are based on apparent consumption (a proxy for waste generated derived from consumption) using figures from domestic consumption of the respective product + imports – exports. American data are based on amounts of waste generated. OECD 1995: 153.

31 Canada's glass recycling figure includes the reuse of refillable money-back bottles. OECD 1997: 164.

Secondary Indicators

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

2 Scientists do not dispute that the increase in equivalent CO_2 has occurred. Since the Industrial Revolution, equivalent CO_2 levels have risen from approximately 290 ppm to nearly 440 ppm in 1994 (Bailey 1995: 87). Humans do not, however, contribute to the main absorbers of infrared light in the atmosphere. Water va-

pour and clouds are responsible for over 98 percent of the current greenhouse effect (Lindzen 1992: 2).

3 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 1995: 1.

4 Easterbrook 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.

Index

1 For a comprehensive discussion of the wide variety of beliefs about nature in this century alone, see Bramwell 1989.

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

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

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