



## Ecosystem Health: The Concept, the ISEH, and the Important Tasks Ahead

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### THE FOUNDING OF ISEH

The International Society for Ecosystem Health (ISEH)<sup>a</sup> came into existence at a time when it was rapidly becoming apparent that the earth's ecosystems were failing, both locally and globally (Tolba *et al.* 1992). Despite worldwide attention drawn to the consequences of ecosystem degradation, and subsequent international agreements and treaties respecting the importance of maintaining the health and integrity of the earth's ecosystems, environmental degradation has continued and even accelerated (Vitousek *et al.* 1997; Ullsten 1998; Salim *et al.* 1999). ISEH was conceived to engage scholars from a variety of fields to bridge or even transcend the natural, social,

and health sciences. A primary goal was to provide the conceptual and methodological foundations for assessing the condition of the earth's ecosystems.

The idea for forming an international society around the concept of "ecosystem health" arose out of an interdisciplinary workshop on diagnostic indicators of ecosystem condition (Ecosystem Medicine: Developing a Diagnostic Capability. Allerton Park, University of Illinois, Champaign-Urbana 1991). Participants and founding members of ISEH were Val Beasley (University of Illinois), Robert Costanza (University of Maryland), David Cox (University of Illinois), Tony Hayes (University of Guelph), David Rapport (Statistics Canada), David Schaeffer (Eco Health Research, Inc.), Christian Thorpe (Kaiser Permanente Medical Center), and David Waltner-Toews (University of Guelph). Founders were an eclectic group of transdisciplinary thinkers from the fields of medicine, veterinary medicine, ecology, and economics who had come together to explore potential transfers from the fields of human and vet-

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erinary medicine into ecology. They agreed that there was a need to carry on these discussions in a wider forum, and that the International Society for Ecosystem Health should be formed for this purpose.

At that time, several other workshops/symposia had already been held on the topic, and others were being planned. These included an Aspen Institute-sponsored workshop on ecosystem health at Wye, Maryland (October 1990), a symposium on "Defining Ecosystem Health: Science, Economics, or Ethics?" sponsored by The American Association for the Advancement of Science, Washington, D.C. (February 1991), a National Oceanic and Atmospheric Administration (NOAA) workshop at the N.E. Science Center Narragansett Laboratory, Narragansett, RI (1992) on "The Health of Large Marine Ecosystems," a NATO-sponsored Advanced Research Workshop on "Evaluating and Monitoring the Health of Large-Scale Ecosystems," Chateau Montebello, Quebec (October 1993), and a Hastings Center workshop on the philosophical and ethical dimensions of ecosystem health (1993).

The inaugural event for ISEH, however, was the 1st International Symposium on Ecosystem Health and Medicine (Ottawa, June 19–23, 1994), co-organized by ISEH and the University of Guelph. With more than 800 participants from 33 countries, this event brought the concept of ecosystem health to the attention of the international scientific community (Shrader-Frechette 1994). The opening keynote address was delivered by the late Henry Kendall on the topic of environmental and population challenges: global prospects. Other keynote addresses explored the interfaces between disciplines from ecology and public health, to environmental management, ethics, and ecological economics. These included, among others, presentations by Robert Costanza (Mageau *et al.* 1995), David Ehrenfeld (Ehrenfeld 1995), Richard Levins (Levins 1995), Tony McMichael (McMichael & Martens 1995), Eugene Odum (Odum 1995), David Rapport (Rapport 1995), Margaret Somerville (Somerville 1995), and M. Gordon Wolman (Wolman 1995).

Collectively, participants represented a wide range of disciplines including anthropology, economics, ecology, environmental management, epidemiology, ethics, law, philosophy, public health, sociology, and veterinary medicine. Although the participants came from varied backgrounds, a shared belief emerged that collaborative efforts that crossed disciplinary boundaries were essen-

tial to arrive at a deeper understanding of regional environmental challenges and solutions. Understanding the forces of transformation of the earth's ecosystems calls for a holistic approach in which humans are "part of" and not "apart from" the ecosystem (Cairns 1994; Borrmann 1996).

## THE CONCEPT OF ECOSYSTEM HEALTH AND THE ROLE OF ISEH

A key mission of ISEH is to encourage understanding of the critical links between human activity, ecological change, and human health (Cairns 1997a; Rapport *et al.* 1998a,b; McMichael *et al.* 1999; Rapport & Whitford 1999). Central to this task is extending the concept of "health" from its traditional domains of application at the individual and population levels to that of the whole ecosystem. This involves the development of methods of assessing the degree to which the functions of complex ecosystems are maintained or impaired by human activity. It also involves formulating new strategies that take account of societal values and biophysical realities to manage human activities so that ecosystem health is enhanced and not compromised further (Farnsworth 1995; Vitousek *et al.* 1997; Gaudet *et al.* 1997; Cairns 1998).

Novel ideas take time to become established, and a few decades is not unusual for the maturation process. Indeed, "ecosystem health" both as a concept and an emerging practice can trace its earliest history to seminal ideas in the writings of the famous Scottish geologist, James Hutton (1788) who developed the concept of the earth as an integrated system. It also finds its roots in the writings of the 1940s naturalist, Aldo Leopold (Callicott 1992). Publications in the late 1970s and early 1980s (Rapport *et al.* 1979, 1981, 1985) provided fresh perspectives along similar lines and mapped out the great similarities between diagnostic challenges at the level of the individual and the whole ecosystem. The term "ecosystem medicine" was coined to describe this new area of investigation (Rapport *et al.* 1979). Later this evolved into principles and concepts of ecosystem health (Schaeffer *et al.* 1988; Rapport 1989).

During the same period and subsequently, advances have been made in the development of methods to measure the health, specifically the biological condition, of aquatic ecosystems, and

to use that knowledge to diagnose causes of degradation (Karr *et al.* 1986; Fausch *et al.* 1990; Karr 1993; Karr & Chu 1995). Those methods have now been applied to assess the condition of aquatic systems and their terrestrial landscapes throughout the world (e.g., Roth *et al.* 1996; Simon 1999).

While the concept of ecosystem health has become widely used and forms the basis for a number of national and international programs, particularly with respect to management of forest, rangeland, coastal, large-marine and freshwater ecosystems, a few scientists (e.g., Calow [1992]; Suter [1993]; Wilkins [1999]) have continued to argue that the concept has serious limitations. Their objections stem from two views. First they argue that ecosystems do not exist as definable bounded entities, and thus ecosystem functions have no grounding in reality. Widespread use of ecosystems as a basis for analysis by leading scientists (e.g., Chadwick *et al.* 1999) suggests that this view is no longer tenable. Second they contend “health” has no validity at levels of organization beyond the individual. If this were true it would delegitimize public health as we know it in relation to human communities and populations. In so doing it would discount many of the now-recognized supra-individual influences on human health (McMichael *et al.* 1999).

Such critics fail to recognize the significance of a “humans in” approach to ecosystem analysis (Bormann 1996; Rapport *et al.* 1999a). Nor do they recognize that ecosystem services can be impaired under stress (e.g., altered nutrient cycling, primary productivity, biodiversity, changes in trophic organization and dynamics, increased incidence of disease) (Rapport *et al.* 1985; Karr 1999). For a recent exchange of views between proponents and critics of the ecosystem health concept, see Wilkins (1999) and Rapport *et al.* (1999b).

There are also two other foundational hurdles that have perhaps limited the development of the ecosystem model. The first is the institutional inertia that has come from super-specialization within academic institutions and culture. Much of the promotion and recognition by traditional peer review prohibits or at least puts at some significant cost interdisciplinary research and collaboration between disciplines with different discourses and methodologies (Somerville & Rapport 1999). As a result, researchers of ecosystem health have had to go, at some risk, to places where traditionalists would not care to venture. Not everyone is prepared or able to take the risk.

A second obstacle has been the definition of “ecosystem health”—a somewhat difficult concept primarily because “health” is one of those elusive properties that is better recognized (observed) by its absence. A large number of definitions have been proposed and most share common elements (Rapport 1995). A concise definition is given by Costanza (1992): “An ecological system is healthy and free from “distress syndrome” if it is stable and sustainable—that is, if it is active and maintains its organization, and autonomy over time and is resilient to stress” (Costanza 1992, p 9). Mageau *et al.* (1995) have elaborated upon this definition, proposing operational measures of ecosystem health in terms of vigor (productivity), organization, and resilience. Some would argue that these concepts do not go far enough and that simple and direct biological measures of ecosystem condition are more convincing and suffice to demonstrate the extent to which human actions have degraded living systems (Karr 1999).

These definitions and measures tend to emphasize the ecological aspects of ecosystem health. A more comprehensive perspective would also take into account the human health dimension. As defined in this journal, the field of ecosystem health comprises “a systemic approach to the preventive, diagnostic, and prognostic aspects of ecosystem management, and to the understanding of relationships between ecosystem health and human health. . . .”

One may question the adequacy of these definitions. An essential component of “health” is the capacity to achieve reasonable human goals (meeting needs). This along with the capacity for renewal, i.e., maintaining organization (including resilience, vigor, etc.), are the essence of health. Health thus embraces both science and the humanities (i.e., values implicit in the selection of goals, etc.) Perhaps, too, there has been too much emphasis on human health rather than human goals.

One thing that becomes clear about the definition of “health” is that it is constantly evolving, and the social context strongly conditions what is considered to be healthy. To give an historical example, consider what constituted “health” in 19th century Cuba. At the height of the sugar cane plantation economy, 10 years of productive work from slaves was regarded as acceptable by the masters. From this perspective, good nutrition was viewed in terms of calories for hard work. The slaves had other ideas and a dual system developed: the planters’ doctors keeping the slaves in “working condition” and the slaves treating everything else with a

mixture of methods brought from Africa, learned from native Americans, and improvised in situ. In today's world, as the middle class demands the right to feel good, "health" includes not being exhausted at the end of a day's work, the right to bear children makes fertility a health issue, etc. As our capacity to understand the world increases and as we have more resources to put into caring for the future, new dimensions of health are agreed upon, often after considerable debate.

For ecosystem health there are properties that can be agreed to now such as the capacity to respond to perturbations, and other attributes that will be controversial such as the capacity to provide ecosystem services to a larger whole. We need to acknowledge this and let the notion of ecosystem health evolve.

It remains a matter of debate as to whether ecosystem health should be considered by itself as a scientific discipline (perhaps within a transdisciplinary framework) or whether it should be considered as a practice that draws upon existing disciplines. On the one hand, it may be argued that ecosystem health is an umbrella field drawing upon the specialized knowledge of other disciplines and putting this knowledge to use in practical ways. On the other hand, it may be argued that ecosystem health is transdisciplinary in nature and is providing new methods and concepts that shed light on the interrelations between human activity, ecological change, ecosystem services, and economic and human health risks (Rapport *et al.* 1998c).

In either case, assessing ecosystem health is highly contextual. While common behaviors under stress have been demonstrated among very different types of ecosystems (Rapport *et al.* 1985; Rapport & Whitford 1999), it has also been shown that there are unique features as well that are contextually determined (Hildén & Rapport 1993; Huq & Colwell 1996; Kevan *et al.* 1997; Yazvenko & Rapport 1997; Buckingham 1998; Kevan & Belaussoff 1998; Karr & Chu 1999). Underlying the analyses, properties of complex systems, i.e., non-linearity, positive and negative feedback loops, the interplay of societal values with biophysical change, uncertainty, and mutual causality are pervasive (Levins 1995).

## TRENDS AND TENDENCIES

What are the general tendencies that are now apparent in the brief history of ISEH? We submit

that the following are significant and encouraging trends:

### PROGRESSION IN ARGUMENTS FROM PHILOSOPHICAL TO QUANTITATIVE

A progression in the discourse from arguments that initially were largely philosophical in content; e.g., ecosystem health as a societal goal, ecosystem health as a metaphor (e.g., Costanza *et al.* 1992) to questions of quantitative methods of assessment at a variety of scales; e.g., indicators of ecosystem health using ecological, public health and socioeconomic data (e.g., Johnson & Patil 1998). This is not to imply that philosophical and ethical issues are less important than the scientific investigations. The two go hand in hand.

### A CHANGE IN THINKING

A progression from consideration of how human activity impacts the biophysical functions of ecosystems to complex representations wherein ecological change is shown to be a prime determinant of human health and economic viability. This requires taking into account societal inputs and or impacts and public health components (Levins *et al.* 1994). Paramount here is increasing recognition given to the role that human values play in the system (Gaudet *et al.* 1997; Salim *et al.* 1999; Ullsten 1998; van Ierland *et al.* 1998).

### A COMMUNITY OF SOCIETIES

A growing interest on the part of other international societies is having ISEH cosponsor their events. ISEH was invited to cosponsor events organized by The Soil Science Society of America (St. Louis, Missouri 1996), The American Phytopathological Society (Rochester, New York 1997), The International Society for Ecological Economics (Santiago, Chile 1998), the European Union of Geological Sciences (Strasbourg, France 1999), and The 31st Congress of The International Union of Geological Sciences (Rio de Janeiro, Brazil 2000). Recently, the International Society for Environmental Epidemiology had a special symposium, "Ecosystem Health: Bridging the Gap" (Edmonton, Alberta, Canada, December 1997).

### ECOSYSTEM HEALTH IN THE CLASSROOM

The development of curricula in ecosystem health in veterinary schools. In Canada and in the

U.S., programs in ecosystem health are being initiated in veterinary schools. Beginning in 1994, an elective field course in ecosystem health has been offered jointly by all four veterinary colleges in Canada (Ribble *et al.* 1997; reprinted in this issue) in response to the recognition that ecosystem health was a logical context for veterinary medicine to address health issues involving nondomestic species (Nielsen 1992). The program engages student problem solving for real cases in an ecosystem health context; for example, urban wildlife problems, lead pollution of marshes, agricultural pollution of estuaries, sour gas leaks in oil fields, etc. At each site a problem was identified and students applied their veterinary skills to deal with the problem but soon discovered that this solution was embedded in a wider circle of expertise and interests. The experience provided "fast track" learning as to the relevance of ecosystem health to the health of domestic animals, wildlife, and people. The University of Illinois (Champaign-Urbana) has offered a program through its school of veterinary medicine that integrates veterinary medicine, environmental concerns, and ecosystem health.

### ECOSYSTEM HEALTH IN MEDICAL SCHOOLS AND SCHOOLS OF PUBLIC HEALTH

Development of ecosystem health curricula in medical schools and schools of public health. In recent years, both schools of public health and schools of medicine, have initiated teaching programs on ecosystem health topics. Within the Faculty of Medicine at the University of Western Ontario, for example, ecosystem health topics have been introduced into the first, second, and fourth years of undergraduate medicine. Students in the fourth year course are exposed to a variety of case studies (e.g., asthma, ozone depletion, changing distribution of vector-borne diseases, antibiotic resistance). Students actively participate in the development of the case materials. Within schools of public health (e.g., Harvard School of Public Health, Johns Hopkins School of Public Health) programs on climate change and infectious diseases, as well as other aspects of regional ecosystem health have been introduced. In the spring of 1999, a workshop organized by the Center for Conservation Medicine (a newly established environmental health collaborative between Tufts University School of Veterinary Medicine, Harvard Medical School's Center for Health and the

Global Environment, and Wildlife Preservation Trust International) will be held at White Oak Conservation Center (near Jacksonville, Florida) to explore the potential for integration between conservation biology and medicine.

### INCREASING SUPPORT FROM FUNDING AGENCIES

For example, in Canada, collaboration between the Medical Research Council, the Social Science and Humanities Research Council, and the National Science and Engineering Research Council resulted in sponsorship of several Research Chairs and programs on aspects of ecosystem health. At the University of Guelph, for example, under this program, both a research chair in Ecosystem Health and a Research Program in Agroecosystem health received support from this collaborative sponsorship among the Science councils of Canada.

### INITIATION OF NATIONAL AND INTERNATIONAL PROGRAMS IN ECOSYSTEM HEALTH

The International Development Research Centre (IDRC) in Canada has an ongoing program in ecosystem health with a focus on the human health impacts of ecological change. IDRC now sponsors research in this area in a number of developing countries. The United States Department of Agriculture (USDA) Natural Resource Conservation Service has initiated a program in "Rangeland Health" that incorporates the biological, social, economic, anthropological, and human health aspects of ecosystem health. That program was initiated by a workshop held in Las Cruces (in early 1999) on integrating what is known about ecosystem health into a comprehensible framework that can be made available to resource managers and users. The workshop also considered applications of Geographic Information Systems to assessing, monitoring and recovering ecosystem health.

Other international collaborations include the Sustainable Development Agreements between Benin, Bhutan, Costa Rica, and The Netherlands. This arrangement recognizes the need to change relationships between countries to achieve more reciprocity, participation, and equity. In the search for indicators that cover all aspects of life and support management of the natural resources and environment in these countries, the use of holistic approaches such as favored by the ecosys-

tem health view play an important role. It is expected that such approaches will receive major attention in the relationship and dialogues between north and south and will stimulate relevant research in developing countries ([de Kruijf & van Vuuren 1998](#)).

## ENVISAGING THE FUTURE

While the future is unknowable in the present, there is an increasing receptivity to an ecosystem health approach to environmental management. It is to be hoped that this receptivity does not result in fossilizing or institutionalizing the field of ecosystem health, for that could lead to the loss in “openness” that is essential for dealing with the complexity of the “humans in” approach to ecosystem assessment. Further, while ecosystem health is becoming articulated as a major societal goal, it is not intended that ecosystem health become a social movement. Rather, it should remain a science and value-based framework for ecosystem assessment and management of human activities in order to preserve, or restore, the health of ecosystems. This framework places major importance on the integration of societal values ([Gaudet et al. 1997](#)), ecological understanding ([Rapport et al. 1995](#); [Costanza et al. 1997](#); [Karr & Chu 1999](#)), and human health ([McMichael 1993](#); [Epstein 1995](#); [McMichael & Martens 1995](#); [Patz et al. 1996](#); [McMichael 1997](#); [Böhm & Saldiva 1998](#)). Ecological disequilibrium can have adverse effects upon human society (e.g., [Cairns & Bidwell 1996a,b](#)).

As we enter the 21st century, the need for innovative methods for conducting ecosystem health assessments, integrating the human health, socio-economic, biophysical, and public policy dimensions will only increase. While the earth may not be in imminent danger as a result of human activities, living systems as they have evolved over millions of years are at risk, and that includes humans. Thus, what is at stake is the living systems we cherish and depend on, as well as much of the fabric of “quality of life” cherished by most, but not all, of the human community. In this respect, the use of the term “ecosystem” needs to be understood not as a “disembodied” entity, which is in many respects similar to the “market” of the economists, but rather in terms of the importance of living systems at the core.

As the challenge of obtaining a viable future intensifies, so too will the need for holistic meth-

ods for assessing ecosystem health and managing human activities in order to achieve it. By “holistic” we refer not to a single theoretical view but to a comprehensive and integrative approach that includes all the messages and signals that we can muster about the condition of the earth’s living systems and the human interdependence with those systems.

ISEH has focused on these issues as it strives to show the relevance of ecosystem health to achieve important societal goals—such as sustaining economic opportunity, sustaining human health, achieving economic equity, and social justice. ISEH, through its various activities, fosters the need to sustain healthy living systems for what they provide to human well-being ([de Kruijf & van Vuuren 1998](#)). In this we are not alone. Many other societies are advancing these goals from their own perspective, e.g., the International Society for Ecological Economics. While continuing to build the intellectual foundations for ecosystem health remains of high importance, equally important is the process of engagement. This in turn brings into play bridging many cultures, not only between academic disciplines but also between sectors of society. For example, the corporate culture is a very different thing than the academic culture, yet the two must achieve some mutual understanding and be able to work together if these larger societal goals are to be achieved. Ecosystem health is a *sine qua non* for sustainable use of the planet ([Cairns 1997b](#)).

## CONCLUDING REMARKS

Ecosystem health as a concept and as a practice is still in the early and formative stages of development. However, much of the intellectual framework for its evolution is in place and new and invigorating collaborations among the natural, social, and health sciences are yielding holistic perspectives that are finding practical applications. By strengthening these collaborative and holistic approaches to environmental management, and particularly by emphasis on the considerable risks to sustainable human health posed by degrading ecosystems, the activities of ISEH will gain in their relevance to human futures.

To this end we will continue to encourage collaborations across disciplinary boundaries ([Somerville & Rapport 1999](#)); continue to encourage the development of the concept of ecosystem health and its philosophical and ethical under-

pinnings; continue to encourage the development of quantitative methods of assessment, both those relating to advanced technologies (use of remote sensing, Geographic Information Systems, etc.) and those that use “nontechnology” (which are more accessible to the public and more likely to engage them as participants in protecting their and our interests); and continue to assist the development of new curricula within professional schools (particularly within schools of veterinary medicine, human medicine, public health, environmental sciences) and promote applications of ecosystem health to environmental management through co-organizing international conferences, such as the International Congress on Ecosystem Health, hosted by the University of California–Davis (Sacramento Convention Center, August 15–20, 1999; [www.vetmed.ucdavis.edu/centers/iseh/ecosystemhealth.html](http://www.vetmed.ucdavis.edu/centers/iseh/ecosystemhealth.html)). It is encouraging to find increasing receptivity to these initiatives. At the same time, as we face the 21st century, there is clear evidence of continued deteriorating conditions in many (most) of the world’s ecosystems (Vitousek *et al.* 1997). Thus the challenge of achieving ecosystem health is ever more evident, and increased energy and efforts toward this goal will be required.

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