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Environmental Indicators for North America

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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

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1 Chapter 1

Environmental Indicators

The State of SOE Reporting

> 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).

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).

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).

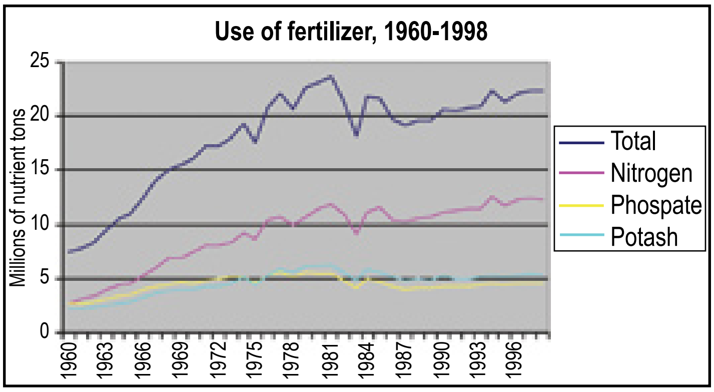
"Benchmarks" are scientifically determined thresholds, such as the maximum level of a pollutant's concentration in the air or water deemed tolerable for human and environmental health (CSIRO 1999). Figure 4 gives an indicator of trends in one aspect of urban air quality, showing the percentage of monitoring 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

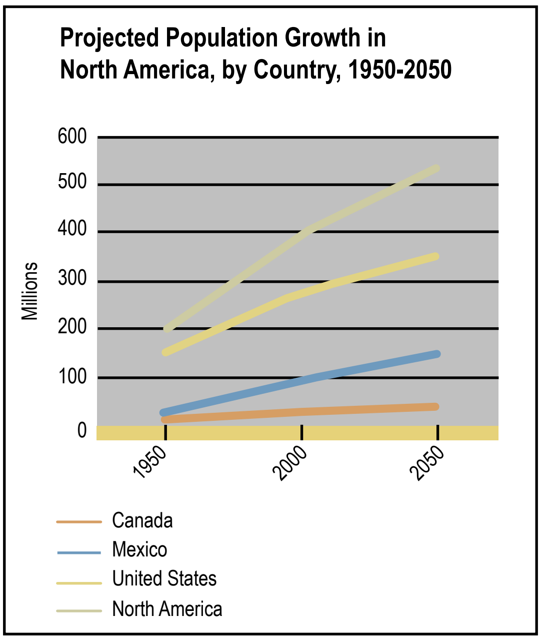
Source: NTREE 2003, 29

Figure 2: A representative indicator showing historical trends



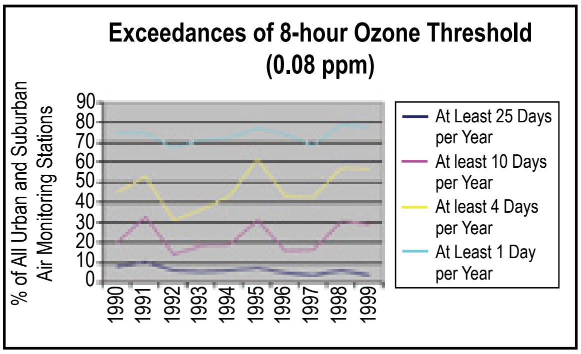
Source: Compiled by author from Daberkow, Taylor, and Wen-yuan Huang 2000.

Figure 3: A predictive indicator showing future trends



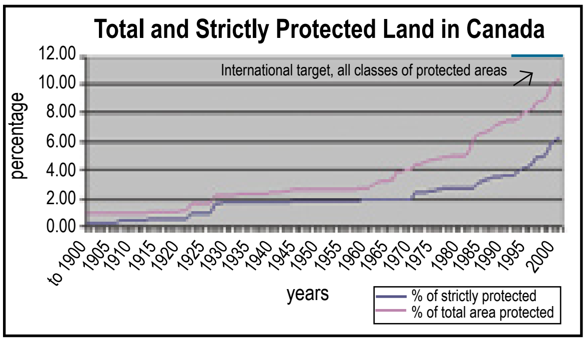
Source: Modified from CEC 2001, 80.

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).

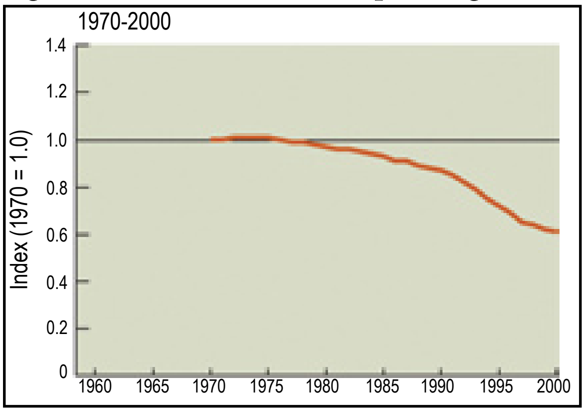
Performance can also be assessed by the use of comparative indices. The Environmental Sustainability Index (ESI), for example, is an aggregated index that measures environmental sustainability

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

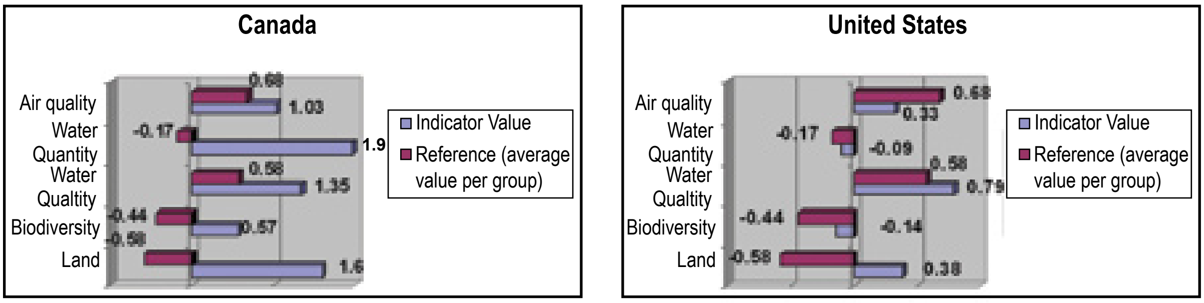


Note: State of the world's natural ecosystems by averaging three sub-indices measuring changes in abundance of terrestrial, freshwater, and marine species, each set at 1.0 and given equal weighing. Source: WWF 2004, 1 http://www.panda.org/downloads/general/lpr2004.pdf

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).

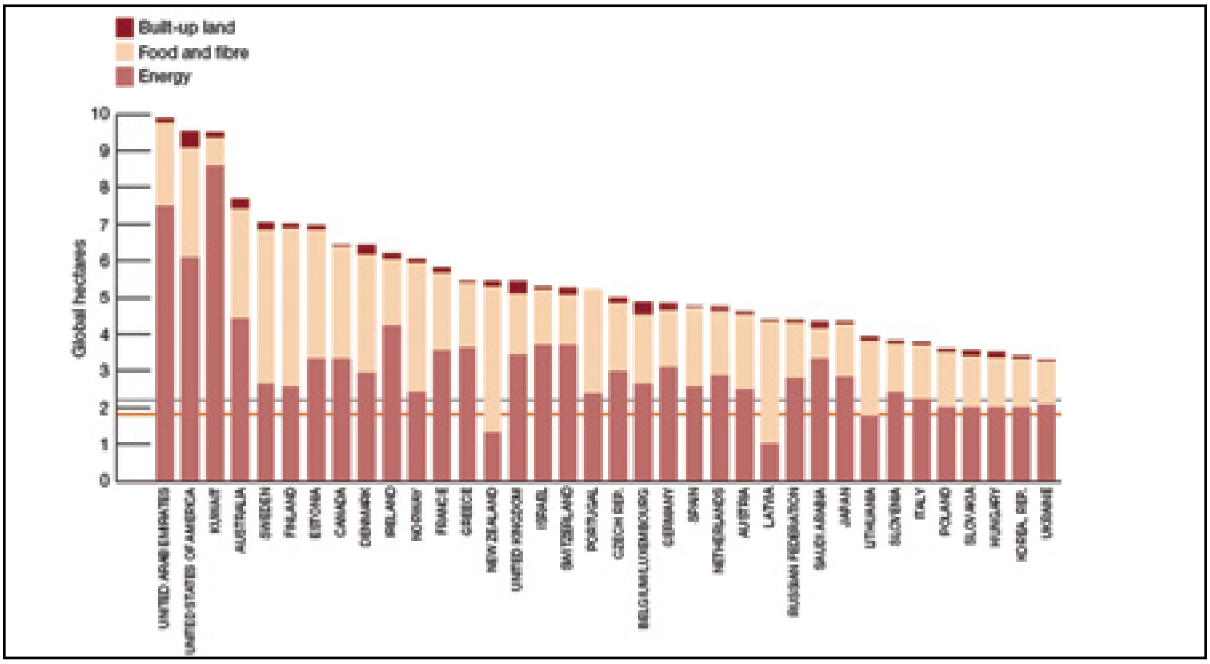
So, as made clear by these examples of ranking systems, care must be taken in designing comparative performance indices so that the standardization of various measurements and definitions is fair and transparent and it is clear what is being measured (Segnestam 2002).

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).

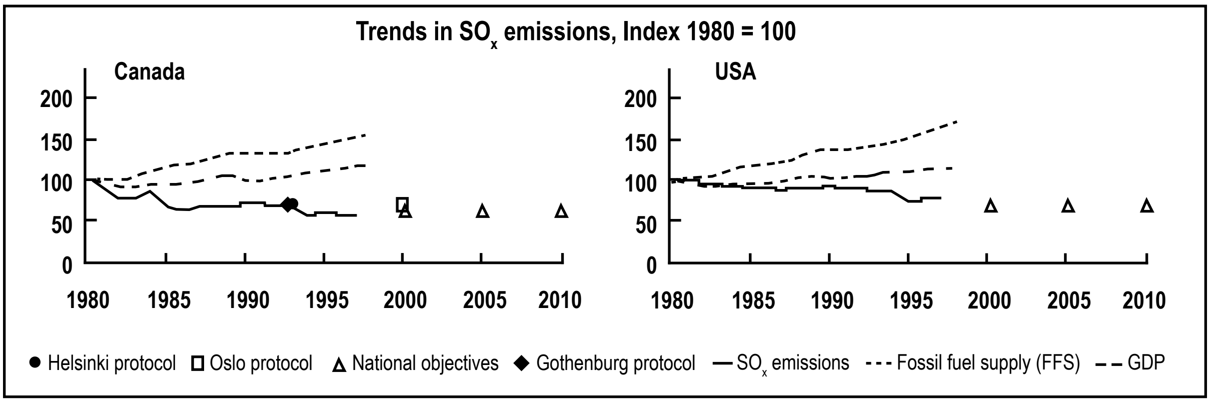
Figure 10 gives an example of a performance index showing the intensity of sulphur dioxide emissions in Canada and the United States and how they are decoupling from GDP. It also contains targets in the form of national and international objectives and shows the progress the two countries

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.

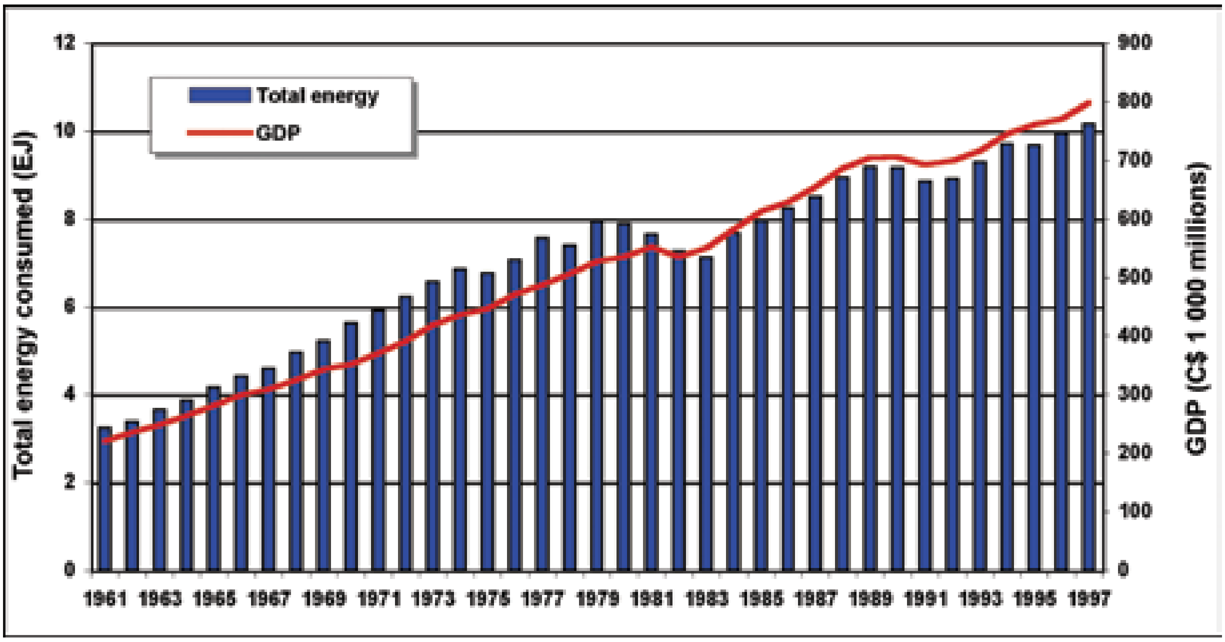
The performance indicator above can also be termed an "intensity" or "efficiency" indicator. Energy is often measured in terms of intensity of use. Energy intensity is the ratio of energy consumption to some measure of demand for energy services. Energy use can be measured against units of production 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



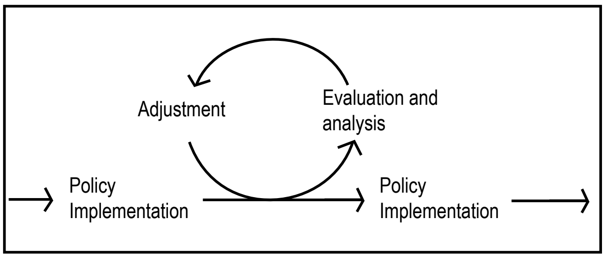
Note: The energy units are exajoules (EJ). An exajoule is 1018 joules. GDP is expressed as 1 000 million of 1992 Canadian dollars.
Source: Adapted from EC 2004b http://www.ec.gc.ca/soer-ree/English/Indicators/Issues/Energy/Tables/ectb01_e.cfm

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

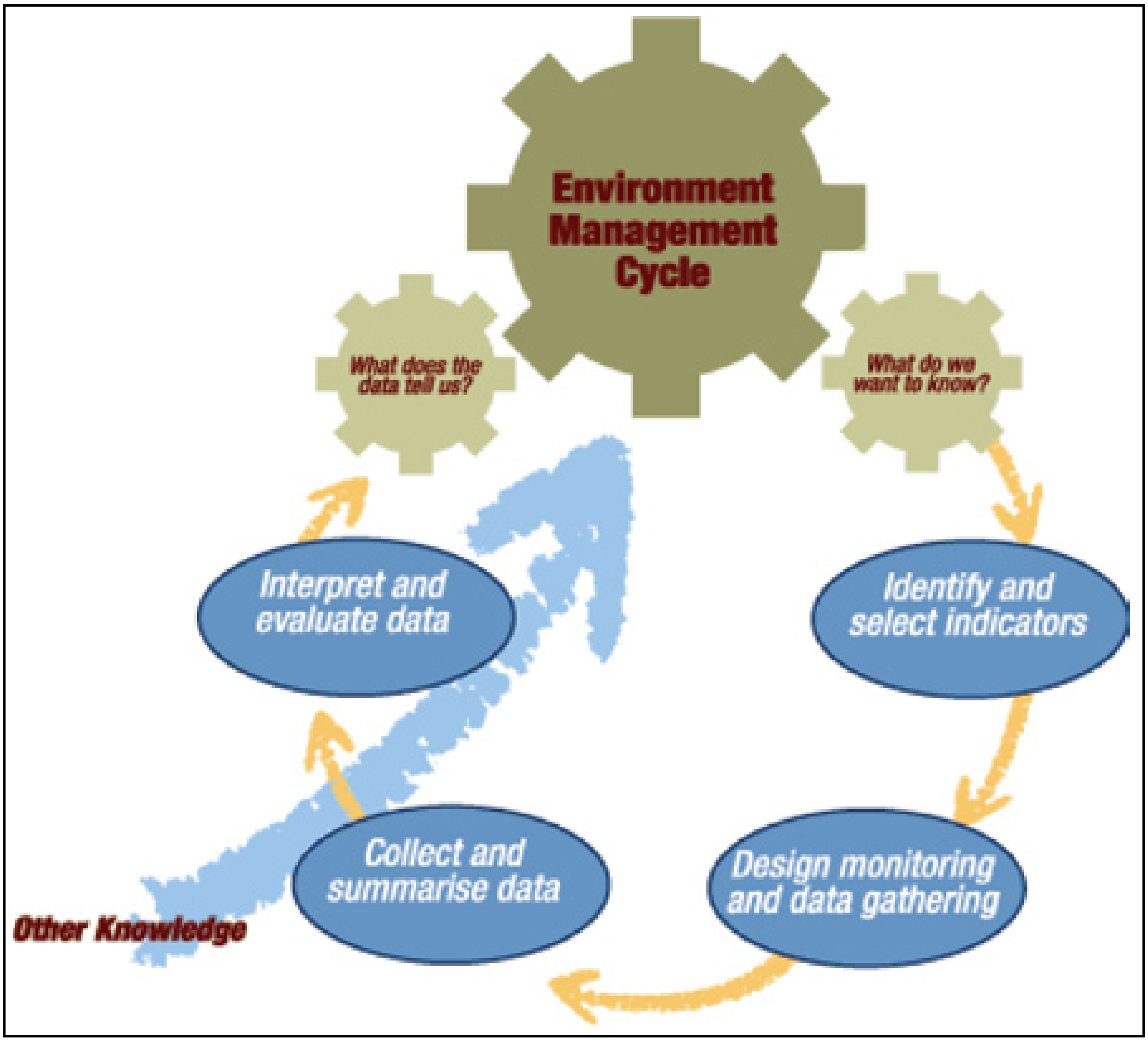
> Indicators function inside the governance process; they are not exogenous factors parachuted in, which can act like a magic bullet causing decision-making to become instantly objective and scientific (Pastille Consortium 2002, 90).

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.

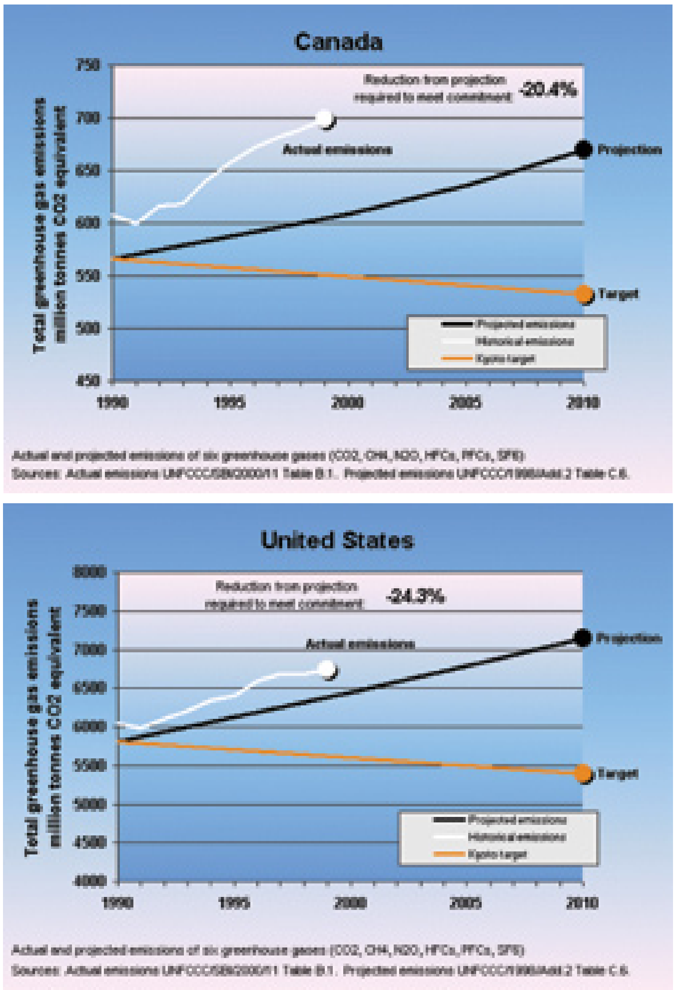
Monitoring programmes are also part of a cycle of environmental management in which policy is informed by the messages provided by indicators. In turn, indicators rely on monitoring and data gathering to provide the necessary inputs (see Figure 13)[3] . The lack of clear causal relationships between 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

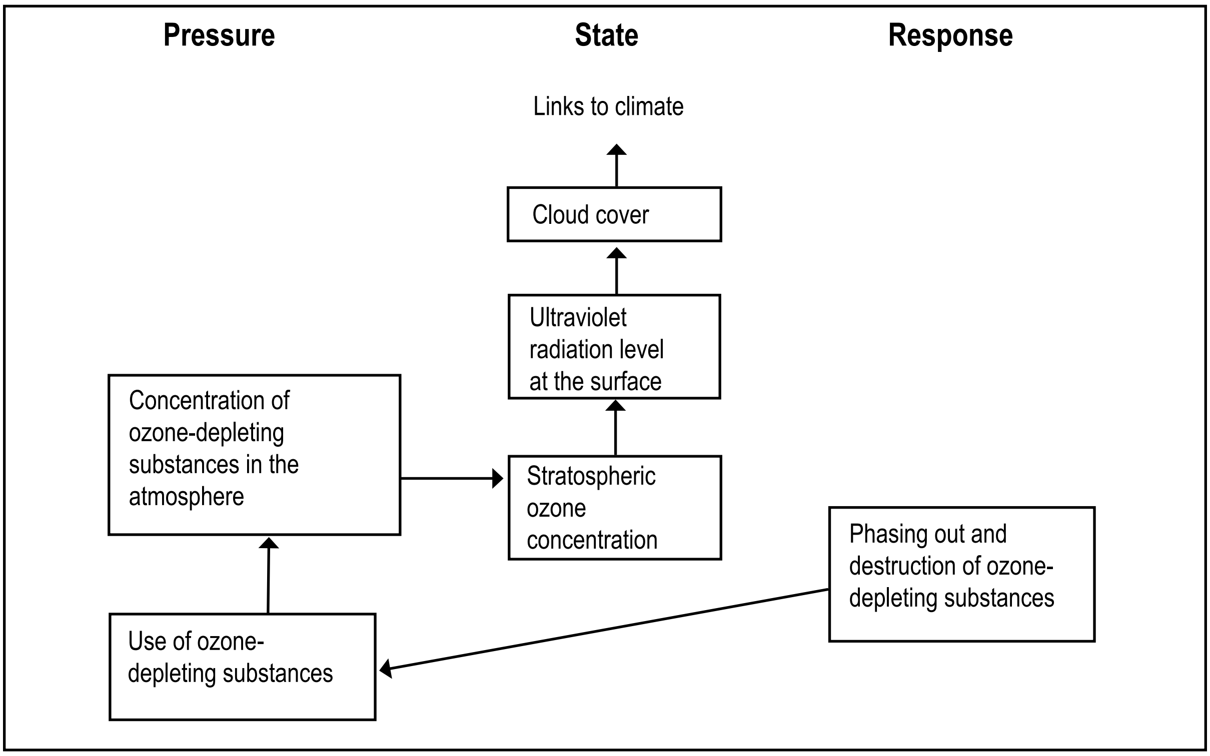
An organizational framework helps to structure indicator selection and development, systemize the analysis and interpretation, identify gaps, and simplify and make explicit the reporting process for the target audience (Rump 1996; CEC 2003). As mentioned earlier, indicators can be organized by jurisdictional 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

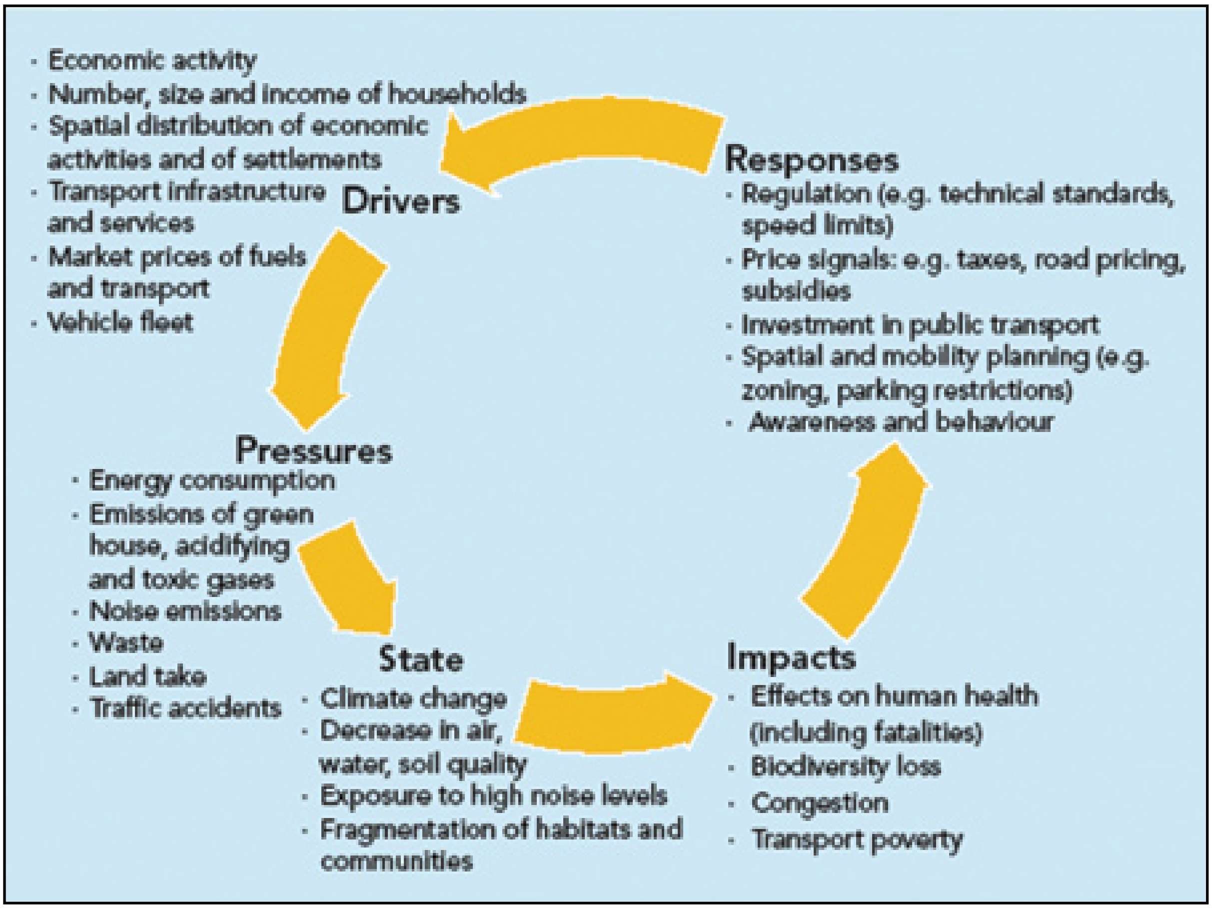
Figure 15: Example of the PSR framework, illustrating the issue of stratospheric ozone



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

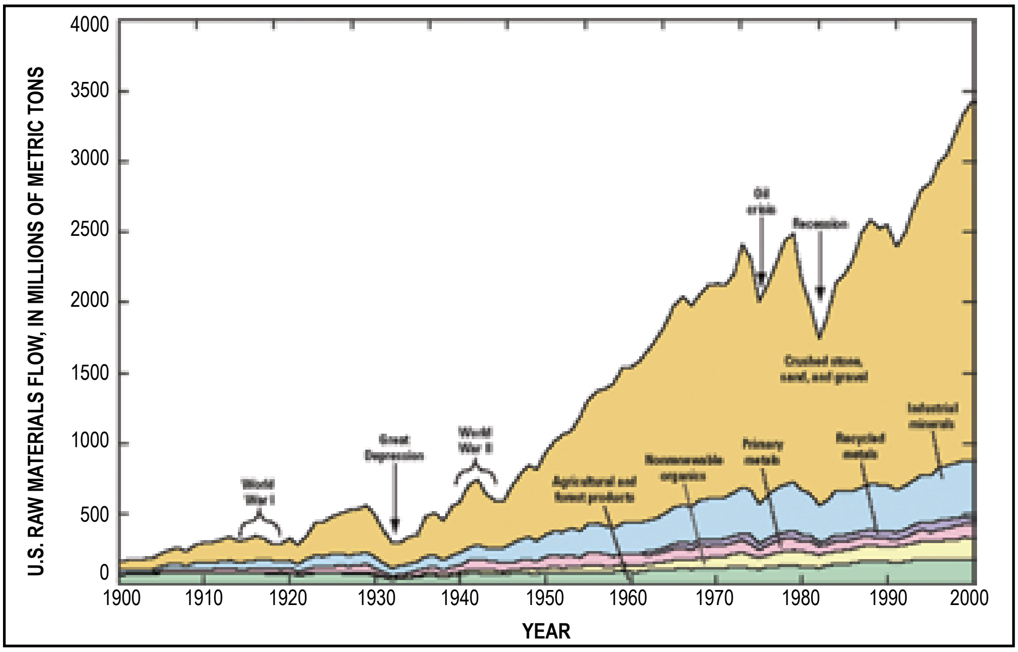
Despite the values and popularity of the PSR framework and its offshoots, it has been criticized

[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).

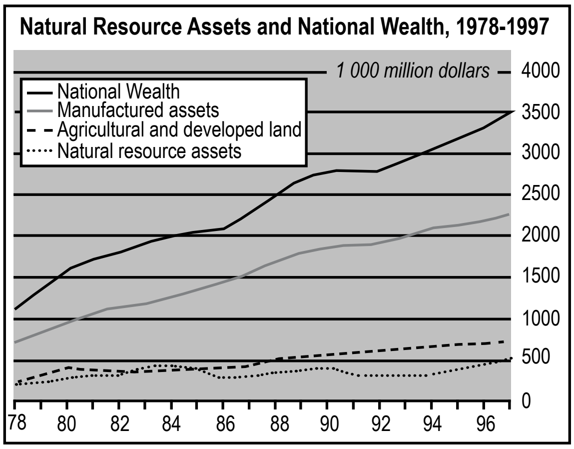
Natural capital flows and accounting approaches

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

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



Source: Modified from Statistics Canada 2000a, 2

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

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