International Monitoring for Environmental Health Surveillance

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ABSTRACT

This paper offers an overview of existing international monitoring systems with relevance for environmental health surveillance. Representative monitoring systems are described that: address areas of chronic and acute exposure, and diseases and behavioural effects resulting from human-environment interactions; have an ecosystem focus with perhaps a secondary motivation of ascertaining human health impacts that may result from ecosystem conditions; and that incorporate socio-demographic and economic data that may reflect population health determinants. General conclusions on the state of environmental surveillance systems and suites of indicators reviewed are provided in relation to their utility for the development of a generic environmental health surveillance system. This review indicates, among other things, that no obvious short list of core indicators exists which spans “environmental health” to provide a sufficient set applicable in a global context. Through a summary of challenges and limitations in existing systems and indicator sets, recommendations are provided for the discussion of indicator selection and organization, and of developing general and widely applicable environmental health monitoring and surveillance systems.

RÉSUMÉ

Dans cet article, les auteurs présentent un survol des réseaux de surveillance internationaux en matière d'hygiène de l'environnement. Ils décrivent des réseaux de surveillance typiques de secteurs d'exposition chronique et aiguë, de maladies et d'effets sur le comportement liés aux interactions entre les humains et l'environnement. De tels réseaux sont centrés sur les écosystèmes et ont peut-être comme intérêt secondaire l'évaluation des impacts des conditions de l'écosystème sur la santé humaine. Ils comprennent aussi des données sociodémographiques et économiques qui peuvent être à l'image des déterminants de la santé de la population. Les auteurs analysent l'état des réseaux de surveillance environnementale et étudient des groupes d'indicateurs en fonction de leur utilité pour la mise sur pied de réseaux de surveillance générale de l'hygiène de l'environnement, et tirent des conclusions générales à ce sujet. Ils soulignent notamment qu'il n'existe pas de présélection évidente d'indicateurs de base couvrant l'hygiène de l'environnement et applicables au contexte planétaire. À l'aide d'une synthèse des problèmes et des limites des réseaux et des groupes d'indicateurs actuels, les auteurs émettent des recommandations quant à l'analyse du choix et de l'organisation des indicateurs et quant à la construction de réseaux de surveillance de l'hygiène de l'environnement de portée générale et applicables à grande échelle.

This paper offers an overview of existing international monitoring systems with relevance for environmental health surveillance. The challenge of generating such an overview may be seen as either very simple or extremely complex. On the one hand, the international organizations that are maintaining primary global data sets are few in number: the World Health Organization, the World Bank and a number of key elements of the United Nations system. On the other hand, if “international” is taken to mean any grouping of more than a single nation, or the extra-territorial observations of a national agency, and if “environmental health” is taken to encompass the state and all of the factors influencing human and ecological well-being, the scale of the challenge explodes. The tact that is taken here lies somewhere between these extremes.

Representative monitoring systems are described that:

- 1) from a public health profession perspective address areas of chronic and acute exposure, and diseases and behavioural effects resulting from human-environment interactions;
- 2) have primarily an ecosystem focus with perhaps a secondary motivation of ascertaining human health impacts that may result from ecosystem conditions; and
- 3) incorporate socio-demographic and economic data that may reflect population health determinants.

The breadth and depth of “environmental health surveillance”

In much of the extensive environmental health literature, the word “environment” brings with it a connotation of *the suite of external factors that are important to human health*. Some of the direct effects of a degraded ecosystem on human health are well understood. These include the impacts of exposure to:

- toxic chemicals,^{1,2}
- air pollution,^{3,4}
- contaminated water, and
- UV radiation.^{5,6}

Additionally, cumulative and synergistic effects of exposure to contaminants are resulting in the definition of new diseases, such as Multiple Chemical Sensitivity or MCS.⁷

Indirect impacts of environmental conditions on human health are becoming

better understood and include such things as the effects of climate change resulting in the extension of the range of vector organisms leading to an increased transmission of infectious diseases (e.g., malaria, dengue, yellow fever), and an increase in severe weather events leading to increased mortality and illness among others.^{6,8-11}

In recent years, the effects of human and animal health care systems on the ecosystem have been gaining a great deal of attention. Particularly relevant are the important negative feedback loops created by health care by-products which degrade ecosystems on which human health depends. Some impacts, such as the effects of overuse of antibiotics¹² and widespread endocrine-disrupting compounds such as birth control pills¹² on aquatic organisms, are emerging as major concerns. In this sense, “environment” relates to the enveloping natural world of which human society is an integral part and includes many (perhaps even a majority of) components that exist in their own right and may or may not directly interact with human society, let alone influence human health.

The human-ecosystem relationship is best seen as a two-way interaction of both stress and nourishment (physical, chemical, and biological). This requires the realization that by using the motivation of concern for human health as the driving force behind action to monitor, protect and remedy environmental conditions, the “environmental health” movement, in some respects, originates in efforts that might be labelled “agenda setting” or “issue framing”. The “agenda” is considered to be the list of subjects or problems to which government officials, or those close to them, are paying some serious attention at any given time.¹³ “Issue framing” is the set of processes by which certain features of a problem area are singled out for attention by particular actors or communities.¹⁴

There has been an evolution, most noticeable over the past 10 years, in the motivations underlying concern for the biosphere. Where once the issue of, for example, acid rain was framed as a concern for the health of forests and lakes, the dominant framing of environmental issues has moved to where the *prima facie* question is: “how does this condition impact human health?” The concluding observation on this point is that by focussing so

much on the discernible human health impacts of environmental stresses, we risk missing more subtle ecosystem changes that could hide important long-term consequences for ourselves and the biosphere.

The matter has been made more complicated by the growing realization that the overall well-being/integrity/health of the ecosystem is a powerful determinant of human well-being and vice versa. In short, because of this interdependency if the ecosystem collapses, so too will the human species. To untangle this, help is sought through applying systems ideas.

Systems ideas have emerged over the past 75 years largely driven by a recognition of the importance of understanding the relationship between conditions of the “whole” to those of constituent parts. Such systems are characterized by: 1) emergent properties which are critical for understanding the whole but may have little or no meaning in terms of constituent parts; 2) a hierarchical structure in which systems are nested within other systems; and 3) processes of communication, feedback, and control that allow for adjustment and adaptation in the face of stress.¹⁵⁻¹⁷

Systems thinking involves the use of conceptual models to link components to the “whole” and the identification of controls and feedback loops. It is the need to assess the state or performance of the constituent parts, controls, feedback loops, and the whole system, that gives rise to indicators or performance measures. In the absence of such a framework (and related expression of values), the choice of indicators among the many that are possible, occurs in a vacuum^{17,p.112} and the results are ad-hoc, reactive to current concerns, and potentially an impediment to anticipatory thinking.^{18,p.11} Environmental health indicators can be thought of as a set of feedback signals that facilitate tracking of conditions within the system that includes people and the enveloping ecosystem.

A large number of models have been developed over the years that in some way address the human-ecosystem interface and are found in the literature of a variety of interests and disciplines including: economics, geography, ecology, health, planning (community, urban, regional, water resources, etc.), quality-of-life, resource management, state-of-environment and more recently, ecosystem health and the

broad interest areas of sustainable development and sustainability. An interesting trend over the past 50 years is clearly discernible in this literature that offers insight into why it is important to include the classical health-oriented organizations and data sets, the focussed environment-oriented organizations and data sets, and others as well in this review.

As perspectives have broadened and more effort has been put into capturing a sense of the larger system, a number of these models have evolved and expanded to overlap and in some cases encompass the subject areas of others. Thus, templates used to guide state-of-environment assessments now have expanded to consider human health, and similarly, population health models now recognize conditions in the surrounding ecosystem as important human health determinants.

Two specific examples are: 1) Evans and Stoddart’s determinants of health model developed through the Population Health Program of the Canadian Institute for Advanced Research;¹⁹ and 2) the evolution of thinking related to the concept of sustainability that in early debate focussed on (mainly renewable) resource management and environment-economy linkages and latterly has swung into a much more holistic concern for ecosystem and human well-being together.

Evans and Stoddart’s conceptual framework links an individual’s well-being to: 1) their physical environment; 2) their level of prosperity (economic environment); 3) their social environment; and 4) a series of factors traditionally dealt with by medical sciences (genetic endowment, health care, disease, health and function, individual’s particular response (behaviour and biology)). Their “social environment” is based on a concern for lifestyle impacts on health but goes farther, recognizing that:

Feelings of self-esteem and self-worth, or hierarchical position and control, or conversely powerlessness, similarly appear to have health implications quite independent of the conventional risk factors.^{19,p.36}

They define “well-being” as “sense of life-satisfaction of the individual,” arguing that this broad sense of well-being should become the objective of “not only health policy, but of all human activity.”^{19,p.40}

Meanwhile, at the core of the concept of sustainability is a value set best described as

TABLE I
Principal Activities Within “Monitoring”

- 1. **Collecting** quantitative and/or qualitative data and information at its source using a variety of survey instruments;
- 2. **Tracking** pressures and conditions either remotely or in situ using a variety of technologies;
- 3. **Organizing** a variety of disparate data into coordinated, centralized databases;
- 4. **Synthesizing** data collected using different methodologies into comparable formats;
- 5. **Assuring** quality and consistency in methodology across all data collection and recording points;
- 6. **Building** capacity in methodology and techniques across jurisdictions through the transfer of knowledge and resources;
- 7. **Interpreting** data in order to draw out key insights;
- 8. **Presenting** information using a variety of interface design strategies and technologies; and
- 9. **Communicating** to decision-makers the underlying message that may be masked by the volume of data.

TABLE II
Organizations that have Contributed to the Development of the UN’s “Working List of Indicators of Sustainable Development”

- 1. United Nations Department for Economic and Social Information Policy and Analysis (DESIPA)
- 2. United Nations Department for Policy Coordination and Sustainable Development (SPCSD)
- 3. United Nations Department for Development Support and Management Services (DDSMS)
- 4. United Nations Department for Humanitarian Affairs (DHA)
- 5. Secretariat for the Framework Convention on Climate Change
- 6. United Nations Children’s Fund (UNICEF)
- 7. United Nations Conference on Trade and Development (UNCTAD)
- 8. United Nations Development Programme (UNDP) and its office to Combat Desertification and Drought (UNSO)
- 9. United Nations Environment Programme (UNEP) and the Secretariat of the Basel Convention
- 10. United Nations University
- 11. the Regional Commissions of the United Nations
- 12. United Nations Centre for Human Settlements (Habitat)
- 13. the International Labour Organizations (ILO)
- 14. the Food and Agriculture Organization of the United Nations (FAO)
- 15. United Nations Educational, Scientific and Cultural Organization (UNESCO)
- 16. World Health Organization (WHO)
- 17. International Telecommunication Union (ITU)
- 18. World Meteorological Organization (WMO)
- 19. United Nations Industrial Development Organization (UNIDO)
- 20. the World Bank
- 21. the International Atomic Energy Agency (IAEA)
- 22. European Communities Statistical Office
- 23. the Organization for Economic Co-operation and Development
- 24. the International Centre for Tropical Agriculture (CIAT)
- 25. IUCN – the World Conservation Union
- 26. International Institute for Sustainable Development (IISD)
- 27. International Institute for Applied Systems Analysis
- 28. National Institute for Public Health and Environmental Protection of the Netherlands (RIVM)
- 29. New Economics Foundation
- 30. Scientific Committee on Problems of the Environment (SCOPE)
- 31. Worldwatch Institute
- 32. World Resources Institute (WRI)
- 33. World Wide Fund for Nature (WWF)
- 34. Wuppertal Institute

Source: United Nations, 1996²³

Figure 1. The results-based triangle of sustainability

a “parallel care and respect for the ecosystem and people within – not one or the other, not one more than the other but both together as one.”^{20,21:p.223} From this

value set emerges an overall goal for achieving progress toward sustainability: “to maintain or improve human and ecosystem well-being.” The convergence with Evans and Stoddart’s thinking is striking, although the sustainability perspective reaches far beyond their anthropocentric focus. Thus, the treatment of environmental health indicators must eventually cover the range of data and information covered by the “results-based triangle of sustainability” shown in Figure 1. From a data/information systems perspective, each corner of Figure 1 can be expanded in a hierarchy of indicators (e.g., see Appendix 7).

Following the Earth Summit in 1992, the UN Commission on Sustainable Development (UNCSD) set out to identify a core set of indicators of sustainability that could be used as a guideline for national reporting. A desire to achieve some degree of compatibility between data and information sets gathered by individual nations to make possible a meaningful global synthesis was the motivation (see Appendix 2 for UNCSD original draft indicators).

The above discussion serves to demonstrate that the range of data sets and related information systems that are implicated by the phrase “environmental health surveillance” is vast.

What is “monitoring” and who is active at the “international” level?

Where is the wisdom we have
lost in knowledge?
Where is the knowledge we have
lost in information?
T.S. Eliot, *Choruses from ‘The Rock’, I*

At the basis of any knowledge-building exercise lies an empirical record: data, methodically captured and recorded, so crucial to building a scientific argument. But as T.S. Eliot laments, data is neither information nor knowledge nor wisdom. So while the collecting of data at its source through a variety of instruments (a narrow definition of monitoring) is crucial for the building of knowledge, there is a range of activities that fall under a broader definition of monitoring; the principal activities in this range are listed in Table I.

Each of these, often building upon one another, “adding value” to the original

data – working to make sense of the system to improve decision-making. It is the “value added” nature of these succeeding activities that places them within the category of “monitoring”. Not all organizations participate in all of these activities.

The 34 organizations listed in Table II are the contributors to the UN-led work on developing a core set of indicators of sustainable development. The nature and breadth of the indicators’ work illustrates the variation in function described above. This listing represents a small proportion of organizations active in environmental health-related indicators work at the international level. The list also reflects the fact that no single organization is mandated to assemble the breadth of information required to track and assess the state of the Earth’s people and ecosystems. Those interested in doing so must draw together data and information from many sources.^{22,p.233}

The scale issue

Whereas the dictionary definition of “international” might refer to issues relating to or involving two or more nations, there is – in the international arena, beyond national or state-specific programs – a spectrum of scales within which any given multi-party monitoring or surveillance-related activity might be categorized. Such a spectrum is set out in Table III.

Example data/information systems and indicator sets

This section presents a summary description of six “surveillance” systems from the vast potential number of organizations that are implicated through the discussion above. In all cases, a “filter” is used in the form of the principal periodic (usually annual) report that is issued to summarize and communicate the principal observations that are drawn from the underlying data and information. Table IV lists the organizations and report titles along with the Appendix numbers that contain the detailed indicator lists.

The following concluding observations arise from a review of the Appendices and the material from which they are drawn.

1. There is no obvious short list of core indicators that spans “environmental health” and provides a generic set that would apply everywhere.

TABLE III

Scales of Data and Monitoring Activities

1. **Global:** data collection on a world-wide scale with no *prima facie* reference to national boundaries, such as monitoring carried out through satellite imaging and remote sensing to measure atmospheric conditions, land use change and marine conditions. A prominent example of such a system is the IGOS (International Global Observing Strategy) Partnership which includes the: Global Terrestrial Observing System; Global Ocean Observing System; and Global Climate Observing System (see Appendix 8).
2. **International:** data collection on a world-wide scale organized on the basis of national monitoring and reporting. National data are forwarded to or collected by international bodies which organize them into international reporting systems. Examples include the United Nations System of National Accounts, reporting by the World Health Organization and various UN agencies.
3. **Multi-national:** data collection exercises organized among a number of countries, undertaken as a regionally coordinated effort or supported by an international agency usually designed to test specific hypotheses across a number of jurisdictions or to meet the objectives of a regional co-operation or governance agreement. Examples include wildlife and habitat monitoring programs co-ordinated by the North American Commission for Environmental Cooperation, pollution monitoring efforts by the Arctic Council, and a variety of programs carried out by the European Commission.
4. **Externally-supported National:** Where a developing country might not have the capacity to monitor important systemic conditions, an international body or the agency of another government may provide resources to build such capacity. Such initiatives have been undertaken, for example, by the Canadian International Development Agency and the United States Agency for International Development.
5. **National:** In order to ascertain how its own performance (measured in terms of locally determined values and preferences) compares to other jurisdictions, or for other domestic policy development purposes, a national (or sub-national) government may organize and interpret data from its own jurisdiction and compare it to data from a range of other jurisdictions. While the extra-territorial data may be acquired from an international body, this activity would constitute a distinct effort from those delineated above since organization, interpretation and presentation of data would add additional value to the existing data exercises. A prominent example of this type is the annual World Factbook compiled by the United States Central Intelligence Agency.
6. **Non-government Organizations (NGO) and Academic:** Again, while their activities may not represent data collection and monitoring efforts distinct from those listed, NGO and academic projects designed to organize, interpret and report on pressures and conditions from an international perspective represent an important contribution to our understanding of human-ecosystem interactions. Just three of the vast range of examples here are: 1) the annual *State of the World* report and *Vital Signs* published by the Worldwatch Institute; 2) work by a number of NGOs aimed at calculating alternative measures of “genuine progress” as a counterpoint to traditional national income measures (e.g., the Genuine Progress Index of the Genuine Progress Institute); 3) the *Penn World Tables* compiled by the Center for International Comparisons at the University of Pennsylvania.

TABLE IV

Example Surveillance Systems with Indicator Sets

Appendix 3.	International Global Observing Strategy (IGOS) Partnership;
Appendix 4.	World Health Organization (WHO) as reflected in their <i>World Health Report</i> ;
Appendix 5.	United Nations Children’s Fund (UNICEF) as reflected in the <i>State of the World’s Children</i> report;
Appendix 6.	United Nations Environment Programme / World Health Organization <i>Global Environment Monitoring System – Freshwater Quality Programme</i> (GEMS – Water Programme)
Appendix 7.	World Resources Institute (WRI) with United Nations Environment Programme, United Nations Development Programme and The World Bank as reflected in their <i>World Resources</i> report;
Appendix 8.	a transboundary perspective as reflected in the work of the <i>State of the Lakes Ecosystem Conferences</i> (SOLEC);
Appendix 9.	a provincial perspective as reflected in the Reports of the Provincial Health Officer of British Columbia.

BUILDING ON STRENGTHS: PAST, PRESENT, AND FUTURE

Figure 2. The Performance Measurement and Progress Assessment Cycle

Appendix 7*

The World Resources Institute (WRI), United Nations Environment Programme (UNEP), The United Nations Development Programme, and the World Bank as reflected in World Resources 1998-1999 (special focus on Environmental Change and Human Health)

1. Economic Indicators

- GNP (Atlas Method), total and per capita
- GDP total and per capita
 - ❑ Exchange rate based
 - ❑ Purchasing power parity (PPP) based
- GDP: average annual growth rate in %
- Distribution of GDP:
 - ❑ Agriculture
 - ❑ Industry
 - ❑ Services
- Average annual Official Development Assistance (ODA)
- ODA as a % of GDP
- ODA per capita
- Total external debt
- Total debt service costs
- Debt service as a % of total exports
- Direct foreign investment
- Central government expenditures
- Commodity indexes, various commodities
- Commodity prices, various commodities

3. Health

- % of low birthweight infants
- % of children under 5 suffering from:
 - ❑ underweight
 - ❑ wasting
 - ❑ stunting
- Daily per capita calorie supply as % of total requirement
- % pregnant women aged 15-49 with anemia
- % children aged 6-11 with goitre
- % of households consuming iodized salt
- % of children under 5 with Vitamin A deficiency
- Crude death rates per 1000
- Infant mortality rate per 1,000 live births
- Under 5 mortality rate per 1,000 live births
- Average annual change in under 5 mortality rate
- Maternal mortality rate per 100,000 live births
- Cases per 100,000 population:
 - ❑ Tuberculosis
 - ❑ Measles
 - ❑ Malaria
 - ❑ Polio
 - ❑ Cholera
- % of births attended by trained personnel
- Percentage of 1-year-olds immunized against
 - ❑ TB
 - ❑ DPT
 - ❑ Polio

4. Urban Indicators

- Urban population
 - ❑ Total
 - ❑ Percentage urban
- Population growth rate:
 - ❑ Urban
 - ❑ Rural
- Population in urban agglomerations > 750,000
- City level:
 - ❑ Population by largest city
 - ❑ Average annual growth rate by city
 - ❑ Urban residential density
 - ❑ Gross city product per capita
 - ❑ Socioeconomic indicators
 - ◆ Informal employment (%)
 - ◆ % poor households
 - ◆ % female-headed households
 - ◆ % female-headed households that are poor
- Crowding (floor area/person)
- % of urban households connected to:
 - ❑ Water
 - ❑ Sewerage
 - ❑ Electricity

2. Population and Human Development

- Population
- Average annual population change
- Average annual increment to population
- Average annual growth of the labour force
- Crude birth rate (births per 1000 population)
- Total fertility rate
- Percentage of population in specific age groups
- Income distribution: gini coefficient
- Percentage of income in each quintile of population (poorest to richest)
- Distribution of agriculture land ownership
 - ❑ Gini coefficient
 - ❑ % owning < 10 ha
- Population in poverty
 - ❑ International poverty line
 - ❑ National poverty line
- % of population with access to (urban, rural, total):
 - ❑ safe drinking water
 - ❑ adequate sanitation
 - ❑ health services
- Health expenditure as a percentage of GDP
- Public education expenditure as a % of :
 - ❑ GNP
 - ❑ Total government expenditures
- Number of public libraries

- Measles
- % of pregnant women immunized for tetanus
- ORT use
- Contraceptive prevalence (%) any method/modern method
- Population per doctor/nurse
- City air pollution:
 - ❑ City population
 - ❑ Mean annual TSP
 - ❑ Mean annual black smoke
 - ❑ Mean annual PM₁₀
 - ❑ Mean annual SO₂
 - ❑ Mean annual NO₂
- Lead in gasoline
 - ❑ Consumption of motor gasoline
 - ❑ Gasoline cost per litre
 - ❑ Market share of leaded gasoline
 - ❑ Maximum concentration of lead in gasoline
- Lead production
 - ❑ Concentrate produced in metric tons
 - ❑ Refined lead produced in metric tons (primary/secondary)
- % of households without (urban/rural):
 - ❑ Piped water
 - ❑ Own flush toilet
 - ❑ Finished floor
 - ❑ Refrigerator
 - ❑ Radio or television
- % of children under 5 with (urban/rural):
 - ❑ Diarrhea
 - ❑ A cough

5. Food and Agriculture

- Index of agriculture production (total, per capita)
- Index of food production (total, per capita)
- Average production of cereals (total, % change)
- Average production of roots and tubers (total, % change)
- Average production of pulses (total, % change)
- Cropland:
 - ❑ Total hectares
 - ❑ Hectares per capita
- Irrigated land as % of cropland
- Average fertilizer use (Kg per hectare of cropland)
- Tractors (average, % change)
- Harvestors (average, % change)
- Food security
 - ❑ Average annual net trade in cereals
 - ❑ Average annual donations or receipts of cereals
 - ❑ Grain consumption as a % of domestic production
 - ❑ Grain fed to livestock as a % of total grain consumption
 - ❑ Average daily per capita calorie supply
 - ❑ Average daily per capita protein supply
 - ❑ Average yield of cereals (kilograms per hectare, % change)
 - ❑ Average yield of roots and tubers (kilograms per hectare, % change)

Appendix 7 – Continued

The World Resources Institute (WRI), United Nations Environment Programme (UNEP), The United Nations Development Programme, and the World Bank as reflected in World Resources 1998-1999 (special focus on Environmental Change and Human Health)

- Per capita water use
- Waste water treated %
- Per-capita solid waste generated
- Households with garbage collection
- Transportation:
 - ❑ Cars per 1,000 population
 - ❑ Percentage of work trips by public transport
- Murders per 100,000 population

6. Forests and Land Cover

- Forest area
 - ❑ Extent by year, average annual % change
 - ❑ Natural forest (extent by year, average annual % change)
 - ❑ Plantations (extent by year, average annual % change)
- Forest industry structure: number of enterprises, number of employees
- Total land area by country
- Closed forests
 - ❑ Original forest as a % of land area
 - ❑ Forests as a % of original forests (current forests, frontier forests)
 - ❑ % frontier forests threatened
- Forest Ecosystems (area, percent protected)
 - ❑ Mangroves
 - ❑ Tropical forests
 - ❑ Nontropical forests
 - ❑ Sparse trees and parkland
- Average annual roundwood production (volume, % change)
 - ❑ Total
 - ❑ Fuel and charcoal
 - ❑ Industrial roundwood
- Average annual production (volume, % change)
 - ❑ Sawn wood
 - ❑ Paper
- Average annual net trade in roundwood
 - ❑ Volume, % change
 - ❑ Value, % change
- Land area and use
 - ❑ Total land area by nation
 - ❑ Population density
 - ❑ Domesticated land as a % of total
 - ❑ Land use (total, % change):
 - ◆ Permanent pasture
 - ◆ Forests and woodlands
 - ◆ Other land

8. Oceans and Fisheries

- Average annual marine catch (total, % change)
- Average annual freshwater catch (total, % change)
- Average annual aquaculture production
 - ❑ Marine fish
 - ❑ Diadromous fish
 - ❑ Freshwater fish
 - ❑ Molluscs and crustaceans
- Average annual balance of trade
 - ❑ Fish
 - ❑ Molluscs and crustaceans
 - ❑ Fish meal
- Per capita annual food supply from fish and seafood (total, % change)
- Marine fisheries, yield and state of exploitation, 1950s – 1990s
- Marine biological diversity of Regional Seas, 1990s (numbers of species, endemic/total)
 - ❑ Seagrasses
 - ❑ Corals
 - ❑ Molluscs
 - ❑ Shrimps and lobsters
 - ❑ Sharks
 - ❑ Seabirds
- Marine mammals (includes % of endemic threatened)

7. Fresh Water Resources and Withdrawals

- Annual internal renewable water resources (total, per capita)
- Annual river flows (from/to other countries)
- Annual withdrawals (total volume, per capita, % of total)
- Sectoral withdrawals (domestic, industrial, agriculture)
- Average annual groundwater recharge (total, per capita)
- Annual groundwater withdrawals
 - ❑ Total
 - ❑ % of annual recharge
 - ❑ Per capita
 - ❑ Sectoral share (domestic, industry, agriculture)
- Desalination water production
- Water quality in European Lakes by lake
 - ❑ surface area
 - ❑ depth (maximum, mean)
 - ❑ catchment area
 - ❑ secchi depth
 - ❑ pH
 - ❑ concentrations of:
 - ◆ chlorophyll
 - ◆ phosphorous
 - ◆ nitrogen
 - ◆ chloride

9. Biodiversity

- National protection systems
 - ❑ All protected areas (IUCN Categories I – V)
 - ◆ Number
 - ◆ Area
 - ◆ % of land area
 - ❑ Totally protected areas (IUCN Categories I – III)
 - ◆ Number
 - ◆ Area
 - ❑ Partially protected areas
 - ◆ Number
 - ◆ Area
 - ❑ % of protected areas (IUCN Categories I – V) at least
 - ◆ 100,000 ha
 - ◆ 1 million ha
- International Protection Systems
 - ❑ Biosphere reserves
 - ◆ Number
 - ◆ Area
 - ❑ World Heritage Sites
 - ◆ Number
 - ◆ Area
 - ❑ Wetlands of International Importance
 - ◆ Number
 - ◆ Area
- Globally threatened species
 - ❑ Mammals
 - ◆ Numbers: total, endemic, threatened
 - ◆ Number per 10,000 km²
 - ❑ Birds
 - ◆ Numbers: breeding, endemic, threatened
 - ◆ Number per 10,000 km²

Appendix 7 – Continued

The World Resources Institute (WRI), United Nations Environment Programme (UNEP), The United Nations Development Programme, and the World Bank as reflected in World Resources 1998-1999 (special focus on Environmental Change and Human Health)

10. Energy and Materials

- Commercial Energy Production (total in petajoules, % change)
 - ❑ Total
 - ❑ Solid fuels
 - ❑ Liquid fuels
 - ❑ Gaseous fuels
 - ❑ Primary electricity
- Total Energy Production (total in petajoules, % change)
 - ❑ Commercial energy
 - ❑ Traditional fuels
- Electricity Production (total in million Kwh, % change)
 - ❑ Total
 - ❑ Thermal
 - ❑ Hydroelectric
 - ❑ Geothermal
 - ❑ Nuclear
- Trade (total in million Kwh, % change)
 - ❑ Import
 - ❑ Export
- % of total final consumption
 - ❑ Industry sector
 - ◆ Total
 - ◆ Iron and steel
 - ❑ Transportation sector
 - ◆ Total
 - ◆ Air
 - ◆ Road
 - ❑ Agriculture
 - ❑ Commercial and public sector
 - ❑ Residential
- Production of selected minerals and materials
 - ❑ Bauxite
 - ❑ Iron ore
 - ❑ Copper ore
 - ❑ Silver ore
 - ❑ Gold
 - ❑ Sulfur
 - ❑ Salt
 - ❑ Nitrogen (ammonia)
 - ❑ Phosphorus
 - ❑ Potassium
 - ❑ Sand and gravel
- Hydraulic cement

- ❑ Higher plants
 - ◆ Numbers: all species, endemic, threatened
 - ◆ Number per 10,000 km²
- ❑ Reptiles
 - ◆ Numbers: total, endemic, threatened
 - ◆ Number per 10,000 km²
- ❑ Amphibians
 - ◆ Numbers: total, endemic, threatened
 - ◆ Number per 10,000 km²
- ❑ Freshwater fish
 - ◆ Numbers: all, threatened
- Endangered species management programs

11. Atmosphere and Climate

- Emissions from fossil fuel burning and cement manufacturing
 - ❑ CO₂ Emissions: total
 - ◆ Solid fuels
 - ◆ Liquid fuels
 - ◆ Gaseous fuels
 - ◆ Gas flaring
 - ◆ Cement manufacturing
 - ◆ Total
 - ❑ Per capita CO₂
 - ◆ Emissions
 - ◆ Bunker fuels
 - ❑ Inventories of National Greenhouse Gas Emissions
 - ◆ CO₂ (fossil fuels, land use change, industrial processes, net)
 - ◆ Methane (fossil fuel extraction, fuel combustion, agriculture (livestock, other) waste) total
 - ◆ Nitrous oxide, total
 - ❑ World CO₂ Emissions from Fossil Fuel Consumption and Cement Manufacturing
 - ❑ Atmospheric Concentrations of Greenhouse and Ozone-depleting Gases
 - ◆ Carbon dioxide (CO₂)
 - ◆ Carbon tetra chloride (CCl₄)
 - ◆ Methyl Chloroform (CH₃CCl₃)
 - ◆ CFC – 11 (CCl₃F)
 - ◆ CFC – 12 (CCl₂F₂)
 - ◆ CFC – 113 (CCl₃F₃)
 - ◆ Total gaseous chlorine
 - ◆ Nitrous oxide (N₂O)
 - ◆ Methane (fossil fuel extraction, fuel combustion, agriculture (livestock, other) waste) total

* For appendices 1-6, 8 and 9, see <http://ottserver1.ottawa.ijc.org/hptf/>

2. Indicators are part of hierarchical systems that extend from the most general perspectives to specific measurable conditions reflected in the data points at source. Appendices 2 through 8 fit this format. Identification and selection of indicators should start at the general level, to be followed by a discussion of the more specific set of indicators that would support a general orientation. Starting instead at the bottom by identifying indicators will fail to point towards the desired generalized objectives.
3. As subtleties of systems come to be understood, indicator sets tend to expand. A good example is that if the issue of distribution (equity and disparity) within nations is added to the WHO indicator set listed in Appendix 3, a significant increase in complexity occurs.
4. Capturing ecosystem conditions, particularly in a range of different settings, is significantly more complex than describing the state of human society, a challenging task in itself.
5. Choosing an indicator set is an important task but only a small part of the larger task of identifying and tracking ongoing change, synthesizing meaning from often contradictory indicators, and communicating the results to key communities. In fact, attention must be paid to a “Performance Measurement and Progress Assessment Cycle” illustrated below in Figure 2.

Each of the elements of Figure 2 require a different set of skills and insights. For example, those who are

comfortable with the science and technique of measurement are often not well schooled in nor comfortable with the qualitative insights that emerge from story and vice versa. Neither of these groups are necessarily skilled in either synthesis and judgement or communication.

6. The phenomena that require attention in assessing "environmental health" function on different time scales. These differences have significant implications for indicators work.

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