Globalisation and Ecological Integrity in Science and International Law

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Edited by

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This book is dedicated to William Rees:
Our inspiration for a long time, and our host for 2010

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INTRODUCTION

LAURA WESTRA, KLAUS BOSSELMANN AND COLIN L. SOSKOLNE

The Global Ecological Integrity Group (GEIG) has been meeting annually since 1992. In 2010, the meeting took place at the University of British Columbia, hosted by William Rees. For this meeting, the GEIG returned to its roots. The chosen focus for 2010 was precisely the initial impetus of the Group's research from 1992 to 1999, that is, the quest for a fuller understanding of the role of ecological integrity in the various fields of human endeavour.

The GEIG quest started with an attempt to find a more thorough and explicit understanding of the scientific meaning of ecological integrity. The most recent thinking of the GEIG is presented in this book and, for ease of access, is divided into seven parts.

We were fortunate to have with us, James Karr, who joined us to address, once again, several of the issues that were central to our research at the start, focussing on the complete dependence of the human enterprise on the integrity of all living systems. Part I of this book is devoted to the "Science of Ecological Integrity", starting with a chapter by James Karr. The work of Pavel Cudlín then traces the interface between ecosystem services and citizens' responsibility for just governance. In the next chapter, Robert Goodland explains the importance of ecological integrity in relation to some of the gravest problems of our times: climate change and hunger. Both this chapter and the next one, by Heather McLeod-Kilmurray discuss the necessity for a radical change of diet on a planetary scale, to ensure sustainability and ecological justice.

In Part II, we return to yet another aspect of ecological integrity, that is, its relation to ethical norms. Donald Brown analyses the ethical implications of the Copenhagen Accord regarding climate change. Peter Brown goes even further, seeking a moral foundation for all governance based on ecological principles. Helmut Burkhardt outlines the main imperatives to be followed to achieve sustainability, and Sheila Collins traces possible scenarios to preserve the "global commons".

After 1999, the GEIG's main focus shifted somewhat, to consider the physical integrity and health of individuals. This required both exploration and explication of the legal dimensions of integrity in relation to human rights. Thus, in Part III, Joseph Dellapenna discusses existing forms of international law, and Sara Seck proposes a turn to "Third World Approaches to International Law" (TWAIL) for the better protection of ecological integrity. Klaus Bosselmann discusses the possible presence of "global constitutionalism", followed by Owen McIntyre who traces the relation between human rights and water in international administrative law. Kathryn Kintzele then presents her research on the ecological aspects of the constitutions of various countries around the world.

In Part IV, we return to the theme pursued in Florence in 2009, the problem of appropriate, ecologically sound governance. Timmer, Kissinger and Rees consider the importance of the regional aspects of governance, necessary in order to diminish the ecological impact of current policies. Alex and Sabina Lautensach then discuss human security in the context of rights, while Michael Schröter exposes the conflicts between liberalism and sustainability. The next two chapters examine the question of the interface between globalization and governance through two regional case studies: in the first one, Philippe Crabbé examines the effects of globalization in sub-Saharan Africa, while in the final chapter of Part 4, Vicky Karageorgu considers inter-basin water transfers in Greece.

In Part V, we further examine one of the major themes our group has studied, especially since 2007 at our Halifax, NS, meeting: the relation between ecological integrity and indigenous peoples. Linda Te Aho and Mimi Lam discuss, respectively, Maori and Saami approaches to the protection of ecological integrity in local landscapes, while Jack Manno explains the forms of governance in the Ononodaga Nation, in the State of New York.

In Part VI, we return to another major theme our group has studied since 1998: the importance of biological and ecological integrity to public health. These three chapters, range from the general problem of Peak Oil, discussed by Donald Spady, to Colin Soskolne and Shira Kramer's analysis of an ongoing legal case regarding decades of industrial pollution around the harbour of Sydney, NS. A general discussion of the interface between cancer and environmental epidemiology follows by Vladimír Bencko, pointing to technological promise for preventative public health.

In Part VII, the final section of this book, we consider issues which have been a more recent focus of GEIG, that is, the role of the media in reporting and presenting unsustainable practices (Rose Dyson), the role of the Internet in general (Robert Rattle), and in reporting environmental disasters (Doug Daigle). This Part speaks to the foundational role of media and communication technologies in influencing cultural values for a sustainable future.

As usual, the papers presented at the meeting included a broad interdisciplinary range of areas and concerns, connected only by the foundational role that ecological integrity plays across the breadth of social and legal concerns.

In his Concluding Chapter, J. Ronald Engel captures the overall sense of the 2010 GEIG meeting, underscoring its prophetic vocation. One of the defining characteristics of GEIG, he notes, is its “prophetic stance” toward the world. While this stance is chiefly rooted in the prophetic heritage of the Western religious traditions, it also has roots in other cultures such as those of indigenous peoples. This deep prophetic theme underlies the motivations for participation in the Group. As the papers in this volume demonstrate, it is with prophetic eyes that GEIG sees the world and assesses what changes are needed and possible.

GEIG is an island of prophetic truth-telling for those who come together each year for a week of rigorous interdisciplinary exchange and mutually supportive interpersonal relationships; and, also for those who turn to its published proceedings for greater understanding of our global problematique. GEIG is a place where we can pursue the prophetic vocation of making the arguments which alone can give us genuine hope for our future. Each step in the prophetic argument that James Karr sets in motion in Chapter One is repeated and developed in a fresh way by each of the subsequent authors of this volume. Each author has an allegiance to one or another expression of the higher law — the unwritten, universal principles of fairness, morality, and justice that hold in judgment all instances of political and economic decision-making.

The 2010 Vancouver conference left participants with the great unanswered question of how, by prophetic argument, we can bring about the changes in the world that our faith in the higher law requires. No prophet has yet given an adequate answer to this question, and nor has GEIG been able to make the argument that will bring about the changes between humans and nature, and between nations and peoples that the world so desperately needs. This question must be an essential part of the future agenda of the Global Ecological Integrity Group if it is to remain true to its prophetic vocation.

PART I

THE SCIENCE OF ECOLOGICAL INTEGRITY

INTRODUCTION

LAURA WESTRA

In this part of the book, we return to the original intent leading to the formation of the Global Ecological Integrity Group (GEIG): the quest for a thorough, scientific understanding of ecological integrity and its role in human society. James Karr's introductory Chapter refers to it, as "an essential ingredient for human's long-term success". The present development of most of the world, fostered by globalization and the unsustainable thrust toward "growth", goes apace with "growing biotic impoverishment" minimal to the presence of ecological integrity. "However", Karr points out, "it is not only non-human species that fall prey, increasingly, to extinction, thus decimating natural systems and the support they lend to all life."

An additional irreparable harm comes from the loss of indigenous/ traditional ecological knowledge (TEK), and the diverse cultures and languages from which that knowledge originates. Karr also lists the many faces of biotic impoverishment, leading to both the direct and indirect depletion of living systems, human and non-human, and for both of which ecological integrity is absolutely necessary. Therefore, Karr maintains, it is necessary to ensure that this understanding is present in all political decisions, and that it is used to shape public policy globally.

Pavel Cudlin et al., argue, in Chapter 2, that "ecological citizenship" requires the appropriate valuation of the ecosystems that have been sustaining human life for millions of years. Over the last hundred years, "expanding human populations", and their "insatiable interests" have combined to cause massive destruction in those systems. The main cause of this disastrous result, Pavel argues, is that only "direct ecosystem provisioning services" are valued by markets, while the "depletion and degradation of natural and environmental resources" (i.e., ecological services), are not perceived as valuable. This chapter concludes with several proposed methods for arriving at an appropriate valuation of ecosystems.

Perhaps the most obvious result of the disintegrity that prevails globally, and of the degradation of natural systemic functions, is the presence of climate change. In Chapter 3, Robert Goodland and J. Ahnang decry the inconclusiveness and lack of political will that characterized the last two meetings regarding climate change (i.e., in Copenhagen (2009), and in Mexico (2010)). They propose a simple and inexpensive way to eliminate the greenhouse gas emissions attributable to livestock's supply chain, from forests cleared to supermarkets. The facts regarding land-based livestock speak for themselves. As more than 50 billion animals will be raised in 2010, one quarter of land worldwide is not used for grazing livestock, and one-third of all arable land is being destroyed, mostly from livestock and feed production.

It is particularly significant that even the World Bank Group's extensive peer review of Goodland and Ahnang's work, by their climate change specialists, approved the publication of the article on which this chapter is based, and that other UN Agencies have also adopted their findings. Yet, while the energy industry is closely monitored (with no significant reduction in the use of fossil fuels), the food industry is neither monitored nor curbed. The authors propose that living "Green" must start with "Eating Greenfully".

In Chapter 4, Heather McLeod-Kilmurray reprises the argument about food governance. She asks why laws, policies and individual actions are not moving in this direction?. Although most environmental protection Acts, Acts related to Agriculture, and other instruments relating to various aspects of food production, speak of "sustainable development", the laws governing food production in the Western world do not oppose "the massive concentrated power of the agricultural industry" despite the fact that "the global adoption of a low meat diet for the next 20 years" would halve the costs "of mitigating climate change up to 2050". This chapter concludes with "principles" and "recommendations" to move forward in that direction, clearly necessary for the survival of humanity and for the attainment of ecological and social justice.

CHAPTER ONE

ECOLOGICAL INTEGRITY: AN ESSENTIAL INGREDIENT FOR HUMANS' LONG-TERM SUCCESS

JAMES R. KARR

Introduction

Human history, like evolution itself, has been marked by relative stasis punctuated by periods of rapid change. Harnessing fire, making and using tools and weapons, and inventing the wheel were early mileposts signaling, we are told, an unbounded human ingenuity. These and other innovations allowed humans to tap natural capital and spread virtually throughout the world, living year-round from sea level to mountain tops, from equatorial heat to polar cold. The success of humans in these diverse natural settings resulted directly from the ability to tune culture and religion to diverse regional conditions. This progress—especially the specialization of nineteenth-century science and the hubris of twentieth-century technology—has led us to believe that we can repeal the laws of nature and forget the connections between society and its life-support systems.

Throughout evolutionary time, the success of living things has depended on the accumulation of information passed from generation to generation in the genetic blueprints of DNA. Humans, though, perfected another connection: the legacy of knowledge and culture passed from parents to their children and their children's children across hundreds, even thousands, of generations. During early human evolution, important knowledge was primarily biological—how to find food and shelter, escape from predators, avoid disease. Humans, like all other organisms, had to know their regional environments and how to support their families within these environments.

But with the agricultural revolution, these connections began to fray. By the nineteenth century, scientific and societal specialization combined with rapid, massive industrialization and free-market economics and seemed to promise escape from dependence on, or even connections with, other living systems. Now the "information age" gives us "virtual reality," completing our isolation from the rest of the living world and, some claim, clinching an end to human need for the biological knowledge so important to our ancestors.

Touting the uncanny ability of humans to be innovative and thus improve their lot, optimists—including economists, technologists, and futurists—see improvement in the human condition as an inevitable outcome of human ingenuity. But the world we have created may not be the ideal world we intended to create. Nature continues to challenge us through the very by-products of our own ingenuity: human ingenuity has had serious unintended consequences, which can no longer be ignored.

The most serious unintended consequence of this attitude is growing biotic impoverishment, the systematic reduction in Earth's ability to support living systems (Woodwell 1990), which extends from the degradation of the global physical and chemical environment to the impoverishment of human culture itself (Chu and Karr 2001). Concern over the implications of this trend for the quality of human and nonhuman life is now widespread, and the concepts of ecological health or ecological integrity are being invoked as guiding principles for policymaking. The multifaceted concept of integrity requires the integration of disciplines from science to philosophy and adds "a totally new note in the discourse of environmental concern" (Westra 1994).

Unintended Consequences

A major consequence of human "progress" is the homogenization of global society; human language, technology, and culture are becoming more homogeneous as we seem to become more independent of the idiosyncrasies of local natural systems. The rich diversity of human cultures is disappearing even more rapidly than the natural systems that nurtured that diversity. English is becoming a global language, and linguists are predicting that at least half of the world's languages will go extinct in the next century. These disappearing languages "are beyond endangerment," says Michael Krauss; "[t]hey are the living dead" (Haney 1995). Knowledge of indigenous medicines and other indigenous cultural adaptations, too, are fast being lost while cellular telephones, gasoline-powered engines, and computers spread to every corner of the globe.

Twenty-first century society is reluctant to acknowledge that ancient wisdom matters in the modern world (Davis 2009).

Another consequence of human "progress" is the impoverishment of Earth's life-support systems (Woodwell 1990; Millennium Ecosystem Assessment 2005, Chu and Karr 2011). Biological diversity declines as natural systems are degraded and destroyed, and ubiquitous pests and weeds homogenize the biological surroundings of humans and their industrial society. The loss of diversity reveals humans' flawed planetary stewardship, but, more important, it represents a loss of the unique life-support systems, including human culture itself, that the human species needs for survival. The integrity of the entire biosphere is threatened.

Global biotic impoverishment, including the homogenization of human culture, means that we are losing the adaptive complexes that once tied each human culture to the geographic region where it evolved. Our ingenuity and hubris let us forget the importance of these connections. It chained us instead to clever ways of extracting resources from environments that are too often depleted by our actions and all too often impoverish local human communities. We inherit and pass on to future generations a legacy of toxic effluents, destroyed and fragmented landscapes, depleted forests and fisheries, and collapsing cultures. The failure to maintain human bonds with place, biology, and culture—our connections to living systems—is likely the single most important challenge that future human generations will face.

We Must Learn from History

We first saw planet Earth from space more than forty years ago and suddenly realized just how isolated we were and how dependent on a small, yet unique, piece of space debris. Until then, we had only seen ourselves up close. From the distance of space, we see ourselves and our planet exposed in an unexpected fragility and vulnerability.

We would do well to remember that, like Earth alone in space, Easter Island is an isolated place, separated from other land by more than 1800 kilometers of ocean. When first settled 1000 to 1500 years ago by some two dozen Polynesian explorers, Easter Island was densely forested, with ample natural resources (Ponting 1991). By the seventeenth century, the population of Easter Island had burgeoned to about 10,000 people, but less than a century later, the island's human society had collapsed. When Western Europeans arrived in 1722, they found a treeless island and a small population living in primitive conditions. These Easter Islanders had no cultural memory of the society—their own ancestors—that only a few generations before had carved and placed the island’s famous massive stone monoliths.

Easter Island is not a unique situation. Environmental changes in soil, vegetation, and water caused by humans are primary factors in the decline of many local and regional civilizations: Angkor Wat, Mesopotamia, Indus, Greece, Rome, Egypt, Maya, Inca, Aztec, and the Moche. Like Easter Island, all are a metaphor for human society on the globe today. In contrast to the optimists’ view of an inevitable and continuous advance to human society, many others believe that humans have overshot Earth’s carrying capacity—as a thriving Easter Island society overshot that of the island—and that nothing short of substantial change in human behavior will reverse this trend. Such concerns are not merely extremist hand wringing; current public policy and legislative initiatives will not protect either natural or human environments.

The complex reasons for this inadequacy lie in the unrelenting hubris of a society that behaves as if it could repeal the laws of nature. Plans generated by economists, technologists, engineers, and ecologists have too often assumed that lost or damaged components of ecological systems are inconsequential or can be repaired or replaced. Yet we see the consequences of this attitude everywhere: In the Pacific Northwest, hatcheries are expected to sustain salmon stocks while little is done to restore degraded river and coastal environments, curtail harvests, or protect seasonal river flow. Throughout the world, expensive fertilizers are expected to replace depleted soil nutrients. Groundwater is depleted to supply unsustainable amounts of water to crops, livestock, and people. These consequences and many others point to the folly of maintaining the status quo.

Multidisciplinary initiatives seeking to improve environmental policy *are* cropping up in many contexts, driven by goals such as environmental justice (Bullard 1994), protection of biodiversity (Millennium Ecosystem Assessment 2005), and control pollutants (Colborn and Clement 1992). They are grounded in concepts such as ecological economics (Jansson et al. 1994), sustaining capitalism (Hart 2005), conservation biology (Groom et al. 2006), and industrial ecology (Ayers and Ayers 2002).

Fruitful use of these concepts requires the human species to recognize its fundamental dependence on living systems and to develop a core societal vision capable of integration—a vision that should be similar to the Socratic vision of medicine. This larger goal has been variously expressed as the protection of biological integrity (Karr 1991), ecological integrity (Karr and Dudley 1981; Nash 1991; Westra 1994), or ecological health (Costanza et al. 1992). Although the terminology varies, all of these visions focus on the reality that healthy biological systems are critical to the success, and survival, of the human species.

Growing Concern

Concern about the integrity of life-support systems has evolved over nearly two centuries. For most of the twentieth century, the most visible demonstration of "environmental awareness" was the conservation movement in the developed world. But voices now coming from all corners of society draw attention to the severity of present ecological crises (Karr 2002: Appendix). A Health of the Planet Survey by the Gallup Organization (Dunlap et al. 1993) showed "strong public concern for environmental protection throughout the world, including regions where it was assumed to be absent."

Scholars too are calling for shifts in human behavior. A worldwide collection of 1575 scientists, including 99 Nobel Prize winners, noted that "human beings and the natural world are on a collision course. . . . A great change in our stewardship of the Earth, and life on it, is required if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated" (Union of Concerned Scientists 1992). In the same year, the National Academy of Sciences and the Royal Society of London (1992) issued a joint statement recognizing the need for industrial countries to modify their behavior radically to avoid irreversible damage to the Earth's capacity to sustain life. A 1993 Population Summit held in New Delhi (Science Summit 1993) called for action to turn 1994 into "the year when the people of the world decided to act together for the benefit of future generations."

Universities and governments have also joined the chorus. In the 1990 Talloires Declaration, the leaders of hundreds of universities from throughout the world expressed their deep concern "about the unprecedented scale and speed of environmental pollution and degradation, and the depletion of natural resources." Business and labor also recognize the need for change. Forty-eight international industrialists and business leaders from more than 25 countries called for renewed efforts by business and government to make ecological imperatives part of the market forces governing production, investment, and trade (Schmidheiny 1992). Stuart Hart (2005) maintains that to be profitable in the future businesses must "simultaneously raise the quality of life for the world's poor, respect cultural diversity, and conserve the ecological integrity of the planet for future generations."

The United Steelworkers of America (1990) overwhelmingly endorsed a report that says, "We cannot protect steelworker jobs by ignoring environmental problems." Further, the "greatest threat to our children's future may lie in the destruction of their environment," and "the environment outside the workplace is only an extension of the environment inside." At the August 1993 Parliament of World's Religions (Briggs 1993), the leaders of Christianity, Buddhism, Islam, Judaism, Hinduism, and other faiths developed a "global ethic." Among other things, that ethic condemns environmental abuses. In an age of unparalleled technological progress, poverty, hunger, the death of children, "and the destruction of nature have not diminished but rather have increased."

The Commission on Life Sciences of the National Research Council (1993) concludes that society possesses many of the "tools to address environmental problems of enormous consequence to our social and economic well-being. But we are not using those tools most effectively." This demonstrates an important modern paradox: As scientific understanding of Earth and human effects on it expand, the threats to Earth's living systems—human and nonhuman—worsen (Karr 2008).

Biotic Impoverishment Goes Beyond Extinction

These organizations and the constituencies they represent recognize that all is not well on planet Earth, but they do not explicitly define the main problem: biotic impoverishment (Woodwell 1990). Biotic impoverishment is visible today in three major forms: indirect depletion of living systems through degradation of the chemical and physical environment; direct depletion of nonhuman living systems; and direct depletion of human systems (Table 1; Karr 1995b, Chu and Karr 2011).

Table 1. The Many Faces of Biotic Impoverishment, with Examples.

A. Indirect Depletion of Living Systems

1. **Soil depletion and degradation** (erosion, degradation of soil structure, salinization, desertification, nutrient leaching, loss of soil biota)
2. **Degradation of water (**pollutants, flow alteration, wetland drainage, depletion of surface and groundwater, homogenization of aquatic biota)
3. **Alteration of global biogeochemical cycles** (nutrient enrichment, acid rain, alteration of water cycle, outbreaks of pathogens and red tides)
4. **Chemical contamination** (land, air, & water pollution by pesticides, heavy metals, and others; bioaccumulation, ocean acidification, fish kills)
5. **Global climate change and ozone depletion (**global warming, alteration of rainfall distribution and amount, effects on health)

B. Direct Depletion of Nonhuman Living Systems
1. **Renewable-resource depletion** (depleted populations of fish and trees; altered food webs; extinctions)
2. **Biotic homogenization** (extinction and invasions)
3. **Habitat destruction and fragmentation (**biotic homogenization, loss of landscape mosaics and connectivity)
4. **Genetic engineering** (homogenization of crops, antibiotic resistance)

C. Direct Depletion of Human Systems
1. **Emerging and reemerging diseases** (occupational hazards, pandemics, AIDS, Ebola, Hantavirus, Lyme disease, nutritional and stress diseases)
2. **Loss of cultural diversity (**genocide, ethnic cleansing, loss of knowledge and linguistic and cultural diversity, loss of knowledge)
3. **Reduced quality of life** (environmental refuges, malnutrition and starvation, failure to thrive, poverty)
4. **Environmental injustice (**environmental discrimination, economic and generational inequity, racism, gender inequity)
5. **Political instability** (resource wars, civil violence, international terrorism, environmental refuges)
6. **Cumulative effects** (surprises, collapse of civilizations, "boom and bust" cycles, "natural" catastrophes, disease and biodiversity interactions)

Indirect Depletion of Living Systems

The primary physical systems that humans depend on are air, soil, and water. The productive potential of soils is degraded by erosion, salinization, desertification, and compaction. But soil is much more than its physical constituents: depletion of the organic activity in soil is also serious. Degradation of water resources--including chemical pollution, surface and groundwater depletion, and flooding--is pervasive. Norman Myers (1993) rightly notes, "Our future will be deeply compromised unless we learn to manage water as a critical ingredient of our lives."

Chemical contamination of air, soil, and water has for many years been the primary focus of government and the public; the primary concern has been the threat to human health from a diversity of chemical pollutants. Special attention has been directed to the narrow problem of contaminants that induce cancers in animals and humans. Other contaminant red flags include bioaccumulation; immunological and developmental deficiencies; and a growing number of reproductive and intergenerational effects.

Historically, the consequences of human activity were limited in space and time, but the increase in toxic chemicals and radioactive materials during the twentieth century has created global problems with legacies that will be present for thousands of years. Some of these affect people directly; many will have long-term indirect impacts on biological systems by altering biogeochemical cycles, global climate, and ozone concentrations.

Direct Depletion of Nonhuman Living Systems

Humans directly deplete renewable natural resources by harvesting fish, timber, and other products. Habitat destruction and fragmentation associated with harvest, urbanization, and other activities have perhaps the farthest-reaching effects on biological systems. Yet relatively little attention has been paid to habitat loss except when it threatens species with extinction. Human activities may even be responsible for increased frequency of red tides in coastal environments and insect and disease outbreaks in forests. Especially devastating to regional living systems is the homogenization of plant and animal communities through extinction and the spread of nonnative species, particularly commensals of human society.

Direct Depletion of Human Systems

The advances of modern medicine over the past three decades have lulled us into a false sense of security about human health and the environment. To be sure, antibiotics to control pathogens and pesticides to control pests have helped check many diseases. Yet, with a few exceptions like smallpox, diseases have not been conquered. Virulent forms of *E. coli*, tuberculosis, influenza, yellow fever, and malaria are becoming more difficult to control. In addition, emerging “new” diseases caused by bacteria (legionnaires’ and Lyme diseases), viruses (Ebola, Hantavirus, HIV/AIDS), and parasites (*Cryptosporidium*) are cropping up. Human population growth and behavior, global travel patterns, resistance to antibiotics, reductions in natural immunity in human populations stressed by other environmental degradation (e.g., global warming), and destruction of natural habitats all contribute to this trend.

The impoverishment of human systems is also manifest as reduced cultural diversity (genocide and loss of knowledge), reduced quality of life and economic deprivation (failure to thrive in infants, malnourishment in 20% of people), and environmental injustice (racism, economic exploitation, lack of intra- and intergenerational equity).

Collectively, this broad sweep of issues illustrates the magnitude of the environmental challenge facing all members of the human community. It also reminds us of the close association and common underpinning of environmental and social concerns, and it provides an opportunity to exercise the ingenuity that has brought us this far. The loss of species; the destruction of agricultural lands; and the differential exposure to environmental hazards of economically disadvantaged people, often people of color, degrade the quality of human life. As human influence expands, the limits of technology, especially unintended consequences of technology, become more obvious. Depletion of water supplies cannot be "fixed" by engineers making water to refill aquifers; lost salmon spawning grounds cannot be "fixed" by adding gravel or "large woody debris."

Citizens and political leaders, humanists and scientists must work together to develop creative solutions. Failure to do so will relegate the world to continued biotic impoverishment and threaten the sustainability of human society. Ecologists' participation in these partnerships is critical to their success. In the same sense that medical doctors must be trained to recognize and understand the attributes of a healthy human, ecologists and environmental scientists must understand the attributes of healthy biological systems--systems that must be sustained over the long term, in the service of humans and for their own sakes.

Ecological Integrity and Ecological Health

If biotic impoverishment is the problem, then protecting the integrity of living systems must be the goal. But how do we define *biological integrity* in a world that is increasingly altered by the actions of humans? How do we reconcile the inevitable changes required to accommodate a growing human population and the proliferation of modern technology while guarding the planet from irrevocable biotic impoverishment? Answering these questions in clear and explicit terms is especially important as we seek to bring scholars from diverse disciplines together to focus on common problems.

What do *health* and *integrity* mean? How do we integrate concepts of integrity in their philosophical, legal, biological, cultural, and ethical senses (Westra 1994)? What kind of health or integrity do we seek? Are we seeking "environmental health," or is that phrase too narrowly associated with the effects of toxic substances on human health? As a societal goal, biological integrity suggests a meaning beyond human health. And the sum of physical, chemical, and biological integrity is ecological integrity (Karr and Dudley 1981).

Aldo Leopold (1949) was the first to invoke the concept of integrity in an ecological sense: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Nearly forty years ago, as the United States Congress drafted the Water Pollution Control Act Amendments of 1972, it sought a broad statement reflecting a vision absent from earlier water resource legislation. "Can we afford clean water? Can we afford rivers and lakes and streams and oceans which continue to make possible life on this planet?" asked the late Senator Edmund Muskie (Congressional Research Service 1972). "These questions answer themselves." Congress explicitly included "integrity"—"to restore and maintain the physical, chemical, and biological integrity of the nation's waters"—as the underlying goal of its legislation. Two major aims are clearly incorporated in this congressional language: active protection of remaining high-quality aquatic systems and a return of the nation's waters to a state of health. Since 1972, the integrity concept has been invoked integrity as a societal goal in diverse ecological and geographic contexts: Great Lakes Water Quality Agreement (1978); amendment to Canada's National Park Act (1988); Kissimmee River (Florida) Restoration Project (1989); National Wildlife System Improvement Act (U.S.; 1997); National Parks (U.S.) Omnibus Management Act (1998); Freshwater Strategy for British Columbia (1999); and European Union Water Framework Directive (2001).

Integrity implies an unimpaired condition or the quality or state of being complete or undivided; it implies correspondence with some original condition. The term most appropriately refers to the condition at sites with little or no influence from human actions; the organisms living there are products of the evolutionary and biogeographic processes influencing that site. Biological integrity (Karr and Dudley 1981; Angermeier and Karr 1994) refers to the capacity to support and maintain a balanced, integrated, adaptive biological system having the full range of elements (genes, species, assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural habitat of a region. Although somewhat long-winded, this definition carries the message that: (1) Living systems act over a variety of scales from individuals to landscapes, (2) A fully functioning living system includes items one can count (the elements of biodiversity) plus the processes that generate and maintain them, (3) Living systems are embedded in dynamic evolutionary and biogeographic contexts that influence and are influenced by their physical and chemical environments.

An evolutionary foundation ties the concept of integrity to a benchmark against which society can evaluate sites altered by human actions. The complex biological systems that evolved at a site have already proved their ability to persist in, and even modify, the region's physical and chemical environment. Their very presence means that they are resilient to normal variation in that environment. Species abundance, for example, changes as a function of changing physical environment and changing interactions among species in a local assemblage. But the bounds over which systems change as a result of most natural events are limited when compared with the changes imposed by human activities like row-crop agriculture, urbanization, or dam building.

Human society sets aside extensive areas in parks and reserves to protect their natural state, to protect their integrity. These areas deserve protection because of the diverse values they provide to society. Water bodies, both on the surface and underground, deserve special protection as well, because they provide water to drink and support recreational and other values. Most important, rivers are the lifelines of a continent, reflecting the condition of surrounding landscapes, linking landscapes across great distances.

Because of the demands of feeding, clothing, and housing more than 6.9 billion people (November 2010), few places on Earth maintain a biota with evolutionary and biogeographic integrity. The growth of human populations in the last few centuries has made our species the principal driver of global change. Providing for human needs has required massive alteration of the planet in ways that preclude a return to the pristine environments of the preindustrial era. Thus, biological integrity is lost on a large share of the planet and is unlikely to be regained. Yet loss of ecological integrity for all lands and waters in all regions of the world is unacceptable on scientific, economic, aesthetic, and ethical grounds.

Health implies a flourishing condition, well-being, vitality, or prosperity. An organism is healthy when it performs all its vital functions normally and properly; a healthy organism is resilient, able to recover from many stresses; a healthy organism requires minimal outside care. The concept of health applies to individual organisms as well as to national or regional economies, industries, and natural resources such as fisheries.

Ecological health describes the preferred state of sites modified by human activity—areas cultivated for crops, managed for tree harvest, stocked for fish, urbanized, or otherwise intensively used. At these sites, integrity in an evolutionary sense cannot be the goal. Healthy land use, with or without active management, should not degrade a site for future human use or degrade areas beyond that site (Karr 1995b). Soils, for example, should not be eroded or otherwise transformed in ways that reduce future productivity. Groundwater should not be depleted.

Land use should not have deleterious effects beyond a site; atmospheric contamination should not result in downwind effects, such as tree death or ozone depletion. Healthy sites should not release contaminants or eroded soils that degrade sites elsewhere.

According to these two criteria—no degradation of a site for future use and no degradation of areas beyond that site—most modern agricultural