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# Environmental Indicators for North America

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UNEP

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# Preface

The purpose of this report is to determine the current status of environmental indicators being used in Canada and the United States. From assessment of these indicators and analysis of current work on a variety of sets of indicators being used in national, regional and global environmental reporting, the author draws lessons about how to begin a bilateral indicators initiative and suggests ways to overcome key challenges.

Unless specified otherwise, in this report a "region" refers to a group of contiguous countries, such as Canada and the United States, rather than a group of states, provinces, or ecosystems within national borders. Environmental indicators are frequently part of broader indicator initiatives that aim to measure progress in achieving sustainability on all fronts, including economic, social, and institutional. This study looks specifically at environmental indicators.

The report aims to answer the following questions:

- What are environmental indicators and what role do they serve? What is the best process to select and develop ideal indicators?
- Which organizations are using or developing national-level environmental indicators for Canada and the United States and which indicators to show environmental conditions and trends at the national scale are in current use in these two countries?
- What parallels and inconsistencies are there between the national-level indicators used by the two countries, and are there common issues and indicators?
- What organizations are working on coordinated regional (Canada and the United States) or eco-regional efforts to track the status of ecosystems shared by the two countries, and what indicators are being used or developed by them?
- What organizations have experience in developing environmental indicators to enable multilateral assessments, and what indicators or sets of indicators are being used or developed by them? What common issues do they address and what indicators do they use?
- How can the lessons about indicators learned from the national and multilateral reporting initiatives be applied to an effort to report on the state of the environment in the North American region?
- What indicators could form a set of "feasible" indicators—indicators that have already been developed for multilateral reporting, or that could easily represent the region in an integrated fashion?

- Can some of these feasible indicators already be used as examples to tell us about changes taking place in the region's environment and, if so, what do they show?
- What are the major sources of data that could be used to design and compute the numerical value of common environmental indicators for Canada and the United States?

The report's chapters are arranged to respond to the questions outlined above. The first chapter may be considered a brief manual about how to develop and use indicators[1]. It provides an introduction to environmental indicators, including examples of a variety of indicator types and sections on the role of indicators and their limitations. Chapter Two describes four environmental indicator reports published since 2002 and looks at three recent bilateral ecosystem reporting initiatives in North America. Chapter Three describes a number of international environmental indicator reports. Lessons learned from the survey are set forth in Chapter Four. Using a select number of feasible indicators, Chapter Five demonstrates how these can be used to provide a snapshot of how environmental conditions are improving, deteriorating, or remaining the same and to rank the two countries against other nations in the state of their environmental assets and progress towards protecting them.

A word of caution about this report's limitations: this is not a comprehensive state-of-the-environment (SOE) report. It assumes the reader has some knowledge of environmental issues in North America, so does not explain them in detail. It does not define, discuss, or analyze the environmental issues many of the illustrative indicators represent—many figures in the report are used primarily as examples of the types of indicators that can be used in environmental reporting. It surveys a select number of indicator initiatives to glean some lessons but is not an exhaustive survey of multilateral indicator and SOE projects. As such, it does not touch on a number of them, such as those undertaken by the EU, Australia and New Zealand, the Mediterranean, and the Baltic region, among many others, although lessons could be learned from these initiatives as well.

The fundamental goal is to ensure that the results of this report help SOE professionals in North America to inform decision-makers through the use of environmental indicators. The result should be a continual improvement of policies and assessment methods to protect the ecosystem goods and services that form the backbone of North America's economic prosperity and human welfare.

[1]See Denisov and others 1998, for a manual about how to produce an SOE report for the Internet; CSIRO 1999, for a guidebook to environmental indicators; and Segnestam 2002, for theories related to sustainability indicators.

A suburb street in Virginia, USA.

*Gyde Lund*

**They say that figures rule the world. I do not know if this is true, but I do know that figures tell us if it is well or poorly ruled.**

*—Goethe 1814, cited in UN Habitat 2001, 114*

*UNEP/ISS/NASA*

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Chapter 1

# Environmental Indicators

## The State of SOE Reporting

The environment is all-encompassing. It is "the totality of surrounding conditions" (Roget 1995). Trying to describe the state of the environment is a monumental task. Even assessing the health of a small part of it—a certain lake that has become polluted, or air quality over a particular city—is fraught with difficulties. This is because any part of the environment is a subset of a larger area and its state is not stable but in constant flux. Furthermore, we still lack a complete picture of how ecosystems work. Finally, the task is complicated by the blurred distinction between ourselves and the environment. It is not simply "out there" where we can get a good look at it from a distant and dispassionate vantage point. Humans are an integral part of the environment. To report on its condition, we have to observe and interpret a complex, dynamic system of which we are an interacting component (Dubos 1994).

> The environment is the sum of the abiotic (physical), biotic (living), and cultural (social) factors and conditions directly or indirectly affecting the development, life, and activities of organisms and populations, in the short and long term (Dubos 1994, 208).

In 1972, the United Nations Conference on the Human Environment urged the international community to prepare periodic international, regional, and sub-regional reports on "the state of, and outlook for, the environment" (UNEP 1972). In response, a number of governments, non-governmental organizations (NGOs), and international organizations began to produce reports to track environmental problems and supply needed data for measuring changes in the quality and quantity of the waters, air, and lands that were clearly showing signs of pollution and unsustainable use. The first reports typically focussed on describing current environmental conditions and recent trends in environmental media (air, freshwater, land, marine resources, forests, and so on) and were aimed primarily at raising awareness (Rump 1996). Given the sheer size of the task, the reports were often encyclopaedic tomes. Much of the data required to note trends was only starting to be gathered, measures were often qualitative and anecdotal, and the separation of the environment into discrete media obscured the links among them and between human activity and environmental change.

Canada played a key role in helping to advance the field of state-of-the-environment (SOE) reporting. In the late 1970s, Statistics Canada developed an "ecosystem" approach that integrated economic and ecological aspects. This conceptual framework evolved into the now widely-adopted pressure-state-response (PSR) model and its offshoots (described in more detail further on), which help to organize the vast amount of information required to portray environmental change and to attempt to reflect the dynamic relationships among human, physical, and biological properties and processes (NIRO 2003a). In addition to portraying environmental issues by political or administrative units (countries, states, municipalities, and so on), some state-of-the-environment (SOE) reports began to present information based on a variety of different units, such as watersheds and other types of ecosystems, or environmental components (soil or vegetation type, for example) and to use different frameworks to organize the information, such as focusing on priority issues (habitat loss or water pollution, for example) or on economic sectors and their impacts (such as agriculture or fisheries) (Rump 1996; US GAO 2004).

Too frequently, however, traditional SOE reports were based on ideas of what their producers thought were important instead of on the needs of users, and the comprehensive nature of the products made them cumbersome. They generally contained a large amount of information that was difficult to digest. Furthermore, they did not appear to have much influence on decision-makers (Keating 2001).

Today, SOE reporting increasingly attempts to serve the needs of or to influence specific users, especially decision-makers. The trend is towards the use of a select number of indicators to address a few issues. Indicators help translate complex data into comprehensible information, can be aggregated into indices, and can help show progress towards a target. SOE reporting has also broadened the range of outputs and communication tools, which may now encompass, for example, a background report, a web version, an educational package, a CD-ROM, and brief, concise indicator summaries, generally issued on a frequent and regular basis (Box 1) (CGER 2000; EEA 2000a; Keating 2001; NIRO 2003a).

The dominant trend in SOE reporting has been a shift away from comprehensive reports towards more focused indicator reports for different audiences (NIRO 2003a, 27).

State-of-the-environment reporting initiatives increasingly attempt to measure progress towards sustainability and sustainable development. This concept rests on the three pillars of environmental, social, and economic sustainability and was clearly articulated in 1987 by the World Commission on Environment and Development in *Our Common Future* (WCED 1987). Subsequently, both the 1989 G7 Economic Summit in Paris and the 1992 Earth Summit in Rio de Janeiro drew attention to the need for indicators to gauge progress towards sustainable development (SD). Since then, the construction and use of SD indicators has proceeded apace (NIRO 2003a; SCOPE 2003)[2].

Today, organizations of all types and sizes are beginning to consider the long-term sustainability of their actions and to measure social, economic, environmental, as well as institutional viability. Seattle is leading the way in the development and use of SD indicators at a municipal level, for example, while the independent Global Reporting Initiative (GRI) is providing organizations and businesses with sustainability-reporting guidelines to analyze the economic, environmental, and social dimensions of their activities, products, and services (GRI 2002; US GAO 2004). In recognition of the relative size of the public sector and a need for harmonization of reporting practices to ensure comparability and consistency amongst public sector organizations as well as private sector groups, the GRI recently launched a process to enable the public sector to apply its reporting framework to measuring progress towards sustainability (GRI 2004). Each of these initiatives has developed environmental indicators as part of a set of indicators to assess progress towards sustainable development.

Finally, SOE reporting is increasingly developing and using sets of indicators or aggregated indices to measure progress towards environmental goals to complement well-known indices that portray economic development, such as GDP, and social well-being, such as the Human Development Index. Examples of such efforts, including those developed to gauge progress towards all aspects of sustainability, are: the Ecological Footprint (see

[2] See Hardi and Barg 1997 for a review of practices related to sustainable development indicators.

**Box 1: Trends in SOE reporting**

State-of-the-environment reporting is moving towards:

- showing the interconnections among environmental, economic, social, and institutional issues;
- producing shorter, more focussed reports based on indicators and addressing specific audiences;
- reducing comprehensive lists of indicators into core sets for better communication, and using indices aggregating several indicators into a more concise picture of complex systems;
- measuring progress towards achieving targets and objectives;
- building environmental reporting into government decision-making, and business and industry plans;
- developing a suite of reporting products derived from the same data to communicate results in a variety of ways;
- incorporating risk-based future scenarios;
- using multiple-effects models rather than simple causal chains;
- providing solutions along with trends;
- consulting with the public in a multi-stakeholder approach during the design and preparation of indicators and reports; and
- adopting new technologies, especially geographic information systems (GISs) and the Internet, enabling access to a wider audience and allowing for interactive reporting.

*Source: Compiled by author from Keating 2001; NIRO 2003a.*

Venetoulis, Chazan, and Gaudet 2004); the Environmental Sustainability Index (see CIESIN 2002; CIESIN 2005); the Barometer of Sustainability (see Prescott-Allen 1997); the Dashboard of Sustainability (see IISD 2002); the Daly-Cobb Index of Sustainable Economic Welfare (see Daly and Cobb 1989), and the Living Planet Index (see WWF 2002; WWF 2004).

> SOE reporting and indicator development are now internationally endorsed and promoted as key components to effective environmental policy and sustainable development strategies (NIRO 2003a, 15).

The following pages of this section take a closer look at the various types of environmental indicators and their role in state-of-the-environment reporting, and provide a review of the literature about how to select and develop environmental indicators.

## What Are Environmental Indicators?

### *Types and presentation of environmental indicators*

To simplify and render messages about environmental conditions clear and concise, the trend in SOE reporting initiatives is to focus on developing environmental indicators and indices. Environmental indicators condense information about conditions and trends in attributes of the natural world.

Indicators are generally understood to be "signs" that point out, or stand for, something. They provide clues about the condition or viability of a system or the state of its health. For example, blood pressure and body temperature are "representative" indicators that help a doctor assess a patient's health. The presence or absence of a particular species in an ecosystem can serve as a representative indication of the presence or absence of certain environmental conditions associated with healthy ecosystems. The "indicator species" is a classic representative indicator frequently relied on in ecology (Box 2) (Gallopín 1997).

> **Indicator:** A parameter, or a value derived from parameters, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value (OECD 2001, 133).

**Box 2: An indicator species**

The great blue heron (*Ardea herodias*), the largest heron in North America, is widely distributed over Canada and the northern US. The subspecies *Ardea herodias fannini* is an ideal long-term indicator for the surrounding ecosystem due to its non-migratory behaviour. With a varied diet including young fish, contaminants from its food build up in the bird's system providing clues about the level of pollutants in the ecosystem of which it is a part. Since 1977, the Canadian Wildlife Service has routinely examined the chemical content of heron eggs found near the Strait of Georgia, which reveal the presence of organochlorine pesticides and industrial organochlorines (EC 2004a).

A great blue heron waits for his dinner on Maryland's Eastern Shore.
*Tim McCabe/UNEP/NRCS*

Environmental indicators can be qualitative and/or quantitative, based on physical, chemical, biological, or economic measures, and they can portray the parameters through a variety of visual means, including graphs, pie charts, tables, data diamonds, maps, and remote sensing from satellites and aircraft. Quantitative representative indicators can provide a snapshot of conditions at a given time, as in Figure 1, which maps the percentage of crown closure to convey or represent forest cover in Canada in 1998. Data representing the "state" or condition of a system are also called "descriptive" indicators.

Representative indicators using quantitative parameters can also reveal trends over time. A graph of time-series data of fertilizer use in the US tells one part of the story of chemicals in the landscape (Figure 2). Thus, as symbols representing the state of an issue or a system, indicators have a significance that extends beyond the actual value of the parameters themselves (Hammond and others 1995).

Representative indicators can be used to show historical trends, as in Figure 2, but they may also attempt to predict future trends, either as projections of historical trends, as in Figure 3, or by using data from models of potential future scenarios (Rump 1996).

Indicators can also measure performance by gauging progress towards a benchmark or target. In performance indicators, the message portrayed is determined by the meaning assigned to the variable (Gallopín 1997).

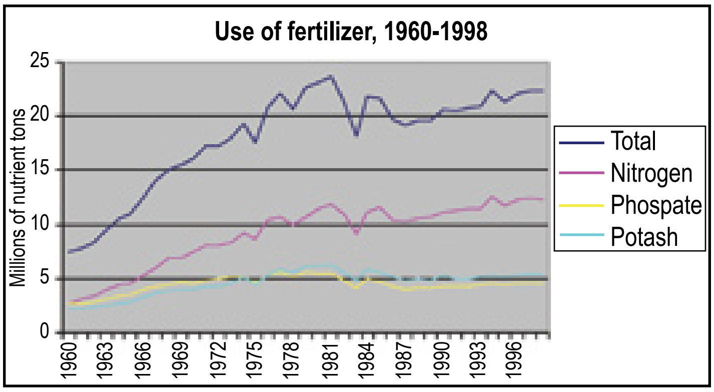
"Benchmarks" are scientifically determined thresholds, such as the maximum level of a pollutant's concentration in the air or water deemed tolerable for human and environmental health (CSIRO 1999). Figure 4 gives an indicator of trends in one aspect of urban air quality, showing the percentage of monitoring stations recording exceedances of the US threshold for average ozone concentrations over an eight-hour period.

Targets, on the other hand, are normative policy-oriented goals or endpoints based on human values assigned to them. National and regional indicators can use targets associated with inter-

**Figure 1: Map of percentage crown closure representing forest cover in Canada**

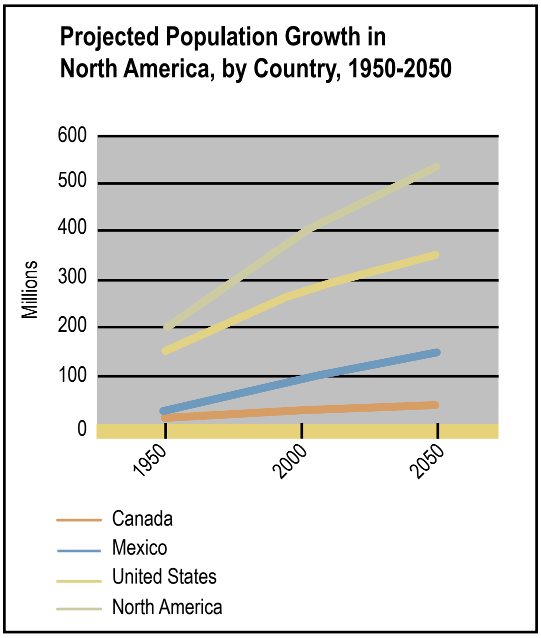
Source: NTREE 2003, 29

**Figure 2: A representative indicator showing historical trends**



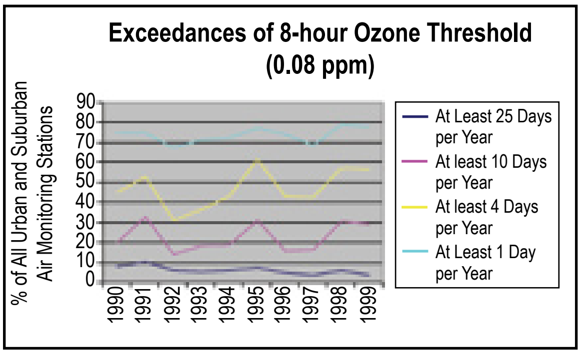

Source: Compiled by author from Daberkow, Taylor, and Wen-yuan Huang 2000.

**Figure 3: A predictive indicator showing future trends**



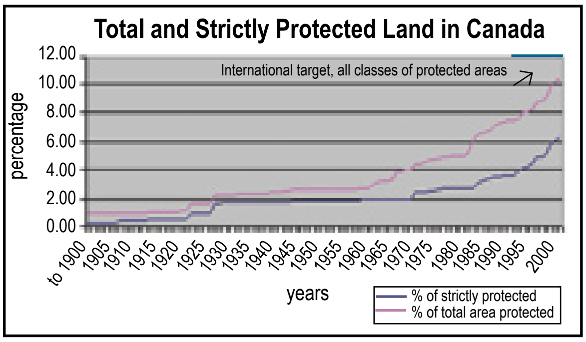

Source: Modified from CEC 2001, 80.

**Figure 4: A performance indicator based on a scientific benchmark**




Source: Adapted from Heinz Center 2003, 188.

**Figure 5: A performance indicator based on a policy target**




Source: Adapted from EC 2003a, 2 with the permission of the Minister of Public Works and Government Services, 2005

national commitments or accords or with national policy goals. The reference point for the indicator in Figure 5, for example, is the international target for the per cent of land to be set aside as protected area.

Box 3 provides examples of a variety of criteria that are used in performance indicators.

When indicators use only one parameter to portray or represent the state of an issue or system, other important factors associated with that issue are absent, so it often takes many indicators to construct a profile of a particular issue of concern (see Box 4).

The use of indices is another way to overcome the inadequacies of indicators based on a single parameter or when the use of multiple indicators risks overwhelming the target audience with too much detailed or complex information. This is done by combining several parameters and condensing and refining the data into an index. An index is a scalar formed by the aggregation from two or more values (MFE 1996; Gallopín 1997). Aggregated indices have the advantage of giving an overall picture of a system's performance in a simple but compelling way and are often the means of choice in SOE reporting to inform decision-makers. In addition to computing aggregate values, an index can include a weighting scheme to even out the relationships among the disparate indicators and their dependence on subjective interpretation (Rump 1996; UNESCO 2003). Indices need to be based on a transparent and unbiased choice of individual indicators, a clearly defined approach to the method of aggregation and weighting, and robust data and analysis.

The Living Planet Index, published by WWF–World Wide Fund for Nature, provides a trend line of the state of the world's natural ecosystems by averaging three sub-indices measuring changes in abundance of terrestrial, freshwater, and marine species. Each index is set at 1.00 in 1970 and given an equal weighting (see Figure 6) (WWF 2004).

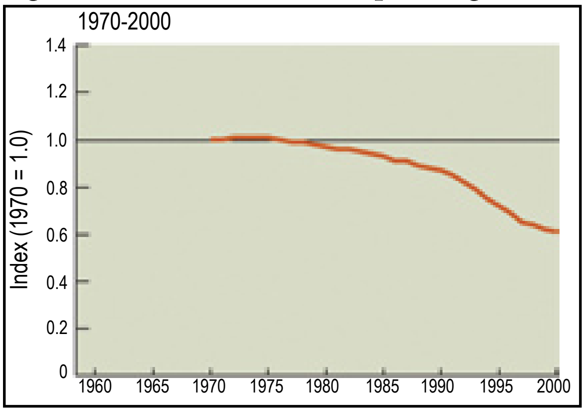
Performance can also be assessed by the use of comparative indices. The Environmental Sustainability Index (ESI), for example, is an aggregated index that measures environmental sustainability

**Box 3: Criteria for performance indicators**

| *Type of criteria* | *Example* |
|---|---|
| **Benchmark** | Highest percentage of households connected to sewage system in a comparable entity in the same jurisdiction |
| **Threshold** | Maximum sustainable yield of a fishery |
| **Principle** | Policy should contribute to the increase of environmental literacy |
| **Standard** | Water quality standards for a variety of uses |
| **Policy-specific target** | Official development assistance shall be 0.4 per cent of gross national product (GNP) |
| **Targets specified in legal agreement** | Per cent reduction in greenhouse gas emissions by target date |

Source: Adapted from Pinter and Swanson 2004b, slide 43.

**Figure 6: An index based on equal weights**

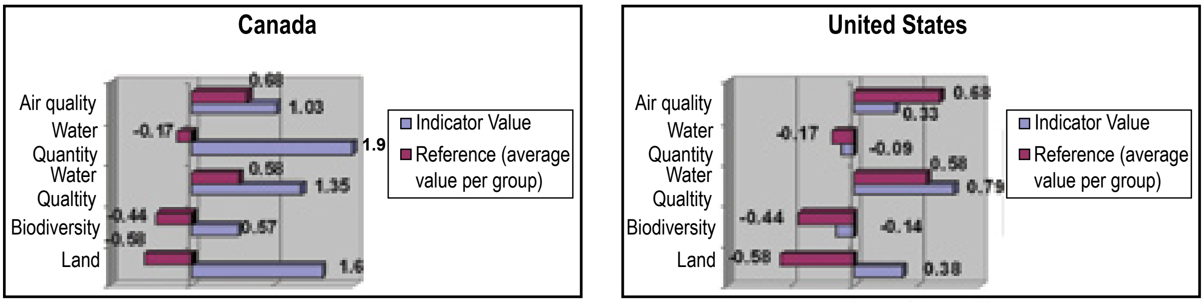



Note: State of the world's natural ecosystems by averaging three sub-indices measuring changes in abundance of terrestrial, freshwater, and marine species, each set at 1.0 and given equal weighing. Source: WWF 2004, 1 http://www.panda.org/downloads/general/lpr2004.pdf

through 22 indicators to track the relative success of 146 countries. Figure 7 provides an example. It shows the indicator for environmental systems (air quality, biodiversity, land, water quality, and water quantity) for Canada and the United States, comparing their achievements against the average value of the country's peer group (CIESIN 2005). Readers should be aware of the definitions and methods used to arrive at such indices, however, since there are numerous difficulties associated with condensing many issues into a single measure, as explained in more detail further on.

In addition to giving absolute scores, performance indices can also measure progress with ranking schemes that compare nations or issues on the same scale, using similar measures and criteria. The value of ranking lies in its ability to spur action on the part of poor performers to improve their position (Yeung and Mathieson 1998). Examples of such indices for aspects of social well-being include the United Nations Development Programme's Human Development Index, Transparency International's Corruption Index, and the World Health Organization's Disability Adjusted Life Expectancy Index. The 2002 Environmental Sustainability Index (ESI) includes tables that rank 142 countries according to five components and twenty indicators. Figure 8 shows the first 30 countries ranked for the sustainability of environmental systems according to this scheme. The component scores are presented as standard, normal percentiles, ranging from a theoretical low of 0 to a theoretical high of 100. According to this system, Canada ranks first and the United States thirtieth (CIESIN 2002).

**Figure 7: A comparative index for environmental systems**




Source: Adapted from CIESIN 2005, Appendix B: 129, 245

**Box 4: A set of indicators creates a profile**

Possible indicators for a profile of greenhouse gas (GHG) emissions:

- Time-series of values showing the overall (total) trend in GHG emissions
- Trends in per capita GHG emissions
- Time-series of values showing the overall trend in concentrations of $CO_2$
- Intensity of GHG emissions (per unit GDP)
- GHG emissions by pollutant category ($CO_2$, $N_2O$, $CH_4$ and fluorinated gases)
- Percentage of GHG emissions by sector of the economy
- Trends in total GHG emissions by individual sector
- Comparison of emission trends with targets (such as the Kyoto Protocol)
- Projections of GHG emissions (according to various scenarios)
- Country comparisons

*Source: Adapted from EEA 2003.*

**Figure 8: A ranking scheme based on the "state" of ecosystems**

| *Rank* | *Country* | *Percentile* | *Rank* | *Country* | *Percentile* |
|---|---|---|---|---|---|
| 1 | Canada | 90.4 | 16 | Peru | 69.3 |
| 2 | Gabon | 81.2 | 17 | Central African Rep. | 68.6 |
| 3 | Finland | 78.7 | 18 | Papua New Guinea | 66.9 |
| 4 | Norway | 77.6 | 19 | Brazil | 66.3 |
| 5 | Venezuela | 77.2 | 20 | Australia | 66.1 |
| 6 | Botswana | 77.2 | 21 | Uruguay | 65.4 |
| 7 | Congo | 75.8 | 22 | Ecuador | 65.3 |
| 8 | Namibia | 75 | 23 | Austria | 64.6 |
| 9 | Iceland | 73.1 | 24 | Paraguay | 63.8 |
| 10 | Argentina | 72.4 | 25 | Latvia | 62.9 |
| 11 | Russia | 72.2 | 26 | Angola | 62.6 |
| 12 | Sweden | 72.1 | 27 | Albania | 62.2 |
| 13 | Bolivia | 71.1 | 28 | Mali | 60.5 |
| 14 | Mongolia | 70.5 | 29 | Nicaragua | 60.5 |
| 15 | Colombia | 69.8 | 30 | United States | 60.1 |

Source: Adapted from CIESIN 2002, Annex 4: 58.

The 2005 Environmental Sustainability Index (ESI) mentioned in relation to Figure 7, ranks 146 countries according to 21 equally-weighted indicators of environmental sustainability, including natural resource endowments, past and present pollution levels, environmental management efforts, contributions to protection of the global commons, and a society's capacity to improve its environmental performance over time. This index shows Canada ranking 6th and the United States 45th (CIESIN 2005).

Another environmental ranking scheme, used by the World Wildlife Fund in the Living Planet Index, produces very different results from the ESI, however. It ranks 73 countries with populations over 1 million based on the "ecological footprint"

The busy city, Toronto, Canada.

*Gracey Stinson/UNEP/MorgueFile*

### Box 5: EEA's smiley-face scheme

The smiley faces in the boxes next to key indicators aim to give a concise assessment of the indicator:

Positive trend, moving toward qualitative objectives or quantified targets;

some positive development, but either insufficient to reach qualitative objectives or quantified targets, or mixed trends within the indicator;

unfavourable trend.

Source: EEA 2003, 13

per person. This measure represents pressures on the environment in terms of natural resource consumption, rather than the state of each nation's ecosystems as in the previous example. A country's footprint is the total area required to produce the food and fibre it consumes, absorb the waste from its energy consumption, and provide space for its infrastructure. Figure 9 shows the 36 countries with the poorest ranking out of the 73 countries with populations over 1 million. In this ranking scheme, Canada and the United States are at the bottom of the scale, at positions number 66 and 72 respectively (WWF 2004).

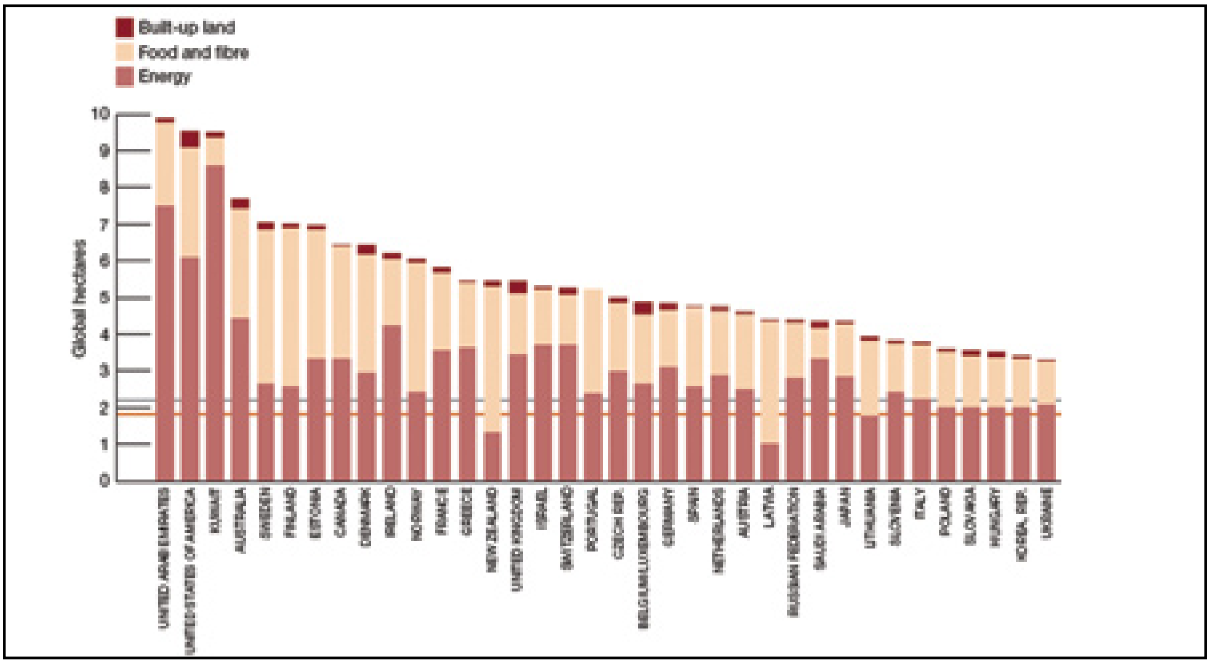
So, as made clear by these examples of ranking systems, care must be taken in designing comparative performance indices so that the standardization of various measurements and definitions is fair and transparent and it is clear what is being measured (Segnestam 2002).

Aggregated performance indices and composite indicators often employ imaginative visual means, with barometers, meters, dashboards, dials, and even happy/sad faces portraying how well or badly a nation or an issue is faring—whether it is improving, remaining stable, or deteriorating. Box 5 shows the "smiley face" scheme used by the European Environment Agency in its assessments (EEA 2003).

More than one parameter can be presented in the same figure when comparisons help to get a message across to the reader or when illustrating the links between one system and another. One attempt at showing the links between the environment and the economy is through the use of a performance index to measure changes in the intensity of natural resource use or emissions output. Performance can be measured by plotting trends to indicate the level of "decoupling" of environmental harm relative to economic growth, such as polluting emissions or waste generation per unit of gross domestic product (GDP). Simultaneously, performance is compared to an earlier time period by showing the intensity of natural resource use over time, starting at a base-line level (OECD 2003).

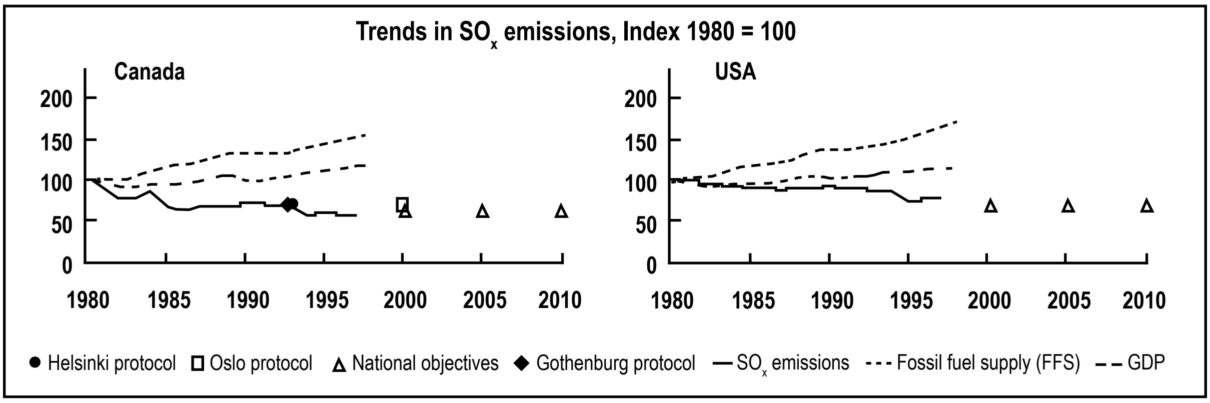
Figure 10 gives an example of a performance index showing the intensity of sulphur dioxide emissions in Canada and the United States and how they are decoupling from GDP. It also contains targets in the form of national and international objectives and shows the progress the two countries

**Figure 9: A ranking scheme based on "pressures" on nations**




Source: WWF 2004, 10 http://www.panda.org/downloads/general/lpr2004.pdf

**Figure 10: A performance index comparing trends**




Source: Modified from OECD 2001, 28

have made in moving towards them since the baseline year of 1980.

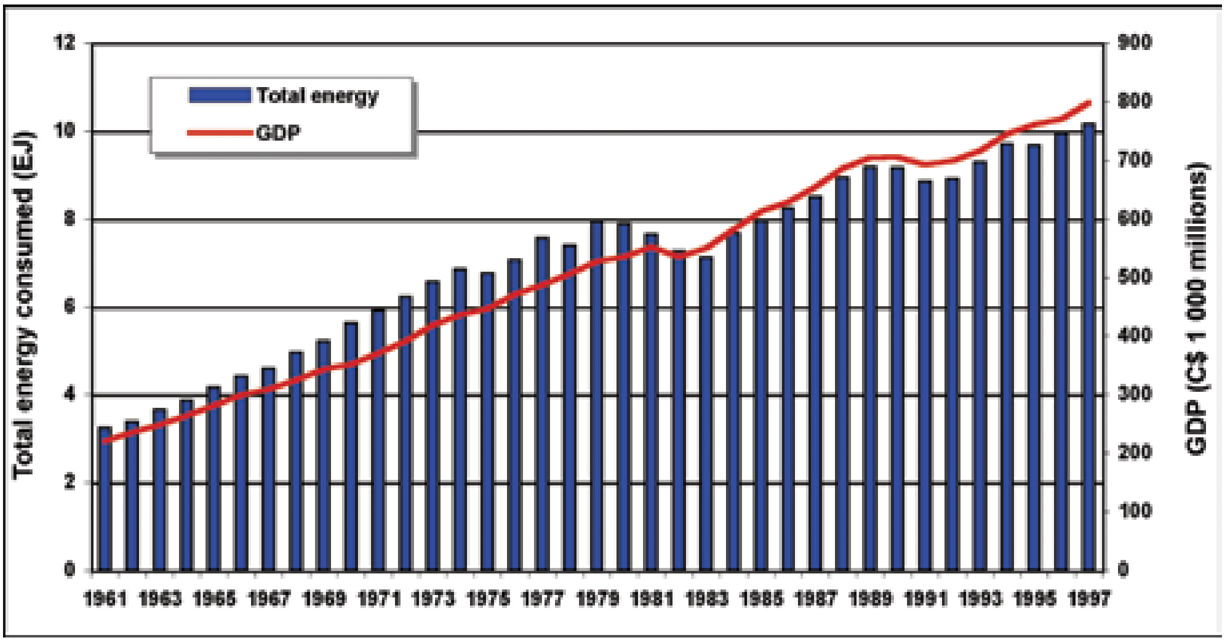
The performance indicator above can also be termed an "intensity" or "efficiency" indicator. Energy is often measured in terms of intensity of use. Energy intensity is the ratio of energy consumption to some measure of demand for energy services. Energy use can be measured against units of production or service delivery, for example, to show progress towards more efficient operations, or against an economic measure such as GDP, as in Figure 11, which shows Canada's energy consumption compared to trends in GDP. In the transportation sector, intensity indicators could measure gallons per passenger mile or gallons per vehicle mile (EIA 1995).

Thus, there is a plethora of types of indicators to choose from to give a snapshot of an environmental issue, from simple representative indicators, to composite indices and other more complex performance indicators. The choice will depend on the author's purpose or goal. The following section looks at the role of environmental indicators.

## The Role of Environmental Indicators

First used primarily to act as the "canary in the coal mine", providing early warning signals for emerging environmental problems, indicators are increasingly being recognized and used for their key role in improving decision making (EC 2001; Pinter and Swanson 2004a).

**Figure 11: An intensity or efficiency indicator comparing trends**



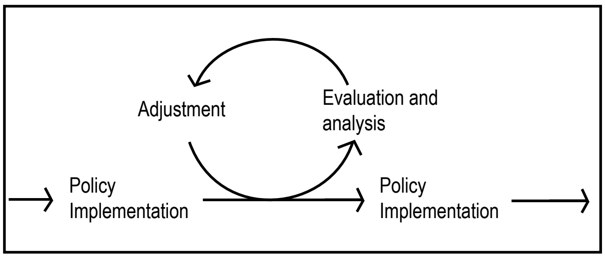

Note: The energy units are exajoules (EJ). An exajoule is 1018 joules. GDP is expressed as 1 000 million of 1992 Canadian dollars.
Source: Adapted from EC 2004b http://www.ec.gc.ca/soer-ree/English/Indicators/Issues/Energy/Tables/ectb01_e.cfm

Environmental indicators are not an end in themselves; rather, they should form part of an iterative policy cycle, which includes policy planning and application, the evaluation of the impacts of policies, and subsequent adjustment of the policy to further progress towards the desired goal. The role of indicators is to incorporate environmental knowledge into decision making at the evaluation and analysis phase (Figure 12).

This phase comprises designing and implementing systems for monitoring and for data collection, and a state-of-the-environment (SOE) programme that includes indicators and their dissemination. Indicators help to outline policy goals in specific terms. They also provide feedback to managers and the public about outcomes. If and when there is a straightforward connection between specific policies and outcomes, indicators can play a key role in the continuous cycle of policy learning and adaptation (Pinter and Swanson 2004a). Ideally, indicators should inform decision making by helping to

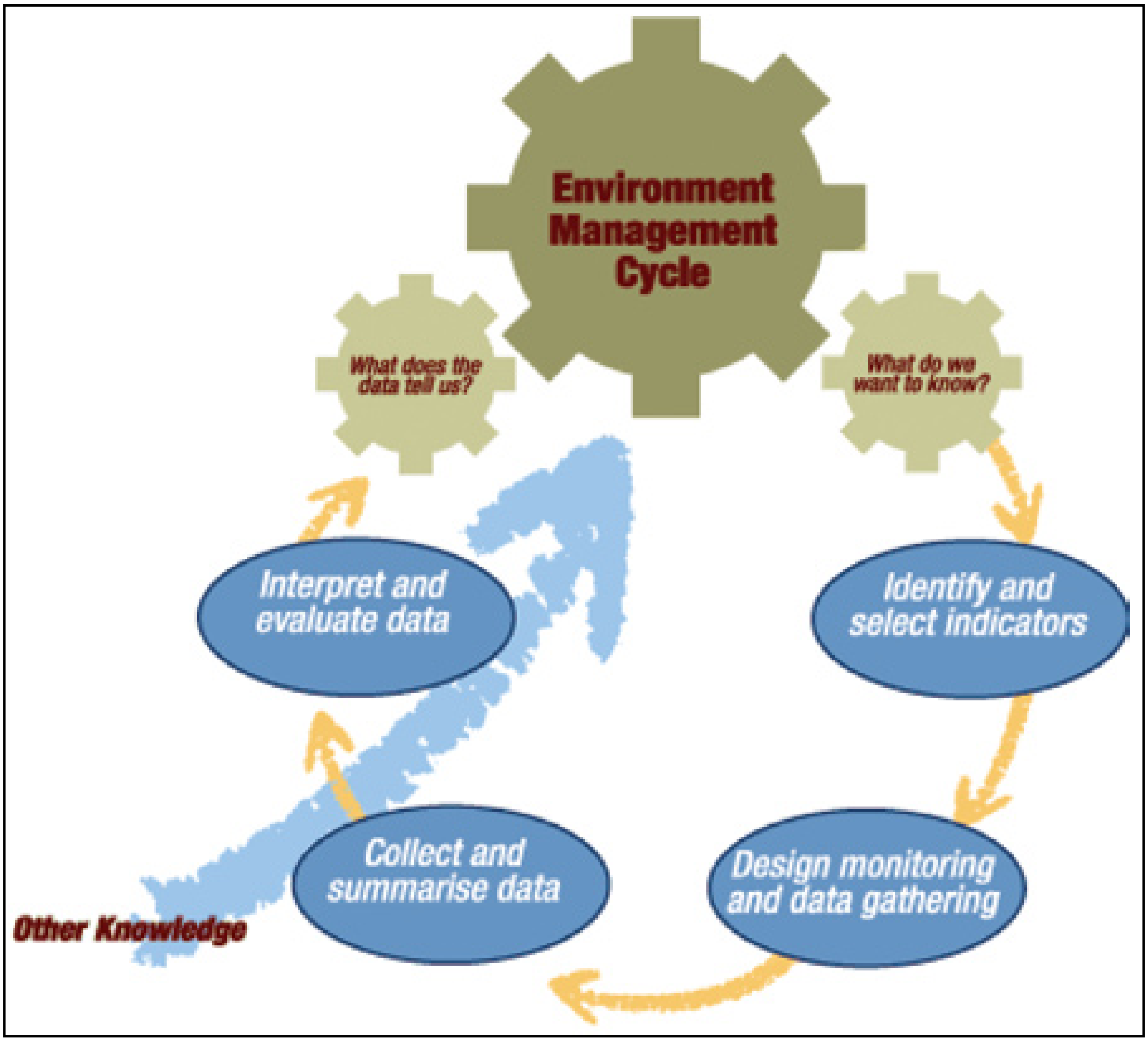
> Indicators function inside the governance process; they are not exogenous factors parachuted in, which can act like a magic bullet causing decision-making to become instantly objective and scientific (Pastille Consortium 2002, 90).

**Figure 12: The role of indicators in the policy cycle**




Source: Adapted and modified from Pinter, Zahedi, and Cressman 2000, 79

**Figure 13: The environment management cycle**




Source: CSIRO 1999 http://www.csiro.au/csiro/envind/code/pages/07.htm clarify issues and by disclosing the relationships between the issues and policy decisions.

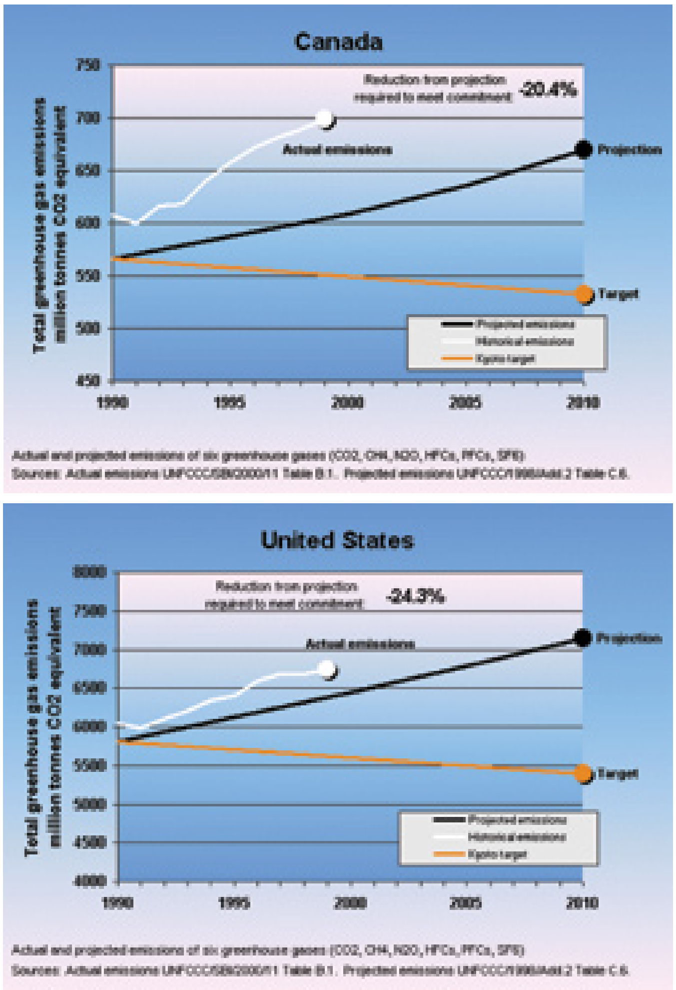
Monitoring programmes are also part of a cycle of environmental management in which policy is informed by the messages provided by indicators. In turn, indicators rely on monitoring and data gathering to provide the necessary inputs (see Figure 13)[3] . The lack of clear causal relationships between actions taken in a management cycle and resulting environmental change, the influence of other unrelated factors, as well as delays between management actions and results are some of the significant challenges inherent in this cycle (GAO 2004).

The best indicators trigger human action, or have the potential to do so (CSIRO 1999 http://www.csiro.au/csiro/envind/code/pages/14.htm).

Predictive, performance, and comparative indicators are the most effective in drawing the attention of decision-makers to the urgency of addressing environmental change. Figure 14 illustrates a predictive indicator with the potential to influence policy decisions. Canada, as signatory to the Kyoto Protocol, adopted time-bound targets to reduce greenhouse gas emissions between 2008 and 2012

[3] See CSIRO 1999 for a description of each stage of this management cycle

**Figure 14: An indicator designed to influence decision making. Actual and projected emissions of GHG compared to Kyoto targets, 1990–2010**




Source: UNEP GRIDA 2001 http://www.grida.no/db/maps/collection/climate6/canada.htm, http://www.grida.no/db/maps/collection/climate6/usa.htm

A 59 kg (130 lb) wolf watches biologists in Yellowstone National Park, USA, after being captured and fitted with a radio collar on 9 January 2003.

*William Campbell/UNEP/USFWS*

**Box 6: Use of indicators to influence the climate change policy cycle**

*Goals and targets:* A national government institutes a climate change policy to support international efforts to curb the human influences on global warming. It sets goals and targets for reducing greenhouse gas emissions and monitors progress with the use of a set of indicators.

*Strategies and instruments:* It initiates financial incentives, such as energy taxes; legal instruments, such as limits on emissions; and other strategies, such as budgetary support for public transportation, that are intended to help achieve the goals and targets.

*Policy implementation:* National, regional, and local governments might implement the policies by monitoring and enforcing emission limits in industry, for example, and improving and increasing bus, subway and train services, as well as cycling lanes and paths, among other measures.

*Impact evaluation:* Indicators are used to measure the effectiveness of the policy change. For example, indicators would help evaluate the policy's performance by comparing data about greenhouse gas emissions before and after the policy change and comparing the rate of progress to the desired goal. The indicators should serve to inform decision making in a cycle of adaptive learning.

*Source: Adapted from Pinter and Swanson 2004b, slide 11.*

by six per cent below 1990 emission levels. Box 6 is an example of different levels of decisions that could be triggered by this indicator.

Performance and comparative indicators are particularly effective means with which to prompt action by decision-makers. If a nation can be shown to be lagging behind others and not making progress in environmental protection, its humiliation can be a potent impetus to improve. As mentioned above, this is part of the rationale for using a highly aggregated index that could roll many aspects about the state of a nation's environment into one easily-understood performance measure that would allow comparing and ranking nations.

In addition to serving policy ends, indicators also have a role in informing the public. When designed and communicated in effective ways, indicators are useful as tools to illustrate concepts and scientific information, helping to change or illuminate the understanding of an issue and drawing attention to important environmental problems (Hezri 2003; NIRO 2003a). The public includes environmental NGOs, some of which may use the information in indicator reports to create and disseminate their own products that help them pressure governments to act.

### *Limitations of indicators*

There are limitations on the use of indicators, however, the first being the risk of oversimplification. The complexities of ecosystems and their functions and how well they are being managed cannot be reduced to a set of indicators or indices, let alone a single representative indicator (Turnhout 2003). One of the key problems is that traditional indicators fail to provide information about the capacity of ecosystems to sustain their supply of goods and services (MFE 2000). And indicators must be deciphered by the reader, opening them up to false interpretation, especially when links between cause and effect are extrapolated. For example, abundant fish harvest trends do not necessarily signify abundant fish stocks, nor do they say anything about the health of the fishery. In fact, history has shown the collapse of overfished stocks all over the world after a period of plentiful harvests (UNDP and others 2000). Correlative conclusions may be drawn from indicators rather than a scientifically causal relationship between a trend and a pressure, or indeed, between specific policies and programmes and changes in the state of the environment.

As intimated earlier, the design of indices is fraught with difficulties. Aggregation will be counterproductive if the index becomes too abstract or if it hides defects in the condensing of many features of an issue into a single measure (Lealess 2002). An index that aggregates "apples and oranges" or issues that cannot be measured in the same units has more serious limitations that should be made explicit and transparent for the reader. Even profiles that use a variety of indicators in an attempt to cover all aspects of an issue can have gaps (Bossel 1999).

When indicators are established but no action follows, their development process and tweaking may actually be serving as a camouflage for inaction, a delaying tactic, or an excuse not to act until the science is "right". An ulterior motive for introducing indicators in a policy-making process can include creating indicators that support a predetermined position (Hezri 2003). Sets of indica-

**Box 7: Questions addressed by the PSR approach**

| *Question to answer* | *Type of indicators* | *What indicators show* |
|---|---|---|
| What is happening to the state of the environment and of natural resources? | Indicators of state | Changes or trends in the physical or biological state of the natural world |
| Why is it happening? | Indicators of pressure | Stresses or pressures from human activities that cause environmental change |
| What are we doing about it? | Indicators of response | Actions adopted in response to environmental problems and concerns |

*Source: Adapted from MAP 1998, 2.*

tors or indices may also reflect the specific expertise and interests of the organization that develops and publishes them rather than the needs of its audience (Segnestam 2002).

On their own, indicators cannot assess policy performance, which involves producing and communicating information about the key interactions between the natural environment and society. Policy effectiveness—weighing the actual policy impact against the goal or desired performance of a single policy—can be achieved by integrated environmental assessment, which is done in the text of an SOE report by analyzing the links between key driving forces and policies and the status of the environment (Pinter and Swanson 2004a).

Thus, indicators cannot stand alone, nor can they disclose all aspects underlying the states or changes in states they reveal: to perform the role of providing information for decision making, indicators need to be interpreted (Segnestam 2002). Interpretation is needed to help clarify their meaning and provide context, but is also useful because there is no universally accepted set of indicators and each reporting agency employs different methods and definitions.

Indicators alone do not trigger action, either. How to effectively ensure the messages they contain are captured by decision-makers and actually kick-start policy change to address the problems they reveal is a challenge. The effective implementation of a well-designed communication plan is an important part of SOE reporting projects.

Finally, with the emergence of new environmental problems or in response to environmental change, it is important that indicators are flexible and can be revised (Bossel 1999). The field of environmental indicators is still evolving and as knowledge and experience accumulates, so the indicators themselves will be transformed to better reflect environmental conditions and trends and to be of more utility to users.

## Organizational and Conceptual Frameworks

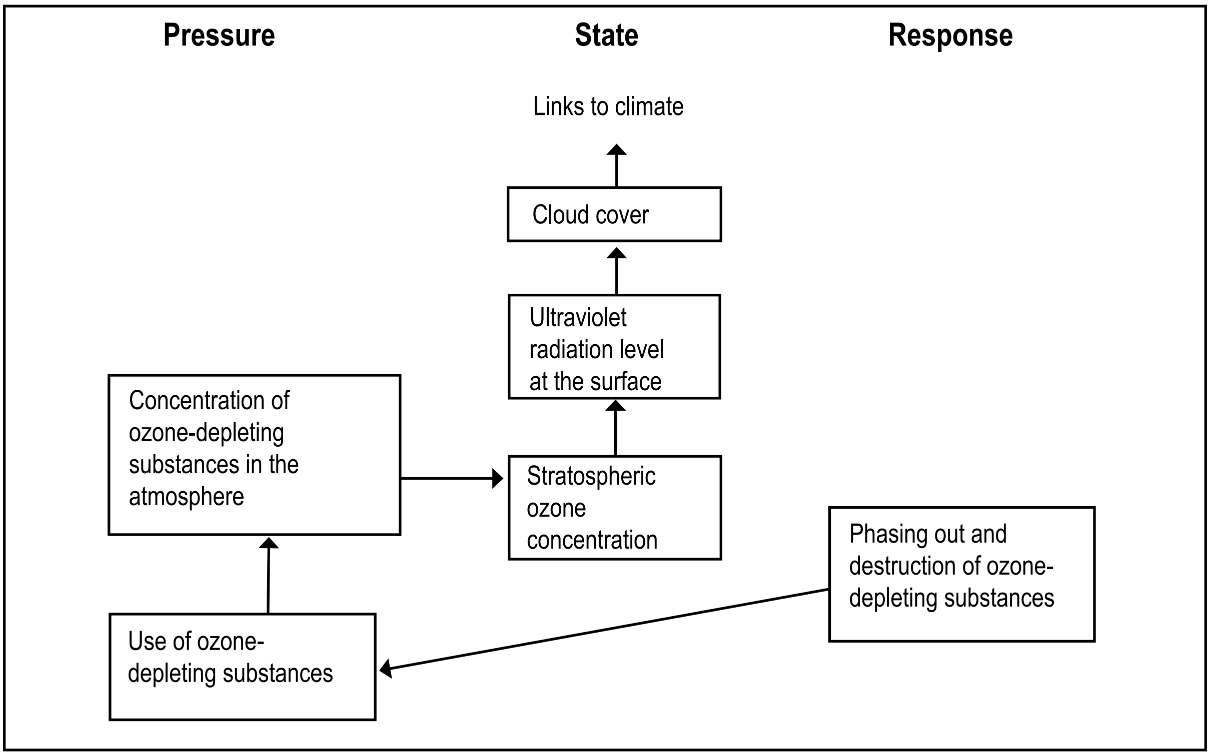
An organizational framework helps to structure indicator selection and development, systemize the analysis and interpretation, identify gaps, and simplify and make explicit the reporting process for the target audience (Rump 1996; CEC 2003). As mentioned earlier, indicators can be organized by jurisdictional or ecosystem boundaries, environmental medium or component, economic sector, special theme, emerging or priority issue, or socioeconomic sector, among other organizing frameworks. SOE and environmental indicator reports that are oriented towards sectors, issues, and environmental media, generally also organize reporting on these themes around an applied conceptual or analytical framework. A variety of frameworks is used in SOE reporting, frequently in combination (NIRO 2003a).

### *The PSR framework*

The most commonly used framework is the pressure-state-response (PSR) model. It organizes the indicators according to how they answer the following questions: "what is happening to the environment? why is it happening? and what are we doing about it?" (Box 7).

State indicators, as represented in this model, describe the quantity of resource assets and the conditions and trends in the environmental media or their components. This includes indicators of the physical size, shape, and location of ecosystems. Pressure indicators can portray both natural and

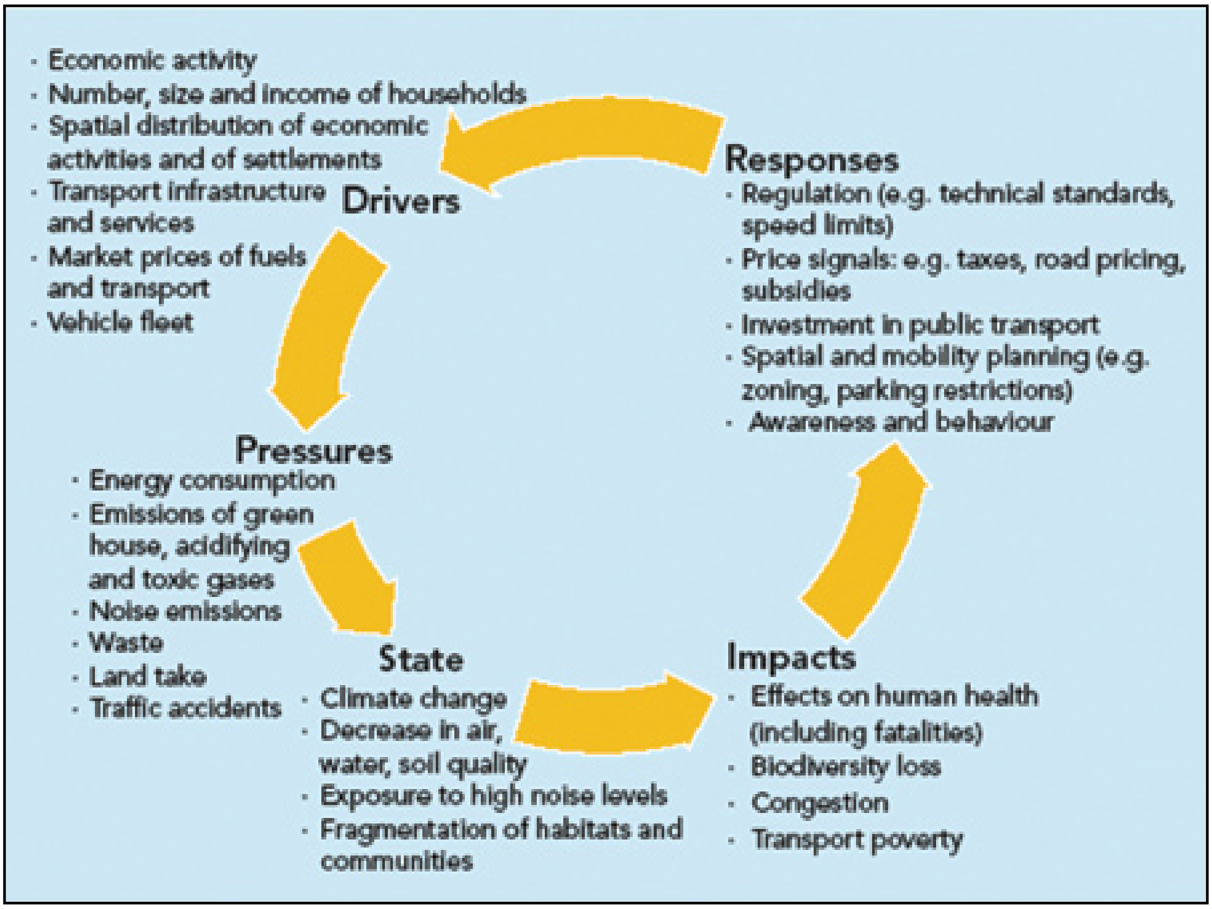
**Figure 15: Example of the PSR framework, illustrating the issue of stratospheric ozone**




Source: Adapted and modified from ANZECC 2000, 10

anthropogenic pressures, and range from drivers and underlying agents of change, such as socioeconomic and political conditions, to direct pressures, such as polluting emissions and resource extraction. Response indicators illustrate those polices and actions taken by governments and civil society to mitigate or redress environmental problems (UNDP and others 2000; Pinter and Swanson 2004b).

**Figure 16: The DPSIR framework, illustrating the issue of transport**




Source: EEA 2000a, 12 http://reports.eea.eu.int/ENVISSUENo12/en/term2000.pdf

**Box 8: DPSIR indicators**

| | |
|---|---|
| *Driving force* | Underlying pressures related to socioeconomic and political agents of change, such as population growth, GDP, and consumption. |
| *Pressure* | Indicators describing variables that directly affect the quality and quantity of environmental goods and services, such as toxic emissions, pesticide applications, harvesting rates of fish or timber, and generation of municipal waste. |
| *State* | Indicators of the biological, chemical, and physical state or condition (quantity or quality) of an environmental media, ecosystem, or component at a given point in time, or as a trend over time. Examples include the area and distribution of forest cover, ambient levels of ground level ozone, number and diversity of species. |
| *Impact* | Indicators of direct effects of environmental pressures on humans, economies, and ecosystems, such as the percentage of beaches affected by advisories or closings, concentration of lead in children's blood, the economic costs of eliminating an invasive species, and the number of yearly outbreaks attributed to waterborne disease-causing organisms. |
| *Response* | Indicators of societal reaction to environmental problems and their causes such as legislation, regulation, economic instruments, education, voluntary action, and budgetary allocation. Examples include the area set aside as protected parks, and trends in recycling. |

*Source: Compiled by author from Mortensen 1997; MAP 1998; EEA 2003; Pinter and Swanson 2004a.*

Figure 15 illustrates a simple indicator profile using the PSR framework.

The PSR approach is a dynamic and comprehensive model that is meant to facilitate the evaluation of policy responses to environmental issues. It is flexible and can be adjusted to allow for greater detail or specific features and its advantages have resulted in its wide adoption and further elaboration.

### *The DPSIR framework*

The PSR framework has been modified over the years to encompass additional categories of indicators, including driving forces and impacts. Driving force indicators depict underlying socioeconomic pressures such as population growth and consumption. Impact indicators answer the question, "Why are the environmental conditions and changes significant?" For example, what impact do the pressures have on ecosystems, economic and social well-being, and human health? (NIRO 2003a). Box 8 describes these categories of indicators and Figure 16 portrays the driving force-pressure-state-impact-response (DPSIR) framework by illustrating potential indicators used to report on the environmental implications of transport[4].

### *Limitations of the PSR framework*

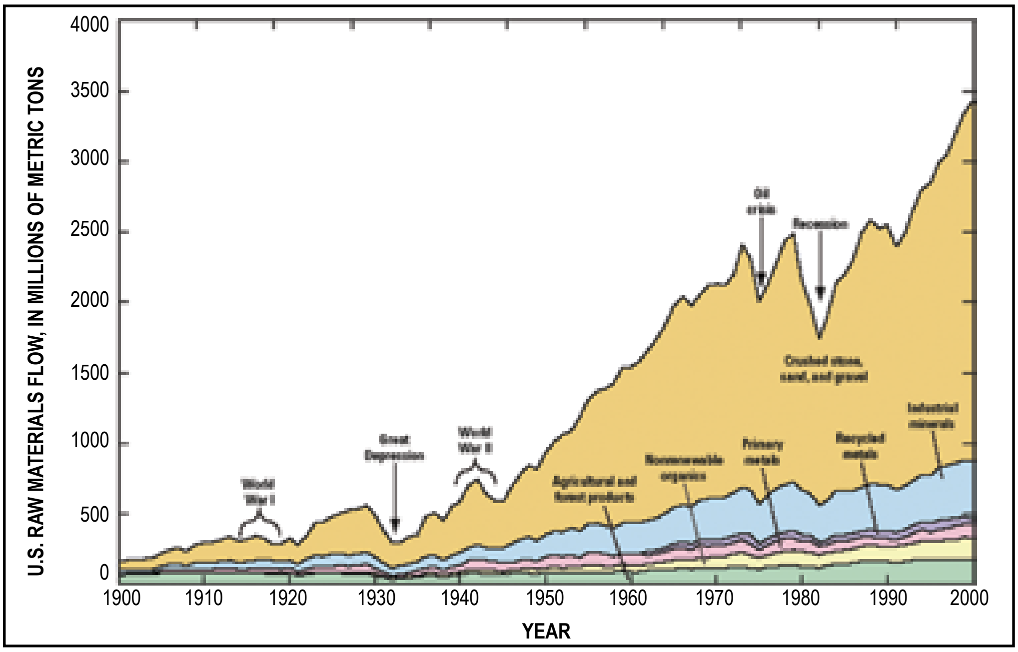
Despite the values and popularity of the PSR framework and its offshoots, it has been criticized

[4] See EEA 2000b for DPSIR profile flow charts for 14 key environmental issues.

This hillside in northern California is covered by wildlfowers.

*Gary Kramer/UNEP/NRCS*

**Figure 17: Material flows indicator: US flow of raw materials by weight, 1900–2000**




Source: Wagner 2002, 4 http://pubs.usgs.gov/circ/2002/c1221/c1221-508.pdf

Looking at the flow of materials from the perspective of a whole system enables the sum of potential consequences to be envisioned, priorities to be set, and methods to combat negative impacts of material flows to be developed (Wagner 2002, 1).

for being overly simplistic in the intuitive assumption of direct cause-and-effect mechanisms: driving forces and pressures are seen as causing states and impacts, and responses are interpreted as acting as a feedback regulator for the issue or profile in question. These assumptions do not reflect the complex systemic relationships among the elements and the fact that they are embedded in a larger system. For example, using the PSR model to show the relationships among a few indicators in a climate change profile could mask the fact that humans are responsible for only part of $CO_2$ concentrations, that $CO_2$ emissions are not the only influence on global temperature, that a carbon tax may be introduced for a variety of reasons, and that such a tax has numerous other (economic and social) consequences apart from affecting $CO_2$ emissions (Bossel 1999). In fact, most states are the result of multiple driving forces and pressures, with pressures also resulting in more than one state (Gallopín 1997; Bossel 1999; von Schirnding 2002; NIRO 2003a). Similarly, some factors can be both pressures and impacts. For example, soil erosion is a pressure on streams, since it causes sedimentation, but it is also an impact indicator of the effects of overgrazing or deforestation (CGER 2000). Natural processes and phenomena also act as pressures on the environment, and it can be difficult to separate the effects of natural processes from human impacts (Berger and Hodge 1998).

Care must be taken in interpreting a profile of indicators arranged according to the PSR framework and its derivatives so that invalid inferences are not drawn, especially since this could lead to erroneous policy recommendations. In short, the PSR framework should be seen as a useful system for organizing indicators without assuming any underlying functional causality (Gallopín 1997).

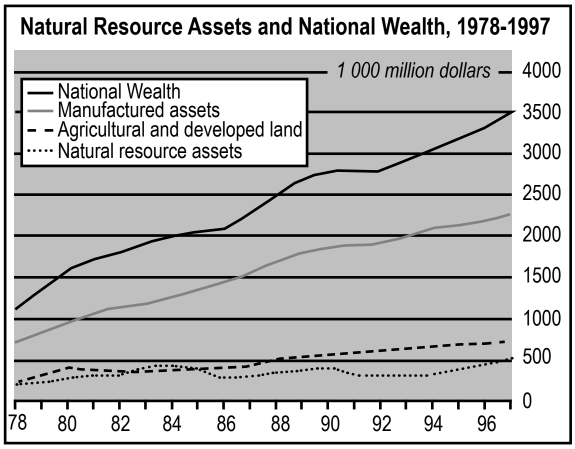
### *Natural capital flows and accounting approaches*

Another conceptual and organizational approach to reporting on the state of the environment is the systems framework, which analyzes system inflows, stocks, and outputs of an issue and then defines indicators to measure them. It has been used to develop sustainability indicators, building sets of them for human systems, support systems, and natural systems (Bossel 1999; UNESCO 2003). In measuring the flows of natural resources, indicators are constructed to calculate the flow of raw materials in physical units through the economy "from cradle to grave", including extraction, production, manufacture, use, recycling, and disposal. Natural capital indicators are "descriptive" indicators, measuring quantities of resource use as a way of measuring their environmental impact. Two goals of this approach are to assess progress towards reducing material throughput in proportion to economic output, and the adoption of effective policies to advance dematerialization (WRI 1997). Figure 17 gives an example of a material flows indicator. It shows material inputs by weight of the principal raw materials in the United States between 1900 and 2000.

The physical flows of natural resources, goods, pollutants, and wastes engendered by an industrial economy can also be measured in economic terms in the same way that economic flows are measured in dollars. Natural resource accounting attempts to put a cost on the deterioration of natural capital (natural resources, land, and ecosystem services). By putting a monetary value on the role of the environment as a producer of goods and services and on the impacts of economic growth on its ability to sustain them, this approach helps to link environmental and economic data and to demonstrate that harming the environment has economic repercussions (Hecht 2000).

Figure 18 gives an example of a natural resource accounting indicator. It shows the value of Canada's natural resources stocks—timber, energy, and minerals—and the contribution of these resources to national wealth between 1978 and 1997. Tracking wealth this way can inform nations as to whether

**Figure 18: Natural resource accounting indicator (in Canadian Dollars)**




Source: Modified from Statistics Canada 2000a, 2

the current level of national income can be sustained (Statistics Canada 2000a).

There are multiple challenges to these systems of environmental accounting, however, including the enormous difficulties in attaching economic values to many important environmental factors. There is much controversy about the merit and viability of assigning market-like values to environmental assets

Connecticut River tideland habitat in the USA undergoing invasive plant control (light colored areas) and native plant community restoration.

*Paul Fusco/UNEP/NRCS*

and processes (Repetto 1994). On the other hand, unlike physical measurement, monetary valuation enables comparison and aggregation across forms of capital because it uses market value as the only "weight" (Smith, Simard, and Sharpe 2001).

### *Biogeophysical approach*

This approach is based on the idea that, to report on the state of the environment, a better scientific understanding of ecosystems and the way organisms and their physical environment co-exist and co-evolve is needed. The underlying concept is that sustaining the global life-support system is a prerequisite for sustaining human societies. The organizing framework is based on a "systems" approach. The indicators summarize individual measurements for different ecosystem characteristics (Hardi and Barg 1997). Biogeophysical measurements reflect the state of knowledge about specific ecosystem properties to reveal changes in the chemical, biological, and physical qualities of the atmosphere, soils, waters, wildlife, and vegetation that comprise "the environment" (Murcott 1997). Biogeophysical indicators portray the state of environmental media and tend to make up the majority of indicators in most SOE reports. A strict biogeophysicial approach does not use indicators to reflect drivers, pressures, and responses but rather shows the condition, changes, and trends in the quality and quantity of ecosystem goods and services.

In sum, environmental indicator initiatives rely on a variety of frameworks to organize the vast amount of information necessary to portray the changing state of the environment. The above is not a comprehensive account of frameworks for environmental indicators[5]. Most SOE reports do not use only one or another of these frameworks but may combine a number of them, depending on the goal and the audience.

The most widely used model is the pressure-state-response approach and its derivatives. This framework continues to be favored and efforts are underway to improve it so it can help express the linkages among sectors and among driving forces, pressures, states, impacts, and responses.

These efforts are in recognition of the need for a framework that better accounts for the interaction between human and ecological systems and the consequences for human well-being (Singh, Moldan, and Loveland 2002). SOE professionals are seeking ways to improve indicators and organizational and analytical frameworks so they can be used more effectively to assess the viability and sustainability of both natural and social systems and their interactions and how to use this information to improve those systems at all levels of organization (Bossel 1999). For example, a framework developed by the World Health Organization helps to select and structure indicators linking health and the environment. The DPSEEA (driving force, pressure, state, exposure, effect, action) framework recognizes that many factors determine exposure and effects. The model has been criticized as being too linear, however, neglecting the complexity of multiple associations between exposure to environmental pressures and impacts on health. The MEME (multiple exposures–multiple effects) model, developed especially for children's environ-

[5] See Murcott 1997, for a detailed list of frameworks; see also Singh, Moldan, and Loveland 2002; Hardi and Barg 1997; Bossel 1999; and OECD 1999.

**Box 9: Steps in a generic indicator development process**

1. Identify themes and issues related to the overarching vision and goal.
2. Propose an initial set of candidate indicators.
3. Select an analytical framework that links goals to indicators.
4. Develop a list of criteria for indicator selection.
5. Evaluate indicators according to criteria.
6. Define a core set and/or a suite of indicator sets for different users.
7. Identify data sources and data gaps.
8. Gather data and populate the indicators; standardize measurement wherever possible.
9. Compare indicator values to targets, thresholds, and policy goals, as appropriate.
10. Disseminate results.
11. Assess strengths and weaknesses of indicator set.
12. Continue development of superior indicators.

Source: Compiled by author from Rump 1996; Hardi and Zdan 1997; CEC 2003.

**Box 10: Potential criteria for environmental issue ranking**

| *Criteria* | *Possible Weighting* | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Reversibility | Less than 1 year | Less than 25 years | More than 25 years |
| Spatial Scale | Global | Transboundary | National |
| Risk Magnitude | Moderate | Significant | Serious |
| Scientific Uncertainty | Low | Moderate | High |
| Public Concern | Low | Moderate | High |

Source: Adapted from Rump 1996, 45.

mental health, is more successful in revealing these complex relationships, since it shows how exposure can lead to many different outcomes (CEC 2003). Thus, frameworks are continually evolving to incorporate the complexity of human environment relationships.

## Methods for Selecting Indicators

The selection and development of indicators usually follows one of two methods. First, the bottom-up approach starts with the available data, then creates the parameters, and finally aggregates the data into indicators along a number of hierarchical levels, using intuitive and mathematical approaches. Usually used in data-rich situations, this approach generally fails to adhere to many agreed-upon criteria for indicator selection (discussed further on), can mask the interrelations among resources and processes, and employs data that may fail to have significance beyond their measured quantity (UNESCO 2003).

Second, top-down approaches start with a vision that leads to policy goals for a real-world outcome, and then to a set of objectively verifiable indicators, followed by actions. Indicators are developed for all levels, from the goal down to activities. The lower the level in the framework, the less importance there is for unanimity in the universality of the indicators (UNESCO 2003). This approach is appropriate for state-of-the-environment reporting initiatives by governments at any level to track performance towards policies, laws, and targets for environmental quality.

The dependence of indicator development on data can lead to the situation in which data availability drives the selection of indicators, which, in turn, reinforces the collection of the same data (UNESCO 2003, 57).

The top-down approach is the preferred method, since its purpose is to link indicators to policy decisions. A survey of indicator initiatives shows that there are a variety of steps in the top-down indicator development process (Box 9).

Generally, the first step is to identify the themes and priority environmental issues to be addressed. For a national or multilateral initiative, the selection will strongly relate to important environmental values and visions held by society and articulated in national policies, such as the goal of environmental sustainability. A tool in this step is to rank issues by priority, which can be facilitated by the use of a weighted scheme such as that suggested in Box 10.

Castle Mountain in Banff National Park, Canada. *UNEP/MorgueFile*

The next step is to identify associated indicators. Often, this step is accomplished with the aid of brainstorming exercises by experts, to develop an initial list of candidate indicators; such a list would contain all suggested indicators regardless of whether or not corresponding indicators and data exist (Pidot 2003). This may be achieved by listing indicators that correspond to policies or management plans, or to a chosen analytical framework such as DPSIR, or by rephrasing goals as questions, then creating candidate indicators to answer them. Box 11 gives an example of the types of questions asked to elicit indicators for air quality used by the US Environmental Protection Agency. The first question corresponds to the state of air quality, the second to pressures, and the third and fourth to impacts.

### *Criteria for selecting indicators*

Criteria may then be proposed with which to evaluate and narrow down the list and a framework is decided upon that corresponds to the initiative's mission and that helps organize the reporting.

**Criteria for selecting indicators**

*Indicators must be* ***TRUE***

**T**: Timely, targeted, and threshold-sensitive

**R**: Reliable, relevant, resonant, and responsive

**U**: Useful to the public, policy-makers, and programme administrators

**E**: Easily accessible periodically from reputable sources

Source: Adapted from SCERP 2002, 1–2.

Agencies involved in developing environmental and sustainability indicators recognize the need to validate the process of indicator selection and development. The literature shows that there is a great deal of consensus on the key criteria for identifying potential indicators. One of the main criteria, as stressed above, is policy relevance. For use in policy making, indicators must provide information about environmental issues of concern, be easy to understand, and be linked to policy goals or targets.

**Box 11: Questions to elicit the identification of potential indicators**

| *Question* | *Indicator Name* |
|---|---|
| **What is the quality of outdoor air in the United States?** | Number and percentage of days that Metropolitan Statistical Areas have Air Quality Index (AQI) values greater than 100 |
| | Number of people living in areas with air quality levels above the National Ambient Air Quality Standards (NAAQS) for ozone (8-hour) and Particulate Matter ($PM_{2.5}$) |
| | Ambient concentrations of ozone, 8-hour |
| | Ambient concentrations of particulate matter ($PM_{2.5}$) |
| | Visibility |
| | Deposition: wet sulfate and wet nitrogen |
| | Ambient concentrations of selected air toxics |
| **What contributes to outdoor air pollution?** | Emissions of particulate matter, sulfur dioxide, nitrogen oxides, and volatile organic compounds |
| | Lead emissions |
| | Air toxics emissions |
| | Emissions (utility): sulfur dioxide and nitrogen oxides |
| **What human health effects are associated with outdoor air pollution?** | No indicator identified |
| **What ecological effects are associated with outdoor air pollution?** | No indicator identified |

Source: Adapted from US EPA 2003, A-2.

Their selection and the rules for calculation must be made in a transparent and objective manner. They should be based on robust data and provide a cost-effective way to measure environmental conditions and progress towards environmental sustainability. Box 12 lists these criteria. Many reflect the conclusions drawn up in the Bellagio Principles, which were endorsed by an international group of practitioners and researchers from five continents in 1996. The principles synthesize insights from practical ongoing efforts in assessing performance in protecting the environment (see Hardi and Zdan 1997). Of course, no single set of criteria will apply to all situations or needs since the environments and policies the indicators are meant to measure differ, as do priorities for data collection and analysis (von Schirnding 2002).

One criterion emerging from the literature and recommended as part of the second and seventh criteria in Box 12 suggests the importance of limiting indicator sets to a small number of indicators. If they are to serve the important function of re-

**Box 12: Criteria for selecting environmental indicators**

**Significant/salient: Will anyone care?**
Provide relevant information responding to concerns about change in important ecological and biogeochemical processes and environmental change that affects wide areas and the health and well-being of people and natural resources. Convey information broader than the parameters measured and help to maintain a focus on this message.

**Clear and easy to interpret: Will people understand them?**
Set forth a limited number of indicators or sets of indicators, which are presented in a clear, straightforward and appealing manner, and are simple and intuitive to interpret while maintaining an appropriate level of detail and scientific accuracy.

**Policy relevant: Will they lead to action?**
Measure progress against policy goals by comparing indicator values to targets. Are part of an iterative and adaptive policy and management cycle, answering pertinent questions, provoking policy debate and action. Are flexible, so new information can lead to adjustments in goals, frameworks, and indicators.

**Reliable/credible: Are they scientifically valid?**
Are measurable and analytically valid. Are based on currently sound and internationally accepted theoretical, conceptual, technical, and scientific standards and principles. Data collection is based on statistical integrity; data are from reliable sources on a recurring basis, are clearly defined, verifiable and robust to changes in measurement technology; and indicators allow for consistent interpretation and valid analyses and conclusions.

**Neutral and legitimate: Can they be trusted?**
Are politically legitimate, with unbiased and transparent selection, analysis, and presentation.

**Comparable: Are they compatible with other sets of indicators?**
Are standardized wherever possible to allow for comparison, especially at the national level of reporting. This may require consensus related to international commitments and targets.

**Cost-effective: Are they affordable?**
Are limited in number, use existing or readily available data whenever possible, and are simple to monitor. Explicit links to policy ensure efficient monitoring and data collection (which are expensive). Financial, human, and technical capacities are available to develop and use the indicators.

**Participatory: Were they selected and developed in a transparent manner?**
Are developed with the participation of a broad range of stakeholders, including decision-makers and others in the management cycle to ensure the indicators or indicator sets are tied to policy goals and monitoring programs, as well as including NGOs, professionals, the private sector, and other members of the public to ensure they encompass community visions and values and to promote “ownership”.

Source: Compiled by author from MFE 1996; Rump 1996; Gallopín 1997; Hardi and Zdan 1997; Mortensen 1997; Bossel 1999; CSIRO 1999; CGER 2000; MFE 2000; Dale and Beyeler 2001; GRI 2002; Pastille Consortium 2002; Singh, Moldan, and Loveland 2002; EC 2003a; EEA 2003; OECD 2003; O'Malley, Cavender-Bares, and Clark 2004; US GAO 2004; TERI n.d..

Saint Lawrence River - Montreal, Canada. *UNEP/MorgueFile*

ducing the number of measurements and parameters that are usually required to describe a situation or system exactly, the size of an indicator set and the level of detail it contains need to be limited. Indicators are meant to provide an overview, so a set with a large number of indicators will tend to clutter it (OECD 2003).

Among the criteria for indicator selection is the requirement for transparency; ideally, a broad range of stakeholders, including decision-makers and others in the management cycle, should be included in the selection process. The participants chosen will depend on the purpose of the indicator initiative, its scope, and the targeted audience (Segnestam 2002).

### *Organizing indicators into sets*

State-of-the-environment programmes may choose to develop more than one set of indicators to represent various levels of scope and scale, depending on the purpose of the programme and the targeted audience (Lealess 2002). The initial

**Box 13: Various indicator sets**

| | |
|---|---|
| **Candidate indicators** | Any and all suggested indicators—resulting from brainstorming among experts—that answer questions about the environment |
| **Feasible indicators** | Candidate indicators that can actually be developed because data are available |
| **Core set** | Indicators selected from the feasible candidates, based on a list of criteria |
| **Supplemental/ complementary sets** | Indicators developed for specific users and/or to show more detail about specific issues or places |
| **Headline or key indicators** | A small set of indicators selected from the core set to best represent each issue |
| **Indices** | Aggregated and composite indicators to give a snapshot for decision-makers |
| **Alarm indicators** | Indicators to be constantly monitored so as to enable timely warning about adverse changes threatening to exceed set thresholds |
| **Diagnostic indicators** | Indicators developed to provide an in-depth analysis of the issues highlighted by the alarm indicators |

Source: Adapted from Segnestam 2002, 14.

brainstorming may result in a list of candidate indicators. From these, indicators are selected according to a given list of criteria to form an organization's core set. Different combinations of indicators can be selected from the core set depending on the need. A set of headline indicators may be required, made up of one or two indicators that best represents each issue. It is a way of highlighting the most salient findings in a SOE report and often forms the basis of an executive summary, providing readers, especially decision-makers, with a quick snapshot of issues and trends. Indices may also be developed to aggregate a range of indicators into one measure (Lealess 2002).

Another approach is to develop one set of alarm indicators to give early enough warning about adverse environmental effects, and a set of diagnostic indicators that provide greater details of a priority issue or place (Segnestam 2002). Box 13 gives some examples of indicator sets.

The final steps relate to populating the selected indicators with data, noting gaps, disseminating the results, and assessing and improving the indicator set. During the dissemination, the indicators will need to be described and interpreted for both the public and decision-makers. A variety of outreach resources can be used to disseminate the results, including web sites, CD-ROMs, full-length and summary reports, and less formal means, which would include posters, brochures, and flyers. Some projects may wish to include the publication of technical notes and training materials (Segnestam 2002).

Ideally, the dissemination process should result in the triggering of action. The indicator process does not usually include designing actions, such as preventive and mitigating measures, and following through with their implementation. But this is the ultimate goal of an indicator project. If a range of stakeholders is involved in the process, including decision-makers, indicator professionals, and data-gatherers, and if there are resources and political willingness, actions should follow dissemination (Segnestam 2002).

This report represents one of the earliest steps in an indicator initiative: the identification of candidate and feasible indicators to form the basis for stakeholder discussions. The next chapter uses the background information presented above to look in some detail at four indicator reports released by Canada and the United States since 2002. The goal is to explore the commonalities in approaches and indicators, learn some lessons applicable to multilateral indicator initiatives, and assess the potential for developing an integrated and cohesive set of indicators with which to report on both countries as a region.

Chicago (USA) from the Navy Pier. *UNEP/MorgueFile*

**What gets measured, gets managed. What gets communicated, gets understood.**

*—cited in Keating 2001, 1*

*ppdigital/UNEP/MorgueFile*

# Chapter 2

# 2 National Indicator Initiatives in Canada and the United States

This chapter describes four environmental or sustainable development indicator reports—two for each country—that form the basis for a first attempt to identify national-level environmental indicators that could feasibly be part of a set of candidate indicators for North America. One of the key exercises for this report was to list the indicators and parameters used in each of the reports in a spreadsheet, organizing the list by the DPSIR framework, and identifying the commonly used indicators. The results of this exercise are shown in Appendix 1: Table 2 (see page 122). To provide context for the list, the following section outlines the history of SOE reporting in each country and describes the reports according to the concepts and approaches outlined in the SOE literature described in Chapter 1.

## SOE Reporting and Indicator Development in Canada

Canada has been a pioneer in state-of-the-environment reporting and indicator development. As mentioned earlier, Statistics Canada, in collaboration with the UN Statistical Office, helped develop a general framework for environmental statistics in the mid-1970s. This work led to the birth of the PSR framework that has been so widely adopted in SOE reporting worldwide (Berger and Hodge 1998). Environment Canada and Statistics Canada established an ongoing SOE reporting programme in December 1986 and collaborated on the first comprehensive national SOE report. Released the same year, the report was a two-volume document oriented mainly to a scientific audience. Two years later, the 1988 Canadian Environmental Protection Act (CEPA) required that the Government of Canada "provide information to the people of Canada on the state of the Canadian environment." Subsequent comprehensive SOE reports in 1991 and 1996 were intended for a wider, more general readership. The 1991 report had 27 chapters covering human activities, environmental components, regional case studies, and priority issues. The 1996 issue was also voluminous. It reported on the state of ecozones, put strong emphasis on sustainability, and also covered a wide range of issues (Keating 2001; NIRO 2003b).

During this time, Environment Canada continued to be seen as a world leader in SOE reporting and was gaining expertise in developing environmental indicators. Canada's 1990 Green Plan had committed the government to producing a preliminary national set of environmental indicators. Environment Canada established an Indicators Task Force to identify criteria and a framework for selecting and developing national-level indicators, to survey key opinion leaders and potential users, and to define qualities with which to select indicators. Survey results showed the need for clearly communicated, flexible indicators that reveal issues of importance and that trigger action. The Task Force developed an integrated indicators system for Canada and in 1991 published *A Report on Canada's Progress Towards a National Set of Environmental Indicators*, which presented 43 preliminary indicators in 18 issue areas. These formed the basis for ongoing multi-stakeholder indicator development, and over the following 10 years, Environment Canada further developed and updated them and began the periodic release of a series of short summary indicator reports (Keating 2001; Lealess 2002; EC 2003a; UN DESA 2003a; NIRO 2003b).

Another attempt to develop a national-level set of indicators was initiated by the Canadian Council of Ministers of the Environment (CCME). In 1990, it established a State of the Environment (SOE) Reporting Task Group. Among its projects were the development of guidelines for SOE reporting and a common set of environmental indicators, but neither was adopted and the Task Group disbanded in early 1997 (NIRO 2003a).

In 1996, the SOE Directorate closed. A small Indicators and Assessment Office was retained, which continued to produce regular, concise indicator bulletins and reports on specific issues rather than the traditional large and comprehensive reports published at five-year intervals (Keating 2001; NIRO 2003b). Regular reporting through the National Environmental Indicator Series has been ongoing since 1992. In addition, during 1998–2002, seven federal SOE reports featured the federal SOE reporting symbol (see Box 14) and were placed on the online SOE Infobase (http://www.ec.gc.ca/soer-ree/English/SOER/default.cfm).

**Box 14: Criteria for Canadian SOE reports**

This symbol may be displayed on reports meeting specific criteria for Canada's 5NR Vision, which are thus considered part of the federal SOE Reporting Program. Reports that display the SOE reporting symbol:

National Environmental Indicator Series

- are recognized as part of a collection of federal publications that meet the SOE reporting criteria and use the widely understood SOE reporting approach;
- reach a diverse audience of people interested in the status of key environmental issues—decision-makers, educators and students, and the general public;
- are accessible through links at "The State of Canada's Environment Infobase" (www.ec.gc.ca/soer-ree/english/default.cfm), which provides an up-to-date listing of federal SOE reports and science assessments; and
- are included in the promotion of federal SOE reporting.

Source: EC 1997.

These include a short 2001 report titled *Tracking Key Environmental Issues,* illustrating the state of environmental knowledge in Canada as well as the state of the environment (EC 2001).

In 1997, Canada adopted a vision for federal state-of-the-environment reporting (called the 5NR Vision), which was developed by Canada's five natural resource departments (responsible for Environment, Agriculture and Agri-Food, Fisheries and Oceans, Health, and Natural Resources). It stipulates that each federal lead agency is responsible for preparing and producing its own SOE reports. The 5NR Vision promotes the use of SOE reporting criteria in designing policy-driven, science-based assessments (Box 14). The main components of the 5NR Vision are environmental monitoring, environmental indicators using a PSR framework, science-based assessments, reporting on critical and emerging issues, an SOE Infobase, and an Internet web site for federal SOE reports (NIRO 2003b).

Statistics Canada has also played a leading role in SOE reporting since the late 1970s, producing the *Human Activity and the Environment* series about every five years. Today, it is a smaller publication, released annually. Through the presentation and analysis of relevant statistics, it explores the relationships between population, socioeconomic activities, and the country's natural systems (air, water, soil, plants, and animals). The agency also produced *Econnections* (now discontinued), which adopted a natural-capital approach using indicators that link the environment and the economy and track progress towards environmental sustainability. It organized sets of indicators along the themes of natural resource stocks, use of land resources, consumption of materials and energy, waste production, and environmental protection expenditures (Keating 2001; NIRO 2003a; NIRO 2003b).

Developing and reporting on a national set of environmental indicators is conducted under the state-of-the-environment reporting program of the National Indicators and Reporting Office, of Environment Canada's Knowledge Integration Directorate. Apart from the indicator work by national SOE initiatives, environmental indicators are being developed and used at many other levels of government, from provincial to municipal, as well as by other bodies interested in improving their environmental performance. Thus, the process of identifying and developing indicators in and for Canada has been evolving ever since the late-1980s.

In September 2004, the Conference Board of Canada, a not-for-profit, non-governmental organization, paid particular attention to the environment in its annual publication, *Performance and Potential.* The publication benchmarks Canada's performance against that of 23 other OECD countries, using 24 environmental indicators organized according to the PSR model. In previous years, the Conference Board's analysis focussed mainly on present actions and gave brief consideration to past damage or future actions that may lessen human impact on the environment. Use of the PSR framework in the 2004 report improved Canada's relative ranking (Conference Board of Canada 2004).

Environment Canada is now developing a strategy to provide more cohesion in its own SOE work and to address the challenge of bringing together many of these indicator initiatives to contribute to an integrated picture of the state of the nation's environment (NIRO 2003a). The strategy will respond to OECD's 2004 recommendation that

**Box 15: Indicator profiles in *Environmental Signals***

- Biodiversity and protected areas
- Toxic substances
- Acid rain
- Climate change
- Stratospheric ozone
- Municipal water use
- Municipal wastewater treatment
- Urban air quality
- Forestry
- Agricultural soils
- Energy consumption
- Passenger transportation
- Municipal solid waste

Source: Adapted from EC 2003a.

Canada expand its information efforts in the area of environmental indicators (OECD 2004a). To assist the strategy and in an effort to fill a gap in information about what indicators have been developed by different indicator initiatives, the National Indicators and Reporting Office is preparing an environmental indicators database (EID). It contains information on existing, preliminary, and proposed environmental indicators, organizing them into the following fields: category, organization, initiative, scope, issue, sub-issue, stage of development, name of indicator, and message (NIRO 2003b).

## *Two National Indicator Reports for Canada*

### *Environment Canada's Environmental Signals series*

On 2 April 2003, Environment Canada released *Environmental Signals: Canada's National Environmental Indicators Series* report, presenting its current national set of environmental indicators. It provides a picture of the state of the nation's environment and measures its performance in improving environmental conditions.

*Conceptual and organizational framework*

Indicator development at Environment Canada's Indicators and Reporting Office and in the Environmental Signals report is organized under four themes. The first three represent principal goals for environmental sustainability: assuring ecosystem integrity, human health and well-being, and natural resource sustainability. The fourth theme represents driving forces—termed "pervasive influencing factors"—identified as population, lifestyle, and consumption patterns. Issues are grouped under these four themes. Indicator development and reporting is based on a "stress-condition-response" model similar to the PSR approach. Each issue section contains a metered indicator, reflecting a trend over time for the indicator that best summarizes the issue. The meter shows whether the issue represented by the indicator is deteriorating, remaining stable, or improving, and to what extent. The reference section provides the method for calculating the meter, which is explained in more detail in the technical supplements. The meter calculations are generally based on percentage change over the past decade. Figure 19 shows an example (EC 2003a).

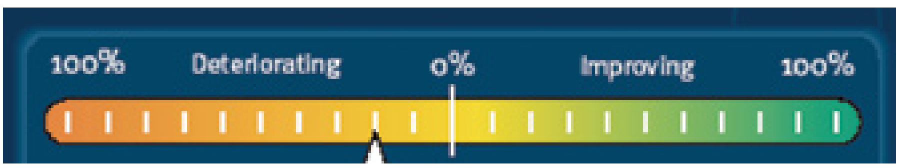
*Selection process*

The current key environmental issues were selected based on a series of consultations with specialists and other stakeholders; analysis of environmental stories in journals, the media, and opinion polls; and assessment of global and national concerns, Canada's Green Plan priorities, and Department of the Environment priorities. The issues were selected according to criteria that include the following: sensitive to change; supported by reliable, readily available data; understood and accepted by intended users; and of long-standing importance (EC 2004c).

*Products and contents*

*Environmental Signals* is a 78-page document, with four major chapters, organized according to the themes described above. It includes a summary at the beginning that highlights the salient indicators showing improvement or decline. The report covers 55 environmental indicators for 13 key environmental issues (Box 15). Within each theme, the report is organized under five headings: the "Context" section is a discussion about what is happening and why it is important; an "Indicators" part presents the main message as illustrated by the indicators; "Actions" discusses what the Government of Canada is doing to address the issue; "Linkages"

**Figure 19: Environment Canada's meter**




**METER CALCULATION**

Percent change in greenhouse gas emissions between 1990 and 2000

Source: EC 2003a

points to other indicators relevant to the theme; and "Challenges" underscores ongoing difficulties.

A brief section looks at national and international actions dealing with each issue and a final section suggests individual actions for more sustainable living and outlines future work towards indicator development in Canada. A technical supplement presents profiles of each indicator, which include: purpose and rationale, methodology, caveats and limitations, targets and/or benchmarks, geographic coverage, units of measure, terminology/glossary, and web sites and/or references, as well as downloadable data tables including sources and metadata (EC 2003a; NIRO 2003a).

The main report was accompanied by *Environmental Signals: Headline Indicators*, a succinct overview for a more general audience. It contains a set of 12 key indicators that provide a series of snapshots with the goal of raising public awareness about progress towards environmental sustainability rather than providing a comprehensive view of the state of Canada's environment. The reports are available at the following web site: http://www.ec.gc.ca/soer-ree/English/Indicator_series/default.cfm.

**Box 16: NRTEE's proposed environmental indicators**

- Air quality: population exposure to ground-level ozone
- Freshwater quality: proportion of water bodies, classified according to major objectives
- Greenhouse gas emissions: trends in aggregate emissions
- Extent of forests: map of forest crown closure
- Extent of wetlands: trends in total area

Source: Adapted from NRTEE 2003.

*Ongoing work*

The development and presentation of Environment Canada's indicators is an evolving process. In addition to developing indicators that track trends in environmental issues, Environment Canada is increasingly working on showing the links among environmental, economic, and social change. Ecological monitoring efforts will eventually provide indicators on the state of ecosystems in addition to their component parts. The national set will incorporate the resulting ecosystem indicators (EC 2004c).

Environment Canada has also proposed the development of a core set of indicators—a single, recognizable set using the soundest approaches from all jurisdictions. The series supports and complements the work of Canada's National Round Table on the Environment and the Economy (NRTEE), which is also developing a core set of national indicators, as described below (NIRO 2003a).

### *The National Round Table on the Environment and the Economy's Environment and Sustainable Development Indicators for Canada*

In its federal budget of February 2000, the Government of Canada requested that the National Round Table on the Environment and the Economy (NRTEE) prepare a recommendation for a small set of indicators linking the economy and the environment. NRTEE was established to identify and explore issues that have both environmental and economic implications and to propose actions that will help balance economic prosperity with environmental preservation. The indicators are meant to supplement and provide context for macroeconomic indicators such as the GDP. NRTEE worked closely with Environment Canada and Statistics Canada to develop realistic and useable environment and sustainable development indicators and released its report in May 2003. The report includes the recommendation that Canada use an expanded System of National Accounts and that the government support the implementation of an information system for the environment to supply "comprehensive, coherent, current and authoritative data". NRTEE does not recommend policy issues oriented to improving environmental performance as a result of needs revealed by the indicators (NRTEE 2003).

*Conceptual and organizational frameworks*

NRTEE adopted the capital model as the basis for developing a set of national indicators of economic sustainability. It focuses on tracking trends related to Canada's key capital stocks (produced, natural, and human), which requires expanding the notion of capital to include basic ecosystem services such as the provision of clean air, water, and a stable climate. According to its mandate, NRTEE's focus is on the long-term sustainability of Canada's development, so although the indicators deal mainly with the environment, they also attempt to track stocks of produced, social, and human capital.

*Selection process*

NRTEE set up the Environment and Sustainable Development Indicators (ESDI) Initiative, which conducted a three-year multi-stakeholder process to develop a small core set of credible and understandable indicators that could measure the environmental and social sustainability of economic activity.

It was guided by a steering committee comprising representatives from other indicator initiatives, especially from Environment Canada and Statistics Canada, and from the business, labour, government, community, NGO, academic, and research sectors of society. Criteria for selection included the need for clear, transparent, unambiguous, and scientifically credible indicators. The selection process included the participation of potential audiences and users.

*Products and contents*

The first part of the 76-page report describes the context for NRTEE's recommendations and describes the capital model. It then presents five indicators linked to different types of environmental capital assets that provide important ecosystem services: air quality, freshwater quality, greenhouse gas emissions, forest cover, and the extent of wetlands (Box 16). A sixth indicator relates to human capital and reports on educational attainment. The following section of the report provides the rationale for the development of each of the proposed indicators, describes them, and, where and to the extent possible, calculates and presents the indicator. Not all of NRTEE's proposed indicators are fully developed yet. It also outlines future efforts in producing and improving each indicator (NRTEE 2003). The report is available at the following web site: http://www.nrtee-trnee.ca/eng/programs/Current_Programs/SDIndicators/ESDI-Report/ESDI-Report_IntroPage_E.htm.

*Ongoing work*

Five of the six recommended indicators were calculated for the first report. Many are still in a preliminary form and NRTEE acknowledges that it will require years of effort to comprehensively extend the SNA and provide a robust set of data for all types of capital. Additional indicators will emerge over time. The intention is also to develop an aggregate measure of capital that can be feasibly converted to monetary values. In the short term, Statistics Canada and Environment Canada will collaborate on reporting the air, water, and climate change indicators. The federal government has declared that it would begin to incorporate key indicators on clean water and air and on emissions reductions into its decision-making (NRTEE 2003; SRP 2004).

## SOE Reporting and Indicator Development in the United States

Until recently, the United States had not produced comprehensive SOE or indicator reports on the state of the nation's environment. The National Environmental Policy Act of 1969, however, mandated the President to deliver an annual

Typical deciduous forestland habitat. *Paul Fusco/UNEP/NRCS*

Environmental Quality Report to Congress on the effects of federal activities on the environment. The Council on Environmental Quality (CEQ) was established and reporting began in 1970; it continued until 1997 (US CEQ 1997; Parris 2000). These reports provided information through indicators and descriptive text on environmental media, ecosystems and biodiversity, energy and transportation, and pollution prevention, among other themes. They included extensive appendices of data tables on environmental trends. Despite the lack of formal SOE reports, the Environmental Protection Agency (EPA) has always made data easily available and accessible for use and interpretation by users. A number of environmental NGOs use these data to support environmental indicators they have developed to inform the public about specific issues. For example, using publicly available data, the Natural Resources Defense Council (NRDC) publishes an annual report on the water quality of the nation's vacation beaches (Dorfman 2004).

Over the years, EPA began to develop environmental indicators, as did various other federal agencies such as the Department of Agriculture, the Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration. More recently, some private companies and corporations have been trying to measure and improve their environmental performance with indicators and to put forth a "greener" image (CGER 2000). For example, a growing number of US corporations are using the Global Reporting Initiative guidelines for developing annual reports about their efforts towards achieving environmental as well as social and economic sustainability. As in Canada, other levels of government, from states to municipalities, also report on the state of the environment in their jurisdictions (ISIN 2002; US GAO 2004).

The Interagency Working Group on Sustainable Development Indicators (SDI Group) is a recent initiative that developed a set of national sustainable development indicators, including environmental indicators. It was set up in response to recommendations by the President's Council on Sustainable Development (PCSD) in a 1996 document called *Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future* (PCSD 1996). It called for a collaborative effort among the federal government and the NGO and private sectors to develop national indicators and report regularly to the public (IISD 2004a). The SDI Group includes representatives from the departments of Interior, Agriculture, and Commerce, and from the EPA. It completed its report, *Sustainable Development in the United States, an Experimental Set of Indicators,* in December 1998 (US IWG 2001). This was a study of over 40 experimental social, economic, and environmental indicators to guide the development of national sustainable development policies and to structure a long-term framework towards that goal by presenting measures of whether economic, environmental, and social endowments are diminishing or improving. In 2001, the SDI Group revised and updated the first report in preparation for the World Summit on Sustainable Development in September 2002 (ISIN 2002; UN DESA 2002).

At the end of 2002, the Council on Environmental Quality (CEQ) began a new initiative to enhance coordination among federal agencies and to develop policy guidelines for future environmental and sustainable development indicators. In part, the new orientation responds to a consensus on the need to gauge the success of environmental policy by outcomes rather than by the amount of money or number of laws and regulations devoted to environmental issues (US GAO 2004). The initiative resulted in the establishment of the Interagency Working Group on Indicator Coordination. The goal is to produce interlocking sets of environmental and human health indicators with which to inform decisions at all levels of government. The Council plans to catalyze agreement on a set of national-level environmental indicators that can be linked to regional and local conditions and to better organize statistical reporting and data collection. The Working Group, however, had no explicit responsibility or authority to catalyze involvement and resources from other federal agencies. In late 2004, the United States Government Accountability Office (GAO) stressed the need for

Runoff from this livestock yard may enter a nearby stream and degrade the water quality. *Tim McCabe/UNEP/NRCS*

**Box 17: Indicator profiles in the EPA draft report**

- Outdoor air quality
- Indoor air quality
- Waters and watersheds
- Drinking water
- Recreation in and on the water
- Consumption of fish and shellfish
- Land use
- Chemicals in the landscape
- Waste and contaminated lands
- Environmental pollution and disease
- Exposure to environmental pollution
- Landscape conditions
- Biotic condition
- Chemical and physical characteristics
- Ecological processes
- Hydrology and geomorphology
- Natural disturbance regimes

Source: Adapted from US EPA 2003.

the CEQ to work on a more concerted, systematic, and stable approach to the development, coordination, and integration of environmental indicator sets (GAO 2004). The CEQ will work in concert with the EPA on a long-term strategy for environmental indicators. The strategy will build on EPA's *Draft Report on the Environment*, released in 2003 as the result of its two-year process of identifying and developing national environmental indicators. The work began in 2001, with the establishment of EPA's Environmental Indicators Initiative, managed by EPA's Office of Information and Office of Research and Development (GAO 2004). In 2003, The Heinz Center, a private research body, published a comprehensive report on ecological indicators for the nation. These two reports are described below.

## *Two National Indicator Reports for the United States*

### *The US Environmental Protection Agency's Draft Report on the Environment*

In November 2001, the EPA launched its Environmental Indicators Initiative, with the goal of developing indicators that would enable the United States to measure and track the state of the nation's environment and support improved environmental decision making. The Indicators Initiative also identifies where additional research, data quality improvements, and information are needed. The initiative aims to be consistent with the EPA Science Advisory Board, National Research Council, and the Heinz Center indicator efforts. The *Draft Report on the Environment 2003* and the accompanying technical document were released in June 2003 (US EPA 2003).

*Conceptual and organizational framework*

The report's two key purposes are to describe EPA's state of knowledge about the current and changing state of the environment at a national level, and to identify and improve measures to track environmental conditions and trends. It uses a modified PSR framework, comprising a "hierarchy of indicators". It reports on those indicators that illustrate changes in the quantity of pressures or stressors; ambient conditions; exposure or body burden or uptake; and the ultimate impacts reflected by changes in human health or ecological condition. The framework does not include driving forces or responses, with the indicators focusing on outcomes rather than actions taken.

*Selection process*

A steering committee comprised of EPA officials guided the process, and other federal agencies and tribal and state governments assisted in reviewing drafts. EPA held a series of thematic workshops at which a series of questions about the state of environmental resources and services was formulated, focusing on outcomes. A multi-stakeholder process led to a set of recommended indicators responding to the questions, and then corresponding data sources from many federal agencies were documented. Expert reviewers evaluated the indicators guided by criteria related to data quality, scientific reliability, utility, and limitations (US EPA 2003).

*Products and contents*

EPA's *Draft Report on the Environment 2003* (ROE), intended for general consumption, is accompanied by a technical document. The main report has an executive summary. The first three of the report's five chapters deal with the current state of air, water, and land and the pressures that affect them. The last two chapters present indicators on human health and ecological conditions (Box 17). Each chapter addresses the issues through a series of questions and answers about what is happening, why it is happening, and what the effects are. They correspond to the framework outlined above (what are the pressures or stressors, ambient

Pawnee Buttes on Pawnee Grasslands, USA. *Gary Kramer/UNEP/NRCS*

conditions, exposure or body burden or uptake, and the ultimate impacts?) Each chapter includes a section on the indicators' limitations. Data from the work of the Heinz Center contributed to some of the indicators in this report. The *Draft Technical Document* discusses the limitations of the currently available indicators and data, as well as the gaps and challenges that must be overcome to provide better answers in the future. It also specifies that there are two categories of indicators, according to the level of adherence to a number of criteria, and it provides additional indicators to illustrate many of the trends noted in the text of the draft report (US EPA 2003). The reports are available at the following web site: http://www.epa.gov/indicators.

*Ongoing work*

In the report, EPA solicits suggestions and feedback from readers about the draft, future directions for its Environmental Indicators Initiative, how to measure results, and how to communicate effectively. The report represents the first step in a longer-term project to create a strategy for developing an integrated system of indicators at local, regional, and national levels. The long-term goal is to improve the indicators and data that guide EPA's strategic plans, priorities, performance reports, and decision making (US EPA 2003). The next report is scheduled for release in the summer of 2006. It will include a set of regional indicators, and work is underway to link the new report to the agency's strategic planning effort (US GAO 2004).

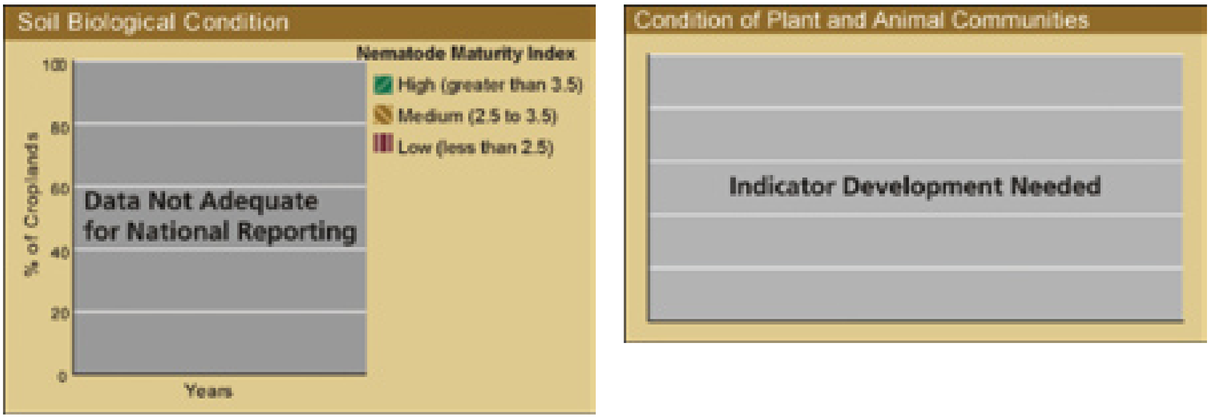
*The Heinz Center's The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States*

In 1995, the White House Office of Science and Technology Policy asked the H. John Heinz III Center for Science, Economics, and the Environment to compile existing data to help assess the health of the nation's ecosystems. The Heinz Center is a non- governmental organization established in December 1995 as a nonprofit, nonpartisan institution dedicated to improving the scientific and economic foundations for environmental policy through multisectoral collaboration. *The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States* was published in 2002 (Heinz Center 2002). It was preceded by a preliminary study in 1999 entitled *Designing a Report on the State of the Nation's Ecosystems: Selected Measures for Farmlands, Forests, and Coasts and Oceans* (Clark, Jorling, and others 1999). The report provides policy-makers and the public with a set of key indicators on the condition and use of ecosystems in the United States, with the goal that the indicators serve as a catalyst for debate about the nation's environmental policy (Dudley 2003; O'Malley, Cavender-Bares, and Clark 2004).

*Conceptual and organizational framework*

The report uses the biogeophysical approach and focuses on six major ecosystem types rather than on the whole gamut of environmental systems and on the state of those ecosystems, leaving aside the pressure and response categories used in the PSR

**Figure 20: Indicators showing critical gaps**




Source: Heinz Center 2002, 102 and 54.

framework. It also identifies core national indicators that provide a highly aggregated view of overall conditions. Measures of ecosystem properties and ecosystem services help to evaluate each ecosystem type and the country as a whole. Ten major characteristics of ecosystem condition are used: extent; fragmentation and landscape pattern; nutrients/carbon/oxygen; chemical contaminants; physical conditions; plants and animals; biological communities; ecological productivity; food/fibre/water; and recreation and other services. The approach presents base-line spatial or productivity indicators and indices and uses about 15 indicators of specific ecosystem conditions for each major ecosystem type. It identifies critical gaps in data and monitoring programmes and indicators that have yet to be developed, rather than only using indicators for which data are already available. It presents these indicators in the issue profiles, with a view to filling in the data as they become available. Figure 20 provides an example of an indicator for which the data are still inadequate for national reporting and an indicator that has not yet been developed (Heinz Center 2002; Dudley 2003; O'Malley, Cavender-Bares, and Clark 2004).

**Box 18: The Heinz Center's core national indicators**

- Ecosystem extent
- Fragmentation and landscape pattern
- Movement of nitrogen
- Chemical contaminants
- At-risk native species
- Condition of plant and animal communities
- Plant growth index
- Production of food and fiber and water withdrawals
- Outdoor recreation
- Natural ecosystem services

Source: Adapted from Heinz Center 2002.

*Selection process*

The indicators were selected through consultations and discussions among a large number (nearly 150) and variety of experts and stakeholders who were part of several committees and working groups. Participants represented the business, environmental, academic, and government sectors. Indicator selection was based on three key standards: policy relevance, technical credibility, and political legitimacy (nonpartisan). Three criteria were used to review the data for the selected indicators: scientific credibility; adequate geographic coverage to represent the nation; and collected through an established and durable monitoring programme. The report's content was steered by a number of other guidelines: the report should be strategic, not encyclopaedic, with 18 or fewer indicators per ecosystem; it should first determine what should be reported, regardless of the availability of data; it should be understandable to non-specialists; it should include information on both the condition of ecosystems and the goods and services that people derive from them; and it should focus solely on the ecosystem's state and condition (O'Malley, Cavender-Bares, and Clark 2004; US GAO 2004).

*Products and contents*

Both a full 270-page report and a short, 24-page summary and highlights edition were published in 2002. The first part of the main report sets out the intent, structure, and overall focus. Part 2 summarizes the findings through the use of ten core national indicators that cut across six ecosystems (Box 18). The following chapters present the indicators that describe the state of each ecosystem: coasts and oceans, farmlands, forests, fresh waters, grasslands and shrublands, and urban and suburban areas. For each of the 103 indicators, the text answers the questions: What is this indicator and why is it important? What do the data show? and Why can't this entire indicator be reported at this time? Part 3 is an appendix. It outlines data availability and gaps and the criteria used to select the indicator for inclusion. It also contains a technical notes section that provides definitions, metadata, and references. The first annual update was released on the organization's web site in 2003. It includes new data for 26 indicators and first-time data for one indicator for which no data were previously available (Heinz Center 2002; Heinz Center 2003; O'Malley, Cavender-Bares, and Clark 2004). The reports are available at the following web site: http://www.heinzctr.org/ecosystems/intro/updates.shtml.

_Ongoing work_

The Heinz Center is actively soliciting feedback and technical comments on the current version. An updated, revised edition of the report is expected to be published every five years, with the next issue planned for 2007. In the interim, the data and indicators are updated annually on the Center's web site. One of the results of the publication of the indicator set is its use to inform the design of the ecological portion of the international Global Ocean Observing System (US GAO 2004).

**A Comparison of Canadian and US National Indicators**

All four agencies developed the indicators through a transparent, multi-stakeholder process, and adopted a set of criteria for indicator approval. The reports each include a succinct summary and are fully accessible online, and the organizations all continue to improve upon the indicators for better reporting in the future. The technical supplements or appendices that accompany the reports provide extensive detail about the rationale, methodology, and data for each indicator. Each agency employed a conceptual framework: the EPA and Environment Canada chose modified PSR approaches; NRTEE adopted a natural capital model; and the Heinz Center restricted reporting to the condition and use of ecosystems, using biogeophysical indicators.

The EPA approached indicator selection by identifying those that could answer a series of questions posed by experts during multi-stakeholder workshops. The Heinz Center wished to develop indicators to accurately reflect ecosystem conditions, whether or not indicators, monitoring programmes, and data already existed. It identified critical gaps in these areas by identifying ideal indicators and by underscoring where they need further development and more-adequate data. NRTEE also selected a set of ideal indicators, some of which are still under development. Unlike the other agencies, Environment Canada chose to provide a performance meter for each indicator profile.

The approaches, frameworks, choice of indicators, and types of products reflect the visions and goals of their creators. All four reports are clear and understandable, making them accessible to decision-makers and the public. They present, describe, and interpret the indicators but are not prescriptive, leaving policy decisions to politicians and other decision-makers. The Heinz Center, which is not a government agency, is explicitly oriented to being politically legitimate or nonpartisan (O'Malley, Cavender-Bares, and Clark 2004), while the NRTEE's report makes recommendations to the federal government about expanding the system of national accounts to include natural and social capital.

The EPA and Environment Canada reports are the most comprehensive, addressing a wide audience and attempting to cover most aspects of each nation's environmental goods and services. The issues they include and the associated indicators resemble each other most. NRTEE explicitly reports on a very small set of indicators that link the environment and the economy and it focuses on the long-term sustainability of Canada's development, not exclusively on the environment. The focus on biological and chemical properties in the Heinz Center's report reflects its goal to exclusively report on the condition and use of US ecosystems. The Heinz Center makes a unique contribution by identifying ideal indicators and by underscoring where they need further development and more adequate data. NRTEE supports Environment Canada's indicator work, just as the Heinz Center supports that of the EPA. There is thus a great deal of correspondence between the two Canadian and the two US sets of issues and indicators.

***Common issues***

Table 1 presents a list of the issue areas addressed by each country in their respective reports and highlights in blue the 11 issues covered by both countries (even if the issue was found in only one of the two reports surveyed for each nation). These common issues are the following: drivers of change, the ozone layer, acid deposition, air quality, toxic substances, waste, freshwater, wetlands, forests, agricultural land, and biodiversity.

Not included in the Canadian reports are indicators for the issues of coastal and marine ecosystems, indoor air quality, national land use, fisheries, grasslands and shrublands, urban areas, and the impact of environmental change on human health. The US reports do not include indicators for climate change, protected areas, energy, and

**Table 1: Comparative table of Canadian and US environmental issue areas**

| | Canada | | United States | |
|---|---|---|---|---|
| **Issues** | **NRTEE** | **EC** | **EPA** | **Heinz Center** |
| Drivers (population, GDP, consumption) | | X | X | |
| Climate change | X | X | | |
| Ozone layer | | X | X | |
| Air quality | X | X | X | X |
| Acid deposition | | X | X | |
| Indoor air | | | X | |
| Toxic substances | | X | X | X |
| Waste | | X | X | |
| Land use | | | X | X |
| Freshwater | X | X | X | X |
| Wetlands | X | | X | X |
| Coastal and marine | | | X | X |
| Fisheries | | | X | X |
| Forests | X | X | X | X |
| Agricultural land | | X | X | X |
| Grasslands and shrublands | | | X | X |
| Biodiversity | | X | X | X |
| Protected areas | | X | | |
| Urban areas | | | X | X |
| Energy and transportation | | X | | |
| Human health & environment | | | X | X |

Source: Compiled by author from EC 2003a; NRTEE 2003; US EPA 2003; Heinz Center 2002.

transportation. Most gaps in issue selection reflect the different mandates and foci of the authors. The absence of indicators representing certain issues does not mean the nations do not monitor and gather data about these issues or report on them in other ways; it may be that the data are not adequate for national reporting, for example. There are many other challenges to developing suitable indicators, apart from the important issue of data, however, as discussed further in Chapter 4.

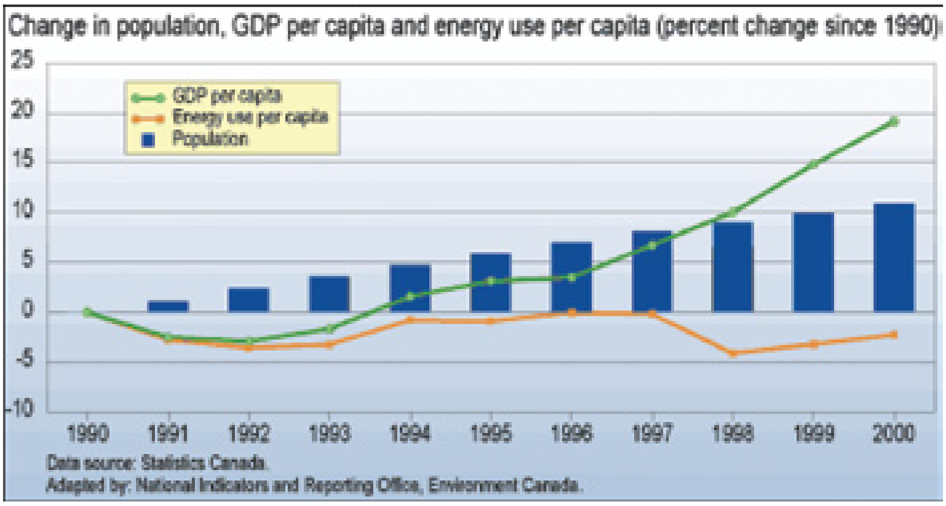
### *Common indicators: Notes on Table 2*

Table 2 (see Appendix 1, pages 122-148) is a chart that provides details on the indicators in each of the reports, allowing for comparison and contrast among them and for the identification of common indicators. In general, the table provides a list of national-level indicators. In some places, however, it also includes ecosystem and sub-regional-level indicators to illustrate environmental trends or conditions where national data or indicators were absent or inadequate. Indicators reflecting social, institutional, and economic conditions and trends that were not explicitly linked to environmental issues (such as a number of the health indicators in the EPA report) were not included. A number of the unique aggregated indices or meters, such as Environment Canada's meters and some indices used by the Heinz Center, were also not included. Some other indicators were omitted if they were not deemed relevant to this study, such as those representing global trends, comparing trends or conditions within the country, or focusing on illustrative case studies.

The table lists the indicators as well as the data and time-coverage, even though some indicators are still being developed and some data represent what is available at present pending better and more complete national coverage. Thus, indicators that are not yet fully developed (such as a number of those suggested by the Heinz Center) are also listed. Although the PSR and DPSIR frameworks have drawbacks related to analysis, the latter is used to organize the indicators for easier cross-referencing among the tables presented in this report. Cross-referencing is also facilitated by reserving each row in Table 2 for similar or "generic" indicators.

The last column lists only the generic indicators used by both countries, regardless of the methodology and data used to develop them. These similar

**Figure 21: Environment Canada's index of drivers of environmental change**



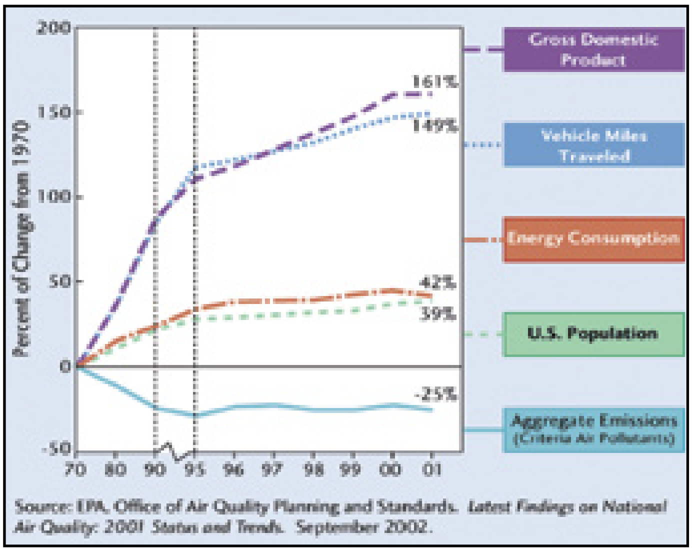

Source: EC 2003a, vi. Metadata from Statistics Canada

indicators are the most comparable and those most likely to be easily integrated. As such, they are candidates as regional indicators for North America. In Chapter 4, these common indicators will be complemented by others drawn from the reports examined in this study, to form a list of feasible environmental indicators for North America.

### *Analysis*

Most of the indicators in Table 2 represent states and impacts, with fewer indicators expressing pressures and very few that are indicative of responses. Both Canada and the United States acknowledge three overall drivers (population, GDP, and energy use), with Canada showing the per cent change since 1990 and the United States reporting on changes since 1970 (Figures 21 and 22). The reports do not present indicators of drivers specific to each issue.

**Figure 22: EPA's index of drivers of environmental change**




Source: US EPA 2003, 1–2.

The Canadian reports contain a restricted number of indicators and, where possible and relevant, used internationally standard measures (such as IUCN categories for protected areas and UNFCCC methods for greenhouse gas emissions). The US reports contain large numbers of indicators and, for the most part, use methods or parameters and standards established nationally.

Table 2 shows that a total of 20 similar indicators are used by both countries and that the issues of air quality and forests are represented by the most indicators, which together form small PSIR profiles. With a few exceptions, each country has adopted different methods for calculating and presenting the data, and indicators refer to different time periods and definitions. For example, both countries report on timber harvests, but Canada uses area harvested to portray the amount produced while the United States reports on the volume harvested. Chapter Four explores such inconsistencies further.

These conclusions are based on a survey of only four reports, however, and the small number of common indicators and their variations does not suggest the impossibility of finding a way for accomplishing integrated bilateral reporting with standard indicators. Appendix 2, which provides data sources for potential indicators for North America, reveals that comparable data are available for many generic indicators not represented in these reports.

The two countries are already involved in efforts to harmonize environmental indicators in order to enable reporting on the state of several shared ecosystems. To learn more lessons about potential environmental indicators for North America, the next section looks at a number of Canada-US binational SOE reporting initiatives and the indicators they are developing.

Logging truck transporting logs to mill, Northwestern Alberta, Canada. *David P. Shorthouser/UNEP/Forestry Images*

**Canada-US Bilateral Environmental and Ecosystem Indicator Initiatives**

Canada and the United States cooperate in international and regional SOE reporting and indicators programmes in recognition that ecosystems, air- and watersheds, and migratory species traverse political boundaries and that both countries often share the driving forces and pressures that affect them. For example, Canada and the United States participate in the Circumpolar Council, which sponsors an Arctic state-of-the-environment report. The first such report, which focussed on pollution, was released in 1997. Two subsequent editions looked at human health and persistent organic pollutants (AMAP 2003; AMAP 2004; NIRO 2003b). Canada and the United States also cooperate to manage and produce environmental indicator reports on the Great Lakes, the Gulf of Maine, and the Georgia Basin–Puget Sound region. These three initiatives are highlighted as case studies in this section.

The Border XXI Program (1996–2000), set up to address environmental issues at the US-Mexico border, has produced a set of environmental indicators for the border region (US-Mexico Border XXI Program 1997). Based on this work, the ten-year Border 2012 Program, launched in 2002, is now developing environment and health indicators to measure progress towards its sustainability goals (US EPA 2000a).

At the trilateral level, the Commission for Environmental Cooperation (CEC) of North America, set up to oversee the NAFTA environmental accord, is mandated to produce periodic state-of-the-environment reports for the NAFTA region. In 2002, it published its first SOE report, *The North American Mosaic.* The CEC anticipates that the next SOE report will introduce a set of environmental indicators that will inform future North American regional environmental assessments (CEC 2001). The CEC also published a report on available indicators of children's health and the North American environment in 2006 (CEC 2006). In addition, the CEC's Pollutant Release and Transfer Register (PRTR) project tracks, analyzes, and publishes available data about the source, release, and transfer of toxic pollutants from industrial activity in Canada and the United States. The CEC's annual report *Taking Stock* will integrate Mexico's data for 2004, creating a North American perspective of pollutant releases for the first time. This project enhances the comparability among the separate national reporting systems and provides a unique regional picture by way of pollutant indicators and data (CEC 2004a).

The CEC is a forum for many other projects that bring scientists and experts together in international working groups to cooperate on protecting the North American environment; many of these efforts provide lessons about how to achieve consensus among different stakeholders from the three countries in taking a common region-wide ecological perspective and adopting a common language for classification systems. One example is the North American eco-region mapping initiative, which succeeded in producing a continent-wide definition and maps of three levels of nested eco-regions (see CEC 1997).

Another trinational-level effort related to producing comparable environmental data is the North American Transportation Statistics Interchange (NATS). Under this initiative, a trilateral group works on the production of transportation, energy, and environment indicators (TEEI). Canada, the United States, and Mexico cooperate to adopt a common list of indicators and are working to compile the statistical data according to a common TEEI framework. They are also working on the opportunities and limitations of the elaborated indicators in terms of their consistency, harmonization, updating, and comparability.

Governments, NGOs, and other stakeholders in Canadian provinces and territories and US states are also working together to develop and use environmental indicators to assess the state of a number of shared ecosystems.

### *The State of the Great Lakes*

The Great Lakes lie within eight US states and the Canadian province of Ontario (Figure 23). Half the trade between the two countries crosses the region,

> The Parties to the Great Lakes Water Quality Agreement (GLWQA) want to establish a consistent, easily understood suite of indicators that will objectively represent the state of major ecosystem components across all Great Lakes basins... . This suite of indicators will also be used to assess the Parties' progress towards achievement of the purpose and general objectives of the GLWQA (Bertram and Stadler-Salt 2000, 4).

and the countries share the lakes' abundant resources and services as well as the pollution and disruption the ecosystem is experiencing (UNEP 2002a). In 1972, Canada and the United States signed the Great Lakes Water Quality Agreement (GLWQA), committing the two countries to controlling and cleaning up pollution in the Great Lakes and reporting on their progress. The amended agreement includes the goal to develop a set of comprehensive indicators on the health of the Great Lakes. To periodically assess the condition of the Lakes and to discuss further action, the US Environmen-

**Figure 23: The Great Lakes**


Source: GLIN 2004 http://www.great-lakes.net/gis/maps/.

tal Protection Agency and Environment Canada began hosting the biennial State of the Lakes Ecosystem Conference (SOLEC). Following the second conference in 1996, it was decided to develop a comprehensive, basin-wide set of indicators to enable reporting in a predictable, compatible, and standard format (Bertram and Stadler-Salt 2000; US GAO 2004).

At the 1998 SOLEC, a suite of easily understood indicators that objectively represent the condition of the Great Lakes ecosystem's components was proposed. This suite is used at each conference to inform the public and report on progress in achieving GLWQA goals, while work continues to broaden the suite and populate the indicators with reliable data (Bertram and Stadler-Salt 2000).

*Conceptual and organizational framework*

SOLEC adopted the state-pressure-human activities model, based on the PSR framework. The indicators nominated for the SOLEC list were extracted primarily from existing Great Lakes documents (Bertram and Stadler-Salt 2000). The indicators were screened using a broad set of SOLEC criteria that fell under the headings of Necessary, Sufficient, and Feasible. The SOLEC indicator framework consists of three nested levels. The first is comprised of geographic zones, issues, and cross-cutting elements; the second represents seven core groups (near-shore and open waters; coastal wetlands; near-shore terrestrial; land use; human health; societal; and unbounded); and the third level presents the PSR indicators (NIRO 2003b).

*Selection process*

The first step of the selection process, taken prior to the 1998 Conference, was to identify a set of indicators that reflects the state of all major Great Lakes ecosystem components. It was guided by a multi-stakeholder SOLEC indicators advisor group that coordinated seven core set advisor groups. Each of these groups identified a set and a short list of indicators for its domain. They strove to recommend indicators that could be applicable basin-wide. The short list was peer-reviewed and revised and ecosystem components needing additional indicator development were identified (Bertram and Stadler-Salt 2000). These indicators form the basis for reporting in the State of the Great Lakes reports, with each successive report building on the former as data become available, allowing the use of ever more indicators from the set. Presently, there are 79 indicators in the SOLEC list. Together, they help to assess the health of the Great Lakes' major ecosystem components. Many of the indicators are still being developed, however, and until more research is conducted and data collected, they cannot be used (Bertram and Stadler-Salt 2000).

*Products and contents*

The 2000 SOLEC report *Selection of Indicators for Great Lakes Basin Ecosystem Health: Version 4* provides a revised list of the indicators proposed in 1998 (Bertram and Stadler-Salt 2000). Difficulties in comparability between the two countries are identified in the short descriptions of each of the indicators. These include information about each indicator's purpose, ecosystem objective, endpoint, features, illustration, limitations, and interpretation. The *State of the Great Lakes 2001* (EC and US EPA 2001) is a 92-page report containing an assessment of the condition of each of the Great Lakes and of the region as a whole. The section devoted to indicators is organized by habitat type and kind of human impact. It includes a section titled "Implications for Managers" showing how managers can both use and contribute to indicator-based assessment (Pidot 2003). It is the first SOLEC report to use the indicator-based format and it reports on 33 of the indicators that make up the entire set. Subsequent reports are based on the suite of ecosystem health indicators developed by participants in the 2002 State of the Lakes Ecosystem Conference (SOLEC).

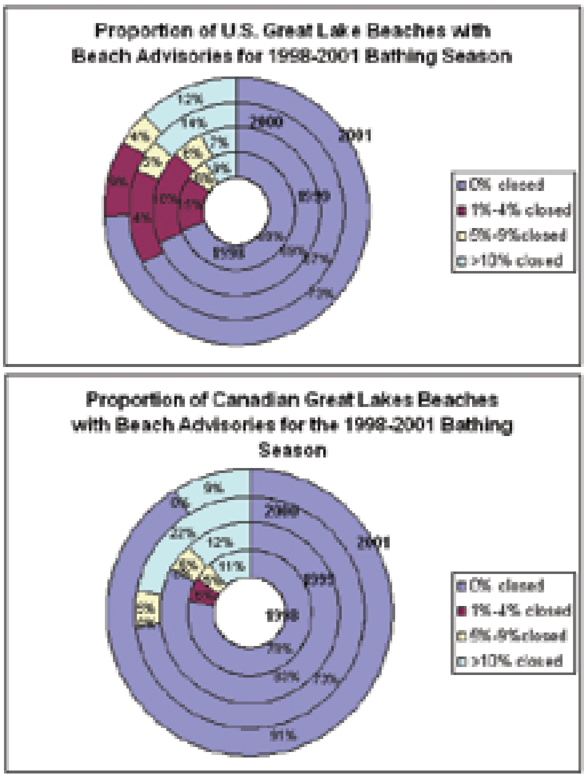
The *State of the Great Lakes 2003* is the fifth biennial report issued by the governments of Canada and the United States. It is a 102-page report,

1000 ft. Laker approaching the Blue Water Bridge at the mouth of the St. Clair River, Michigan USA. *UNEP/USACE*

which includes summaries of separate indicator reports and a status report on each of the Great Lakes and connecting channels (EC and US EPA 2003). It provides assessments of 43 of the indicators proposed by the Parties. These particular indicators were included because data were available. They are presented in the report under the headings of State, Pressure, and Response indicators (EC and US EPA 2003).

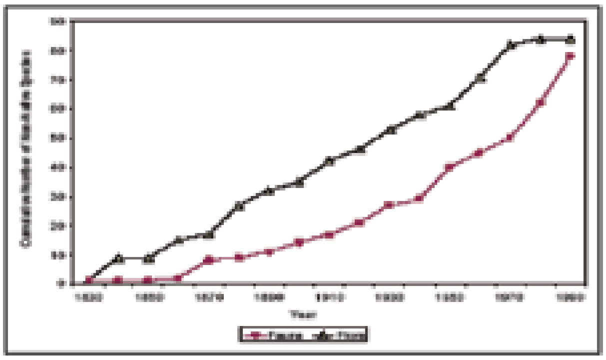
*Implementing Indicators 2003* is a technical report that compiles all the indicator reports that were circulated for review at SOLEC 2002 and provides full references for the information presented in each indicator report. In some cases, the indicators represent the entire basin, while in others they highlight certain geographic locations. The compilation of a database currently comprising over 800 indicators is an ongoing part of the work. The following two figures present examples of indicators from the State of the Great Lakes 2003 report. Figure 24 is an attempt to show Great Lake beach advisories and closures in both countries in a comparable way. Figure 25 presents an ecosystem-level indicator showing the cumulative number of introduced species in the Great Lakes. The 2003 report is available from the following web site: http://binational.net/sogl2003/sogl03eng.pdf

**Figure 24: Beach advisories in US and Canadian Great Lakes beaches**




Source: Adapted from EC and US EPA 2003, 82.

**Figure 25: Cumulative number of introduced species in the Great Lakes since the 1830s**



Source: EC and US EPA 2003, 76.

*Ongoing work*

The suite of Great Lakes indicators is constantly evolving as modifications and refinements are made to reflect a greater understanding of the ecosystem and human interactions with and within it, and to ensure that the information is accessible and useful. Progressively more indicators are reported on at each yearly conference, a process that will continue until the whole suite is included (Bertram and Stadler-Salt 2000; EC and US EPA 2003). The two governments are planning to integrate monitoring and reporting into existing Great Lakes activities at all levels of government as well as within industry. The SOLEC indicator set helped to influence the United States Fish and Wildlife Service's decision to focus on developing an ecosystem/watershed approach to the environmental management of the Great Lakes (US GAO 2004).

***Georgia Basin–Puget Sound***

The Georgia Bay–Puget Sound region (Figure 26) comprises the densely populated parts of the state of Washington and the province of British Columbia surrounding an arm of the Pacific Ocean that flows between Vancouver Island and the mainland.

An initial attempt to provide a sense of the current state and trends in this ecosystem in an integrated way across the Canada–United States boundary (GBPSEI 2002, 1).

In 2000, nearly seven million people lived in this region, with 57 per cent in the United States and 43 per cent in Canada. The area is experiencing rapid population growth: by 2020, the two core urban areas of Seattle and Vancouver are together expected to count about a million additional people. Pressures on the ecosystem have resulted in

**Figure 26: Georgia Basin–Puget Sound**


Source: GBPSEI 2002.

Scenic view from Port Townsend, Washington USA.
*Gary Wilson /UNEP/NRCS*

a need to address the environmental, social, and economic implications of that growth (GBPSEI 2002).

Government officials, scientists, and other stakeholders from both countries increasingly work closely to find cooperative solutions to shared environmental issues in the region. For example, Environment Canada and the US Environmental Protection Agency recently issued a joint report on the characterization of the Georgia Basin/Puget Sound airshed. The two countries have been working together to develop regional indicators since 2000. The Canada–United States Working Group on Environmental Indicators was formed with the view of developing and using a suite of indicators to report on sustainability in the region. It grew out of the British Columbia–Washington Environmental Cooperation Council, which began in 1992, and the Joint Statement of Cooperation by Environment Canada and the US EPA in 2000. The latter commits the two countries to work together at the federal level on transboundary issues. The Working Group is also improving the transfer of knowledge and best practices, developing shared goals and strategies, and implementing joint action programmes (GBPSEI 2002). In 2002, the Working Group released its *Georgia Bay–Puget Sound Ecosystem Indicators Report* (GBPSEI 2002), which uses six indicators to look at several aspects of the state of the environment in the transboundary region.

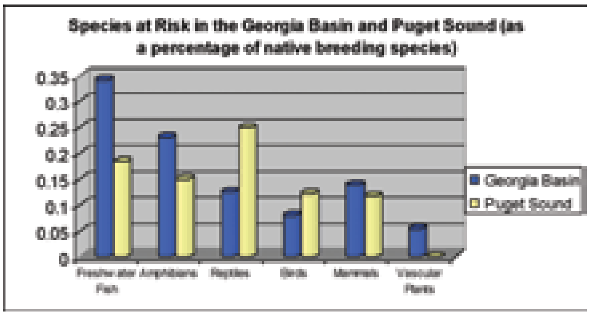
*Conceptual and organizational framework*

The report does not explicitly refer to the PSR or any other framework. Each indicator is presented in terms of what is happening, why it is happening, why it is important, how it compares with other regions or locations, and what is being done to address the issues of concern.

*Selection process*

Work began in 1999 to identify key indicators for which data were available on both sides of the boundary. Data specialists started by compiling all applicable monitoring data collected in the region to identify the best and most readily available and comparable data with which to develop a suite of indicators for the region (Pidot 2003). Only six indicators were initially selected, since differences in purpose, definition, measurement, and classification of data from different jurisdictions, as well as differences in the variety of regulatory and administrative frameworks presented challenges to developing harmonized indicators and an integrated basin-wide picture. The bilateral indicator for assessing

**Figure 27: Species at risk, using a standardized assessment method**




Source: Adapted from GBPSEI 2002, 14.

the conservation status of species was made possible because of a standardized method developed by the Association for Biodiversity Information, which includes a network of conservation data centres across North America (Figure 27). Except for the population indicators and a map showing the percentage of protected land, issues on each side of the border are portrayed with different indicators (GBPSEI 2002).

*Products and contents*

The report presents six indicators: population, air quality, solid waste, persistent organic pollutants (POPs), species at risk, and protected areas. As the key pressure on the shared ecosystem, the population indicator is the first in the report. It also portrays population distribution across the region through a series of maps. Technical backgrounders are provided for the indicators, which include data, data sources, methodology, references, contacts, and supplementary information. The organization and presentation of the technical information is not consistent across the two reporting jurisdictions. The reports are available online at: hhttp://www.env.gov.bc.ca/spd/gbpsei/index.html.

*Ongoing work*

The initiative is ongoing, with new indicators being developed and the original indicators modified as new data become available. For example, the $PM_{10}$ indicator may be modified or replaced in the future by an indicator showing trends in $PM_{2.5}$ concentration (GBPSEI 2002).

### *Gulf of Maine*

The Gulf of Maine is bordered by the states of Massachusetts, New Hampshire, and Maine and by two provinces, New Brunswick and Nova Scotia (Figure 28). This shared ecosystem is considered to be among the most biologically productive marine systems in the world: its waters and shoreline habitats host some 2,000 species of plants and animals.

**Figure 28: The Gulf of Maine**


Source: GMCME 2004d http://gulfofmaine.org/knowledgebase/aboutthegulf/. Map created by Richard D. Kelly, Jr., Maine State Planning Office, for the Gulf of Maine Council on the Marine Environment.

A bilateral effort is underway to maintain and enhance environmental quality in the Gulf of Maine. It is led by The Gulf of Maine Council on the Marine Environment, a US-Canadian partnership of governmental and non-governmental organizations. The Council stresses the importance of viewing the Gulf of Maine as a single ecosystem and promoting cross-boundary collaboration to help manage the region's resources and address environmental concerns. One of its long-term aims is to identify and track a set of regional environmental indicators and produce a "State of the Gulf" report (GMCME 2004a).

The Gulf of Maine is shared by Canada and the United States and is considered among the most biologically productive marine systems in the world.

Discussion about potential indicators began in December 2002 at the Atlantic Northeast Coastal Monitoring Summit, which also explored the potential for integrated regional monitoring. It was followed in January 2004 by the Northeast Coastal Indicators Workshop, where the initial selection process for regional indicators began (GMCME 2002; GMCME 2004b). Finally, the Gulf of Maine Summit was held in October 2004, bringing together and integrating the work of the many agencies, organizations, and institutions in the Gulf. The Summit was organized by the Gulf of Maine Council on the Marine Environment and


Lobster boat tied up at the Lobstermen's Co-op., Boothbay Harbor, Maine USA. William B. Folsomr/UNEP/NMFS

the Global Programme of Action Coalition for the Gulf of Maine (GPAC). The latter is a bi-national, multi-stakeholder working group dedicated to the implementation of the United Nations Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-based Activities (Gulf of Maine Summit 2004a; GPAC n.d.). Just prior to the Summit, pre-summit drafts of *Regional Ecosystem Indicators for the Gulf of Maine* (Gulf of Maine Summit 2004b) and *Tides of Change Across the Gulf: An Environmental Report on the Gulf of Maine and Bay of Fundy* (Pesch and Wells 2004) were released to inform participants of proposed indicators and to catalyze discussion.

*Conceptual and organizational framework*

In 2003, the Office of Ocean and Coastal Resource Management, of the National Oceanic and Atmospheric Administration (NOAA), produced a set of nutrient indicators as a contribution to the "State of the Gulf" report. The indicators are organized around a modified PSR framework and include the following categories: environmental indicators, context indicators, stressor indicators, impact indicators, and management response indicators (Mills 2003). *Tides of Change* presents indicators in chapters that respond to questions about current conditions and trends, causes of those conditions, and actions to reverse them—similar to a PSR approach (Pesch and Wells 2004).

*Selection process*

A steering committee first drafted straw conceptual models, key questions, and indicators for discussion at the January 2004 workshop. Feedback on them was sought through an indicators web survey. The key goal is to achieve consensus on a list of key indicators focusing on six major issues: fisheries, eutrophication, contaminants, coastal development, aquatic habitat, and climate change. Regional work groups strived to crystallize core indicators for presentation at the Summit (GMCME 2004b). Regional watershed forums were organized and convened by local groups over two years, using a consistent but flexible format. To identify priority issues, they each used a consistent reporting mechanism that evolved into the GPAC indicator matrix, adapted from that of EPA. Each forum used "traffic light" colours to signify its level of concern with an issue, based on its knowledge and perceptions of local problems. The colours in the key correspond to a spectrum, from "definite problem" to "no problem". Matrices were drawn up for the following: changes in land use and integrity of water and riparian zones; contaminant issues; changes in species; changes in resource use; and presence of critical habitats and natural areas related to fisheries. *Tides of Change* summarizes results from the watershed forums and provides in-depth chapters on several key issues facing the Gulf: land use; contaminants and pathogens; and fisheries and aquaculture (Pesch and Wells 2004).

Rock, foam, and fog. *Captain Albert E. Theberge UNEP/NOAA*

Products and contents

*The State of the Gulf Report: Nutrient Indicators* was published in 2003, providing information on potential nutrient indicators for inclusion in the Gulf of Maine Council's "State of the Gulf of Maine" report. It surveys nutrient indicators used in existing reports from organizations within the US and internationally and provides a list of the most prevalent ones used. It then suggests potential indicators in the categories listed above and outlines some general principles to guide the process of selecting and developing a suite of nutrient indicators for the Gulf of Maine (Mills 2003). The *Regional Ecosystem Indicators for the Gulf of Maine: Pre-Summit Draft* (Gulf of Maine Summit 2004b) presents 12 fishery indicators, 8 coastal development indicators, and 12 contaminant indicators. Each indicator is accompanied by technical notes that describe the following: purpose, ecosystem objective, measure, outcome, illustration, features, limitations, interpretation, comments, and references. In addition, draft indicators related to aquatic habitats, nutrients (see above), and climate change were also prepared. *Tides of Change* examines how environmental, economic, and social trends are influencing land use, contaminants (including sewage, nutrients, pathogens and mercury), and fisheries and aquaculture. Indicators for these trends provide historical context, reveal current conditions, and track progress. Bilateral or regional indicators include indicators of historical change in population density and rural/urban mix in the region; species at risk; beaches with closures; average mercury concentrations; landing of all species; finfish aquaculture; and community composition of fish. The report includes an overview of recent successes in addressing regional environmental issues, and a report summary (Pesch and Wells 2004). The reports can be viewed online at: http://www.gulfofmainesummit.org/docs/index.html.

Ongoing work

The goal of the Gulf of Maine Summit is to set the stage for the preparation of a "State of the Gulf of Maine" report. The aims of the report are to provide structure for an integrated monitoring

**Box 19: Issues selected by the bilateral indicator initiatives**

| Great Lakes | Georgia Basin–Puget Sound | Gulf of Maine |
|---|---|---|
| Near-shore and open waters | Population | Fisheries and aquaculture |
| Coastal wetlands | Air quality | Eutrophication |
| Near-shore terrestrial | Solid waste | Contaminants |
| Land use | Persistent organic pollutants | Coastal development |
| Human health | Species at risk | Aquatic habitat |
| Societal | Protected areas | Climate change |

Source: Compiled by author from EC and US EPA 2003; GBPSEI 2002; Gulf of Maine Summit 2004b; Pesch and Wells 2004.

programme; identify information gaps, problem areas, and research needs; compile information on standard protocols and quality assurance; help inform and engage the public on environmental issues; and advocate for enhanced science, policy-making and management (Nedeau 2003). After the 2004 Summit, the suggested indicators were to go through a period of review and refinement, followed by work to integrate them into regional strategies (GMCME 2004c).

### *Analysis*

The development of bilateral indicators for ecosystems shared by Canada and the United States is a fairly recent undertaking. Several initiatives, such as the CEC's indicator development work for environmental reporting in North America and the Gulf of Maine indicator initiative, are still in the initial stages of development. The three case studies presented above represent important ecosystems shared by Canada and the United States. All three indicator initiatives grew out of bilateral agreements and previous cooperative action to protect the shared ecosystems, with one of the major goals of the State of the Great Lakes work explicitly oriented to reporting on progress in achieving the purpose and general objectives of the GLWQA. Given the large extent of the Great Lakes ecosystem and the high degree of pressures upon it, it requires a larger set of indicators. Two of the case studies are focussed on shared water bodies and the important resources and ecosystem services they provide, with the majority of indicators representing their physical, chemical, and biological aspects. The indicators for Georgia Basin–Puget Sound, a densely populated region, represent a wider variety of issues. The indicator set is small and the indicators are more closely associated with the important human population and its impacts (Box 19). The latter initiative relied on indicators for which data were available, while the other two sought indicators that would answer questions about the state of the shared water bodies.

All three initiatives are based on multi-stakeholder participation for the indicator selection, attempt to develop compatible and standardized indicators, and include ongoing indicators review and refinement. The Great Lakes and the Georgia Basin–Puget Sound reports include technical documents that describe and explain each of the indicators. The Gulf of Maine project has not released its final set of indicators at the time of writing.

Given the focus on specific ecosystems and the fact that many ecosystem-level indicators may not easily serve as nation-wide indicators, lessons learned from these bilateral initiatives have more to do with the process of collaborating across borders to construct compatible environmental indicators than the actual content of the indicator sets. More information about the process of cross-border collaboration could be gleaned from a more in-depth study of these initiatives through interviews and other means.

To develop a more comprehensive list of basic indicators that could help form the basis for regional reporting for North America, the next chapter looks at indicators used or prescribed by international agencies that report on the state of the global environment. In some cases, these organizations have already harmonized or standardized data across nations.

O N T A R I O
TRANS-CANADA HIGHWAYS
Nakina
Pagwa River
Hearst
Longlac
Kapuskasing
Cochrane
South Porcupine
Sioux Lookout
Dryden
Nipigon
Atikokan
Thunder Bay
Timmins
Kirkland Lake
Michipicoten
Chapleau
Earlton
Cobalt
New Liskeard
Haileybury
Isle Royale
Lake Superior
Hancock
Keweenaw Pen.
Sault Ste. Marie
Thessalon
Elliot Lake
Capreol
North Bay
Sudbury
Ishpeming
Marquette
SOO CANALS
Blind River
Ironwood
Escanaba
Petoskey
Alpena
Wausau
Green Bay
Appleton
Oshkosh
Sheboygan
Traverse City
Cadillac
Muskegon
Bay City
Saginaw
Grand Rapids
Lansing
Kalamazoo
Flint
Pontiac
TORONTO
Kitchener
Hamilton
Peterborough
Oshawa
DETROIT
Windsor
CHICAGO
Lake Michigan

K. Giese/UNEP

# 3 Chapter 3

# International Environmental Indicator Initiatives

In 1987, the World Commission on Environment and Development (WCED or the Brundtland Commission) noted the "limited capability for ... combining basic and comparable data needed for authoritative overviews of key environmental issues and trends" and that without these overviews "the information needed to help set priorities and develop effective policies will remain limited" (WCED 1987, 321). Reporting efforts on the state of the global environment or on regions shared by more than one nation face numerous challenges. These include the lack of consistency among monitoring programmes, reporting methods, and data, among others. There are also gaps in country capabilities for studying, analyzing, and reporting on environmental issues (NIRO 2003b).

The United Nations Environment Programme (UNEP) was one of the first agencies to try to overcome these obstacles to reporting on the state of the global environment. It produced an annual state-of-the-environment report from 1973 through 1992 and the biennial *Environmental Data Report* from 1987–1988 through 1993–1994 (Parris 2000). UNEP's work in environmental reporting continues with the GEO series described below, and today it is joined by numerous other efforts to provide both data and analyses on the state of the environment, at an international level. Increasingly, these initiatives include the development and use of environmental indicators.

The Millennium Development Goals (MDGs), which commit the international community to work towards a world free of poverty, hunger, disease, and gender inequity, also include a set of environmental indicators: The eight indicators inform the seventh goal, "Ensure environmental sustainability". They are populated by data from harmonized sources, so are consistent and allow for comparison, but they are very limited in scope and address primarily the environments of developing countries (UN 2004).

This section looks at the Commission for Sustainable Development (CSD) and UNEP's environmental indicator initiatives, both prompted by the 1992 Earth Summit's call for better indicators for regular and reliable global overviews, and at the OECD's environmental indicators for its member countries.

## UN Commission for Sustainable Development

Agenda XXI, adopted at the 1992 Earth Summit in Rio de Janeiro, recommends the harmonized development of national, regional, and global-level sustainable development (SD) indicators, and regular reporting and data provision with a suitable common set of regularly updated indicators (Box 20).

> "The United Nations Conference on Environment and Development (The Earth Summit) held in 1992 recognized the important role that indicators can play in helping countries to make informed decisions concerning sustainable development. Agenda 21 calls for the harmonization of efforts, including the incorporation of a suitable set of these indicators in common, and regularly updated and widely accessible reports and databases".

Source: Shah 2004, 1.

**Box 20: The 1992 Earth Summit called for harmonizing indicator efforts**

The United Nations Commission on Sustainable Development (CSD) was created in December 1992 to monitor and report on the implementation of the Earth Summit agreements. The CSD recognized an urgent need for global action to combine national and international information efforts and to promote comparability, accessibility, and quality of that information (Luxem and Bryld 1997; UN DESA 2003b). It began a work programme, with the goal of providing national decision-makers with a list of indicators to use in national policies and in reports to the CSD and other international agencies.

Countries are encouraged to adopt and use this set as a starting point for their national indicator programs

*Conceptual and organizational framework*

The CSD approved its five-year Work Programme on Indicators of Sustainable Development in 1995. It included strategies for defining SD indicators, making them accessible to decision-makers at the national level, elucidating their methodologies, and providing training and other capacity-building initiatives (Mortensen 1997). Coordinated by the UN Department for Economic and Social Affairs (DESA), Division for Sustainable Development, the Programme organized the chapters of Agenda XXI under four major themes—social, economic, environmental, and institutional (Shah 2004). A preliminary working list of 134 indicators published in 1996 used the driving force–state-response (DSR) framework and was subjected to voluntary national testing and expert-group consultation. The framework evolved into one focusing on themes and sub-themes of sustainable development rather than exclusively on the Agenda XXI chapters. Reasons for the change include the fact that the DSR framework is less suited to social and economic indicators than to environmental ones and that the theme framework better assists national policy decision-making and performance measurement (Luxem and Bryld 1997; Shah 2004; UN DESA 2004a).

*Selection process*

The Programme selected indicators in accordance with a number of criteria that are similar to those used by other organizations, differing only in their particular focus on the relevance to Agenda XXI and all aspects of sustainable development. Using these criteria, the CSD and its Secretariat worked in close cooperation with a large number of international governmental and non-governmental organizations and national governments to select the indicators. It was guided by three principles: the development and use of indicators at a national level; building on existing national and international indicator work undertaken by other organizations and countries; and the cooperation and collaboration of a wide range of experts. Methodology sheets were developed for each indicator through a broad international consultation process (Gallopín 1997; Luxem and Bryld 1997).

*Products and contents*

The final product, published in 2001—*Indicators of Sustainable Development: Guidelines and Methodologies*—is a detailed description of 15 sustainable development themes and 38 sub-themes, a final proposed framework, and a core set of 58 indicators with their methodology sheets. Nineteen of the 58 are environmental indicators. The methodology sheets describe policy relevance, underlying methodology, data availability, and sources for each indicator (UN DESA 2001a). Governments began preparing national reports in 1993 and in 1997 the results of submissions between 1994 and 1996 were published in a series of country profiles, on the occasion of the five-year review of the Earth Summit (Rio + 5). A second series of country profiles was released for the 2002 World Summit on Sustainable Development in Johannesburg. This 2002 country profile series provides a comprehensive overview of the status of national-level Agenda XXI implementation (Luxem and Bryld 1997; Shah 2004; UN DESA 2003b; UN DESA 2004a). This series report is available at: http://www.un.org/esa/sustdev/natlinfo/indicators/indisd/indisd-mg2001.pdf.

Toronto, Canada.

*UNEP/MorgueFile.com*

**Box 21: CSD environmental indicators**

| | |
|---|---|
| Climate change | • Emissions of greenhouse gases |
| Ozone layer depletion | • Consumption of ozone-depleting substances |
| Air quality | • Ambient concentrations of air pollutants in urban areas |
| Agricultural land | • Arable and permanent crop land area<br>• Use of fertilizers<br>• Use of agricultural pesticides |
| Desertification | • Land affected by desertification |
| Forests | • Forest area as a per cent of land area<br>• Wood harvesting intensity |
| Urban areas | • Area of formal and informal settlements |
| Oceans and marine | • Algae concentration in coastal waters<br>• Per cent population living in coastal areas |
| Fisheries | • Annual catch by major species |
| Freshwater | • Annual withdrawal of ground- and surface water as a per cent of total available water<br>• BOD in water bodies<br>• Concentration of faecal coliform in freshwater<br>• Per cent population w/ adequate sewage disposal facilities<br>• Per cent population w/ access to safe drinking water |
| Biodiversity | • Area of selected key ecosystems<br>• Protected area as a percentage of total area<br>• Abundance of selected key species |
| Energy and consumption | • Per capita annual energy consumption<br>• Material use intensity |

Source: Adapted from UN DESA 2004a.

*Ongoing work*

The indicators are not final or definitive, but can be adjusted to fit national conditions, priorities, and capabilities. Countries are encouraged to adopt and use this set as a starting point for their national indicator programmes. Wide adoption and use of the core set is meant to help improve information consistency at the international level. Box 21 shows the CSD's list of issues and associated environmental indicators.

**United Nations Environment Programme: GEO Indicators**

Like the CSD's indicator initiative, the United Nations Environment Programme's *Global Environment Outlook* (GEO) project was initiated in response to Agenda XXI's environmental reporting requirements. It also responds to a UNEP Governing Council decision in 1995 that requested the production of a comprehensive global state of the environment report. One of GEO's goals is to promote consensus on identifying the global and regional issues the international community needs to address and on prioritizing environmental problems and action.

UNEP has been reporting on the state of the global environment through the *Global Environment Outlook* (GEO) series of reports since 1997. There are two key elements of GEO: a cooperative, integrated environmental assessment process, and a report series. The former involves a participatory process between UNEP and a global network of collaborating and associated centres. The reports are issued at regular intervals in print and electronic formats. The three global reports published to date—GEO-1 (1997), GEO-2000, and GEO-3 (2002)—have described the state of the world's environment through thematic, qualitative appraisals of key environmental issues and trends, analysis of

**Box 22: GEO Year Book indicators (2003)**

| | |
|---|---|
| Climate change | • $CO_2$ emissions<br>• global average glacier mass balance |
| Ozone layer depletion | • CFC consumption |
| Forests | • global forest cover |
| Oceans and marine | • living marine resources catch |
| Freshwater | • total and per capita water use<br>• population with access to improved sanitation<br>• population with access to improved water supply |
| Biodiversity | • threatened species<br>• protected areas |
| Energy and consumption | • energy use |
| Natural disasters | • number people killed and number affected by natural disasters |

Source: Adapted from UNEP 2004a.

relevant socioeconomic driving forces, and assessment of policy responses in all the world's regions. They also identify emerging issues and look at potential future scenarios. The next comprehensive GEO report (GEO-4) is due in 2007.

Until recently, the GEO reports did not include a standard set of indicators, although they made use of indicators as a reporting tool. In 2003, a new series was launched with the release of a year book, which includes a set of indicators that will be used in the annual publication. This will allow for the tracking of trends in these issues over time. The full comprehensive GEO reports will no longer be published biennially but rather at five-year intervals.

Separate national and regional or sub-regional assessments are also published, as are technical and other background reports. In 2002, UNEP released *North America's Environment: A Thirty-Year State of the Environment and Policy Retrospective*, a data-rich integrated environmental assessment of North America emphasizing the linkages between policy and the environment. Most of the data that underpin the GEO reports are available on the Internet through the GEO Data Portal. Some 400 different variables, as national, sub-regional, regional and global statistics or as geospatial data sets (maps), can be accessed and downloaded (UNEP 2002a; 2002b).

*Conceptual and organizational framework*

GEO analyzes environmental issues using the DPSIR framework and focuses on integrated reporting—that is, revealing the links among socioeconomic, environmental, and policy issues, as well as producing and communicating policy-relevant information on those key interactions. The reports also identify emerging issues and attempt to envision future policy options and priorities, based on current and past experience and using a scenario approach to examine a range of future outcomes related to possible policy decisions taken today (Pinter, Zahedi, and Cressman 2000). In the *GEO Year Book*, UNEP continues to rely on the PSR model, with the conviction that despite the model's drawbacks, key trends in pressure, state, and response dynamics for major environmental issues can still be captured successfully. It notes that, not surprisingly, several of the indicators in the report coincide with those selected for monitoring internationally agreed-upon environmental goals and targets, including those in the Millennium Declaration (Millennium Development Goals—MDGs) and the World Summit on Sustainable Development (WSSD) Plan of Implementation (UN DESA 2004b; UNEP 2004a).

> The GEO Indicators are a set of selected quantitative parameters which reflect headline trends for the major global and regional environmental issues addressed under the GEO reporting process (UNEP 2004, 66).

This cypress bay is a haven for many different species of wildlife. *Dot Paul/UNEP/NRCS*

*Selection process*

GEO is produced through a participatory process in each region of the world, involving stakeholders and experts in disciplines related to environment and development issues, especially policy-makers, regional organizations, and NGOs (Pinter, Zahedi, and Cressman 2000). In keeping with the participatory orientation of the GEO process, the selection of themes and indicators for the GEO year books are based upon a collaborative/comprehensive tracking and stocktaking process established with many partners.

*Products and contents*

The first *GEO Year Book* was released in March 2003 and the second (2004/5) at the beginning of 2005. This new annual series highlights significant environmental events and achievements during the year, with the aim of raising awareness of emerging issues from scientific research and other sources. It includes a selected set of trend indicators (Box 22 shows the indicators used in the 2003 edition), providing a consistent and harmonized oversight of major environmental changes on an annual basis, which makes it easy to track major environmental issues over the years. The GEO indicators are grouped by environmental thematic areas and issues. For each issue, only one or two indicators, or a few at most, are presented. These are considered to be the most suitable and reliable indicators currently available to illustrate the particular issue. The year books include an overview section that looks at the major issues, a section devoted to a special theme, and one that looks at the future; the 2003 edition, for example, contains a short section on key issues for "Small Island Developing States" and includes a feature section focusing on freshwater and one on emerging challenges and new findings. The feature focus of the 2004/5 edition is "Gender, Poverty, and Environment". Definitions of terms used, data sources, and technical notes are provided in an Annex. The indicators are presented at the global, regional and, in a few cases, sub-regional level, based on the regional classification used in the GEO-3 report. All data and documentation were extracted from the GEO Data Portal (UNEP 2002b; UNEP 2004a). The year book can be accessed at: http://www.unep.org/geo/yearbook/103.htm.

*Ongoing work*
Future annual statements will be released at the beginning of every year in between the comprehensive GEO reports.

**Organisation for Economic Co-operation and Development**
The OECD's indicator initiative began in 1991 in response to an OECD Council Recommendation on Environmental Indicators and Information requesting it to "further develop core sets of reliable, readable, measurable and policy-relevant environmental indicators". This advice was reiterated in 1998 with another Recommendation to "further develop and use indicators to measure environmental performance" and again with the OECD's environmental strategy for the first decade of the 21st century, which laid out the goal of measuring progress through indicators and further developing and using indicators and targets to measure environmental progress at the national level (NIRO 2003b). Environmental indicators work at the OECD is conducted as part of its three-year programme, which began in April 1998, to help member countries measure progress towards sustainable development.

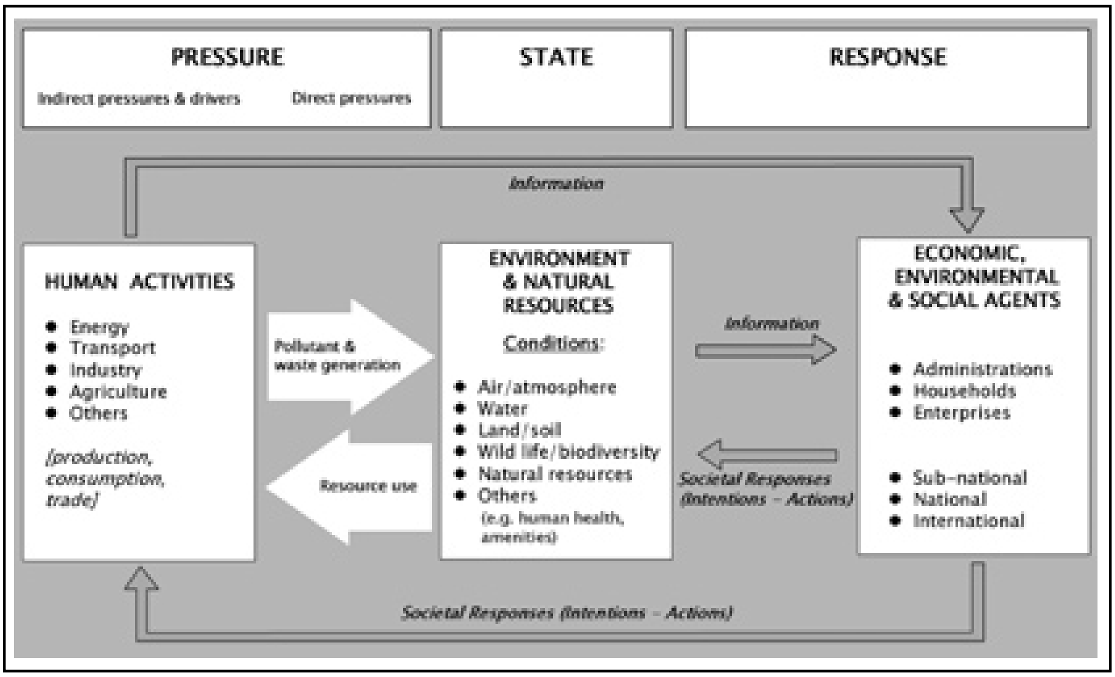
The OECD has developed a number of sets of indicators, using harmonized concepts and definitions that respond to different needs: A core set of environmental indicators measures progress on the environmental front and includes some 50 indicators that reflect the main concerns in OECD countries. Another set of indicators focuses on sectoral trends of environmental significance, their interaction with the environment, and related economic and policy considerations. It is designed to help integrate environmental concerns into sectoral policies, with each set focusing on a specific sector (transport, energy, household consumption, tourism, agriculture). A third set is derived from the OECD work on natural resource and environmental expenditure accounts and focuses on the efficiency and productivity of material resource use. In addition, a small set of key indicators—10 to 13 of them—selected from the core set, is published to help raise public awareness, compare environmental performance across OECD nations, and focus attention on key issues of common concern (Lealess 2002; OECD 2003; OECD 2004b).

Data largely come from the *OECD Environmental Data—Compendium*, which has been published every two years since 1985. These data are the result of a biennial data collection and treatment process that includes a detailed questionnaire sent to member countries. Data are harmonized through the work of the OECD Working Group on Environmental Information and Outlooks (OECD 2004b).

OECD environmental indicators are regularly published and used in the OECD's work in reviewing countries' environmental performance and in monitoring the implementation of the OECD Environmental Strategy.

*Conceptual and organizational framework*
One of the OECD's major contributions to the field of environmental indicators is its efforts to harmonize individual member initiatives by developing a common approach and conceptual frame-

**Figure 29: OECD's PSR framework**




Source: OECD 2003, 21 http://www.oecd.org/dataoecd/7/47/24993546.pdf work. It focuses mainly on indicators to be used in national, international, and global decision making, but is also applicable to the sub-national or ecosystem level. OECD helped to pioneer the use of the PSR model (Figure 29) during the 1980s and early 1990s and its work on this conceptual framework influenced similar activities by a number of countries and international organizations (Linster 1997).

OECD's various sets of indicators were developed with recognition that there is no unique set of indicators, that indicators are only one tool among others, and that they need to be interpreted in context. Another OECD contribution is its work on monitoring progress towards sustainable development by elaborating indicators that measure the decoupling of environmental pressure from economic growth (OEDC 2003; OECD 2004b).

*Selection process*

The development of harmonized international environmental indicators is done in close cooperation with OECD member countries, building on agreement among them to use the PSR model as a common reference framework and to identify indicators using three basic criteria: policy relevance and utility for users, analytical soundness, and measurability. Member countries agree to use the OECD approach at the national level by adapting indicator sets to suit national circumstances and to interpret them in context to acquire their full meaning (OECD 2003).

*Products and contents*

In 2001, the OECD identified a shortlist of environmental indicators, *Key Environmental Indicators,* selected from the OECD core set of environmental indicators and closely related to its other environmental indicators sets. The key indicators are updated every year and the list is available for free. The set consists of ten theme areas, each of which has one main indicator for which data are available for a majority of OECD countries, and has possibly also one or more supplementary "medium term" indicators, representing those that require further development related to basic data availability, underlying concepts, and definitions (Box 23). The indicators are interpreted in the text, with a description of main policy challenges, a comparison of each nation's performance, and historical trends for the OECD as a whole. Related indicators from the core set are listed for reference, pointing users

**Box 23: OECD set of key environmental indicators***

| | |
|---|---|
| Climate change | • **$CO_2$ emission intensities** |
| | • Index of GHG emissions |
| Ozone layer | • **Indices of apparent consumption of ODS** |
| | • One index of apparent consumption of ODS |
| Air quality | • **$SO_x$ and $NO_x$ emission intensities** |
| Waste | • **Municipal waste generation intensities** |
| | • Total waste generation intensities |
| | • Material flows |
| Freshwater (quality) | • **Waste water treatment connection rates** |
| | • Pollution loads to water bodies |
| Freshwater (resources) | • **Intensity of use of water resources** |
| Forests | • **Intensity of use of forest resources** |
| Fish | • **Intensity of use of fish resources** |
| Energy | • **Intensity of energy use** |
| | • Energy efficiency index |
| Biodiversity | • **Threatened species** |
| | • Species and habitat or ecosystem diversity |
| | • Area of key ecosystems |

**Main indicators in bold.*

*Source: Adapted from OECD 2004b.*

**Box 24: OECD environmental indicators**

| | |
|---|---|
| Drivers | • GDP<br>• population growth and density |
| Climate change | • $CO_2$ emission intensities<br>• GHG concentrations |
| Ozone layer depletion | • ozone-depleting substances<br>• stratospheric ozone |
| Air quality | • air emission intensities<br>• urban air quality |
| Waste | • waste generation<br>• waste recycling |
| Agricultural land | • intensity of use of nitrogen and phosphate fertilizers<br>• nitrogen balances<br>• livestock densities<br>• intensity of use of pesticides |
| Forests | • intensity of use of forest resources<br>• forest and wooded land |
| Fisheries | • fish catches and consumption |
| Freshwater | • river quality<br>• waste water treatment<br>• intensity of use of water resources<br>• public water supply and price |
| Biodiversity | • threatened species<br>• protected areas |
| Energy and consumption | • energy intensities<br>• energy mix<br>• energy prices<br>• private consumption<br>• government consumption |
| Transportation | • road traffic and vehicle intensities<br>• road infrastructure densities<br>• road fuel prices and taxes |
| National responses (expenditures) | • pollution abatement and control expenditures<br>• trends in official development assistance as % GNP |

Source: Adapted from OECD 2001.

to more ample and detailed information if desired (Lealess 2002). *Key Environmental Indicators* is available online at: http://www.oecd.org/dataoecd/32/20/31558547.pdf.

A special document combines indicators from the four sets described above to produce a set of environmental indicators. The first *Environmental Indicators: Towards Sustainable Development* was published in 1994, followed by two other editions, in 1998 and 2001 (OECD 2001). The 2001 edition of the OECD Environmental Indicators report is an update of the 1998 edition. It includes indicators selected from the OECD core set, some socioeconomic and sectoral indicators with environmental significance, and others that were endorsed by OECD environment ministers at their meeting in May 2001. There are nine environmental themes in one section, and in another section are six socio-economic themes related to environmental issues, most of which act as pressures. Each thematic sub-section includes a statement about the issue it covers and its importance; an overview of related OECD work; how it fits in the PSR framework; references; and a summary of major trends. It also presents the key indicators. Box 24 gives a list of the indicators in this publication.

*Ongoing work*

The OECD continues to review and improve its programmes and indicators. Its indicator sets are regularly refined to evolve as scientific knowledge, policy concerns, and data availability change and improve. The quality of data, data consistency, and data gaps are of particular concern. The set of key indicators is expected to eventually include issues such as toxic contamination, land and soil resources, and urban environmental quality, for example (OECD 2003). The organization is employing strategies to identify areas in which collaboration is possible to improve overall quality and comparability and to create a methodology guide for data monitoring, collection, and documentation. It is also considering how member countries can exchange information and learn about metadata standards from each other and how to promote the exchange of information with non-members and other international organizations (OECD 2003; EC 2004b).

### *Other initiatives*

*World Resources Institute*

World Resources Institute (WRI), an independent nonprofit organization, is a world leader in generating harmonized environmental data at the global level. Every two years since 1986, it publishes a lengthy and authoritative assessment of the health of global ecosystems. In recent years, WRI's biennial report has been produced in collaboration with the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and The World Bank (Keating 2001). This is a global reporting series, which provides timely statistics and analysis of environmental issues. The front section of each edition highlights a major theme, which is analyzed with data-rich prose. The second section, "Global Conditions and Trends", is consistently presented in each edition. This section is devoted to a broad compilation of standardized national-level environmental and social reference data covering the issues of biodiversity and protected areas; forests and grasslands; coastal, marine, and inland waters; agriculture and food; freshwater; atmosphere and climate; energy and resource use; and safe water and sanitation. The report's foreword is a forum for the collaborating agencies to promote policy recommendations. In collaboration with UNEP, UNDP, and The World Bank, the World Resources Institute was one of the earliest organizations to publish sets of national data for a global perspective on environmental media (Parris 2000; IISD 1997; IISD 2004a). The report does not include a set of graphic indicators.

In 2000, WRI expanded its data provision service to include an online, searchable database called EarthTrends, which includes country profiles, data tables with complete time series data, detailed metadata reporting on research methodologies, and an evaluation of the information's reliability. It also includes feature articles analyzing current environmental trends. The site gathers data from the world's leading statistical agencies and is supported by The World Bank, UNEP, the Netherlands Ministry of Foreign Affairs, the Swedish International Development Agency (SIDA), UNDP, and the Rasmussen Foundation (WRI 2004). Like UNEP's Data Portal, EarthTrends is a valuable source of data for multilateral environmental reporting.

Of WRI's large number and variety of projects geared towards promoting sustainability, a few are involved in developing environmental indicators; they include the Material Flow Analysis project, the Pilot Analysis of Global Ecosystems (PAGE), and a project oriented towards assessing environmental and human water scarcity, freshwater biodiversity, and wetlands goods and services (WRI 2004).

*Worldwatch Institute*

Another major player among initiatives that use indicators to report on the state of the global environment is the Worldwatch Institute. It produces an annual *State of the World* report and a shorter annual report called *Vital Signs* that use indicators to track trends. Issued every year since 1984, the *State of the World* publications report on "progress towards a sustainable society". They each consist of some 8–10 chapters written by staff members, covering the salient environmental issues of the year in data-rich text (Worldwatch Institute 2004).

*Vital Signs* covers "the environmental trends that are shaping our future" through the use of key indicators to track trends in environmental change. These include trends in food production, agricultural yields, energy consumption and production, atmospheric issues, the economy, transportation, communication, health and social issues, and military and governance features. Two pages are devoted to each indicator, with one displaying graphic representations of the indicator and a table of the data, and the other providing interpretation and context. A number of the key indicators are repeated from year to year. The publication contains a second section on special features that is dedicated to tracking new and emerging issues and bringing these to the reader's attention. One of the distinctive characteristics of this report is the inclusion of many driver and response indicators that are usually lacking in many other indicator initiatives. These indicators show trends in issues such as perverse subsidies to activities that harm the environment and the shift to taxing these activities. Other examples of driver indicators include trends in automobile production, meat consumption, and agricultural subsidies. Examples of response indicators include those that track trends in wind-generating capacity and solar-cell production, the market in pollution controls, bicycle production, and biomass energy use.

***Common issues***

A glance at the boxes listing the indicators in each of the reports surveyed above (Boxes 21–24) makes plain the similarity in the choice of issues selected by international agencies involved in creating sets of indicators for environmental reporting at the global level. Box 25 shows the issues or themes addressed by the reports.

***Common indicators***

It follows that there should also be considerable similarity in the environmental indicators that have been developed for the issue areas in all three international initiatives. Table 3 lists the issue areas, with the corresponding indicators that are generic to at least two of the three initiatives described in this chapter.

***Analysis***

UNEP and OECD populate the indicators with data and publish these, but the CSD's list of indicators functions as a "menu" for individual nations, so there is no common data set, and no central agency that collects and reports on the indicators. OECD's issues reflect the concerns of member countries, while those identified by UNEP and the CSD are more inclusive, since they also reflect those of developing nations. The CSD and OECD include population and economic growth as well as development assistance in their sets of indicators, since the CSD's mandate extends to all aspects of sustainability and the OECD measures environmental sustainability in relation to economic growth. The OECD also provides indicators of pollution abatement and control expenditures and official development assistance to show national responses to both national and global environmental and sustainability problems.

Table 3 shows that there are a total of 21 similar or common indicators found in all the international reports, reflecting a much greater correspondence among them than found when comparing the indicators in the four North American reports. In a hierarchy ranging from international to ecosystem-level issues and indicators, it is obvious that the lower the level, the more the indicators focus on characteristics specific to the area and the greater the differences in the issues and indicators selected to portray the regions. Such was the case in the cross-border case studies in Chapter 2 (see Box 19). As also noted about the North American reports, response indicators among the international indicator initiatives are fewer in number, with impact and pressure indicators the most represented.

**Box 25: International environmental issue areas**

- Drivers (GDP, population, consumption)
- Climate change
- Ozone layer
- Air quality
- Waste
- Freshwater
- Coastal and marine ecosystems
- Fisheries
- Forests
- Agricultural land
- Biodiversity
- Protected areas
- Energy and transportation
- Natural disasters
- National responses (expenditures)

Source: Compiled by author from UN DESA 2004a; UNEP 2004a; OECD 2004b; OECD 2001.

**An integration of North American and international indicators**

Table 4 (page 58) compares generic indicators common to North America with those most used in the international reports. It reveals that there is a good deal of overlap between them, with similar indicators for a number of issues. There are gaps, however: indicators for indoor air, toxic substances, land use, coastal and marine ecosystems, grasslands and shrublands, and urban areas are not commonly found in either the North American or international reports. OECD confirms the gaps in a number of these indicators, including pollution from toxic substances (toxic metals, organic compounds, and fibres); population and area exposed to air pollutants; effects of air pollutants on human health and on the environment; and indoor air pollution. As will be seen in Chapter 4, lack of data is often the main reason for these gaps (OECD 2002b).

**Table 3: Indicators common to at least two international initiatives**

| *Issue area* | *Common indicators* |
|---|---|
| Drivers (population, GDP, consumption) | • per capita GDP |
| Climate change | • per capita $CO_2$ emissions<br>• total annual $CO_2$ emissions |
| Ozone layer | • ODS consumption |
| Air quality | • ambient concentrations of $SO_2$ and $NO_2$ |
| Waste | • generation of industrial, hazardous, and radioactive waste, and municipal solid waste (MSW)<br>• waste recycling and reuse |
| Freshwater | • water use as % of annual renewable water<br>• % total population with access to improved sanitation<br>• % population with access to improved water supply |
| Fisheries | • total fish catches |
| Forests | • forest harvests as % annual growth<br>• forest area as % of total land area |
| Agricultural land | • fertilizer use/unit agricultural land area<br>• pesticide use/unit agricultural land area |
| Biodiversity | • # of known mammals, birds, fish, reptiles, amphibians, and vascular plants<br>• threatened species as % of species known |
| Protected areas | • protected area as % of total land area |
| Energy and transportation | • per capita energy use<br>• energy use/GDP |
| National responses (expenditures) | • official development assistance as % GNP |

Source: Compiled by author from UN DESA 2004a; UNEP 2004a; OECD 2004b; OECD 2001.

Issues common to the North American reports but not represented by most international initiatives include acid deposition and wetlands. Although not exclusively North American issues of concern, they are of particular significance to Canada and the United States. Internationally important issues that some of the North American reports surveyed neglect include climate change, fish resources, protected areas, natural disasters, and expenditures. Neither the Heinz report nor the EPA draft report includes indicators of climate change. The ecosystem focus of the former precludes this issue and the EPA chose not to report on greenhouse gas emissions due to the "complexities of this issue" (US EPA 2003, 1–11). Some indicators important for developing countries have less significance in Canada and the United States, such as population with access to improved sanitation and population with access to improved water supply.

The results of this exercise in identifying common indicators among national and international indicator initiatives is confirmed by recent work conducted by Environment Canada during its deliberations on a strategy for environmental indicators and state-of-the-environment reporting in Canada. A background paper notes the need to work on improving the overlap between national and international issues and indicators (NIRO 2003b). Table 5 (page 59) integrates the most commonly used indicators from both the national and the international initiatives as a starting point in compiling a list of candidate indicators for North America.

Based on the lessons learned from this study, the following section examines the challenges in developing multilateral indicators and makes some recommendations for future environmental indicator initiatives for the North American region.

**Table 4: Indicators common to North American and international initiatives**

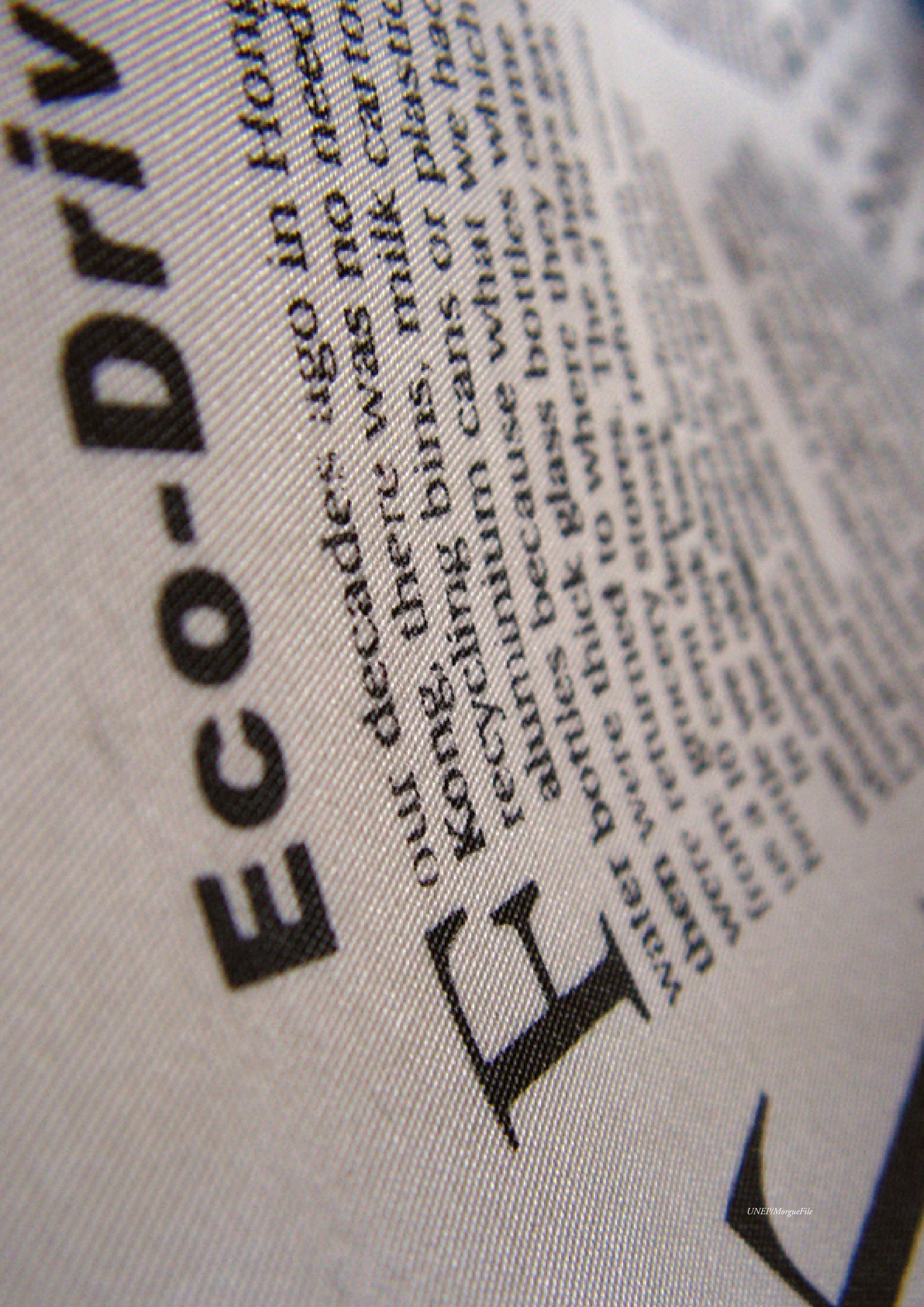
| *Issues* | *Common North American indicators* | *Common international indicators* |
|---|---|---|
| Drivers (population, GDP, consumption) | • % change in population, GDP per capita, and energy use | • per capita GDP |
| Energy and transportation | • trend in gasoline use by motor vehicle | • per capita energy use<br>• energy use/GDP |
| Climate change | | • per capita $CO_2$ emissions<br>• total annual $CO_2$ emissions |
| Ozone layer | • ODS production<br>• $O_3$ levels over North America | • ODS consumption |
| Air quality | • criteria pollutants emissions<br>• concentrations in average annual $PM_{2.5}$ levels<br>• $O_3$ concentrations by region | • ambient concentrations of $SO_2$ and $NO_2$ |
| Acid deposition | • change in wet sulphate deposition<br>• change in wet nitrate deposition | |
| Indoor air | | |
| Toxic substances | | |
| Waste | • municipal solid waste (MSW) management | • generation of industrial, hazardous, and radioactive waste, and municipal solid waste (MSW) recycling and reuse |
| Land use | | |
| Freshwater | • municipal water extraction | • water use as % of annual renewable water<br>• % total population with access to improved sanitation<br>• % population with access to improved water supply |
| Wetlands | • % land area in wetlands | |
| Coastal and marine | | |
| Fisheries | | • total fish catches |
| Forests | • timber harvest<br>• area of forest cover<br>• forest bird populations<br>• area burned in forest wildfires<br>• area of protected forest | • forest harvests as % of annual growth<br>• forest area as % of total land area |
| Agricultural land | • % farmland susceptible to water erosion | • fertilizer use/unit agricultural land area<br>• pesticide use/unit agricultural land area |
| Grasslands and shrublands | | |
| Biodiversity | • # threatened species or % of all species | • # of known mammals, birds, fish, reptiles, amphibians, and vascular plants<br>• threatened species as % of species known |
| Protected areas | | • protected area as % of total land |
| Urban areas | | |
| Natural disasters | | • human loss due to natural disasters |
| National responses (expenditures) | | • total official development assistance as % of GNP |

Source: Compiled by author from OECD 2004b; UN DESA 2004a; UNEP 2004a; EC 2003a; US EPA 2003; NRTEE 2003; Heinz Center 2002; OECD 2001.

**Table 5: Integration of common national and international environmental indicators**

| Issue | Common indicators drawn from all the reports surveyed |
|---|---|
| Drivers (population, GDP, consumption) | • per capita GDP<br>• % change in population, GDP per capita, and energy use |
| Climate change | • per capita $CO_2$ emissions<br>• total annual $CO_2$ emissions |
| Ozone layer | • ODS consumption<br>• ODS production<br>• $O_3$ levels over North America |
| Air quality | • criteria pollutants emissions<br>• ambient concentrations of $SO_2$ and $NO_2$<br>• concentrations in average annual $PM_{2.5}$ levels<br>• $O_3$ concentrations by region |
| Acid deposition | • change in wet sulphate deposition<br>• change in wet nitrate deposition |
| Indoor air | |
| Toxic substances | |
| Waste | • generation of industrial, hazardous, radioactive, and MSW<br>• MSW management (recycling and reuse) |
| Land use | |
| Freshwater | • municipal water extraction<br>• water use as % of annual renewable water<br>• % total population with access to improved sanitation<br>• % population with access to improved water supply |
| Wetlands | • % land area in wetlands |
| Coastal and marine | |
| Fisheries | • total fish catches |
| Forests | • forest harvests as % annual growth<br>• forest area as % of total land area<br>• forest bird populations<br>• area burned in forest wildfires<br>• area of protected forest |
| Agricultural land | • fertilizer use/unit agricultural land area<br>• pesticide use/unit agricultural land area<br>• % farmland susceptible to water erosion |
| Grasslands and shrublands | |
| Biodiversity | • # of known mammals, birds, fish, reptiles, amphibians, and vascular plants<br>• # threatened species or % of all species |
| Protected areas | • protected area as % of total land |
| Urban areas | |
| Energy and transportation | • per capita energy use<br>• energy use/GDP<br>• trend in gasoline use by motor vehicles |
| Natural disasters | • human loss due to natural disasters |
| National responses (expenditures) | • total official development assistance as % GNP |

Source: Compiled by author from OECD 2004b; UN DESA 2004a; UNEP 2004a; EC 2003a; US EPA 2003; NRTEE 2003; Heinz Center 2002; OECD 2001.



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# Chapter 4

# 4 Developing Indicators For North America

The national, bilateral, and international indicator reports highlighted above reveal ample consensus on the usual steps and criteria for the selection and development of indicators, the key role of indicators, the main issues to address, and the basic generic indicators to use. The challenges in developing a set of indicators to present an integrated picture of the status and trends in the North American environment lie mainly in data availability, reconciling the discrepancy in methodologies underlying even similar and common indicators, differences in time period and format and other parameters, and the disparity in the standards and targets used in performance indicators. Other challenges relate to the selection of "ideal" indicators to fill gaps, the appropriate level of aggregation, and the suitable number of indicators to use. This section examines these and other challenges and suggests ways to overcome them.

## Lessons Learned

### *Issue areas*

Chapter Three reveals the similarities between the environmental issues of concern to Canada and the United States, the overlap with the themes presented in global indicator reports, and the existence of a number of gaps. For example, neither the Heinz Center's report nor the EPA draft report includes indicators of climate change. The ecosystem focus of the former precludes this issue and, as pointed out earlier, the EPA chose not to report on greenhouse gas emissions due to the "complexities of this issue" (US EPA 2003, 1–11). Gaps in the issue areas addressed, however, are generally due to lack of data and the difficulty in making links between concerns and environmental causes; both these challenges are addressed below. These difficulties should not preclude identifying critical issues and including them in a state-of-the-environment report along with ideal indicators that may still be in development, as done by NTREE and the Heinz Center. Plentiful data exist for a number of issue areas that are weakly represented in some reports, including urban, transportation, and energy issues. These are particularly pertinent to North America's impact on both the local and global environment.

Of course, as the reports show, the issues addressed by any North American environmental indicators initiative will depend on the vision and goals of the stakeholders involved and on available resources. A vision based on the goal of global environmental sustainability would require that North America measure and reduce its impact on global systems. State-of-the-environment reporting efforts by Canada and the United States should strengthen assessments of their ecological footprint.

### *Frameworks*

The variety of conceptual and organizational frameworks used by the organizations examined above reflect their various mandates, goals, and audiences. There is no standard or ideal framework. The approach with which to develop a set of North American environmental indicators will depend on the organization undertaking the initiative and its needs. Some of the lessons learned from the various frameworks are discussed below.

*Lessons from the PSR approach*

As shown in the previous chapters, despite its drawbacks, the PSR framework and its derivatives continue to be the models of choice for numerous initiatives, including Environment Canada, SOLEC, UNEP, and OECD. When indicators are complemented with text explaining context and providing integrated analysis as done by UNEP in its GEO reports, for example, use of this framework avoids the risk of oversimplification and false cause-and-effect conclusions.

> If governments want to promote sustainable development, they have to make sure that prices and incentives are right. That job requires identifying subsidies, measuring them and assessing their impact (de Moor and Calamai 1997, 2).

By organizing the presentation of indicators using the DPSIR approach (as in Appendix 1: Table 2), this study reveals the dearth of indicators representing both drivers of environmental change and responses to it. This lack is partly because

Early morning shot of a local farm in Colebrook, Ontario Canada. *UNEP/MorgueFile.com*

some initiatives have not yet finalized their sets of indicators, the mandate of others restricts the scope of reporting to pressures, states, and impacts, and one of the goals of effective reporting is to limit the number of indicators to a small set. Worldwatch Institute, which was mentioned but was not part of the detailed study, includes many response indicators in its *State of the World* and *Vital Signs* reports and these make a valuable contribution that could provide model response indicators for other SOE initiatives.

The EPA and Environment Canada reports both include a graph depicting overarching indicators that act as drivers of change in most environmental media. None of the reports, however, isolates drivers specific to each of the issue areas. Examples of such drivers are trends in subsidies to agriculture, fisheries, fossil fuels, water provision, waste collection and disposal, and other perverse subsidies that provide incentives for unsustainable practices.

If governments want to promote sustainable development, they have to make sure that prices and incentives are right. That job requires identifying subsidies, measuring them and assessing their impact (de Moor and Calamai 1997, 2).

There are many types of subsidies, including direct budgetary grants and payments to consumers or producers; tax policies such as credits, exemptions, and other preferential tax treatments; the public provision of goods and services below cost; capital cost subsidies such as preferential loans and debt forgiveness; and policies that create transfers through market mechanisms (de Moor and Calamai 1997). Without acknowledging and measuring drivers such as these subsidies and including them alongside indicators of environmental conditions, decision-makers can easily overlook the connec-

**Box 26: Measuring environmentally harmful subsidies**

The stocktaking of OECD work on subsidies to date has identified five main approaches to measuring them, some of which overlap:

1. Programme aggregation—adding up the budgetary transfers of relevant government programmes; in most cases data are at the national, and not sub-national level.
2. Price-gap—measuring the difference between the world and domestic market prices of the product in question.
3. Producer/consumer support estimate—measuring the budgetary transfers and price gaps under relevant government programmes affecting production and consumption alike.
4. Resource rent—measuring the resource rent foregone for natural resources.
5. Marginal social cost—measuring the difference between the price actually charged and the marginal social cost.

Source: Potier 2002, 192.

tions between environmental decline and policies that affect the market. Canada and the United States are making progress in addressing these issues, which could be illustrated through the use of indicators.

The OECD is working on developing methods to measure how much various forms of government support, including subsidies, depart from a level playing field (de Moor and Calamai 1997). It has identified a number of approaches to measure environmentally harmful subsidies (Box 26). Developing robust indicators for this kind of driver of environmental change is still a challenge, however, due to a wide range of measurement problems, including differences in definitions of "subsidies", "support", and "transfers" and in methodological approaches; patchy and incomplete data; and non-comparable subsidy estimates across various sectors (OECD 2002a). To remedy the need for greater consistency and international consensus, international efforts are underway to develop a more common reporting framework to enable the creation of aggregate indicators that would be useful for monitoring and that would help standardize data collection and reporting (Steenblik 2002).

Assessing trends in responses is also important because, if responses can be linked to improved conditions (states) and diminishing impacts, the information provides incentives to decision-makers to strengthen and increase support for responses to environmental ills.

Response indicators should include those that address issues that have an impact on global environmental quality, such as population growth and poverty, even though the issues may not appear critical in developed regions such as North America. Population growth continues to be an important indicator in North America: the United States is one of the three most populous countries in the world (after China and India) and is expected to still be among the top three in 2050. When combined with a pattern of high consumption and energy use, large populations are a potent driver of environmental change. The funding of national and international population programmes will help the world attain an early demographic transition to a stable or smaller population (Speth 2004), so the contribution Canada and the United States make to such programmes could be included in a set of North American indicators.

A street in New York City, New York USA.

*UNEP/MorgueFile.com*

**Box 27: Examples of response indicators**

| Issue | Examples of response indicators |
|---|---|
| ***Population growth*** | Indicators that measure incentives for population control, such as the percentage of GNP spent on funding national and international population programmes. |
| ***Poverty*** | Indicators that measure poverty alleviation, such as the percentage of GNP that goes towards funding Official Development Assistance (ODA). Others could include the contribution to the Global Environmental Facility and other environmentally targeted development aid; exports or transfers of cost-effective and environmentally sound technologies to developing countries; indicators of fair trade, debt relief, opening of markets to developing countries; and so forth. |
| ***Market failures*** | Indicators to measure progress in adopting ecological fiscal reform to correct the market, such as full-cost pricing (making prices reflect the full environmental costs), the elimination of perverse subsidies, and tax incentives. Indicators could measure investments and subsidy programmes in environmentally benign technologies and alternative energy, such as green-building incentives. They could be developed to measure tradable emission permits; pollution taxes (carbon, sulphur, and other emissions, and taxes on landfilling, incineration, and municipal garbage collection); user fees; congestion taxes; taxes on motor fuel, electricity, and water; product charges levied on pesticides, chlorinated solvents, batteries, beverage containers, plastic bags, disposable cameras and razors, industrial packaging; and so forth. Other indicators could relate to tax exemptions or credits for environmentally-friendly activities, such as purchasing a hybrid car. A possible indicator is revenue from environmentally-related taxes as a percentage of GDP. |
| ***Consumption*** | Response indicators could measure sustainable consumption. Indicators related to green-labeling product certification could include the number of acres or percentage of forests certified as sustainably managed (under the Forest Stewardship Council, for example); the number of fisheries certified as sustainable (under the Marine Stewardship Council's programme); the numbers or percentage of cropland area certified as organic; the percentage of sales in fair trade, organic, and shade-grown coffee and cocoa and other goods, such as certified organic cotton; the number of tourism companies and hotels (and other service providers) certified as sustainable; and certified sustainable investments in environmentally and socially responsible stocks. Other possible indicators that show responses to consumption include the number of programmes for recycling consumer durables; the percentage of government purchasing budgets devoted to green goods and services; indicators of dematerialization and intensity of use (measuring consumption against trends in GDP); trends in composting (number of composting facilities); percentage of waste water re-used as "grey water" for industrial processes; the number of companies issuing "sustainability reports" recommended by the GRI; and so on. |
| ***Ecosystem degradation*** | Indicators that measure actions related to ecosystem conservation and restoration, ("freeing rivers, restoring wetlands, replanting forests, recharging groundwaters, regenerating wastelands, reclaiming urban brownfields, reintroducing species, removing invasives" (Speth 2004, 200). Examples of indicators include the number of acres in conservation easements and land trusts; number of acres of erodable cropland retired; acres under soil conservation practices and Integrated Pest Management (IPM); and others. |
| ***Energy use*** | Indicators to measure responses to energy use and transportation issues include trends in wind, solar, and geothermal energy (such as the percentage of electricity supply; the annual rate of growth; or trends in generating capacity); trends in the factory price for photovoltaic modules; trends in solar cell shipments; sales of compact fluorescent bulbs; sales of hybrid electric vehicles; sales of bicycles; miles of bicycle routes; trends in companies and corporations adopting GHG emission reduction commitments; and others. |
| ***Environmental awareness*** | Indicators that show progress in delivering environmental education. For example: the number of advanced degrees in environmental science, engineering, conservation, natural resources management, and so on; the number of curricula, materials, and training opportunities that teach the principles of sustainable development; the number of school systems that have adopted K–12 voluntary standards for learning about sustainable development similar to standards developed under the US National Goals 2000 initiative; and others. |

Source: Compiled by author from PCSD 1996; Pembina Institute 2004; Speth 2004; Worldwatch Institute 2004.

Likewise, their contributions of Official Development Assistance (ODA) indicate a response to world poverty. In their lists of indicators, the OECD and the CSD include an indicator of the share of funding for ODA in recognition of the UN target of 0.7 per cent of gross national product (GNP) agreed to by the international community in 1970 (ICPD 1994). This is an important indicator because a large proportion of foreign aid is meant to help alleviate environmental problems in the developing world (Boyd 2001). The inclusion of such indicators supports international commitments to the Millennium Development Goals, which focus on reducing poverty, hunger, inequality, ill-health, and other manifestations of poverty, as well as on achieving environmental sustainability. These goals are mutually reinforcing and have positive repercussions on the global environment as well as on local conditions in developing countries.

SOE programmes that publish response indicators are not only demonstrating the commitment of their governments and society to resolving environmental ills, but are also providing information to decision-makers and the public about the kinds of actions that can be taken to address environmental problems. Box 27 lists some examples of response indicators.

Finally, the key reason for including drivers and responses in a set of environmental indicators is to emphasize the relationship between environmental conditions and human activity. Reporting with state or condition indicators alone can divorce environmental quality from human responsibility. Pressure indicators are also important in this regard since they are usually direct stresses from human activities.

*Lessons from the natural capital framework*

Both Canada and the United States have been advised to broaden their systems of national accounts at the federal level. NRTEE's report recommends that the Canadian government expand its System of National Accounts to allow measurement of the nation's overall base of capital assets. The US National Academy of Sciences panel in the United States concluded that "extending the US national income and product accounts (NIPA) to include assets and production activities associated with natural resources and the environment is an important goal" and that "a set of comprehensive non-market economic accounts is a high priority for the nation" (Nordhaus and Kokkelenberg 1999: 2–3). Indicators showing physical flows of natural resources can provide useful signs related to consumption, one of the abiding drivers of environmental change in North America; a bilateral environmental indicator initiative should include them. Another aspect of this framework is the effectiveness of assigning economic value to environmental goods and services and to the impacts upon them, which helps to link environmental and economic data.

*Lessons from the biogeophysical approach*

Indicators that measure biogeophysical conditions and trends in the environment form the core of most environmental indicator and SOE projects. Biogeophysical performance indicators focus on scientific thresholds. If based on sound science, indicator programmes using this approach can claim to be unbiased and non-partisan because they make no connection between environmental change and policy. The Heinz Center's rationale for this approach is that the indicators can serve as a catalyst for debate about US environmental policy.

One of the drawbacks of using thresholds to measure environmental quality is that current science is not yet able to identify them with much precision (NTREE 2003). Indicators of ecosystem capacity and those that indicate a threshold beyond which damage may be irreversible are difficult to develop since they require information about ecosystem functioning that is still limited. In addition, thresholds for the same type of ecosystem may differ between regions. The relationship between the complex interactions among ecosystem elements and the effect on ecosystem capacity is often unclear. Identifying ideal capacity indicators could highlight the need for more support for research into ecosystem functioning.

*Linkages*

The matter of developing a framework that will help indicators accurately show the links among drivers, pressures, states, impacts, and responses remains a hurdle. The relative absence of indicators for the issues of human environmental health and natural disasters can be explained by the fact that the links between human health and the environment and natural disasters and human agency are still difficult to establish and portray with reliability. The costs to human health and ecosystem services, such as the cost of health care for those suffering from the impacts of air pollution and such as costs related to damage to forests, lakes, crops, and buildings caused by acid rain, are all difficult to measure because the impacts are the results of more than one pressure. More work is required to develop impact indicators that measure the human health consequences of environmental change and more generally, to develop a framework that helps make the connections between the elements of the DPSIR model.

In addition to the methodological difficulties to explain or establish links between economic and environmental processes expressed in different space and time scales, there are other elements of inter-sectoral characteristics that also lack clear linkages: for example, different policies—urban, environmental, agricultural, communications, and so forth—have synergic effects that are difficult to explain through indicators.

A way of showing links between pressures and responses is to compare closely-related activities in the same sector, such as timber-harvesting rates and regeneration and replanting rates. Another example is showing the use of non-renewables relative to investments in a renewable substitute, such as oil extraction versus tree planting for wood alcohol (Speth 2004). And as mentioned above, assigning a monetary value to the environment helps to link the environment and the economy.

The OECD has developed "intensity" indicators that are useful to linking indicators that help show the decoupling of energy use and economic growth as a sign of progress. Developing internationally comparable intensity or energy efficiency indicators is made difficult, however, by the structural, behavioural, and economic differences among countries. As well, each country has its own measures, definitions, currencies, income accounting, and monitoring techniques (EIA 1995). Canada and the United States have similar-enough economies, however, that some types of intensity indicators could feasibly be harmonized to give a bi-national picture.

While more linking indicators and frameworks that help recognize links are being developed, indicator reports must continue to rely on interpretation provided by accompanying text. UNEP's integrated assessment method used in the GEO series, for example, is an effective way of linking environmental change to policy decisions.

**Box 28: Indicators for decision-makers**

1. Performance indicators with policy targets or standards that clearly show where policies and regulations need to be improved or enforced.
2. Comparative indicators or indices that show progress relative to other nations.
3. Highly aggregated indices that give visual snapshots of performance.

Source: Compiled by author.

> Indicators prove valuable only if they are publicized and used by citizens' groups, the media, government, and development agencies (Brown, Flavin, and Postel 1991, 130).

### *Informing policy*

Perhaps the most challenging task in developing and using environmental indicators is to ensure they enter the policy cycle and influence decisions. In a recent survey of a number of indicator projects in North America, the author relates that according to one of her interviewees, a recent national indicator report "... did not garner any perceptible notice from the policy-makers for whom it was intended" (Pidot 2003, 15). Environmental problems need long-term investments and politicians are often focussed on their own short political terms. Without political will, environmental budgets remain small. Financial constraints can curtail monitoring and data collection and so affect inputs to indicator and SOE programmes (Segnestam 2002).

In addition to improving the development and use of driver and response indicators, using indicators that show linkages, and including assessment in the text, as underscored above, Chapter 1 suggested the use of performance and comparative indicators to get the attention of policy-makers and spur the will to act (Box 28).

#### *Policy targets, guidelines, and standards*

The national indicator reports surveyed use relatively few indicators that measure progress against international policy targets. More commonly, they use parameters related to national standards or guidelines that gauge progress against thresholds for environmental and human health. Targets, guidelines, and standards as well as the level of enforcement vary among countries, however. Canada and the United States are working together at several levels to improve the comparability of some of their standards and guidelines, especially with respect to water and air standards and especially in border regions.

National criteria for maximum levels of drinking water contaminants are comparable in Canada and the United States, with standards and norms varying among states and provinces. Canada's national objectives are provided as guidelines, however, while US standards are legally enforceable (EC 2003b). Similarly, criteria for air quality in the two countries are comparable both in the concentration levels and in the goal of providing adequate health protection. The Canadian objectives (National Ambient Air Quality Objectives—NAAQOs), although more stringent in many cases, are non-binding: they have no attainment plans or schedules, and there is no reporting mechanism to determine the extent of implementation (CEC 2004b). In 1998, standards similar to those in the United States were set for particulates and ozone, to be achieved by 2010. The US air standards for six criteria pollutants are defined by the National Ambient Air Quality Standards or NAAQS. They are legally enforceable (OECD 2004a). Such are the difficulties in comparing and contrasting air quality standards, regulations, and enforcement among the three countries, that the Commission for Environmental Cooperation refrains from attempting to do so, noting that "components of these systems are not always directly comparable" (CEC 2004b, 1).

The CEC is committed to establishing a process for developing greater compatibility of environmental technical regulations and to improving the quality, comparability, and accessibility of environmental information across North America.

Unless national policy targets are comparable for countries in a multilateral reporting initiative, the ideal policy-oriented performance indicators are those that use targets set by multilateral and international agreements or other international targets and recommended standards. For example, the impacts of air pollution can be gauged by reporting on the number of days per year that the WHO standards are exceeded. Indicators include the average annual measured concentrations for sulphur dioxide, nitrogen oxide, carbon monoxide, ozone, particulates, and lead.

Within North America, some efforts to align standards, such as regulations for vehicles and fuels, are proceeding apace: increasingly stringent emission standards for motor vehicles have been adopted, for example, and by 2010 Canadian national standards on $NO_x$ and VOCs will be aligned with US standards (OECD 2004a).

When reporting on issues for which standards are incongruous, bilateral and multilateral indicator reporting initiatives may need to portray performance indicators for each nation separately, showing each one's success in achieving its own targets or adhering to national standards. Finally, when performance indicators based on national or state and provincial standards and guidelines are too different, reporting on the bilateral or multilateral scale may require indicators that are focussed on absolute values.

> Indicators that are internationally agreed upon will provide an opportunity for comparisons of environmental performance between countries (Brunvol 1997, 2).

<u>*Comparative indicators*</u>

Policy-makers can be alerted to environmental change and prompted to act to reverse unsustainable practices through exposure to SOE programmes that compare performance either against the status of the issue at a previous date, or to the progress made by other nations. As underscored in Chapter 1, this could be achieved by providing indices with clear visual clues to the state of progress, such as meters and happy/sad faces, and by using comparative indices. Despite the difficulties in developing composite indices, these can be more useful for cross-country comparison than individual indicators. Using relative ranking rather than absolute score is a means to stimulate change, and this method should not be eschewed by a reporting programme because of the challenges in devising fair and unbiased ranking schemes. None of the reports surveyed, except the OECD's, included ranking or comparative indicators.

By way of example, two studies have used comparative indicators to assess Canada's performance against that of other OECD countries. A 2001 survey ranks Canada's environmental record against 28 other OECD countries for 25 environmental indicators (Boyd 2001). In 2004, the Conference Board of Canada extended its analysis of Canada's socioeconomic performance to the environment in its flagship publication *Performance and Potential*, benchmarking Canada against the best countries in the OECD. Its classification scheme awards "gold", "silver", or "bronze" levels to individual indicators according to whether the outcome is in the top third, middle third, or bottom third of the range of performance for 24 OECD countries (Conference Board of Canada 2004).

<u>*Highly aggregated indices*</u>

The issue of developing and using one index of environmental quality as a single, easy-to-understand measure of national environmental performance, of the performance of any one issue (such as water or air quality), or on the integrity of an ecosystem is a controversial one . Those involved in developing NRTEE's indicators, for example, agreed not to support the use of an index where the score is based on "the aggregation of differently weighted indicators based on different units" (NRTEE 2003, 48).

On the other hand, as noted earlier, easy-to-understand indices can attract the attention of policy-makers.

### *Lack of comparability*

The issue of incompatible standards illustrates one of the most challenging aspects of developing indicators to portray a region. To be meaningful for decision-makers and to allow for performance evaluation and international comparison, it is essential to have coherence or comparability among countries through harmonization (OECD 2003).

The European Environment Agency sums up the common goal of multilateral indicator initiatives: "The overriding objective would be to develop as far as possible a common set supported by a shared system of relevant environmental data information in which all interested parties would co-operate and play a role" (EEA 2003, 10).

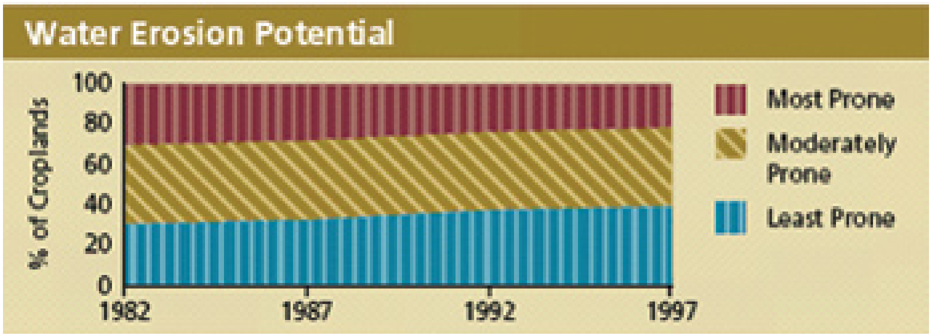
Although many Canadian and US indicators highlighted in this survey appear similar, there are varying degrees of differences in definitions and methodologies, making the standardization of environmental variables across the countries very difficult. The Georgia Basin–Puget Sound indicator project provides a good example of the types of challenges faced by two countries attempting to report on the environmental state of a shared ecosystem: solid waste is defined differently in each jurisdiction and monitoring techniques and methods of data analysis for inhalable particles differ somewhat between them. "The British Columbia $PM_{10}$ indicator measures the percentage of monitored communities in which $PM_{10}$ levels exceed 25 µg/m$^3$ more than 5 per cent of the time annually, or 18 days per year. The Washington State $PM_{10}$ indicator for the Puget Sound region measures the number of days $PM_{10}$ concentrations at sample stations in monitored communities fall into ranges of 0–24 µg/ m$^3$, 25–49 µg/ m$^3$, 50–74 µg/ m$^3$, and 75 µg/ m$^3$ and over" (GBPSEI 2002, 5, 8).

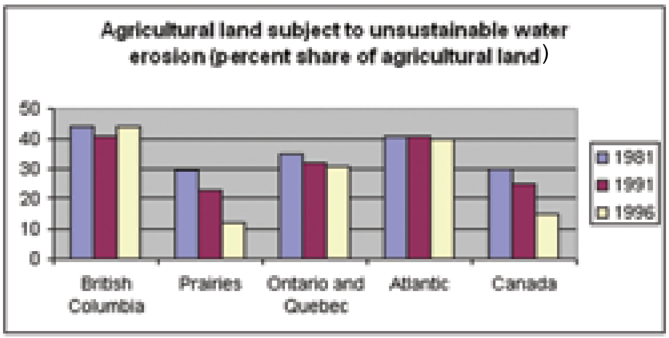
Even among the agencies that have achieved some success in harmonizing data across nations, users need to be aware of the caveats provided in technical notes that explain remaining disparities. For example, the OECD's data for the concentration of particulates reflects different measurement methods for Canada from those for the United States and different definitions of the size of the particulates (OECD 2002b). Canada's National Indicators and Reporting Office (NIRO) suggests that standardizing the steps in air quality monitoring and reporting would ensure that national and international data are the same (NIRO 2003b).

Some more examples from the indicator projects surveyed above serve to illustrate the challenge related to the lack of comparability. The conservation status of species is an important indicator for assessing biodiversity. Canada's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the status of wildlife species whose future may be in doubt and determines the status designation. COSEWIC assesses species using a standardized process adapted from the World Conservation Union (IUCN) criteria and classifies

A ferryboat plying Puget Sound in the late afternoon. *Mary Hollinger/UNEP/NOAA*

**Figure 30: Water erosion indicators for Canada and the US**




Source: US EPA 2003, 100; Compiled by author from Shelton and others 2000 http://www.ec.gc.ca/soer-ree/English/Indicator_series/Excel/agri3.xls.

species into seven categories: Extinct, Extirpated, Endangered, Threatened, Special Concern, Not at Risk, and Data Deficient (Government of Canada 2004). Environment Canada's Environmental Signals report uses a biodiversity indicator that shows the numbers of endangered and threatened species, subspecies, and populations according to these COSEWIC designations. In 2000, the Canadian Endangered Species Conservation Council (CESCC) published a report that provides a more general status assessment of species in Canada that is not meant to replace the in-depth and targeted COSEWIC evaluations or provincial and territorial equivalents. It uses somewhat different categories, classifying species as one of Extirpated/Extinct; At Risk; May Be At Risk; Sensitive; Secure; Undetermined; or Not Assessed, Exotic, or Accidental (CESCC 2000).

In the United States, formal at-risk species status reviews are conducted through distinct state and/or federal administrative processes. The US indicator reports (US EPA and the Heinz Center) use a biodiversity indicator for threatened species based on a scheme developed by NatureServe, which uses five categories: Critically Imperiled; Imperiled; Vulnerable to Extirpation or Extinction; Apparently Secure; and Demonstrably Widespread, Abundant, and Secure. NatureServe represents an international network of biological inventories—known as natural heritage programmes or conservation data centres—operating in all 50 US states, Canada, Latin America, and the Caribbean. The system uses standard criteria and rank definitions so that conservation status ranks are comparable across organism types and political boundaries. But Natural Heritage lists of vulnerable species and official lists of endangered or threatened species have different criteria, evidence requirements, purposes, and taxonomic coverage. For these reasons, they normally do not coincide completely with the official designation of "rare and endangered" species (US EPA 2003). The bilateral indicator for assessing the conservation status of species in the combined Georgia Basin–Puget Sound region was made possible because of NatureServe's standardized method (see Figure 27 in Chapter 2).

In another example, both countries report on water erosion but express the parameters using different methods (Figure 30). The US indicator above in Figure 30 shows the percentage of cropland falling in three categories of water erosion potential: most prone, moderately prone, and least prone. Canada, on the other hand, expresses the risk of water erosion in five classes only, the lowest of which (tolerable) is considered sustainable since it is offset by sufficient soil building. The indicator (below) shows the per cent of land by region that is subject to the other four classes of water erosion (Shelton 2000; EC 2003a). Both Canada and the United States use parameters related to the universal soil loss equation (USLE) to develop these water erosion indicators. It is thus feasible that an indicator could be devised to use data from both countries using the same methodology and expressing the results in a comparable way.

Despite the differences between the two countries in the way they report on these two issues, the two examples above show that internationally-accepted methodologies exist. Other examples include the protocols and statistical treatments for measuring mean annual $O_3$ level over each country, and guidelines for reporting to the United Nations

**Box 29: CSD's methodology sheets**

1. Indicator
(a) Name
(b) Brief Definition
(c) Unit of Measurement: %.
(d) Placement in the CSD Indicator Set

2. Policy Relevance
(a) Purpose
(b) Relevance to Sustainable/Unsustainable Development (theme/sub-theme)
(c) International Conventions and Agreements
(d) International Targets/Recommended Standards

3. Methodological Description
(a) Underlying Definitions and Concepts
(b) Measurement Methods
(c) Limitations of the Indicator
(d) Status of the Methodology
(e) Alternative Definitions/Indicators

4. Assessment of Data
(a) Data Needed to Compile the Indicator
(b) National and International Data Availability and Sources
(c) Data References

5. Agencies Involved in the Development of the Indicator
(a) Lead Agency
(b) Other Contributing Organizations

6. References
(a) Readings
(b) Internet sites

Source: Adapted from UN DESA 2001.

Apart from indicator work conducted by the Commission for Sustainable Development, the OECD, and UNEP, described in Chapter 3, a number of other international indicator initiatives provide guidelines for using standardized indicators. The United Nation's Habitat programme has developed an indicators system for reporting on urban issues. Its *Urban Indicators Tool Kit* provides a quantitative, comparative base for assessing the condition of the world's cities and for measuring progress towards achieving urban objectives (UN Habitat 2003). The World Health Organization's report *Environmental Health Indicators: Framework and Methodologies* establishes a set of indicators for monitoring trends in environment and health (Briggs 1999). Another WHO report provides lists of potential indicators for children's environmental health (see Briggs 2003). As mentioned before, the Commission for Environmental Cooperation coordinated North American efforts to select and publish a core set of children's environmental health indicators (CEC 2006). Both countries report on the sustainability of their forests using indicators established by the Montreal Process (See CCFM 2000 and USDA 2004)[10].

Protocols and guidelines are often drawn up by multilateral indicator initiatives to ensure a degree of comparability among the nations involved; they frequently stipulate the use of internationally accepted methods and provide guidelines for how to express results in a comparable manner. The Commission for Sustainable Development's very useful system of methodology sheets is an example (Box 29) (UN DESA 2001a; UN DESA 2001b).

Satellite remote sensing is a scientific method of reporting on environmental conditions that overcomes the problem of comparability across nations. It is a promising way to provide overall, integrated views of the extent of ecosystems and certain aspects of their condition even when they cross political borders. Another advantage is that photos are excellent visual tools. However, they are often only available at the appropriate scale for one time period. In 2005, UNEP released *One Planet Many People: Atlas of Our Changing Environment*, which uses paired images as an effective tool to portray environmental change.

### *Spatial and temporal scales*

<u>*Spatial scale*</u>

Information needs vary at local, regional, and global levels. Indicators developed for local-level issues or to portray properties of a specific ecosystem may not be useful for another spatial scale or lend themselves to aggregation for a higher spatial level. Deciding on the trade-off between the simplicity of aggregation and the loss of detail it entails is one of the challenges of developing national and global level indicators. Different indicators may be needed for each scale (CSIRO 1999; UNESCO 2003).

Most indicators are developed for use at the national level. Finding meaningful indicators to represent conditions within the various sub-regions and ecosystems of a country is a challenge. This is especially the case with large countries with high levels of heterogeneity such as Canada and the United States (Gallopín 1997). Air and water quality indicators are particularly difficult to develop at higher levels of synthesis or aggregation since international and national air- and watersheds do not exist and political boundaries usually define both data collec-

[10]Canada's framework is 80 per cent compatible with the Montreal Process (CCFM 2000).

tion and policy decisions (Segnestam 2002; NIRO 2003b). Developing indicators that overcome the difficulties inherent in portraying different territorial (or water-based) units—ecosystems, watersheds, landscapes, and so on—using socioeconomic data that are organized by administrative units remains a hurdle. Furthermore, many ecological indicators only apply to a specific area or ecosystem or to a particular species or population and so cannot serve as nationwide indicators (CGER 2000).

International SOE reporting initiatives, such as those undertaken by OECD, UNEP, and WRI and partners, depend on national-level indicators and data provided by contributing countries. Country-, region-, and ecosystem-specific indicators often accompany international indicators sets (MAP 1998). Since country-specific conditions are seldom comparable, international and regional comparisons are usually accompanied by interpretation that explains the ecological, geographical, social, economic, and institutional contexts.

This survey illustrates some of these challenges: as yet, there is an unexplored opportunity to report coherently on many different aspects of uniform territorial spaces that traverse political boundaries, in part because of the different pressures human activity exerts on those places (population pressures, for example) on each side of the border.

*Temporal scale*

Including indicators for emerging environmental issues is a way to influence decisions and help prompt action. By the time environmental change is confirmed by trend indicators, they are no longer useful in designing preventive policies. On the other hand, indicators with historical data sets allow the tracking of trends over relatively long periods of time. This supports the measurement of environmental change and enables tracking the success of earlier policy measures.

The other challenge related to the temporal scale of indicators concerns the difficulty in matching data collected during different time periods. Table 2, which provides the dates of the time series for each indicator, is testimony to this fact. OECD and UNEP note the great variety in consistency and completeness of time series data for issues and nations, which hampers a systematic and meaningful presentation of trends over longer periods and makes comparison problematic (UNEP 1999; OECD 2003).

> The time scale of an indicator also affects the usefulness and interpretation of indicators (Segnestam 2002, 21).

### *Numbers and sets of indicators*

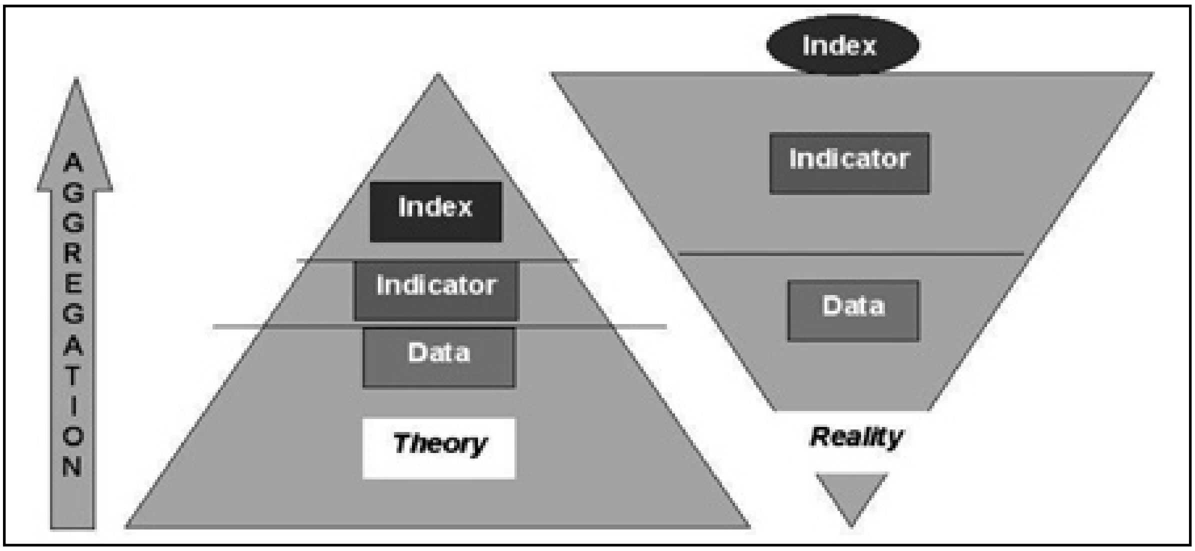
There is a great deal of consensus in the literature that the number of indicators should be kept to a minimum. The Heinz Center had some difficulty in reducing the number of indicators to a minimum. The aim was to be succinct so that the report would actually be read and absorbed by policymakers (Pidot 2003). Following recommendations received during review, the CSD shortened its first list of indicators to a smaller, core set from which individual users can select those that best fit their needs. The solution for the creators of the State of the Great Lakes reports was to try to develop indicators for all important issues and to select from the list a limited number to be included in products tailored for particular audiences (Pidot 2003). Similarly, the OECD developed a suite of indicator lists adapted to different uses. The two Canadian reports contained far fewer numbers of indicators than the two US reports highlighted in this study, favouring a concise approach oriented to policy makers. The list of indicators in UNEP's first yearly report is also limited. Sometimes, the limited number of indicators was not a choice. NRTEE focussed on only six indicators because these could be developed in the short term, and the Georgia Basin–Puget Sound Environmental Indicators group kept its initial list of indicators short due to a limited budget and staff, and plans on increasing the number in the next edition. Most of the initiatives included a select few headline or key indicators in a summary section. In short, it appears that it is considered important to either keep indicator sets short, or to at least highlight key indicators.

> The number of environmental indicators represents a critical issue. The inherent purpose of indicators dictates that the number should be limited (Rump 1996, 75).

### *Data limitations*

All the initiatives surveyed (as well as the literature examined) noted the lack of available data to support indicators and the wide variation in the availability of data. Of the 103 indicators in the Heinz report, full or partial data are provided for 58 (or

**Figure 31: The information pyramid**




Source: Singh, Moldan, and Loveland 2002, 18 http://na.unep.net/publications/newtools.pdf

56 per cent). Forty-five indicators (or 44 per cent) do not include data, either because of the lack of available data for national reporting or because the indicator itself needs further development (Heinz Center 2003). Seventy per cent of the indicators in the EPA's Draft Report on the Environment suffered from insufficient data (US GAO 2004).

SOLEC developed monitoring programmes to fill data gaps, but often lacked the budget to create data sets for all indicators of interest (Pidot 2003).

A sobering and recurring theme throughout many of these reports is the lack of suitable data to quantify important aspects of the state of the environment in ways that are comparable across the geographic extent and time-horizon of the report (Parris 2000).

Canada's National Round Table on the Environment and the Economy (NRTEE) and the EPA both noted two major data problems: the lack of comparable data across each country, limiting the ability to provide a national snapshot, and gaps in spatial and time-series data (NRTEE 2003; US EPA 2003). In theory, indicators and indices should be informed by a broad base of reliable primary data, as in the pyramid on the left in Figure 31; in reality, the information pyramid is upside down (Singh, Moldan, and Loveland 2002).

As noted in Chapter 3, there are few indicators for indoor air, toxic substances, land use, coastal and marine ecosystems, grasslands and shrublands, and urban areas in both the North American and international reports. The North American initiatives are weak in reporting on fish resources, protected areas, natural disasters, and expenditures. Data limitations contribute to the lack of adequate indicators for these issues.

The temptation is to use indicators for which data are readily available, but the literature notes the importance of not narrowing the options when developing indicator sets (Gallopín 1997). The Heinz Center's initiative in defining ideal indicators provides a model of how to stimulate efforts to gather needed data. Not only are data lacking, but frequently, available data are not suitable for populating indicators because of variable quality. Data timeliness also affects the success of indicators. By the time indicators are released, even the most current environmental data are often out of date by several years, limiting the effectiveness of their impact on policy (OECD 2003).

UNEP notes this lack of high-quality, comprehensive, and timely data on the environment, especially in the areas of freshwater quality, marine pollution, waste generation and management, and land degradation. These gaps limit the ability to accurately assess the extent of problems associated with these issues (UNEP 2004a). At the North American level, the issues for which the amount and quality of data are lacking include coastal and marine ecosystems; grasslands and shrublands; indoor air quality; numbers of species; invasive species; wetlands; and urban areas.

The comparability and compatibility of data across nations is another important issue. As noted elsewhere, without data that refer to the same definition, standards, and dates, aggregation to regional and global levels is very difficult (UNEP 1999).

Both Canada and the United States are attempting to address issues related to data acquisition, compatibility, and timeliness within their own borders, tapping solutions now available due to advances in digital technologies. In response to EPA's outmoded data management systems that relied on databases that were generally not technically compatible, the United States initiated the National Environmental Information Exchange Network to transform the way data are exchanged among the EPA, states, and other partners. The aim is to convert historical system-specific data flows to network flows using the Internet and standardized data formats, to secure real-time access and to allow the electronic collection and storage of reliable and accurate information (Exchange Network 2004; Network Blueprint Team 2000; US GAO 2004). In addition, the United States is working on the National Ecological Observatory Network (NEON). It will be an observation system based on an integrated, continent-wide cyber-infrastructure to enable ecological forecasting and provide "nationally networked research, communication, and informatics infrastructure for collaborative, comprehensive and interdisciplinary measurements and experiments on ecological systems" (NEON 2004).

Another effort to standardize environmental information is the Global Earth Observation System of Systems, or GEOSS. This is a ten-year international cooperative initiative to enable projects that endeavor to monitor the land, sea, and air around the world to communicate with one another so as to combine and widely disseminate the information (GAO 2004). In partnership with other nations, the United States will work towards the goal of establishing this international, comprehensive, coordinated, and sustained system to observe the Earth using and making compatible existing and new hardware (US EPA 2004).

In 2000, Canada began work on establishing the Canadian Information System for the Environment (CISE), which is intended to be a better approach to collecting and using environmental information. The goal is to develop an integrated, strategic environmental information system, linked to economic and human health information systems, that would support a national set of sustainable development and national environmental indicators and provide comprehensive, continuous, and credible information on the state of the environment. It is envisioned that CISE would provide a clearinghouse of environmental standards, indicators, policy targets, and data sets, using new Internet technologies to link databases held by different organizations through a distributed database structure and agreed-to standards (CISE 2004; NIRO 2003a).

At the international level, the International Steering Committee for Global Mapping is working on a global spatial data infrastructure of known and verified quality and consistent specifications, which will be open to the public. Data are produced through cooperation among national mapping organizations participating in the Global Mapping project. There is an integrated data set for Mexico, Canada, and the United States, and the three countries are working together on a new digital database for a framework for comparative data. They use an interoperable web server approach, and access to the data will be free (ISCGM 2004).

The Global Biodiversity Information Facility (GBIF) is another effort to put data sets of environmental information together and make them interoperable globally. Its aim is to become an interoperable network of biodiversity databases that will allow access to the vast amount of biodiversity data held in a variety of collections throughout the world (GBIF 2004). Such interoperable data systems should be invaluable to bilateral SOE and indicators projects in North America.

***Management and monitoring issues***

New data are frequently expensive and time-consuming to collect, so SOE reporting and indicator initiatives often rely on existing data, especially at higher spatial scales. Ideally, the identification of a need for indicators to fill gaps in knowledge should influence the design of monitoring programmes, prompting the gathering of data to populate new indicators. For example, by producing a comprehensive list of indicators, SOLEC expects to influence future monitoring and data-gathering efforts. It is believed that involving multiple stakeholders in the development process, where they learn about what information is necessary and sufficient to characterize the health of the Great Lakes ecosystem, helps to foster cost-efficient, standardized, and relevant monitoring programmes (Bertram and Stadler-Salt 2000). Similarly, in identifying indicators that still need to be developed and for which data are lacking, the Heinz Center also points to where additional monitoring is needed. NRTEE identified the need for good-quality information and recommended that the Canadian government

> It is critical that both the scientists who will operate environmental monitoring networks and the scientists who plan to use the resulting data be involved in system design, system upgrade, data evaluation, and data dissemination (CGER 1997, 31).

improve and expand data structures and information systems required to report on national capital and to invest in improved monitoring and information systems to overcome the paucity of good-quality, national-level information on environmental issues (NRTEE 2003).

Frequently there is a lack of coordination among monitoring networks and between monitoring and indicator initiatives. Chapter 1 noted the need for both these systems to be embedded in an iterative policy cycle with long-term goals and objectives. Ideally, indicator professionals and scientists involved in monitoring, along with other stakeholders, should collaborate in designing SOE programmes and indicators.

During deliberations about indicators for the Gulf of Maine, participants agreed that an integrated monitoring network would enable the region to compare data on a regional basis and would allow for future status and early warning assessments. A united approach would help to provide managers and regulatory officials with a common message and would make it more likely that the message will be heard (GMCME 2002).

### *Collaboration*

During the preparation for its national environmental indicators and reporting strategy, Environment Canada noted the lack of collaboration among the nation's various indicator initiatives. There is "a patchwork quilt of indicators and models, with too little consistency, and too much potential for either overlap and duplication of effort or gaps that need to be addressed. In the end, the lack of linkages—the lack of knowledge sharing—may be seriously inhibiting the ability of environmental indicators and reporting programmes to support sound policy-making for sustainable development" (NIRO 2003a, 19). Since 2002, Environment Canada and Statistics Canada have been working hand-in-hand to develop their respective indicator sets and to generate or stimulate the generation of needed data. By the same token, the US Government Accountability Office notes that better coordination is needed to develop environmental indicator sets that inform decisions (US GAO 2004). The EPA and the Heinz Center in the United States are also collaborating in their respective indicator initiatives. The three cross-border ecosystem initiatives highlighted in Chapter 2 are examples of successful collaboration between Canada and the United States, with the participation of a wide range of stakeholders, including many levels of government. At the binational level, however, the two countries have not yet established an ongoing collaborative effort to develop and use indicators to portray the conditions and trends of their larger shared environment.

> If all of these efforts are performed in isolation, the methods and data could differ enough that 1) the tracking of global and cross-jurisdictional issues would not be possible and 2) lessons-learned in one country for a given issue may be difficult or impossible to apply in another (NIRO 2003b, 32).

### *Summary of lessons learned*

- The PSR and DPSIR frameworks are sound tools: they are used and understood internationally; they are still being perfected and can be adapted to the needs of each user.
- The better use of driver and response indicators enables the development of a more complete DPSIR profile for each issue and stimulates an understanding of the linkages among drivers, impacts, and responses.
- Intensity indicators, pressure-impact indicators such as material flows, pressure-response indicators, and natural capital accounting indicators are some of the ways to help show linkages.
- Biogeophysical indicators will continue to form the core of SOE reporting initiatives; scientifically sound benchmarks are still being improved.
- Human environmental health indicators are increasingly being developed.
- Integrated environmental assessment makes inter-linkages more explicit.
- Performance indices and relative ranking of country performance can stimulate decision-makers to address environmental issues.
- Indicators that measure progress in adhering to goals and targets in international and bilateral agreements use definitions and methodologies that have already been agreed upon.
- Methodologies agreed-upon internationally for measuring environmental conditions allow for comparability.
- Protocols or guidelines foster the use of comparable methodologies for multilateral indicators.
- When available, satellite remote sensing provides visually explicit indicators of land-use change.
- Developing indicators for emerging issues early on in the monitoring stage can influence

data gathering.

- Historical trend indicators can enable the evaluation of policy performance.
- Spatial scale is important to consider at each level of decision making, as well as in how data are collected.
- Indicators developed by international agencies and organizations such as OECD, UNEP, and WRI and partners are useful for multilateral reporting, since national-level data have already been synthesized or aggregated to represent regions.
- When interpreted in context, country-specific and ecosystem-level indicators are useful in accompanying multilateral or international indicators.
- Sets with a limited number of indicators are more readable; core sets of indicators can be adapted to different needs.
- A smaller set of headline or summary indicators is useful to decision-makers.
- Complementary indicators can be used to reflect concerns related to the author agency's mandate, goals, and programmes.
- Identifying ideal indicators regardless of the availability and quality of data and the existence of a fully developed indicator can stimulate targeted monitoring.
- Ideally, the interval between the period to which data refer and the date when the indicators are released should be as short as is practicable.
- Interoperable data systems are being developed and will increase access to standardized data.
- Cooperation between indicator practitioners and the scientists involved in monitoring helps to embed indicator projects in the management and policy cycles.
- Indicator projects for shared ecosystems provide lessons in how to collaborate to develop multilateral indicators.

**Conclusions**

This section consolidates the findings and recommendations and suggests steps towards the goal of creating a core set of harmonized environmental indicators for Canada and the United States. Ideally, stakeholders from both countries and all levels of the management cycle would cooperate to develop a common set of indicators and a shared environmental data system based on common

Beaver Dam on Mcgregor Ranch, near Rocky Mountain National Park, USA. *Gary Kramer/UNEP/NRCS*

A humpback whale tail in the Gulf of Maine. Captain Albert E. Theberge/UNEP/NOAA

monitoring methods. Given that national governments are still grappling with how to create more comparability among sub-national levels of state-of-the-environment reporting and monitoring, the approach to achieving this goal should remain flexible and be based on gradual improvement over time (CEC 2003).

The following proposed steps are adapted from the generic steps outlined in Box 9:

1. Set out the vision and goals of the indicator project.
2. Identify stakeholders from both countries representing all levels of the management process (governments, monitoring programmes, statistics departments, and so forth—see Figure 13). Hold a brain-storming session to identify themes and issues related to the overarching vision and goals.
3. Prioritize the issues (see Box 10).
4. Develop sets of questions related to each issue to prompt the identification of indicators (see examples in Box 11).
5. Propose candidate indicators that respond to the questions posed.
6. Select an analytical framework that links goals to indicators (see Chapter 1).
7. Develop a list of criteria for indicator selection (see Box 12), complementing generic criteria with those related specifically to the project's vision.
8. Evaluate indicators according to the criteria.
9. Narrow down the indicators to a limited and manageable set. Define complementary sets of indicators if need be (see Box 13).
10. Decide on levels of aggregation and types of indices; identify headline or key indicators.
11. Prepare methodology sheets for each indicator (see Box 29).
12. Identify data sources (see Appendix 2).
13. Gather data to populate the indicators, beginning with existing data (see Table 6).
14. Standardize measurement wherever possible; note incongruities, with a view to improving comparability.
15. Compare indicator values to targets, thresholds, and policy goals as appropriate, beginning at the international and bilateral levels but using national-level targets in the absence of higher levels of agreement.
16. Identify data gaps, retaining unpopulated indicators and those that reveal incomparability between the two countries in the indicator set(s), to stimulate efforts to fill gaps.
17. Decide on a suite of products to communicate the results.
18. Disseminate the results, focusing on policy-makers.
19. Conduct an assessment of the use of the products by decision-makers.
20. Assess strengths and weakness of the indicator set(s).
21. Continue to develop superior indicators.

The information in this report should facilitate many of the steps suggested above. The indicators in Appendix 1: Table 2, extracted from the national-level Canadian and US reports surveyed, could inform a first list of candidate indicators, as proposed in Step 5. The following table (Table 6) is a list of indicators for which comparable data already exist for both nations either separately or as an integrated region. It provides sources of these data and is a first step towards step 13, "Gather data to populate the indicators, beginning with existing data". Data for a large number of these indicators are derived from the OECD, allowing the data to be integrated so as to provide a North American perspective. Based on this list, Chapter 5 provides a set of indicators for which comparable data exist as an example of how indicators can be used to show trends. Finally, Appendix 2 contains a preliminary list of data sources for a select set of environmental issues, facilitating Step 12, "Identify data sources".

In summing up, this report has shown the significant role environmental indicators can have in informing environmental policy. To help deliver information to decision-makers, SOE projects need to include a range of indicators related to a vision for a sustainable environment. Regular, periodic assessments of progress towards environmental goals, using clear and compelling indicators, will give decision-makers a means to measure progress towards environmental sustainability. SOE reports should include a set of core indicators that reveal conditions and trends and that include indicators of drivers and responses, intensity indicators, and performance and comparative indicators linked to targets and benchmarks. The links between policy and environmental conditions can be shown by careful interpretation of indicator profiles, while efforts should continue to improve conceptual frameworks that reveal linkages among the elements of the DPSIR approach and that integrate multiple effects into the model. Work should continue on developing indicators to show the links between human health and well-being and human-induced environmental change. Regional SOE initiatives should also acknowledge links with the rest of the world, by revealing impacts on the global environment, for example.

Implicit in the steps set out above is the need for cooperation between the two countries to produce a first set of environmental indicators for the region. This will require collaboration in decisions about which international indicators are most appropriate and in the development of new regional indicators that render data, definitions, and methods comparable. Finally, the selected indicators should refer to a vision for the environmental health of the North American region. Regular, periodic assessments of the region's progress towards environmental goals shared by the two countries that reveal conditions and trends with clear and compelling indicators will give decision-makers a means to measure progress towards environmental sustainability.

Sunset on Lake Waterton in Waterton, Canada. *UNEP/MorgueFile*

**Table 6: Feasible bilateral environmental indicators for Canada and the United States**

| Issue | Feasible bilateral indicators | Potential sources |
|---|---|---|
| **Economy** | GDP | OECD 2002b |
| | structure of GDP | OECD 2002b |
| | per capita GDP | OECD 2001 |
| **Population** | total population | OECD 2002b<br>FAOSTAT 2004 |
| | population growth and density | OECD 2001; OECD 2002b; UNDP 2003; FAOSTAT 2004 |
| **Consumption** | total and per cent by type, per capita private final consumption expenditure | OECD 2002b |
| | total private final consumption expenditure, and as per cent GDP | OECD 2001; OECD 2002b |
| **Energy** | energy supply per capita | IEA 2003a; OECD 2001 |
| | energy supply per unit GDP | IEA 2003a; OECD 2001 |
| | total primary energy supply | EIA 2003a; OECD 2001 |
| | total primary energy supply by source (per cent share of total) | EIA 2003a; OECD 2001 |
| | total and per capita energy consumption | OECD 2002b; IEA 2003a |
| | energy consumption by source | IEA 2003a; OECD 2002b |
| | energy consumption/GDP | IEA 2003a; OECD 2002b; UN 2004 |
| **Transportation** | road traffic/unit GDP | OECD 2001 |
| | road fuel prices and taxes by type | OECD 2001; OECD 2002b |
| | road network length | OECD 2002; IRF 2004 |
| | road vehicle stocks | OECD 2001; OECD 2002b |
| | road traffic per network length | OECD 2001 |
| | road traffic volumes | OECD 2001; OECD 2002b |
| | transport by mode | OECD 2002b |
| | consumption of road fuels | OECD 2002b |
| | consumption of alternative and replacement fuels for road motor vehicles | Statistics Canada 2000b |
| | annual receipts from road user taxation | IRF 2004 |
| | average price of fossil fuel to end-users | Statistics Canada 2000b |
| | new model year fuel efficiency for road motor vehicles | Statistics Canada 2000b |
| | federal emission control requirements for passenger cars and light trucks | Statistics Canada 2000b |
| | energy consumption by transport sector, and mode | OECD 2001; OECD 2002b; Statistics Canada 2000b |

| Issue | Feasible bilateral indicators | Potential sources |
|---|---|---|
| **Climate change** | per capita $CO_2$ emissions | OECD 2001; Marland & others 2003 |
| | total annual $CO_2$ emissions, and by source | OECD 2001; Marland & others 2003; UN 2004 |
| | $CO_2$ emissions/unit GDP | OECD 2001 |
| | $CO_2$ emissions from energy use | OECD 2001; OECD 2002b |
| | GHG emissions | UNFCC n.d.; IEA 2003b, OECD 2002b |
| | average temperature variation in North America | CCME 2003; NCDC and NOAA 2004 |
| **Ozone layer** | ODS consumption and production | OECD 2001; UNEP 2002c; UN 2004 |
| | $O_3$ levels over North America<br>total column $O_3$ over selected cities | US EPA 2003<br>OECD 2001 |
| **Air quality** | $SO_X$ and $NO_X$ emissions per unit GDP | OECD 2001; OECD 2002b |
| | per capita $SO_X$ and $NO_X$ emissions, and intensities | OECD 2001 |
| | total $SO_X$ and $NO_X$ emissions, and by source | OECD 2001; OECD 2002b |
| | ambient concentrations of $SO_2$ and $NO_2$, selected cities | OECD 2001; OECD 2002b |
| | concentrations of particulates, selected cities | OECD 2002b |
| | emissions of CO by source | OECD 2002b |
| | emissions of VOC by source | OECD 2002b |
| | $O_3$ concentrations by region (eastern and western Canada and US) | EC 2002 |
| **Acid deposition** | trends in Canada-US $SO_2$ emissions | EC 2002 |
| | trends in Canada-US $NO_X$ emissions | EC 2002 |
| | change in wet sulphate deposition | EC 2003c; EC 2002 |
| | change in wet nitrate deposition | EC 2003c; EC 2002 |
| **Indoor air** | | |
| **Toxic substances** | PCBs in Great Lakes fish tissue | US EPA 2003 |
| | Great Lakes atmospheric deposition of PCBs and DDT | US EPA 2003 |
| | contaminant levels (ppm DDT and PCBs) in double-crested cormorant eggs, Great Lakes | EC 2003 |
| | toxic releases and transfers, matched industries and chemicals | CEC 2004a |
| | mercury emissions from power plants | CEC 2004a |
| **Waste** | generation of hazardous, industrial, and radioactive waste and municipal solid waste (MSW) | OECD 2002b |
| | per capita generation of household and municipal solid waste (MSW), and nuclear waste | OECD 2001; OECD 2002b |
| | production of industrial and hazardous waste/unit GDP | OECD 2001 |
| | recycling rates (%) of paper, cardboard, glass<br>municipal solid waste (MSW) management (recycling and reuse) | OECD 2001; OECD 2002b<br>OECD 2001; OECD 2002b |

| Issue | Feasible bilateral indicators | Potential sources |
|---|---|---|
| **Land use** | map of North American land cover characteristics | Loveland & others 2000; Earth Observatory 2002 |
| **Freshwater** | water extraction by use | OECD 2002b; FAO 2004a |
| | water extraction by source | OECD 2002b |
| | water use as per cent of annual renewable water | OECD 2001; FAO 2004a |
| | water quality in selected rivers | OECD 2001; OECD 2002b |
| | total and per cent population with access to improved sanitation | OECD 2001; WHO and UNCF 2004 |
| | per cent population with access to improved water treatment | OECD 2001; OECD 2002b |
| **Wetlands** | total area and number of wetlands of international importance | Ramsar 2004 |
| | total area of permanent wetlands | Loveland & others 2000 |
| | number and distribution of marine protected areas | GBRMPA, The World Bank, and IUCN 1995 |
| | marine or littoral protected areas (total area, number) | Loveland & others 2000 |
| **Fisheries** | living marine resources catch | FAO 2004b |
| | total fish catch | FAOSTAT 2004; OECD 2001 |
| | total fish harvests and per cent of world capture by major marine fishing area and species | OECD 2001 |
| | aquaculture production | OECD 2002b; |
| | fish consumption | OECD 2002b |
| **Forests** | forest harvests as per cent annual growth | OECD 2001 |
| | current forest cover (geospatial) | UNEP-WCMC 2004 |
| | average annual rate of change | FAOSTAT 2004 |
| | forest area as per cent of total land area | FAO 2001a; FAO 2001b |
| | area burned in forest wildfires | EC 2003c; Heinz Center 2003 |
| | FSC-certified forests | UNEP-WCMC/WWF 2004 |
| | forest plantation extent | FAOSTAT 2004 |
| | per cent of forests protected | UNEP-WCMC 2004 |
| **Agricultural land** | extent of cropland (per cent and total) | OECD 2002b; FAOSTAT 2004 |
| | apparent consumption of nitrogenous and phosphate fertilizers, and commercial fertilizers | OECD 2002b |
| | fertilizer use/unit agricultural land area | OECD 2001 |
| | pesticide use/unit agricultural land area | OECD 2001 |
| | consumption of pesticides | OECD 2002b |
| | irrigated area | OECD 2002b |
| | selected livestock numbers | OECD 2002b |
| | selected livestock densities | OECD 2001 |
| | N and P from livestock per area land | OECD 2001 |
| | water abstractions per area of irrigated land | OECD 2001 |
| | total energy consumption by agriculture | OECD 2002b |
| | soil surface N balance | OECD 2001 |

| Issue | Feasible bilateral indicators | Potential sources |
|---|---|---|
| | ha under organic management, and as per cent of agricultural area | Willer and Yussefi 2004 |
| | agricultural (crop and livestock) production | OECD 2002b |
| **Grasslands and shrublands** | extent of pastureland or permanent pasture (per cent and total) | OECD 2002b; |
| **Biodiversity** | number of known mammals, birds, fish, reptiles, amphibians, and vascular plants | OECD 2001; OECD 2002b; NatureServe 2004 |
| | all known ecological communities (alliances and associations) | NatureServe 2004 |
| | all known ecological systems | NatureServe 2004 |
| | number of threatened species or per cent of all species | OECD 2001;OECD 2002b; NatureServe 2004 |
| | distribution of threatened animal and plant species | IUCN 2003 |
| **Protected areas** | total area protected and as per cent total land (IUCN categories) | WCMC 2004; Chape & others 2003; OECD 2001; UN 2004 |
| | marine protected areas (IUCN), numbers and area | Chape & others 2003 |
| | map of protected areas in North America | GeoGratis 2004 |
| **Urban areas** | percentage urban population growth rate | UN DESA 2003 |
| | urban population growth | FAOSTAT 2004 |
| | map of night-time lights | DMSP 1994–1995 |
| | total rural/urban population | FAOSTAT 2004; |
| **Natural disasters** | number of people killed due to natural disasters | OFDA/CRED, EM-DAT 2003 |
| | number of people affected by natural disasters | OFDA/CRED, EM-DAT 2003 |
| | major floods and related losses | OECD 2002b |
| | major climatic and meteorological disasters | OECD 2002b |
| | number of weather-related disasters | PSEPC 2004 |
| **National responses (expenditures)** | total official development assistance, and as per cent GNP | OECD 2001 |
| | pollution abatement and control expenditure (public and business) as per cent GDP, and per capita | OECD 2001 |

Source: Compiled by author.

UNEP/MorgueFile

5

## Chapter 5

# Using Indicators To Track Environmental Trends In North America

This chapter presents a selected set of environmental indicators for which comparable data exist for Canada and the United States. The mandate and scope of this survey did not include developing a list of ideal indicators for North America, so the indicators below do not adhere to the many suggestions made in Chapter Four. Rather, it is a “quick and dirty” exercise using available information. As revealed in the previous chapters, reliable, up-to-date and comparable data are presently missing for a number of issues of importance to the North American region. For this reason, this chapter does not include trends or comparative data on the area and status of wetlands and coastal and marine ecosystems; nor does it include indicators on indoor air quality, on human health impacts of exposure to urban air pollution or toxic substances, or on impacts of natural disasters, among other issues for which there are gaps in data or in the existence of fully developed indicators. An attempt was made to use a consistent time period, so most of the indicators show trends between 1990 and 2000. They generally show data for each country, as well as for the two countries together, representing North America. In most cases, the data derive from the OECD. The first section includes a number of indicators of drivers of environmental change. For the most part, comparative indicators show each country’s rank within the OECD or the world.

The chapter provides examples of how indicators can show trends clearly and how they can be used to compare progress with other regions and nations. To make the messages clear to decision-makers and the interested public, each indicator is accompanied by explanatory text and happy, neutral, or sad faces (see legend, below). These symbols are subjective interpretations of the trends as environmental threats or opportunities and render them visually striking. Although incomplete, the indicator set gives an idea of the status of some of North America’s environmental assets and where the picture looks unsustainable, the sad faces provide warning signs and a wake-up call to prompt action.

**Legend for Chapter 5**

Positive trend, moving towards qualitative objectives or quantified targets

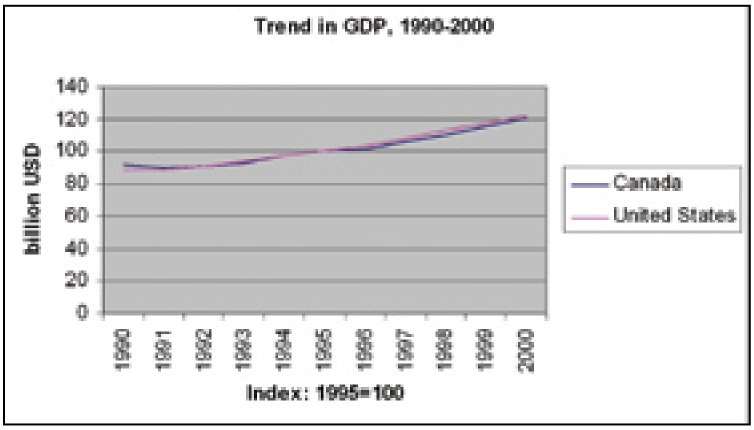
Some positive development, but either insufficient to reach qualitative objectives or quantified targets, or mixed trends within the indicators

Unfavourable trend

## The Economy

### *GDP*

**Figure 32: Trend in GDP, 1990–2000**




**Economy up**

Good or bad? a source of debate

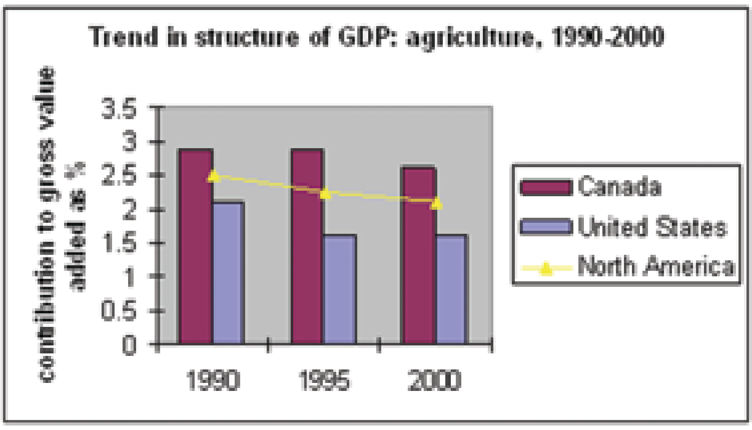
Source: Compiled by author from OECD 2002b, 9.

This indicator shows the changes in volume of gross domestic product (GDP) between 1990 and 2000 (Figure 32). Data are expressed as indices (1995=100) calculated from the value of GDP at constant prices.

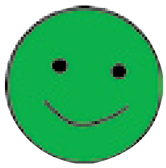
Gross domestic product measures the output of goods and services but ignores the environmental costs of economic activity. Thus, a positive interpretation of this upward trend is a false assumption because externalities—costs associated with pollution, waste disposal, and the extraction and decline in natural resources, as well as the value of ecosystem goods and services taken as "free"—are not accounted for in the calculations of GDP. In fact, in the short term, cleaning up pollution and extracting resources contributes to economic growth. On the other hand, a strong economy is also one that can finance environmentally-friendly technologies. Efforts are under way to develop an indicator that gauges progress in a more balanced way.

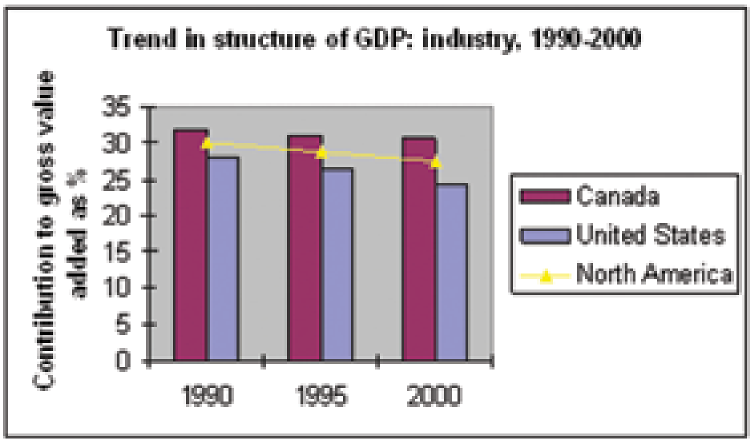
### *Structure of GDP*

**Figure 33: Trends in the structure of GDP: agriculture, industry, services, 1990–2000**

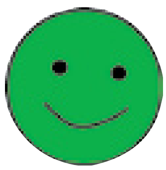


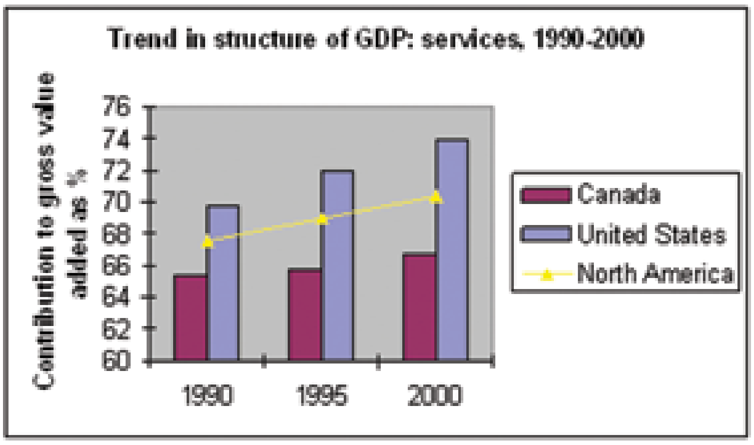

**Value of agriculture down**



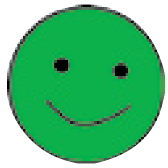



**Value of industry down**






**Value of services up**



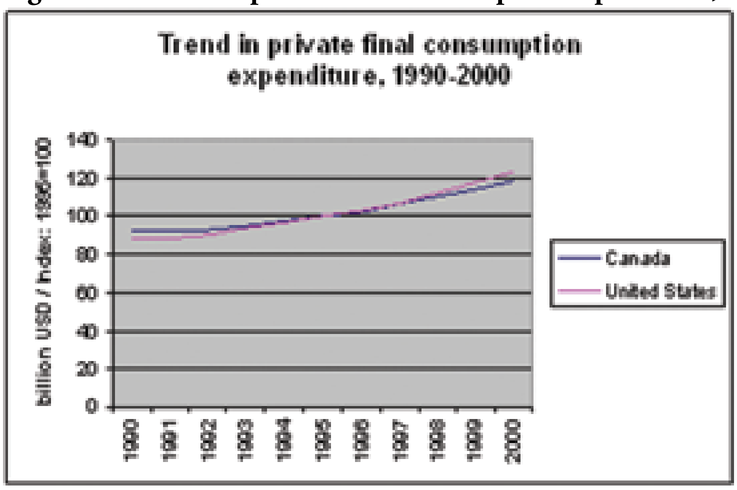
Note: Data for agriculture include hunting, forestry, and fishing. Industry data include energy and construction. Data on services exclude financial intermediation services indirectly measured. Source: Compiled by author from OECD 2002b, 10.

These indicators show the structure of GDP for three sectors of the economy, and changes since 1990 (Figure 33). Data represent the value added by each economic sector as its contribution to GDP. They are expressed as a percentage of gross value added.

The shift away from an economy based on industry and agriculture to one in which the service sector plays a greater role has implications for energy consumption since the service sector is less energy-intensive. This has contributed to a decline in North America's share of world energy consumption (EIA 1999). In addition to its heavy use of energy, agricultural and industrial activities as presently practiced also damage the environment in other ways, including through air, soil, and water pollution. The 'happy' face next to the downward trend in the value of agriculture is not meant to imply that agriculture is a 'negative' activity: a graph showing a growing trend towards the value of sustainable agriculture in the structure of GDP would be deemed a positive trend since it would indicate increased support for practices that build soils, reduce the use of agrochemicals, preserve rural landscapes, and improve livelihoods in the sustainable/organic farming sector.

### *Private consumption*

**Figure 34: Trend in private final consumption expenditure, 1990–2000**



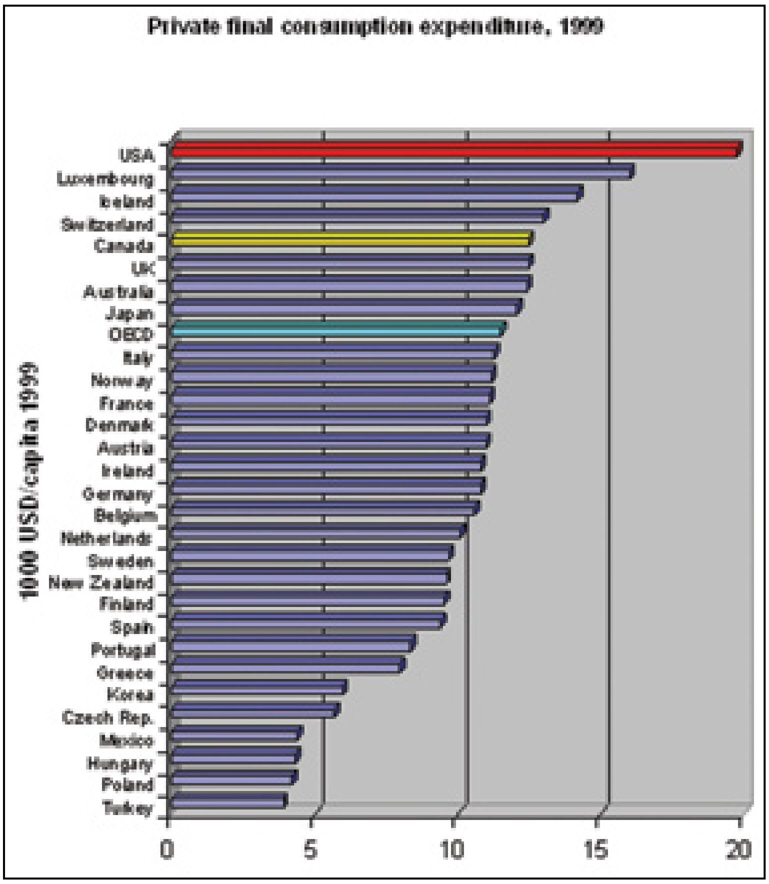

**Private consumption up**

Source: Compiled by author from OECD 2002b, 11.

This indicator shows the changes in volume of private final consumption expenditure between 1990 and 2000 (Figure 34). Data are expressed as indices (1995=100) calculated from the value of private final consumption expenditure at constant prices.

The indicator shows the trend in consumption by households and the private nonprofit organizations that serve them in Canada and the United States. Increased consumption in North America mirrors increases in GDP; both are associated with greater use of materials and energy, the production of waste, and emissions of pollutants into the environment.

**Figure 35: Private final consumption expenditure, 1999**




**Canada and the United States are among top 5 countries with highest personal consumption**

Source: Adapted from OECD 2001, 77.

This indicator shows the per capita consumption by households and the private nonprofit organizations that serve them for each of the member countries of the OECD in 1999, in thousands of US dollars (Figure 35).

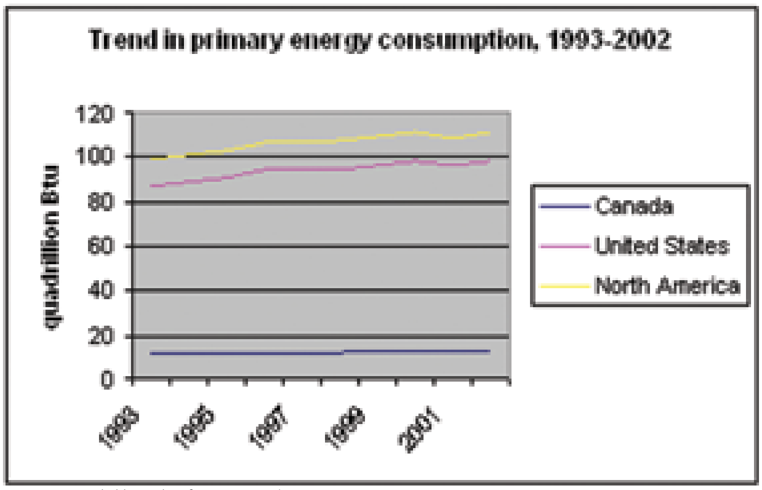
This comparative indicator reveals that private consumption in Canada and the United States is higher than in almost all other developed countries.

Cultures that promote consumption contribute to greater environmental pressures by helping to increase the demand for and use of energy resources, including: fuel for private cars; water; manufactured goods; and packaging. It also implies increases in greenhouse gas emissions and the production of waste.

## Energy use

### *Primary energy consumption*

**Figure 36: Trend in primary energy consumption, 1993–2002**




**Energy consumption up**

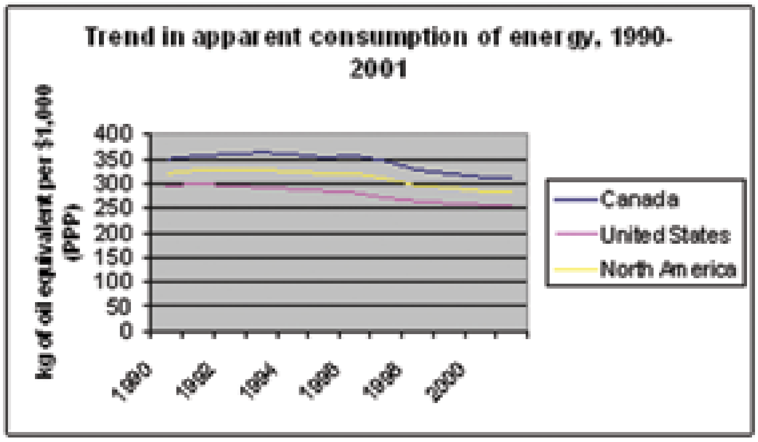
Source: Compiled by author from EIA 2004a.

This indicator shows the upward trend in the consumption of primary energy between 1993 and 2002 (Figure 36). Primary energy refers to petroleum, natural gas, coal, and electric power, and other (hydro, nuclear, geothermal, solar, wind, and wood and waste). Total energy consumption is the amount of primary energy used on average by each person. Consumption equals: indigenous production plus imports minus exports plus stock changes minus energy delivered to international marine bunkers (WRI 2004).

North America has seen a rise in energy consumption over the past decade. Between 1992 and 2002, overall energy consumption rose by 14.6 quadrillion British Thermal Units (Btu). In 2002, Canada and the United States used 13.07 and 98.03 quadrillion Btu of energy respectively (EIA 2004a). The consumption of energy puts a variety of pressures on the natural environment and human health. The exploration for, and extraction of fossil fuels and the construction of hydroelectric dams damages, alters, or destroys wildlife and human habitat and other valuable natural resources and landscapes, while burning fuels results in air pollution and associated respiratory problems in exposed populations, the emission of greenhouse gases that contribute to climate change, and polluting emissions that help form smog and acid rain. Canada and the United States rank as two of the world's highest consumers of primary energy.

***Energy intensity (apparent consumption)***

**Figure 37: Trend in apparent consumption of energy, 1990–2001**




**Intensity of energy use down slightly**

Source: Compiled by author from UN 2004 http://milleniumindicators.un.org/unsd/mi/mi_series_results.asp?rowId=648.

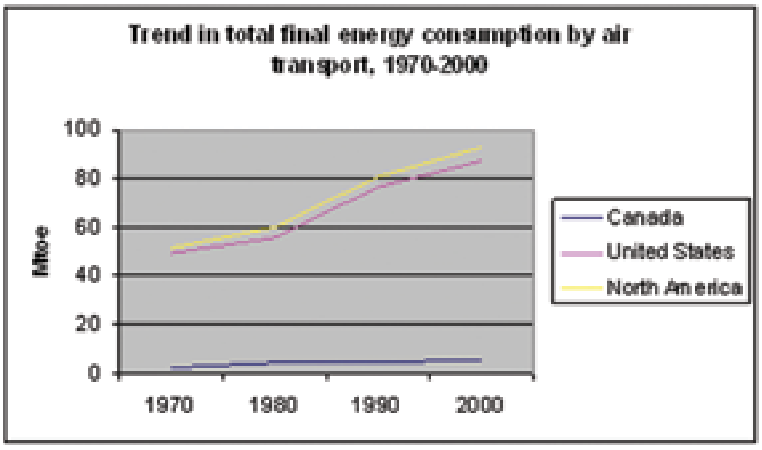
This indicator shows the intensity of energy use (Figure 37). This means the total amount of energy consumed per dollar of gross domestic product. Total primary energy domestic supply (sometimes referred to as energy use) is calculated by the International Energy Agency (IEA) as: production of fuels plus inputs from other sources plus imports minus exports minus international marine bunkers plus stock changes. "Purchasing power parities" (PPP) refers to the number of currency units required to buy goods equivalent to what can be bought with one US dollar (UN 2004).

North America's energy/GDP ratio has continued a slow decline that began in 1970. This reflects a shift to less resource-intensive patterns of production and a dematerialization of GDP as the service and information-based sectors increase in importance to the economy. Canada and the United States are among the most energy-intensive countries in the industrialized world, however. In 2002, Canada's energy intensity (per GDP) was 16,452 Btu per $1995 in purchasing power parity (PPP), well above that of the United States, which was 11,047 Btu/$1995. In 1999, Canada was 33 per cent less energy efficient than the United States (Boyd 2001). Although declining somewhat, Canada's energy intensity remains high due to its energy-intensive industries (EIA 2004b) and to increased population and economic growth (Boyd 2001). One reason for the slow decline in the Untied States is that newer homes are about 18 per cent larger than the existing housing stock and so require more energy for heating, cooling, and lighting (EIA 2003).

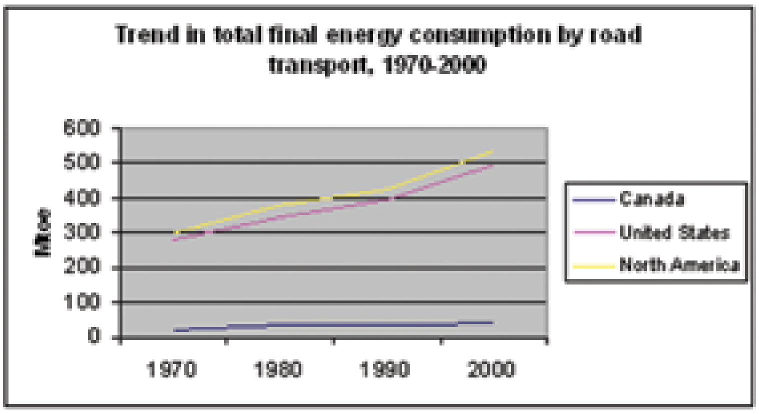
## Transportation

*Energy consumption by transportation*

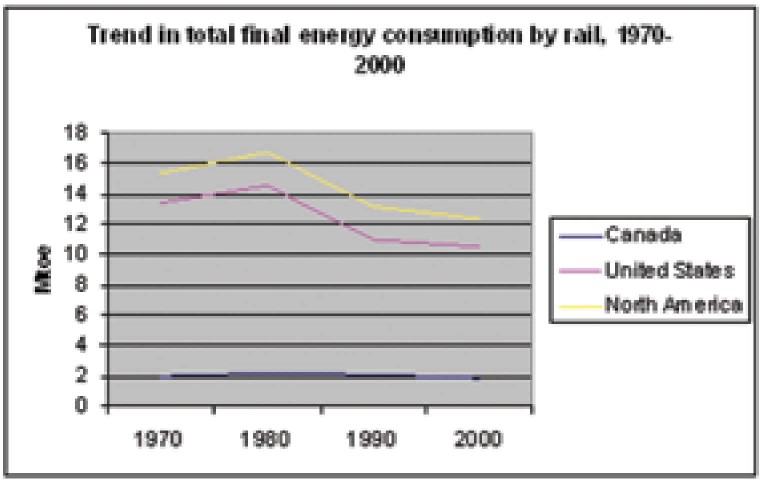
**Figure 38: Trends in energy consumption by transportation sector: air, road, rail, and total, 1970–2000**



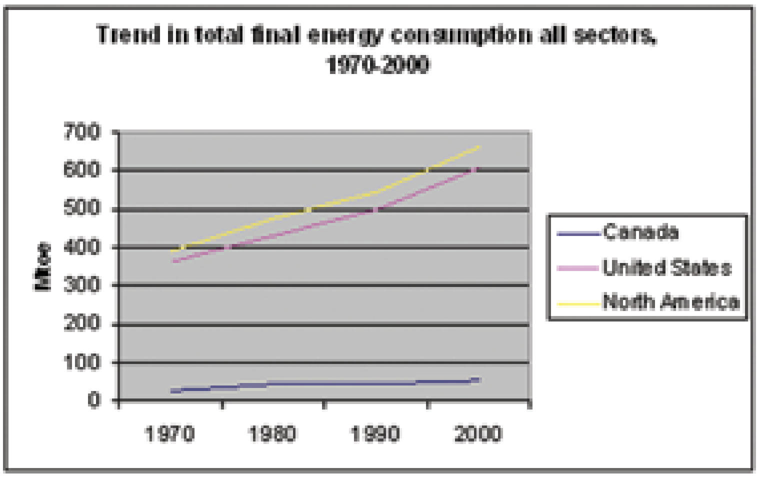

**Energy consumption by air transport up**




**Energy consumption by road transport up**




**Energy consumption by rail transport down**




**In total, energy consumption by all transport sectors together is up**

Source : Compiled by author from OECD 2002b, 21.

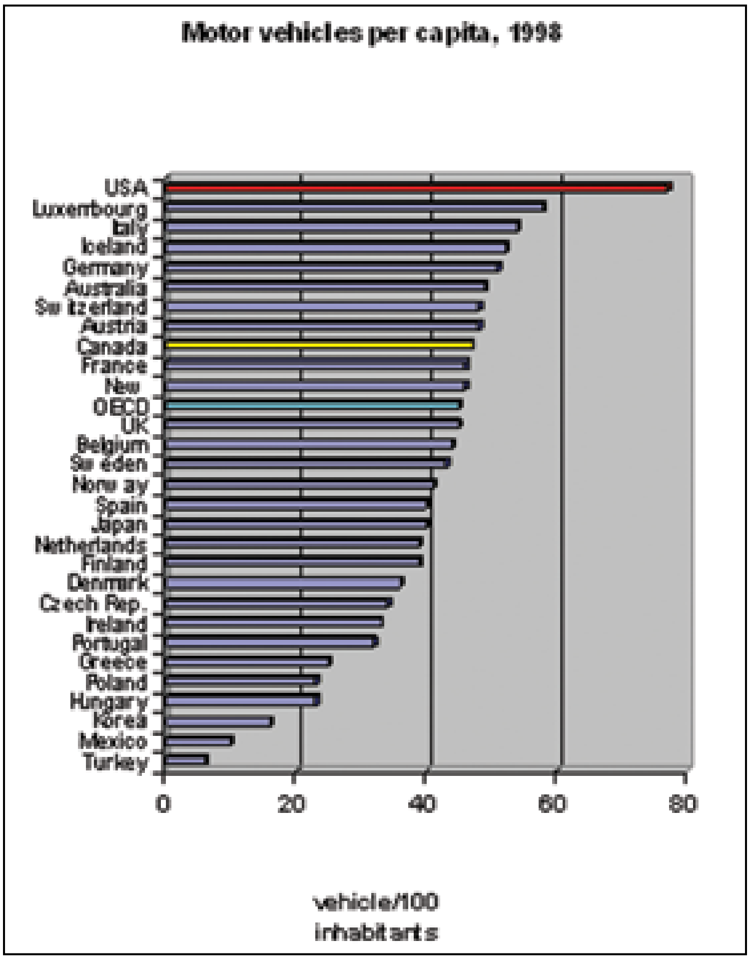
These indicators show trends between 1970 and 2000 in total final energy consumption by air, road, and rail and by the transport sector as a whole, measured in millions of tonnes of oil equivalent (Figure 38).

The total amount of energy consumed by the North American transport sector has risen significantly over the past decade—from 273 to 332 million tonnes of oil equivalent. The decline in energy used by rail was more than offset by rises in energy use for air and road transport. The transportation sector is responsible for about 33 per cent of energy use in North America. In both the United States and Canada, a recent shift towards the use of larger and less fuel-efficient vehicles such as sports utility vehicles (SUVs), reversed a previous trend towards fuel efficiency improvements. For example, energy efficiency in Canada's passenger transportation sector decreased 1.1 per cent between 1990 and 2002 (EIA 2004b). Energy use by the transport sector, especially road fuel consumption, is a major contributor to local and regional air pollution and to emissions that contribute to climate change. In fact, motor vehicles represent the single largest human-made source of air pollution in the United States (OECD 2002b).

***Motor vehicles***

*Comparative indicator*

**Figure 39: Motor vehicles per capita, 1998**




**Canada and the United States among top nations with most passenger vehicles per person**

Source : Adapted from OECD 2001, 87.

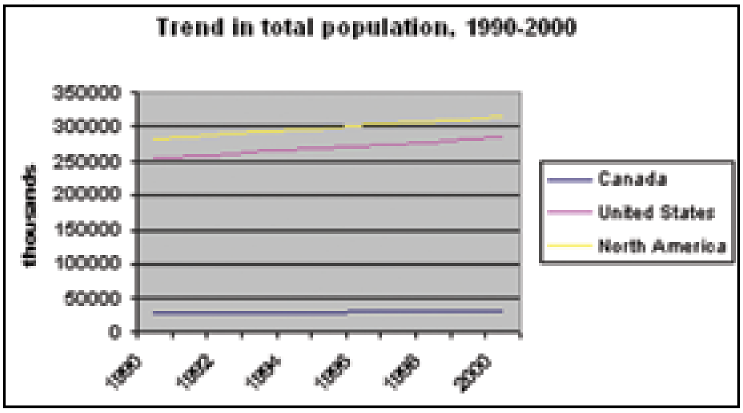
This comparative indicator shows the number of vehicles (passenger cars, goods vehicles, buses and coaches) per 100 inhabitants in OECD countries (Figure 39).

The United States and Canada are among the top nine OECD countries in passenger vehicle ownership per person. In the United States, there are three vehicles for every four people, compared to Western Europe and Japan, where there is typically one for every two people (Brown 2001). The environmental impacts of motor vehicles and the infrastructure that serves them include the expropriation of land for roads and highways, the use of materials and energy, polluting emissions, and greenhouse gases. The implications for human health and quality of life include risks of respiratory illness from air pollution, deaths and injury from accidents, and the detrimental effect of noise and traffic congestion.

# Population

## *Total population*

**Figure 40: Trend in total population, 1990–2000**




Source: Compiled by author from FAOSTAT 2004.

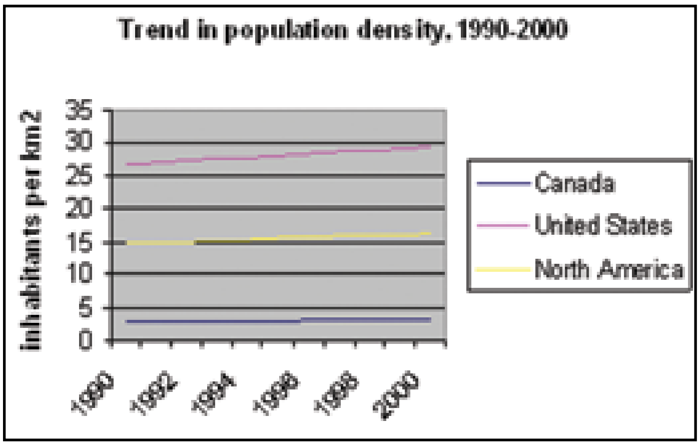
**Total population up**

This indicator shows the trend in total population from 1990 to 2000 (Figure 40).

The total population of North America in 2000 was 315.8 million (FAOSTAT 2004). It is presently growing at less than one per cent annually (PRB 2004). The United States is one of the three most populous countries in the world (after China and India) and is expected to still be among the top three in 2050. When combined with a pattern of high consumption and energy use, large populations are a potent driver of environmental change.

## *Population density*

**Figure 41: Trend in population density, 1990–2000**




Source: Compiled by author from OECD 2002b, 7.

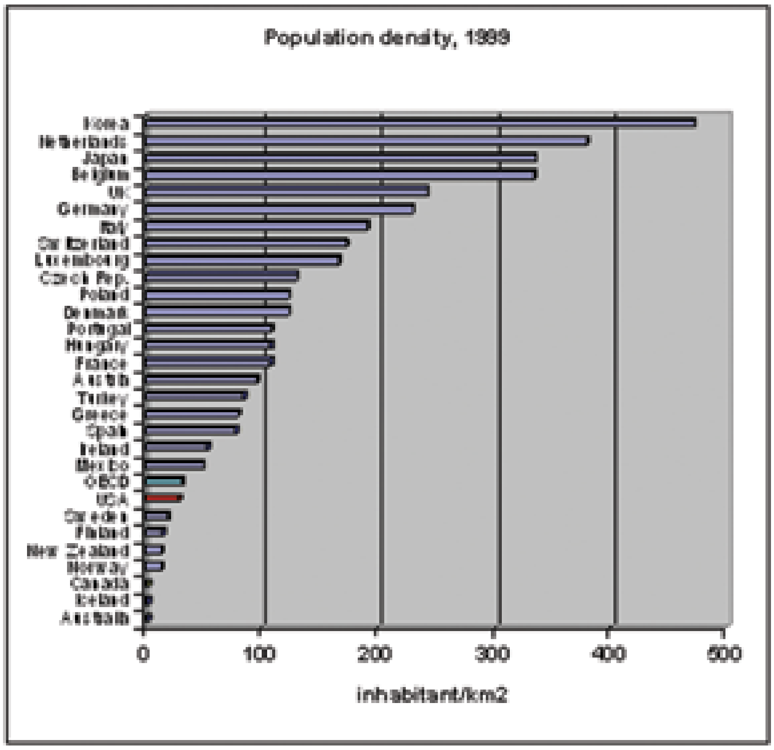
**Population density up slightly**

This indicator shows average population density in North America, measured by the number of inhabitants per square kilometer (Figure 41).

Average population density is increasing slightly in North America. About 79 per cent of North Americans live in relatively densely populated urban areas (Statistics Canada 2001a; US Census Bureau 2002). Changes in population densities are often used as a surrogate for urbanization (Brown and others 2004). Because the density indicator is an average measure of the number of inhabitants per square kilometer, it appears to show that Canadians are sparsely spread out across the country. This is due to Canada's relatively small population and its large land mass. In fact, most Canadians live in the southern part of the country, with 79.7 per cent living in urban areas (Statistics Canada 2001a). Densely populated areas are usually associated with high pressures on the environment, including demands for water, energy, materials, as well as waste disposal and the use of land—often productive agricultural land—for urban infrastructure. On the other hand, when planned for sustainability, dense settlement patterns have the potential to reduce environmental pressures compared to the impact of sprawling suburbs. "Smart" growth of urban areas reduces environmental impact through clustering a mixture of residential, office, retail, and outdoor recreational uses together, thereby shrinking travel distances and encouraging walking, cycling and public transit that reduces the use of fossil fuels.

*Comparative indicator*

**Figure 42: Population density, 1999**




Source: Adapted from OECD 2001, 74.

**Canada and the United States among the world's least densely populated countries**

This comparative indicator shows the population density (inhabitants per square kilometer) of OECD countries in 1999 (Figure 42).

Canada and the United States are among the least densely populated countries in the OECD. The settlement patterns of several much more densely populated nations, such as the Netherlands, Belgium, the United Kingdom, and Germany, are generally much "smarter" in terms of energy expenditure on transportation and the environmental impacts of water use and waste disposal associated with urban areas.

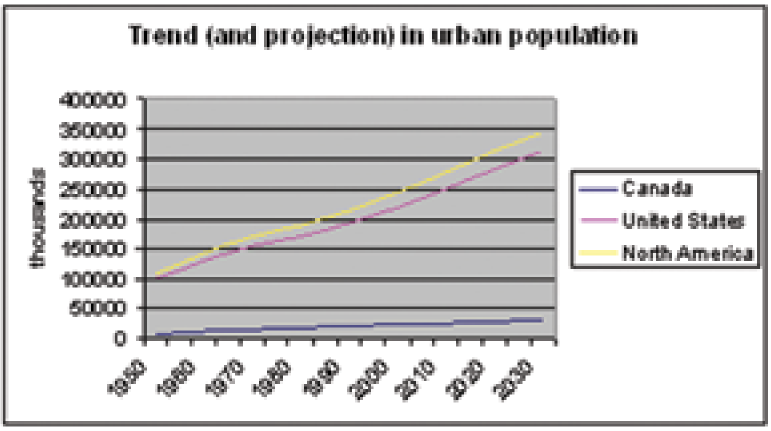
New York City USA, 2005

*UNEP/MorgueFile*

## Urban Areas

### *Urban growth*

**Figure 43: Trend (and projection) in total urban population, 1950–2030**




Source: Compiled by author from FAOSTAT 2004.

**Population in urban areas will continue to increase**

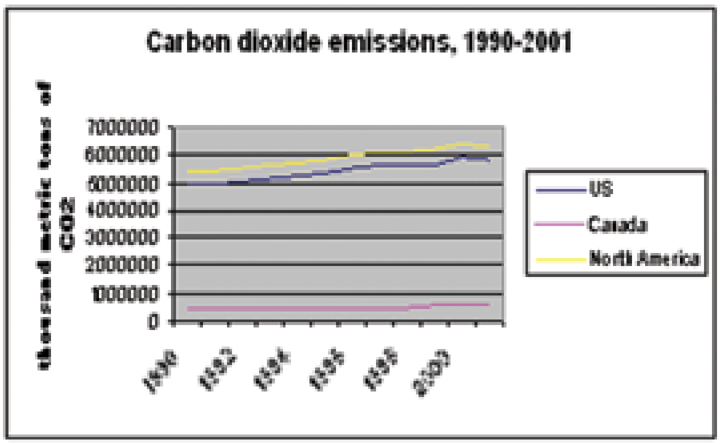
This indicator shows the historical trend in the number of people living in urban areas from 1950, projecting the trend from 2000 until 2030 (Figure 43). The urban/rural population is obtained by systematically applying the proportion of urban population ratio to the total population. The urban population estimates are based on the varying national definitions of urban areas.

The indicator reflects total population growth in urban areas, showing that the number of people living in cities and towns in North America will continue to grow. In 2000, more than 80 per cent of the US population lived in urban areas and the urban population was growing by more than 2 million people per year (USDA n.d.). If accompanied by urban planning that avoids the pitfalls of suburban sprawl and focuses on "smart" growth and the sustainable use of energy and resources, this trend could have positive impacts on the environment. However, the past decade has seen a decrease in household size and a trend toward population growth in suburbs and smaller towns and centres outside large cities (Brown and others 2004). One of the impacts of such growth is the conversion of rural land. In 2000, rural areas in the United States were being lost to urban uses at a rate faster than about 12 million km$^2$ (3 million acres) per year (USDA n.d.).

## Climate Change

### *$CO_2$ and greenhouse gas emissions*

**Figure 44: Trend in total $CO_2$ emissions, 1990–2001**




Note: Original source of data: UNFCCC online database. "United States" includes territories. Source: Compiled by author from UN 2004.

**$CO_2$ emissions up slightly**

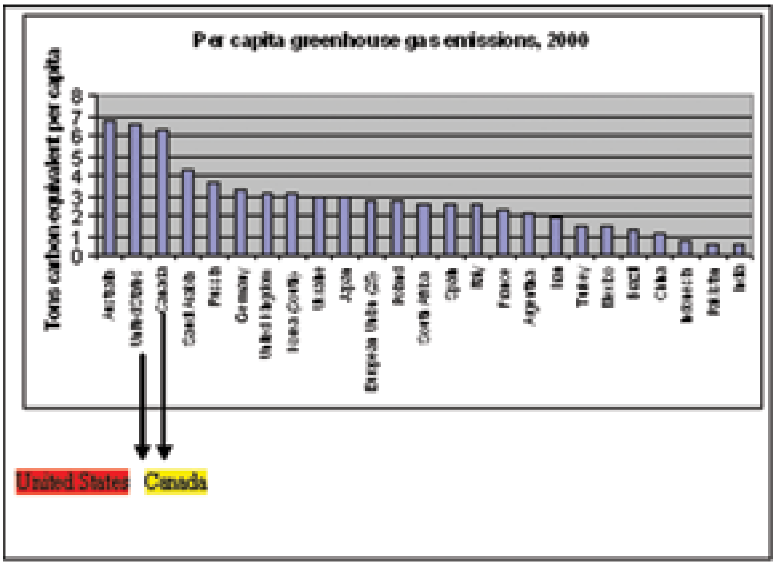
This indicator shows $CO_2$ emissions in North America from 1990 to 2001 (Figure 44). The data are in thousands of metric tonnes of carbon dioxide (not carbon).

Carbon dioxide emissions in Canada and the United States continued to increase during the 1990s. Canadian greenhouse gas emissions grew by more than 13.5 per cent between 1990 and 1999 (Boyd 2001). Emissions of $CO_2$ from fossil fuel combustion (which contribute 80 per cent of global warming potential) in the United States grew by 17 per cent from 1990 to 2001 (US EPA 2003). By 2002, the US was responsible for emitting 1.65 thousand million tonnes of carbon (Marland and others 2003) and was the world's largest producer of $CO_2$ from fossil fuel combustion, accounting for 24 per cent of the world total (EIA 2004b). US emissions have declined somewhat in recent years due to a slower economy, but with stagnating hydroelectric and nuclear energy generation, a stronger economy, and the continued increase in the sale of SUVs, emissions will likely grow again (EIA 2003).

There is a strong correlation among the trends in GDP, population, energy use, and $CO_2$ emissions, suggesting the significance of the first two of these as drivers of energy use and the associated emissions from the burning of fossil fuels. There is a general consensus among scientists that greenhouse gas emissions from human activity are contributing to global climate change.

*Comparative indicator*

**Figure 45: Per capita greenhouse gas emissions, 2000**




**Per capita emissions of greenhouse gases in Canada and the United States are among the highest in the world**

Source: Adapted from Baumert and Pershing 2004.

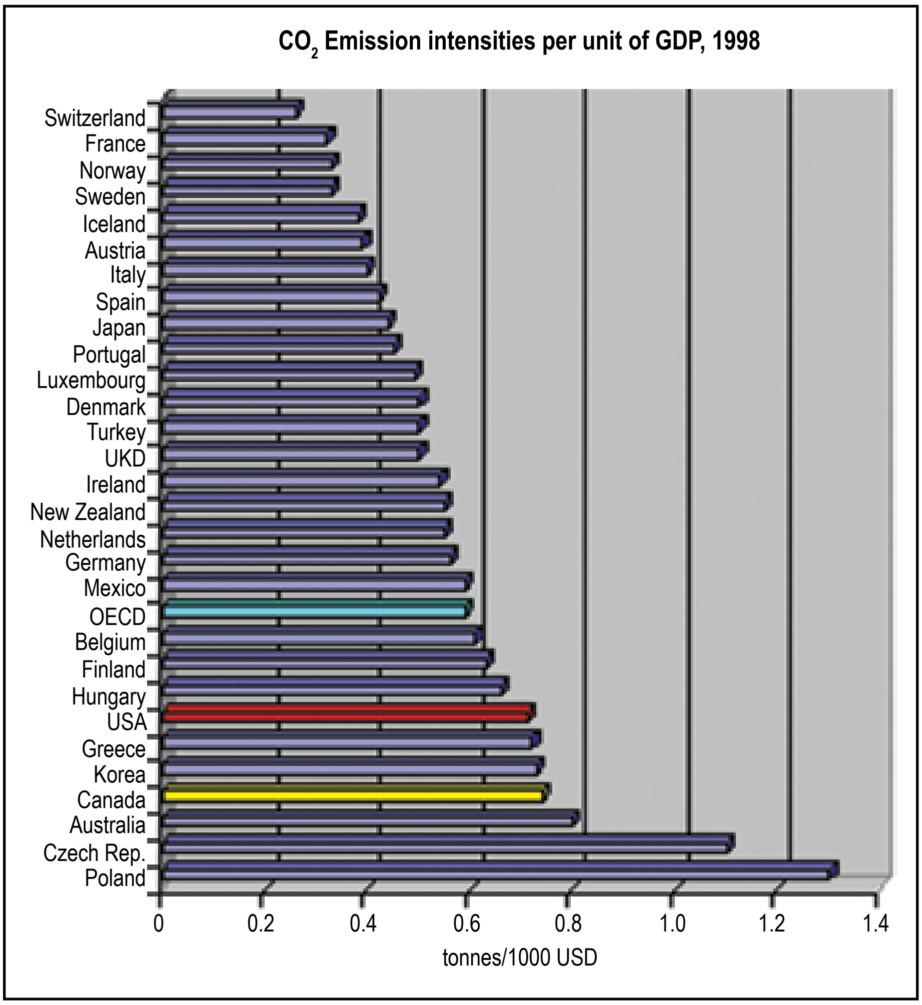
This indicator shows the top 25 greenhouse gas–emitting countries in the world, in absolute terms (Figure 45). Emissions include $CO_2$ from fossil fuels and cement, and non-$CO_2$ gasses.

Per capita greenhouse gas emissions (GHG) in North America have been consistently high and well above those for any other region (Marland and others 2003). In 2000, Canadians each produced an average of 18.7 thousand metric tonnes of carbon dioxide. The per capita yearly rate in the United States was 20.6 (UN 2004). In the United States, emissions per person increased about 3.4 per cent between 1990 and 1997 (US EPA 2000b). With greater hydroelectricity and nuclear generation (that do not emit GHGs), Canada's per capita emissions are slightly lower than those of the United States.

## Carbon intensity

*Comparative indicator*

**Figure 46: $CO_2$ emissions per unit GDP, 1998**




Source: OECD 2001, 15.

**Canada and the United States are among the 7 nations with the highest carbon intensities**

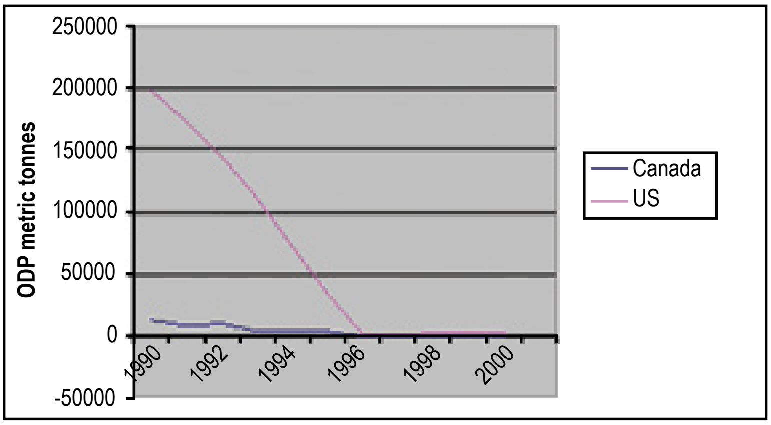
This comparative intensity indicator shows per capita $CO_2$ emissions (gross direct emissions) from energy use (fossil fuel combustion) among the OECD countries in 1998 (Figure 46), measured in tonnes of $CO_2$ relative to GDP (1 000 US dollars). GDP data refer to 1991 prices and purchasing power parities (PPPs). Since national inventories do not provide a complete and consistent picture of all greenhouse gas emissions, energy-related $CO_2$ emissions represent overall trends in direct GHG emissions (OECD 2001).

Carbon intensity and energy intensity are closely related. Canada and the United States have among the world's highest carbon and energy intensities. Increased consumption of fossil fuels for electricity generation, increased energy consumption in the transportation sector, and growth in fossil fuel production (largely for export) have influenced Canada's high carbon intensity relative to other nations. The high reliance on carbon-intensive coal for energy generation contributes to the high carbon-intensity rating of the United States (EIA 2003).

## Ozone Layer

### *CFC consumption*

**Figure 47: Trend in ozone-depleting CFC consumption, 1990–2000**




Source: Compiled by author from UN 2004.

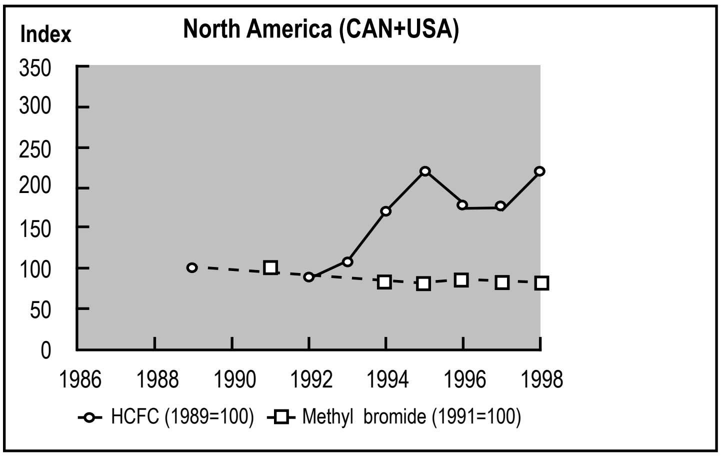
**Ozone-depleting CFC consumption rapidly down to zero**

This indicator shows the trend between 1990 and 2000 in consumption of chlorofluorocarbons (CFCs), the synthetic compounds formerly used as refrigerants and aerosol propellants that are known to harm the ozone layer of the atmosphere (Figure 47). Consumption is defined as: production plus imports minus exports of controlled substances (UN 2004). Basic data are weighted with the ozone-depleting potentials (ODP) of the individual substances (OECD 2001).

As a result of the Montreal Protocol, Canada and the United States rapidly decreased their consumption of CFCs and reached targets earlier than called for. As of 1996, there has been no production or consumption of these substances except for certain essential uses, although there are still releases to the atmosphere from previous production or consumption (OECD 2001).

### *HCFC and methyl bromide consumption*

**Figure 48: Trends in consumption of HCFCs and methyl bromide, 1988–1998**




Source: Modified from OECD 2001, 113.

**HCFCs still up and methyl bromide still in use**

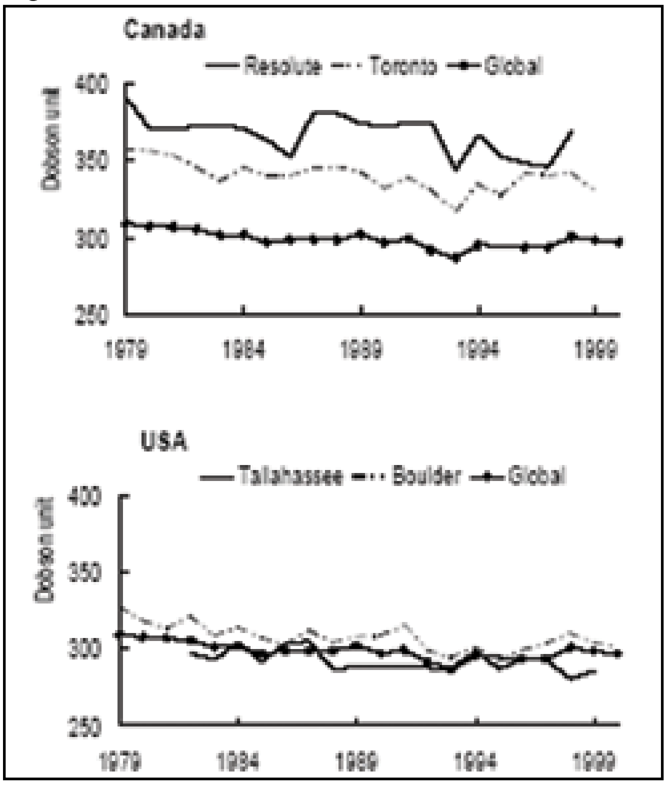
This indicator shows apparent consumption (used as a proxy for actual emissions) of hydrochlorofluorocarbons (HCFCs) and methyl bromide (Figure 48). Dotted lines refer to data not available. The year 1989, representing 100, is the index for HCFCs and 1991 is the methyl bromide index.

This indicator shows that North America, like other industrialized countries, continues to use HCFCs. Although they have only 2 to 5 per cent of the ozone-depleting potential of CFCs, concentrations of HCFCs are still increasing in the atmosphere. It will take another 20 years before use of HCFCs is phased out under current international agreements and the molecules will remain in the stratosphere for a long time after that (OECD 2001).

Under the Montreal Protocol, Canada and the United States agreed to reduce methyl bromide by 25 per cent by 1999 (compared to 1991 levels), 50 per cent by 2001, 70 per cent by 2003 and 100 per cent by 1 January 2005. In March 2004, the two countries were among 11 nations to receive critical-use exemptions that will allow this substance to continue to be used in small quantities until 2005 (UNEP 2004b).

*Total column ozone*

**Figure 49: Trend in total column ozone over selected cities, 1979–1999**




Source: OECD 2001, 23.

**Ozone column thickness over Canada and the United States down slightly**

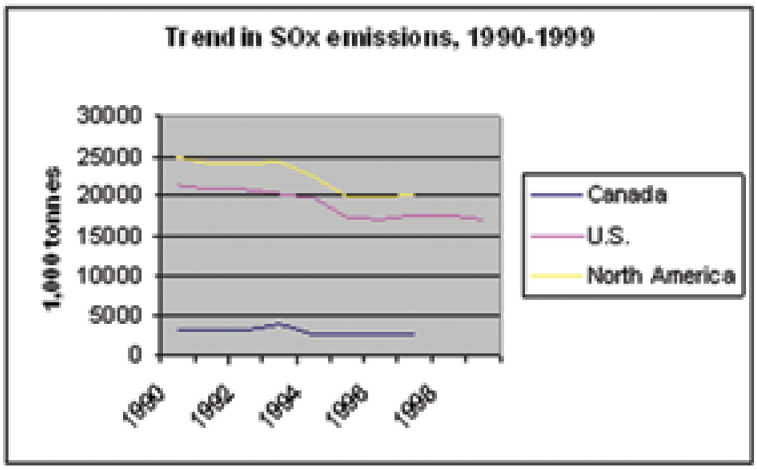
These indicators show trends in the thickness of total column ozone over selected cities in Canada and the United States, in Dobson units (Figure 49). Total column ozone refers to tropospheric plus stratospheric ozone. Dobson units are used to estimate the ozone layer's thickness. One hundred Dobson units represent a thickness of 1 mm of ozone at 0 degrees Celsius at sea-level pressure. Data are annual averages of daily values (OECD 2001).

Between 1997 and 2001, the average amounts of total column ozone in the Northern Hemisphere mid-latitudes (35°N–60°N) were three per cent below the pre-1980 values (NOAA 2002). Thinning of the ozone layer allows increased amounts of ultraviolet radiation to reach the earth. This contributes to the increase in the incidence of skin cancers in North America. It may also cause stress on some marine phytoplankton and affect productivity. Although the ozone layer is recovering, its full restoration will take decades because of the continued use of ozone-depleting products produced prior to the Montreal Protocol ban (US EPA 2003) and due to recent exemptions.

## Air Quality

### *$SO_x$ emissions*

**Figure 50: Trend in total emissions of $SO_x$, 1990–1999**




Note: Data refer to man-made emissions only; $SO_2$ only.
Source: Compiled by author from OECD 2002b, 9.

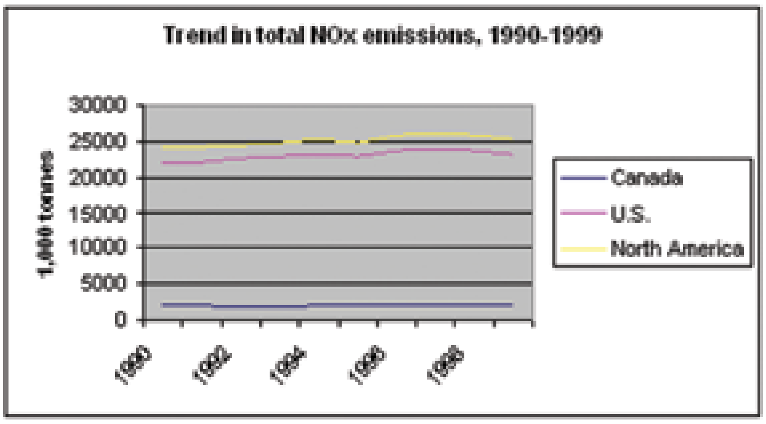
**$SO_x$ emissions down**

This indicator shows the amount of sulfur oxides (given as quantities of sulfur dioxide) emitted between 1990 and 1999 as a result of human activity (Figure 50).

Sulfur dioxide emissions decreased significantly over the last ten years in both countries, generally due to efforts to attain both regulatory and voluntary targets to reduce acid rain. As a result, sulfate levels in lakes in eastern North America have declined appreciatively (OECD 2004a). Acid rain can harm aquatic ecosystems and change species composition, as well as impair forests and crops. Electric utilities are the major source of total North American $SO_2$ emissions. In the United States, well over 90 per cent of these emissions come from coal combustion. In Canada, non-ferrous mining and smelting contributes the majority of $SO_2$ releases (EC 2002a). The emission of $SO_2$ and the resulting acid rain are linked to energy consumption, and to fossil fuel use in particular. Canada and the United States have seen a significant decoupling of $SO_x$ emissions from GDP recently (OECD 2001).

### *$NO_x$ emissions*

**Figure 51: Trend in total emissions of $NO_x$, 1990–2000**




**$NO_x$ emissions up slightly**

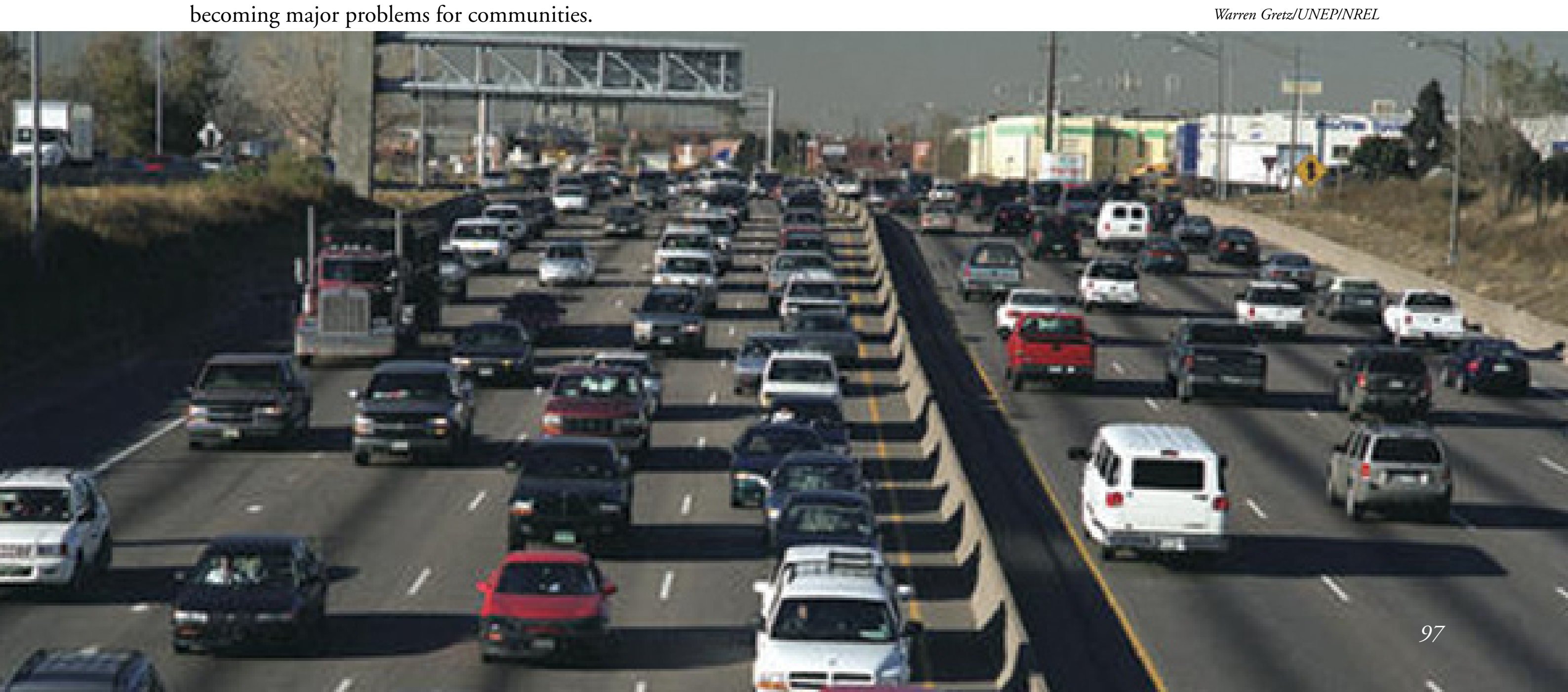
Note: Data refer to man-made emissions only.
Source: Compiled by author from OECD 2002b, 16.

This indicator shows the amount of nitrogen oxides (given as quantities of nitrogen dioxide) emitted between 1990 and 1999 as a result of human activity (Figure 51).

Emissions of $NO_x$ have not declined as much as those of $SO_x$ during this ten-year period. Fossil fuel combustion by motor vehicles, residential and commercial furnaces, industrial and electric utility boilers and engines, and other equipment are the principal sources of $NO_x$ emissions that result from human activity (EC 2002a). Gains made through pollution regulations and progress in technical pollution controls in North America have been offset by the steady growth in road traffic and other uses of fossil fuel that generate $NO_x$ (OECD 2001). Compared to most OECD countries, emissions of traditional air pollutants in North America remain generally high (OECD 2004b). $NO_x$ contributes to acid rain and to the formation of smog.

Increasing traffic, as well as the associated air pollution and fuel consumption, are becoming major problems for communities.

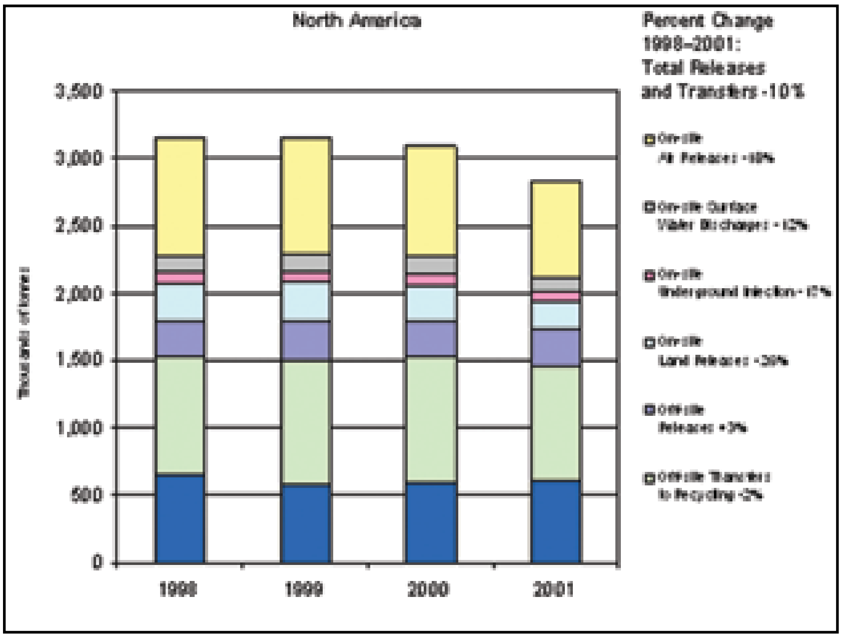
*Warren Gretz/UNEP/NREL*



## Toxic Substances

***Releases and transfers***

**Figure 52: Change in releases and transfers of pollutants, 1998–2001**




Source: Adapted from CEC 2004a, xxv.

**Toxic emissions down**

This indicator shows the trend in the on- and off-site release and transfer of toxic substances in Canada and the United States (Figure 52). Data include 155 chemicals common to the pollutant release inventories of each country (NPRI and TRI) from selected industrial and other sources. They represent data that have been consistently reported over the 1998–2001 period and include chemicals, as well as manufacturing facilities, electric utilities, hazardous waste management facilities, chemical wholesalers, and coal mines.

"Total releases and transfers of chemicals in North America decreased by 10 per cent from 1998 to 2001. Total releases decreased by 16 per cent, on-site releases decreased by 19 per cent, other transfers for further management decreased by 8 per cent, and transfers to recycling decreased by 2 per cent. However, off-site releases increased by 3 per cent. Compared with a decrease in total releases of 16 per cent for all matched chemicals from 1998 to 2001, releases of carcinogens decreased by 20 per cent and chemicals known to cause cancer, reproductive or development harm (California Proposition 65 chemicals) decreased by 26 per cent" (CEC 2004a, xxv).

Weldon Springs Ordnance Works. TNT contaminated water in excavation. St. Louis, MO USA.

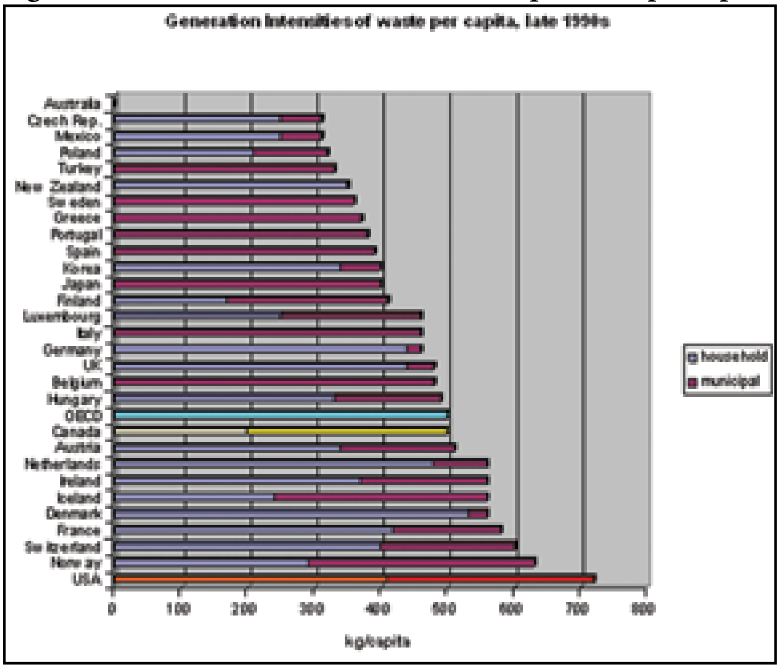
*Bill Empson/UNEP/USACE*

## Waste

### *Municipal waste*

*Comparative indicator*

**Figure 53: Generation intensities of municipal waste per capita, late 1990s**




**Canada and the United States among highest per capita producers of municipal waste**

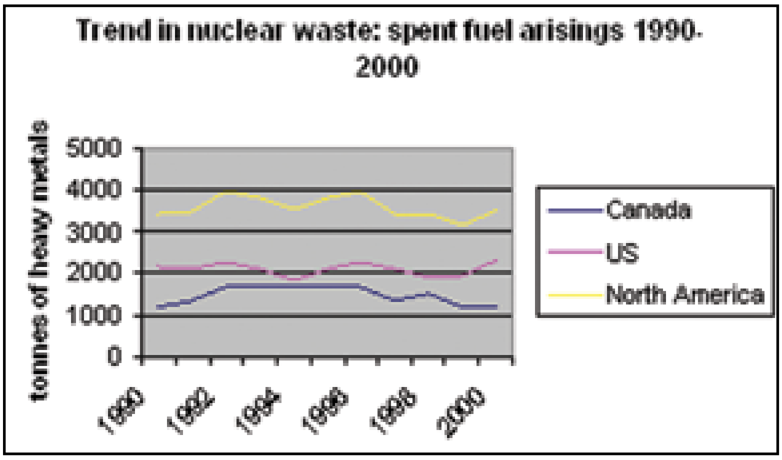
Source: Adapted from OECD 2001, 37.

This indicator shows the amount of household and municipal waste generated per capita in the OECD countries in the late 1990s (Figure 53).

Canada and the United States are among the top ten per capita producers of household and municipal waste in the OECD, with the United States topping the list. The generation of waste in North America generally mirrors private final consumption expenditure and GDP. The disposal of municipal waste has various environmental impacts, including toxic air emissions from incinerators, methane emissions from landfills, and the contamination of soils and water from leaking landfills.

### *Nuclear waste*

**Figure 54: Trend in nuclear waste: spent fuel arisings, 1990–2000**




**Radioactive waste generation steady**

Source: Compiled by author from OECD 2002b, 27.

This indicator presents annual spent fuel arisings in nuclear power plants (Figure 54). Spent fuel arisings are one part of the radioactive waste generated at various stages of the nuclear fuel cycle (uranium mining and milling, fuel enrichment, reactor operation, spent fuel reprocessing) (OECD 2002b).

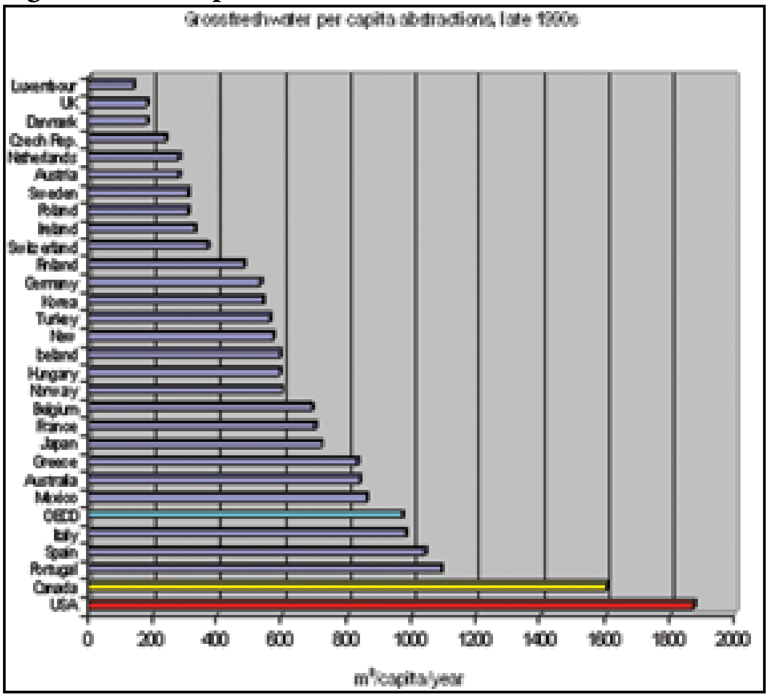
The steady generation of radioactive waste over the past decade reflects the continued use of nuclear power but the lack of growth in the number of nuclear power plants in North America. Nuclear waste is a serious threat to human health and the environment and, despite efforts to increase the efficient use of nuclear fuel and to optimize storage capacity, there are concerns about the region's capacity to store spent fuel (Fukuda and others, n.d.).

## Freshwater

### *Use of water*

*Comparative indicator*

**Figure 55: Per capita freshwater abstractions, late 1990s**




Source: Adapted from OECD 2001, 49.

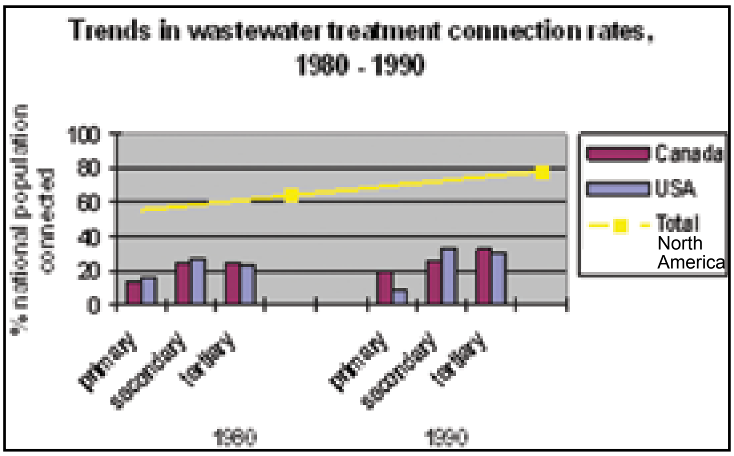
**Canada and the United States are the highest per capita users of water in the world**

This indicator shows the yearly amount of water used per capita in each of the OECD countries (Figure 55). Use is measured as abstractions, or total water withdrawal without deducting water that is reintroduced into the natural environment after use (OECD 2001).

The United States and Canada respectively are the two highest users of water on a per capita basis in the world. In fact, per capita water abstraction is two or three times greater than that of most OECD countries. In both countries, the electric power sector accounts for most water use (about 64 and 48 per cent of the total water abstraction in Canada and the United States respectively). Canada's high per capita use is accounted for to some degree by this reliance on hydroelectric power. This is followed by irrigation in the United States, with 34 per cent, and the manufacturing sector in Canada, which accounts for about 14 per cent of total abstractions. In Canada, agriculture accounts for only 9 per cent of abstractions (Hutson and others 2004; OECD 2004a). The pressures accounting for high water use in both countries include infrastructure development and maintenance; water-use conflicts; drought in the prairies; urban sprawl; and climate change (Gaudet 2004) as well as unrealistic water pricing. High water-use, especially for irrigation in drought-prone regions, is causing the unsustainable use of fossil water from aquifers while dams and water diversions to supply users have disrupted ecological processes and wildlife habitat.

### *Wastewater treatment*

**Figure 56: Trend in wastewater treatment connection rates, 1980–1997**




Source: Compiled by author from OECD 2001, 45.

**Wastewater treatment connection rates up**

Wastewater treament center

Kyer Wiltshire/UNEP/City of Santa Cruz

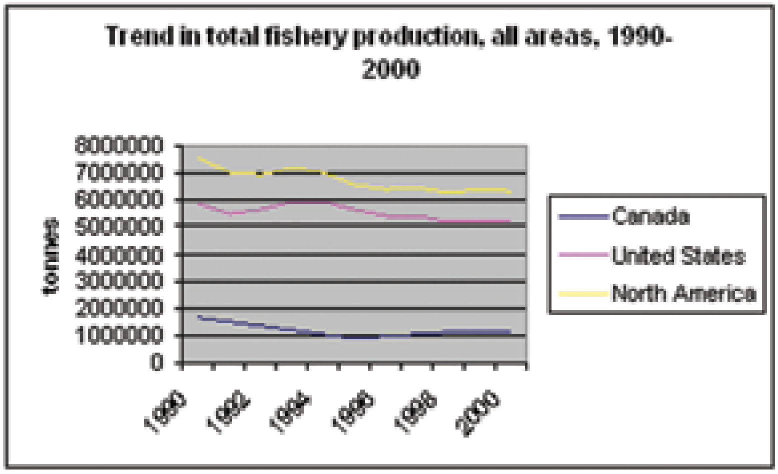
This indicator shows the percentage of the population connected to public wastewater treatment plants in the late 1990s, according to the type of treatment—primary (physical and mechanical processes), secondary (biological treatment technologies), and tertiary (advanced chemical treatment technologies)—and the total (Figure 56).

The indicator shows the steady rise in the percentage of the population served by sewage treatment. In 1996, wastewater treatment facilities provided for 73 per cent of the total US population. The indicator shows that at the same time, there was a steady increase in the proportion of facilities providing secondary and tertiary treatment. Untreated sewage and wastewater is still released into the environment, however. Newer statistics show that by 1999, 73 per cent of Canadians were served by municipal sewer systems, although about 3 per cent of Canadians were serviced by sewage collection systems that discharged untreated sewage directly into lakes, rivers, or oceans (EC 2002b) and only 33 per cent of the population was served by tertiary treatment (Boyd 2001). Numerous coastal areas and inland beaches in both Canada and the United States are frequently closed to recreational uses, fishing, and shellfish harvesting due to the pollution from such discharges or from storm water runoff that contains contaminants from inadequate sewage treatment.

## Fisheries

### *Fish harvests*

**Figure 57: Trend in total fishery production, all areas, 1990–2000**




**Fish production down**

Source: Compiled by author from FAOSTAT 2004.

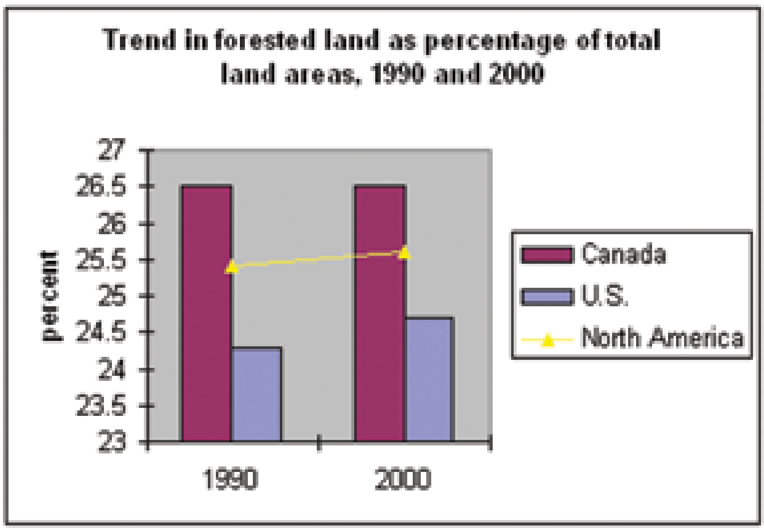
This indicator shows the tonnes of fish (species of fish in the nine divisions of the FAO International Standard Statistical Classification of Aquatic Animals and Plants) produced in all fishing areas of Canada and the United States from 1990 to 2000 (Figure 57).

There has been a downward trend in the volume of fish harvested from North American waters since 1990. Since they collapsed in the early 1990s, cod stocks in the cold waters off the Canadian Atlantic coast have not rebounded. There was a 78 per cent drop in Atlantic catches of groundfish in Canada between 1990 and 2002 and a marked decline in salmon stocks began in 1995 on the West Coast (Statistics Canada 2001b). Although US federal management of fisheries was strengthened in 1999 and overfishing of some stocks has been eliminated, of a total of 909 stocks reviewed in 2003, 76 were deemed to be overfished and 60 fish stocks thought to be fished at too high a rate, while the status of nearly 75 per cent of fish stocks managed by the federal government remained unknown (NMFS 2004). Both the United States and Canada recently adopted tougher fishing controls and are reducing the size of their fishing fleets (UNDP and others 1998).

## Forests

### *Forest area*

**Figure 58: Trend in total forest area as per cent of land area, 1990 and 2000**




**Forested area up slightly**

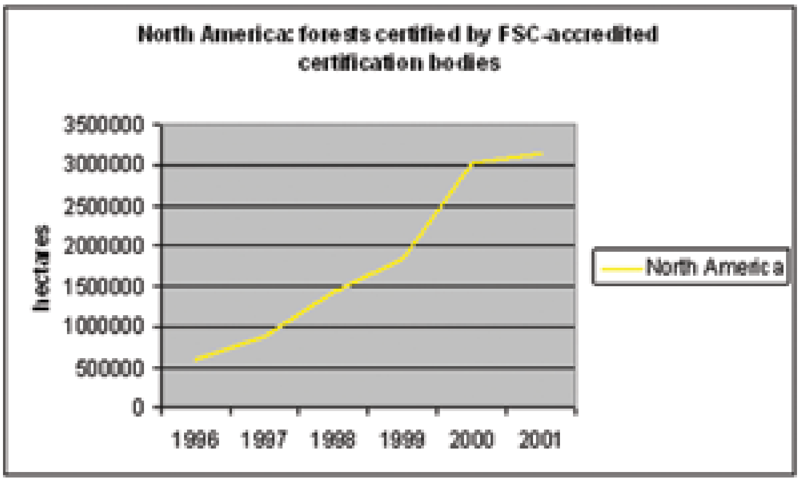
Source: Compiled by author from UN 2004 (metadata: FAO).

This indicator shows the per cent of total land area under forests in 1990 and 2000 (Figure 58). Forest includes natural forests and forest plantations. It refers to land with a tree canopy cover of more than 10 per cent and area of more than 0.5 hectares (UN 2004).

The area of forested land in North America is growing. There were substantial increases in forest areas in the United States during the decade, but these were partly offset by declining areas of other wooded land. The total area grew by about 3.9 million hectares (9.6 million acres) (FAO 2003). Canada's wooded area is assumed to have remained fairly constant over the decade, at 417.6 million hectares (1 032 million acres), of which over 70 per cent has never been harvested (OECD 2004a). North America is about 25.6 per cent forested, slightly below the global average of 30 per cent (FAO 2001b). The indicator does not reveal any information about the quality of the forests in terms of fragmentation, age of stands, insect and fire damage, and air pollution impacts, among other indicators of forest health.

### *Certified sustainable forests*

**Figure 59: Trend in FSC-certified forests, 1996–2001**




**Area of certified forests up**

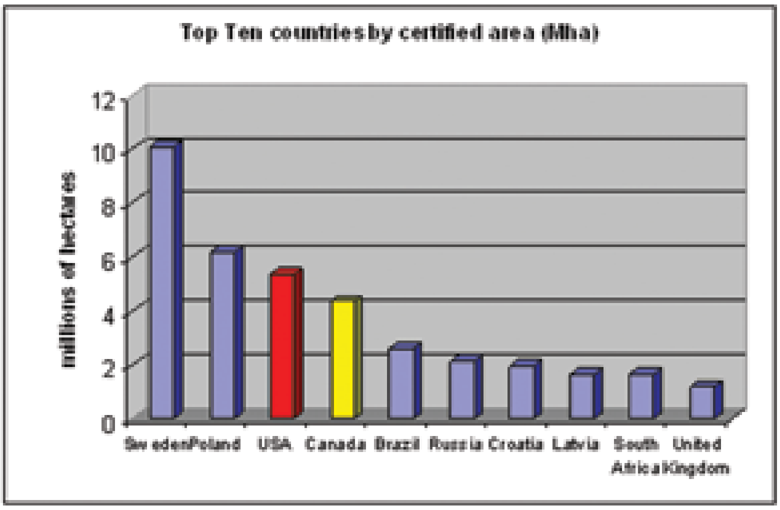
Source: Compiled by author from FSC (online data service) 2004.

This indicator shows the number of hectares certified as sustainable by accredited Forest Stewardship Council (FSC) bodies, from 1996 to 2001 (Figure 59). FSC-endorsed certification of a forest site signifies that an independent evaluation by one of several FSC-accredited certification bodies has shown that its management meets the internationally recognized FSC Principles and Criteria of Forest Stewardship. Some of the criteria include the assurance that areas of natural wealth and endangered wildlife habitat are not being negatively affected and that forest management does not put the forest's natural heritage at risk (FSC 2004; UNEP-WCMC 2004).

Although the Forest Stewardship Council (FSC), one of three major certification programmes in North America, was only created in 1993 and forest certification is still fairly new, the amount of certified forest worldwide has grown rapidly (Segura 2004). One of the drivers of this growth has been increased public awareness of forest destruction and degradation and the demand by consumers for wood and other forest products that do not contribute to this destruction but rather help to ensure sustainable forestry (FSC 2004). In 2003 alone, Canada doubled its certified lands, largely due to the first large-scale FSC certification in the boreal forest in Northern Ontario. Canada's growth in certification was a major factor in the 31 per cent increase in certified forest areas worldwide. At 56 million hectares, Canada has twice as much total certified area as the United States. One of the reasons for the difference is that a large share of forest products in the United States comes from non-industrial, privately-owned forest lands, where certification is much harder to implement than in Canada, where the expansion of certification has been on large-scale public lands (FSC 2004; IISD 2004b).

*Comparative indicator*

**Figure 60: Top ten countries with certified forests**




**United States and Canada are among the top four countries by certified forest area**

Source: Adapted from UNEP-WCMC/WWF 2004.

This comparative indicator ranks the top ten countries in the world in 2004 by the area (in millions of hectares) of land certified by the Forest Stewardship Council (FSC) (Figure 60).

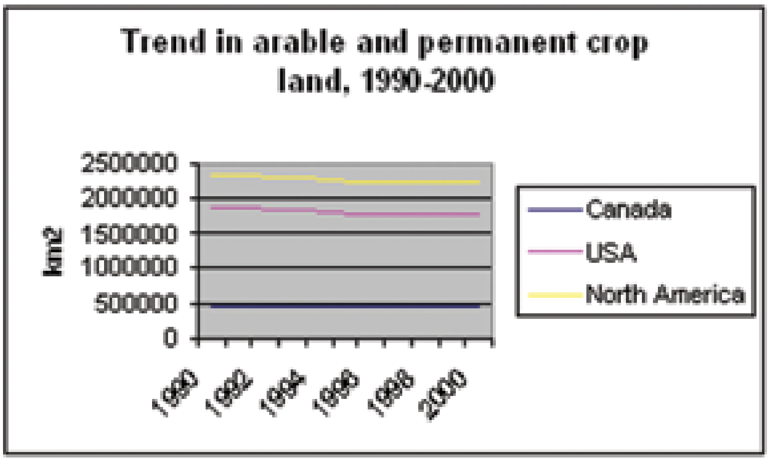
Canada and the United States are among the top four countries in the world with land certified by the Forest Stewardship Council. The FSC is one of three dominant North American forest certification programmes. The other two are the Canadian Standards Association (CSA) and the Sustainable Forestry Initiative (SFI) (IISD 2004b).

Aspens in fall color in Uncompahgre National Forest, USA. *Gene Alexander/UNEP/NRCS*

## Agricultural Lands

### *Area of cropland*

**Figure 61: Trend in arable and permanent-crop land, 1990–2000**




Source: Compiled by author from OECD 2002b, 7.

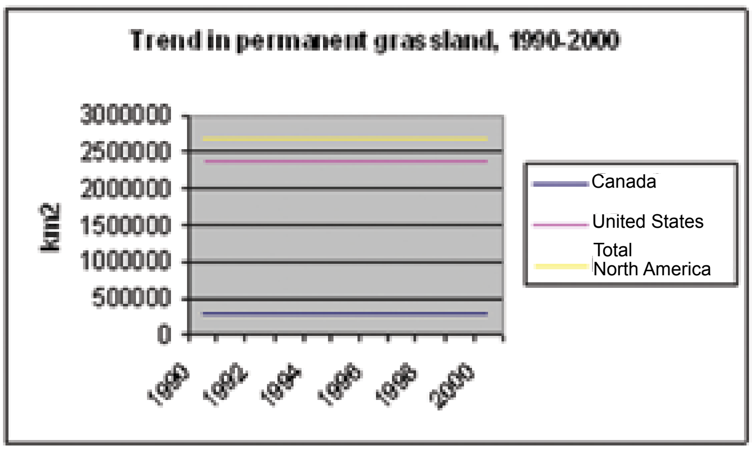
**Area in cropland down slightly**

Arable and permanent-crop land is the sum of the areas of arable land and land under permanent crops. "Arable land" refers to all land that can be cultivated to plant seed, including meadows and land that is left fallow (at rest, without a crop) in the cycle of crop rotation. Permanent crops are those that occupy land continuously for many years, rather than are completely replanted annually. They would include, for example, orchard and other trees; vines; shrubs and perennials grown for flowers, leaves, seed, fruit; and nursery stock (with the exception of trees grown for reforesting)(OECD 2002b).

There has been a slow decline in the amount of land under rotational and permanent crops in North America since 1990 (Figure 61), continuing a trend since the 1950s. In the United States, cropland area decreased 11 per cent between 1950 and 2000, from 35 per cent of the land area to 31 per cent (Brown and others 2004). In Canada, only 4.5 per cent of the total land area is arable and permanent-crop land (OECD 2004a). The decline in total area devoted to cropland in the United States is the result of a number of processes, including the conversion of agricultural land to other uses (especially urbanization), abandonment of poor-quality land, increases in productivity in the agriculture sector, and intensification of agriculture on land still cultivated. The decline varies by region, with the cornbelt and parts of the west showing stable cropland area while regions east of the Mississippi River experienced declines. Where the dominant factor is exurban growth and the abandonment of agricultural lands (especially in the Eastern United States), environmental impacts such as changes in the functioning of ecological systems and concerns about the potential for restoration are most significant, especially given the large areas affected. The ecological state of cropland varies depending on the intensity of irrigation and the use of fertilizers, pesticides, and herbicides (Brown and others 2004).

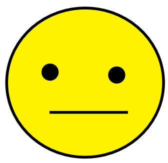
### *Area of grassland*

**Figure 62: Trend in permanent grassland, 1990–2000**




Source: Compiled by author from OECD 2002b, 8.

**Area in permanent grassland steady**



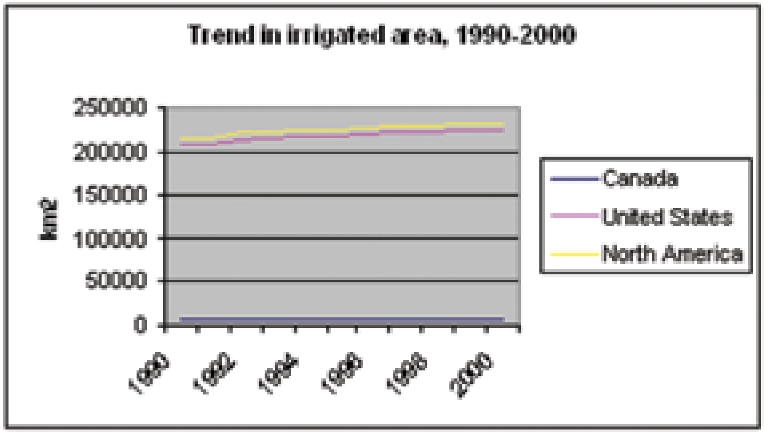
This indicator shows the 1990–2000 trend in the area (in square kilometers) of permanent grassland (Figure 62), which refers to land used for five years or more for herbaceous forage, either cultivated or growing wild.

The area devoted to grassland in North America has remained steady since 1990. This trend was preceded by a decline that started in the mid-1960s due to efforts to improve the forage quality and productivity of grazing lands that led to the need for less pasture and range to sustain grazing herds (Heimlich 2003). In the Western United States, the loss of grasslands to other uses has been offset by the conversion of land back to rangeland (Conner and others, n.d.). With about 31 per cent of the land in the contiguous United States under grassland, pasture, and range in 1997, this is the largest major land-use category in the country (Heimlich 2003). In Canada, only 2.9 per cent of the land base is permanent grassland (OECD 2004a). Native grasslands and rangelands support the livestock industry in both countries (Conner and others, n.d.).

Grasslands are important ecological areas because they store substantial amounts of carbon and cycle nutrients. While reclaiming land for pasture helps to soften the total loss of rangeland, the ecological value of reclaimed grassland is not as significant as undisturbed native grasslands. Population growth and development in the Great Plains can be a threat to the existence and health of grasslands, leading to loss, deterioration, and fragmentation—between 1990 and 2000, the population of the 22 states west of the Mississippi River increased by 17.3 per cent (Conner and others, n.d.). Grasslands are one of the world's most endangered ecosystems, and some experts consider them to be one of North America's highest conservation priorities. In the United States, the Endangered Species Act lists about 55 prairie grasslands wildlife species as either threatened or endangered (Bachand 2001).

### *Irrigated area*

**Figure 63: Trend in irrigated area, 1990–2000**




Source: Compiled by author from OECD 2002b, 10.

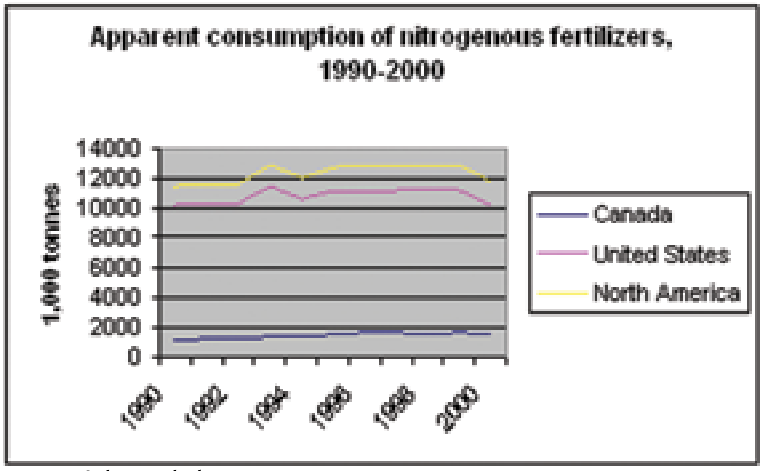
**Area under irrigation up**

This indicator shows the trend in the amount of land under irrigation between 1990 and 2000 (Figure 63). The data on irrigation relate to areas purposely provided with water, including land flooded by river water for crop production or pasture improvement (controlled flooding), whether this area is irrigated several times or only once during the year (OECD 2002b).

The amount of land under irrigation in North America has risen steadily since 1990. The United States, with 224 000 km$^2$ (55 351 605 acres) of irrigated land in 2002, has significantly more land under irrigation than does Canada, with only 7 200 km$^2$ (1 779 159 acres). Irrigation, the largest use of water in the United States, represents about 80 per cent of the nation's water consumption and as much as 90 per cent of freshwater consumption in the Western States (Heimlich 2003). Much of this water irrigates crops in dry regions. Irrigation from groundwater sources exerts a major pressure on available water resources (OECD 2002b). For example, irrigated agriculture is the dominant land use overlying the High Plains aquifer, which yields about 30 per cent of the water used for irrigation in the United States. From 1980 to 1997, the average area-weighted water level in the High Plains aquifer declined 0.8m (2.7 ft) (USGS 2003).

### *Fertilizer use*

**Figure 64: Trend in apparent consumption of nitrogenous fertilizers, 1990–2000**




**Fertilizer use up slightly**

Note: US data includes Puerto Rico.
Source: Compiled by author from OECD 2002b.

The indicator shows the trend in apparent consumption of nitrogenous fertilizer in North America between 1990 and 2000 in thousands of tonnes (Figure 64). The data in this indicator refer to the nitrogen (N) content of commercial inorganic fertilizers.

The use of nitrogenous fertilizer in North America continues to increase. The major source is commercial fertilizer, followed by animal manure. In the United States, consumption of all nitrogen products increased over 17 per cent between the 1991–92 and 1996–97 period. In Canada, nitrogen demand grew by 33 per cent in the same period (Korol and Larivière 1998). Given the much smaller agricultural base, Canada's fertilizer consumption is not nearly as high in absolute terms as that of the United States. Of all OECD countries, however, Canada's increase in the use of nitrogen fertilizer has been the largest (OECD 2004a). Increases vary across the country. More land in agriculture and more intensive use of the land in western Canada led to an increase of nearly 50 per cent since 1990, while in central Canada, a shift in crops and better management resulted in a decrease in fertilizer use despite increased yields in corn and other crops (Korol and Larivière 1998). In the United States, increases in the area planted account for the growth in use of commercial fertilizer, which rose to over 22 million tonnes during 1996–98. In 1998, 12.3 million tonnes of nitrogenous fertilizer was used, representing 55.4 per cent of total commercial fertilizer use. The increase was generally due to greater corn productivity that led to more demand by farmers (Daberkow, Taylor, and Wen-yuan Huang 2000).

Dietary preference, especially the consumption of meat, is a significant driver of nitrogen use in agriculture. The concentration of industrial livestock farming has led to the concentration of manure. When manure application exceeds the uptake by crops, excess nitrogen enters the environment (CGER 2000; Howarth and others 2002). The impacts include air- and water-quality impairment, and especially the eutrophication of aquatic and estuarine systems. Excess nutrients from fertilizer runoff transported by the Mississippi River are thought to be the primary cause of a large "dead zone" in the Gulf of Mexico (Larson 2004).

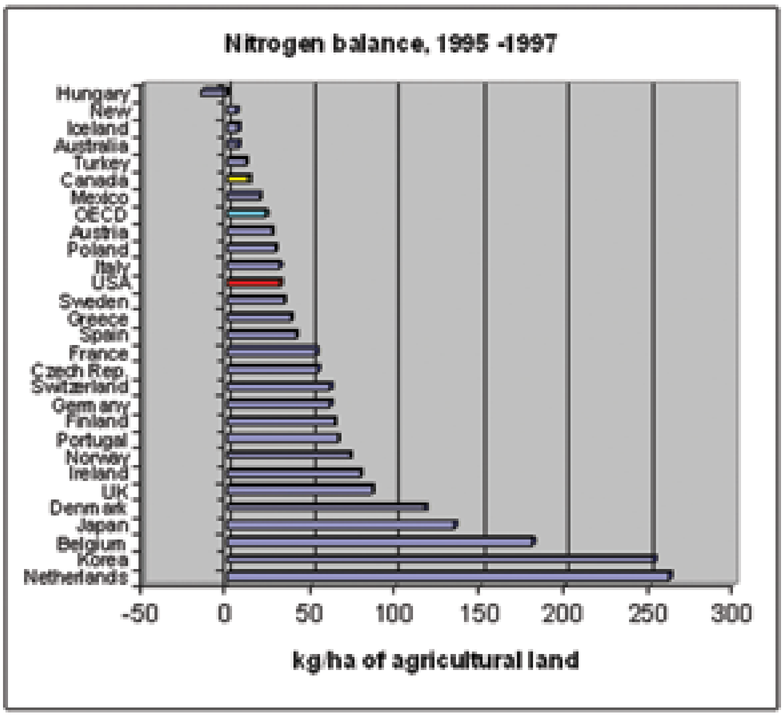
A manure slurry is applied to this field to help manage the animal waste and to add nutrients to the soil.

*Tim McCabe/UNEP/NRCS*

*Nitrogen balance*

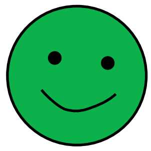
*Comparative indicator*

**Figure 65: Nitrogen balance, 1995–1997**




Source: Adapted from OECD 2001, 97.

**The nitrogen balance of agricultural land in Canada and the United States is less than in most other industrialized countries**



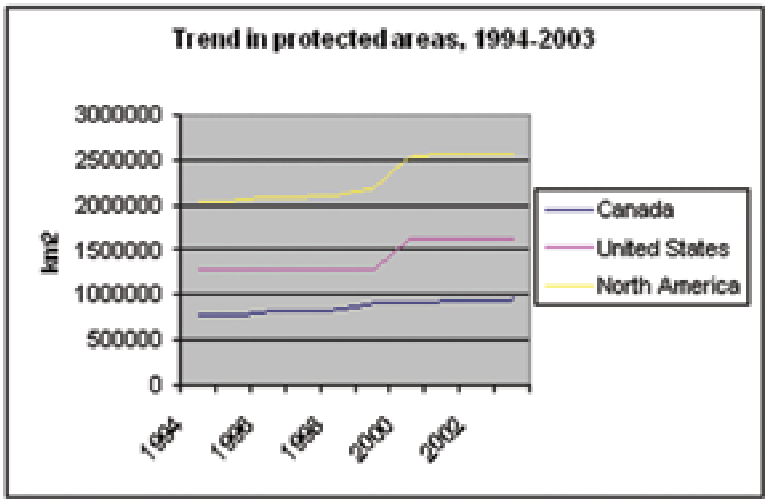
This indicator shows the average nitrogen balances in OECD countries between 1995 and 1997 (Figure 65). The nitrogen balance is the annual total quantity of inputs, mainly from livestock and chemical fertilizers, measured in kilogrammes per hectare of agricultural land. It provides information about the match between nutrient inputs and nutrient outputs and the potential loss of nitrogen to the soil, the air, and to surface or groundwater. The data exclude nitrogen loss to the atmosphere from livestock housing and stored manure (Daberkow, Taylor, and Wen-yuan Huang 2000; OEDC 2001).

Canada and the United States have relatively low nitrogen surpluses compared to other OECD nations. The impacts on the Canadian environment are felt regionally rather than at the national level (OECD 2004a). In the United States, nitrogen balances also vary regionally and from year to year, depending on the crop, the level of yields, and nutrient uptake (Daberkow, Taylor, and Wen-yuan Huang 2000).

## Biodiversity

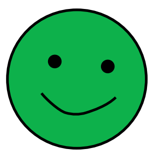
***Protected areas***

**Figure 66: Trend in protected areas, 1994–2003**




Source: Compiled by author from UN 2004.

**Protected areas up**



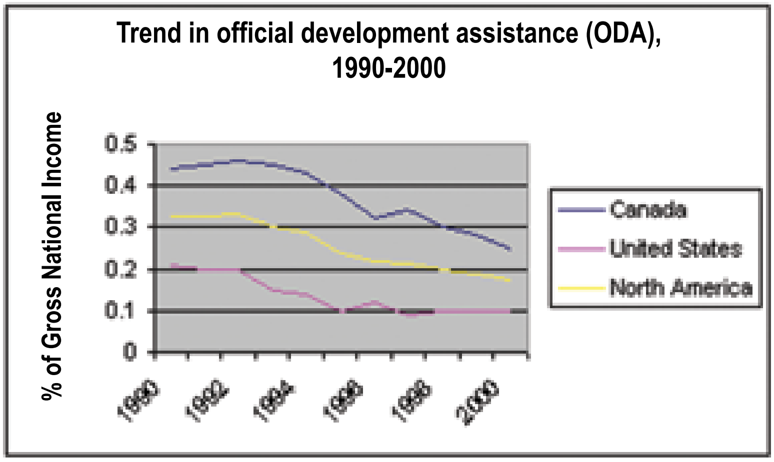
This indicator shows the trend in the area (square kilometers) of land and water set aside to protect and maintain biological diversity and natural and associated cultural resources (Figure 66). Protected areas are managed through legal or other effective means. The definition includes IUCN categories I–VI: areas under strict protection, national parks and monuments, areas conserved through active management, and protected landscapes and seascapes (UN 2004).

The area set aside for protection in North America has increased over the last decade, from 2 million to 2.6 million km$^2$ (494 million to 642.4 million acres). While such areas in North America and elsewhere may be categorized as protected, they vary in level of effective management. In 2003, some 10.9 per cent of the land area in the region was under some form of protection. The world average was 10.8. In Canada, 6.3 per cent of the land was protected under IUCN categories I–VI (excluding marine and littoral areas) in 2003 (WRI 2004). Canada has about 20 per cent of the world's remaining natural areas (OECD 2004a); some two-thirds of the land occupied by Canada's terrestrial ecoregions has some form of protection, but the other third has virtually none (NRCan 2004). Over the past decade, however, there was a 40 per cent increase in the area protected (OECD 2004a). Canada's target is to protect 12 per cent of its land. In the United States in 2003, 15.8 per cent was protected under IUCN categories I–VI. Although there has been a general increase in the area protected in the United States over the past 10 years, only three new parks have been created since 2000.

## National Responses

### *Official development assistance*

**Figure 67: Trend in official development assistance (ODA), 1990–2000**




**Official development assistance down**

Source: Compiled by author from OECD 2002b.

This indicator presents the trend in official development assistance (ODA) related to gross national income (Figure 67). Data refer to loans (except military loans), grants, and technical cooperation by the public sector to developing countries (OECD 2002b).

This is an important response indicator, since a large part of ODA goes towards conserving natural resources, protecting the environment, and funding population programmes in developing countries. It is appropriate that North America provide such aid to less developed regions since North America's large ecological footprint means that its activities have important impacts on regions beyond its shores, and since its own environmental quality depends on the health of global ecosystem goods and services. The indicator shows that Canada reduced the percentage of its gross national income devoted to ODA from 0.44 per cent in 1990 to 0.25 per cent in 2000 and the United States reduced it from 0.21 per cent to 0.01 per cent during this time. These amounts fall far short of the UN target, agreed to by the international community in 1970, of 0.7 per cent (ICPD 1994).

# List of Acronyms and Abbreviations

| | |
|---|---|
| AQI | Air Quality Index (US) |
| $C_{10}H_{12}N_2O$ | cotinine |
| CCs | collaborating centres |
| CCME | Canadian Council of Ministers of the Environment |
| CEC | Commission for Environmental Cooperation of North America |
| CEPA | Canadian Environmental Protection Act |
| CEQ | Council on Environmental Quality (US) |
| CESCC | Canadian Endangered Species Conservation Council |
| CFCs | chlorofluorocarbons |
| CISE | Canadian Information System for the Environment |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| COSEWIC | Committee on the Status of Endangered Wildlife in Canada |
| CRP | Conservation Reserve Program (US) |
| CSA | Canadian Standards Association |
| CSD | United Nations Commission for Sustainable Development |
| DDE | dichlorodiphenyldichloroethylene |
| DDT | dichlorodiphenyltrichloroethane |
| DESA | United Nations Department for Economic and Social Affairs |
| dkl | decalitre |
| DPSEEA | driving force, pressure, state, exposure, effect, action |
| DPSIR | driving force, pressure, state, impact, response |
| DSR | driving force-state-response |
| EID | environmental indicators database |
| EJ | Exajoules |
| EPA | Environmental Protection Agency (US) |
| ESDI | Environment and Sustainable Development Indicators |
| ESI | Environmental Sustainability Index |
| FSC | Forest Stewardship Council |
| ft | feet |
| g | gram |
| GAO | United States Government Accountability Office |
| GBIF | Global Biodiversity Information Facility |
| GDP | gross domestic product |
| GEO | Global Environment Outlook |
| GEOSS | Global Earth Observation System of Systems |
| GHG | Greenhouse gases |
| Gl | gallon |
| GLWQA | Great Lakes Water Quality Agreement |
| GNP | gross national product |
| GPA | United Nations Global Programme of Action for the Protection of the Marine Environment from Land-based Activities |
| GPAC | Global Programme of Action Coalition for the Gulf of Maine |
| ha | hectare |
| HCFCs | hydrochloroflorocarbons |
| Hg | mercury |

| | |
|---|---|
| IEA | International Energy Agency |
| IUCN | World Conservation Union (International Union for the Conservation of Nature and Natural Resources) |
| K | Potassium |
| km | kilometre |
| l | litre |
| lbs | pounds |
| $m^3$ | cubic metre |
| MDGs | Millennium Development Goals |
| MEME | multiple exposures–multiple effects |
| mg | milligram |
| MSW | municipal solid waste |
| $N_2$ | nitrogen |
| NAAEC | North American Agreement on Environmental Cooperation |
| NAAQO | National Ambient Air Quality Objectives (Canada) |
| NAAQS | National Ambient Air Quality Standards (US) |
| NAFTA | North American Free Trade Agreement |
| NATS | North American Transportation Statistics Interchange |
| NEON | National Ecological Observatory Network (US) |
| NGO | Non-governmental organization |
| NIRO | National Indicators and Reporting Office (Canada) |
| $NO_x$ | nitrogen oxides |
| $NO_2$ | nitrogen dioxide |
| $NO_3$ | nitrate |
| NOAA | National Oceanic and Atmospheric Administration (US) |
| NPL | Superfund National Priorities List (US) |
| NPRI | National Pollutant Release Inventory (Canada) |
| NRDC | Natural Resources Defense Council |
| NRTEE | National Round Table on the Environment and the Economy (Canada) |
| $O_3$ | ozone |
| ODA | official development assistance |
| ODP | ozone-depleting potential |
| ODS | ozone depleting substances |
| OECD | Organization for Economic Co-operation and Development |
| P | phosphorous |
| Pb | lead |
| PBTs | persistent bioaccumulative toxics |
| PCB | polychlorinated biphenyl |
| PCSD | President's Council on Sustainable Development (US) |
| PM | particulate matter |
| $PM_{10}$ | particulate matter with an aerodynamic diameter less than 101micrometer |
| $PM_{2.5}$ | particulate matter with an aerodynamic diameter less than 2.51micrometer (fine particulate) |
| POPs | persistent organic pollutants |
| ppb | parts per billion |
| PPP | purchasing power parities |
| PRTR | Pollutant Release and Transfer Register |

| | |
|---|---|
| PSR | pressure-state-response |
| RCRA | Resource Conservation and Recovery Act (US) |
| Rn | radon |
| RPA | Resource Planning Act (US) |
| SD | sustainable development |
| SDI Group | Interagency Working Group on Sustainable Development Indicators (US) |
| SFI | Sustainable Forestry Initiative |
| SIDA | Swedish International Development Agency |
| $SO_x$ | sulphur oxides |
| $SO_2$ | sulphur dioxide |
| $SO_{42}$ | sulphate |
| SOE | State-of-the-environment |
| SOLEC | State of the Lakes Ecosystem Conference |
| SUV | sports utility vehicle |
| TEEI | transportation, energy, and environment indicators |
| TRI | Toxics Release Inventory (US) |
| μg | microgram |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USLE | universal soil loss equation |
| VMT | vehicle miles travelled |
| VOC | volatile organic compounds |
| WCED | World Commission on Environment and Development |
| WHO | World Health Organization |
| WRI | World Resources Institute |
| WSSD | World Summit on Sustainable Development |

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## Appendix 1: Table 2–Comparative table of Canadian and US environmental indicators

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| **Drivers** | **Drivers** | **Drivers** | **Drivers** | **Drivers** |
| | % change in population, GDP per capita and energy use per capita since 1990 (to 2000) | % change in population, GDP, energy consumption, VMT, and aggregate emissions of criteria air pollutants since 1970 (to 2001) | | % change in population, GDP per capita and energy use |
| ***Energy and Transportation*** | ***Energy and Transportation*** | ***Energy and Transportation*** | ***Energy and Transportation*** | ***Energy and Transportation*** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | primary energy consumption (exajoules [EJ]), 1958–2000 | | | |
| | fossil fuel consumption (total, crude oil, natural gas, coal) (EJ), 1958–2000 | | | |
| | secondary energy use (EJ), with actual use and energy saved through improved efficiency, 1990–2000 | | | |
| | passenger travel (car, plane, bus, train), (thousand million passenger-km), 1976–2000 | | | |
| | automobiles, vans, and light trucks fossil fuel use, (thousand millions litres of gasoline), 1950–1998 | | per capita annual gasoline consumption for motor vehicles, 1997 | trend in gasoline use by motor vehicles |
| | urban automobile and transit use (thousand millions passenger-km), 1976–2000 | | | |
| *State* | *State* | *State* | *State* | *State* |
| | | | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | new vehicles fuel efficiency ($l/10^2$ km), 1977–2001 | | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| **Pollution Issues** | **Pollution Issues** | **Pollution Issues** | **Pollution Issues** | **Pollution Issues** |
| | | | | |
| ***Climate Change*** | ***Climate Change*** | ***Climate Change*** | ***Climate Change*** | ***Climate Change*** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| total GHG emissions (gigatonnes $CO_2$ equivalents), 1980–2000 | total GHG emissions (gigatonnes $CO_2$ equivalent), 1980–2000, with Kyoto benchmark | | | |
| *State* | *State* | *State* | *State* | *State* |
| | mean Canadian temperature variation, 1961–1990 (5-yr avgs) | | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | # weather-related disasters, 1900–1999 | | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **$O_3$ Layer** | **$O_3$ Layer** | **$O_3$ Layer** | **$O_3$ Layer** | **$O_3$ Layer** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | new supplies: $O_3$ -depleting substances (CFCs and all ODSs) (kilotonnes, CFC-11 equivalent), 1979–2000 | US production of selected ODSs ($10^3$ metric tonnes of CFC-11 equivalent ), 1958–1993 | | trends in ODS production |
| *State* | *State:* | *State* | *State* | *State* |
| | | | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | mean annual $O_3$ level over Canada (Dobson units*), 1957–2001 | $O_3$ levels over North America (Dobson units), 1979 and 1994 | | trend in $O_3$ levels over North America |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **Air Quality** | **Air Quality** | **Air Quality** | **Air Quality** | **Air Quality** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | $SO_2$ emissions for total Canada and eastern Canada ($10^6$ tonnes), 1980–2000, with targets | sectoral $SO_2$ emissions ($10^3$ short tonnes), 1982–2001 | | trend in criteria pollutants emissions |

*defined as thickness of 1 mm of ozone at 0°C at sea level pressure

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | $NO_x$ emissions ($10^6$ tonnes), 1980–2000 | sectoral $NO_x$ emissions ($10^6$ short tonnes), 1982–2001 | | |
| | non-methane VOC emissions from all sources (kilotonnes), 1980–2000 | sectoral VOC emissions ($10^3$ short tonnes), 1982–2001 | | |
| | | sectoral, direct $PM_{10}$ emissions ($10^3$ short tonnes), 1985–2001 | | |
| | | sectoral direct $PM_{2.5}$ emissions ($10^3$ short tonnes), 1992–2001<br>sectoral Pb emissions ($10^3$ short tonnes), 1982–2001 | | |
| | | criteria pollutants aggregate emissions change (%) compared to growth measures, 1970–2000 | | |
| | | $10^8$ toxic air pollutants: national air toxics emissions ($10^6$ tonnes/day) 1990–1993, 1996 | | |
| *State* | *State* | *State* | *State* | *State* |
| | total suspended levels PM, $NO_2$, $SO_2$, and CO (% maximum acceptable levels) 1980–2000 | | | |
| | average annual ambient $PM_{2.5}$ levels (5 cities, µg/m³), 1998, 1999, 2000 | annual average $PM_{2.5}$ concentrations, 6 categories (µg/m³), 2001 (map) | | average annual $PM_{2.5}$ concentrations |
| | national ambient levels: ground level $O_3$ (ppb), 1990–2000 | | % air pollution monitoring stations (urban and suburban areas) with $O_3$ exceeding 8-hour mean concentrations (4 ranges) 1990–2002 | |
| | ground-level $O_3$ mean concentrations (ppb) for eastern and western provinces, 1982–2000, with Canada-wide standard as benchmark | 8-hour $0_3$ regional concentrations (ppm), 1982–2001 (map) | air monitoring stations exceeding 8-hour $O_3$ threshold for <4 days, and >4 days, 2002 (2 maps) | trend in $O_3$ concentrations, by region |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | percent reduction in concentration of 6 criteria air pollutants, 1982–2001 compared to 1992–2001 | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | # and % days w/ Air Quality Index (AQI) greater than 100, 1988–2001 | | |
| mean daily 8-hr max $O_3$ exposure by population (ppb), 1986–2000 | | people (#) living in areas w/ 8-hr $O_3$ and PM2.5 levels above NAAQS, 2001 | | population exposed to 8-hr $O_3$ above acceptable levels |
| | | Pb (g/dkl) in blood of children 5 and under, 1976–1980, 1988–1991, 1992–1994, 1999–2000 | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **Acid Deposition** | **Acid Deposition** | **Acid Deposition** | **Acid Deposition** | **Acid Deposition** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | Canada and eastern Canada total $SO_2$ emissions ($10^6$ tonnes), 1980–2000, with targets | sectoral $SO_2$ emissions ($10^3$ short tonnes), 1982–2001 | | |
| | $NO_x$ emissions ($10^6$ tonnes), 1980-2000 | sectoral $NO_x$ emissions ($10^3$ short tonnes), 1982–2001 | | |
| | | $SO_2$ power plant emissions ($10^6$ tonnes), 1980–2001 | | |
| | | $NO_x$ power plant emissions ($10^6$ tonnes), 1990–2001 | | |
| *State* | *State* | *State* | *State* | *State* |
| | | | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | lake $SO_4^2$ level trends (% lakes studied in 3 regions), 1981–1997 | | | |
| | lake acidity trends 1981–1997 (% of lakes studied) | | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | wet $SO_4^{2}$ deposition 4-year mean (kg/ha, 7 categories), 1980–1983 compared to 1996–2000 (map of eastern North America) | wet $SO_4^{2}$ deposition (kg/ha), 1989–1991 compared to 1999–2001 (map of US) | | change in wet $S0_4^{2}$ deposition distribution |
| | wet $NO_3$ deposition (kg/ha, 7 categories) 4-year mean, 1980–1983 compared to 1996–2000 (map of eastern North America) | wet $NO_3$ deposition (kg/ha), 1989–1991 compared to 1999–2001 (map of US) | | change in wet $NO_3$ deposition distribution |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| **Indoor Air Quality** | **Indoor Air Quality** | **Indoor Air Quality** | **Indoor Air Quality** | **Indoor Air Quality** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| *State* | *State* | *State* | *State* | *State* |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | % homes w/ young children exposed to environmental tobacco smoke, 1986–1998 | | |
| | | $C_{10}H_{12}N_2O$ (μg/ml) in blood of children age 5 and under, 1990–1991 and 1999–2000 | | |
| | | # homes and % national housing units above EPA Rn action levels, 1991 | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| **Toxic Substances** | **Toxic Substances** | **Toxic Substances** | **Toxic Substances** | **Toxic Substances** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | % emissions change (15 toxic substances w/ matched data (NPRI), 1995–2000 | total Toxics Release Inventory (TRI) releases across industry (short tonnes), 1998, 1999, 2000; yearly totals; and change by industry 1998–2000 | | |
| | Hg emissions ($10^3$ kilograms), 1990–2000 | | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | total Toxics Release Inventory (TRI) releases by industry (%), 2000 | | |
| *State* | *State* | *State* | *State* | *State* |
| | | trends in toxic chemicals (energy recovery, quantity released, quantity treated, recycled), 1998–2000 (short tonnes) | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | PCBs and DDT Great Lakes atmospheric deposition (kg/yr), 1992–1998 | | |
| | contaminant levels (ppm DDE and PCBs) in double-crested cormorant eggs at 4 sites, 1970–2000 | Great Lakes fish tissue PCBs (ppm), 1972–2000 | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | 17 waste minimization priority chemicals (WMPC) releases ($10^6$ lbs), 1991–1998 | | |
| **Waste** | **Waste** | **Waste** | **Waste** | **Waste** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | municipal solid waste (MSW) generation rates (total tonnes and per capita lbs/day), 1960, 1970, 1980, 1990, 1995, 2000 | | |
| | | total amount radioactive waste generated, by type and unit, 2000 | | |
| *State* | *State* | *State* | *State* | *State* |
| | | composition of total municipal solid waste generated (%), 2000 | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | # and location of MSW landfills in 4 regions, 2000 | | |
| | | # and location of RCRA hazardous waste management facilities, by EPA region, 1999 | | |
| | | # and location of Superfund National Priorities List (NPL) sites by status and milestone, 1990–2002 | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | total non-hazardous solid waste disposal and recycling/reuse by sector (megatonnes), 1996, 1998, 2000 | municipal solid waste (MSW) management (composting, recycling, combustion, landfill), (megatonnes), 1960–2000 | | trends in MSW management |
| | per capita non-hazardous solid waste disposal and recycling/reuse (kg/person), 1994, 1996, 1998, 2000 | source reduction of MSW (megatonnes), 1992–2000 quantity of RCRA hazardous waste generated (% by region) and managed (% by method) | | |
| | | # and location of RCRA corrective action sites | | |
| **Natural Resources and Services** | **Natural Resources and Services** | **Natural Resources and Services** | **Natural Resources and Services** | **Natural Resources and Services** |
| **Land Use** | **Land Use** | **Land Use** | **Land Use** | **Land Use** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | | |
| *State* | *State* | *State* | *State* | *State* |
| | long-term (pre-settlement) | long-term (pre-settlement) and recent trends in ecosystem extent (% of all lands in 4 types), 1950s–1990s | and recent trends in ecosystem extent (% of all lands in 4 types), 1950s–1990s | |
| | | | long-term (pre-settlement) extent (% of total land area) and 1992 extent (acres) of 6 ecosystem types, with changes from 1950s | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | | change in ecosystem area compared to 1955 (Macres) | |
| | | | land cover (6 categories) and ocean depth (6 categories) (map) | |
| | | bird species (types of birds), as characteristics of landscape composition, and pattern, as an indicator of landscape condition, 1995–1996 | natural ecosystem services | |
| | | terrestrial plant growth index, by ecosystem, 1989–2000 | | |
| | | | fragmentation of landscape pattern (national level) | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | | % of land area and stream and coastline length, according to the level of disturbance, management, or physical alteration | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **Freshwater Resources** | **Freshwater Resources** | **Freshwater Resources** | **Freshwater Resources** | **Freshwater Resources** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | freshwater withdrawals: sectoral sources ($10^9$ gallons/day), 1960–1995 | total freshwater withdrawals for irrigation, thermoelectric, industrial, municipal and rural use ($10^9$ gallons [Bg]/day), 1960–1995 | trends in municipal water extraction |
| | | | total withdrawals: surface water and groundwater (Bg/day), 1960–1995 | |
| | daily municipal water use/capita (l/person) 1983–1999 | | | |
| | total daily municipal water use (Gl/day), 1983–1999 | | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | water abstractions/irrigated land area (m3/ha/year), 1997 | | |
| | | cultivated land: % irrigated areas share, 1997, and % change since 1980 | | |
| | | sources of acidity (watershed sources, organic or acid deposition) in acid-sensitive lakes and streams, 1984–1986 | | |
| | | Hg, dioxin, PCBs, PBTs toxic release to water, 2000 | | |
| *State* | *State* | *State* | *State* | *State* |
| | | extent of ponds, lakes, and reservoirs, excluding the Great Lakes (Macres), 1950s–1990s | extent of ponds, lakes, and reservoirs, excluding the Great Lakes (Macres), 1950s–1990s | |
| | | est. streams and rivers mileage, 1997-2002 | length of small, medium, and large streams and rivers | |
| | | extent of submerged aquatic vegetation in estuarine systems (acres) | riparian land cover of streams and rivers (% riparian miles, each of 3 land use catergories), 1990's | |
| | | | % of lake and reservoir area with low-, medium-, and high-clarity water | |
| | | | stream habitat quality | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| freshwater quality index | | | | |
| | | | % stream, pond, lake, and riparian zone miles and wetland acres that have been altered | |
| | | | groundwater levels | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | $NO_3$- levels (mg/l) in streams of forests, grasslands and shrublands, farmlands, urban and suburban ecosystems, 1992–1998 | | |
| | | $NO_3$- load carried by 4 major rivers (kilotonnes/yr), 1950s–2000 | $NO_3$- load carried by 4 major rivers (kilotonnes/year), 1950s–2000 | |
| | | total N yield (lbs/acre/year) from major watersheds (6 categories), 1996–1999 (map) | total N yield (lbs/acre/year) from major watersheds (6 categories), 1996–1999 (map) | |
| | | annual mercury wet deposition (μg/m2), 2001 (map) | | |
| | | number of contaminants in streams and ground water (% of sites, 3 categories), 1992–1998 | number of contaminants in streams, ground water, and streambed sediment (% of sites, 3 categories), 1992–1998 | |
| | | summary of detections of 1 or more pesticides in streams and ground water (frequency of detection as % of samples), 1992–1998 | | |
| | | watersheds in sediment quality inventory (1980–1999) containing areas of particular concern (APCs) (map) | | |
| | | % tested sites (large rivers) w/ total P concentrations (4 ranges ppb) 1991–1996 | | |
| | | | % all lakes with indicated total P concentration (4 ranges ppb) | |
| | | | % urban/suburban stream sites w/ detected number of contaminants (3 catagories), 1992–1998 | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | | % stream sites exceeding # human health and aquatic life standards or guidelines (3 categories) , 1992–1998 | |
| | | | % groundwater sites exceeding # human health standards or guidelines (3 categories), 1992–1998 | |
| | | | streambed sediment: % stream sites exceeding # aquatic life standards or guidelines (3 categories), 1992–1998 | |
| | | | % urban/suburban stream sites w/ chemical contaminant concentrations above aquatic and human health standards and guidelines, 1992–1998 | |
| | | animal mortality events (#/5yrs, regional), 1985–1989, 1990–1994, 1995–1999 | animal mortality events (#/5yrs, regional), 1985–1989, 1990–1994, 1995–1999, and by region (6) | |
| | | tropic state index for northeast lakes, 1991–1994 | | |
| | % municipal population on sewers with 2ndary and/or 3tiary treatment, 1983–1999 | | | |
| | total estimated P loadings to waters from municipal wastewater treatment plants (tonnes/year) | | | |
| | | # reported waterborne disease outbreaks (#/yr) associated with drinking water (type of water system), 1971–2000 | outbreaks (#/yr) attributed to waterborne disease-causing organisms (drinking water or recreational contact), 1970s to 2000 | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | | % gauged streams/rivers w/ major, moderate, and minimal low flow and high flow changes, 1970s, 1980s, and 1990s, against 1930–1949 reference period | |
| | | | % gauged streams/rivers w/ low and high flows increase, decrease, or timing, 1970s, 1980s, 1990s, against 1930–1949 reference period | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | population (total and %) served by community water systems w/ no reported national health-based standards violations, 1993–2002 | | |
| **Wetlands** | **Wetlands** | **Wetlands** | **Wetlands** | **Wetlands** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | | |
| *State* | *State* | *State* | *State* | *State* |
| % wetland area (5 categories), 1986 (distribution map) | % wetlands area, 1986 (distribution map) | est. wetland extent (acres), 1977–1982 and 1997–2002 | freshwater wetlands (% land area), 1950–2000 | trend in % land area in wetlands |
| | | | extent of freshwater wetlands (Ma), 1950s–1990s, and historic total (1780) | |
| | | | Atlantic and Gulf Coasts coastal vegetated wetlands (Ma), 1950–2000 | |
| | | altered freshwater ecosystems trends in selected freshwater wetlands (acres), 1954–1997 | | |
| | | regional non-federal wetland losses and gains and reasons for conversion (%), 1992–1997 (map) | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | average annual wetland loss (acres), 1954–1974, 1974–1983, 1986–1997 | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **Coastal Resources** | **Coastal Resources** | **Coastal Resources** | **Coastal Resources** | **Coastal Resources** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | | |
| *State* | *State* | *State* | *State* | *State* |
| | | est. estuarine surface area (acres) and coastline (miles), 1996–1998 | | |
| | | coastal living habitats extent ($10^6$ acres), 1950s–1990s | coastal living habitats extent ($10^6$ acres), 1950s–1990s | |
| | | % of total regional shoreline, in types of coastal shoreline, by region, 2000 | % of total regional shoreline in types of coastal shoreline by region, 2000 | |
| | | % coastal areas where benthic communities are in good, fair, or poor condition, in Mid-Atlantic, South Atlantic and Gulf of Mexico, 2000 | % ocean bottom area where benthic communities are undegraded, moderate, or degraded, by region, 1990–1997 and 1999–2000 | |
| | | water clarity: % estuarine area with good, fair, or poor light penetration, 1990–1997 | | |
| | | estuarine area with poor, fair, or good dissolved oxygen conditions, 2000 | % estuarine and coastal areas by level of dissolved oxygen | |
| | | % Mid-Atlantic estuarine areas with low, intermediate, or high total organic carbon content in sediments, 1997–1998 | | |
| | | chlorophyll concentrations (ppb) in 9 ocean regions, 1998–2000 | chlorophyll concentrations (ppb) in 9 ocean regions, 1995–2000 | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | % estuaries w/ high, moderate, or low eutrophic condition levels, 1998 | % estuaries with high, moderate, and low chlorophyll concentrations | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | | sediment contamination of ocean | |
| | | sediment enrichment (% area) by metals, pesticides, and PCBs due to human sources in estuaries of 5 regions, 1990–1997 | coastal sediment contamination (% area exceeding indicated # guidelines) in estuaries of 5 regions, 1990–1997 and 1999–2000 (3 categories) | |
| | | | coastal sediment in estuaries (% area) exceeding # of guidelines (3 categories) for aquatic life, 1990–1997 and 1999–2000 | |
| | | | sea surface temperature change (Western and Eastern regions, against 14-yr average), 1985–2000 | |
| | | reported sources of pollution (%) that resulted in beach closings or advisories, 2001 | | |
| | | number of beach days that beaches are closed or under advisory, 2001 | % "beach-mile-days" affected by various levels of Enterococcus | |
| | | # unusual marine mortaities, 1992–2001 | # unusual marine mortalities, 1992–2001 | |
| | | | # harmful algal blooms of low, medium or high intensity | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | coastal erosion management | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| **Fish Resources** | **Fish Resources** | **Fish Resources** | **Fish Resources** | **Fish Resources** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | commercial fish and shellfish landings by region (megatonnes) 1950–2000 | |
| *State* | *State* | *State* | *State* | *State* |
| | | | % commercially important fish stocks w/ known status (increasing or decreasing volume), by region, 1981–1999 | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | | % fish samples exceeding number of standards or guidelines for aquatic life (3 categories), 1992–1998 | |
| | | occurrence (% of fish samples) of contaminants (3 categories) in fish tissue, 1992–1998 | occurrence (% of fish samples) of contaminants (3 categories) in fish tissue, 1992–1998 | |
| | | watersheds w/ fish tissue concentrations exceeding health-based national water quality Hg criteria, 2001 (map) | | |
| | | watersheds with fish tissue concentrations exceeding health-based national water quality PCBs criteria, 2001 (map) | | |
| | | fish abnormalities (% fish examined), 2001 | concentration of PCBs, mercury, and DDT in edible tissue of seafood from coastal waters | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | % river (miles) and lake (acres) under fish consumption advisory, 1993–2001 | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| **Forests** | **Forests** | **Forests** | **Forests** | **Forests** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | total area harvested (kha), 1950–1998 | | timber harvest (by primaryproduct category and by region, $Bft^3$), 1950–2002 | trend in timber harvest |
| | | owner group (public/private) timber removals (thousand millions square feet [$Bft^2$]), various years from 1952 to 2001 | owner group (public/private) timber growth and harvest by region ($Bft^3$), 1950–2002 | |
| | | | recreation in a forest setting (thousand millions times/yr, 11 categories), 2001 | |
| *State* | *State* | *State* | *State* | *State* |
| forest crown closure (each $10^2$ ha), from satellite images, 1998 (map) | | forest lands acreage est., 1977–1982 and 1997–2002 | acres of forests (Ma) East and West, 1600–1900 and 1950–2000 | trend in forest cover |
| total area of each of 12 ecosystems with crown closure over 10%, 1998 | | trends in forest types (increasing or decreasing in area), by region (Western, Eastern), 1963–1997 | trends in forest types (increasing or decreasing in area), by region (Western, Eastern) 1963–1997 | |
| | | acres of forest land ownership (private and public) by region (4 regions), 2001 | acres of forest by land ownership East and West (public, forest industry, other private), 1997 | |
| | | | % forest lands with stands in several age classes, 1997 | |
| | forest bird species population status (3 categories) in 4 forested ecozones (number of species), 1968–2000 | populations (# of tree and bird species or groups of species) of representative forest species, by diameter class (<-50%; -50% to 0%; 0 to +50%; >+50%), 1970–2002 | | trend in forest bird populations |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | % trees in each of 4 RPA regions with diminished biological component: (% yes and % no), 1990–1999 (map) | | |
| | | contribution of forest ecosystems to total global carbon budget: average Mt/yr net carbon pool change, 1953–1996 | forests C storage (gigametric tonnes), 1950–2000, East and West | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | forest cover and neighborhood size (% mostly forested), in the East and West (immediate, local, and larger neighborhood), 1992 | forest cover and neighborhood size (% mostly forested) in the East and West (immediate, local, and larger neighborhood), 1992 | |
| | spruce budworm defoliation: consecutive yrs (two categories), 1980–1996 (map) | acres forest disturbed by insects, forest fires, and disease (Ma), 1979–2000 | acres forest disturbed by insects, forest fires, and disease (Ma), 1979–2000 | |
| | forest fires ($10^3$) and area burned (Mha), 1970–2000 | | % forest lands burned by wildfire (compared to pre-settlement) | trend in area burned in forest wildfires |
| | | % change in annual harvest, annual growth, and growing stock since 1990 | | |
| | | | total area of forest community types with significantly reduced areas (since pre-settlement) | |
| | | | number of community types with significantly reduced area that are increasing or decreasing in size (4 categories) | |
| | | ozone injury to trees (% of plots in 4 regions), 1994–2000 | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | frequency distribution of % of plot area exhibiting evidence of surface compaction on FHM program plots, 1999–2000 | | |
| | | | % forest streams with mean $NO_3$- concentrations (1 of 4 ranges), 1992–1998 | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | trend in % strictly protected area, for 4 ecozones, 1992–2001 | | % forest area in East and West in 1 of 4 management categories, 1953–1997 | trend in area of protected forest |
| | | | forest planted timberland (% area), 1953–1997 | |
| | | | % natural/semi-natural forest land area, 1953–1997 | |
| | | | forest natural/semi-natural timberland (% area), 1953–1997 | |
| **Agricultural land** | **Agricultural land** | **Agricultural land** | **Agricultural land** | **Agricultural land** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | % farmland actively used for crop production, pasture, or haylands, 1992 | |
| | | | % use non-cropland areas of farmland landscape, 1992 | |
| | | agricultural pesticides use (Mlbs active ingredients/yr), 1992 and 1997<br>fertilizer use (millions of nutrient tonnes), 1960–1998 | | |
| *State* | *State* | *State* | *State* | *State* |
| | | farmlands (croplands and pasturelands) acreage est., 1977–1982 and 1997–2002 | croplands (% farmland area), by region, 1992 | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | extent of croplands (acres), 1997 (map) | total acres in croplands (Ma), 1950–2000 | |
| | | | trends in % soil organic matter (dry weight), by % cropland, and by region | |
| | | | % croplands in different ranges on Nematode Maturity Index (NMI) | |
| | | | status of animal species in farmland areas | |
| | | | native vegetation remaining in cropland areas | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | change in cropland, CPR land, and pastureland acreage, 1982, 1987, 1992, 1997 | | |
| | | % change (6 categories) in cropland area, 1992–1997 (map) | | |
| | | | degree of fragmentation of farmland landscapes by development | |
| | | | % of natural patch areas in compact, elongated, and intermediate patches | |
| | | # watersheds with low, moderate, and high potential for sediment runoff from croplands and pasturelands, 1990–1995 (map) | | |
| | | # watersheds with low, moderate, and high potential for pesticide runoff from farm fields, 1990–1995 (map) | | |
| | | estimates of risk of nitrogen export by watershed, 1992 | | |
| | | estimates of risk of phosphorus export by watershed, 1992 | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | wind and water erosion distribution on croplands and CRP lands (tonnes/yr), 1997 (map) | | |
| | | croplands most prone to wind erosion, (dot = 2*104 acres), 1997 (map) | croplands most prone to wind and water erosion, (dot = 2*104 acres), 1997 (map) | |
| | % share agricultural land (5 regions) subject to unsustainable water erosion, 1981, 1991, 1996 | | % farmland, according to potential for wind and water erosion (3 categories), 1982–1997 | % farmland susceptible to water erosion |
| | | | % cropland with different levels of salt content (dS/m)<br>habitat quality of farmland streams | |
| | % change in residual N levels on agricultural land, in regions (3 categories), 1981–1996 | | % farmland streams and groundwater sites w/ mean $NO_3$- concentrations (1 of 4 ranges), 1992–1998 | |
| | | | average # pesticides in farmland streams and shallow groundwater wells, 1992–1998 | |
| | | | % streams and shallow groundwater wells with pesticide concentrations exceeding standards and guidelines for human health and aquatic health, 1992–1998 | |
| | | | % farmland streams w/ mean annual P concentrations (1 of 4 ranges), 1992–1998 | |
| | | pesticide residues in food (% of samples), 2000 | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | % change in # bare soil days on agricultural land, in 5 regions, between 1981 and 1996 | | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| **Grasslands and Shrublands** | **Grasslands and Shrublands** | **Grasslands and Shrublands** | **Grasslands and Shrublands** | **Grasslands and Shrublands** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | cattle ($10^6$) grazing on grasslands, shrublands and pastures (rather than feedlots), during July, 1994 to 2002 | |
| | | | acres of grassland/shrubland by land use (Macres), 1994–2002 | |
| *State* | *State* | *State* | *State* | *State* |
| | | grasslands and shrublands acreage, est. 1977–1982 and 1997–2002 | grassland/shrublands from 1992 satellite image | |
| | | extent (acres) of grasslands and shrublands, 1992 (lower 48 states) and 1991 (Alaska) | extent (acres) of grasslands and shrublands, 1992 (lower 48 states) and 1991 (Alaska) | |
| | | | total C stored in grasslands and shrublands (soils and plants) ($10^9$ metric tonnes) | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | | % grassland/shrubland streams and rivers with at least 1 no-flow day/yr, and % where zero-flow duration periods are longer or shorter than 50-year mean, 1950s–1990s | |
| | | | area and size of grassland and shrubland patches (% of total in patches – 5 size categories) | |
| | | | grassland and shrubland groundwater $NO_3$- (% sites tested, 4 categories) | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | | % grassland and shrubland areas where depth to groundwater falls within several ranges | |
| | | | fraction of grassland and shrubland areas that burn more or less often as before European settlement | |
| | | | riparian condition | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **Biodiversity** | **Biodiversity** | **Biodiversity** | **Biodiversity** | **Biodiversity** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | % all watersheds w/ different #s of non-native fish species w/ estabished breeding populations, 2000 | % all watersheds w/ different #s of non-native fish species w/ estabished breeding populations, 2000 | |
| | | | different #s established breeding populations of non-native fish species, by watershed, 2000 (map) | |
| | | | population trends comparison between selected non-invasive native and invasive grassland/shrubland bird species, 1966–2000 | |
| | | | % forest, and % grassland/shrubland area covered by non-native plants | |
| *State* | *State* | *State* | *State* | *State* |
| | | population trends (% species increasing) of invasive and native, non-invasive birds, 1966–2000 | population trends (% species increasing) of invasive and native, non-invasive birds, 1966–2000 | |
| | | | % of all sites (fish and benthic animals) with different levels of disturbance | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | | plant growth index, (regional), based on 11-yr average, by ecosystem and regional, 1988–2000, and 2000 map | |
| | | fish diversity: # fish species (low or high diversity), 1997–1998 (map) | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | endangered and threatened species and subspecies, and populations (#s) in each of 3 ecozones, 2001 (map) | at-risk land and freshwater plant and animal native species, by risk categories (% all species), 2000 | at-risk land and freshwater plant and animal native species, by risk categories | #s threatened species or % of all species 2000 |
| | status change in reassesed species at risk (4 COSEWIC categories), 1985–2002 | % imperiled species (ecosystem), 2000 | % land plants and freshwater species at risk, (regional) 2000 | |
| | | at-risk native forest species (% of all forest species), by risk category, 2000 | at-risk native forest species (% of all forest species), by risk category, and at-risk species by region, 2000 | |
| | | at-risk native grassland and shrubland species (% of all grassland and shrubland species), by risk category, 2000 | at-risk native grassland and shrubland species (% of all grassland and shrubland species), by risk category, 2000 | |
| | | | % wetland plant communities (4 degrees risk elimination, regional), 2000 | |
| | | | % native marine species at extinction risk (5 categories, regional), 2000 | |
| | | | degree to which "original" plants and animals are either absent entirely or are at risk of being lost from metropolitan areas | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | strictly protected areas (IUCN I–III) and total protected areas (all classes), as % Canada's total area, 1900–2000, showing international target | | | |

| NRTEE (Canada) | Environment Canada | United States EPA | The Heinz Center (USA) | Common Indicators |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | % strictly protected ecoregions (4 categories), 2001 (map) | | | |
| | # strictly protected sites in each size range (7 categories, $km^2$) | | | |
| **Urban Areas** | **Urban Areas** | **Urban Areas** | **Urban Areas** | **Urban Areas** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | % urban/suburban area that is impervious (4 categories) | |
| *State* | *State* | *State* | *State* | *State* |
| | | extent of non-federal developed land (metropolitan area boundaries), 1997 (map) | acres of urban and suburban areas, by region (Ma), 1992 | |
| | | | urban/suburban area as % of total region's land, 1992 | |
| | | | % of urban/suburban land composed of wetlands, croplands, grass/shrublands, and forests, by region, 1992 | |
| | | patches of forest, grassland, shrubland, and wetland in urban and suburban areas, by region (% of all natural lands), 1992 | | |
| | | | total patches of forest, grassland, shrubland, and wetland, in urban and suburban areas, and by region (% of all natural lands), 1992 | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | change in acres of developed land (urban and suburban areas and rural transportation land), by watershed, 1982–1997 (map) | suburban/rural land use change | |

| **NRTEE (Canada)** | **Environment Canada** | **United States EPA** | **The Heinz Center (USA)** | **Common Indicators** |
|---|---|---|---|---|
| *Environment and Sustainable Development Indicators for Canada* | *Environmental Signals: Canada's National Environmental Indicators Series* | *Draft Report on the Environment 2003* | *The State of the Nation's Ecosystems* | *Generic indicators common to both countries* |
| | | | % urban/suburban land that is undeveloped (5 categories, regional), 1992 | |
| | | | % all natural areas w/in urban and suburban lands w/ varying size patches (5 catagories, regional), 1992 | |
| | | | % streams draining urban watersheds with average $NO^{3}$- concentrations in 1 of 4 ranges, 1992–1998 | |
| | | | % streams draining urban watersheds with average annual P concentrations in 1 of 4 ranges, 1992–1998 | |
| | | | average difference between urban and rural air temperature (% metropolitan area in 1 of 3 categories) | |
| | | | # and type of "disruptive" species found in metropolitan areas, and by region | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **Natural Disasters** | **Natural Disasters** | **Natural Disasters** | **Natural Disasters** | **Natural Disasters** |
| *Pressure* | *Pressure* | *Pressure* | *Pressure* | *Pressure* |
| | | | | |
| *State* | *State* | *State* | *State* | *State* |
| | | | | |
| *Impact* | *Impact* | *Impact* | *Impact* | *Impact* |
| | | | | |
| *Response* | *Response* | *Response* | *Response* | *Response* |
| | | | | |
| **National Responses** (expenditures) | **National Responses** (expenditures) | **National Responses** (expenditures) | **National Responses** (expenditures) | **National Responses** (expenditures) |
| | | | | |

# Appendix 2: Data Sources for Selected Issues

## General

*International*

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North America's environment—air currents, watersheds, and wildlife and their habitat —is not dissected by political borders. But Canada and the United States often measure environmental conditions and report on them using different indicators. This report examines the environmental indicators used by both nations, suggests a way develop a set of North American indicators, and using a number of common indictors, provides a snapshot of the level of progress being made in protecting the environmental assets and services that underpin North America's economy.

For further information

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