4

Chapter 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).

Comparative indicators

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).

Highly aggregated indices

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).

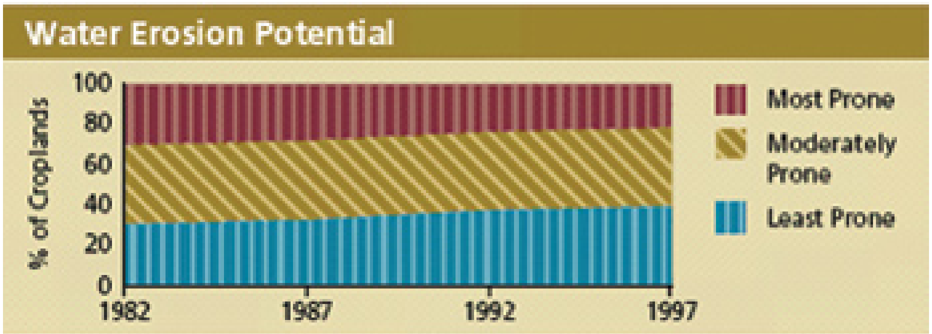
Although many Canadian and US indicators highlighted in this survey appear similar, there are varying degrees of differences in definitions and methodologies, making the standardization of environmental variables across the countries very difficult. The Georgia Basin–Puget Sound indicator project provides 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).

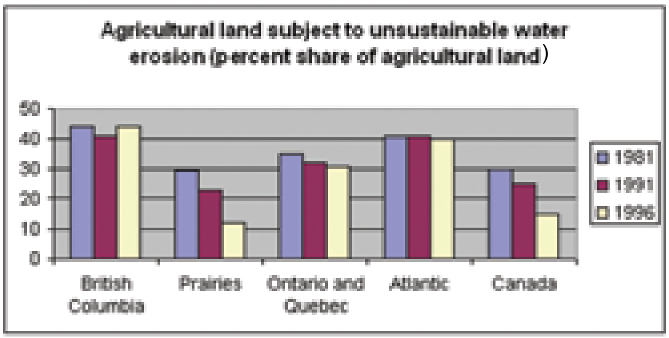
Even among the agencies that have achieved some success in harmonizing data across nations, users need to be aware of the caveats provided in technical notes that explain remaining disparities. For example, the OECD's data for the concentration of particulates reflects different measurement methods for 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

Spatial scale

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

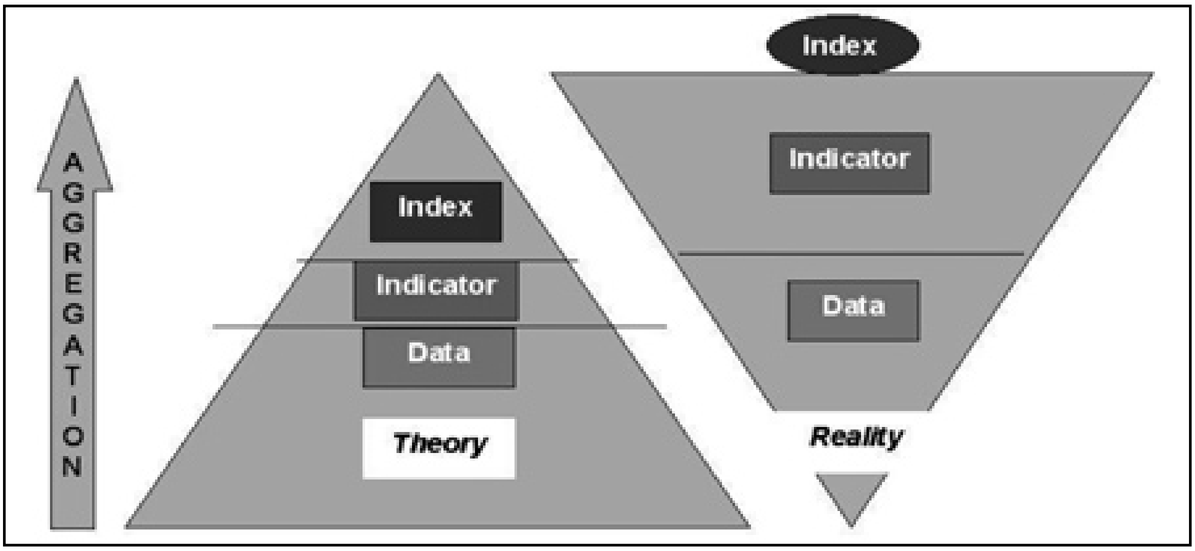
There is a great deal of consensus in the literature that the number of indicators should be kept to a minimum. The Heinz Center had some difficulty in reducing the number of indicators to a minimum. The aim was to be succinct so that the report would actually be read and absorbed by policymakers (Pidot 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 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 total column O_3 over selected cities	US EPA 2003 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 municipal solid waste (MSW) management (recycling and reuse)	OECD 2001; OECD 2002b 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