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A Look at Some Environmental Indicators

Introduction

Indicators of any kind are simply ways to measure progress or show a direction. In their most simple form they answer basic questions such as how much, how many, and what size. More sophisticated and properly constructed environmental indicators can do several things, including informing us about the state and extent of changes in environmental conditions (e.g., the quality and availability of environmental resources – land, air, water, forests, etc.) as a result of the effects of both human activity and natural events at a spatial and on a temporal level. Indicators can also show how effective the actions taken by society have been in avoiding/mitigating environmental impacts, and shed light on what's been done to restore the capacity of the natural environment to provide the services and materials essential for life and well-being.

Indicators can be qualitative or quantitative and be gathered from various sources including: surveys (e.g., censuses or sample surveys of population, housing, agriculture, enterprises, households, employment, and different aspects of environment management); administrative records of government and non-government agencies in charge of natural resources as well as other Ministries and authorities; remote sensing (e.g., satellite imaging of land use, water bodies or forest cover); monitoring systems (e.g., field-monitoring stations for water quality, air pollution or climate); and, scientific research that is academic or more company/business specific.

To be useful, environmental indicators should have the following features:

- Meet a purpose and be normative such that they can display the difference between the desired and the actual value to provide feedback that ultimately addresses behavioural change.
- Have a wider significance than the immediate meaning of a simple number; indicators go beyond basic statistics.
- Have intrinsic importance, being used not for the sake of measuring things but as early warnings and to detect sensitivity or vulnerability which ultimately enables action.

Gauging the state of the environment, however, is still a relatively new activity. There were hints that more scientific research and information was needed in 1972, as articulated in principle 20 of the Declaration of the United Nations Conference on the Human Environment.[1]

> *Principle 20*
>
> *Scientific research and development in the context of environmental problems, both national and multinational, must be promoted in all countries, especially the developing countries. In this connection, the free flow of up-to-date scientific information and transfer of experience must be supported and assisted, to facilitate the solution of environmental problems; environmental technologies should be made available to developing countries on terms which would encourage their wide dissemination without constituting an economic burden on the developing countries*.

[1] http://www.unep.org/Documents.multilingual/Default.asp?DocumentID=97&ArticleID=1503.

Then in 1984, the United Nations developed and published A Framework for the Development of Environment Statistics[2] that described detailed sets of statistical variables to facilitate the identification and selection of information for national and international data collection. It wasn't until the late 1980s/early 1990s, in response to the World Commission on Environment and Development's 1987 Brundtland Report ("Our Common Future"[3]), that work to define the scope and type of indicators began in earnest. This was the first time the term sustainable development was introduced to the conversation among nations about the impact of industrial development and economic growth on the natural environment. Despite the vague definition of sustainable development, the Commission recommended developing clear "criteria and indicators for environmental quality standards and guidelines for the sustainable use and management of natural resources"[4] and for annual reporting and auditing of performance. However, it wasn't until 1995 that the first list of environmental and related socio-economic indicators was identified[5]; this was followed in 1999 with the first concerted international data collection effort. Canada developed an initial set of crude national environmental indicators beginning in 1993.[6] BC's efforts in this area began in the late 1990s.[7]

Today, several international bodies publish a variety of environmental statistics, including the United Nations Environment Programme (UNEP) and the Division of Sustainable Development (UNDSD), the Organization for Economic Co-Operation and Development (OECD), the Statistical Office of the European Communities (Eurostat), and the Inter-Secretariat Working Group on Environment Statistics (IWG-Env). The latter entity is charged with coordinating and harmonizing development of standards, methods, data collection, and capacity-building programmes in environmental statistics, and it also seeks to provide linkages to statistics on sustainable development and environmental-economic accounting. In Canada, Statistics Canada and Environment Canada along with various provincial Ministries and non-profit entities collect data that eventually can be used in developing indicators. The Ministry of Environment here in BC tracks a number of relevant topic areas, including: air, climate change, contaminants, land, marine, plants and animals, sustainability, waste and water.

The Importance of Data

The challenge, of course, is implementing a data gathering and reporting system that has reliance over time, avoids duplication, and offers meaningful information to decision-makers. Good information is essential for deriving sound indicators. The old adage, junk in junk out, is true. Therefore, whether the information is quantitative (i.e., statistics) or qualitative (i.e., expert judgement, observation, case studies, etc.), it must have integrity, be rational, and rest on more than intuition or emotional responses. Even in the current era of Big Data, data science, which is more than just data-mining, is an emerging area of academic thinking and practice rather than a mature body of knowledge.[8] What this means is that we think we know more than we probably do about our social, economic and natural environments. Society must be careful as to how much weight is given to any one measure and how it is used in combination to describe complex systems.

[2] http://unstats.un.org/unsd/environment/history.htm.
[3] http://conspect.nl/pdf/Our_Common_Future-Brundtland_Report_1987.pdf.
[4] Our Common Future, p217.
[5] http://unstats.un.org/unsd/environment/indicators.htm.
[6] Environmental Signals, Canada's National Environmental Indicator Series 2003.
[7] Environmental Reporting in BC, http://www.env.gov.bc.ca/soe/archive/#catalogue.

[8] Data Science and its Relationship to Big Data and Data-Driven Decision Making, Foster Provost, Leonard N. Stern School of Business, New York University, and Tom Fawcett, Data Scientists, LLC, New York.

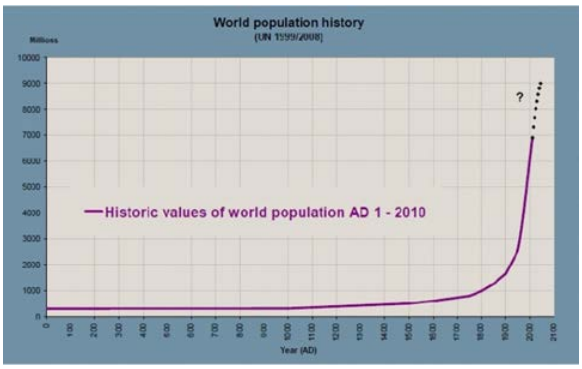
Industry, government, academia, First Nations and other stakeholders alike often call for decisions to be based on scientific data. But there are lots of opportunities to manipulate and exploit information for the wrong reasons. Given that humans are lazy when it comes to processing information – we tend to take the path of least resistance and least effort - we will "seek data that are likely to be compatible with the beliefs [we] currently hold."[9]

That said, it has been shown that "the more data-driven a firm is, the more productive it is—even controlling for a wide range of possible confounding factors. The differences are not small: one standard deviation higher on the [data-driven decision making] DDD scale is associated with a 4–6% increase in productivity."[10] If this is true for business, then it is also true for government and for others who rely on data to prove their point.

Environmental Indicators

Returning to our main topic, there are a few global measures of how we are performing relative to environmental challenges. The OECD's Environment at a Glance report is one attempt to compare countries and to explore the question, "how successful are we in breaking the link between economic growth and environmental damage?"

Not surprisingly, in many discussions of environmental issues population growth is a key starting point. The world is adding 82 million people each year. Along with more people, the push to either maintain or improve the standard of living leads to increased pressures on the natural environment. Raising living standards often requires more raw materials, which come from the natural endowment of the earth. There is not one thing we consume or service we rely on that is not in some way linked to the use of natural capital. Even the knowledge economy depends on natural resource-based products to build the communication systems that enable the sharing of ideas – metals and plastics for computers and fiber-optics, satellites and cell phones. The more people we add to the planet, the more they will want what today's affluent nations have – and who can blame them?

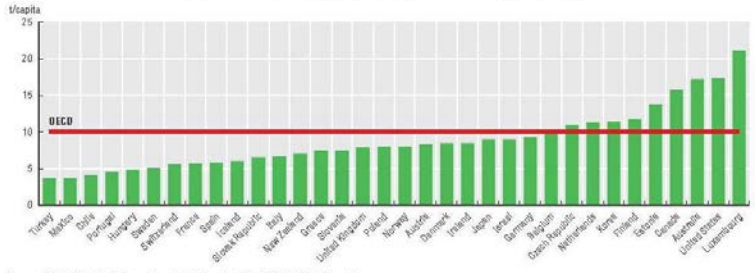


Even though the pace of economic growth in most OECD countries has slowed, the absolute demands placed on the natural environment are still increasing, largely owing to economic development and rising populations in emerging markets. The challenge is to do more while using less or differently. While some progress has been made, there is a long way to go.

Not surprisingly, greenhouse gas emissions worldwide continue to grow as our economic systems are dependent on energy, which is predominately fossil-based. While the OECD countries now account for less than 50% of global GHG emissions, they still emit more on a per person basis (10 tonnes per capita) than emerging economies. Over time, GHG emissions have been partially decoupled from GDP in some advanced economies, including the United States. Canada's overall GHG emissions increased between 1990 and 2010, but energy intensity per unit of GDP decreased, leading to a small decoupling except in the transport sector. BC's greenhouse gas emissions appear to be in decline, but with the province's current focus on developing natural gas and LNG this trend is likely to be reversed later in the decade.

[9] Thinking, Fast and Slow, Daniel Kahneman, 2011.
[10] Strength in Numbers: How Does Data-Driven Decision Making Affect Firm Performance, Erik Brynjolfsson (MIT), Lorin M Hitt (University of Pennsylvania), Heekyung Hellen Kim (MIT), 2011.

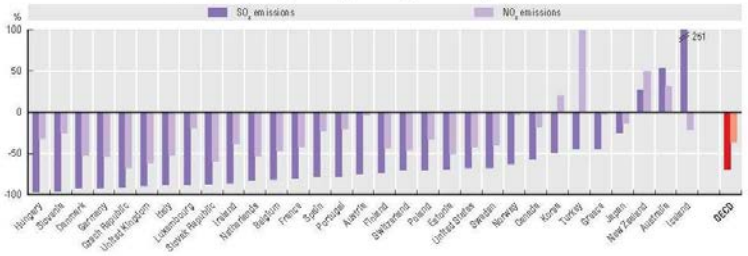
e 1.6. **Carbon dioxide (CO_2) emission intensities per capita, 2010**



Source: IEA, CO_2 Emissions from Fuel Combustion (2012) (database).

StatLink http://dx.doi.org/10.1787/888932976745

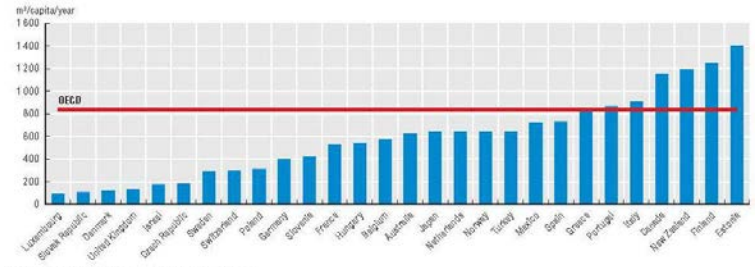
1.11. **Change in SO_x and NO_x emissions, since 1990**



Source: European Monitoring and Evaluation Programme (EMEP) (2012); OECD Environment Statistics (database); UNFCCC, "National Inventory Submissions 2012".

StatLink http://dx.doi.org/10.1787/888932976840

1.15. **Gross freshwater abstractions per capita, latest available year**

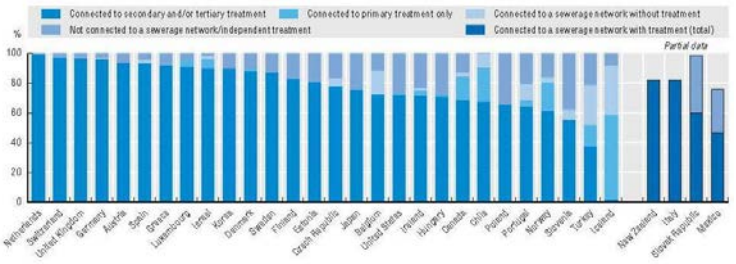


Source: OECD Environment Statistics (database).

StatLink http://dx.doi.org/10.1787/888932976916

1.20. **Sewage treatment connection rates, latest available year**

% of national population connected to a wastewater treatment plant



Source: OECD Environment Statistics (database).

StatLink http://dx.doi.org/10.1787/888932977011

1.8. **Threatened species – mammals, birds and vascular plants, latest available year**

	Mammals		Birds		Vascular plants	
	Species known or assessed, number	Species threatened, %	Species known or assessed, number	Species threatened, %	Species known or assessed, number	Species threatened, %
Australia	387	24	872	13	19 462	7
Austria	101	27	242	27	2 950	33
Belgium	84	21	220	20	1 818	23
Canada	218	19	664	9	5 111	3
Chile	175	25	461	11	5 516	7
Czech Republic[1]	91	19	210	52	2 754	42
Denmark[1]	67	16	209	16	2 909	4
Estonia	69	3	386	10	1 943	9
Finland[1]	65	11	240	13	1 240	15
France[1]	99	10	389	23	11 730	..
Germany[1]	93	34	264	36	3 272	27
Greece[1]	115	25	440	14	5 850	4
Hungary[1]	90	38	393	15	2 510	7
Iceland[1]	..	..	75	44	490	10
Ireland[1]	57	2	457	24	2 001	6
Israel[1]	105	56	210	19	2 288	17
Italy	118	41	473	18	6 711	8
Japan	160	21	700	14	7 000	25
Korea[1]	124	7	515	11	4 296	2
Luxembourg[1]	64	52	132	17	1 323	27
Mexico[1]	535	35	1 096	22	25 008	2
Netherlands[1]	48	25	213	21	1 490	22
New Zealand[1]	32	25	161	37	2 319	10
Norway[1]	88	18	248	15	2 962	7
Poland	105	12	448	8	2 980	11
Portugal[1]	103	26	291	33	3 607	..
Slovak Republic[1]	90	22	219	22	3 352	30
Slovenia	89	38	387	27	3 452	10
Spain[1]	158	13	368	27	8 750	14
Sweden	66	17	246	17	2 272	14
Switzerland[1]	83	33	211	34	2 592	29
Turkey	161	14	460	4	11 000	12
United Kingdom[1]	76	8	247	2	1 530	9
United States[1]	453	17	831	12	19 569	27

1. See Annex B for country notes.
Source: OECD Environment Statistics (database).

StatLink http://dx.doi.org/10.1787/888932978227

Note: The charts and tables on this and subsequent pages are taken from the OECD's Environment at a Glance 2013.

On other air pollutants, substantial reductions have been made on sulphur dioxide emissions while nitrogen oxide emissions within the OECD have decreased despite the growth in road transportation. Both of these substances are contributors to regional and local air pollution. In China, for example, some people describe current air quality as a "crisis" situation, with recent Beijing levels of small particles (PM2.5) at 329 micrograms, while large particles (PM10) were at 126 micrograms.[11] Other cities in China have even higher levels of air pollution. Any level of PM2.5 greater than 300 micrograms is considered to be hazardous for human health by the World Health Organization; 25 micrograms is the standard to measure against. Many Chinese cities resemble London, UK back in the 1950s.

In OECD countries, there has been an absolute decoupling of air pollutant emissions and GDP. Canada has done well on this performance measure, with a -73% and -65% change between 1990 to 2010 in SO2 emissions intensity per unit of GDP and emissions intensity per capita, respectively, and -49% and -34% for NOx intensity measures. British Columbia has also been successful in reducing local air pollution, with downward trends in almost all measures of air quality.

Water use and indicators of stress are more challenging to measure given location-specific endowments. Overall, OECD countries report stable extraction rates, even though there is increasing demand for water (OCED demand is expected to grow by 55% by 2050), partly because of efficiency gains and more use of water pricing. However, about 1/3 of OECD countries face medium to high water stress, while countries like Canada and provinces like British Columbia, which are well endowed, are faring well and continue to be high per capita water users as a result. Not surprisingly, agriculture remains a significant source of water demand, globally. BC's new *Water Modernization Act* is scheduled to be tabled in the legislature this year and will likely lead to additional monitoring and data collection efforts that can be used in developing more robust indicators of water use.

Waste is the natural by-product of any activity. There are very few closed systems that produce no waste. Waste management and related infrastructure (solid waste and waster water) is an important service provided by most governments on some level. Presently, about 80% of OECD populations are connected to some form of municipal waste water treatment system. At the same time, solid waste generation has risen and now averages 530 kg/person on a global basis (390 kg/person in Canada). With ongoing urbanization, capacity constraints at landfills, and aging existing facilities, water and waste water infrastructure replacement and refurbishment are now significant challenges for many OECD countries. These are capital intensive developments which come at a time when most governments have little room for additional expenditures.

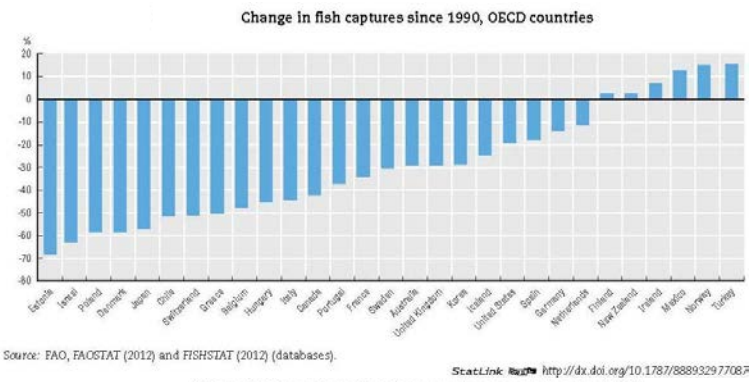
In terms of protected areas, which can be seen as a proxy measure for biodiversity, overall protected areas now stand at 11% of the world's land mass, but this does not necessarily address biodiversity representation or needs. Globally, most experts see growing threats to biodiversity. Canada performs well in this domain, relatively speaking. Our vast landmass and low population density mean that the percentage of threatened species is low when compared to many other

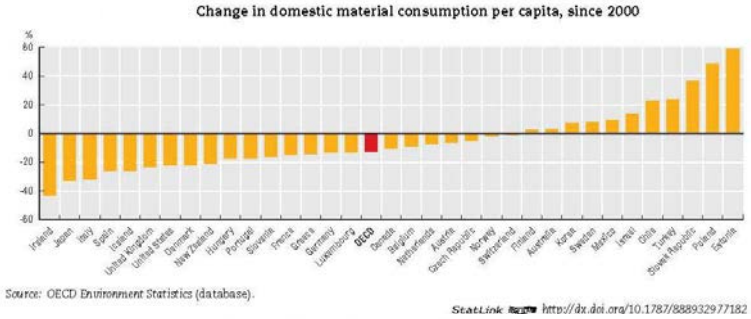
[11] Real Time Air Quality Index for February 28, 2014: http://aqicn.org/city/beijing/.

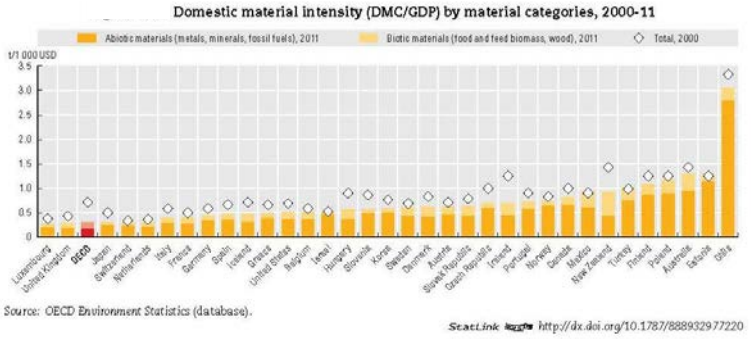
countries. In aggregate, Canada has the highest total protected square kilometers of "wetlands of international importance" in the OECD, at ~131,000 km2. British Columbia scores favourably on all measure of protected areas.[12,13]

Forests are the most diverse and widespread terrestrial ecosystems on the earth. Humans have always depended on products from timber as well as the ecosystem services provided by forests (e.g., as water filter and soil generator). The good news is that in OECD countries forested areas are generally considered stable at 30% of the total land mass. But significant deforestation continues, especially in developing countries in tropical and semi-tropical climates, where there is pressure to accommodate population growth and to meet the demand for agricultural land.

Alarmingly, 30% of global fish stocks are over exploited, and fish catches are increasing because of population growth, a shift to more protein-rich diets in some countries, incidental catch and the harvesting of new species previously thought to be "worthless." However, Canada's total fish catch declined by 48% between 1990 and 2010, while aquaculture production jumped by almost 300%. This could be considered a negative development for the fisheries industry, with fewer boats and fewer independently operating fishing businesses. But the trend is positive for the aquaculture industry since concerns regarding fish-farms can be managed given that they are location-specific. This is a hotly debated topic, especially in British Columbia, as is often the case for "new industries" that must go through management and regulatory growing pains on their way to maturity. A significant challenge for all wild fisheries is the difficulty of regulation and monitoring outside of national management zones and boundaries.

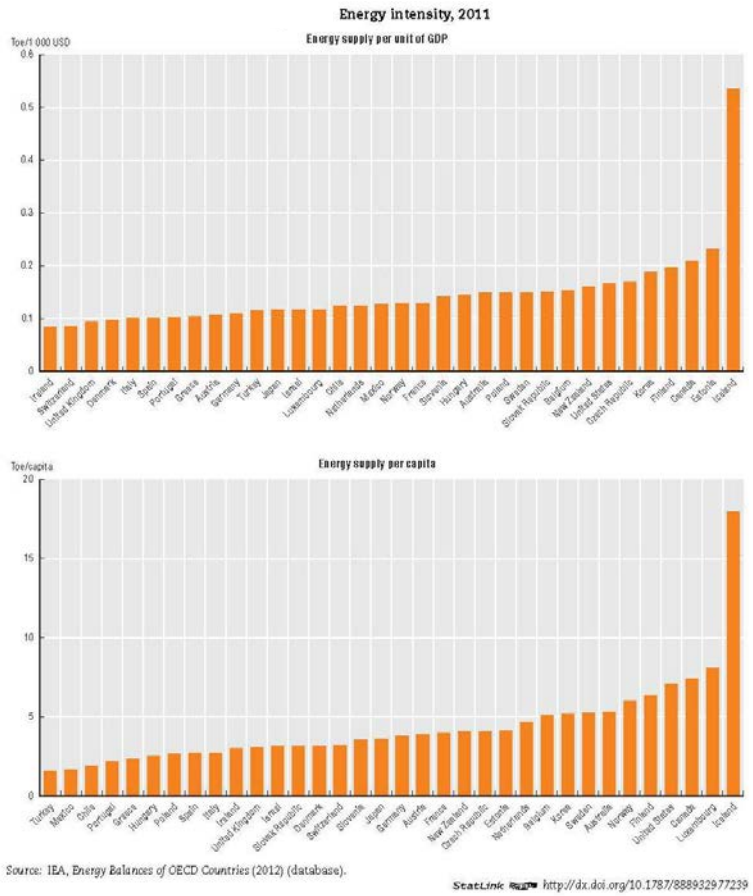






Raw materials are the basis of all of the goods and some of the services that we consume. Materials consumption is measured in two ways – domestic consumption (tonnes per capita) and intensity (tonnes per USD 1,000), or the amount of a resource needed to produce a value added output. In general, it seems that intensity is improving, meaning we are becoming more efficient with all phases of production, but per capita materials consumption in OECD countries is still high at 17 tonnes per person per year. Of 35 OECD countries, Canada is 9th highest but consumption per capita has declined by 10% since 2000.

[12] World Bank protected areas data 2010.
[13] Thinking About Conservation Policy.



Transportation and energy are fundamental pillars of any economy. Energy intensity – total primary energy supply per unit of GDP – has decreased across all OECD countries, and a decoupling of environmental effects and energy use has largely been achieved. Per capita energy use has also improved but the change has been slower and more variable, in part due to structural components of various economies including income, geography, energy policies, energy prices, and countries' natural endowment of energy sources. On the other hand, transportation is still strongly coupled with GDP. Private vehicle ownership continues to increase in tandem with economic growth, and in about 30% of OECD countries road traffic is growing faster than GDP. Canada's vast geography and rather small population relative to its land mass means we rank 5th lowest (or best) out of 33 OECD countries on motor vehicle density per network length.

Food is one of the seven basic human needs, according to Maslow. Agriculture and the production of food, therefore, play a central role in human survival and quality of life. But food production takes large amounts of land (>40% in OECD countries) and water (>70% globally), and it results in nitrogen and phosphorous from fertilizers. Indicators suggest there is increased productivity of 1% per year in the agriculture sector, along with a decline in contaminants of 5% per year, in the OECD countries. Within the 34 countries ranked, Canada's use of nitrogen as well as residual levels of nitrogen are among the lowest.

Challenges and Conclusions

The development and use of environmental indicators is becoming more common. Many international and national/regional governments are now tracking various environmental trends, employing more robust measures that are more sophisticated than in the early days of measurement. At the same time the various drivers of change, population growth in particular, are increasing the pressure on the environment in absolute terms. More complex problems and feedback in stressed systems mean that coming up with adequate and resilient environmental indicators is a complex exercise. Among the complications are:[14]

- insufficient institutional development, overlapping mandates and functions, and poor interagency coordination;
- laws that generally don't explicitly refer to environmental statistics, as this is a relatively new domain;
- inadequate monitoring programs, and programs that serve too many purposes;

[14] Challenges in the development and use of ecological indicators, Virginia H. Dale, Environmental Sciences Division, Oak Ridge National Laboratory and Suzanne C. Beyeler, Institute of Environmental Sciences, Miami University, Oxford, Ohio.

- where indicators exist, there are often too many and they are not tied directly to an objective but exist as data collecting vehicles; and,
- a tendency to over-react when patience and judgement are required.

Overcoming the challenges requires addressing measurement gaps, improving data availability, communicating properly with non-scientists, sharing information, and accepting that there will sometimes be areas of uncertainty that should lead to dialogue rather than confrontation.

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