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Part 1

A collection of papers by

John Cairns, Jr.

Eco-Ethics and Sustainability Ethics

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The world has enough for everyone's need but not enough for everyone's greed.
~Gandhi

In our era, the road to holiness necessarily passes through the world of action.
~Dag Hammarskjold

Small doubt, small enlightenment; big doubt, big enlightenment.
~Korean Zen Master Nine Mountains

Dharma urges seekers to develop an unselfish view of the world because the reality is that we are all interconnected; our fates are intertwined.
~The Buddha

When trying to generate compassion for all beings, it is essential to remember that you are one of them.
~Lama Surya Das

Only in the last quarter of my life have we known what it means to be custodians of the future of the Earth — to know that unless we care, unless we check the rapacious exploitations of our Earth and protect it, we are endangering the future of our children and our children's children. We did not know this before, except in little pieces, people knew that they had to take care of their own . . . but it was not until we saw the picture of the Earth, from the moon, that we realized how small and how helpless this planet is — something that we must hold in our arms and care for.
~Margaret Mead

DEDICATION

This book is dedicated to Jean, the blithe spirit, who graces my life.

Jean enriches my life in so many ways that I find it difficult to enumerate them. However, one of the most important things is that she has helped me keep my sense of perspective. For 60 years she has called me 'Johnny,' but when she was about to give me an important message she prefaced it with 'Cairns.' If I happened to be complaining about obstacles to the completion of a manuscript, she would say "Cairns, stop whining and finish the manuscript!" When I related to her some environmental degradation I found shocking and that perturbed me greatly, she would say, "Look at that hummingbird on those beautiful flowers."

An important help with my perspective was the continual reminder that resting on one's laurels at any age was simply not a good idea. In June 2001, our daughter Karen was telling Jean about an award that had been given to me. Even on medication to alleviate Alzheimer's and Parkinson's, Jean rose to the occasion: "Big deal," she said. Her comments through the years were not said disparagingly, but lovingly, so that I would not be diverted from the research being carried out. It was acceptable to feel joy in awards and to express satisfaction that one's peers thought the work fit to receive recognition; it was not acceptable to stop or even markedly reduce the research that was a major source of joy.

In contrast, when Jean married me, and even when I was courting her, her support was unwavering, firm, and unconditional. My undergraduate grades were barely adequate, and I had no idea whatsoever of the type of career that would interest me on a sustained basis. Then WWII came, interrupted my education, and put me at some risk.

Jean's firm support and faith in me never wavered after the war when my applications to a long list of undergraduate academic institutions were rejected. When I was accepted at Swarthmore College and had to commute to classes (usually a total of two or more hours daily), and then study until late at night, she never complained. Graduate school came next and further postponement of having our own house and other amenities that most of our peers were enjoying. In short, when my academic prospects were dim, Jean supported me in every way.

When I became enthralled with studying ecotoxicology, and, ultimately, restoration of damaged ecosystems (which, in the middle of the last century, were both far from mainstream science), her comments were invariably supportive. Acquiring academic recognition took a long time, as it should, but Jean's stance remained constant throughout this period. When the awards and honors finally began to arrive, her stance immediately shifted so that I would not let them go to my head. Never once did I feel she was unappreciative or was neglecting any of my achievements, but, rather, she was furnishing the type of partnership I needed at each stage of my career. She never criticized or complained when some of my peers got recognition that I had not yet received, and, when recognition did come, she made sure that it did not distort my perspective.

When I thought it would be interesting to accept an unpaid summer position offered me at Rocky Mountain Biological Laboratory by my former advisor Robert Enders (food and lodging were provided), she was enthusiastic. She did not complain that the unpaid leave from the Academy of Natural Sciences reduced our annual income by nearly 20%.

In 1966, I resigned from a secure position at the Academy of Natural Sciences to venture into university teaching and research, a move that took us from family and friends in Philadelphia. Not only did Jean not complain, she encouraged me to do this. When research space failed to materialize at the University of Kansas, Jean neither reproached me for not demanding the space promised nor did she complain about leaving Pennsylvania for an unviable situation.

Another aspect of Jean's enrichment of my life deserves attention. As is the case with most people who carry out research of any kind, I tended to get very intense, sometimes at what would have been unacceptable levels had Jean not diverted me. She is the one who made it attractive to exercise daily by walking in the woods, folk dancing, swimming, and the like. For 57 years, she ensured that we frequently got to classical music concerts, plays, lectures on subjects that I might easily have passed up, and a variety of other activities.

Jean enlarged my perspective on life. She connected me to the wider world and showed me its beauty. It is all too easy to become narrow in vision when one lives within academia, seeing only the geography and

landscape of this specialized land, with its own culture, and speaking only its language. Jean has been my link to everything beyond this horizon: to people, other cultures, and other languages. Her interests covered a variety of topics — music, books, social and political activism, social justice issues. One of Jean's greatest gifts was her perception of the natural world. For her, there was a language with which to converse with clouds, birds, animals, mosses, fungi, and even rocks. She shared with me her personal gift of direct experience with nature. The sense of being 'completed' by her is the loss I feel most deeply now.

Sometime in early 1998, I began to realize that her mental function was significantly impaired. Her memory loss had been noticeable during 1997 to our children and was cause for concern to them. However, because the changes were incremental, and possibly because of denial, I did not realize that these were more than usual for a normal aging process. When it was clear that Jean had dementia and concomitantly less energy, I naturally stayed with her all the time. For a while, I could leave her at our home on Bishop Road in Blacksburg, Virginia, where we had lived for approximately 30 years. Since the area was isolated and difficult to access, I eventually moved us to a townhouse in a retirement village. Shortly after the move, a neighbor reported that, when I went into my office on campus, Jean would wander around the parking lot looking for me. From that day on, in spring of 2000, I took her with me to the office and decreased the number of times I went. Fortunately, my colleagues Darla Donald and Bobbie Niederlehner had worked with me for such a long time and had so much sympathy with my situation that the work flow continued unabated, although I would have sacrificed writing if Jean had needed more attention.

The writing provided peace of mind for me for a long time, because I could dictate or write while Jean dozed. Now that she is in the nursing home in the same retirement village, I have more time for writing. Jean and I have been together for so long (over 61 years) that I can accurately predict what she would say to me in almost every situation. In addition, the habits I acquired under her tutelage, such as music, plays, and the like, remain.

Writing has been a continual source of serenity. Such concentration, while not precisely the same as meditation, serves the same purpose. Writing was a solace available at all times and, together with other forms of support, truly essential to maintaining my emotional stability.

Sometimes the veil of Jean's dementia lifts fleetingly, and I glimpse the blithe spirit I love and cherish. With her eyes twinkling, Jean will deliver one sentence with her usual wry humor before the veil of dementia descends. The humor is always in context and both funny and loving. The effort that this touch with reality requires is known only to Jean. For me, seeing her as she was for most of our lives is an unexpected joy because it happens with no warning. Even when this return to me disappears completely, the bond between our spirits will be strong because it was forged over so many years. At present, for all too brief flashes, I glimpse what we shared and feel a surge of joy.

I am well aware that even the relationship we now have is temporary. But what a joy that Jean shared so much of her life with me!

ACKNOWLEDGEMENTS

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ESEP Book 1 contains the author's photograph, academic degrees, professional certifications, and honors. ESEP Book 2 lists the author's service with consulting, the National Research Council, and national committees.

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Virginia Farm Bureau Federation, Advisor
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The Wilderness Conservancy at Mountain Lake, Board Member through March 2000

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Chair, Committee on Restoration of Aquatic Ecosystems: Science, Technology and Public Policy, 1989–92
Committee on US Geological Services Water Resources Research, 1991–93
Committee on Waste Disposal Options, 1992–93
Board on Environmental Studies and Toxicology (BEST), 1992–93
Correspondent, National Academy of Sciences Committee on Human Rights, 1991–present
Report Review Committee (final approval of all National Academy Press publications), 1993–98

Service on Other Committees of National Importance

Advisor, Division of Forestry, Fisheries, and Wildlife, TVA

Advisor, Laboratory Reorganization Committee, Office of the Administrator, US EPA

American Institute of Biological Sciences, Task Force for the '90s, 1990–2000

Biological Assessment Methods, American Society for Testing and Materials

Biological Water Quality Committee, Ohio River Valley Water Sanitation Commission, 1969–88

Board Member, International Union of Biological Sciences

Board Member, Ohio River Basin Consortium for Research and Education, 1985–90

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Carey Arboretum Review Committee, New York Botanical Gardens

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Man and the Biosphere, United Nations (through State Department), 1974–88

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Panel Member, Court Appointed Scientific Experts, American Association for the Advancement of Science, 2000–01

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US EPA Environmental Biology Review Panel, 1987–91

PREFACE

I am deeply grateful to Prof. Otto Kinne and Inter-Research for the opportunity to share my thoughts with colleagues over the entire planet. Neither the publishers nor I will receive any money for this book. We believe that the development of eco-ethics and sustainability ethics is essential to the future of humankind and other life forms.

ESEP Book 1 consists of a series of articles from a variety of journals; as a result, some unavoidable redundancy occurred so that each article could 'stand alone.' In this volume, a much larger proportion of articles was written for *Ethics in Science and Environmental Politics* (the publication organ of the Eco-Ethics International Union; EEIU, www.eeiu.org), so I assumed a greater commonality of literacy in the readers and, thus, less redundancy is necessary. However, as was the case for ESEP Book 1, the articles were first published in peer-reviewed journals and then, if they engaged the readers' minds, were added to ESEP Book 2.

Some articles cover a broad area, such as "A declaration of eco-ethics," while others cover a more narrow area, such as "Ethics in science: ecotoxicology." Some address the consequences of unsustainable, unethical practices, such as those that result in "Environmental refugees." Others, such as "Integrating top-down and bottom-up sustainability strategies," address the integration of information necessary for implementing eco- and sustainability ethics. Various issues not addressed in ESEP Book 1, such as terrorism and the ethics of humankind inhabiting the planet indefinitely, are explored in a preliminary way in ESEP Book 2.

The 21st century will almost certainly be characterized by both the frequency and intensity of environmental crises. Technology and science will be helpful in coping with these crises but, to be truly effective, must be used in an ethical context. The probability is high that some global ecological threshold (e.g. climate change, population size, air and water quality) will be crossed with unpredictable consequences.

Article 1

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A Declaration of Eco-Ethics

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ABSTRACT: Eco-ethics is the essential foundation for sustainable use of the planet. Such a foundation must consist of a series of value judgments to which humanity is committed. This declaration is a tentative attempt to provide some illustrative examples.

KEY WORDS: Eco-ethics · Declaration · Web of life · Interdependence · Sustainability

The following tentative Declaration of Eco-Ethics was inspired by Professor Otto Kinne's publications (1997, 1998, 2001, 2002), which document successive steps in the development of eco-ethics. In contrast to most traditional ethics, eco-ethics is subject to progressive maturation, comments and criticism. An initial version of this declaration will appear soon in Common Ground (Cairns in press). It is reproduced here with permission of Dr. Jeffrey Yule, Common Ground Editor. While the article has been in press, I thought of five additional statements (Nos. 13–17) that are appropriate for the declaration, and they are added to this version.

(1) We are creatures of the planet and all species are our evolutionary relatives. We acknowledge our dependence on the biospheric life support system and pledge to act in ways that enhance its integrity.

A statement of respect for the interdependent web of life is totally inadequate! Furthermore, respect does not exclude, but also does not require, stewardship and constant care and attention. An ethical life requires all of these, motivated by love. An uncharitable person might conclude that, since humans are part of the web, these feelings are a type of narcissism; however, humans are individually part of the web for a brief time on a small temporal scale.

(2) We should value individual worth and dignity of each individual in the context of an ecological life support system with a multitude of individuals, each of whom has potential worth and value. We should deplore individual acts that diminish sustainable use of the planet and applaud and cherish acts that further this goal.

We should respect the *potential* worth and dignity of each individual until we see contrary evidence — not based on skin color, religious belief, age, gender, or ethnic origins, etc. However, merely having the potential does not justify unqualified endorsement unless the potential is demonstrably realized in ways that do not degrade the biosphere or endanger other individuals. More importantly, the actions eliciting respect should enhance biospheric integrity and the human con-

dition in order to deserve genuine respect. If humans, individually and as a society, are unwilling to make judgments on these issues, natural selection will 'judge' them.

(3) We acknowledge that our spirituality had its genesis in nature and vow not to profane it by destroying its source. People who would argue that spirituality comes from a higher power doubtless believe nature does also, so the source is identical.

(4) We acknowledge that we are part of a living continuum and that participating in the destruction of this continuum is self-destruction.

(5) We embrace an ethical system that preserves the planet and its biosphere for all creatures of the planet as well as our descendants.

The central issue has been stated by Wilson (1984, p. 12) with his usual clarity: 'The one process now going on that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us.'

(6) The interdependent web of life is sacred and, thus, should be treated with reverence and care. We pledge not to endanger this system through excessive accumulation of material goods, excessive use of energy, or by usurping the place of other species to a degree that precludes their continued existence.

(7) We pledge to adjust our individual and societal behavior so that it is compatible with biospheric integrity instead of further modifying the biosphere so that our technological society can expand and grow.

(8) We pledge to view ourselves as parts of the biospheric system and behave in ways that do not block its cyclic phenomena so that the flows remain continuous.

(9) We acknowledge that human independence is an illusion! Humans have always been dependent on the interdependent web of life and will continue to be so. In the 21st century, much of society is nearly totally dependent on technology as well. Even though we depend on both systems, we worship technology and degrade the web of life. We pledge to reaffirm on a daily basis the dependence of both human society and its technology on natural systems. *Interdependence is a reality and is a better conceptual model than the mistaken dichotomy of independence/interdependence. However, it is clearly more difficult to visualize and may be too great a shift in approach at this time.*

(10) We acknowledge that our physical bodies will ultimately return to the biosphere and become parts of fish, insects, trees, soil, the hydrologic cycle, and the atmosphere. We pledge to cherish the biospheric shrine to which our physical bodies will return.

(11) We affirm that the only sustainable practices are cyclical and that many linear processes are unsustainable. We pledge to avoid these linear processes to the best of our ability and espouse cyclical processes that constitute the basis of the interdependent web of all life.

(12) We acknowledge that the biospheric world has existed for billions of years and that the world of anthropogenic artifacts (roads, cities, shopping malls, etc.) has only existed for a few millennia. We pledge to integrate these two worlds so that the recent one does not endanger the ancient one.

(13) We pledge to honor every individual, institution, and organization that practices eco-ethics and value this attribute more than material possessions.

(14) We vow that cultural, disciplinary, special interests, and the like will not compromise our eco-ethical standards. This task is difficult but not impossible in a politically charged environment. Consensus and mutual accommodation in the quest for a harmonious relationship with natural systems will be essential.

(15) We affirm the importance of environmental education as the foundation for understanding and dialogue across barriers of discipline, culture, socioeconomic status, and politics. Environ-

mental education provides the necessary threads to weave what Orr (1993) terms 'the vessel of community,' which unites specific knowledge with people, local knowledge, social structures, and ecological systems. Environmental education has, from its beginnings, emphasized both knowledge and motivation to act (Stapp et al. 1969). We now add the important concept of action competence (Breiting & Mogensen 1999) to this mixture. Action competence turns motivation into skills and direct involvement at personal, community, national, and international levels.

(16) We vow to incorporate the precautionary principle into our decision-making processes at all levels. The precautionary principle (Raffensperger & Tickner 1999) states that, even in the absence of conclusive scientific evidence, we shall act to protect the health of humans and the environment. In order to enable citizen participation in the decision-making process, incorporation of this principle rests upon increased citizen understanding or literacy about scientific evidence, scientific processes, risk assessment, assessment of alternatives, and basic concepts of human and ecological health and well-being. A literate public is the foundation for the democratic process and the involvement of all stakeholders.

(17) We pledge to remain optimistic about achieving sustainable use of the planet, however unattainable it may seem. Our ability to rally the world depends on an unwavering commitment to this goal. The deeply pessimistic view of human nature expressed by Thomas Hobbes' *Homo Homini Lupus* — 'every man is a wolf to every other man' — is not the path to a habitable planet.

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Article 2

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A Preliminary Declaration of Sustainability Ethics: Making Peace with the Ultimate Bioexecutioner

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ABSTRACT: Sustainability is a utopian vision that requires living harmoniously with nature, which will exact harsh penalties on species that exceed Earth's carrying capacity and violate nature's laws. To make this vision a reality, humankind needs a global ethical consensus on sustainable use of the planet—sustainability ethics. Sustainability ethics has the goal of developing a sustainable, mutualistic relationship between humankind and the interdependent web of life that serves as Earth's ecological life support system. The quest for sustainable use of the planet is a value judgment that has more than one component. Arguably, the most important is increased attention to and compassion for posterity's quality of life, in short, leaving a habitable planet for future generations. This requires leaving natural capital and the ecosystem services it provides undiminished at the least and increased at best. Although material possessions can be left to direct descendants, protecting the planet's ecological life support system must not only be for all of humankind's descendants but those of the 30+ million other species with which we share the planet. This is difficult because the recipients are distant (as individuals) both temporally and spatially. Therefore, this quest will not be realized until an agreement emerges on the values and attitudes necessary to make sustainability a reality. Science can then develop the standards and criteria necessary to reach this goal. In view of present unsustainable practices, a basic ethical consensus is necessary to develop sustainable practices.

KEY WORDS: Sustainability · Sustainability ethics · Eco-ethics · Social contract · Ecocentric viewpoint

> *In the end, however, success or failure will come down to an ethical decision, one on which those now living will be defined and judged for all generations to come.* E. O. Wilson, 2002

ECO-ETHICS AND SUSTAINABILITY ETHICS

Important similarities are present in the concepts of eco-ethics (Kinne 2003) and sustainability ethics. Both focus intently upon the ethical relationship between humankind and natural systems. Both deplore the folly of humankind's present unsustainable course, which includes exhausting the planet's nonrenewable resources such as fossil fuels, water, and minerals. Both deplore the overharvesting of renewable resources such as oceanic fisheries and old growth forests. Both agree that global environmental quality is being degraded by automobile emissions, pesticides, nuclear

wastes, greenhouse gases, chlorofluorocarbons, and the like, which produce such environmental responses as biotic impoverishment (i.e. species extinction), global warming, and acid rain. Both are deeply concerned about the exponentially growing human population; increased per capita affluence, as measured by consumption of material goods; and the increasing disparity in per capita distribution of the planet's resources.

Sustainability ethics is a consilience (literally 'leaping together') of econ-ethics and eco-ethics. As Kinne notes, both concepts are required for sustainability.[1] Arguably, the major difference between eco-ethics and sustainability ethics is that the latter envisions that *Homo sapiens* will exist on the planet indefinitely. Since species come and go in the evolutionary process, one might question whether the infinite existence of humans is an ethical position. A related difference is that eco-ethics is ecocentric while sustainability ethics is both homocentric and ecocentric. Sustainability ethics is defensible if one assumes humankind and natural systems are co-evolving in a mutually beneficial way. The concept is not ethically defensible if one assumes sustainable use of the planet has the primary goal of manipulating natural systems so that they are always optimally beneficial to humankind, even if this manipulation impairs the integrity of natural systems and subverts the natural successional processes of species turnover and replacement over evolutionary time. A pivotal issue is how humankind addresses situations in which humans have exceeded natural carrying capacity. If humankind attempts to evade natural law by enabling unsustainable practices such as exponential population growth, sustainability will be a vision but not a reality.

A concomitant pivotal issue is how humankind develops the ability to assess ecological risks with enough 'lead time' to take precautionary action to avert catastrophic outcomes. Ecosystems are notoriously non-linear, chaotic, and complex, and, as a result of this predicament, they suffer from the same challenges observed in weather systems, brain physiology, or quantum mechanics. As one physicist has stated (P. Leigh, pers. comm.): 'Relativity eliminated the Newtonian illusion of absolute space and time; quantum theory eliminated the Newtonian dream of a controllable measurement process; and chaos eliminates the Laplacian fantasy of deterministic predictability.' Biologist E. O. Wilson (1998) takes the matter one step further: 'Biology is almost unimaginably more complex than physics, and the arts equivalently more complex than biology.' In a recent presentation on Policy Options for Controlling CO_2, Stephen Peck (Electric Power Research Institute), a leading atmospheric economist, opened his talk by asking: 'How many of you believe we should undertake severe economic sacrifices for controlling greenhouses [gases]?' Few in the audience raised their hands. Later, Leigh (pers. comm.) conveyed to Peck that one also needs to ask how many believe that no action (currently in place) is an appropriate response to this problem. Obviously, most people believe that something needs to be done; the question remains of what degree. The perception and science of risk are extremely challenging when uncertainties remain so high and complexities so compounding. The issue surrounding sustainability is often clouded with the lack of consensus regarding what to sustain; or worse, even where clarity is achieved, consensus is missing on determining sets of indicators for verifying that goals have or have not been reached. Science is essential in choosing endpoints or indicators for the latter situation, but ethics is essential for establishing goals.

The transition from unsustainable to sustainable practices will be gradual, but it must be carried out within an ethical framework so that the goals are clear and universally applicable and gross violations of ethics universally condemned. As Hillary (2000) remarks, the trade debate has been

[1]Kinne, O (2002) Revisiting eco-ethics and econ-ethics. ESEP 2002:88-89, available at http://www.esep.de/articles/esep/2002/e23.pdf

transformed into a globalization debate. However, protests at the World Trade Organization indicate that globalization has become a contentious process, especially with regard to the environmental trends associated with it. However, globalization could also be a broad cultural integration, ideally guided by ethics. Finally, nature is violent, profligate with the lives of individuals in ways that preserve the species and the system, practices infanticide, and sacrifices lives in pursuit of reproductive success. Yet humankind proposes to achieve perpetual use of the planet while maintaining a harmonious relationship with nature. Sustainability ethics must be the basis for the complex ethics necessary to make this hypothesis defensible.

An executioner is employed to kill those sentenced to death by law. Generally, law is interpreted as the laws of one species, *Homo sapiens*, and is usually carried out by representatives of a nation state. Before humans appeared on the planet, nature's laws were supreme. Technology and creativity have given humankind the illusion that it is the only species exempt from nature's laws; some short-term evidence supports this view, but the long-term evidence does not. Quick technological fixes may temporarily postpone a crisis, but, inevitably, the unexpected side effects may be worse than the original problem.

The framework for coping with environmental crises already exists. One only needs to substitute the term 'environmental problems' for the word 'terrorism' in American President Bush's State of the Union Address: 'This country has many challenges. We will not deny, we will not ignore, we will not pass along our problems to other Congresses, to other presidents and other generations. We will confront them with focus, clarity and courage' (Bush 2003). The growing linkages to potential human influences on the atmospheric/ocean grid via greenhouse gases are widely discussed in leading scientific journals and the mass media. How can one scientifically discount these concerns? American television commentator Andy Rooney's closing remarks regarding the space shuttle Columbia tragedy fit equally well when considering sustainable use of the planet: 'Rarely does man concern himself with caring about future generations, but the space program is one example where he does.'[2] Clearly, sustainable use of the planet should be another.

THE ECOCENTRIC SOCIAL CONTRACT

Sustainable use of the planet is basically an ecocentric contract. Since neither future generations nor other life forms can communicate with humans presently alive as well as humans can with each other (despite isolating factors such as language), a consensus is much more difficult, arguably impossible, than in a homocentric context. The ethical responsibility of humans for the well being of other species has been discussed at some length. However, sustainability ethics has as a central component humankind's ethical responsibility for a dynamic relationship that has the potential for the co-evolution of a mutualistic relationship between humankind and the interdependent web of life. This responsibility does not preclude a satisfying relationship with individuals of other species. However, it is more difficult to achieve since an ecosystem's identity is not as apparent as the identity of an individual of another species.

Liberalism of the early 19th century recognized the self-interest of the individual as the driving force in both economics and society as a whole. Friedman (1962) postulated two primary sets of values: freedom, and values relevant to the individual in the exercise of freedom (individual ethics). The free market (pure capitalism) assumes that individuals should be allowed to pursue their

[2] "A Death in the Family" (2003) 60 Minutes. Exec. Prod. Don Hewitt. 2 February 2003. Columbia Broadcasting System, New York

economic interests freely, regardless of whether they do so in a selfish, generous, foolish, or wise way. Economic growth of this sort has taken on many of the attributes of a global ideology. It ignores or gives only lip service to the integrity of natural systems and the protection of endangered species, aesthetically pleasing vistas, wildlife preserves, nature parks, and the like. A global ethic does not mean a minimum ethic that offends no one and requires no major changes in behavior or lifestyle. A global ethic inspires behavior and practices that are sustainable and compassionate to other life forms as well as human descendants.

The planet is already in a logarithmic phase of environmental change that began in the 20th century, if not earlier (e.g. McNeill 2000). There is too little time left for humankind to avoid a major environmental catastrophe. Abandoning political rhetoric, nationalistic posturing, and electioneering is essential at all levels—local, national, and international. Statesmanship, guided by ethics and reason, will lead humankind from unsustainable to sustainable practices. This course will benefit all life forms, including humans, by providing a habitable planet. Sustaining, let alone raising, standards of living as presently defined is resource intensive, but could be resource friendly while increasing social capital and generally improving the quality of life if material possessions are not central to defining quality.

Nation states have had well over a century to embrace sustainable practices and have failed miserably in moving toward sustainability. Some nation states have done far better than others, but only a few. A criterion for when nation states have taken sustainability seriously is cessation of environmentally damaging federal subsidies. Despite the disproportionate influence of special interest groups upon their policies, nation states have a major role to play in the quest for sustainable use of the planet. Once their citizens make it abundantly clear that they want more positive policies (and implementation of these policies) designed to protect the environment and leave a habitable planet for future generations, the nation states should perform adequately, although some legislators will remain under the influence of special interest groups. The United Nations has already gathered much useful information needed to indicate where global policy changes are needed to achieve sustainability, but stronger support is needed from the nation states for change to become fully effective.

The probability of crossing a major ecological threshold before reaching a consensus on a global ethic already appears substantial and rapidly increasing. The environmental crisis appears to be understood by many of the world's people, but less so by its leaders. Alternatively, and most likely, it is well understood by the latter, but they are afraid it would be political suicide to bring bad news (i.e. abandoning unsustainable practices) to the general public. This situation might even be a case of co-dependency: the general public in affluent nation states are addicted to their present lifestyle and reward political leaders who encourage this addiction. The political leaders are also rewarded with campaign funds provided by special interest groups, some of which receive governmental subsidies for environmentally damaging activities.

Hausman (2000) illustrates how the government may confuse citizens with government-generated misinformation. Sagan (1993) discusses the related issue of pseudo-science. When a natural instinct for science and inherent curiosity about how the world works is unsatisfied, people turn to superstition and pseudo-science. Sustainable use of the planet is dependent upon literacy in science and technology, and pseudo-science and superstition will be substituted for robust science unless the latter is explained in a non-intimidating way. One could justifiably state the same idea about ethics in science and environmental politics, which is why such organizations as the Eco-Ethics International Union are so important. Demographic shifts are already large and increasing,

but they are modest compared to the number of environmental refugees that could easily result from a modest rise in sea level (e.g. Cairns 2002).

Average citizens are becoming more concerned, but not yet alarmed, by increasing damage to the biosphere. When sufficient numbers become truly alarmed, they will decide what sort of planet they hope to leave to their descendents. Of course, citizens will be more effective in democratic parts of the world than in the non-democratic parts. Non-governmental organizations will grow rapidly and be devoted to sustainable use of the planet, eco-ethics, and the like.

Harsh penalties will emerge for those who engage in unsustainable practices. The burning ethical issue is: will humankind develop and administer the penalties or wait for nature to do so? If humankind takes the responsibility for carrying out the penalties, these will be repugnant and distasteful but, in the long run, might prevent nature's even harsher penalties. Humankind developed the unsustainable practices and is ethically responsible for replacing them with sustainable practices. Unsustainable practices will be stopped! The only question is how they will be stopped.

As Van De Veer & Pierce (1994) note, almost all traditional moral outlooks assume that only harm or benefit to humankind is morally significant. A corollary assumption is that all other life forms, as well as non-living material, have no value except in their utility to humankind as a means to an end. Another question is whether ecosystems, rather than the individuals who make up those ecosystems, are the real source of inherent value. Both eco-ethics and sustainability ethics assert the importance of natural systems. Both also assert that individuals whose practices impair ecosystem integrity are guilty of unethical behavior. The balance between preserving ecosystem integrity and individual freedom is very delicate.

The declarations that follow represent a preliminary attempt to determine the ethical position that will enable humankind to use Earth indefinitely, while simultaneously preserving the integrity of the ecological life support system upon which humankind is dependent.

DECLARATION OF SUSTAINABILITY ETHICS

The preliminary draft of this declaration was written in 2000 and subsequently published (Cairns 2002). After a declaration of eco-ethics[3] was published, it seemed appropriate to follow it with a declaration of sustainability ethics. In order to make this declaration congruent with that of eco-ethics, significant modification of the original pledge has been necessary.

Declaration

We living representatives of humankind, in order to leave a habitable planet for our descendants and those of other species, hereby declare:

1. Humankind is a component of the interdependent web of life—if it damages the web, it damages its future.
2. Humankind cannot survive without the natural capital and ecosystem services the web of life (the biosphere) provides and will not use for itself the resources needed to maintain the web's integrity and function.
3. Humankind will follow nature's model, which is based upon systematic recycling and reuse, and will not produce either products or wastes that are harmful rather than beneficial to natural systems.
4. Humankind will use technology and creativity to protect nature's resource reserves rather than to make them more readily available on demand.

[3]Cairns J Jr (2002) A declaration of eco-ethics. ESEP 2002:79–81, available at http://www.esep.de/articles/esep/2002/E21.pdf

5. Humankind recognizes that no form of exponential growth on a finite planet is sustainable. Exponential economic growth may postpone the consequences of violating nature's laws but also increases the magnitude of the penalties for exceeding the planet's carrying capacity.
6. Humankind pledges to limit its acquisition of material goods to what Earth can afford rather than what humans can afford.
7. Humankind proclaims that, henceforth, any degradation of Earth's biospheric life support system will be restored to predisturbance condition whenever possible and repaired when restoration is not a viable option.
8. Humankind pledges to reject a lifestyle that drives other species to extinction and to esteem other life forms.
9. Humankind pledges to take precautionary actions when adverse consequences to the biosphere would occur from activities of the species; consequences might be severe, even in the face of significant uncertainty.
10. When nation states violate the laws of nature by continuing unsustainable practices, humankind will feel compassion for the suffering but will recognize that the only way to ensure respect for nature's laws is to let the guilty suffer the consequences as they do for violations of human law. Arguably, this will be the most difficult part of the declaration to adhere to, but failure to do so will leave a less habitable planet for future generations.

ILLUSTRATIVE SUSTAINABILITY ETHICS FOR NATION STATES

1. Cease all environmentally damaging subsidies. (This pledge will be particularly difficult to initiate at both the corporate and individual citizen level. The corporate level will be difficult because of the well-financed special interest groups. The individual level will be difficult because of the perceived encroachment upon individual rights. For example, the human population must eventually stabilize on a finite planet. Many individuals will resist population control unless everyone participates (for example, an income tax deduction that does not increase for more than two children). The world's population will stabilize; the only question is will humankind achieve it before nature does? Sustainability is, arguably, the most important nation state security issue.)
2. Develop and implement an energy policy that is not based on fossil fuels. (This pledge, too, is inevitable, so it might as well begin now.)
3. Tax the inefficient use of fossil fuels in vehicles, industry, and housing during the transition to renewable energy.
4. Protect both natural capital and ecosystem services and encourage accumulation of natural capital by means of ecosystem restoration and repair.
5. Develop and implement bioregional plans that foster sustainable use of both private and government land and property.
6. Develop and implement sustainable policies that protect the integrity of the hydrologic cycle and water quality.
7. Ensure protection and restoration of wildlands so there will be ecosystems on which restoration and management models can be based.
8. Develop and implement policies that reduce biological impoverishment (species extinction) and encourage maintenance of biodiversity.
9. Require that industrial, municipal, and household wastes be suitable for re-incorporation into natural systems in a beneficial way.
10. Prohibit the production of hazardous wastes whose long-term half-life requires isolation from natural systems and humankind (i.e. nuclear wastes and persistent toxic chemicals).

CONCLUSIONS

Humankind is carrying out an experiment at spatial and temporal scales unprecedented in human history. Worse yet, most people are unaware that humanity's present lifestyle is unsustainable. Most humans see the world at a local or regional scale, but must now extrapolate at scales essential to sustainable use of the planet. Personal experience is inadequate for viewing the entire range of phenomena essential to the quest for sustainability. Much of the necessary information must come from scientists and other professionals, but the details will require a higher and broader literacy level than most humans possess. As a consequence, faith is essential in both the information and the people who generated it. Trust develops when individuals and nation states share a common ground. The process of globalization has made Earth a common ground to an extent unprecedented in human history. As a species, humankind has evolved from small tribal groups with a small common ground to nation states with a much larger common ground. Much of humankind has not yet adapted to this larger common ground, as ethnic wars in other countries indicate. Now, exponential growth of the human population has, in a blink of an eye in evolutionary time, thrust humankind into a global community that concomitantly has a rapidly deteriorating environment and the depletion of natural capital. Regrettably, the conditions of an increasingly impersonal world, the result of living in enormous groups (almost nation cities), have decreased any feeling of connectedness at a time when sustainable use of the planet requires it most. Sustainability ethics, the ethics of a sustainable world, appears to be the most promising means of reestablishing the feeling of connectedness, before a global catastrophe results from unsustainable practices. Ethics offers the prospect of transcending the many isolating mechanisms that have resulted in culture wars, which will almost certainly be exacerbated by resource wars.

It is imperative that humankind live sustainably and in harmony with other life forms. Failure to adapt to new conditions resulted in extinction of species long before humans appeared on the planet. The human race cannot plea bargain with nature. It can develop, however, an ethic compatible with the desire for a sustainable world.

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Article 3

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Ethics in Science: Ecotoxicology

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ABSTRACT: Predictive ecotoxicology emphasizes the probable environmental outcome of exposure to toxics, rather than the mere appraisal of existing damage, and in so doing raises some complex but interesting ethical issues. Awareness of endocrine-disrupting chemicals is blurring the line between humankind and other life forms in toxicity testing by providing evidence that both humans and wildlife suffer adverse reproductive and developmental effect. There is a wide variety of chemicals that have been reported as potential endocrine disruptors. Finally, with the increasing loss of wildlife habitat, protecting the quality and ultimate fate of the remaining habitat from the effects of toxic substances becomes increasingly important to the moral quest for sustainable use of the planet.

KEY WORDS: Eco-ethics · Ecotoxicology · Community toxicity testing · Landscape toxicity testing · Predictive ecotoxicology

No man is an island, entire of itself; Every man is a piece of the continent, a part of the main.
John Donne

INTRODUCTION

Ecotoxicology (the science of the potential effects of toxicants upon the biosphere) is a logical extension of the field of toxicology (the science of the effects of chemical substances upon individual organisms). Literally, ecotoxicology applies to all biological organization levels, from a single species embedded in its niche to the biosphere, including humans. The use of the prefix 'eco' implies that tests will use endpoints characteristic of levels of biological organization higher than single species.

The central theme of this article is the moral calling: (1) to protect the integrity of the remaining wildlife habitats from the effects of toxic substances — a quest that is directly related to sustainable use of the planet and (2) to reduce the impact of toxic substances upon habitats whose integrity has been impaired so that unassisted recovery processes can occur either naturally or with human assistance. Today, the scope and scale of increased toxicants in the environment is so great that a collective responsibility is required. In addition, the rate at which chemical substances are introduced into the environment exceeds humankind's ability to satisfactorily evaluate their environmental impact.

A major intractable problem in achieving sustainable use of the planet is caused by the concept of collective entitlement, i.e. the idea that humankind is entitled to use the planet as it chooses despite adverse effects upon other life forms. In contrast, the concept of collective responsibility states that humankind is collectively responsible for most environmental degradation. Arguably, the rate and intensity of humankind's impact on the environment is so great that a collective responsibility for it is mandatory.[1] Chemical substances are released into the environment, and, at certain concentrations and for particular exposure times, they may cause harm to both human health and the environment (Cairns 1980). Ecotoxicology is a probabilistic determination of that harm, based on scientific information. However, how to use these findings for minimizing humankind's impact on the environment is both an ethical and regulatory issue. The latter will only be true if the primary responsibility is delegated to nation states (Cairns 1993).

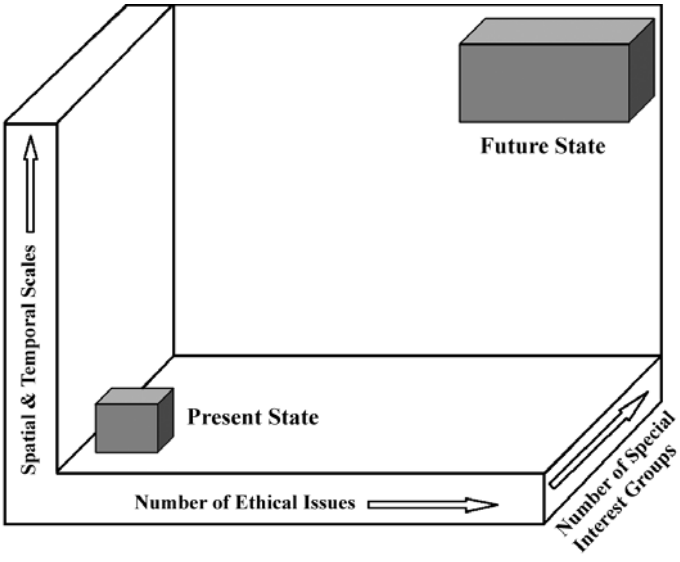

Fig. 1. The relationship between the increasing complexities of science and associated ethical issues. Both should be kept in harmony

Humankind is engaged in a global experiment in which there have been massive changes in both the biological and physical worlds. Most of these effects were unintended (e.g. holes in the ozone layer, global warming, biotic impoverishment), but this does not diminish the severity of the consequences. Never before in human history has humankind introduced toxicants into ecosystems on such a scale and with such speed. Moreover, this is an uncontrolled experiment. Such factors as overpopulation, mass human migration, habitat alteration and the like are of critical importance (but are beyond the scope of this article). That most humans are ignorant of the experiment does not exempt them from the consequences, nor does it excuse them from the responsibility for the experiment and the fate of other species in the experiment. In addition, an experiment that involves the entire planet is difficult, arguably impossible, to simulate. The increased uncertainty of this global experiment creates a very important challenge to ethics. Fig. 1 depicts the relationship between the increasing complexity of science and the concomitant increase in the complexity of associated ethical issues. The growth of science must not outpace the growth of ethics. The rate of technological change is exponential in nearly every field (Toffler 1984). Technological change is ex-

[1]See J Cairns Jr (2002) Goals and conditions for a sustainable world, ESEP Book 1, Inter-Research, Oldendorf/Luhe, Germany, available at www.esep.de/journals/esep/esepbooks/CairnsEsepBook.pdf

ponential, while the ability to evaluate effects is much slower. This is true for chemical substances that ecosystems must assimilate. The assimilative capacity for chemical substances is not infinite and, consequently, optimizing the use of assimilative capacity is both an ethical and scientific problem (Cairns 1977). Thus, humankind is left squarely in a reactive mode.

ETHICAL ISSUES IN TOXICITY TESTING

Chemical analyses cannot determine toxicity to living material; determination of toxicity requires living material. However, sacrificing some living material should only be done with the hope that its use will benefit the biosphere. If humankind discharges chemical substances into the biosphere without ecotoxicological testing, the lives of individuals of many species will be lost and adverse effects will be experienced at all levels of biological organization (e.g. subcellular, cellular, species, community, ecosystem, ecoregion, and so on). In addition, new properties emerge at each higher level that were not evident at lower levels. Toxicity testing also involves deaths, but the information gained should protect more individuals over a longer period of time than having no direct information at all.

Animal rights activists are concerned about testing animals for the development of products they regard as frivolous (e.g. cosmetics) that are not necessary to the well-being of the animal being tested. However, these activists who object to all toxicity testing have not always evaluated the ethical issue carefully. Organisms are exposed to toxicants both in nature and in the laboratory. If the toxicity testing meets rigorous scientific criteria and standards, fewer organisms will die if the tests are carried out than will die if the tests are prohibited. This is the underlying ethic of ecotoxicology. Accordingly, it is especially important that ecotoxicology, as a newly developing field, embraces a standard, uniform code of ethics.

The major ethical issue concerns how to protect the 30+ million species with which humankind shares the planet. Neither facilities, personnel, nor funds exist to estimate the tolerance of each species for all toxic substances. Moreover, roughly 100 000 chemical substances are in daily use, while thousands more are developed annually. The American Chemical Society has a data bank that illustrates the tempo and developmental magnitude of new chemical substances, most of which (arguably all of which) eventually enter the biosphere in their original form or as transformation products. Naturally, these chemicals interact, sometimes synergistically. One example is a condition called poly-pharmacological poisoning in which patients are ‘adversely affected by combining several medications’ (Leigh 2003, pers. comm.). Determining the toxicity tests that should have priority is both an ethical and scientific issue. These issues usually are resolved by the processes of risk analysis and hazard evaluation (Cairns 1992).

Many instances exist in which only a few thousand or even a few hundred individuals remain of a species. These rare or endangered organisms are also exposed to ubiquitous chemical substances. Obviously, these organisms, and some others that may be only of regional interest, need even more protection from toxic substances than the less-threatened species. Since these organisms should not be used for toxicity testing, a useful alternative is to provide a continuous feedback loop from the environment that gives the overall environmental condition (e.g. Cairns 1975, 1981). Another alternative is to use surrogate species, which may sometimes work well (e.g. Harte & Hoffman 1989) but is generally unsatisfactory (e.g. Kenega 1987, Maki 1979, Peakall & Tucker 1985, Mayer et al. 1987). Instead of testing rare, endangered, and threatened species, protecting their ecosystem health and habitat might give more hope for their survival. In short, component testing (i.e. species) is unacceptable if the species is already at severe risk.

ENDOCRINE DISRUPTORS

Awareness of endocrine-disrupting chemicals (note: '…proper regulation of life processes in animals requires cooperation between the nervous system and regulatory molecules known as hormones that are secreted by endocrine glands, critical for maintaining physiological balance, etc.' [Leigh 2003, pers. comm.]) is blurring the once strong dichotomy between the effects of chemicals on humans and those on all other life forms. Persuasive evidence exists that endocrine disruptors cause adverse reproductive and development effects on a wide variety of species; a wide variety of chemicals have been reported as potential endocrine disruptors. Comparable compassion for all life forms simplifies the ethical issues but would require substantive changes in humankind's attitudes toward lower forms of life. The exact number of species affected is not known, but a significant number of vertebrates have exhibited endocrine disruption symptoms. If humans would acknowledge that they are part of the interdependent web of life, this would be a major step in the development of a uniform code of ethics.

COMMUNITY TOXICITY TESTING

Predicting the response of a system to various chemicals by extrapolating results from single species laboratory toxicity tests low in environmental realism is difficult (e.g. Cairns 1980, 1983, 1985, 1995). Environmental realism requires that all important variables be included in each test. However, replicability is enhanced if one studies each variable in a system where other variables are reasonably constant. Thus, there is a dynamic tension between the desire for replicability and the equally compelling desire for an environmentally realistic test. It would be a logistical nightmare to attempt testing large numbers of species individually, so an attractive alternative is to test them in naturalistic groups, i.e. communities (Cairns 1984, 1986a). Microcosms and mesocosms are attempts to strike a balance between complexity and replicability. They are not miniature ecosystems but rather, tests that simulate important ecological cause/effect pathways and attributes of natural systems. Even with all their faults, these have a role in toxicity testing. The endpoints in 'standard' toxicity tests do not include parameters such as those for endocrine disruptors, whether antagonist or protagonist. Most ecotoxicological tests are carried out in laboratories and are difficult to validate in natural systems (e.g. Cairns 1986b). Naturalistic communities are not easy to assemble, nor are results easy to interpret when the toxicity tests are completed. Community level tests are more environmentally realistic than single species toxicity tests since community level tests provide information on interactions among and between species that are absent from single species tests (Cairns & Niederlehner 1995). Consequently, the comparatively large number of species involved ensures that the response range will be more environmentally realistic than one from single species toxicity tests.

Under these circumstances, environmental surprises are probable if the safe concentration of a chemical is based on faulty data or invalid assumptions. Even wealthy, scientifically advanced countries such as the US have a difficult time generating adequate information for a sound judgment. Community toxicity testing is, at best, an intermediate level of ecological complexity, and the results may not be reliably extrapolated to higher levels, such as ecosystem, landscape, bioregion and biosphere. This comment is not intended to denigrate ecotoxicology, which provides essential information needed to prevent damage to human health and the environment, but rather to show that science alone is inadequate to make sound judgments. Ethics guided by science will alleviate, but not eliminate, these problems. 'Those that possess the highest ethical standards in ecotoxicology may still be unable to disentangle this complexity for making sound scientific judgments. Addi-

tionally, if the rate of new chemical introductions into the environment is exponential this further taxes if not overwhelms the system for establishing responsible safeguards' (Leigh 2003, pers. comm.).

ECOSYSTEM AND LANDSCAPE TOXICITY TESTING

Direct toxicity testing is not feasible at the ecosystem and landscape levels of biological organization. Even so, scientists are increasingly recognizing that most ecological studies are too small, both temporally and spatially, to detect and/or predict toxicant effects upon many important natural processes (e.g. Holl & Cairns 2003). Toxicants produce effects throughout large, complex, multivariate landscapes in a variety of ways. In addition, what appear to be small-scale toxicological impacts can become landscape impacts when similar or interactive events occur over a large area. Landscape-scale effects can also occur when a toxicant directly affects a particular ecosystem while simultaneously indirectly affecting another. A landscape perspective is increasingly important in an era in which humankind is altering the climate on a global scale, which will affect large-scale transport of toxicants. Chemical substances get distributed in landscapes, but their effects at this level of ecological complexity are rarely studied. Finally, exogenous forces further complicate efforts to achieve a predictive ecotoxicology, which will require trend analysis to set priorities for toxicity testing.

Since even ecotoxicologists have difficulty keeping abreast of the literature in this rapidly developing field, it is unlikely that average citizens or political leaders can acquire adequate scientific literacy to make sound judgments unless there is an ethical framework into which scientific conclusions can be placed. The complexity and high levels of uncertainty are daunting obstacles for professionals, so the prospect of average citizens making sound scientific judgments is limited. However, evaluating the ethical component is far less difficult because it is based on values rather than masses of scientific evidence. At this level of biological organization, it becomes apparent that humankind is part of a large-scale experiment that makes dispassionate, objective analysis difficult and increases the probability of denial of scientific information. A robust ethical foundation will alleviate, but not eliminate, these problems.

GLOBAL TOXICITY TESTING

The global level of biological organization is the ultimate test system, involving the entire planet. Persuasive evidence indicates that many anthropogenic chemical substances in the environment are capable of adversely affecting or disrupting endocrine function in vertebrate organisms. The average person has no method of escape from this experiment. All humans are experimental organisms in global experiments (e.g. global warming).

One of the most pernicious myths of the 20th century was that it was impossible to have economic growth without some environmental damage. In the last part of the 20th century, two concepts emerged which disproved this myth: natural capitalism (e.g. Hawken 1993, Hawken et al. 1999) and industrial ecology (e.g. Tibbs 1992, Graedel & Allenby 1995, Allenby 1999). Natural capitalism is based on the concept that natural resources and living systems, together with social and cultural systems, are the basis of human capital. Industrial ecology is based on the assumption that industrial systems and natural systems can co-exist as a hybrid system. Natural capitalism recognizes the critical interdependency of the production and use of human-made capital and the maintenance and supply of natural capital. Industrial ecology, which envisions hybrid industrial/ecological systems that would combine design systems that are generally viewed as polar opposites,

recognizes the need for pristine ecosystems, which are already in short supply, as well as the interim need for pure industrial systems.

The hybrid industrial/ecological systems provide several important contributions to natural capitalism and maintenance of ecosystem services. First, under certain conditions, the systems may provide a buffer zone between industrial and natural systems. In other conditions, a buffer zone may not exist; for example, endocrine-disrupting chemicals such as Triclosan and others that are in so many commonly used consumer products are widespread beyond the industrial system that produces them. Second, the systems provide good, large-scale test designs that would provide an early warning of toxicity effects (Cairns 2003). Third, if properly designed, they should increase both natural capital and ecosystem services. Fourth, to be useful as a research information source, each design should have unique features and be free from 'one size fits all' government regulations. Standard designs are also a useful source of research information. In theory, since the data benefit industry, the general public, and, most importantly, natural systems, this design should not be a problem. In practice, however, some industries may be reluctant to share findings that, on occasion, might affect their reputation adversely.

Clearly, the relationship of humankind to these industrial/ecological hybrid systems is unprecedented in many respects and requires a new set of ethical guidelines. At the moment, it seems almost certain that the ecological component will not be self-maintaining and will require continuous subsidies of nutrients, species, etc., and will almost certainly be a naturalistic community of plants and animals (National Research Council 1992) rather than one assembled by natural processes. Industrial ecology is compatible with sustainable use because the environmental analysis expands in time (from short-term to long-term habitability) and space (local to global). Global considerations include such obvious items as climate change and total human population, as well as problems ubiquitous to the planet, such as persistent pesticides, air quality, and biotic impoverishment. While local issues remain important, sustainable use of the planet also requires a systems-level perspective. However, individuals find it more difficult to develop empathy for the biosphere than for a local ecosystem. Developing ethical guidelines for humankind's relationship with the biosphere and the other life forms should be far less difficult.

CAN A CORPORATION HAVE ETHICS?

Many of the toxic substances in the environment are produced by corporations, which presents a number of ethical problems in ecotoxicology. Established by humankind, corporations are artifacts to make money. In this process, they provide jobs, goods and services. Corporations are not new life forms; they are non-living, legal artifacts. They will live as long as humankind persists on the planet and they cannot be sent to prison. In a matter of days they can change their citizenship or even their identity and attributes. Fuller (1984, p 10) stated this superbly in his classic *Grunch of Giants*: 'Corporations are neither physical nor metaphysical phenomena. They are socioeconomic ploys— legally enacted game-playing….'

The life of corporations is an important issue in ethics in ecotoxicology since they cannot be treated as individuals. However, in the US, claims have been made that corporations have the right of free speech just as individuals; a particularly interesting situation was reported by Hartmann.[2]

[2]See T. Hartmann (2003) Now corporations claim the 'right to lie.' Commons Dreams, available at www.commondreams.org/views03/0101-07.htm

Consumer advocate Marc Kasky sued Nike, a multi-billion dollar corporation, alleging a number of specific deceptions. Nike did not refute the allegations in court, but chose to argue that corporations should enjoy the same free speech right to deceive that individual humans have in their personal lives. Nike representatives reasoned that, if people have the constitutionally protected right to say 'the check is in the mail' when it is not or 'that looks great on you' when it does not, a corporation should have the same right to say whatever they want in their corporate public relations campaigns. The argument went all the way to the California Supreme Court, where Nike lost; the case may go to the US Supreme Court in 2003. Even though individuals in the US get to have their say, a corporation is not a person and having its say should not include the right to deceive people. Clearly, however, the concept of corporate personhood is not dead. As far back as 1978, the US Supreme Court decided in *Boston vs. Bellotti* that corporations are persons and are entitled to the right to donate to political causes. If corporations have this right, they can affect legislation and even judicial appointments. Combined with the right of free speech comparable to that of an individual, the effects of corporations upon environmental politics and ecotoxicology could be enormous. Accordingly, a code of ethics for corporations is essential for the ecotoxicological field. An illustrative ethical code for corporations producing chemical substances follows.

1. Fully disclose the potential of all products and wastes to produce harm to human health and the environment
2. Fully disclose uncertainties in the estimates of no evidence of harm (e.g. statements of 'no evidence of harm' when there is simply 'no evidence' are unethical)
3. Pledge to abide by the ethical norms of human society in the area and/or the ethical norms of those societies that purchase goods and services (multi-national corporations should abide by the highest ethical norms of the societies that are its marketplace for goods or services or in which it has operational facilities)
4. Pledge not to change the corporate identity to avoid ethical responsibilities
5. Pledge that the highest administrative officers will serve the consequences the judicial system would impose on an individual
6. Pledge to give a formal statement of the corporation's ethical principles and make it easily available to the general public
7. Pledge to establish a bonding system to pay for damages caused by unethical activities as judged by the corporation's own statement of ethics
8. Pledge to restore ecosystem damage immediately, even if the corporation has not posted a bond to ensure funds will be available for this process
9. Pledge to send annual statements of ethical principles to the United Nations and International Courts of Law
10. Pledge that the primary justification for societal approval of the existence of the corporation is to serve the common good on the planetary common ground
11. Pledge not to produce any chemical substances or waste products (e.g. radioactive wastes) that are incompatible with nature's cyclic processes, with the ultimate goal of accumulating natural capital and increasing ecosystem services
12. Pledge that the ethical principles are congruent with sustainable use of the planet
13. Pledge not to engage in any activity incompatible with sustainable use of the planet, even if this activity is not prohibited by law
14. Affirm that no right transcends that of human descendants and other life forms to inherit a habitable planet

ETHICS AND SPECIAL INTEREST GROUPS

If each discipline, profession, or special interest group had only its individual code of ethics, finding common ground with others would be difficult. Clearly, some type of universal ethic is essential—an isolated group could develop its own code that is congruent with the universal code and meets the needs of the specialized group as well. Codes for each discipline should be published in specialty journals of that field. In fact, many disciplines already have published ethical codes, while some require a formal statement of compliance as a condition of membership. Some illustrative, discipline-specific examples from ecotoxicology follow.

1. Although the primary purpose of ecotoxicological tests is to protect natural systems and the organisms in them, I pledge to design tests to minimize suffering of organisms used in experiments.
2. I pledge to do only testing necessary for a sound scientific decision.
3. I pledge to avoid testing for organizations that expect the tests to support their point of view rather than to reach a scientifically sound decision.
4. I pledge to avoid carrying out ecotoxicological tests involving endangered, threatened, or rare species.
5. I pledge to display all test results upon which my analysis was based. If some information was not used due to equipment failure and the like, I pledge to provide this also, together with the justification for not using it.

CONCLUSIONS

Each discipline or profession should have a statement of ethical values unique to that discipline, but should also be committed to a more general 'umbrella statement' to which all are committed. Sustainable use of the planet requires both specific and general ethical statements since such use requires the contributions of all disciplines and professions. Failure to live up to discipline-specific ethical standards should result in severe penalties, such as loss of credibility.

Each discipline or profession should have a board to judge cases of alleged malpractice. The average citizen and/or his/her representatives will not have sufficient literacy in the wide variety of components needed for sustainable use of the planet. As a consequence, assurance is needed that the highest ethical standards are being met in order to achieve sustainability.

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Article 4

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Ethical Issues in Ecological Restoration

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ABSTRACT: The acid test of humankind's relationship to natural systems is the degree to which ecological damage caused by humans is repaired by humans. Technology and science are available, so the remaining stimulus needed for implementation of ecological restoration is the ethical responsibility to do so. Ecological restoration can be regarded as enlightened self-interest for humankind since it increases both natural capital and ecosystem services. However, well-designed ecological restoration projects should have a major ethical component since the future of non-human life forms on Earth requires more than self-interest. Although the field of science has provided various rationales for ecological restoration, ethical issues associated with such activities must also be considered. If, as seems likely, human society and natural systems are co-evolving, restoration of damaged ecosystems will improve both ecological and human health. The term 'ecosocietal restoration' emphasizes this close relationship. However, if ecological restoration considers only human needs and does not emphasize ecological integrity, human-dominated ecosystems could become the norm. Such domination is already marked but the relationship could easily worsen. This article lists seven major ethical issues in ecological restoration. This list is not encyclopedic but illustrative. Finally, there are five questions that human society must address that require robust scientific information to make a sound ethical judgment.

KEY WORDS: Eco-ethics · Sustainability · Ecological restoration · Co-evolution · Species extinction

We must share in the action and passion of our time for fear of being judged not to have lived.
Former US Supreme Court Chief Justice Oliver Wendell Holmes

The art of living consists not so much in complicating simple things as in simplifying those that are not.
Frances Hertel

INTRODUCTION

The science of restoring damaged ecosystems has been covered in many publications, but this article provides some illustrative examples of ethical issues in the restoration process. Persuasive reasons exist for believing that precise replication of the predamaged condition of an ecosystem is highly unlikely, though not totally out of the question (Cairns 1989, Hobbs & Norton 1996). The most persuasive reason that predamaged conditions are not attainable is that the sequence of previous climatic and biological events is unlikely to be repeated. There is ambivalence between saving nature for both present and future enlightened use by humankind (i.e. sustainable use of the

planet) and saving natural systems because humankind has an ethical responsibility for the fate of the 30+ million species with which it shares the planet. This ambivalence is quite evident in the proposed principles for the new Earth Charter, which is being proposed as a guide for local, regional, national, and international efforts to protect natural systems.[1] Stone (1988) believes that this quest is for a single coherent and complete set of principles suitable for addressing all moral quandaries. If one views the planet's ecological life support system (natural capital and ecosystem services) as essential to the survival of humankind, there should be no ethical ambivalence.

Therefore, restoration ecologists have a number of restoration options: (1) assembling a naturalistic plant and animal community that closely resembles the structure and function of the ecosystem in its predisturbed condition, but without the identical species once present; it may be possible to use all of the predisturbance species that are still available, together with other species, to produce a naturalistic community more closely resembling the predisturbance community, (2) constructing an ecosystem more able to withstand anthropogenic effects, since these are probably what damaged the ecosystem now being repaired, and (3) allowing natural recovery processes to determine the outcome, which most likely will include exotic and pioneer species that may not replace lost services and perhaps will have deleterious effects on adjacent ecosystems. As Berger (2003, pers. comm.) points out, '…achievement of that outcome may take eons, or may produce a different stable state than manifested by, or tended toward by the ecosystem destroyed'. All these options must be considered in the context of human society's dependence on ecosystem services (those ecological functions that are useful to human society) for survival, as well as humankind's ethical responsibility for the survival of non-human life forms.

The considerable attention given to sustainable use of the planet in recent years has increased the chronological scope of restoration policy, and increasing global interdependence, both ecological and economic, has enormous policy implications for the geographic dimensions of restoration policy. The National Research Council (2003) report distinguishes between the products of science (knowledge or data generated by research) and the approach required to meet the needs of decision makers. Although the geographic scale is not global, the processes used to support restoration, such as priority setting, identifying science gaps, and communicating research results, are quite similar. Since this is a large-scale undertaking, it deserves serious attention. In addition, natural selection judges harshly the misallocation or unsustainable use of resources. Finally, humankind must remember its ethical responsibility for the damage done to natural systems and make reparations accordingly (e.g. Cairns 2002).

GENESIS OF ETHICAL ISSUES

Humans cannot eradicate all species. Berger (2003, pers. comm.) cautions, '…if all domesticated species were annihilated, the billions of people who depend on them for survival would likely starve…'. Such losses would fatally injure human society as presently known (Cairns 1994, 1995a). If human society does not acknowledge its dependence on ecological life support systems, it will lose the species that cannot resist or tolerate present practices and be left with those that can. Unwanted species (e.g. invasive exotics) also pose a major threat that may be as serious for natural systems as loss of species. Baskin (1996) provides an excellent discussion of the problem of squelching the rising tide of unwanted species. Protection of indigenous species may well be as threatened by invasive exotic species as by anthropogenic stress.

[1]Details are available in a special issue of *Earth Ethics* (Smith 1996)

On the other hand, a compassionate relationship with natural systems would preserve and possibly enhance ecosystem services, which surely are essential for sustainable use of the planet. It is also a *sine qua non* that human society will not support large-scale protection of the environment or landscape-level ecological restoration unless the justification for doing so is both compelling and persuasive.

With some exceptions, the purely religious approach generally maintains that all species were created, as humans were, and, therefore, deserve both compassion and esteem (Cairns 1995b). Obviously, human society has not acted as if this is a widespread, deeply held belief. If human society cannot survive without the services provided by ecosystems, the need to change the relationship with them is very compelling!

A beginning can be made by illustrating the services currently recognized as provided by natural systems. A future possibility is that, as ecological literacy improves, every function of natural systems will be regarded as a service. Illustrative ecosystem services include: (1) capture of solar energy and conversion into biomass that is used for food, building materials, and fuel, (2) decomposition of wastes such as sewage, (3) regeneration of nutrients in forms essential to plant growth (e.g. nitrogen fixation), (4) storage, purification, and distribution of water (e.g. flood control, drinking water purification, transportation, etc.), (5) generation and maintenance of soils, (6) control of pests by insectivorous birds, bats, insects, etc., (7) provision of a genetic library for development of new food and drugs through both Mendelian genetics and bioengineering, (8) maintenance of breathable air, (9) control of both microclimate and macroclimate, (10) provision of buffering capacity to adapt to changes and recover from natural stresses such as famine, fire, pestilence, (11) pollination of plants, including agricultural crops, by insects, bats, etc., and (12) aesthetic enrichment from vistas, recreation, and inspiration.

GENESIS OF THE IDEA THAT HUMAN SOCIETY AND NATURAL SYSTEMS ARE CO-EVOLVING

Cairns (1996) asserts that human society has been dependent for most of its existence on an ecological life support system that provides a variety of services. Cairns (1994, 1995a, c, 1996, 1997a) has further postulated that human society and natural systems are co-evolving. Raven & Johnson (1986) have defined co-evolution as the simultaneous development of adaptations in two or more populations, species, or *other categories* [emphasis mine] that interact so closely that each is a strong selective force on the other.

The Agricultural and Industrial Revolutions have provided a variety of technological services that supplement the ecological life support system. In recent years, the demand for natural resources, the encroachment of industrial and agricultural systems on natural systems, and the wastes of human society have endangered the ecological component of the life support system. If sustainable use of the planet is the goal (meaning not depriving future generations of either of these life support systems), then the demand for technological services must be restrained so that ecological services are not threatened or damaged.

Schneider & Londer (1984) indicate that climate and life are co-evolving. The World Commission on Environment and Development report (1987) and Cairns[2] discuss sustainable use of the planet with the clear implication that present usage will not result in sustainability. Vitousek et al. (1986) note that humans appropriate approximately half of the photosynthesis on the planet; this per-

[2]See Cairns J Jr (2002) Goals and conditions for a sustainable world. ESEP Book 1. Inter-Research, Oldendorf/Luhe, Germany. Available at http://www.int-res.com/journals/esep/esepbooks/CairnsEsepBook.pdf

centage is surely a rather large share for one species out of many millions. The effect of this imbalance on the ecological life support system is not clear, but losing so much photosynthetic energy to humans must be damaging. Until the effects are clear, this rate of use should not be exceeded. As Flannery (1994) notes in the dedication of his book to the Australasians, 'if they are to preserve their unique natural heritage, their newly forged nations must cease to be the realms of the future eaters.' Until sustainability is achieved, all are 'future eaters' and, in order to cease being so, must learn to cherish fellow species and natural systems and to actively care for them.

If human society will acknowledge its dependence on ecological services, then it is admitting that loss of these services can have an adverse effect upon humankind (e.g. Cairns & Bidwell 1996a, b). Wilson (1987) has noted that, if humans and other large vertebrates were to disappear, the 'little things that run the world' (e.g. invertebrates) would not be seriously endangered and some, arguably, would thrive. However, if the 'little things that run the world' disappeared entirely, humans and other large invertebrates[3] would be seriously threatened and probably driven to extinction because of the absence of the services 'the little things' provide.

Unquestionably, humans can affect other species sharing the planet by depriving them of habitat (e.g. water or other vital resources), exposing them to toxic substances, over-harvesting breeding stock, and the like. Since each entity (human society and natural systems) can affect the other both beneficially and adversely, the relationship fits the definition of co-evolution. Therefore, it seems eminently reasonable to determine whether this relationship, as it now exists, will lead to sustainability. If not, perhaps the relationship can be improved so that use of the planet over the next decade, millennium, or more would permit more humans and other species to live a quality life than would otherwise happen with the present relationship. This concept leads to a number of issues involving both science and ethics. One of the most important issues concerns determining the conditions to be met in order to achieve sustainability (Cairns 1997b).

THE ROLE OF SCIENCE AND ETHICS IN SETTING SOCIETAL GOALS

Both science and ethics are involved in making decisions on environmental assessment. Ideally, they are called into play sequentially (Suter 1993), i.e. a subjective human perception of a problem leads to objective scientific investigation of the causes and possible management actions; then, alternate actions and their projected costs and benefits are evaluated for effectiveness and congruence with other societal goals. As this process of impact assessment and management is applied to larger areas, longer time frames, and more complex and interconnected problems, distinguishing ethical claims from scientific ones becomes increasingly difficult because the uncertainty inherent in scientific information increases with the scale of the environmental problem.

A decision that seems to be empirically based to some scientists may seem to be based on ethics to others — because, while some professionals judge the uncertainty of the scientific data acceptable, others judge it excessive. Tolerance of scientific uncertainty and tolerance of risk are both proper subjects for debate before decisions are made. However, they are linked — acting with an intolerance of uncertainty often demands a high tolerance for risk. For example, there is uncertainty about the precise degree of temperature change due to anthropogenic greenhouse gases, which is being used as a justification for inaction. However, this intolerance may result in humankind being exposed to more severe consequences than it would be if precautionary measures had been taken to reduce greenhouse gas production.

[3]An erratum published 2 July 2003 corrected the original text to 'vertebrates'

Science makes probabilistic statements about the nature of the world but does not offer a course of action. Science also helps to define problems and gather information about the extent and severity of environmental change and clarifies the links between environmental change and human self-interest. The basic ethical question here becomes: Does human self-interest differ from that of ecological integrity? An increased ability to measure those ecological functions that, in the aggregate, constitute the ecological life support system upon which human society depends would, arguably, provide increasingly convincing evidence to support the process of restoring and conserving natural systems. While this information is essential to effective management action, this scientific data cannot set goals.

Ethics, politics, and priorities are involved in setting goals. Is there a consensus about what society should do? Political action based on underlying ethical beliefs emerges as a result of consensus. In addition, there is never enough money to do all the ecological preservation and maintenance that would benefit human society over the long term. Ranking desirable goals and expediting some, while delaying others, is thus a political process.

ETHICAL PROBLEMS IN ECOSOCIETAL RESTORATION

Does restoration ecology represent a new trend in human society's relationship with natural systems, enhancing a benign co-evolution? Or, are restoration ecologists merely running a group of environmental 'body shops' that repair damaged ecosystems without appreciable effect on either rates of ecological destruction or human society's guiding beliefs? Even if so, environmental consultants and their firms should carry out ecological restoration at every opportunity because it adds to the body of knowledge on restoration methodology and costs. At worst, ecological restoration could be used as another justification for continued damage to natural systems. Furthermore, the global rate of ecological destruction is so enormous that the comparatively few attempts to repair ecological damage are dwarfed by comparison. Indeed, there are similarly daunting ethical problems associated with ecological restoration.

1. Most ecological restoration is carried out to repair damage caused by human mismanagement. If management is the disease, how can it be the cure? Noss (1985) has said, 'This is the irony of our age: "hands on" management is needed to restore "hands off" wilderness character.'

2. Some mitigative restoration is carried out on relatively undamaged habitat of a different kind. For example, created wetlands may replace an upland forest or an upland forest may be destroyed to attempt to replicate the wetland that once occupied a particular lowland area. Logically, this secondarily damaged habitat should be replaced by yet another mitigative action. Sacrificing a relatively undamaged habitat to provide mitigative habitat of another kind may well cause ecological harm. However, created wetlands, for example, do have ecological value (Atkinson & Cairns 2001).

3. The ecological life support system is viewed as a commodity. A homocentric viewpoint would justify viewing the system as a commodity. An ecocentric view would emphasize the system's intrinsic value and natural rights. Sustainability ethics attempts to combine a homocentric and ecocentric viewpoint.

4. At the current state of knowledge, restoration projects are likely to have unforeseen outcomes. For example, they may provide an opportunity for invasive exotic species to become established in areas in which they had difficulty in doing so.

5. Well-meaning restoration efforts may displace the species best able to tolerate anthropogenic stress. By attempting to return an ecosystem to its predisturbance condition, the evolution of the species capable of co-existing with human society may be hampered. For example, some species

might otherwise develop a resistance to anthropogenic stresses. Attempts to manipulate the environment in such a way as to promote the success of one or two species may impede both the natural successional process and also exclude other species that would otherwise be there. For example, restoring a stream to favor trout may not optimize conditions for a wide variety of aquatic invertebrates.

6. Similarly, if ecological restoration is carried out on an extremely large scale, human-dominated successional processes could become the norm. For example, ecological reserves might be lost that preserve endangered and threatened species that may one day be extremely useful.

7. Finding sources of recolonizing species for damaged ecosystems is increasingly difficult. Should one remove them from quality ecosystems and risk damaging that ecosystem or use pioneer species or, worse yet, exotics with the hope that the more desirable species will eventually colonize naturally?

Ethical problem #1 — Human management: the cure or the disease?

Quammen (1996) discusses the biotic impoverishment caused by ecosystem fragmentation, and Darlington (1943) observes that restriction of area often limits both the number and kind of animal species in isolated faunas. An ecological landscape, Quammen (1996) notes, is like a tapestry that, when fragmented, is not what it once was. Ecological fragmentation due to barriers such as highways, parking lots, power line right of ways, airports, and ubiquitous housing developments is so commonplace in developed countries such as the US and much of Europe that it is accepted as a norm.

At the State University of New York at Binghamton, a major campus road must be crossed by salamanders on the way to their spawning grounds. The roadside curbs are sufficiently high to represent an extremely difficult exit barrier for the salamanders once they are on the roadway, while initially falling off a curb might well cause significant skin damage. Fortunately, environmentally sensitive persons installed ramps so that the salamanders have a more accommodating means to cross the roadway. When I visited in 1994, the roadway itself had been closed during the annual spawning migration, and presumably still is during the mating season.

Forman et al. (2003) provide a superb analysis of the ecological problems caused by roads. It illustrates the conflict inherent in simultaneously pursuing two goals that are incompatible: (1) optimizing the benefits of an expanding road system, such as economic growth, more jobs, better access to schools, hospitals, and the like, and the ability to live at some distance from one's place of employment, and (2) the wish to preserve the natural environment and reduce the threats to it as well, such as improved air quality, reduced traffic congestion, or preserved land from encroaching development. In short, too many human artifacts impair ecological integrity. Forman et al. (2003) provide a well-structured, useful synthesis for resolving one of the current major problems, i.e. attempting to optimize two goals simultaneously.

Continents are, in a sense, large ecological islands made up of a mosaic of habitats with isolating barriers such as lakes, rivers, escarpments, and the like. However, generally, ecological corridors permit species movement or transport from one area to another. Given the degree to which ecological islands have been created on continents and the degree to which holes in the ozone layer, acid rain, and transport of hazardous chemicals over considerable spatial scales have occurred, barriers exist to both invasion and successful colonization of damaged ecosystems. Ecological restoration must necessarily be a crucial component of enlightened management for sustainable use of the planet.

The National Research Council (1992) notes that restored ecosystems are more likely to be self-regulating at the landscape level. This statement is a reiteration of the well-established phenomena of island biogeography — namely, that large islands generally contain more species than small islands. The seminal publication authored by MacArthur & Wilson (1967) notes that all systems have a decolonization rate (i.e. species are lost from that area), and this phenomenon must be offset by a countervailing colonization rate, which produces a dynamic equilibrium. Discussed at length by MacArthur & Wilson (1967), this equilibrium cannot be maintained unless invading species have access to all areas that are losing species. This process is more likely to occur at the landscape level than between isolated patches that have significant anthropogenic barriers between them.

In short, given the effect of humans on ecosystems, enlightened management is the only viable solution to reach sustainability. For example, human society might develop ecological management-derived solutions to avoid creating ecological islands by fragmenting ecosystems through planning at a landscape or ecoregional level.

Ethical problem #2 — Mitigative destruction of ecosystems

In Gunnison, Colorado, an airport taxiway affected existing wetlands, so mitigative (replacement) wetlands were established west of the airport near the sewage treatment plant. These wetlands were adjacent to already existing wetlands but, had they been located on a grouse mating ground or some other crucial habitat, a reasonable person might question the justification, even though the intent was the replacement of a particular lost habitat type. This issue will require robust professional judgment — prescriptive government regulations should be avoided.

When mitigative restoration elsewhere replaces a wetland that has been lost due to some developmental activity, the replacement may cause ecological damage to another habitat or ecosystem. If total ecological destruction exceeds total ecological repair, then the ecological damage has merely been shifted to another location. Arguably, the effort has not increased the quality or health of regional ecosystems collectively (bioregions), but merely replaced one habitat with another (National Research Council 1992).

Decision makers need to get in a mental helicopter and rise above a highly localized situation to question whether the ecological landscape has been improved by the effort. Sometimes, mitigation is viewed as purchasing or donating by setting aside a quality ecosystem in another location as a substitute for damage that has occurred. However, nothing has been added to the total ecological capital of the region. Merely agreeing to protect an already existing ecosystem as compensation for proposed damage of another does not increase ecological capital. If the ecologically damaging development proceeds before mitigation occurs, ecological capital will diminish during the restoration period, which may be many years (National Research Council 1992).

Ethical problem #3 — The resource/commodity trap

In the US and much of the rest of the world, the term ‘natural resources’ is commonly used when referring to natural systems or ecosystems. *Webster’s New International Dictionary* defines a resource as ‘a means of supplying a want; stock that can be drawn on; means of support.’ In this view, the products of natural systems are treated as commodities with a marketplace value that is relatively easily calculated. In some cases, the harvest from natural systems can be replaced with technological alternatives, i.e. natural wood can be replaced with plastics (although petroleum does have biological origins) and whale meat can be replaced by soybean derivatives from agribusiness.

Another view is expressed by F. Henry Lickers, Director of the Department of the Environment for the Mohawk Council of Akwesasne, Cornwall, Ontario (1990, pers. comm.): Earth is humankind's mother and should not be treated as a commodity. In this view, preventing ecological damage is a moral/ethical obligation. If accidental damage occurs, healing it is a cultural imperative (e.g. Leopold 1966) if one believes ecosystems have intrinsic value beyond their usefulness to humans. This is a subjective value as opposed to the 'objective' commodity context.

Clearly, some ecological restoration can be carried out within a commodity context. For example, a clear-cut forest could be revegetated with the goal of yet another harvest.

> Although a clear-cut forest could be revegetated for commercial ends, that would probably entail the replanting of a single species, or at most a small number of species, which is not ecological 'restoration.' In other words, trees could be recreated in this manner, but not a forest. Were an effort made to truly restore a multi-species, multi-age forest ecosystem, that would undoubtedly not be cost-effective for commercial forestry purposes. (Berger 2003, pers. comm.)

Although this type of restoration is perceived to have a fairly certain outcome, the time required is not easy to predict accurately. In any case, human society's relationship with natural systems is dramatically different from that espoused by Lickers. If natural systems are viewed as commodities, is restoration to predamage ecological condition justified? Is restoration likely to be supported by a society viewing natural systems as commodities?

In terms of sustainability, progress in thinking should move from respect to esteem to acknowledgement of dependence upon the planet's ecological life support system. Respect is optional. Esteem means highly regarded and, thus, less likely to be viewed as optional. Dependence means humankind cannot do without it. This progress in thinking would place societal and individual behavioral norms in quite a different context than the resource/commodity point of view. However, policy must be based on how people behave (i.e. pragmatic and realistic). As pointed out by Berger (2003, pers. comm.), 'Policy can also be normative and prescriptive as well; or it can be ameliorative and corrective in intent, i.e. neither may be "based on how people behave," but on how we want them behaving' in particular contexts. This situation does not mean abandoning efforts to move toward an actively caring model for natural systems, but, rather, is an acknowledgement that, on the path to this model, human society must be able to recognize some short-term benefits.

If the natural systems being restored are viewed as commodities that can be harvested, exploited, or altered in some major way, then restoration management practices must be altered accordingly (e.g. the repair of a clear-cut forest with one or a few species). This point of view will likely be incompatible with restoration for the purpose of increasing habitat for rare and endangered species and the like. In addition, such systems are not likely to be self-regulating, thus increasing management costs and efforts.

In the commodity context, the concept of 'restoration of natural systems' might not justify the name and might be more analogous to agricultural systems or forestry systems with regular harvesting. Even though the level of complexity might be greater following repair, the term 'ecological restoration' would probably be inappropriate. Although this idea will be unpalatable to most ecologists, it may well be one that is more and more accepted by society in general as population pressures increase in the 21st century. If this is to be avoided, the educational system must do a better job in ensuring environmental literacy in all disciplines!

Perhaps the commodity model could be replaced by one of compassion. If compassion and esteem are to be afforded to future generations and natural systems (including the other species

with which humans share the planet), as well as compassion for presently living individuals, ecological restoration can be carried out in a sustainable use of the planet context. This would reduce or eliminate the resources available per capita problem hypothetically depicted in Fig. 1 if human population size and level of affluence are stabilized in time. The intersection point is now purely theoretical. Quality of human life, resilience of natural systems, and so on, need extensive discussion and evaluation before even a crude but reliable intersection point can be determined. However, having compassion in one category modifies achievable compassion in the other categories, making sustainability possible only when all three are in balance. As Fig. 2 shows, focusing on compassion in only one or two categories is not enough. Sustainability requires a balance of all three categories. This also means making some difficult ethical choices and decisions that can be avoided if one isolates each of these areas from the others. Surely, isolating interactive components is not an effective way of either carrying out ecological restoration or achieving sustainable use of the planet.

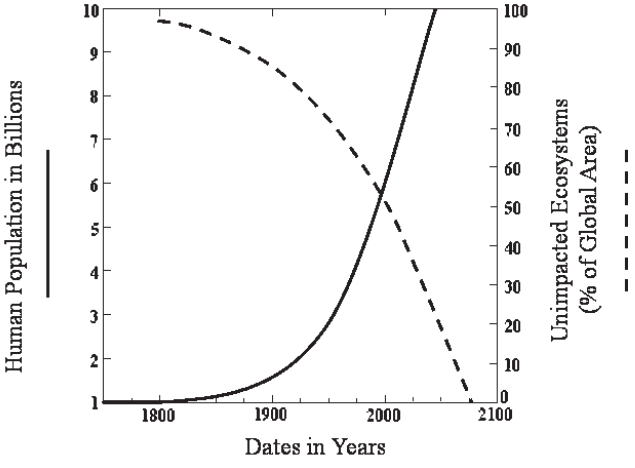

Fig. 1. Theoretical relationship between human population numbers and unimpacted natural systems. Figures given are speculative

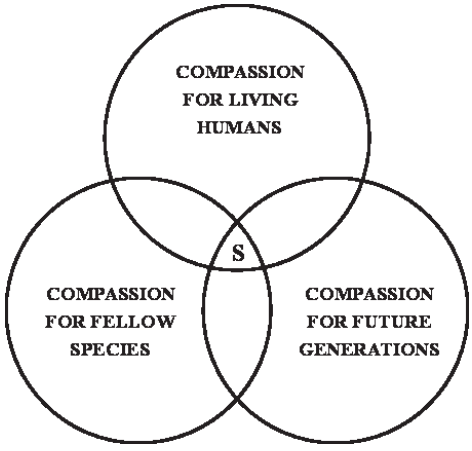

Fig. 2. Three pillars of sustainable use of the planet (S). Ecological restoration requires compassion for fellow species and will leave a more habitable planet for future generations. It will also demonstrate a compassion for living humans by improving the quality of the planet's ecological life support system and by making damaged ecosystems more esthetically pleasing by making them more naturalistic. Both ecological restoration and sustainable use of the planet are acts of compassion if viewed from an ecocentric standpoint, or acts of enlightened self-interest if viewed from a homocentric standpoint

Ethical problem #4 — Uncertainty of outcome

A colleague once wore a tee shirt that was captioned 'Life is uncertain — eat dessert first!' Clearly, uncertainty about the future of social security in the US, the rate of global climate change, the number of humans simultaneously living on the planet in the 21st century, the stock market, and most other areas of living is uncomfortably high. Human society's lives are neither risk-free nor precisely predictable. Uncertainty accompanies almost every prediction (Lemons 1996), not only in ecological restoration activities but other areas of science as well. As Yogi Berra has reputedly stated, 'predictions are unreliable — especially about the future.'

Ecological restoration also will have unforeseen outcomes, even when carried out by the most skilled professionals. Important variables may be omitted; episodic events such as floods or droughts may occur at inconvenient times; exotic invaders may appear abruptly; and, almost certainly, the sequence of biological and meteorological events that resulted in the characteristics of the ecosystem before it was disturbed will not be repeated. One may take comfort in the high probability that the repaired ecosystem will almost always be ecologically superior to the damaged ecosystem. Furthermore, a healthy ecosystem is almost certainly going to provide more services to human society than the damaged ecosystem.

Habitat restoration also should dampen the rate of biotic impoverishment (loss of species), which reduces uncertainty about the delivery of ecosystem services. However, present rates of species loss will almost certainly have effects now difficult to predict. Diamond (1994) discusses species losses in an extremely broad paleontological context. However, for this discussion, evidence on 'recent losses' is instructive.

Diamond (1994) estimates that 171 species and subspecies of birds are known to have become extinct since the year 1600. Of this total, 155 species and subspecies, or more than 90 %, lived and became extinct on islands. Hawaii alone lost 24 species and subspecies. Roughly 20 % of the world's species of birds are confined to islands; therefore, nine-tenths of the historical bird extinctions have occurred in island ecosystems holding one-fifth of the total species. Diamond (1994) focused on terrestrial systems surrounded by water, although other kinds of ecological islands exist (e.g. a forest surrounded by grassland), and analyzed not only the effects of humans upon island species but also the effects of ecosystem collapse upon human societies.

Mt. Kilimanjaro in Africa, a mountain ecosystem surrounded by a totally different plains ecosystem, is also an ecological island, as is Lake Malawi, which is surrounded by land. A patch of wetland surrounded by California freeways and freeway exits is just as much an ecological island as an island off the coast. Some species have access; others do not. Getting there can be hazardous and surviving there, if the area is small, is less likely than it is on either a large island, such as Australia, or an even larger land mass such as Eurasia.

Uncertainty about the effects of species loss will be reduced if recolonization occurs. Some articles in the popular press suggest natural recovery of ecosystems may be noteworthy, but reaching the predisturbance condition is unlikely. For example, McKibben (1995) discusses the reforestation of the eastern US. Some evidence indicates partial recovery of the forests themselves and, sometimes, much of the life they once supported. In such instances, however, Berger (2003, pers. comm.) points out that '…few trees are comparable in height and girth to those of the aboriginal forest, and certainly certain species, such as the chestnut, are now missing'. McKibben (1995) discusses 'quick devastation, quick recovery,' but this is not always true ecologically. For example, large oil spills may cause damage that cannot be quickly overcome. If recolonization is achieved by species not present before ecological damage occurred, the uncertainty about the outcome may remain high. Berger (2003, pers. comm.) continues, 'If the species are not the same, then assuredly we do not have perfect structural (species) restoration, but we may have a restoration of certain if not many important species and some ecosystem functions'.

Since 1961, I have worked intermittently at Rocky Mountain Biological Laboratory, situated at the mining town of Gothic, Colorado, which was abandoned by all but one inhabitant and his dog in the late 1800s when the early promise of mining proved illusory. Converted into a biological station in the 1930s, this area has since been occupied during summer by varying numbers of biologists, rarely exceeding 250. In recent years, between two and four people have been wintering there.

Thus, the Laboratory had a period of intense use with accompanying dramatic changes in the ecosystem, followed by disuse, and, subsequently, over half a century of occupation by persons likely to inhabit the area with as little disruption to the native plants and animals as possible. In spite of this nearly ideal opportunity for recovery, the ecosystem does not resemble the predisturbance ecosystem, nor is it likely to in the foreseeable future. Recovery is not automatic, but is rather an accident of climate, soil, and economics (McKibben 1995). Assisted recovery (restoration) '…is also dependent on the success of restoration planning, implementation/management, and the cooperation of natural forces' (Berger 2003, pers. comm.).

In addition, many species of wildflowers in the southern Appalachians have not returned (McKibben 1995), almost 100 years after the forests were last cut. While some species may return, they must come from elsewhere or be brought there by human management. The fewer barriers to the recolonization of species, the more likely natural recovery to some semblance of predisturbance conditions will occur. Landscape fragmentation makes recolonization difficult, even if the original species remain in the region.

Ethical problem #5 — Displacement of species best able to tolerate anthropogenic stress

Well-meaning ecological restoration efforts might eliminate those species that had initially colonized disturbed areas and were able to tolerate anthropogenic stress. The restoration efforts might replace tolerant species with species intolerant of the present practices of human society; these intolerant species will subsequently be eliminated unless human society alters its present behavior. Some species that are needed most for long-term sustainable use of the planet are almost certainly included in the group of species with poor resistance to present practices (for example, species that control 'pests' or pollinate plants). These species are in the most need of protection and are, collectively, the ones most needed to provide a vast array of services useful to human society. These species may not yet even be recognized as valuable to the interdependent web of life because, in many cases, they have not received scientific names. If they are not even named, it is unlikely that substantive information is available about their ecological functions, some or possibly all of which are of unperceived value.

Unquestionably, many of these intolerant species control population densities of those species that resist human control (i.e. pests). They may do so by preying upon them, successfully competing with them for space or nutrients, or by favoring other competitive species. On the other hand, if human society's practices and behavioral norms are not changed, ecological restoration carried out with species sensitive to anthropogenic effects will result only in a repetition of the ecological disasters that necessitated the restoration in the first place. For example, restoration with species intolerant of oil spills is useless if oil spills continue.

It is difficult to accept that damaged ecosystems may not be restored to some naturalistic assemblage of plants and animals resembling the predisturbance condition. This realization is especially unpleasant if it means the loss of restored habitat essential to the maintenance of a bioregion or landscape. Probably most important is the strong possibility that ecosystems tolerant of anthropogenic stress may not furnish ecological services that bear a close resemblance to those furnished by the indigenous ecosystem before it was damaged. Most ecologists would undoubtedly choose the restoration model that closely resembles the predisturbance condition. However, if there is no assurance that the conditions that caused the damage are unlikely to be repeated, society will cease to support ecological restoration efforts; the present level of support is hardly overwhelming.

It is distressing to think that species that are removed as landscapes are restored might actually turn out to be quite desirable some day. However, the species that might be removed in favor of establishing predisturbance species are not those that would be eliminated from the larger landscape. For example, r-selected species are highly tolerant of disturbance and, thus, are doing very well in frequently disturbed landscapes. In the future, society might have uses for some species that are currently defined as weeds (e.g. tobacco has found practical value in biotechnology). Adaptive management must incorporate new scientific evidence, but it must be done in a systematic and orderly fashion.

An additional important ethical problem arises relative to restoration and climate change. Climate change, for example, will flood restored wetlands as sea level rises and obliterate them. The ethical problem becomes whether to restore an ecosystem, even if it will only function in the short term, or whether to put the money to other valid ecological purposes. Additional related problems concern how much money should be put into restoration, how to prioritize resources for restoration, how much of a social/political furor should be created if society fails to get itself on a sustainability trajectory (one in which rates of resource restoration are greater than or equal to rates of destruction), and how to sanction those who wantonly destroy nature and fail to restore it.

Ethical problem #6 — Should human-dominated successional processes become the norm?

Without question, if ecological restoration with species able to tolerate anthropogenic stress is chosen, whatever successional processes result will be human-dominated (i.e. exogenously managed). Even if the practices that caused the ecological damage are reduced, the damaged ecosystem still may not be repaired to the predisturbance condition in both structure and function.

Substantial portions of most countries' landscapes are human-dominated (i.e. urbanized, developed, non-wild). As a consequence, these ecosystems will almost certainly be inhabited by species that are resistant to, or tolerant of, human activities and which will invade the ecologically damaged areas even if there are ongoing restoration attempts. Additionally, exotic species often thrive in stressed or altered ecosystems and are likely to invade areas that are undergoing ecological restoration.

Continual management is needed to keep exotics under even partial control during some ecological restoration attempts. Nonsuch is a 14.5-acre island in Bermuda. Even with its small size, intensive continual management is necessary to keep the exotic species inhabiting most of the other portions of the Bermudan system from overwhelming the indigenous species (e.g. Bermuda cedar, yellow-crowned night heron) being reestablished on Nonsuch. The restoration effort is valuable because it demonstrates the difficulties of restoring a portion of a landscape with severe anthropogenic stress (e.g. non-native plants established on the mainland, whose seeds are transported by birds that roost on Nonsuch at night) that is dominated by exotics, although this stress is not directly exerted on the island.

The lesson of this restoration effort is that human-dominated successional processes would clearly be the norm if it were not for continual intervention by researchers, land managers, government officials, and environmentalists on behalf of the reestablished indigenous species. There are several justifications for making this restoration effort: (1) Bermudians should always be able to see what their country once looked like before intensive occupancy by humans; (2) indigenous species characteristic of the islands should be maintained so that, if recolonization efforts were to be undertaken elsewhere in the Bermudan system, colonizing species would be available; (3) it is always helpful when examining ethical and scientific questions, such as the ones posed in this dis-

cussion, to have some hard evidence of the difficulties involved and the degree of management necessary (e.g. during my visit decades ago, two employees worked full time removing exotics; Wingate 1988, pers. comm.).

Ethical problem #7 — Obtaining recolonizing species for damaged ecosystems without damaging quality ecosystems

In many parts of the world, ecological landscapes are heavily dominated by human society's artifacts — highways, power lines, shopping malls, altered land contours — and the number of relatively pristine ecosystems is small and diminishing. Even these relatively untouched ecosystems are threatened by airborne contaminants (such as acid rain), waterborne contaminants, or exotics living in greatly altered ecosystems. Habitat fragmentation has reduced genetic diversity for many species, and other problems are associated with diminished habitat area. As a consequence, one is reluctant to remove indigenous species from quality habitats for the purpose of recolonizing areas that have been damaged, even when the probability of success is fairly high. Removing a number of individuals of an already diminished population would have a variety of adverse effects, and moving too few might result in unsuccessful recolonization.

Obviously, considerable ethical judgment will be necessary in making these decisions about recolonizing species, and, inevitably, the decisions will not be the same from one site to another. These issues must be discussed and evaluated before the restoration is ever started so that the risk to the species sources are explicitly stated and the probability of success is related to the risks of doing further damage.

On the other hand, if recolonization is successful, another potential source of recolonizing species for other damaged ecosystems will have been established. However, microhabitat differences are often difficult to detect and may be responsible for the success or failure in a recolonization effort.

The National Research Council (2003) has provided a useful review of the Critical Ecosystem Studies Initiative (CESI), a project launched by the US Department of the Interior to provide scientific information to advise restoration decision making and to guide its own land management responsibilities for South Florida ecosystem restoration. However, CESI should be a useful information source about the complexities of large-scale restoration projects. CESI's most important contribution to the ecological restoration process is the graphic depiction of organization, cost sharing, and sums of money involved in major restoration projects.

FAKING NATURE

A small but insistent group has suggested that ecological restoration (as opposed to natural ecological recovery) is 'faking nature' (e.g. Elliot 1997). Most species modify their environment to some extent, but none on the scale of humans, particularly over the last few centuries. In addition, ecosystems are dynamic, so change is the norm rather than the exception. Species that adapt to the changes survive; those that do not become extinct. Finally, ecosystem restoration is based on natural processes subsidized in various ways by humankind (for example, use of hatcheries to reestablish a fishery).

The ultimate goal of ecological restoration is to produce a naturalistic, self-regulating community of plants and animals. Ideally, human assistance should only be required for the initial stages; that is, until the ecosystem becomes self-regulating. If the ultimate goal is to have natural processes take over, how can the assistance be considered 'faking nature'? An important criterion for restora-

tion success is the degree to which the restored system accumulates natural capital and provides ecosystem services of benefit to a majority of species, not just humans.

Many ecosystems being restored will require subsidies for a considerable time period, but ultimately, in evolutionary time, all will become self-regulating, although they may not always be perceived as beneficial to humankind. Stated another way, if humans became extinct, all ecosystems would become self-regulating, just as they have become self-regulating following a number of mass extinctions that occurred before humans appeared on the planet. However, future self-regulation measures may not favor humans as much as present ecosystems have in the last centuries. The fact that humans are responsible for the present biotic impoverishment (species extinctions) does not diminish, in the long term, the prospects for ultimate recovery when the stressor (humankind) disappears.

CONCLUSIONS

This discussion has offered a few illustrative examples of the interface between science and ethics with regard to ecological restoration. Some of the questions that human society must address follow.

1. Is a world consisting entirely of human-dominated ecosystems desirable?
2. If not, under what circumstances should restoration to predisturbance be chosen or rejected?
3. If ecological restoration is carried out with species tolerant of anthropogenic activities, ecosystems will not resemble the predamaged conditions, and their services may not correspond with those of the ecosystem in the predisturbance condition. What information is needed to make an informed judgment in this situation?
4. Is it possible to have sustainable use of the planet for 1000 or more years and under conditions not appreciably worse than those at present if ecological repair does not equal the rate of ecological destruction?
5. Does sustainable use of the planet mean ecosystems that fill minimal expectations of services and other amenities or, in addition to quantity, is quality an expected attribute of sustainability?

Other questions raised by Berger (2003, pers. comm.) that are beyond the scope of this article include: How can fraudulent restoration efforts, which are completed merely to give cover to developers, be detected and prevented? Do environmental consulting firms that offer and promise mitigative restoration often serve merely to facilitate development? Who should pay for restoration? Does society need to adopt a variant of ‘the polluter pays’ principle to this problem? Other important ethical problems regarding restoration include determining when to discontinue a restoration effort — when is restoration done and regarded as a success — and when monitoring should cease (Holl & Cairns 2002).

These serious ethical questions are but a few of the many that cannot be answered by science but will require robust scientific information in order to make a satisfactory judgment. Ecological and environmental literacy for the general population and its representatives must be greatly improved to deal with these complex multivariate issues. Furthermore, both the temporal and spatial scales are much greater than those with which most political systems are accustomed to coping. The complexity level of the problems requires multidimensional approaches. While the challenge is great, the opportunity for systems level science and thinking has never been greater, nor has human society’s stake on the outcome.

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Article 5

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Integrating Top-down/Bottom-up Sustainability Strategies: an Ethical Challenge

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ABSTRACT: Sustainable use of the planet will require multiple sustainability strategies, which will range from the entire system, the entire Earth, to the local or regional. Strategies starting at the highest system level are referred to as 'top-down,' and strategies designed for components, local or regional, are referred to as 'bottom-up.' Doubtless, several intermediate levels will eventually be required, although the number is far from clear at this time. It is abundantly clear that both top-down and bottom-up strategies must be integrated effectively or neither will work well. Furthermore, there will be significant uncertainties at both levels of organization, which will be reduced as evidence accumulates. However, sustainability is too complex and dynamic to reduce scientific uncertainty to a level desired by most decision makers. A greater emphasis on sustain-ethics and value judgments will improve communications between those working at different organizational levels since humankind's wish to leave a habitable planet for its descendants and those of other life forms is clearly a value judgment.

KEY WORDS: Top-down strategy · Bottom-up strategy · Sustainability strategies · Eco-ethics · Value judgments

Knowledge of what is does not open the door directly to what should be.

Albert Einstein

I know of no more encouraging fact than the unquestionable ability of man to elevate his life by conscious endeavor. Henry David Thoreau

INTRODUCTION

The Options Spring 2002 issue is devoted entirely to Achieving Sustainable Development: The 21st Century Imperative. Jernelöv's (2002) editorial notes that human security issues relating to the supply of water, food, and energy, and the protection of Earth's life support systems have been high on the International Institute for Applied Systems Analysis' priority list since its creation approxi-

mately three decades ago. The same Options issue notes that human dimensions must be placed at the core of sustainable development to meet the needs of present generations without sacrificing the livelihoods of future generations. Not featured is eco-ethics—the ethics of humankind's relationship with the planet's biospheric life support system, despite the fact that the natural capital and services it provides is the sine qua non of sustainability.

Sustainable use of the planet is the most complex problem in human history. Its goal is to change humankind's behavior and practices so that the human species can inhabit its planet indefinitely. To accomplish this goal, it is essential that a mutualistic relationship develop between human society and natural systems. This relationship, in turn, will require a combination of econ-ethics and eco-ethics (e.g. Kinne 2002). Both economics and ecology are derived from the Greek word *oikos*, which means household. The term *household* was originally used (and still is) in a much more restricted way; however, humankind is now beginning to perceive Earth as the ultimate household. Econ-ethics requires an ethical economic system that will benefit humankind. The economy must be structured in a way that will not damage the planet's ecological life support system. Econ-ethics and eco-ethics used concomitantly to enhance sustainable use of the planet would be sustain-ethics (this term initiated in this paper). Neither natural systems nor future generations can demonstrate appreciation or gratitude for sustain-ethics while present generations still live, but ethical behavior gives a peace of mind that is its own reward. However, sustain-ethics, in addition to compassion for natural systems and future generations, also includes compassion for disadvantaged members of the human species who could express appreciation to humans now alive for improving the human condition.

There must be a global strategy for sustainability ('top-down strategy') but also a strategy that considers the unique issues and ecosystems of each bioregion ('bottom-up strategy'). Holistically practicing top-down and bottom-up sustainability strategies, including several intermediate 'connecting' levels, is a formidable, daunting task. The most promising way to connect these interdependent activities is an ethical 'cement'—sustain-ethics. It is unclear whether the top-down strategies should work directly with the bottom-up strategies or whether there should be one or more intermediate steps. Ideally, the shorter the communication chain the more rapid and effective communication will be, but there are many obstacles to this simple two-strategy model.

The lofty goals of sustainability are fairly easily stated and seem to strike a responsive chord in anyone wishing future generations of humankind to have a habitable planet. How this will be implemented in various ecoregions with different problems is not particularly clear; even less clear is the way in which different ecoregions will interact with each other and how the humans who occupy them will be persuaded to follow a global sustainability strategy.

It is abundantly clear that both top-down and bottom-up strategies are being developed, although the rate of development of the latter varies dramatically from one country to another and from one bioregion to another. In addition, global acceptance of whatever top-down strategy eventually emerges will doubtless be markedly influenced by local conditions.

Both global and regional strategies must be integrated effectively or neither will work well. Humankind has only one finite planet, and damage to one part of it almost guarantees damage to other parts that are distant geographically, spatially, and even temporally. It remains to be seen whether humans can grasp a problem of such complexity for an infinite period of time. After all, sustainable use means being able to continue these practices indefinitely. However, if it is not possible to address effectively a problem of such complexity, humankind will suffer enormously. Therefore, the attempt must be made despite many inherent difficulties.

OBSTACLES TO TOP-DOWN/BOTTOM-UP SUSTAINABILITY STRATEGIES

The obstacles to developing a sustainability initiative are essentially the same as those hampering development of a global sense of community. Even taken individually, they both have inherently formidable obstacles. In the aggregate, one wonders how they will ever be transcended. Illustrative examples of obstacles to bottom-up strategy development include: (1) language barriers, (2) ethnic and religious conflicts, (3) disparities in per capita wealth, (4) disparities in educational opportunities, particularly in developing scientific and environmental literacy, (5) differences in the balance between individualism and a sense of community, (6) differences in age distribution within the local population (e.g. predominantly young or predominantly elderly), (7) level of biophilia (humankind's innate affinity for the natural world), (8) degree of compassion for individuals of the human species distant in time (future generations) or space (in far geographic localities), (9) level of equity and fairness in resource allocation among members of the human species and those of other life forms, and (10) a lack of willingness to do more than the law requires in achieving sustainable use of the planet. Illustrations of obstacle 10 include focus on individual 'rights' (Cairns 2002a,b) rather than individual responsibilities, lack of accountability for one's own actions, greedy desire to acquire material wealth at others' expense, disregard for the appearance of one's environment (e.g. littering in public parks and freeways), corporate efforts to obtain today's profits without regard for the long-term effects of today's practices, elected officials' actions geared toward satisfying constituents' immediate demands (to keep the vote) instead of doing what is best for the survival of the local ecosystem, and the waste of resources that is a part of affluent societies' consumerism.

The obstacles to development of a top-down strategy are equally formidable. Illustrative examples include: (1) the enormous difficulty in visualizing solutions to goals over large temporal and spatial spans, (2) integrating huge temporal and spatial spans in a mutualistic fashion, (3) ensuring that no component of the top-down strategy negates or compromises an important component of the bottom-up strategy, (4) developing continuous feed-back loops between top-down and bottom-up strategies, (5) developing a harmonious working relationship between top-down and bottom-up strategists, (6) ensuring that minutia do not distract from the holistic scope of the top-down strategy, (7) detecting changes in either natural systems or human society that require mid-course corrections, (8) coping with 'rogue' nations and uncooperative nations in an ethical way while maintaining sustainable practices, (9) acquiring and maintaining the financial base necessary to operate the Global Sustainability Organization (GSO), (10) determining when the precautionary principle should be applied, and (11) determining how to orchestrate the GSO in a democratic fashion while promptly eliminating unsustainable practices.

Clearly, the same obstacles exist for both top-down and bottom-up—they will, however, not be resolved in an identical fashion. These illustrative examples do indicate how important ethics will be for both strategies. As humankind moves from small group, tribal units toward a global community, shared ethical values become ever more important to the survival of the human species.

UNCERTAINTY AND ETHICS

There are four major classes of scientific uncertainty, particularly in resolving environmental issues such as sustainability: (1) framing uncertainty, (2) modeling uncertainty, (3) statistical uncertainty, and (4) decision—theoretic uncertainty (Shrader-Frechette 1996).

Durham (1992) remarks that scientists provisionally accept a hypothesis that has survived rigorous attempts to falsify it, even one with obvious deficiencies, if there is no better (i.e. more prob-

able) hypothesis available. Physics has often been regarded as one of the 'hardest' sciences with a superb record of validating hypotheses. Yet, Carnap (1966) states that since hypotheses have an infinite number of observational consequences that can never be conclusively validated, scientists sometimes opt, in an uncertain situation, for provisional acceptance of the best available non-falsified hypothesis. Thus, uncertainty is the norm, even within disciplines noted for their precision.

Uncertainty is likely to be orders of magnitude greater in the quest for sustainable use of the planet, which requires input from all disciplines. Further, experimentation is difficult, not only because there is only one planet but also because of a natural reluctance to experiment with human subjects. Cairns & Smith (1996) analyze some of the ways in which these uncertainties associated with both top-down and bottom-up strategies can be reduced and make recommendations on how the validation process might belatedly be integrated into the ecotoxicological field. These approaches should be useful, properly modified, when integrating top-down and bottom-up approaches in general. As Cairns & Smith (1996) note, it is difficult (and in some cases impossible) to measure directly how a stressor affects an ecosystem. For example, society cannot wait 20 or more years to determine the specifics of the ecological effects of radioactive wastes. While this uncertainty is being reduced, ethical principles will be a useful component of societal decisions. Ethical principles are extremely important since scientific uncertainty may never be satisfactorily reduced in time periods of interest to human society.

Sustainable use of the planet is an aspiration involving levels of complexity transcending most scientific endeavors. Arguably, one of the most important facets of this complex problem is that most environmental laws and regulations place the burden of proof for demonstrating human health or environmental damage on governmental regulatory agencies or non-governmental organizations wishing to demonstrate harm from development or technological activities. The universal standard, which is generally used to meet burden of proof requirements, is often the normal standard of scientific proof, such as a 95% confidence level or an equivalent criterion. The scientific community, in order to minimize Type I errors and, therefore reduce speculation in scientific data interpretation, adopted this standard. But when such a standard is utilized as a basis for developing sustainability strategies, the scientific uncertainty that inevitably pervades such situations means that the burden of proof usually is not met, despite the fact that some information might demonstrate impairment to the quest for sustainability. Finally, as a consequence of the absence of a robust understanding of scientific uncertainty and its implications for sustainability, decisions mean that policymakers/managers will not have adequate scientific information to guide them in terms of whether or to what extent decisions should reflect a precautionary approach. Since humankind has only one finite planet on which to achieve sustainable use, it is abundantly clear that the usual requirements to reduce scientific uncertainty, such as use of controls, multiple testing under variable conditions, and the like, cannot be met. Ethics are especially important in such circumstances.

Humankind is now moving from the age of reductionist science to an age of synthesis or integrative science. This transition does not mean that reductionist science is no longer appropriate, but rather that as levels of complexity in any system increase, new properties emerge that were not apparent at lower levels. Consequently, one means of reducing uncertainty in this age of synthesis is how congruent a particular hypothesis or body of evidence is with other related bodies of evidence within the particular system being studied. Both top-down and bottom-up sustainability strategies will require synthesis and also a means of coping with scientific uncertainty. Again, ethics should be a major factor in the decision making process.

POLICYMAKERS/MANAGERS AND SOCIAL AND NATURAL SCIENTISTS

It is well to remember that all sustainability strategies involve both macro- and micro-coevolution of human societies and natural systems. If successful sustainability strategies are developed, they will also require coevolution in understanding between and among policymakers/managers and natural and social scientists. These coevolutionary interactions will greatly influence sustainability issues, as well as issues of how humans behave toward the environment, those in other cultures and financial circumstances. Most importantly, it will require abandoning the many unsustainable practices found in almost every culture on the planet and substituting sustainable practices despite the attractiveness of the unsustainable ones to which humans have become accustomed. These are groups unaccustomed to working together on a long-term, meaningful basis on such a complex issue as sustainability strategies. At worst, some groups have no regard for or even trust in some of the other groups, and, at best, there is often a poor understanding of the ways in which other groups function. Ethics is an obvious 'bridge' between groups so that misunderstandings can be reduced or eliminated.

One would expect the primary initiative in developing integrative programs covering the broad spectrum of groups just described to come from the world's universities and colleges, particularly those in which the responsibility for generating new knowledge and communicating it to students is a major responsibility. Regrettably, this does not occur at either the rate or scale necessary for achieving sustainability for a variety of reasons. Among these are increased teaching loads and budget cuts at state- and federally-supported institutions, which do not permit the extensive time necessary for faculty in one discipline to develop a deep understanding and productive relationships with those in other disciplines. Arguably most importantly, students do not perceive the need for developing such a broad perspective because they cannot, at present, see the relationship to the job market and their future professional growth. Consequently, it is highly unlikely that there will be adequate, experienced personnel skilled in integration and synthesis at the temporal and spatial scales required for sustainability initiatives as well as the diversity of components needed for successful implementation. Such personnel cannot be produced overnight, nor is it likely that many persons with a disciplinary bias can be persuaded to take a holistic view of sustainability initiatives. As a consequence, it will be of greatest importance to utilize the relatively few available personnel as effectively as possible in the short term and to prepare a much larger group that is sufficiently holistic to implement sustainability initiatives. The most important aspect of educational institutions' budget cuts is fewer personnel and less scientific information for a considerable period of time. Uncertainty will not be significantly reduced and may even increase. Thus, ethics is now of major importance.

HOW MANY LEVELS OF SUSTAINABILITY STRATEGIES?

Going from global to local or regional directly follows Dubos' famous injunction 'think globally, act locally.' The problem is that insightful global thinking will require an information mass well beyond the capability of most (and possibly all) individuals to assimilate and understand. Even if an individual, or even a small number of individuals, did have such a capability, there would be a problem of trust because they would undoubtedly not represent all religions, all cultures, all language groups, and so on. Furthermore, since effective sustainability strategy implementation will involve numerous professional and non-professional groups and a mixture of science and value judgments, a diversity of viewpoints would strengthen the policy decisions, if the diversity did not impede reaching consensus. In the first two decades of the 21st century, it is extremely unlikely

that there would be adequate numbers of competent personnel to function as integrators of concepts and information and synthesizers of both concepts and value judgments. If there is a global public will to increase the number of competent professionals, undoubtedly this could be done over a period of several decades or more. The initial problem would be the lack of suitable faculty and other professionals to educate and inform the large numbers of additional personnel needed. Furthermore, much on-the-job training would be required, and a large number of qualified personnel would be required to spend most, if not all, of their time on synthesis and information integration rather than on increasing the literacy of additional personnel.

At the bottom-up level, there are numerous areas where adequate or nearly adequate numbers of competent professionals are available. There are also numerous areas where the idea of sustainability is not even being discussed in the most general way. So, there is a major educational problem at the bottom-up level, although in most respects it differs significantly from the top-down approach. A major problem in increasing literacy at the bottom-up level concerns trying to increase all citizens' literacy in the requirements for sustainable use of the planet and deciding what organization(s) should be responsible for quality control, planning, financing, and the like. There is also the crucial question of how to transfer increased sustainability literacy from areas where the literacy is high to areas where it is low or non-existent. This problem will almost certainly be exacerbated by cultural, religious, and language difficulties, to name just a few. Ethics should help reduce these problems because it may furnish a common ground in which diversity can be appreciated but not divisive. Kung (1998) defines a comprehensive ethic—founded on the bedrock of mutual respect and humane treatment of all beings—that would encompass the ecological, legal, technological, and social patterns that are reshaping civilization. If humans are going to have a global economy, a global media, a global technology, Kung (1998) argues that there must also be global ethics to which all nations and peoples of the most varied backgrounds and beliefs can commit themselves. Earth can and should be held together by ethics. As Common (1995) notes, there is no purely scientific basis on which to decide the alternative positions between economists and ecologists. Differences primarily reflect dissimilar value systems (e.g. Myers & Simon 1994). This is one reason why sustainability issue decisions are so difficult and contentious. It is abundantly clear that the debate on sustainability issues would be more productive if participants explicitly stated their ethical values that, together with scientific evidence, support the positions they are taking.

At the outset, there seems to be no choice but to begin with only the top-down approach and the bottom-up approach with no intermediate stages. This design will undoubtedly cause difficulties, but these will doubtless be less if there are competent personnel in both categories rather than a large number of unqualified people at intermediate organizational stages or, worse yet, at all organizational stages. This immediately calls to mind the problem of quality control, which has been successfully resolved by the disciplines representing reductionist science but has yet to be resolved for integrative science or synthesis.

As the number of qualified personnel increases and the general literacy about sustainability increases, more levels of organization between top-down and bottom-up not only will be possible but most likely essential.

CONCLUSIONS

For initial stages, the primary focus of sustainability initiatives should be restricted to top-down and bottom-up strategies with no intermediate levels, for reasons already stated. As the number of

trained personnel and the information base, including case histories, expands, so also can the number of intermediate stages between the two extremes. Exacerbating the complex problems already discussed in a preliminary fashion will be the certainty that there is no precise indication of how much time is left to put these top-down/bottom-up strategies in place. Many professionals think environmental problems are already severe and that a number of crucial environmental thresholds and breakpoints have already been crossed. Resilient systems usually permit an overshoot if it is not too severe and not sustained for an exceptional time period. However, many unsustainable practices are increasing exponentially while social adjustments lag far behind. Possibly, it will require a major collapse of one of the planet's life support systems to change the mood from complacency to serious concern. This also would mean that the time to cope with the problem and to increase sustainability literacy will be substantially decreased. Consequently, one hopes that reason guided by evidence will result in some precautionary measures being taken, such as increasing training programs at universities and colleges and, as soon as possible, in general school systems, which will enable all citizens to become literate in this area.

Clearly, a greater emphasis on ethics and value judgments with regard to sustainable use of the planet is long overdue. Science can show what probably is done; technology can show what might be done; but ethics can help humankind decide what should be done.

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Article 6

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Environmental Refugees

John Cairns, Jr.

Sea level rise, loss of arable land, inadequate water supplies, exceeding local carrying capacity for humans, and a host of other events might easily produce environmental refugees in unprecedented numbers. These events are also likely to destabilize political systems, adding even more refugees. These probable events pose some serious ethical problems that are rarely discussed in public forums. (1) Should countries that contributed to the problem (e.g., global warming) accept a proportionate number of refugees? (2) How can the more fortunate countries assist countries that are highly probable sources of refugees in a mutualistic way? (3) Is sustainable use of the planet possible for any country if environmental refugees are produced in large numbers anywhere on the planet? (4) Can countries with weapons of mass destruction blackmail countries living sustainably when environmental problems become unmanageable? (5) Should processes that limit populations of other species be allowed to keep human population size within regional carrying capacity if the countries producing the refugees refuse to adopt sustainable practices? It is almost certain that refugees will cause loss of individual freedom in the country of origin and probably in the countries to which they flee. In resource poor areas, survival will be the primary focus. In the "host" countries, resources will be strained, perhaps even leading to rationing and price control.

MAKING A COMPASSIONATE DECISION

Humans become environmental refugees when they have exceeded the carrying capacity of that portion of the planet that supported them. In some cases, the refugees are not the primary cause of the problem (e.g., sea level rise due to global warming). In other cases, they are directly responsible (e.g., exponential population increase). Should these two groups be treated differently? In the case of the population increase, individuals often do not feel responsible since large families are part of their culture. Afghanistan and the Gaza Strip both have high birth rates and poor resource bases, but this is not frequently part of the public discourse. Until this issue is faced, we will be treating symptoms rather than causes.

When countries capable of absorbing environmental refugees are at or beyond their carrying capacity, every individual on the planet becomes a potential environmental refugee with no place to go. How should human society respond to this situation, which may be closer than we think. The human population is increasing, but natural systems are decreasing.

Estimates of the rate of appearance of environmental refugees are extremely difficult to make. However, the precautionary principle requires that, when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-

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and-effect relationships are not fully established scientifically (Raffensperger and Tickner 1999). A substantial increase, both for compassionate and environmental reasons, in environmental refugees is likely to cause serious harm to both human health and the environment. The threat of disease is abundantly clear, but the potential for physiological and psychological damage also deserves serious consideration.

The estimated 1.2 billion people living on US$1/day/capita are already at serious risk. Prudence requires extending this to the over 3 billion with only US$3/day/capita or less. Arguably, even more important is the increasingly stressed condition of Earth's natural systems: collapsing fisheries, shrinking forests, eroding soils, deteriorating rangelands, expanding deserts, rising atmospheric carbon dioxide levels, falling water tables, rising temperatures, more destructive storms, melting glaciers, rising sea levels, dying coral reefs, and biotic impoverishment – extinction of species (e.g., Brown, 2001). Under these daunting conditions, Earth is expected to support nearly 90 million additional people each year. Since there seems to be no generally acceptable solution to this problem, the question is not whether the number of environmental refugees will increase, but where, when, and at what rate. How should we respond to this impending crisis?

One hopes that we will respond with compassion, but will it be focused on the symptoms or the causes? Cairns (1998) notes that sustainable use of the planet requires compassion for (1) humans presently alive, (2) future generations, and (3) other life forms, present and future, that constitute the planet's ecological life support system. Wildlife managers may have compassion for individual deer but will thin the population when it exceeds the carrying capacity of its environment. One may feel compassion for wild horses and burros but be unaware that they are having significant deleterious effects upon threatened and endangered plants. Multidimensional compassion requires a modest level of environmental literacy but, most important, it requires making some value judgments that we would rather avoid.

Most of the planet's political units, possibly all, are not living sustainably at present. Some countries, especially in Europe, are on the road to sustainability, but accepting large numbers of environmental refugees might delay or block achieving sustainability. This situation would adversely affect the lives of future generations but would be more emotionally acceptable to people now living. Living unsustainably would also adversely affect future generations of humans and other life forms. Attempting to exclude environmental refugees would be repugnant to many individuals and might be exceedingly difficult if their numbers were of epic proportions. Furthermore, attempting to exclude large numbers of people in an era when bioterrorism is increasingly possible might lead to extremely unfortunate consequences. As Hardin (2001) remarked, human population control places society in what novelist Joseph Heller called a "catch-22" situation: "If a proposal might work, it isn't acceptable; if it is acceptable, it won't work."

The Peoples Republic of China (PRC) probably has the most realistic solution – the welfare of the group has precedence over individual wishes. The PRC is attempting to keep the human population at a level compatible with what is perceived to be within the country's carrying capacity. Affluent societies view such coercion with horror. But, exceeding the country's carrying capacity will lead to disease, famine, and other equally distasteful conditions, and, although individual reproductive "rights" are severely restricted, the group's survival is not as likely to be endangered. The ethical dilemma is that many humans value individual freedom and cannot bear to stand by while others suffer, even those so geographically remote that we are unlikely to encounter them personally. Many members of human society are also concerned about the fate of other life forms (biophilia) and wish to protect the health and integrity of the interdependent web of life. Last, but far

from least, we hope to leave a habitable planet for future generations of our own and those of other species. Doing this is a real challenge.

SUSTAINABILITY AND CARRYING CAPACITY AS ETHICAL ISSUES

Sustainable use of the planet requires that human society not exceed the planet's carrying capacity for *Homo sapiens*. Despite this close relationship, the term *carrying capacity* is not included in the index of *Our Common Future* (The World Commission on Environment and Development 1987). Perhaps the frequent use of the term *sustainable development* made this connection awkward since *development* is usually associated with growth and sustained growth is not feasible on a finite planet. Of course, growth in quality could theoretically continue indefinitely, but the word *growth* is usually associated with increased abundance of human artifacts (e.g., shopping malls, urban areas, etc.). Sustainable population size is mentioned in *Our Common Future* as well as protecting the environment. It is a paradigm shifting book, but an understanding of carrying capacity is essential to sustainability.

Cohen (1995) analyzes the difficulties in estimating Earth's carrying capacity for humans, which is affected by affluence, life style, etc. Wackernagel and Rees (1996) illustrate how carrying capacity can be increased by reducing the size of the per capita ecological footprint.

Ehrlich and Ehrlich (1970), Grant (1992), Abernethy (1994), Hardin (1993a), Douthwaite (1999), and Smail (1997) feel that we have already exceeded the planet's long-term carrying capacity. One should not get the impression from this long list of citations that they represent the majority view. This idea of exceeding the carrying capacity is definitely a minority view, but it appears to be growing steadily. The majority view, of continual growth and development, is so ubiquitous that it appears to approach a consensus. Publications strongly espousing a contrary view are Simon's part of Myers and Simon (1994), Eberstadt (1997), and Simon (1981). It is well to remember that individuals with strongly held beliefs usually reject contrary evidence and paradigms shifts occur only when the contrary evidence is overwhelming (Kuhn, 1971). Increasing numbers of environmental refugees just might cause a shift from accepting exponential population growth as the norm to a conviction that the world is overpopulated with humans.

If, as seems likely, a paradigm shift does occur toward a belief that the world is overpopulated, this will undoubtedly have a major effect upon the way environmental refugees are regarded. It is exceedingly difficult to predict how people will react to this new awareness. Some illustrative possibilities follow.

(1) Some people will decide that, if they are on the "Titanic," they might as well have a good time since the situation is out of control.
(2) Some societies will concentrate on ways to divert environmental refugees to other countries and to protect their own borders from invasion.
(3) Some societies will treat the symptoms (e.g., providing food and shelter) without getting at the cause (e.g., overpopulation and exceeding the area's carrying capacity).
(4) Some countries producing environmental refugees might try to correct the causes, but this seems unlikely. Correction could occur if aid depends on meeting certain conditions (the World Bank is a good example of this strategy for monetary problems).
(5) Some may try to take over resources of other countries, as did Germany and Japan during World War II and Iraq during the Gulf War.
(6) Some may attempt to reduce population size through "ethnic cleansing" (i.e., extermination of a subgroup).

(7) Some countries may decide it is in their enlightened self interest to help less fortunate countries with their problems. Since this strategy will require a redirection of resources from their own citizens to those of other countries, there will almost certainly be significant resistance. Even if the plan is accepted, there will undoubtedly be calls for a date beyond which help diminishes or ceases. This time line is likely to be considered unreasonable by the recipient country.
(8) The United Nations should play a major role in addressing the problem, but will need more authority and allocation of resources than it now has.

A folk proverb states "No single raindrop believes it is the cause of a flood." So, the solution must start with increased environmental literacy at the individual level. Leaders at all levels of political organization (up to the United Nations) will need to think beyond their special interests to view the problem at a systems level. Science and technology can provide critical assistance in addressing this problem, but the primary issues are of an ethical and guiding values nature. Arguably, the resolution of the environmental refugee problem should be primarily the responsibility of the world's religions, but the world's religions seem unable to work in harmony; some have serious internal problems as well. If human intelligence was not an evolutionary mistake, the solution depends on reason guided by ethics. The solution is easy to visualize, but exceedingly difficult to implement. Resources must be redistributed to reduce human suffering, but in a way that does not damage the natural environment or make the planet less hospitable for any descendants. Only major, rapid social evolution will make this goal a reality.

A MICROCOSM OF A PROBABLE FUTURE

The country Tuvalu, a collection of nine small, low islands a considerable distance east of Australia, will be abandoned by its inhabitants in the near future. Tuvalu has endured lower level flooding, salt water intrusion of its drinking water supply, and increased coastal erosion as a result of sea level rise. Tropical cyclones (hurricanes) have also increased in the last decade. Although the population is only about 11,000 people, this number is particularly significant because the entire population must leave (for more details see Earth Policy News-Sea-Level Rise, news@earth-policy.org). The Tuvaluans have requested that New Zealand accept its entire population, although no decision has been reached yet. Wherever they go, it will doubtless be an enormous cultural shock.

The President of the Maldives refers to his country as an "endangered nation" because it is also threatened by sea level rise. Most of the country's 1,196 tiny islands are barely 2 meters above seal [*sic*] level. Even a 1-meter rise in sea level would be hazardous in the event of a storm surge. The Maldives has a population of about 311,000 people, a more serious logistical problem than the 11,000 from Tuvalu.

These small island nations have existed for many generations, but future generations will be denied this opportunity. In both cases, the carrying capacity for humans will be reduced to zero, and technology will not save them unless it is employed in the global reduction of anthropogenic greenhouse gases.

No substantive discussion has occurred on the issues raised by these two illustrative situations. These two refugee problems are particularly significant because there is literally no place in their own country for the population to go. Arguably, even more significant is that the situation developed because of anthropogenic greenhouse gases whose origin is virtually entirely outside both countries. Since coastal areas are generally heavily populated, the number of people displaced globally could increase by an order of magnitude or more. The time to react through social change

may be as little as 50 years. For example, Smedsrud and Furevik (2000) estimate that the Arctic Ocean could be free of ice during summer in 50 years. A free and open exchange of ideas on these critical ethical issues is essential (Brown, 2000).

SOURCES AND SINKS

There is no place on Earth where humans cannot exceed the carrying capacity. The concept of carrying capacity assumes limits on the number of individuals that can be supported at a particular level of resource consumption or use without damaging the integrity of the ecological life support system, which would then reduce future carrying capacity. However, as Abernethy (2001) notes, the concept of carrying capacity is widely discounted, in part because it varies and is difficult to quantify. Additionally, new technologies may increase carrying capacity. Finally, technological and economic optimists reject evidence that resource limitations on a finite planet exist (e.g., Simon, 1981). However, rejecting evidence that carrying capacity is not unlimited on a finite planet does not free human society from the consequences of bad judgment as the presence of environmental refugees indicates.

Any area of the world substantially below human carrying capacity might act as a "population sink" if accepting a number of environment refugees did not add enough to the current population size to exceed carrying capacity. The United States was a major sink for environmental refugees from Ireland during the famine that resulted from the failure of the potato crops. The Americas have accepted a sizable number of immigrants over several centuries. In terms of carrying capacity, the method of a population increase is not the focus, but rather total size and per capita demand on resources.

At the beginning of the 20th century, a number of areas might have qualified as population sinks. By the end of the 20th century, with dramatic increases in population and use of resources, arguably there were none. The United States has large numbers of legal and illegal immigrants, but its very large per capita ecological footprint (e.g. Wackernagel and Rees, 1996) ensures that a growing population, if maintaining current per capital levels of resource consumption, would be environmentally ruinous. As a consequence, if the United States continues to accept large numbers of immigrants, it should reduce the size of its per capita ecological footprint.

In order to achieve a sustainable world, environmental and other types of refugees must be considered in a global context. This imperative requires that some estimates of the carrying capacity of each country be determined despite the difficulties in doing so. Because of the possibility of error in such estimates, it would be prudent to include a safety factor, as is included for elevators, bridges, airplanes, and the like. This methodology will doubtless be fiercely resisted by the proponents of continued growth who rarely accept responsibility for "unforseen" consequences. It is also abundantly clear that some countries have already exceeded their carrying capacity and can only survive by exporting surplus population.

Since population sinks are exceedingly scarce and may disappear entirely early in the 21st century, it is essential that all countries implement sustainable practices, including population stabilization. Since failure to do so will have adverse effects upon the entire planet, all possible help should be given to all areas of the world that need assistance. Staying within the planet's carrying capacity is a formidable, seemingly impossible, task given the ethnic and religious conflicts, plus terrorism, that appear in the news daily. Were it not for the unthinkable consequences of doing nothing, this would appear to be unacceptably visionary and utopian. However, for those aware of the ecological collapse of other civilizations and the fate of other species that exceeded their car-

rying capacity, it is clear that nature has a solution to every problem – but not always one benefiting human society. On the ecological stage of the evolutionary theater, those 'actors' (i.e., species) who blow their lines do not remain on stage very long.

WHAT IF?

In the last half century, many environment catastrophes progressed from possibilities to probabilities. Arguably some, such as aquifer depletion, global warming, loss of arable land, desertification, extinction of species, deforestation, and habitat loss, are so well documented that only those in severe denial ignore the evidence. Prudence requires asking the question "What happens if these trends continue?" Clearly, loss of agricultural water because of aquifer depletion, loss of arable land including desertification, and global warming will result in a reduction in the global food supply despite the urgent need due to continuing population increase. If the glaciers and ice caps continue melting, low elevation coastal lands and even entire islands will be lost. The ethical problems fall into two categories: (1) ones in which refugees are dislocated as a consequence of cumulative effects of widespread practices (for example, production of greenhouse gases) and (2) ones in which refugees are dislocated as a consequence of regional activities.

REFUGEES RESULTING FROM CUMULATIVE EFFECTS

Rising sea levels will clearly displace large numbers of people from low lying coastal areas and islands. Since the United States produces approximately 25% of the anthropogenic greenhouse gases, should it be responsible for 25% of the global refugees? This number would reach the millions and possibly tens of millions. Since this issue has not been discussed in the depth required, it seems unlikely that the United States, or any other country, is prepared to accept large numbers of environmental refugees. Yet, in terms of responsibility, those who created the problem should bear a proportionate share of the remedial measures. In an ethical sense, this responsibility represents part of the true cost of producing greenhouse gases not included in current economical models. From an ethical standpoint, lives of many people are being adversely affected by economic practices over which they have little or no control. Ignoring responsibility for the problems created by current economic models is not a defensible position from either an ethical point of view or a holistic economic view.

The refugees from distant countries, such as Bangladesh, could not reach the United States in large numbers without assistance. However, if the United States contributed to the global warming problem that displaced them, surely it has an ethical and moral responsibility to provide some proportionate assistance to environmental refugees. India and Burma, Bangladesh's two largest neighbors, are unlikely to have the resources to host millions of refugees, especially if the sea level rise is rapid. In addition, global sea level rise will produce environmental refugees in virtually every country with coastal areas.

This situation is remarkably similar to Raspail's (1975) parable "The Camp of the Saints," but on a global scale. Raspail asks what is to be done at all levels of human society – global consciousness, governments, societies, and especially individuals. Doing nothing at any level is almost certain to further damage the planet's ecological life support system since there would be more people on less land. Little has changed since Raspail wrote his superb fictional work except the temporal and spatial spans have markedly increased and the next such event may not be fictional. Human society is no better prepared to either live sustainably or to let starving refugees die in order to preserve the ecological life support system for future generations, other life forms, or even persons alive at

present. Humans still do not agrees upon a universal ethos or set of guiding values that might prevent such a tragedy from happening. If the ecological life support system is badly damaged, civilization as we know it will collapse as well. Nevertheless, it is difficult to deny that the world is overpopulated (if billions are living on US$3/day or less), and the global population is still growing. It is also unlikely that the growing disparity in the size of the ecological footprint, either at the individual or sovereign state level, will be reduced voluntarily. Individualism is much more easily practiced than universalism, although one might attribute racism for the situation Raspail (1975) describes. However, he affirms that the confrontations that result from this situation are neither racist nor racial, but rather simply part of the permanent flow of opposing forces that shape human society. Even if we accept this hypothesis, it does not help us to decide what to do if societal practices result in mass migration. By comparison with the events that could produce millions of environmental refugees, the loss of life and damage to property resulting from the 11 September 2001 terrorist attacks on the United States was trivial. This comparison does not diminish the horror of September 11, but rather puts the potential horror of possible environmental catastrophes in perspective.

Even if refugees are predominately non-violent, they would be desperate. As a consequence, they might be unthinkingly merciless to those perceived as denying them access to food, shelter, and other amenities possessed by the inhabitants of the country to which they have migrated. They are seeking access to the "promised land" and, since their chances of dying are already great, will not let anything get in their way. Nature has a brutal way of dealing with populations of any species that exceeds the carrying capacity of its habitat.

Predictably in "The Camp of the Saints," political and religious leadership and the news media each view the mass migration narrowly in the light of their own restricted paradigms. This fictional account fits the present world situation even better than when it was written. Apocalyptic visions are particularly hard on liberals and even nations choosing to ignore the future. Optimism is a splendid concept until it requires ignoring the most basic laws of nature. The exuberant optimism of Simon (1981), asserting that technology and human ingenuity can solve all resource problems may have delayed serious attention to the problem. Hardin's (1993a,b) superb books provide an excellent discussion of human society's curious reluctance to question conventional wisdom.

Environmental refugees already exist (some even in boats), but, whatever happens, the basic question will remain – will nature address the consequences of natural capital depletion and exceeding Earth's carrying capacity or will human society attempt to do so? It is exceedingly difficult to determine the best compassionate view. One's instinct is to feed the starving billions, which may then continue exponential growth and create more starving billions. An alternative compassionate view is to cease unsustainable practices (e.g., infinite growth on a finite planet) so that we will leave a habitable planet for our descendants. Above all, natural capital and the planet's ecological life support system must be protected. To accomplish this protection, there seems to be no alternative but to live sustainably. Balanced compassion for those presently alive and for their descendants is the easy answer, but is difficult to implement. Still, human society may have sufficient reason and wit to learn to live sustainably and the resolve and courage to avert catastrophe.

REGIONAL PERSPECTIVE

The image of a world teeming with environmental refugees is daunting, even for wealthy countries such as the United States. If global warming raises the sea level, where should the people from Florida, Louisiana, and other states with inundated coastal areas be relocated? How will internal migration affect immigration policy? Is a class action suit against the producers of large quan-

tities of anthropogenic greenhouse gases likely? If not, will there be an alternative form of compensation for property loss?

In China, the world's most populous country, a huge dust bowl is developing in the northwest (e.g., Yang and Li, 2000). In India, China, and the United States, water tables are falling rapidly and reducing irrigated agriculture (e.g., International Water Management Institute, 2001). In all of these and similar situations elsewhere in the world, a major debate will be whether to send food to the newly impoverished people or take the people to the food while the stressed area is ecologically rehabilitated, a process that may take decades.

Human societies have survived some horrendous periods. Europe recovered from the "black death" (bubonic plague). China has managed to persist despite devastating famines. The Union of Soviet Socialist Republics (USSR) recovered from staggering loss of human life, both civilian and military, during World War II. Neither the Civil War nor the great depression destroyed the United States. The population of tiny Easter Island endured population losses that may have been as much as two thirds of its total and probably included cannibalism.

Even if the huge loss of human life is ignored, there are persuasive reasons for living sustainably. Arguably, the most compelling reason is that earlier civilizations that collapsed for environmental reasons did so in comparative isolation from the others. Globalization has changed this possibility dramatically, especially with the advent of weapons of mass destruction. Globalization increases the risks to both human society and the planet's ecological life support system. However, life forms exist in all sorts of odd places, such as thermal vents in the ocean floor. One might reasonably conclude that some life forms will survive regardless of the fate of humans and will be able to manage quite well without humans, as some life forms did for billions of years. Presumably, diversification would then occur as it did following five great extinctions.

A human society that lives sustainably might do so entirely as a matter of enlightened self interest despite considerable benefits to the planet's ecological life support system and a diverse array of other life forms. Living sustainably might be pleasurable to quite a few humans, perhaps even enough to make sustainable use of the planet possible.

THE LESSONS OF PEARL HARBOR AND SEPTEMBER 11

The United States was both unprepared and shocked by the Japanese attack on Pearl Harbor on 7 December 1941 and the terrorist attacks on the World Trade Center and the Pentagon on 11 September 2001. The lesson from Pearl Harbor and the September 11 terrorist attacks is that complacency can be dangerous, often fatal. The United States and some other countries are also complacent about the ability of society to assimilate culturally the present large number of immigrants and still display the cultural cohesion displayed nearly to the end of the 20th century. Cultural diversity did not fare well in the former Yugoslavia and the Middle East and may yet be an obstacle rather than a strength in Afghanistan. The pious wish that inhumanity will cease has done little to improve the human condition. It would be better to assume that conflicts will continue and to determine realistically how they can be resolved intelligently, perhaps even with wisdom and civility.

If, as is becoming increasingly probable, there will be teeming millions of environmental refugees, it will mean that we were terribly wrong about the carrying capacity of the world for our species. Disease, starvation and resource wars will doubtless occur simultaneously but the root cause will be a social disequilibrium resulting from overpopulation and bad long-term management of natural capital. Persuasive evidence has been available that the carrying capacity has been exceeded for the last half of the 20th century, and the evidence is unmistakable in the 21st century. World War II

and the Gulf War were resource wars. Hitler wanted "living room" for the German people and resource poor Japan needed almost every kind of resource. The Gulf War was unmistakably an oil war. The ideal of proportionately sharing resources is unlikely unless there is a limitation on the "right" to breed. China has imposed such limitations to both avoid exceeding carrying capacity and to lessen the disparity within the country between the "haves" and the "have nots". Menzel's (1994) stunning family portraits show both the vast difference in material possessions and our common humanity. This illustrates how illusory the process of moving from poverty to wealth has become. Unless there are effective restraints on individual freedom to breed, average per capita resources on a finite planet will be reduced resulting in either resource wars or forcible redistributing of resources. Individual freedom, as defined at present, will necessarily be restricted unless human society is prepared to let the impoverished suffer and die. In an age with abundant terrorists with access to weapons of mass destruction, this does not appear to be a viable alternative even if there were no ethical and moral objections to it.

ECONOMIC DISCOUNT RATES

The fatal flaw for humans may well be our view of economic discount rates – that is the damage is far off but the pleasures or other perceived benefits are now. In the United States (and doubtless elsewhere) diets to reduce weight mostly don't work. So how does one make living sustainably and reducing the likelihood of producing huge numbers of environmental refugees possible? Alternatively, one might increase the short-term penalties for living unsustainably. But that would be regarded as an unacceptable invasion of the "rights" of nations, organizations, and individuals. Of course, human society is beginning to live more sustainably (e.g. Brown, 2001) but at a rate unlikely to prevent the appearance of large numbers of environmental refugees. One hopes that if this does occur the damage will not be too severe to permit a mid-course increased rate of implementing sustainable practices at a global level. The third alternative is to let nature take its course, probably with very large numbers of environmental refugees and greatly intensified resource wars as resources become increasingly depleted. The outcome in an era of increased terrorism and ubiquitous presence of weapons of mass destruction is not pleasant to contemplate. However, if present trends continue, this outcome is more than a possibility; it is, regrettably, an increasingly likely outcome. Afghanistan may well be a microcosm of this global scenario.

PERCEIVED ECONOMIC OPPORTUNITY

Abernethy (1979, 1993) hypothesizes that a sense of expanding economic opportunity encourages people to raise their family size targets; falling expectations and the perception of heightened competition for limited resources results in reproductive caution. Abernethy (in review) calls this the *economic opportunity hypothesis*. If this hypothesis is correct, the likely outcome is an increased reproductive rate for environmental refugees since their perceived economic opportunities should be much greater in the host country than in the country from which they fled. Of course, the economic opportunity hypothesis should be self-correcting over a long time span because reproductive caution is triggered by the tougher economic, social, and environmental conditions usually associated with rapid population growth. Undoubtedly, the outcome will vary according to the rapidity with which the refugees share perceived economic opportunities of local residents, which in turn will be influenced by many other factors. However, if a sense of expanding opportunity encourages the refugees to raise their family size targets, the effects of the first perception will last at least one generation.

CONCLUSIONS

Environmental refugees already exist. The only uncertainty deals with future numbers and the rate at which they will be produced. Living sustainably would reduce both actual numbers and the rate at which they are produced. Already established trends increase the probability that there will be a significant number of environmental refugees in the next few decades. Perhaps these numbers might provide an early warning of future realities that could cause a pronounced shift toward sustainable practices. At the very least, the consequences of not living sustainably should become more apparent to the general public and heads of state.

Two primary scenarios emerge: (1) human society learns to live sustainably within Earth's carrying capacity for the human species or (2) human society does not learn to live sustainably, and nature (i.e., disease, starvation, etc.) reduces population size to a sustainable level, which might well be substantially below current population size if the ecological life support system is damaged. Environmental refugees are particularly important because the circumstances that produced them are almost certain to have reduced the area's carrying capacity.

The number of environmental refugees could be substantially reduced by acceptance of a few basic assumptions.

1. Infinite growth on a finite planet is not possible.
2. Humans are dependent upon the planet's ecological life support system, which they cannot continue to damage without suffering severe consequences.
3. Achieving sustainable use of the planet will not be possible if human population or per capita consumption of resources continues to increase.
4. Just because carrying capacity is difficult to estimate does not mean that it does not exist.
5. Although living sustainably will require many difficult adjustments, nature's solutions to exceeding carrying capacity (e.g., famine and disease) are even less acceptable than the conditions necessary for achieving sustainability.

Arguably, the major obstacles to avoiding the appearance of large numbers of environmental refugees are: (1) the shocking low level of environmental and scientific literacy of most individuals, particularly among decision makers, (2) the ecstatic pronouncements that things are getting better and better despite enormous damage to the environment and the billions of humans living on a few US dollars per day, (3) the robust evidence that many unsustainable practices that cause severe environmental damage are subsidized, (4) a discounting system that favors short-term results to the detriment of long term benefits, and (5) human society has chosen to give a higher priority to material capital than to social capital.

Sustainable use of the planet would not only reduce the number of environmental refugees but, if practiced with compassion, would provide a fair and equitable use of ecological resources without damaging them. Such practices would improve the quality of life for those now alive and would leave a more habitable planet for future generations. Sustainable use would emphasize care and nurture of the planet's ecological life support system upon which the future of humankind depends. Sustainable use of the planet provides exciting new opportunities for all components of human society. Moreover, it would benefit other life forms and ideally would diminish or eliminate worldwide species extinction rates and biotic impoverishment.

All great social change begins with a vision, which often seems utopian and unattainable. Depletion of resources and environmental damage may already be too extensive to permit a transition to sustainability without producing a huge number of environmental refugees.

Environmental refugees are the direct result of the failure or disequilibrium of the ecological life

support system. Ecosystem damage is increasingly of anthropogenic origin, which means that human society has the opportunity to reduce the damage, and thus, the number of environmental refugees. If the ecological carrying capacity has been reduced, humans are increasingly controlled by the same factors that reduce population size of other species. Technology may soften the blow but is unlikely to eliminate it. Since individual freedom is an important issue on much of the planet, steps taken to reduce the number of environmental refugees should be given serious and immediate attention. All countries should demand that carrying capacity is not reduced either by ecological damage or by increased human population size and per capita resource consumption. War and preparation for war diverts resources from civilian consumption, and war usually results in considerable ecosystem damage. Ecological restoration can repair some of the damage but is difficult to implement when there is a war or a serious threat of war.

Since 90% of the human population growth is in third world countries and since exponential growth almost always outstrips the ability of the social system to keep up, this situation requires immediate attention. An obvious beginning is to provide free methods of family planning for those who wish to employ them. Clearly, freedom of choice is highly desirable unless it leads to populations that exceed the country's carrying capacity. China has undertaken exemplary but not perfect actions to stay within carrying capacity. Some of the measures seem extreme to many people in countries with more per capita resources, but no viable alternative has been offered. Doing nothing could result in millions of deaths, loss of political stability, and dramatic reduction of quality of life.

For a few decades early in the 21st century, countries with declining populations might offer temporary relief by accepting large numbers of immigrants. However, if the immigrants increase their numbers exponentially and the country of origin continues to do so as well, the 'benefits' will be strictly short term.

The worse case scenario is for the country exporting environmental refugees to continue to do so after the recipient country exceeds its carrying capacity. This could happen if the sea level rise put the receiving country over its carrying capacity while the same sea level rise increased the number of environmental refugees from the country exporting them. A loss of arable land due to salinization or exhaustion of ground water aquifers could produce a similar result. The worse case scenario could easily destabilize a region further and increase the rate and number of environmental refugees, thus exacerbating the problem and requiring more resources to cope effectively with it. Disease, famine, and war are likely outcomes of the worse case scenario. The best way to avoid this situation is for all countries to get within their carrying capacity expeditiously. Given the vast religious, cultural, and ecological diversity in the world, this task will not be menial. Terrorism and ethnic conflict worsen the situation still further. Finally, carrying capacity is difficult to calculate, and the prerequisites will only be known with confidence when sustainability has been achieved.

Cultural and social changes of this magnitude will probably not be possible until some catastrophic event demonstrates the concept of carrying capacity so that even the most environmentally illiterate persons can understand it. One hopes intelligence and reason will prevent such a situation but *Homo sapiens* evolved as a small group species and has not yet become proficient in addressing huge group (regional, continental, or global) problems.

Former U.S. President Carter (2002) states the basic problem succinctly. He feels that the most important challenge is to share wealth, opportunity, and responsibilities between the rich and the poor because, if the chasm between rich and poor grows wider, the world will be neither safe nor secure. Carter then noted that nearly a billion people are illiterate and more than half the world's

people have little or no health care and inadequate funds to obtain food, shelter, and clothing. With over half of the world's people already living precariously, it would not take much to create a massive environmental refugee problem. Over half the refugees from many areas might well be 15 years of age or younger. Integrating these refugees into the indigenous population would be a daunting task for even the wealthiest country, and, arguably, an impossible task for an impoverished country. As Dickinson (1999a) remarked, anyone traveling the world today encounters a sea of young men and women. In the poorer nations of Asia, Africa, Latin America, and the Middle East, fundamentalist revolutions and unrest find their acolytes among jobless young males. Dickinson (1999b) maintains that nature is the final arbiter. Denial, ignorance, self interest, and the like will not persuade nature to alter natural law or grant exceptions or variances to it. Hardin (1999) remarked that even if we were able to talk with other animals it is not likely we would hear them debating the problem of population control. Debate is unnecessary for other species since nature takes care of the problem by ensuring that a successful species does not become too successful. Nature's solution to the problem is not 'nice,' but it is the most likely outcome if we refuse to debate and resolve the problem within our own species. Hardin's message is simple – if human society does not voluntarily live within limits (i.e., carrying capacity), nature will see that it does. Denial that the problem exists is not an acceptable solution.

In many areas of the world, fertility rates are now falling, possibly because maintaining current standards of living is becoming more difficult. Still, ecological collapse, economic collapse, and a number of other factors might well dramatically increase the total number of refugees, of which environmental refugees may represent a significant portion. It is possible that all or most of the problems explored in this article may never occur. It is probably that some will. It would be prudent to at least consider how these problems will be resolved, who is responsible for doing the work, who will pay for the work, and, finally, who will take corrective action if the trends are very unfavorable. A sizable number of refugees would most probably destabilize the environment, the host society, and its economy. Each time this occurs, the number of environmental refugees will increase and the number of countries willing and able to host them will decrease. Precautionary measures to reduce the probable number of environmental refugees would benefit global society and make whatever problems occur more manageable.

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Article 7

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Terrorism, Racism, Speciesism, and Sustainable use of the Planet

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ABSTRACT: The 11 September 2001 attacks on the World Trade Center in New York City and the US Pentagon in Washington, DC have seized our attention and undermined our sense of security. These terrorist actions showed a contempt for other persons and their beliefs and practices. They are extreme demonstrations of a feeling of superiority which ignores the inherent worth of life by killing or wounding some and depriving others of resources that improve their quality of life. In this respect, terrorism is similar to racism and speciesism in that all are expressions of feelings of superiority over other life forms and that all are incompatible with sustainable use of the planet. It is proposed that both terrorism and racism have their genesis in speciesism. Sustainability requires a mutualistic relationship between humans and the millions of other species that collectively constitute the planet's ecological life support system. It further requires enhancement and protection of natural capital, as well as the enhancement and protection of the technological and economic life support systems that depend upon natural capital. Both terrorism and racism endanger the fair and equitable allocation of resources and the quality of human life of present and future generations. This is probably both the cause and effect of resource allocations. However, to achieve sustainable use of the planet, humans must acknowledge the inherent worth of other life forms. There is no guarantee that abolishing terrorism, racism, and speciesism will enable human society to achieve sustainable use of the planet; however, it is difficult to envision achieving sustainability if they persist.

KEY WORDS: Terrorism · Sustainable use of the planet · World peace · Sustainocentric dynamics · Resource wars

> *Shall I not inform you of a better act than fasting, alms, and prayers? Making peace between one another: enmity and malice tear up heavenly rewards by the roots.* Muhammad

DISRUPTERS

Terrorism, racism, and speciesism are disrupters that might well destroy everything human society purports to value (e.g. a quality life) and possibly even the human species. New ways have emerged for the 'powerless' to inflict major damage on the 'powerful.' Disrupters can damage severely both the infrastructure and morale of powerful nations at a relatively low cost to the perpetrators, although some of them lose their lives in the process. Threats to large suspension bridges and nuclear power plants have had significant disruptive effects, even without being implemented.

Although human society has made some ethical progress in the last century, it is far from achieving a universal ethos (a guiding set of values). However, technical progress in weaponry has been remarkable during the same period, and dependence upon the technological life support system has become even greater as cities' populations have increased dramatically. However, with sufficient commitment to sustainable use of the planet, the efforts to instigate rage and fanaticism can be rendered less effective. There is, after all, nothing inevitable about the present escalation of violence. This novel situation requires a creative and far reaching response that is constructive rather than destructive. Achieving sustainable use of the planet seems to be better suited to this purpose than war or counter-terrorism.

PEACE AND SUSTAINABILITY

Peace is a necessary prerequisite for sustainable use of the planet, but not a guarantee that it will be achieved (Cairns 2000). War is a profligate user and destroyer of resources, and sustainability requires both protection and accumulation of natural capital. The latter requires that peace exist not only among humans but also with the biosphere and the millions of species it contains.

Terrorism, racism, and speciesism are all based on a feeling of superiority of 'us' over 'them.' Arguably, racism and terrorism had their genesis in human feelings of superiority over other life forms, which have been extended to include other members of the human species as well. Since the genetic makeup of all humans is extraordinarily similar, racism cannot be justified by genetic makeup (Ehrlich 2000).

Unquestionably, human genetic makeup differs considerably from the 30+ million other species on the planet. However, most of the services that these other species provide (albeit unintentionally) cannot be replaced by human technology (Hawken et al. 1999). Further, new technology enabled humans to usurp the vast supply of unexhausted resources and develop still unoccupied (by humans) areas of the planet (Ward 1973). However, the redistribution of resources among humans (via taxation, welfare, and insurance) has not had much effect upon the increasingly disparate wealth among humans, as evidenced by the increasing range in sizes of ecological footprints (Wackernagel & Rees 1996).

The ecological footprint in hectares per person is 5.1 in the US, 1.8 for the world as a whole, and 0.4 in India. It is worth emphasizing that there is no strong correlation between quality of life attributes that humans profess to cherish and the size of the ecological footprint. For example, Kerala, a southern Indian state, has a per capita income of about US$1/day, but life expectancy, infant mortality, and literacy rates are similar to those of industrialized countries. Such attributes as a sense of community are difficult to quantify, but they might well be higher in less industrialized areas than in countries with a large ecological footprint, since acquiring and caring for material possessions does significantly reduce time for family, friends, and reflection. Wackernagel & Rees (1996) conclude that Kerala's exceptional standard of living, coupled with a small ecological footprint, is based more on accumulated social capital than on manufactured capital.

Terrorism increases the size of the ecological footprint both per capita and per nation (defensive measures) without increasing life quality. Racism attempts to justify inequity and unfairness in access to resources. Both terrorism and racism are based on feelings of superiority over other members of *Homo sapiens*, and both affect equity in resource utilization. If human society does not protect and accumulate natural resources (natural capital) and uses the existing resources at an unsustainable rate, solutions to terrorism and racism will not markedly benefit future generations because inadequate resources will make life very difficult or impossible.

HOMOCENTRIC VS ECOCENTRIC

Rowe's (1999/2000a,b) book reviews of *Consilience* (Wilson 1998) and *The Ecology of Eden* (Eisenberg 1998) illustrate part of the homocentric vs ecocentric dichotomy. Rowe believes that Wilson views all things through the lens of science and devalues other lenses or perspectives. I believe that if one adds Wilson's other books such as *Biophilia* (Wilson 1984) or *The Biophilia Hypothesis* (Kellert & Wilson 1993) and the human tendency to focus on all life forms as a biologically based need, then the various perspectives (psychological, biological, cultural, symbolic, aesthetic) clearly emerge. Collectively, these constitute far more than a scientific 'lens' or narrow perspective. Most importantly, Wilson's unifying theme is that humans are a part of, not apart from, ecosystems (i.e. ecocentric). As Rowe notes, Eisenberg is homocentric – the world and its biosphere exist for humans who are 'the crown of creation.' The Earth Spirit Rising followers of theologian Thomas Berry assert that the world does not exist except through the eyes of humans and that humans are the culmination of the evolutionary process. Very few evolutionary biologists would subscribe to this concept.

Publications on sustainable development (e.g. World Commission on Environment and Development 1987) are centered on indefinite occupancy of the planet by human society. However, I believe that sustainable use (rather than development) of the planet is a better description of a realistic goal, i.e. the use envisioned is by human society in the context of a mutualistic relationship with natural systems (e.g. Cairns 1997). Arguably, a mutualistic relationship acknowledges an interdependence and diminishes, but does not eliminate, the feeling of human superiority over other life forms. This concept is ecocentric in that human behavior would be modified to preserve and enhance ecological integrity, but is homocentric in that the primary benefit of sustainability is indefinite use of the planet by *Homo sapiens*.

ONE SPECIES, ONE GOAL

The primary goal of sustainable use of the planet is indefinite use by future generations of humans. No publications on sustainability specify restricted use by any ethnic, religious, or other category of the human species. It could not be otherwise! The quest for sustainable use of the planet will require the combined efforts of all human society, and this goal will only be possible if all have a hope for a quality life for their descendants. The goal may not be achieved even if terrorism and racism are markedly reduced, but, if they continue at present levels, sustainability will remain beyond human society's reach.

REDEFINING TERRORISM

The *Random House Dictionary* defines terrorism as the use of violence and threats to intimidate or coerce. This definition clearly is limited to members of the human species and perhaps a limited number of other species. The terrorist actions in the US in September 2001 deprived many people of their lives, physically injured others, left an entire nation in severe trauma, and caused severe property damage (i.e. loss of human habitat). However, in the same vein, economic development of human society kills or injures individuals of other species and deprives them of essential habitat. Depriving other life forms of habitat necessary for their survival is neither an attempt to intimidate or coerce. However, in terms of their potential for survival, it is far more devastating than damage to human artifacts (property) that can, and undoubtedly will, be replaced. As a consequence, I have included habitat loss of other species under terrorism despite the very evident semantic problems. A new word is needed!

It would be a dreadful mistake to commit the common error of anthropomorphosis when thinking about the cognitive abilities of other animals. Hauser (2000) has persuasively demonstrated that animals do have complex mental operations well adapted to the ecological niches they occupy. The inevitable conclusion is that habitat destruction and fragmentation must be psychologically disturbing to a significant number of species. For migratory species, the loss of habitat used for many generations must certainly be disturbing. Additionally, many humans have witnessed 'road kills' as animals unsuccessfully attempt to move from one part of their range to another over a road. Even though the word *terrorism* may be inappropriate, since there is usually no intent to intimidate or coerce, the results are quite similar – human society has deprived other life forms of life and habitat.

RELATIVE RISKS

In the US, far more individuals are killed or injured annually by gunshots or drunken drivers than were killed or injured in the 11 September terrorist attacks. However, the emotional and political response was orders of magnitude greater on 11 September. Of course, when deaths occur daily from less spectacular causes, the aggregate numbers are not the attention grabbers they would be if all the deaths occurred in one day in one or two places.

The risks of massive deaths due to famine and dislocation because of global warming are also quite large and should not be ignored. Risk management is a multidimensional activity. Sustainable use of the planet involves risks (Orvos & Cairns 1998) and will fail if only certain risks, such as terrorism, get a disproportionate amount of attention.

SUSTAINOCENTRIC DYNAMICS

Sustainable use of the planet requires the co-mingling of global, regional, and local perspectives. For example, global warming requires a planetary perspective. Pulliam's (1988) ecological 'source/sink' model requires a bioregional approach. In this model, some habitats become sources from which surplus populations migrate to less suitable habitats that act as sinks for the surplus population. Sources can become sinks and sinks can become sources if the area and temporal span of the study are large. At a local level, ecological restoration is essential whenever damage occurs so that the source/sink balance is not disrupted.

Both local and bioregional dynamics are difficult, but not impossible, to model and predict. At the global level, misjudgments will be exceedingly costly and possibly fatal to human society. Of course, one can always make the case, as Eisenberg (1998) does, that humans are a product of nature and what they do is 'natural.' However, destroying the habitat of other species and driving many of them to extinction does not correspond to the human compassion and sympathy of society displayed on 11 September 2001 for victim's families. Destroying the habitat of other species on a massive scale is a dysfunctional relationship rather than a healthy, mutualistic one. As Eisley (1970) notes, such a mutualistic relationship must involve the full range of human abilities, interests, and values, especially those that are cultural achievements. Three decades ago, Caldwell (1972) listed some immediate steps that had developed over at least a century and had, he then thought, become too obvious to ignore. It seems increasingly likely that some crucial environmental threshold will have to be crossed and result in an impact that will affect all human society as the 11 September 2001 terrorist attack appears to have had on the US. By definition, sustainable use is permanent use and, thus, a sustainocentric position must last, not for a few months, years, or even centuries. Since the ecological life support system is dynamic, the relationship of human society with natural systems must also be dynamic and will require continuous informed judgment and

modification of behavior. A central question is 'What evidence will be required to induce a significant behavioral change in human society?'

THE THRESHOLD PROBLEM

The 11 September 2001 terrorist attacks in the US provided some interesting information on the damage level needed to elicit a marked shift in the response of politicians and the general public to terrorism. Earlier attacks on US embassies and the U.S.S. Cole (both abroad), the Oklahoma bombing of a US federal building, and even the first bombing of the World Trade Center in New York City did not result in a major paradigm shift in the US's anti-terrorist activities. The 11 September attacks did, although the durability of the shift will not be proven for a number of years. The global response to the 11 September events is far less certain in both the short and long term.

The crossing of a threshold that would result in disequilibium of the planet's ecological life support system will neither be detected as easily nor, because of the complexity of the biosphere, be as easily understood by politicians and the general public. It is probable, not just possible, that a major ecological threshold could be crossed without anyone, even scientists, being aware of it, as there are serious problems in detecting thresholds, even at lower levels of biological organization (Cairns 1992). The simulation of biospheric thresholds is problematic but will doubtless improve if surveillance of the biosphere is undertaken in a systematic and orderly fashion. Even when such information is improved, it will be essential to remember that each threshold is variable because it is embedded in a multivariate system that affects it. Meadows et al. (1992) has a superb discussion of this issue. But, as Meadows (2001) writes, overshoot does not mean collapse, and material and energy throughout the world must be cut, but not people, not living standards, not the dream of a better world.

RECRUITS FOR TERRORISM

Arguably, overpopulation with its concomitant large numbers of idle young who are searching for a meaning to life produces a few individuals willing to give their lives to strike at the perceived enemy. The rapidly increasing gap between the 'haves' and 'have nots' exacerbates the problem. It should come as no surprise that Afghanistan, one of the poorest countries of the world with a high birth rate, should host terrorists and permit training camps. As long as breeding grounds for terrorists exist, there will always be people to incite the emotional youth and 'masterminds' to train and organize them.

Since 11 September 2001, CNN and other international news organizations have had numerous programs depicting how terrorists and their families are honored and respected in some countries. Terrorists' families are cared for financially and the terrorists' pictures and names are prominently displayed on public thoroughfares in cities, museums, and the like. Any society that respects and honors terrorists will inevitably be a breeding ground for them. Youth can achieve a status otherwise unavailable to them and simultaneously bring honor and even financial rewards to their families. Terrorists are cheered on by multitudes who are unwilling to take such drastic measures. The more horrific the terrorist acts, the easier it seems to obtain new recruits. The important issue is that underlying all of this is a feeling of superiority – because God is on their side.

THE ROLE OF RELIGION

Dubos (1972) remarks that, as a member of an international team preparing a report (*Only One Earth: The Care and Maintenance of Our Small Planet*), he had to think in global terms, i.e. each part

of the planet is interacting with all other parts and each earthling belongs to the family of man. Dubos affirms that these two attitudes are not incompatible but are, in fact, complementary. He believes that, from family to clan, from clan to nation, and from nation to federation, enlargements of allegiance have occurred throughout history without weakening the earlier loves. Dubos' key concept is that humans can develop a loyalty to planet Earth while maintaining an emotional attachment to both their countries and cultural diversity. It is exceedingly difficult to believe in sustainable use of the planet in these chaotic times, with terrorism, racism, and monumental biotic impoverishment, but the alternative is unthinkable because it reflects a picture of the human species that will be difficult to face. Appeals to reason are easy to make but difficult to implement. Reason shows that destroying the planet's ecological life support system and each other is not a sustainable way to live. Sustainability is both a social and an ecological problem, with human society's relationship with natural systems at its core.

Similarly, if religions wish to survive, human society must learn to live sustainably. Religious leaders who fail to chastise those who chant 'death to America' or who rejoice in the events of 11 September 2001 are morally bankrupt as are all cults based primarily on hate. Religious leaders who remain silent when natural systems are destroyed and species driven to extinction are no better because neither posture favors sustainability. Tucker & Grim (2001) assert that there is an emerging alliance between world religions and ecology: (1) no one religious tradition has a privileged ecological perspective; (2) although religions are necessary partners in the current ecological movement, they are not sufficient without the indispensable contributions of science, economics, education, and policy; (3) there is frequently a disjunction between principles and practices – ecologically sensitive ideas in religions are not always evident in environmental practices of particular civilizations; and (4) religions have all too frequently contributed to tensions among ethnic groups.

In *The Descent of Man*, Darwin (1871) confronted the apparent evolutionary anomaly of ethics. From an evolutionary viewpoint, the most ruthlessly selfish individuals would find more success in the competition for mates and resources and, thus, would transmit their traits to their descendants. In short, 'goodness' may be quite fatal to an individual practicing it. Darwin addressed this issue by noting that membership in a closely knit society, which can only exist if its members refrained from antisocial conduct, selects for 'goodness.' Sustainable use of the planet merely expands this view to a global level, which includes other species, humans, and their descendants (Callicott 2001). The present vast potential for nuclear, biological, and chemical warfare will put Darwin's hypothesis to a severe test. In terms of the events in 2001, Leopold's (1949) observation – that ecology simply enlarges the boundaries of the community to include soils, water, plants, and animals – is astonishingly accurate.

ISOLATING MECHANISMS

Terrorism, racism, and speciesism are isolating mechanisms based partly, arguably primarily, on a feeling of superiority to other life forms. As Ehrlich (2000) remarks, humans are small-group animals trying to live in gigantic groups in an increasingly impersonal world in which individual natures are based on ever smaller fractions of society's culture. Ehrlich notes that humans will never deal with the devils in the details unless they see the big picture. In an era of specialization, the big picture is exceedingly difficult to see. Even the educational systems have developed isolating mechanisms (Cairns 1993) that keep disciplines apart, although the mechanisms are less formidable than they once were (Cairns 1999). However, over two decades ago, Kahneman (1980) remarked that

the increase in humans' power over the environment had not been accompanied by a concomitant improvement in the ability to make rational use of that power. While conscious evolution can be accelerated by shocks (e.g. 11 September 2001), the threshold needed to have an effect might require millions of human deaths and far greater loss of other life forms. A biospheric collapse will be costly and more difficult, perhaps impossible, to repair. Perhaps then an office of planetary security would be created, hopefully in time to take preventative action.

HISTORY VS CONSCIOUS EVOLUTION

Durant & Durant (1968) make three important observations about biology and history. (1) Life is competition, which may be peaceful when food abounds but violent when the mouths outrun the food (in the 21st century, it seems appropriate to substitute the word *resources*, including food, for the word *food* alone). (2) Life is selection, and some individuals are better equipped than others to meet the tests of survival. Since Nature (defined as total reality and its processes) has not read very carefully the US Declaration of Independence or the French Revolutionary Declaration of the rights of man, humans are all born unfree and unequal. Durant & Durant note that inequality is not only natural but that it increases as the complexity of civilization increases. (3) Life must breed. Nature has a passion for quantity as a prerequisite to the selection of quality. Nature is more interested in the species than in the individual and makes little distinction between civilization and barbarism.

These ideas are exceedingly difficult to place in a sustainability context. As McNeill (2000) notes, the enormity of ecological change in the 20th century indicates that in the 21st century history and ecology must be viewed concomitantly. He writes that modern history is written as if the planet's ecological life support systems were stable (which they are not) and are present only as a backdrop to human affairs. Similarly, the field of ecology should incorporate the dynamics of historical change and the complexity of social forces. As the events of 11 September 2001 and the anthrax scares that followed clearly demonstrate, human society has a choice between making the major societal and individual choices that might lead to sustainable use of the planet or valiantly trying to maintain the status quo and risking one or more global catastrophes.

Ehrlich (2000) remarks that there is no easy formula for understanding the human past or today's human nature or for projecting the human future. He notes that cultural evolution has resulted in the extinction of many past civilizations and that the present global civilization had better move rapidly to modify its cultural evolution and cope with its deteriorating environmental circumstances before it runs out of time. This challenge is daunting because society and its scientists have only a dim idea of the ultimate consequences of the environmental changes that have already occurred. If one adds the increased scale of terrorism and the costs of reducing it and repairing the damage, even the most optimistic individuals must have some doubts about the effectiveness of present activities and how they will affect the progress toward sustainable use of the planet. For example, disruption in oil production might either hasten development of alternative sources of energy or result in more conflict. The divisiveness caused by terrorism, religious extremism, racism, speciesism, and ethnic conflict is all the more troubling when global society may be approaching crucial ecological thresholds more rapidly than previously thought.

DESIGN WITH NATURE

Nature favors quantity and from that quality is selected. Quality in these terms are components (i.e. species) that have a mutualistic relationship with the interdependent web of life. Over billions of years, this system resulted in the accumulation of much natural capital, although there were

'downturns' resulting from climatic change and concomitant extinction of species. In fact, the exponential growth of the planet's human population has been possible because of this accumulated natural capital (e.g. petroleum, coal, fossil water, topsoil, old growth forests, and the like). In addition, technology has not only enabled humans to harvest natural resources faster than their replacement rate but has also markedly reduced the threat of disease and health problems in general, which, together with increased resources per capita, have supported the expansion of the human population. However, continuation of this population growth is only possible if the governing conditions are reasonably stable, which is increasingly unlikely. Developed countries are dependent upon inexpensive energy, relatively stable climate, rapid economic growth, and, above all, reasonably stable social conditions. In an era when there are weapons readily available to discontented and enraged individuals, stable social conditions are problematic. Unfortunately, societal catastrophes diminish concern for the ecological life support system, which is still being taken for granted. Attitudes and behaviors can be dramatically altered by catastrophic events, and one wonders how devastating the ecological 'wake up' call will be and how resilient human society will be if it occurs before the terrorist and racist problems are significantly resolved.

How much optimism that these social problems will be satisfactorily resolved is justified? Emlen (1995) speculates that humans possess a set of biologically based predispositions for interfacing with one another. Sustainable use is based on the assumption (faith) that human society will ultimately select rational solutions to societal problems, despite massive evidence to the contrary. Regrettably, many people tend to seek answers to terrorism, racism, speciesism, and other issues impeding the quest for sustainability in ways that circumvent rational analysis. Ehrlich (2000) believes that an initial step in resolving some of the human predicaments is the creation of a more deliberate style of cultural evolution – one that would direct change in a variety of ways more beneficial to most human beings. However, Ehrlich cautions that biological evolution did not equip hominid ancestors with a desire to address gradual changes in their environmental niche because they were then not capable of detecting or influencing such alterations.

For example, human society in developed countries is even now hostage to countries that supply petroleum. Within countries such as the US, which have major traffic congestion, more highways are being built despite the persuasive evidence that attempts to relieve the problem actually exacerbate it (e.g. Freund & Martin 2001). More energy efficient public transportation would not only alleviate this problem but should also reduce greenhouse gases. Public transportation might be more vulnerable to terrorist attack, but it would also put society on the path to sustainability. This illustration is just one example of the issues that should be widely discussed in the quest for sustainability. Loss of individual transportation would require changes in behavior but would probably increase long-term security. Of course, the automobile is not the only artifact requiring oil, but it is the one most closely associated with individuals and, therefore, symbolic of the dominant automobile culture in the US. Billions of dollars have been spent on 'star wars' defense – a technology with highly uncertain results. If an equivalent amount were to be spent on alternative power sources (e.g. fuel cell engines, wind and solar power), the US would be far less dependent on Middle East oil and less likely to become embroiled in its wars. If terrorists succeed in destabilizing the present Middle East governments, many lives will be lost as a consequence of the refusal to give alternative energy sources a high priority. Failure to develop sustainable alternative energy sources places the entire world at risk and impedes the transition to sustainable use of the planet. Most important, failure to address these issues results in unsustainable use of resources and resource scarcity results in conflict.

RESOURCE WARS

Klare (2001) feels that much conflict results from the dependence of developed countries on the oil-rich Persian Gulf region and feels that the campaign against the Al-Qaeda and other terrorist networks is essentially a police action. There is little doubt that this theory enjoys overwhelming support from the international community. An overpowering military campaign, even if successful, might risk failing in the police action if too many civilian casualties occur and give the impression that this is an ethnic/religious war. Since Al-Qaeda is purported to be operating in as many as 60 countries (some Muslim) active cooperation in police and intelligence personnel will be required. Negative repercussions in even a few of these 60 countries, especially in the Muslim world, would impede these essential sources of information. Geography makes it difficult to separate police action and intelligence to minimize terrorist threats from the resource issue, but it may be essential if the military activity is prolonged in order to continue the police action and intelligence sharing for many years.

The sine qua non of sustainable use of the planet is an ecocentric utilization of resources. Resource wars will impede, if not negate, the quest for sustainability. To avoid intensified global resource wars, those countries using resources in the most profligate way should lead the transition to sustainability as an ethical imperative. Wealthy individuals should be willing to do the same, despite their ability to buy resources in an open market far in excess of the world average per capita consumption. Individuals may feel that they can afford large amounts of material goods and energy use, but Earth cannot afford such behavior. Perhaps the feeling of increased vulnerability, heightened by the events of 11 September 2001 and after, will increase individual and societal sensitivity to the plight of others who are already vulnerable as a result of poverty and other undesirable features of the human condition. This feeling should be bolstered by the recognition that those who are members of societies that feel hopeless are breeding grounds for terrorists.

TERRORISM AND SUSTAINABILITY

In the US and other developed countries, the present energy supply and delivery system is particularly vulnerable to terrorist attacks. Since 11 September, ‘energy security’ has been debated in the US as a national defense component. In October 2001, the US news media widely reported an incident when a single gunman fired several bullets into the Alaskan pipeline; one penetrated it. Containing the spillage of crude oil took three days and 100 workers. This occurence curtailed shipment of approximately 17% of the American oil production. Ironically, shifting to alternative energy sources, such as solar panels and windmills, would both reduce vulnerability to terrorist attacks on steam electric power plants and take a giant step toward sustainability.

If the ‘war on terrorism’ is drawn out over many years, prudent policy makers will surely consider the illustrative measures just discussed. If they do, the terrorists will have pushed society a significant distance on the road to sustainable use of the planet.

ANALYSIS

Baudrillard (2002) has provided a superb analysis of terrorism – like viruses, terrorists are ubiquitous with no boundary to hem them in. Baudrillard believes that every means of domination elicits its own antidote. In this context, nature might reasonably be regarded as the ultimate bioterrorist. Dominance by one species often temporarily results in vastly exceeding its resource base. This situation, in turn, exacerbates disease and famine, which are often accompanied by a substantial reduction of the resource base through overutilization. Arrogance resulting from dominance may

give the illusion that factors that limit other species do not apply to the dominant group. Regrettably, this description fits a species that believes there is a cornucopia of natural resources on a finite planet and that it is not dependent upon the planet's ecological life support system.

Baudrillard (2002) astutely remarks that the globe itself is resistant to globalization. While focusing primarily on terrorist events within human society, the remark applies equally well to nature, which has a large array of diverse and constantly changing species (on an evolutionary time scale).

There is abundant evidence on the degree to which racism has been subsidized by many components of human society. Since the terrorist attacks on the World Trade Center and the Pentagon on 11 September 2001, the astonishing degree to which international terrorism has been subsidized is emerging. However, the degree to which speciesism is subsidized may well be larger than either racism or terrorism. Subsidies that harm the environment also harm large numbers of the planet's species. Using tax dollars to finance activities that harm other species is governmental speciesism. Myers & Kent (1998) estimated the environmentally damaging subsidies total to be US$1.9 trillion per year. They (Myers & Kent 2001) recently raised the total to US$2.5 trillion per year as a result of further analyses and stated that a more in-depth treatment would result in an even larger total. Hawken (1997) believes the worldwide total of environmentally damaging subsidies might even be as large as US$10 trillion. All these authors provide persuasive arguments that ending these subsidies would benefit both the environment and the economy as well as other species. Arguably, eliminating environmentally damaging subsidies would benefit the human species and millions of others as well.

Why then has more not been done? In the US, at least, the answer is clear. Lawmakers practice 'pork barreling,' which means that elected officials garner funds from the public coffers to benefit their home districts. While the entire citizenry would not approve these projects, a small social component rejoices when persuaded it is getting more than its fair share. The net result, however, is an enormous waste of money because every member of the US Congress must at least give the appearance of bringing home some 'pork' to his/her district. The situation is even worse – campaigns for reelection to the US House of Representatives is every two years, for the US Presidency every four years, and for the US Senate every six years. The reelection campaigns as presently carried out require huge sums of money, much of which comes from special interest groups that expect to be rewarded by special benefits, including direct or indirect subsidies. This lack of equity and fairness in the distribution of tax resources is not only bad for the environment but is also a fertile breeding ground for terrorists and racists. Terrorists may be trained in foreign countries but, to be a global threat, they must operate everywhere. This design requires a 'safe haven' in every country, which will be provided by those with a grudge against society. Both terrorism and racism divert and consume resources that otherwise could be used to improve the health and integrity of the planet's ecological life support system and improve the probability of achieving sustainability. Speciesism results from a failure to leave enough resources for them to flourish and, in all too many cases, to survive.

CONCLUSIONS

Sustainability would be difficult to achieve even in the absence of terrorism, racism, and speciesism; however, their reduction undoubtedly is an essential step toward sustainability. The means to achieving this goal is not immediately apparent, but it is so essential that a much more concerted effort is indispensable. If, as many think, global society is fast approaching critical ecological thresholds, time is short. Social evolution at a rapid pace unparalleled in history may be

essential. However, exactly what course social evolution should take is far from clear. As a start, it would be prudent to diminish all clearly unsustainable practices, although how this can be done without seriously eroding individual freedom is unclear. An essential consideration for sustainability is that the alternative is unthinkable.

It may be arrogant to assume that one species, *Homo sapiens*, is capable of remaining on the planet indefinitely. The quest for sustainable use of the planet may merely be an elaborate form of denial that the human species cannot persist for the entire life of the planet, just as some people deny death by refusing to prepare personal wills. No matter how much violence humans do to their own species, it is improbable that humans can extinguish all life on the planet. Doubtless, there would be a rediversification of other species, especially if humans became either a relic species or extinct. In this scenario, it is worth considering how the human species should make its final exit. If humans cannot use the planet indefinitely, it would reflect well upon them if they left the planet in good shape for other life forms. Doubtless, other species would neither appreciate this gesture nor show gratitude for it, but humans would know that they acted with compassion rather than anger.

Nature's cybernetics are sometimes finely tuned, sometimes violent. Unquestionably, human society is engaged in an unprecedented global experiment for which the consequences are uncertain. Crossing multiple crucial ecological thresholds will not be immediately apparent because ecological health monitoring is far from robust and because ecological change often occurs in temporal spans not customary in societal decision making. By comparison the US anthrax scare (e.g. Cook 2001) is a comparatively minor risk, yet the economic consequences are already severe. Moreover, the earlier unshakable faith in the powers of technology to shield humankind from global risks is, at the very least, weakened. Clearly, environmentalists who grossly exaggerated damage (e.g. Lake Erie is dead) in the 1970s are partly to blame for this situation. If the possible, even probable, non-linear crossing of a crucial environmental threshold occurs and creates an environmental 'surprise,' one hopes the response will be a combination of changed societal behavior and development of appropriate technology. Terrorism, racism, and speciesism may well be the fatal obstacles to attaining a global societal ethos on which a mutualistic relationship between human society and natural systems can be based.

On an economic note, resistance to tax increases is strong, even in wealthy countries. As a consequence, diverting resources from destabilizing activities makes sense. Terrorism and racism are socially destabilizing, and speciesism is ecologically destabilizing; all result in the consumption of resources. However, it will be difficult to get these resources reallocated to sustainable use of the planet if the destabilizing activities are reduced. Persuasive evidence indicates a close link between human health and ecosystem health, even though it is difficult at present to quantify the economic benefits of ecosystem health. Compelling ethical reasons demand an increase in ecosystem health and integrity but, in the present value system of human society, economic values will almost certainly prevail.

However, there are hopeful case histories in this regard; Ellison (2002) reports that the Allegheny Energy's calculation of the value of 12,000 acres it was selling to the US Fish and Wildlife Service included the value of the ecosystems. As a consequence of including the value of the land's ecosystems, the traditional estimates were more than doubled. Thus, there is at least some hope for a market-based conservation system.

Terrorism, racism, and speciesism must ultimately be judged by the ways in which they affect the interdependent web of life – the planet's ecological life support system. Actions that improve its health and strengthen its integrity have value, and those that diminish its health and integrity have

no inherent worth (Cairns 2002). Leopold (1949) espoused the landscape viewpoint in his 'land ethic,' and Tansley (1935) also espoused the ecosystem concept in which organisms should be considered in the context of their chemical/physical/biological environment. The cult of 'rugged individualism' encourages the perspective that each person is somehow separate from the interdependent web of life. The view of Earth from space does not seem to have altered this perspective markedly. There is a persistent belief that human ancestors were different than present ones (e.g. Krech 1999; White 2000). Ehrlich (2000) notes that, about 50,000 years ago, human ancestors wiped out most of the Pleistocene megafauna, completely changing (possibly coupled with climate change) the biota of much of the planet. Diamond (1984) discusses the widespread absence of a conservation ethic in preindustrial humans. However, Wilson (2002) believes that ultimately, in a more democratic world, it will be the ethics and desires of the people, not their leaders, who give to or take away power from the government and the non-governmental organizations. Grishchenko (2001) states:

> There is not enough veneration, reverence, or worship towards the protection of nature. The consequences of human activity have become so serious, on such a global scale, that it is now impossible to simply shut nature away from civilization in an attempt to solve the problem by itself. Such an approach was reasonable about 200 years ago. Now, in many cases, it is necessary to compensate for these anthropogenic effects.

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Article 8

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Espousing Sustainable Use of the Planet in an Age of Instant Gratification

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Sustainable use of the planet requires societal and individual behaviors compatible with a multi-generational preservation of natural capital. However, citizens of the United States and many other developed countries "want it all right now." The instant gratification of perceived "needs" without regard for future consequences is totally incompatible with sustainable use of the planet, which espouses preservation of ecosystem health and integrity. Instant gratification views ecosystems as commodities to be used or even replaced with anthropogenic artifacts (e.g., shopping malls, etc.). Societal behavior suggests a strong bias toward the latter paradigm. The United States, Europe, and parts of Asia have enjoyed an era of great economic prosperity, which has endured for an incredible period of time. With low unemployment and, by contemporary standards, low rates of inflation, personal debt is extremely high, as are the numbers of declared individual bankruptcies, although the latter does fluctuate. Television and radio advertisements proclaim methods of generating credit for additional gratification of "needs." However, billions fo people, arguably somewhat over 3 billion, have US$3/day per capita or less for all their needs. Their goal is to survive, and thought of sustainable use of the planet are not likely to enter their minds.

IMPORTANT CONSIDERATIONS

The instant gratification paradigm and the current economic state influence a number of important considerations in discussing sustainable use of the planet.

Disparity in Distribution of Resources

A nation, the United States, of over 270 million people (Bureau of the Census, 1998, 373) is using approximately 25% of Earth's resources, although the global population is slightly in excess of six billion. Furthermore, disparity in distribution of resources is growing (Lardner, 2000), but the Durants (1968) conclude that the concentration of wealth is natural and inevitable and is periodically alleviated by violent or peaceable partial redistribution. In an increasingly violent world, the hope for a peaceful, non-violent redistribution of wealth, so that there is more equity and fairness, seems rather remote – and this scenario is not likely to facilitate the transition to sustainable use of the planet. Cairns (2000) notes that peace does not assure sustainable use of the planet, but it is an important pre-condition. Clearly, many societal practices are unsustainable for even a modest

long term, such as 50 years, and many are barely sustainable in the short term (e.g., depletion of ground water aquifers).

Ecological Footprints

If countries with present low per capita resource use were to increase it to averages of the United States, this demand could not be sustained. Even on a short-term basis, these increased demands would result in even more extensive, possibly irreversible, environmental degradation. Brown et al. (2000) and Smil & Yushi (1998) provide some persuasive evidence on other countries regarding the consequences of achieving per capita parity with the United States in certain categories. For example, China's per capita consumption of beef of a mere 4 kg per year is less than one-tenth of the 45 kg per year per capita in the United States. (In Uruguay – a tiny country of barely 3 million people – beef consumption is 62 kg per year per capita, the highest in the world, and cattle are exclusively grass-fed and feedlots are not significant. (This information was furnished by the INAC – in an email in 1999 from Instituto Nacional de Carnes – the National Beef Institute of Uruguay.) If the additional beef for China were produced primarily in feedlots, this endeavor would require an amount of grain equivalent to the entire harvest in the United States, only one-third of which was recently exported. If China matched oil consumption per capita in the United States, this change would require more than the present global production of oil. Even modest increases would have a dramatic impact. If the per capita consumption of chickens in China were to increase to only one additional chicken per year and those chickens were fed primarily on grain, this increase would require as much grain as all the grain exports of Canada, which is the world's second largest exporter. Paul Siegel (personal communication) supplied some information on pounds of grain required per pounds of chicken produced; even if other countries were to match present achievements in the United States, which they now do not, this feat would still require enormous quantities of grain (for more detailed information, see Anon. [2000a] and Aho [1999]). If China were to consume seafood at Japan's per capita rate, it would require 100 million tons more than the present total catch. These and other startling data were first called to my attention by Myers' (2000) fascinating discussion of this problem, and he makes a persuasive case for an ecology and an economy of hope in the United States.

Although per capita living standards have risen dramatically in the People's Republic of China in recent years, they are still far below those of many individuals in affluent countries, such as the United States, Canada, and much of Europe. As a caveat, it is well to note that, even in affluent countries such as the United States, many individuals, including children, are not adequately nourished. In addition, a number of countries have citizens who are not as well off as the average citizen in China. However, China has over one-quarter of the planet's human population and is a rapidly growing economic and military power. It would be ethically, morally, and politically unacceptable to tell the Chinese that they cannot approach the standard of living in the United States. However, if the Chinese do so in the fashion that the United States, Canada, and many other developed countries have done with large per capita ecological footprints (e.g., Wackernegel & Rees, 1996) the ecological damage to the planet will be enormous. Reducing the size of one's per capita ecological footprint does not necessarily mean a comparable reduction in quality of life as measured by such indices as literacy, longevity, and overall health care. A recent United Nations report provides persuasive evidence that the United States spends more per capita on health care than any other country, but is 18th in the actual quality of care. Therefore, consideration must be given to ways in which the per capita ecological footprint size can be reduced without reducing the qual-

ity of life and ways that ecosystem health is maintained, otherwise what future generations receive will be shoddy indeed.

Another facet exists to the ethical, moral, and political dilemma just mentioned. The United Nations Population Division (2000) discusses the need for developed countries, whose demographics may result in larger numbers of elderly than people of working age, to import working age individuals. Clearly, the imported workers cannot be expected to live in poverty while surrounded by affluence, and they should reasonably expect the same retirement benefits and medical care that the aging population, whom they are aiding, is receiving. In the United States, at least, there are serious doubts about the ability of the Social Security System to provide adequate retirement benefits for those persons expecting to retire in 2025 and beyond. The health care system in the United States is debated regularly in the United States Congress, on television and radio talk shows, and in the press. The basic question becomes how to develop sustainable practices that will enable future generations, wherever they may be, to have a quality of life comparable to current standards.

A New Social Contract

Economies and technologies have transformed society but should not be the guide in choosing values. Human society is acting as if economic growth and new technologies will provide values. The unique intelligence of humans is being used to avoid facing long-term problems that become more intractable every day. There is a tyranny to the aggregate of seemingly small, individual decisions that collectively may control life in ways that are unanticipated (e.g., Kahn, 1966; Odum, 1982). The quest for sustainable use of the planet is about determining what social contract will best allocate resources to a unlimited number of generations with an equitable and fair distribution of resources to those presently alive.

ACHIEVING A SENSITIVE RELATIONSHIP WITH THE ENVIRONMENT

The disparity in allocation of resources among humans is minuscule compared to the disparity in allocation of resources among the 30 plus million species that inhabit the planet. One species, *Homo sapiens,* is clearly using a disproportionate share of space and, arguably, an even more disproportionate share of the resources. An even greater disparity exists in compatibility with natural biological cycles. The wastes of every species on the planet are of considerable use to a variety of other species, which transform them and reincorporate them into the bio/geo/chemical biospheric cycles. Humans, on the other end, produce a variety of wastes, mostly through their industrial technologies, that are not readily reincorporated into natural cycles and that often threaten ecological integrity. The irony is a blatant disregard for ecosystem health and the well being of other species since, in the aggregate, they constitute the ecological life support system upon which human society depends for its survival and the natural capital that is the basis of economic well being. Hawken et al. (1999) discuss how sensitivity to ecosystem health can increase natural capital and simultaneously be economically profitable.

Some formidable obstacles resist preserving the biospheric life support system and the millions of species that represent its components. The system is complex and dynamic and requires a high level of ecological literacy for even a modest understanding of its structure and function. Furthermore, the newly developing field of ecotoxicology, which focuses on response to toxicant stress at the ecosystem level, is still attempting to determine what concentrations of toxicants, either singly or in mixtures, exceed critical response thresholds or breakpoints. One of the complications is that, while surrogate systems such as micro- and mesocosms are suitable for controlled laboratory

experiments and have some of the attributes of ecosystems, they are not miniature ecosystems and therefore are of limited use. In short, no precise evidence exists on when harm will occur at the ecosystem level. As a consequence, extraordinary rates of economic growth are occurring in ecologically sensitive areas or are affecting these areas by extracting resources from them.

The precautionary principle (e.g., Raffensperger and Tickner, 1999) suggests that, when an activity raises threats of harm to human health or the environment, precautionary measures should be taken, even if some cause-and-effect relationships are not fully established scientifically. Stated another way, the precautionary principle requires that society forgo some short-term economic gains if the consequences of acquiring them may be severe, even if significant uncertainty about the outcome exists. This principle is the essence of long-term planning and thinking, which in turn is the keystone to sustainable use of the planet. Economic development generally overrides environmental considerations, even at the individual level where the person involved professes a respect for natural systems.

One example is the current problem in the Commonwealth of Virginia, where I reside, of the proliferation of chip mills. These mills grind large quantities of trees for paper and chipboard since trees of many different ages and species all furnish suitable raw material for the chip mill process. Despite the fact that, since 1985, more than 120 chip mills have been constructed in the South, a landowner, Kathy Liston, was surprised and indignant when industry loggers "disregarded her rights as a landowner when they damaged several streams and historic sites on her land" (Anon., 2000b). Inevitably, a Virginia's Chip Mill Study Committee was appointed in 1999 by the Virginia Legislature to study the problem, despite the fact that case histories abound in other states. By the time the committee's report is ready, much additional environmental damage will doubtless have occurred. Even when information is abundant on a particular subject, such as chip mills, and its deleterious environmental effects, the information may not be used by either individuals or governments to take precautionary action. In the case history just cited, the property owner asked: "Isn't the state supposed to look out for citizens and not big timber companies?" The Virginia Department of Forestry (VDOF) environmental guidelines for best management practices are voluntary, not mandatory, and VDOF only takes action if evidence indicates sediment directly entering the streams as a result of logging operations. Responsibility for sustainable use of the planet rests on both individual citizens and their governments. If neither is willing to take precautionary action, even when case histories abound, the prospects for sustainable use of the planet are dismal. Even when the evidence for environmental damage is abundant and apparent immediately, economic development usually, but not inevitably, triumphs.

Natural systems are even more indifferent to the fate of *Homo sapiens* than the latter is to the fate of the millions of species that they contain. Although natural systems are greatly affected by human activities, they are not dependent upon humans as evidenced by the fact that they existed for billions of years before the human species appeared on the planet. As Hinckley (2000), Myers (2000), and others have noted, human society must focus optimistically on what can be done even though it cannot ignore what has been done. Negativism and pessimism can be averted, however, if the problems of human society are examined with an intent to provide a solution to them. Irrational optimism is faith in the future in the absence of sufficient literacy to envision viable solutions to present problems. Not only are solutions to virtually all environmental problems available, but sufficient case histories can confirm or validate their efficacy. The major issue in sustainable use of the planet is developing a focus on long-term ecosystem and human health in an age where instant gratification is arguably the norm.

Case histories (Hawken et al., 1999; Anderson, 1998; Wackernegel & Rees, 1996; Natrass & Altomare, 1999; Common, 1995; Roodman, 1998; National Research Council, 1996) abound on successful ways to develop a more sensitive relationship with the environment, while simultaneously improving the quality of human life. Economic growth, technology, and science will not solve the problems. Long-term thinking, compassion, and the concern for future generations must be incorporated into a new social contract, which must then be implemented. These choices come from ethics, ethos, spiritual values, and a sense of equity and fairness for future generations, those presently living, and the species with which humans share the planet and the ecological life support system upon which human society depends. Information abounds (as in the case of the chip mills), but information is not knowledge and knowledge is not wisdom. Reason guided by intelligence is the essence of long-term planning, as is the ability to exercise these qualities in the face of uncertainty by utilizing the precautionary principle. Human society is capable of shifting to a new paradigm and will undoubtedly develop a sense of community in doing so. This community will include not only humans but other forms of life as well.

Sustainability in some form will be achieved. The big questions become: (1) how much human suffering and ecological damage must occur before human society ceases to deny that present instant gratification practices are unsustainable? and (2) if humans inadvertently cross crucial ecological thresholds and restore the damage to natural capital, will societal memory act on this information or must it be repeated endlessly in each region of the world?

CONCLUSIONS

Caldwell (2000) has been discussing the question "can American society make sound environmental decisions?" for three decades and he (Caldwell, 1970) has written:

> Can we really elect to have a high-quality environment? Does the structure of American society – pluralistic, democratic, historically based in favor of "Everyman's laissez-faire" – permit the shaping of its environment in any way other than by combat and compromise? The question is not whether conflicts of interest in the environment can be eliminated. There is no prospect, in a diverse world, that they will be. A second practical question is how to raise the levels of information and social concern at which the process of bargaining and accommodation occurs. To improve the human environment, both men and politics must be improved. Men make politics; political institutions influence human behavior; and behavior is heavily influenced by attitudes, beliefs, and values. Purposeful shaping of the environment involves the purposeful shaping of outlooks on life. The quality of the future environment depends, therefore, upon the shaping of attitudes, beliefs, and values through present education.

Caldwell's 1970 statement of the problem cannot be substantially improved. However, societal coherence, not only in the United States but more markedly so in other countries, is greatly diminished. At the same time, the range of attitudes and beliefs appears to be much greater, and the prospects of achieving sufficient consensus for effective societal decision making is, arguably, greatly diminished. Economic globalization has, if anything, made the power of special interest groups much greater and has definitely increased the disparity in the distribution of per capita wealth. Most humans are still living in the short-term present, and instant gratification is definitely more socially acceptable than it was three to five decades ago. Even the belief that environmental decisions should be based on "sound science" has fewer advocates, but the probabilistic component of science, which is its essence, is not well tolerated.

Although the information base is enormously larger at the beginning of the 21st century than it was just a few decades ago, it does not seem to have resulted in comparable increases in knowl-

edge and wisdom. An uncharitable person might conclude that knowledge and wisdom have been diminished because the frenetic pace of life does not permit a careful systematic examination of available information and the reflection upon the information that sets one on the path to knowledge and wisdom.

Intelligence, creativity, and ingenuity are gifts disproportionately endowed on one species, *Homo sapiens,* and could lead to sustainable use of the planet and a high quality of life for many generations to come. However, if the traits are used merely for instant gratification of material "needs" without regard to members of one's own and other species, sustainable use of the planet will become a distant, unattainable goal. A persuasive case could easily be made that those working toward achieving sustainable use of the planet are irrational optimists; however, giving up is unthinkable!

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Article 9

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Reparations for Environmental Degradation and Species Extinction: a Moral and Ethical Imperative for Human Society

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ABSTRACT: While the history of reparations within *Homo sapiens* is lengthy, only recently has the concept been applied to events that have caused degradation or damage to natural systems. Some effects have been unmistakable, even to the untrained eye, and reparations have been made in a short temporal span. However, what should be done about ecological damage that has occurred incrementally over large temporal or spatial spans? If all parties involved are no longer living (e.g. slavery, colonialism), should the descendants of one group, who had nothing to do with the situation and are individually innocent, pay descendants of the other, who did not suffer directly? Degradation of the planet's ecological life support system will cause all humans to suffer, directly or indirectly, regardless of the degree to which they contributed to the damage. Repair of ecological damage is an act of enlightened self-interest, as well as an ethical imperative. Although current events may make restoring the planet's ecological life support system seem futile, even irrational, the forces of destruction cannot exceed those of restoration for a substantial period of time without resulting in severe disequilibrium, whether societal or ecological. The only long-term hope for the human species — sustainability — is a constructive, compassionate approach. Regardless of what happens to humankind, it is probable that some species will survive until the sun fails. Even if the human species does not, it seems ethical to make an exit that is notable for acts of compassion rather than acts of rage and revenge.

KEY WORDS: Environmental reparations · Sustainability · Ecological restoration · Ecological life support system · Ecological damage · Eco-ethics

Be the change you want to see in the world. — Mahatma Gandhi

No raindrop feels it is responsible for the flood. — Folk saying

INTRODUCTION: UNDERSTANDING REPARATION

Reparation generally refers to making amends for some wrong/injury by restoring or repairing, by which the injured individual/group is recompensed for real or imagined damage by the individual/group perceived as causing the damage. It also refers to monetary compensation; this mean-

ing is applied exclusively to humans as a consequence of acts of war, and so forth. This particular definition, then, is applicable in the context of damage to natural systems caused by humans.

The United Nations convened a global conference on racism in Durban, South Africa in the latter part of 2001. Given African colonial history, one might reasonably expect a discussion of reparations for colonialism and slave trade to be central to the conference's agenda (Clark 2001)[1]. Clark (see footnote 1) notes that, as an antiracist white American, he had been accustomed to thinking of race and race privileges in terms of the American experience. However, he reports that radical black thinkers such as Delany, DuBois, James and Fanon have always understood that a white supremacist power structure is a *global* structure. White privilege is a global privilege, backed by a global ideology of 'white supremacy'. It must be recognized, understood, and opposed globally. This mindset is an interesting context in which to examine the relationship of *Homo sapiens* with the 30+ million other species sharing the planet. Present attitudes toward other life forms are as Clark (see footnote 1) notes about race and racism — a mixture of self-congratulation and defensiveness. In evolutionary and geological time frames, major human power over other species is a relatively new development. Until humans developed primitive technologies, they were not a particularly dominant species and lived in fear of predators such as large, powerful animals that could do much damage to a comparatively defenseless human. It is quite clear that human ancestors have been responsible for the extinction of many species, including the megafauna of the Americas and many islands and continents. Undoubtedly, the development of technology and the concomitant domestication of a small number of plants and animal species increased the security of humans in terms of food, shelter, warmth, and protection against the vagaries of nature and the losses to other previously more powerful species.

Racism is a consequence of both power and a sense of superiority that has enabled humans to dominate the planet and affect the distribution of economic, political, and cultural power. This set of beliefs may have had its genesis in the relationship of humans with other life forms on this planet (i.e. speciesism).

HOMO SAPIENS AS A SMALL-GROUP SPECIES

As Ehrlich (2000) notes, humans have been a small-group species for practically all the time they have inhabited the planet. Advancement occurred first with the agricultural revolution and later with the industrial revolution. These two events made it possible for humans to live in larger groups that were more and more detached from truly wild ecosystems. In these small tribal groups, each person could know every other person fairly well, which was good because one's life depended on this knowledge. During this long period of small-group existence, humans may have been short of material possessions, while their creature comforts such as food, shelter, and warmth were both uncertain and inadequate by present-day standards. The earlier situation has not substantially improved for the millions of refugees, the estimated 1.2 billion people living on the equivalent of US$ 1 per day or less, or even the 3 billion people living on an estimated US$ 3 or less per day. As Ehrlich (2000) notes, humans are increasingly trying to substitute material possessions for nonmaterial relationships, such as a sense of community or a harmonious relationship with the other life forms with which humankind shares the planet.

[1] See Clark K (2001) The global privileges of whiteness. Monkey Fist, available at www.monkeyfist.com/articles/764

HUMAN SOCIETY'S RELATIONSHIP WITH NATURAL SYSTEMS

Although a majority of the population claims to favor the environment, natural systems are not flourishing; in most of the world, the rate of ecological damage exceeds that of ecological repair. Caldwell (1972), early on, espoused a sustainable relationship between humans and the biosphere, as did Passmore (1974). Ehrlich (2000) notes that humans are currently present in both large numbers and enormous concentrations, which leads to a 'disconnection by distance' — less concern is given to environmental degradation problems that are perceived as temporally or spatially distant. Even after the agricultural revolution, forest dwellers, peasants and nomadic herders controlled the global resources on which they depended. This situation led to superior husbandry of these resources (e.g. Gadgil 1991, Bawa & Gadgil 1997). On the other hand, Bawa & Gadgil (1997) note that the inhabitants of wealthy countries are able to draw their resources from the entire biosphere. Consequently, they often have little or no knowledge of where these resources come from and, therefore, little informational feedback on the condition or health of the ecosystems supplying these resources. Accordingly, the issues of intergenerational equity, the ethics of the treatment of other species that constitute the ecological life support system and the condition of those humans now alive whose subsistence is dramatically lower than the average for the US and other wealthy countries become increasingly difficult to avoid (Birch 1993, Cairns 1998).

Dubos (1980) notes that writing his book *The Wooing of Earth* turned out to be both sweet and sour. The sweet came from his belief that human beings can improve on nature and, to his knowledge, that they can correct environmental damage by deliberate social action. The sour had two ingredients: human society's propensity to spoil desirable environments, whether of natural or human origin, and fear that nature's mechanisms of recovery may eventually fail to cope with the increasing use and misuse of resources and energy. Dubos acknowledges that he had been happily conditioned by the very humanized environments of the Île de France where he was reared and the Hudson highlands in the US where he and his wife owned a once-abandoned farm on which they managed, with some success, a civilized return of the forest. Dubos notes that he still regards these regions as more appealing now than they would be if they had remained in the state of wilderness and he tends to regard, in a similarly favorable way, many other such environments all over the world. Most people probably prefer the humanized environments, although more hardy and adventurous types prefer the few remaining nearly wild areas of the planet.

The degree to which human society can humanize the planet without destroying the integrity of the interdependent web of life that constitutes its ecological life support system is a major question and an important ethical and moral consideration in determining what, if any, reparations should be made as a consequence of degrading natural systems. Dubos (1981) discusses these issues thoroughly; however, Ehrlich (2000) has neatly packaged many issues developed in the years since the Dubos book was published. For the purposes of this discussion, the dependence of human society on ecosystem services and the planet's ecological life support system is crucial. If reparations are endorsed for injustices within human society, humans should at least consider the possibility of reparations for injustices to other life forms that share the planet.

ARE REPARATIONS DESIRABLE?

People who respond to this question generally fall into four categories: (1) people who believe that human society is dependent on the planet's ecological life support system and would make reparations to restore ecological integrity as an act of enlightened self-interest, (2) people who believe that human creativity, ingenuity, and technology free them from nature's laws (e.g. resource

limitations) that constrain other species, but might still make reparations for ecological damage and the extinction of many species as a moral and ethical response, (3) people who acknowledge dependence on the planet's ecological life support system and might make reparations both as a matter of enlightened self-interest and as a moral and ethical responsibility, (4) people who claim that human creativity and technology (plus a few domesticated species) will rescue humans from any catastrophe, feel no ethical responsibility for environmental damage and will do nothing.

Within each of the first three categories, people might decide to take action at levels ranging from highly localized to regional, landscape, political entities, and/or global. Additionally, people might express their response over small or large temporal spans. Finally, some individuals might wish to focus on charismatic species, such as the tiger, rhinoceros, various primates, whooping cranes, and the like, while others may focus on habitats or ecosystems.

Cairns (2001) notes that one way to reduce immigration pressures on environmental refugees is to make things more attractive in the impoverished areas of the world, thus reducing the incentive to migrate. In other words, subsidizing their environments, including ecological repair, would both reduce pressures to migrate and improve the quality of life. The questions remain of whether (1) reparations should be implemented by mutually agreed upon coercion (i.e. laws and taxes) or (2) if this should be left to individual or non-governmental compassion, either of which will require a fairly high consensus on a global ethos or guiding set of values, or (3) whether some persons will say they are only willing to participate in reparations if they are assured that everyone else will be forced to contribute in a comparable fashion, making laws necessary.

The category of decision made and speed with which it is implemented will be strongly, arguably almost entirely for most people, based on the evidence of consequences of inappropriate past actions or present practices. In the US both individual and national indebtedness is quite high and a large number of people already feel they are overtaxed by various levels of government. Individual savings rates are low, and most people feel they have little or no discretionary income. They are unlikely to take the question of environmental reparations seriously unless the perceived or actual consequences are fairly severe. However, since it appears probable that human society will suffer serious consequences for many of its present environmental practices, the question of reparations should not be dismissed entirely.

WHAT FORM SHOULD REPARATIONS TAKE?

If a species has been driven to extinction by humans, there is little that human society can do to make reparations to that species, even if, by some gigantic leap of science, some members might be produced from preserved genetic material. Without the habitat in which the species thrived, it almost certainly would not be self-maintaining and, worse yet, without its natural habitat, it would be a caricature of the living creature that once existed. For example, what reparations could possibly be made by North Americans to the passenger pigeon, driven to extinction both by individual slaughter and habitat destruction? Reparations should be made at the systems level, because of both the close relationship between a species and its habitat and the sheer numbers of species driven to extinction during the period that *Homo sapiens* has existed.

Perhaps the issue might be more manageable by considering the plight of species, not yet extinct, that exist in trivial numbers, such as the American bison or buffalo. Once on the verge of extinction, its numbers have increased substantially compared to the recent past, but these numbers represent only a fraction of the individuals that existed two centuries ago. The evidence of this remarkable recovery of the species demonstrates persuasively that species are capable of a

restoration if they are given protection and suitable habitat. The question then arises: what percentage of the original habitat should be returned as partial reparations for the much larger amount taken from the species? Many species, both plant and animal, that are accustomed to living on prairies as did the buffalo, would benefit by this redistribution of resources. Of course, merely reallocating the space without engaging in a substantial amount of ecological restoration is not likely to provide the desirable result, nor will the desirable result be achieved if the integrity of the restored system is not closely monitored. Monitoring is defined in this discussion as surveillance undertaken to ensure that previously established quality control conditions are being met or, if they are not being met, to immediately initiate corrective actions. In this way, ecological monitoring is viewed much the same as monitoring in an intensive care ward at a hospital or in industrial operations. In short, ecological and biological reparations should be based on explicit goals. Monitoring will validate the degree to which these goals are being met and indicate the need for mid-course corrections if progress is not satisfactory. Giving back even small land tracts for nature preserves can be a very contentious and thorny issue, one in which people's representatives may not always follow the wishes of the majority of citizens. Economic 'progress' and development advocates personally benefit financially from such activities and, consequently, these individuals will devote much time and energy to them. The average citizen has too many obligations to have an intense focus on the environment that is comparable to developers.

ESTABLISHMENT OF WILDLIFE CORRIDORS CONNECTING LARGE NATURAL AREAS

Ecologists know that fragmented ecosystems will not support as many species as could be supported if the fragments were joined into a single unit, or possibly even connected by wildlife corridors. In the US, and presumably in many other countries, local and federal governments have the right of eminent domain that permits them to build roads, power lines and other similar artifacts, such as dams, by commandeering private property. Wildlife corridors could benefit from similar domain, although protests would doubtless be even more vigorous than they are in the other situation. In recent years exercising the right of eminent domain has become increasingly difficult; however, in the long run, human artifacts, such as highways, usually win. If eminent domain is used to 'benefit' the human species (usually at the expense of other life forms), it seems quite reasonable to use it to benefit natural systems, especially since they are in increasingly scarce supply. Cutler (unpubl. data) suggests that it would be beneficial to offer landowners in various watersheds the cost-share benefits, paid riparian easements and other benefits that landowners in some other watersheds enjoy. These offers would constitute a form of reparations by human society for ecological damage in their particular bioregion and, at the same time, if nature were given more protection and help, make that bioregion a better place to live and visit.

The National Research Council (1992) has suggested targets for the percentage of aquatic ecosystems to be restored by the year 2010. The actual percentages are unimportant, although they represent only a tiny fraction of the total of impaired or degraded ecosystems. The point is to start the process of ecological restoration in a small way in each ecoregion and then determine when the process should stop, if ever. Human society should work on these matters at a local level, but integrate the reparation efforts into larger spatial and temporal scales. Once some large-scale degree has been achieved in making reparations on land, it would be well to consider the more difficult problem of the oceans. For those unfamiliar with wildlife corridors and other means of conserving wild species in fragmented landscapes, Newman (2000) provides additional source references.

REPARATION GOALS AND COMPONENTS

A number of factors should be incorporated into establishing reparation goals for environmental degradation and species extinction: (1) Natural systems cannot express gratitude for reparations in the way that one human or society might to another — this inability does not diminish the ethical and moral responsibility of human society for making reparations for damage caused to other life forms. (2) Environmental degradation damages the planet's ecological life support system on which human society is dependent. As a consequence, reparations are merely a matter of enlightened self-interest. (3) Although humans cannot make effective reparations to extinct species, they can take steps to diminish the rate of species extinction by protecting the integrity of the remaining natural systems and restoring damaged ecosystems at a rate exceeding that of damage. (4) Although ensuring that the rate of ecological restoration matches that of ecological damage is a desirable goal, it does not constitute reparations in any meaningful sense of the word. (5) Reparations in the form of ecological restoration should have explicitly stated spatial, temporal, and bioregional components. (6) Extensive restoration monitoring to ensure that previously established goals are being met is essential to the implementation and improvement of a reparations strategy.

In most bioregions, using 20 years as a time frame for ecological restoration should, in most cases, enable environmental professionals to separate trends in recovery from natural variability of the system. Ecosystems will have varying time frames, which can be adjusted according to unique local conditions (e.g. National Research Council 1992).

The National Research Council (1992) used a variety of data sources to estimate both the number and percentage of river miles damaged and the percentage of lakes and wetlands suffering ecological damage. Establishing a goal of restoring 10 % of the damaged ecosystems within a 20-year time frame should enable environmental professionals to take advantage of economies of scale. Additionally, large restored ecosystems are more likely to become self-maintaining than restored fragments. Finally, this percentage is sufficiently large so as to facilitate one or more major restoration projects in each bioregion, which will have the advantage of serving as demonstration projects, increasing regional literacy in ecological restoration, and being a source of local and regional pride. Using the increments mentioned above, it would take a century to restore 50 % of the damaged ecosystems to some degree.

Natural capital (e.g. Hawken et al. 1999), the basis of other types of capital on which human society depends, furnishes ecosystem services and other benefits. Natural capitalism recognizes the critical interdependency between the production and use of human-made capital and the maintenance and supply of natural capital. The traditional definition of capital deals with accumulated wealth in the form of investments, factories and equipment. In actuality, an economy needs four types of capital to function properly: (1) human capital in the form of labor and intelligence, culture, and organization, (2) financial capital, consisting of cash, investments, and monetary instruments, (3) manufactured capital, including infrastructure, machines, tools, and factories, and (4) natural capital that is made up of resources, living systems, and ecosystem services. Arguably, the most effective means of making reparations at the systems level is the restoration and accumulation of natural capital. Although the restoration of natural systems is not dependent on familiarity with this concept, it is a useful metaphor to enable those not well acquainted with restoration ecology to relate it to the concept of capitalism with which the average person feels more comfortable.

It is essential to articulate values, ethos, and ethics that can effectively replace economic preferences. Additionally, all of these should be equally effective for both short- and long-term perspec-

tives. Consequently, the estimate of a century time frame does not seem excessive, although human society will want to make course corrections, adjustments and the like depending on information gathered in the various stages.

ESTIMATING REPARATIONS COSTS

Because of extensive anthropogenic damage done to the environment, initial reparation costs will be high. In many cases, substantial quantities of toxic materials will have to be removed, species will have to be assisted in recolonizing the damaged ecosystem, and the like. With each additional area that acquires a naturalistic community of plants and animals, natural recolonization of nearby damaged areas inevitably will be increased. Therefore, one of the most expensive portions of ecological restoration, namely assisting species to recolonize, will be less and less necessary as the restoration proceeds. As the number of naturalistic communities increases and their distance from damaged ecosystems decreases, ecological restoration can be left more and more to natural processes once the hazardous condition of the site have been eliminated or reduced. The establishment of wildlife corridors between natural areas, most of which will inevitably pass through damaged ecosystems, will increase markedly the likelihood of natural recolonization.

The most publicly understood portion of any reparation is likely to be the actual process of ecological restoration, while the most likely costs to be ignored or underestimated are those of monitoring the restoration process (Holl & Cairns 2002). It is essential to establish restoration goals before any restoration is implemented and to establish monitoring guidelines, quality control criteria and standards, and conditions that will provide an early warning that restoration goals and objectives are not being met. Finally, once these goals have been achieved, it is essential to establish a monitoring system, often using the same criteria used in the restoration process but at a lower frequency and number of endpoints to confirm that the system is healthy or to provide early warning when it is not.

AVOIDING MIXED-USE NATURE PARKS

When a local government obtains an ecologically interesting tract of land, often it is tempted to turn the land into a mixed-use park that typically has features desirable to both the local citizenry and financial interests, but is not a nature park. In making reparations for environmental damage, including loss of species habitat and the like, the concept of a nature park should be based on protection and respectful observation of wildlife, environmental education, and contemplation of nature. The Brown Farm nature park (Browder et al. 2000) in the town of Blacksburg, Virginia, US, is an excellent illustration of the problems likely to be faced by any area attempting a design with nature driven primarily by ecological principles rather than those of active human recreation (e.g. football fields, soccer fields, baseball diamonds, and the like). The Brown Farm site has 169 acres supporting 12 different ecosystems along Toms Creek. Citizens made their views clear on the future of Brown Park in a meeting in November 1999 (a two-day workshop attended by about 500 Blacksburg residents); 80% of the citizens preferred nature preservation, environmental education and passive recreation. The following January, the town sponsored a second public meeting to poll citizen reaction to three proposed plans for the park. Of the 243 comments collected from residents, 64% favored a nature park plan without any playing fields or active recreation. A compromise closely resembling the master plan of mixing both a nature park and active-use elements was rejected by citizens by a 3:1 margin. Browder et al. (2000) made the following recommendations regarding the Brown Farm Park decision: (1) Reduce the number of structures, trails and parking

spaces. Does a nature park require four lots with 270 parking spaces? (2) Keep all parking away from streams and open water by placing most parking at the park's perimeter. (3) Do not create a new lake or pond. (4) Eliminate the 30-acre area for active recreation and reserve a smaller area for potential future recreation, not necessarily active. (5) Specify a process by which decisions about development of this reserve area involve citizen participation. (6) Establish a working group for the Brown Farm Park, composed of knowledgeable citizens, to review the park's final master plan. (7) Develop guidelines for park use, program development, and vegetation/ecosystem restoration and management.

This illustrative case history is almost certainly not unique when ecological considerations are dominant. The Brown Farm was, at one time, a disturbed ecosystem (i.e. a working farm). Abandoning the agricultural processes permitted significant ecological recovery to occur unassisted in a relatively short time period. To the proponents of soccer fields and the like, the farm is an 'unused space', meaning that it is not used for active human recreation. The farm, however, is heavily used by species of plants and animals, and it is one of the few areas easily accessible to town residents that contains significant numbers of species not found abundantly in the town (e.g. otters). The major lesson to be learned from the Brown Park saga is that, even when a disturbed ecosystem undergoes natural recovery, a battle may occur between those who wish to displace a recovered natural system with human artifacts and those who wish to have a fragment of a natural system easily accessible to local citizens. That this battle is occurring in a university town makes it abundantly clear that education alone is not the key to either making reparations for damage to natural systems or protecting natural systems.

HOW MUCH SPACE SHOULD BE ALLOCATED TO NATURAL SYSTEMS?

With the human population still growing and affluence at historically high levels, the worst possible case situation is that humans will continue to displace natural systems until the ecological life support system no longer functions as it should. Typically, the rate of social change has lagged far behind that of technological development and the new conditions that are inevitable consequences of almost every form of exponential growth. The allocation of a specific percentage of Earth's surface to natural systems will depend primarily on three factors:

(1) How much space is essential to maintain the level of natural capital and the delivery of ecosystem services on which human society depends? The information available to answer this question is simply not adequate. What is abundantly clear is that, if current practices continue, some major ecological threshold will be crossed, placing ecosystems in disequilibrium and, consequently, destabilizing human society. The likelihood of crossing such a threshold is not only possible but also highly probable. Worse yet, the information feedback on such issues as species impoverishment, condition of natural systems, and degradation rate of natural systems is inadequate to make a precise judgment. Prudence dictates that much more ecological restoration be carried out as reparation for environmental degradation and that the rate of impoverishment or loss of natural systems be dramatically reduced.

(2) Even if the threshold were known, human society would still have to decide how much of a safety factor to allow so that chances of accidentally crossing the threshold would be diminished. The use of safety factors is generally accepted for elevators, bridges, automobiles and other human artifacts. In fact, the American Society for Testing and Materials determines such thresholds for manufactured goods, and human society develops safety factors to reduce the probability of risks or hazards developing because of unusual conditions or weaknesses in the data upon which

the threshold was estimated. Taking such precautions has not proven popular where environmental conditions are an issue because understanding the consequences of not using such measures requires a level of ecological literacy that is still uncommon in the general population or among most world leaders. Nevertheless, if society employs such practices for the products of technology, surely it is reasonable to do so to protect the planet's ecological life support system from being impaired by this technology.

(3) To what degree should human society acknowledge an ethical and moral responsibility for other life forms beyond that essential to the maintenance of the ecological life support system on which society depends? Since society is so protective of the economic system, it is well to remember that non-human societies have economic systems as well (e.g. Tullock 1994). Most of these are much older than the human economic system and, presumably, most are vulnerable to stresses caused by anthropogenic activities.

ILLUSTRATIVE QUESTIONS REGARDING REPARATIONS

(1) If restoring natural capital is crucial to human society, to what extent should this be left to natural processes?
(2) If active human intervention seems justified, what forms should it take?
(3) Will excessive human intervention result in ecosystems markedly differing from those primarily resulting from natural processes?
(4) If species used to recolonize a damaged site are removed from another habitat, will that habitat be damaged?
(5) Can an estimate be made of the time required for each option (i.e. natural processes versus human intervention)?
(6) Is the difficulty of both natural recolonization or transport of appropriate species to the damaged site a major problem?
(7) Is the goal a naturalistic assemblage of species or the species in the predisturbance community?
(8) If the goal is a naturalistic community, what attributes are essential and/or desirable?
(9) If the goal is a predisturbance community, what difficulties might be anticipated in reestablishing native species?
(10) Are hazardous materials or some other obstacles to recolonization present? If so, what should be done about them? Two obvious choices are removal of the hazardous materials or recolonizing with species tolerant to them, if available.
(11) If a naturalistic community is established with species not indigenous to the area, are these likely to be invasive and displace indigenous species elsewhere?
(12) What organization is responsible for monitoring the ecological integrity of the restored area?
(13) Does the responsible organization have the authority to take immediate corrective action if the restored system is endangered or degraded?
(14) Are adequate funds available to implement monitoring and corrective actions?
(15) How much of all of the above can be entrusted to volunteers?
(16) Is the restored system likely to be self-maintaining? If not, what steps should be taken to maintain the degree of restored ecological integrity?

CONCLUSIONS

Reparations for environmental degradation and species extinction will benefit both natural systems and human society and are indeed a moral and ethical imperative for human society. If the reparations take the form of ecological restoration, by increasing the percentage of naturalistic communities of plants and animals and decreasing the number of damaged ecosystems, the process will benefit human society by providing increased natural capital and ecosystem services, other life forms by increasing habitat necessary for survival, and future generations of the human and other species by making the relationship between human society and natural systems more mutualistic than it now is. There are major obstacles to making effective reparations for environmental degradation. Some illustrative examples follow:

(1) Many humans regard areas without human artifacts as 'unused areas', neglecting to honor the fact that they are essential to the survival of other life forms.

(2) Some people will always attempt to establish human artifacts (such as playing fields) in natural areas set aside for human contemplation of nature and attempt to call them nature parks because fringe areas 'will still be available for birds and wildlife'.

(3) A majority of the citizens' wishes to have more natural systems will not easily weaken the resistance of elected officials to protect these areas, since their economic value is not easily demonstrated. As Myers with Kent (1998) notes, there are huge numbers of lobbyists and huge amounts of money spent to lobby for economic development, typically at the expense of natural systems.

It seems unlikely that humans could eliminate all species and all natural systems without wrecking human society in the process. Human intelligence guided by reason should enable the development of an environmental or ecological ethos (a set of guiding beliefs) that would lead to a more reverent attitude toward other life forms and the development of a mutualistic, rather than damaging, relationship. Reparations for environmental damage would be a beginning in the development of a mutualistic relationship between human society and natural systems and a gift to the descendants of both humans and other life forms.

In more general terms, this choice is between biophilia and biophobia. Doubtless, most readers will regard the latter as too strong a word. However, if natural systems could speak, they might assert that human society is damaging their ecological integrity at an unsustainable rate and driving to extinction many of the species that inhabit what remains by fragmentation, persistent toxic chemicals and the threat of global warming. Damaging natural systems is not the path to serenity and happiness. Human society needs to reevaluate its relationship with the interdependent web of life of which it is a part. If it then regrets previous actions regarding natural systems, the first remedial step should be reparations in the form of ecological restoration.

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Article 10

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Absence of Certainty Is Not Synonymous with Absence of Risk

John Cairns, Jr.

Once harm has been done, even a fool understands it.
Homer, *The Iliad*, Book XVII, 1.32

Bad things happen. Although human society has been remarkably successful in developing techniques to preempt some bad events, the successes have raised expectations. As we have devised ways of reducing some risks, smaller risks seem more significant. Simultaneously, technological solutions to some problems have created new risks of their own. The environmental risks that have resulted, both from growth in human population and technologies, fall into two main categories: 1) the possible consequences of misplaced wastes and 2) the wholesale shift of land area from natural systems producing many different ecosystem services to human-managed systems producing at most one or two. The significance of these changes to human society is the subject of much debate. The debate has, at times, become so polarized that it is difficult to distinguish what is known from what is supposed. The basic concepts of risk and uncertainty are keys to following this debate.

Every possible change or action has risks and benefits. Risks are those consequences that human society finds undesirable, and benefits are the desirable consequences. However, risks and benefits both have three components: 1) how likely is it (probability)? 2) how good or bad is it and how large a spatial and temporal area does it affect (magnitude)? and 3) what is the quality of the information on which estimates of probability and magnitude are based (uncertainty)? Uncertainty is a component of both risks and benefits that results from imperfect knowledge about the probability or magnitude of the consequences of a change.

While high uncertainty may obscure both the probability of a risk and the magnitude of harm, uncertainty does not eliminate risk. Unrecognized risks are still risks; uncertain risks are still risks; and denied risks are still risks. For example, before the research of Pasteur, Lister, and Koch in the late 1800s, the concept that germs could cause disease was unrecognized. Surgeons routinely operated without washing their hands. The risk of dying from surgery was recognized and weighed against possible benefits. However, many people died, and others gave up possible benefits of surgery because the risk of infection was unabated. Similarly, in the British Navy, it was observed that lime juice reduced the incidence of scurvy among the crews of sailing ships on long voyages

(hence “limeys”). Even so, no move to put lime juice on every ship was made for decades.

As we deal with potential risks to larger, more complex systems, the uncertainty associated with estimates of risk becomes irreducibly larger. How should we, as a society, respond to the increasing need to make decisions about risks that carry high uncertainty? Choices that were relatively easy when dealing with well-characterized, linear systems become more difficult as the problems become larger and the knowledge of present state, likely future behavior, and interconnections between the many elements of complex systems is limited. Two kinds of mistakes in this regard are possible: false positive errors and false negative errors. If we act to ameliorate a risk that later proves invalid, we have made a false positive error and have expended resources without any resulting benefit. If we choose not to act to ameliorate a risk that later proves valid, we have made a false negative error and forfeit simpler, more parsimonious, and less wrenching solutions to risks by failing to act in a timely fashion. If response time is even longer, expensive remediation may be necessary or resources may be lost for which there is no possible replacement, including, but not limited to, human life. As the systems whose future is being predicted become larger and more complex, the errors grow more costly.

Both science and ethics have roles in environmental decision making. In most risk assessment schemes, science and ethics come into play sequentially. Ethical considerations define what society considers as a problem requiring action. Science contributes probablistic statements about the nature of the world, the connections between events, and probabilities of future happenings, but science does not tell us what we should do. Ethics or societal consensus comes into play again in the risk management phase as the relative importance of uncertainties, risks, and benefits is weighed and a course of action is chosen. The decision maker can make an educated guess about the future, but must weigh the uncertainty of the prediction against the unpleasant consequences should the decision be wrong. The uncertainty of an estimate of risk can be of little importance if the magnitude of harm is large and the balancing magnitude of benefits is small. In addition, a large probability of a small adverse effect in combination with widespread and large benefits might be judged acceptable.

The appropriate degrees of tolerance for both risk and uncertainty are important matters of public debate, and these concepts are closely interlinked. The uncertainties of benefits need to be scrutinized as well as those of risks. Intolerance of uncertainty will guide choices that require a higher tolerance of risk as actions are delayed and methods for abatement are limited by the progression of impact from early to late stages. The absence of certainty is not synonymous with the absence of risk.

In areas of great uncertainty, it is more difficult to distinguish between ethical claims and scientific ones. The response to similar risks and similar uncertainties varies depending on factors such as whether the risk is consistent with our ethics, whether the risk is freely chosen or imposed, and whether the associated benefit comes directly to us or to society at large or to people other than those bearing the risk. Some substantial risks, like the risk of injury in a car accident, are accepted willingly because the benefit is large and very direct. A similar risk without such direct benefits may be begrudgingly accepted or rejected. If an estimate of risk has high uncertainty and is inconsistent with our belief system, we may well deny it, declaring the true picture to be lost in the uncertainty. Thus, a decision that seems to be based on empirical evidence to one person may, at the same time, appear to be based on ethics to another because the first person judges the level of uncertainty associated with the scientific evidence acceptable while the second person judges it too high.

Table 1. Examples of the varying qualities of information used to estimate risk

Scientific observations
Single
Results of one or more controlled and replicated studies
Observations of one or more natural systems
Multiple
Meta-analyses of multiple designed studies
Synoptic surveys of natural systems
Consilient
Observations showing that multiple lines of evidence are consistent and can be connected with other phenomena
Educated Guesses
Models used to link several well-studied processes together
Models used to extrapolate from studied conditions to unstudied ones
Models used to extrapolate from one spatial, temporal, or hierarchical scale to another
While most predictive models cannot be directly compared to observed effects because they predict future behavior, often at scales that are untestable, the most convincing models will be consensual (the state of the art as determined in peer review) and will be based on observations of relevant processes at the highest possible level (*9*)
Speculation
Untested unifying principles
Models in which the component processes are not based, at the highest possible level, on observation
Hyperbole
Overstatement or catatrophizing of information
Biased selective citation of information; anecdotal evidence when meta-analyses are possible
Redefinition of key terms
Hiding or misrepresenting the uncertainty associated with information

Uncertainty is a function of the extent and quality of knowledge about a problem. The evidence used to estimate a risk can vary widely in quality (Table 1). Shrader-Frechette (*1*) suggests that part of the anti-science backlash recently described by several authors [see Ehrlich and Ehrlich (*2*)] might be attributed to a failure of scientists and decision makers to clearly distinguish observed effects from educated guesses, or further, from speculation. While society must learn some tolerance for the irreducible uncertainty resulting from complexity, it should be intolerant of uncertainty resulting from a simple failure to collect information or from sloppy scientific technique or interpretation. The costs for collecting this information should be borne by those who will benefit from the action, and not by those supporting a precautionary stance. Simple self-interest demands that even small and uncertain probabilities of risks of large magnitude or irreparable harm must be taken seriously. The scientific method is not capable of proving an action is "safe."

The best that can be offered is repeatedly finding no evidence of adverse effects. And, in fact, when common statistical methods are chosen that emphasize the control of Type I errors, the benefit of the doubt falls toward the conclusion of no-adverse effect (*3*). There will be more false negatives (concluding no-adverse effect when in fact there is one) than false positives (concluding an adverse effect when in fact there is none).

Quality and credibility of scientific evidence can be judged. Wilson (*4*) lists five attributes of robust scientific evidence: 1) repeatability, 2) economy (yielding the largest amount of information with the least amount of effort), 3) mensuration, 4) heuristics, and 5) consilience (the explanations of different phenomena most likely to survive are those that can be connected and proved consistent with one another). Shrader-Frechette (*5*) described a risk spectrum: at one end are cultural relativists who believe that risks are only cultural constructs, and at the other end are naive positivists who believe that risk assessment is completely objective, neutral, and value free. The cultural relativists underestimate or dismiss the scientific component of risk assessment. The naive positivists underestimate or dismiss the ethical components. However, those who simply deny the existence of risks may be an important third group.

Denial (*6*) is still a common reaction to many potential environmental risks such as global climate change, environmental endocrine disruptors, and increased human population size and affluence. Regrettably, denial of risk blocks the accumulation of data that would improve estimates of risk and consequence.

Denial also polarizes public debate into "them" and "us" categories. This polarization serves as news entertainment but does not advance the understanding of complex issues. This obstacle is particularly unfortunate since complex, multidimensional problems are not as amenable to rapid resolution though reductionist scientific approaches as previous problems have been. Instead, these problems must be approached by using integrative scientific efforts on a scale larger than in the past. Deniers can be subdivided into two overlapping groups: those who believe there are no problems and those who believe that any problems arising can be solved by human ingenuity. Exemptualists [e.g., see Simon in Myers and Simon (*7*)] believe human creativity and technology exempt human society from risks that result from the biophysical laws of nature. The related, but less sweeping, view is that a technological solution can be found for every problem created by technology (*8*). These views diminish the importance of risk assessment in their belief that any and all risks can be abated successfully as soon as they become bothersome enough.

In conclusion, some of the risks that are most vigorously denied (e.g., global warming, damage to the ozone layer, overpopulation) would, if realized either singly or in combination, markedly reduce the prospects of leaving a habitable planet. The tendency to discount risks that are temporally or spatially distant or those on larger temporal or spatial scales runs counter to aspirations for sustainable use of the planet.

As stated previously, unrecognized risks are still risks; uncertain risks are still risks; denied risks are still risks! The precautionary principle embodies the belief that it is prudent to attempt to diminish risks with particularly severe consequences, even if the probability of occurrence is moderate or the uncertainty high. Excessive confidence in our own ability to solve problems after harm has been done could result in awkwardness or tragedy.

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Article 11

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The Diminished Charge on the Intellectual Electric Fence

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ABSTRACT
The divide between the two cultures (scientific and inductive/literary and deductive) identified by C. P. Snow has diminished appreciably in the last 40 years. Cultural exchanges may not be as effortless as they were in much earlier periods, but they have improved and are still improving. At its worst, the separation of the two cultures was unfortunate, but not a threat to the survival of human society. Toward the end of this century, two new cultures have emerged with dramatically different views of the relationship that *Homo sapiens* has with natural systems. The "environmentalists" believe that humans are a part of natural systems and depend upon them to keep the planet habitable. The "exemptionalists" believe that intelligence, creativity, and technology can free human society from the biophysical laws of nature that restrict other species. Economic and political forces tend to keep these two new cultures farther apart than the cultures described by Snow. A position of compromise seems very unlikely. The general public and political leaders seem mostly unaware of these two cultures, but global practices are dominated by the economic growth exemptionalist model. At the very least, literacy on these issues should be raised to the degree essential for an informed choice.

This time, like all times, is a very good one, if we but know what to do with it.
– Ralph Waldo Emerson

INTRODUCTION

For over half a century, I have been a cautious traveler through the zealously defended specialized tribal units of academe. This exciting, but often stressful, journey was not initially of my own choice. I began by majoring in a conventional tribal unit (biology) with a minor in two reasonably friendly tribes (chemistry and physics). In graduate school, I enrolled in a major subtribe (zoology). At the end of my first year of graduate school, Ruth Patrick offered me a position as a protozoologist on one of her two river survey teams at the Academy of Natural Sciences in Philadelphia, Pennsylvania. The study covered the effects of pollution upon an entire river system rather than just a

particular species, genus, or family of organisms. The team interacted with engineers, chemists, and regional planners, as well as industrial personnel, elected officials, regulatory officials and even the news media. Reducing environmental pollution was socially valuable and scientifically challenging! In an era where graduate assistantships were almost unheard of, I was even paid. What more could one want? As a bonus, my efforts were considered quite satisfactory for an MS thesis. C. P. Snow's seminal volume on the two cultures had not yet appeared, so it was a great shock to find that many of my peers did not congratulate me on my good fortune. I was shocked further when I encountered the view that research was either “pure” or “applied.”

CROSS CULTURALISTS

Moving from one culture to another (scientific to literary/inductive to deductive) is easier than one might think. However, one must project the new tribal role convincingly. The Society of Friends (Quakers) distinguishes between birthright members and convinced members, which is an appropriate but not prejudicial view of a cultural change. Unlike the Quakers, those who have changed academic disciplines are often more aggressive champions of disciplinary purity than those who remain in their original disciplines. I know and respect individuals who have switched from economics to urban and regional planning, law to economics, etc. but who are quite tolerant, even supportive, of those exploring the interfaces between and among disciplines; however, these individuals seem to be the exception rather than the rule. Many people who have switched disciplines are stalwart defenders of disciplinary purity (in the new discipline) despite the illogic of this position.

PSEUDO-CROSS CULTURALISTS

The increased flow of extramural funding into interdisciplinary programs, particularly those related to the environment, has resulted in a number of classical disciplines hiding behind an interdisciplinary facade in order to acquire grants. One of the classic forms of this deception has been to add a descriptor to the original designation—Department of X and Environmental Sciences. To distinguish between facade and an enlarged scope, one must examine each faculty member's publications and professional memberships to determine how many are in a specialized discipline and how many are in professional journals that are predominantly environmental. In some cases, there is substance behind the name change, but the device of adding to an existing name is generally easier than launching a new department in an era of decreased educational funding. Regrettably, this maneuver is often a panic response to declining enrollment and it is often temporarily successful because prospective students and their parents do not investigate the department and the facade serves its purpose.

Another variation in an era of austere funding is to collect a group of small disciplinary entities under an umbrella of “interdisciplinary studies.” Again, prudence requires a check of each faculty member's publications, professional memberships, and the like to determine the percentage of participants who are truly interdisciplinary. An aggregation of individuals with strong disciplinary bias does not an interdisciplinary center make! On the other hand, most such entities must start small and develop gradually. They deserve encouragement and support, and those designed as graveyards for out-of-favor disciplines will soon fade away.

A third ploy for appearing interdisciplinary is to establish an applied journal with a title that does not sound too applied. This rather transparent maneuver benefits both cultures. The applied authors who publish in the journal acquire more status and theoreticians do not lose face. I regard this as a sound move to make the transition to consilience less traumatic.

CLOSET MULTICULTURALISTS

At a national and international level, it is amazingly easy to avoid cultural conflicts. For my entire career, I have been fascinated by protozoan community structure and function. Publications in this field are read by those with similar interests but usually by few others. I recently received a letter from a colleague at another institution commenting how one's interests change with retirement. He had just encountered a publication of mine in toxicology—a field in which I have been publishing since the early 1950s. Even when this cultural anomaly is discovered, the discoverer finds a charitable explanation—in this case that "my interests have changed after retirement." But in order to be accepted in a specialized journal, one must usually maintain the focus of that publication. In short, one must invest time in acquiring the tribal language and rituals of each culture. Some months ago, I was invited to submit a manuscript for a major anniversary of a particular interest journal. It seemed appropriate to show the consilience of this field with a number of issues of importance to human society. One reviewer thought the manuscript satisfactory and recommended publication. The second strongly opposed publication and remarked that the paper appeared to be an address (possibly at a banquet) to a learned society. I regarded this as a compliment, but it was clearly not so intended. The second reviewer concluded that, if published, the article might do no harm. Clearly, the second reviewer felt the article had some merit—it was viewed as an address to a learned society. But it was clearly outside of that journal's culture—at least in the second reviewer's opinion. The editor chose to publish the article. But such an article is definitely not appropriate for someone wishing to remain a closet academic multiculturalist. It is possible to appear to have a specialized approach, while promotion and/or tenure are a problem, and still function in an interdisciplinary mode if one is careful.

CONSILIENCE AND SUSTAINABLE USE OF THE PLANET

As Collini (1993) notes, the topics raised by Snow are not the exclusive property of any one discipline. Arguably, the most effective solution for most for the world's major problems precludes confining any one of them to academic pigeonholes. This need for interdisciplinary thinking is particularly true of the quest for sustainable use of the planet, which reached public consciousness with the report of the World Commission on Environment and Development (1987). But predictably, special interests have dominated the field as evidenced by the reports on sustainable agriculture, transportation, energy, cities, fisheries, water supply, and the like. An uncharitable person might assume that the primary purpose was to ensure the perpetuation of the special interests rather than leaving a habitable planet for future generations. Some books on subsidies (e.g., Myers and Kent, 1998), which document the large amounts of money involved, provide persuasive economic evidence to support this view. Perhaps in such cases, the financial motivation is more important than cultural differences.

PROLIFERATION OF THE CULTURES

Collini (1993) remarks that, in place of the old apparently confident empires depicted by Snow, the map shows many smaller states with networks of alliance and communication between them that crisscross in complex and sometimes surprising ways. I agree with this statement entirely, hence the title of this paper. These largely self-contained "tribal" units; each has its own language, rites of passage, journals, annual meetings, and geographic territory on an academic campus that preclude cultural exchanges. The tribal identities are both acknowledged and preserved by the use of the terms *multidisciplinary* and *interdisciplinary* rather than *transdisciplinary*. One hope is that

students would rebel against the resultant compartmentalization, but colleagues in many institutions tell me that students focus on the courses they perceive will result in a professional position and tend to ignore the other courses. Of course, some exceptional students have broad interests, but these are hampered in large introductory courses by diminished civility toward both fellow students and faculty as evidenced by talking in class, late arrivals, early departures, and other distracting behaviors. The biggest threat to cultural barriers is an awareness of and respect for the attributes of other cultures. An uncivil environment does not facilitate development of such awareness and respect.

For faculty, other difficulties also exist. Effective communication with those in other disciplines is hard, time-consuming work. More emphasis on increased teaching does not encourage learning about other disciplines. Of course, some faculty would not bother with other academic cultures, however much time was available. But others would. Academic institutions must find some way to permit communication among disciplines for those who wish to do so without penalizing those who do not. Perhaps this would be an effective use of the traditional sabbatical, which is increasingly threatened in a variety of institutions.

Time management problems are not new despite efforts of many professionals to act as if they have just appeared. As Wilson (1998) remarks, an academic career requires 40 hours each week for teaching, advising, committee service, and the like. An additional 20 hours are needed to conduct respectable research, and another 20 hours will result in really important research. Merely putting in the time does not ensure success. Creativity requires focus, even addiction, in order to make an important discovery. Time management is difficult enough, even within a subdiscipline, and requires massive effort to achieve desired results even in a modest multidisciplinary outlook, which is why Wilson's observation on time is so important. What might inspire individuals to aspire to an operational level of competence in more than one academic culture?

As Collini (1993, p. iv) observes, outsiders tend to see uniformity in other groups and find distinctions within their own. Legislators and the general public often view faculty of institutions of higher learning in this way (e.g., high pay, little work). Wilson (1998), viewing the system from the inside, characterizes it as a series of petty fiefdoms. Both views have merit. Even religious organizations espousing racial, economic, and other forms of diversity end up being predominantly all white or all black and of a relatively modest economic range. It is simply too much work to convert “creed” to “deed.” Even when a predominantly black and a predominantly white congregation agree to a “sister congregation” relationship, the outcome is usually unsatisfactory. Achieving desired results is simply too much of an effort on a continuing basis for most people. This statement is not intended to denigrate such efforts, but rather to recognize that individuals feel most comfortable with others of their own “culture,” whatever that might be., because they can relax most completely with those sharing a common experience base. This division is why most academics cannot communicate well with the general public. Those who can, such as Carl Sagan, are often accused of shallow scholarship by their colleagues (e.g., Diamond, 1997a).

Given these obstacles, why are there so many examples of consilience (e.g., Wilson, 1998)? The most important reason is almost certainly simple curiosity – the creative mind is usually not confined by tribal boundaries. Second, the rewards are always greater, per unit of time spent, in relatively unexplored territory. However, publishing a discovery made in the comparatively unexplored area between disciplines is another matter entirely, as I found when working with an optical physicist, Silvero P. Almeida, on the use of laser holography to identify diatoms (e.g., Almeida et al., 1978, Cairns et al., 1982). Journals in each field thought there was too much “extraneous” mater-

ial from the other field. Once the basics were published, it was easier for future publications to cater to specialized interests. A third reason for transdisciplinary work is funding. It is generally easier to get funding to solve problems of interest to a wealthy someone else than to solve problems primarily of interest to the researcher only. A high percentage of such problems transcend disciplinary boundaries. Most research requires extramural funding. When asked to define academic freedom, Isaac Asimov is reported to have replied "extramural funding." Outside funding protects one, to a degree, from local tribal politics and, if it does not, it at least enhances mobility. Funding definitely enables a researcher to attract the cream of the graduate student crop, who can always find someone to pay for their thesis or dissertation research. All other aspects being equal, graduate students are more likely to pick a major professor who can also pay for page charges, reprints, trips to professional meetings, and other means to make potential employers and the larger academic community aware of their research. This attraction is enlightened self-interest and increases the probability that the graduate student will be a credit to the major professor. In my opinion, funding can also dramatically speed up the development of a collegial relationship between graduate student and major professor, since both have a high stake in the outcome of the funded research. It is worth noting that much funding that once went to interdisciplinary teams is now going to multidimensional professionals who are capable of the interfaces between disciplines.

A significant portion of my research (and, of course, student research under my direction) for half a century was funded by people who had problems they wanted solved. The ones I agreed to tackle were fascinating ones that would otherwise not have occurred to me. For example, would fish avoid heated wastewater discharges from a steam-electric power plant (late 1940s and 1950s)? Or decades later, how does one keep an exotic species (the Asian clam) from fouling a power plant cooling system? Both involved various kinds of engineers, attorneys, regulating personnel, chemists, corporate executives, fishermen, toxicologists, fisheries and wildlife professionals, journalists, and local citizens. Cultural and disciplinary differences were not obstacles to gathering evidence on a problem of interest to all. Of considerable importance to me was the written assurance that the results could be submitted to a peer-reviewed professional journal *whatever the outcome*. This assurance required a considerable amount of mutual trust, which developed gradually over years of working together. The main point here is that only a few such relationships are possible at any one point in time. Furthermore, the trust was personal, not institutional, and had to be developed accordingly when new people appeared. New movements in biotechnology, where patents etc. are involved, are rapidly reducing these agreements. This scenario, regrettably, is true of other areas as well.

CONVERGENCE

As Eisenstadt and Schluchter (1998, p. 2) note, theories of modernization and of modernity, as formulated in the 1950s and 1960s, were based on the assumption of convergence. It was believed that modernization would wipe out cultural, institutional, structural, and mental differences and, if unimpeded, would lead to a uniform modern world. As human society nears the end of this century, there is much to diminish the confidence in the principle of convergence. Worse yet, there is a dangerous paradigm in its place.

THE ECONOMIC GROWTH PARADIGM

Human society has essentially turned to the economic growth model to solve all problems related to the human condition such as poverty, malnutrition, overpopulation (higher income fam-

ilies have fewer children), housing, cultural differences, education, and the like. Absent military conquest, economic growth is perceived as the only viable means for a country to sustain increases in national wealth and living standards. Some developing countries feel that a 7 percent annual economic growth rate, for the next decade at least, is the minimum necessary to provide enough jobs and improve the human condition. This growth rate means doubling the economic level in 10 years in countries where environmental damage is already severe. Nevertheless, people in developing countries aspire to the level of affluence in developed countries, most notably the United States. However, the ecological footprint (i.e., the productive land needed to support each individual with existing technology) is 5 hectares (1 hectare is 2.5 acres) in the United States and 3.5 hectares in Europe. In many developing countries, the figure is less than 0.5 hectare per individual. Raising the entire world to levels of affluence in the United States would require three planet Earths. But, optimistic economists state that human ingenuity and technology make resource limitations obsolete (e.g., Myers and Simon, 1994). According to them, carrying capacity applies to other species, not humans. Those espousing infinite growth on a finite planet have ignored a very important component of risk analysis. The precautionary action principle espouses precautionary action even in the face of high uncertainty if the consequences are likely to be unacceptable or severe.

THE PRECAUTIONARY PRINCIPLE

Over the last decade, the principle of precautionary action has been emerging. On January 23-35, [*sic*] 1998, an international group met at Wingspread in Racine, Wisconsin, and formulated four parts to the principle of precautionary action.

1. People have a duty to take anticipatory action to prevent harm.
2. The burden of proof of the harmlessness of a new technology, process, activity, or chemical lie with the proponents, not with the general public.
3. Before using a new technology, process, chemical, or starting a new activity, people have an obligation to examine “a full range of alternatives,” including the alternative of doing nothing.
4. Decisions applying the precautionary principle must be “open, informed and democratic” and “must include affected parties.”

These parts can be less elegantly stated as “Better safe than sorry,” “Look before you leap,” and “An ounce of prevention is worth a pound of cure.” The compartmentalization of “the two cultures” identified by Snow or Wilson's (1998) petty academic fiefdoms will likely continue, possibly somewhat weakened, until some extraordinarily compelling reason exists to make consilience essential; for example, the destabilization of human society as it is presently known.

DOMINANCE OR ESTEEM

The degree of dominance that *Homo sapiens* has achieved over natural systems in the last century is dramatically greater than when humans first successfully domesticated biota in a few parts of the planet (e.g., Diamond, 1997b). In evolutionary time, this degree of dominance is a new situation. Moving beyond dominance of nature to respect for the integrity of natural systems in the absence of perceived consequences for not doing so will require a dramatic change in the relationship between academic cultures. If unmistakable consequences are required to precipitate this change, both human society and natural systems will suffer greatly. If irreversible damage has not occurred, human society will have the opportunity to progress in its relationship with natural systems.

WHAT IF THE EXEMPTIONALIST MODEL IS WRONG?

In science, the validation process is a *sine qua non*, but there is no comparable assurance that "humans are exempt from the laws of nature" is a valid assumption! Exemptionalists believe that human technology, creativity, and ingenuity exempt our species from the iron biophysical laws of nature that limit other species. Wilson (1998) has even facetiously named this "new species" *Homo proteus* or "shapechanger man". Wilson lists these among the cultural attributes: "Indeterminately flexible, with vast potential. Wired and information driven. Regrets the current loss of nature and all those vanishing species, but it's the price of progress and has little to do with our future anyway." There is no robust validation of the assertion that human society is not dependent upon other creatures for the services provided by the ecological life support system. Continuing most forms of exponential growth on a finite planet almost certainly involves serious risks. If the global average of children per woman dropped to 2.1, there would still be nearly 8 billion people on the planet in 2050 and 8.5 billion in 2150. At 2.2, population would peak at 12.5 billion in 2050. And, at present, approximately 1.3 billion (or 1 in 5) people have cash incomes of less than US $1.00/day. The slightly more affluent group of 1.6 billion above them would have incomes of US $1-3.00/day. These two groups are already a destabilizing force because of starvation, malnutrition, and discontent. They represent over 0.4 of Earth's population, and a global recession could vastly increase their proportionate numbers.

FURTHER DIMINISHING THE CHARGE ON THE INTELLECTUAL ELECTRIC FENCE

Anyone paying modest attention to the history of World War II is well aware of interservice rivalries that persisted, even when the outcome was uncertain (e.g., Astor, 1995). Those willing to transcend petty territorial conflicts and take great risks can achieve results dramatically disproportionate to their numbers (e.g., Lord, 1977). Sustainable use of the planet, if possible, will not be achieved in a climate of cultural or disciplinary isolation. Consilience has occurred and is occurring, but not to a degree adequate for addressing problems of the human condition in the first half of the next century. Consilience cannot flourish in a climate of ethnic and religious conflict and other forms of social unrest. Exponential growth and the consequent rapid doubling times bring on crises more rapidly than the social system can handle them. Money, energy, and resources then flow to address the symptoms rather than the causes. Floods, for example, are caused by such factors as deforestation, loss of wetlands, increases in impervious surfaces, and climate change. The effects are exacerbated because humans colonize flatland flood plains and attempt technological solutions (e.g., levees, channelization) rather than developing new social contracts.

Snow's lectures and writings on the two cultures have provoked much academic debate and discussion. Wilson's *Consilience*, a search for a common system of knowledge, provides hope that human society may achieve sustainable use of the planet in the next century. It has been 40 years since Snow's ideas appeared, and human society has, arguably, 40 years to achieve sustainability.

The way humans manage the use of natural resources is a paradigm for the way they structure their societies. The way they respond to the extinction of life forms is a reflection of the value they place on the quality of life of future generations. Arguably, the determining feature of the time is the way in which humans preserve resources and ecological capital for future generations. Links exist between justice and human society's relationship with natural resources.

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Article 12

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Materialphilia, Biophilia, and Sustainable Use of the Planet

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Key words: Consumerism, materialism, sustainability, biophilia, economic growth, ecosystem integrity, biospheric life support system

SUMMARY

Conflicts over global resources involving war or terrorism, or both, destroy natural capital and, thus, make resources scarcer. Sustainable use of the planet will require a fairer, more equitable distribution of resources not only among humans but with the millions of other species with which humans share the planet. The quest for greater material possessions – materialphilia – is unsustainable on a finite planet that has a growing population and greater expectations per capita of material affluence. However, biophilia, the innately emotional affiliation of human beings to other living organisms, should, if widely practiced, result in a greater accumulation of natural capital. This strategy should lead to greater protection of the planet's ecological life support system, which is a primary need for sustainability.

And he said unto them, Take heed, and beware of covetousness:
for a man's life consisteth not in the abundance of the things which he possesseth.
King James Version of the Bible, Luke 12:15

CONFLICT OVER RESOURCES

The dependence of the United States on foreign oil lowers national security. Even oil from the Arctic National Wildlife Refuge would have to travel through a new pipeline connected to the Trans-Alaska Pipeline System, which is 800 miles long and quite vulnerable to terrorist attacks. On 4 October 2001, a single gunman fired bullets into the pipeline and caused a spill of almost 300 000 gallons of crude oil. Nearly 100 workers needed three days to repair the pipeline damage, but the environmental damage cannot be repaired as quickly. One persuasive analysis (Klare, 2001) supports the conclusion that many of the world's conflicts are a consequence of the dependence of developed countries, especially the United States, on the oil resources of the Persian Gulf region. Klare (2001) feels that the campaign against Osama bin Laden and the Al-Qaeda terrorist network is basically a police action that might be jeopardized if it takes on the attributes of an ethnic/religious war and too many civilian casualties occur.

BIOPHILIA AND MATERIALPHILIA

The term *biophilia* originated with Harvard biologist E. O. Wilson (1984), who defines biophilia as 'the innately emotional affiliation of human beings to other living organisms' (Wilson, 1993, p.31). If the term *materialphilia* does not exist, it should. Materialphilia is best defined by the ubiquitous bumper sticker: 'He who dies with the most toys, wins.' One tragedy of the present is that humans are increasingly attempting to fill non-material needs (sense of community, the emotional affiliation of humans to other living organisms, spirituality, and serenity) with material goods to which, in most cases, they have no permanent attachment. Wilson (1993) notes that *biophilia*, like other patterns of complex behaviour, is likely to be mediated by rules of prepared and counter-prepared learning – the tendency to learn or to resist learning certain responses as opposed to others. He further states that

> The biophilia hypothesis goes on to hold that the multiple strands of emotional response are woven into symbols composing a large part of culture. It suggests that when human beings remove themselves from the natural environment, the biophilic learning rules are not replaced by modern versions equally well adapted to artifacts.

These two quite different paradigms represent important components of the human condition with regard to the quest for sustainable use of the planet. Wackernagel and Rees (1996) have beautifully illustrated how large the per capita ecological footprint of the United States is compared to the size of ecological footprints of other countries. However, happiness is not highly correlated with the amount of material possessions (Menzel, 1994). Even in the United States, the disparity in wealth (as measured by material goods) is radically greater now than it was at the beginning of the previous century. Durant and Durant (1968) conclude that concentration of wealth is natural and inevitable and is periodically alleviated by violent or peaceable partial redistribution. Consequently, two crucial questions emerge with regard to this component of the human condition: (1) will the redistribution of material resources be violent or peaceful? and (2) will the redistribution be accompanied by a paradigm shift from materialphilia to biophilia, thus preserving the planet's ecological life support system?

The path to a mutualistic co-existence

Most humans now alive could not survive unaided by technology in a true wilderness. For most of human history, *Homo sapiens* existed in small numbers and were spread thinly over the planet. Only the developments of the agricultural and industrial revolutions have permitted the numbers of people now existing on the planet (somewhat over 6 billion in 2000). True wilderness only exists at present on the land masses in fragmented, disconnected enclaves. The vast portions show anthropogenic effects that are well documented and ubiquitous. The effect of humans on the biosphere has been so rapid and profound in the twentieth century that, as McNeill (2000) notes, the consequences of environmental transformation on this scale and complexity remain among the most worrisome riddles of our common future.

Humanization of earth

Dubos (1980) remarks that the humanization of Earth inevitably results in destruction of the wilderness and of many living species that depend on it. As a consequence, there is a fundamental conflict between ecological doctrine and human cultures: 'Our species has been shaped by the Earth and we feel guilty and somewhat incomplete when we lose contact with the forces of nature and with the rest of the living world' (Dubos, 1980, p.17) Dubos (1980) uses the term *wooing* (from

the word *woo*). In view of the scientific information generated in the over two decades since Dubos' book was published, I interpret this term, as applied to the planet, to mean getting the favour of, such as enjoying the full benefits of ecosystem services for the indefinite future and having abundant natural capital on which other forms of capital depend (Hawken *et al.*, 1999). The term wooing might also apply to having the favour of the psychological and emotional benefits as exemplified by the innately emotional affiliation of human beings to other living organisms (Wilson, 1984, 1993). Clearly, the giant, uncontrolled experiment on Earth (McNeill, 2000) could hardly be called wooing. Furthermore, wooing implies more than a mutualistic co-existence. I regard wooing as an actively caring, affectionate relationship. Actively caring should begin with implementing precautions to avoid damage to the Earth.

THE ECOLOGICAL AND SOCIETAL CONSEQUENCES OF MATERIALPHILIA

Under present practices, artifacts that are produced to satisfy materialphilia result in robust economic indicators but shockingly poor indicators of ecosystem health. A few illustrative examples follow.

(1) Numerous examples of water shortages (e.g. Brown, 2001) and misuse of water resources (e.g., Postel, 1999) exist.
(2) Biotic impoverishment (i.e. declining biodiversity) is proceeding at a rate unprecedented in human history (e.g. Heywood and Watson, 1995) and uncommon in geologic time (e.g. Brown, 1991).
(3) A steadily widening gap between the ‘haves’ and ‘have-nots’ is resulting in the loss of a sense of community and, ultimately, a rise in social disequilibrium.
(4) Materialphilia is, arguably, the primary obstacle to resolving the differences between economists, who take their cues from the financial markets, and ecologists, who take their cues from the condition or health of the planet's ecological life support system.
(5) Two things cannot be optimized simultaneously. Optimizing materialphilia results in being defined by one's possessions. Optimizing biophilia results in being defined by one's relationship with other life forms, including other humans.
(6) Materialphilia destroys or consumes ecological capital, so it decreases the probability of passing on a habitable planet to future generations. A natural system with unimpaired integrity is an ecological endowment providing interest (ecosystem services) that will continue indefinitely, as long as ecological integrity is maintained. If integrity is impaired, both capital and interest are diminished.
(7) In an era of less rampant materialphilia and more isolated economies, the ecological collapse of civilizations was isolated both temporally and spatially. In the integrated global economy of the twenty-first century, there is an increased risk of a global collapse.
(8) *Homo sapiens* has evolved to cope with a variety of external threats (e.g. predators and disease), but has not yet prepared the species to cope with ‘internal’ threats that result from unprecedented population growth and a concomitant increase in per capita material possessions.

BALANCING MATERIALPHILIA AND BIOPHILIA

All possessions, except those necessary for survival, must be reevaluated. An object might be a treasured possession because it is a reminder of a departed loved one. However, accumulation of numerous artifacts lessens the likelihood of a close association to any particular item. The media

and other advertisements espouse a view that one is defined by possessions. On the other hand, publications and biographies of famous people usually focus on their ideas, beliefs, and actions. When possessions are emphasized in these settings (e.g. Imelda Marcos, the widow of the former Philippine president), it is often mentioned in a derogatory fashion. In contrast, Goffman (1961) describes the horror of being separated from one's worldly goods in the dehumanizing stripping process experienced by persons in prisons, the military, and, even to some degree, in certain nursing homes. Physical objects are a significant means of satisfying both lower- and higher-order needs in Maslow's hierarchy (Maslow, 1954). No one would dispute that some artifacts contribute significantly to meeting basic needs for survival (e.g. food, shelter, warmth). Then, two important questions arise: (1) at what point do artifacts cease to satisfy higher-order needs and actually impede attaining them? and (2) do our beliefs, ideas, and actions define our human condition better than material possessions?

Finally, I am haunted by the vastly disproportionate levels of material possessions in Menzel's (1994) global family portrait. Worse yet, the gap appears to be increasing (e.g. Giles, 2001). Is this gap in material possessions sustainable and, if not (as Durant and Durant (1968) believe), how will it be reduced? How should human society balance materialphilia and biophilia? The ultimate choice is between living things and artifacts. Natural capital (ecosystems) is renewable if used but not abused. If humans have compassion for other humans alive at present, for their descendants, and other species with which they share the planet, they must preserve the natural capital on which all other forms of capital depend (Hawken *et al.*, 1999). This compassion, in turn, requires that biophilia dominate other patterns of complex behaviour, such as materialphilia. Regrettably, this change will be a major paradigm shift for those persons whose behaviour is dominated by materialphilia.

SHIFTING THE PARADIGM

During the twentieth century, a wide variety of new knowledge and technology appeared (e.g. McNeill, 2000), but neither knowledge nor technology guarantee wisdom. A wise shift to a new paradigm should not cause excessive loss of the positive features. However, homocentric views that allow degrading and harming natural systems are not conducive to sustainable use of the planet. Excessive individualism, consumerism, etc., which do not preserve the integrity of the planet's ecological life support system, must be replaced by an ecocentric point of view in which humans are a component of the interdependent web of life rather than apart from it. Hirsch (1976) stated the problem well by calling attention to the divergence between what is possible for the individual and what is possible for all individuals. The ecological life support system could not endure the consequences if all individuals had ecological footprints as large as those of the United States, Canada, and many other developed countries. However, most individuals want more material possessions and will go to great lengths to acquire them. In the United States, both spouses may be employed, and some have several jobs in order to afford more possessions. As a consequence, social capital is diminished. Economist Schumpeter (1942) even suggested that capitalism would eventually undermine the non-capitalistic ethos necessary for its survival. Tullock (1994), another economist, illustrates the economics of non-human societies. He asserts that government is not necessary for the economics of non-human societies; however, the great flexibility that a large brain gives humankind produces problems for which a government is necessary. Less flexible social species can manage without government. Humankind's economy of growth in material possessions views natural capital as a resource to be consumed rather than as a planetary life support system whose

services make the planet habitable for humankind. Regrettably, the focus on human economy has diverted attention from the preservation of natural capital upon which other capital depends.

The perpetual economic growth paradigm on a finite planet is a paradigm that hampers the quest for sustainable use of the planet. However, an equally troubling paradigm is coupled with the global human population net gain of over 80 million persons per year. This paradigm is the belief that liberty and equality are complementary and mutually reinforcing attributes. Tanton argues that they are antithetical properties (Rohe, 2002). Durant and Durant (1968) point out that humans and their technology as a group are protected from some of the processes and trials of evolution, but they add the caveat that the group itself must meet the tests of survival. Durant and Durant (1968) propose three biological lessons of history. First, life is competition. Second, life is selection – inequality is not only natural and inborn, but it grows with the complexity of civilization. Third, life must breed – nature has a passion for quantity as a prerequisite to the selection of quality. This vision is not the one most humans have of either sustainable development or sustainable use of the planet. If humankind does not control both population size and level of affluence (resource consumption to produce material goods), the same limitations (i.e. disease and famine) that affect other species will also affect humans. In addition, humankind has weapons of mass destruction not available to other species. These weapons will undoubtedly be used in the resource wars when resource allocation is not viewed as equitable and fair. The questions asked today and the ways in which they are answered will be a major determinant of the future of humankind, as will stochastic events, over which humans have little or no control and often lack the means of predicting when and how they will occur.

AN ILLUSTRATIVE CASE HISTORY

Among the consequences of materialphilia is the disposal of the packaging material itself. New York City's 11 000 tons of garbage produced daily is sent to New Jersey, Pennsylvania, and Virginia. Clearly, citizens of New York are not living sustainably since they must export their garbage to other states. Approximately 550 tractor trailers are needed daily to transport the garbage as much as 300 miles away from New York City. The tractor trailers form a convoy nearly 9 miles long, which uses much energy, impedes traffic and pollutes the air. Localities needing an increased cash flow even rejoice in the fees obtained. State governments are less enthusiastic since they are responsible for increased road maintenance, traffic problems, complaints from areas through which the garbage passes, increased air pollution and noise. Furthermore, tax dollars are subsidizing this garbage transfer for which many receive few or no benefits and much aggravation. Recently, the state of Virginia Governor, Mark Warner, attempted to add a statewide landfill tipping fee of US$5/ton to generate revenue for land conservation, water quality improvements and urban redevelopment, but it was defeated in the Virginia Senate 23 to 17 (Sluss, 2002). Garbage and trash burials are regarded by the federal government as interstate commerce and, as a consequence, are protected to some degree. This circumstance impedes attempts of local governments to live more sustainably by reducing the volume of garbage and trash.

As is the case with most sustainability issues, much could be accomplished if remedial measures were taken by a majority of citizens, i.e. using materials that are easily recycled and reducing the total amount of garbage and other waste materials. This problem could also be addressed at the local, regional or state levels by markedly increasing the tipping fee per ton of garbage. At the national level, interstate transport of garbage and other wastes could be banned. All of these measures could easily be undertaken if biophilia were increased and materialphilia decreased.

In the United States (and doubtless other countries as well), there is significant resistance to remedial measures at all levels. Furthermore, some individuals will only reduce their consumption of material goods if others are forced to do so. This situation would require mutually agreed upon coercion (i.e. laws). Although the 'bottom-up' (at the individual level) approach to sustainable use of the planet is very appealing, the 'top-down' approach will probably be necessary since social change rarely keeps up with exponential growth of both population size and level of affluence.

Orr (1994, p. 133) states the dilemma quite well: human society must choose between biophilia and biophobia. Science and technology have provided the power to destroy completely, as well as the knowledge of the probable consequences of doing so. For most people, the attraction to material goods is much stronger than the attraction to living organisms. Sport utility vehicles (SUVs) require much more fossil fuel per mile driven than ordinary automobiles, but, ironically, they are often purchased to visit natural systems. The future of humankind will be strongly influenced by the balance society selects between biophilia and materialphilia.

CONCLUSIONS

The world's largest consumer of resources is the United States, a country that believes in the quick fix and is impatient with difficult, slow solutions. The quest for sustainable use of the planet will require much, much more than a quick fix. The transition from materialphilia to biophilia, an essential component of sustainability, will be slow and require almost infinite patience. Yet, it is likely to produce a raft of blessings for humankind.

Ultimately, the global vision of an unlimited economic cornucopia from which unlimited material possessions flow (materialphilia) must be altered to a vision of a mutualistic relationship with other life forms (biophilia). The technological means to accomplish this are available at present, and an ethical foundation for the new vision exists but is not widely accepted. The momentum of societal practices based on the acquisition of possessions may cause ecological damage beyond repair. Nature, of course, has already survived five periods of great species extinction, but the time span required for ecological recovery is so great that human society is unlikely to benefit. Nevertheless, the means to substitute sustainable for unsustainable practices are available and, if implemented expeditiously, might well make the vision a reality.

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Article 13

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Interrelationships between the Precautionary Principle, Prediction Strategies, and Sustainable Use of the Planet

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In this article, I examine the relationships between new concepts of human activity in the environment and several prevention strategies used to plot a course toward sustainable use. Natural capitalism and industrial ecology are relatively new concepts that provide a framework for environmental management. Although the precautionary principle puts into policy a determination to prevent environmental damage before it occurs, natural capitalism and industrial ecology go beyond the prevention of environmental damage to the optimization of environmental interactions. The risk assessment tools necessary for preventive management continue to be essential. However, additional tools are needed to go beyond prevention to optimization. A holistic, scientific approach to the human place within the environment is needed, including both interdisciplinary and large-scale research.

Key words: environmental management, natural capitalism, precautionary principle, prediction strategies, sustainability.

The increased rate and extent of change in both natural systems and human society increase vulnerability to serious environmental “surprises.” However, the number of environmental surprises may be significantly reduced by developing a holistic strategy that focuses on aspects of human society's relationship with natural systems. In this commentary I present a series of concepts for sustainability that are almost certainly linked, based on both case history and experimental evidence. Interrelatedness is assumed because the entire planet appears to be functioning as a single system (e.g., National Academy of Engineering 1997; National Research Council 1996; Odum 1989, Youngquist 1997). Ideally, these concepts would be more closely linked, but there is a good

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explanation for this situation. “Top down” research, that is, research that is based on the entire system, is not common. “Bottom up” research, that is, research based on the system components, is very common. This is true for most scientific research, including toxicology. One can make a case for using ecosystem services as toxicologic end points (Cairns 1995). Ecosystem health concepts are useful as management tools (Cairns and Niederlehner 1995). Finally, it should be possible to develop a field of landscape ecotoxicology (Cairns and Niederlehner 1996). These “top-down” approaches should be combined with the “bottom-up” approaches for a holistic view of an entire system at various levels of organization.

A major problem in developing predictive models for complex, multivariate systems is the possibility of discontinuities (a lack of continuity or the appearance of irregularities). System-level monitoring can provide an early warning of a discontinuity if it is well designed. One must assume that the systems being studied are sustainable in order to apply the precautionary principle effectively. This change in focus will involve determining which human practices are unsustainable and requires reexamination of methods of prediction, detection, and tolerance of risk. In this article, I examine the relationships between the reworked concept of humans in the environment and prevention strategies. The precautionary principle puts into policy a determination to prevent environmental damage before it occurs. However, natural capitalism and industrial ecology advocate going beyond prevention of environmental damage to a goal of optimizing environmental systems. Tools to implement these new paradigms include a holistic, scientific approach to the place of humans within the ecosystem, including both interdisciplinary and large-scale research combined with the traditional tools in risk assessment, such as threshold determination and biomonitoring.

Sustainable Use or Sustainable Development

The general aim of sustainability is to optimize use without abuse of the planet's ecologic life support system. In doing so, human society is attempting to provide for the needs of the current and future generations. But, it is far from clear that "sustainable use" or even "sustainable development" of the planet can be achieved. Both concepts are homocentric because each envisions perpetual occupation of the planet by one species over all others; the primary objective is perpetuating and improving the lot of humans and not the optimization of the integrity and health of the planet's ecologic life support system and natural capital. In contrast, sustainable use of the planet acknowledges human society's dependence on the planet's ecologic life support system in the form of natural capital and seeks to optimize a harmonious, mutualistic relationship between human society and natural systems (Cairns 1994).

It may be necessary to adopt new paradigms in which balancing the planet's technologic and ecologic life support systems is a primary goal (Cairns 1996). A promising new paradigm is natural capitalism (Hawken et al. 1999). Natural capitalism recognizes the critical interdependency between the production and use of human-made capital and the maintenance and supply of natural capital. The traditional definition of capital is accumulated wealth in the form of investments, factories, and equipment. In fact, human economy requires four types of capital to function properly.

- Human capital, in the form of labor and intelligence, culture, and organization
- Financial capital, consisting of cash, investments, and monetary instruments
- Manufactured capital, including infrastructure, machines, tools, and factories
- Natural capital, made up of natural resources, living systems, and ecosystem services.

Natural capital is the aggregate of all the systems in the biosphere. Natural capital is not only the

basis for other forms of capital but is the source of the ecosystem services that constitute the planet's ecologic life support system. At present, humankind's continuing progress is restricted by the decreasing fisheries brood stock, reduced by overfishing. Underground aquifers are being depleted more rapidly than the recharge rate because of the increasing efficiency of pumping technology. All the chainsaws in the world cannot compensate for the disappearance of primary forests, including topical rainforests. These are just a few examples of natural capital. Although natural systems are the source of desired materials, such as wood, water, and fish, they are also important because of the services they provide (e.g., Costanza et al. 1997). A forest provides services such as water storage and flood management. Healthy natural systems automatically supply services such as breathable air, quality water, rainfall, oceanic productivity, topsoil, and waste processing (both natural and anthropogenic). Natural capitalism advocates both protection and accumulation of natural capital; if natural capital is accumulating, less concern about protecting it may be appropriate. Enhancing natural capital forces human society to focus on practices that enhance the integrity of natural systems. One of the expectations of natural capitalism is that cumulative ecologic damage from harvesting natural resources would be markedly reduced.

A concomitant component of natural capitalism is industrial ecology (Tibbs 1992). Industrial ecology recognizes hybrid industrial-ecologic systems. Industrial systems are designed as interlocking artificial ecosystems that interface with natural systems. The human-made and natural systems are managed rather than artificially viewed as separate and minimally related. This change in view encourages changes in industrial processes so that they are more congruent with ecologic processes. All waste products from industrial production are designed to be reintroduced into natural systems as a useful resource to those natural systems, not merely as nontoxic waste. Because this approach requires attention to cycling, it can also serve as an early warning signal when industrial components are not congruent with ecologic processes.

Inherent in both natural capitalism and industrial ecology is the premise that human society will benefit from preventing damage to environmental systems before it occurs. Thus, the tools used in environmental management to predict and prevent damage come into play.

The Precautionary Principle

The precautionary principle focuses on preventing environmental damage before it occurs. The precautionary principle (Raffensperger and Tickner 1999) states

> When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.

The principle itself has support from the Third Ministerial Declaration on the North Sea that was signed by various North Sea states (NAVF 1990) and by the United Kingdom (Her Majesty's Government 1990), as well as the United Nations Rio Declaration (Cameron 1994).

The precautionary principle is a policy statement that the uncertainty inherent in a scientifically based assessment of risk should not negate management action. The precautionary principle becomes particularly important when dealing with problems of large temporal or spatial scales, such as global warming or human population growth, where uncertainties involved in prediction of risk are necessarily high and will remain so even with continuing research. Generally, there is less uncertainty and, consequently, less reliance on the precautionary principle for local, well-characterized risks and the intermediate levels in between.

Although science is viewed as the incontrovertible foundation for making policy decisions, sustainable use of the planet requires a dynamic interaction between science, social ethos, and policy. Environmental science can establish a baseline of the nominative state of natural systems and estimates of the stress caused by toxic chemicals, habitat alterations, climate change, and so on. From this information, predictive models can be developed. Precautionary measures will clearly depend on accurate information about ecologic thresholds and breakpoints that would cause disequilibrium. This will require effective communication between these three components. However, the societal ethos (or set of values) has not been clearly articulated, and policymaking has been confused by claims that the health and ecosystem risks have been exaggerated and that precautions to prevent harm have been exaggerated. Sustainable use of the planet requires that these essential interactions be improved.

Arguably, one of the strongest components of the precautionary principles is the emphasis on a comparative analysis of alternative courses of action. The goal is to determine whether each course of action is technologically and scientifically feasible and, if it is, what benefits, as well as the effects upon natural systems and human health and safety, are expected. It is not clear where the responsibility for this evaluation should lie. Many believe it is the responsibility of the national governments. For example, in the United States after the 11 September 2001 terrorist attacks, citizens were stunned to learn that the U.S. Federal Aeronautics Administration had never considered this possibility of terrorists using hijacked commercial airplanes in this way. Should the government be held responsible for not anticipating (or preventing) this attack?

There is a strong belief in some quarters that the precautionary principle is hostile to science. However, a large number of these statements appear in publications that are not peer-reviewed. In fact, the precautionary principle requires scientists to develop and improve the methods and procedures for studying complex natural systems, interactions of system components, cumulative effects, and the like. But the effort requires that both integrative and reductionist science (by specialists) ultimately be analyzed by a transdisciplinary group or team. One problem is the willingness of some specialists, government agencies, and industries to declare some chemical or course of action “safe” because the public demands a simple guideline. On the other hand, sustainability requires an understanding of very complex systems and the recognition that science does not fully understand the complexity of the natural world; consequently there will always be some degree of uncertainty. The precautionary principle was developed as a concept to defragment both science and policy. Jane Lubchanco (1998) (former president of the American Association for the Advancement of Science) stated the problem eloquently:

> The future is quite likely to involve increasing rates of change; greater variance in system parameters; greater uncertainty about responses of complex biological, ecological, social; and political systems; and more surprises.

In contradiction to the precautionary principle, many people believe in a potential technologic solution to every environmental problem. Under this assumption, damage to the environment is acceptable, because any resulting scarcity, discomfort, or death will motivate the technologic achievements that will relieve the problem (Myers and Simon 1994). Doubtless, the precautionary principle will not be implemented until there is a general recognition that there is not a technologic solution to every environmental problem caused by technology. In addition, while environmental goals may be multifaceted, it is not mathematically possible to maximize for more than one variable

at the same time (von Newmann and Morgenstern 1947). Yet, there is no global agreement on what should be optimized.

The precautionary principle leads to precautionary measures. When the goal is to prevent damage before the fact, active management of the environment is undertaken. These measures can include discharge limitations, restrictions on land use, protection of key ecologic components, or harvesting restrictions. Before any of these management actions take place, a scientific phase must be undertaken in which a risk is assessed. This assessment of risk often involves tools such as the determination of thresholds, application factors, and biomonitoring.

However, prevention of damage is a less ambitious goal than those expressed in natural capitalism and industrial ecology. The goal of optimizing both human-made and natural systems and their myriad interactions goes beyond that of preventing damage.

Prediction Strategies

Interdisciplinary. Tools to implement a management strategy that not only prevents environmental damage before the fact but also optimizes the place of humans in the environment must include a holistic, scientific approach. Such an approach must include both interdisciplinary and large-scale research that is combined with the traditional tools of risk assessment. This will be most effective if prevention opportunities were analyzed at the same time.

The age of specialization and reductionist science has solved many problems but has left society poorly equipped for estimating the outcomes of anthropogenic and natural stress upon both natural and socially complex multivariate systems. Human society places primary responsibility for the generation of knowledge upon its major research universities. However, these institutions may not be ideally structured for this pursuit. An emphasis on disciplines, rather than on issues, isolates individual professionals in a university spatially (housing by discipline), intellectually (different rites of passage for each discipline), and economically (some disciplines are "haves" and others are "have-nots"). One of the primary justifications for these isolating mechanisms is that each discipline has so much information to assimilate, and in many instances requires so much technical skill, that a high degree of specialization is essential to professional survival. Moreover, the best way to achieve professional status is to publish in a limited array of similar, specialized journals using a unique disciplinary language, often described by uncharitable outsiders as jargon. Communicating in a form understandable to the general public is regarded as "soft" science of low quality (Cairns 1993). Arguably, many of the difficulties that interdisciplinary teams experience in achieving a synthesis result less from ignorance of the components of the problem and more from viewing problems too narrowly in order not to lose status in their discipline. The situation is exacerbated when the problem involves both natural and social sciences or any two or more groups with little common ground.

The basic assumption of the holistic, interdisciplinary approach is that, by examining large systems, one assesses attributes not observable in the fragments or components of the system and also gains important insights into which components are "key" and most worthy of detailed study. This method is sometimes referred to as the "top down" approach. Its counterpart, the "bottom up" approach, or reductionist strategy, assumes that the more restricted the field of study the more fundamental it is and that, by robust understanding of the fundamentals or components, the nature of the system will become evident. The effectiveness of the "bottom up" strategy is always markedly diminished by variables only observable at the systems level. The "top down" strategy is often made less effective by reductionist bias and institutional barriers resulting from a disciplinary organization.

The quest for sustainable use of the planet involves enormous spatial and temporal scales; the spatial scale is global and the temporal scale involves an infinite number of human generations. Although assessing the relationship between human and natural systems is the primary challenge, risk assessment tools are also challenged by such a scale. An implicit assumption is that whole systems have attributes not held by species or other levels of biologic organization. For example, at the single species level, one cannot study predator/prey relationships, energy flow, or nutrient cycling.

Thresholds. The determination of thresholds is the most basic of risk assessment tools. Thresholds seek to define the degree of stress that biologic systems can tolerate without displaying observable symptoms of harm. In reality, both individuals and ecosystems have numerous thresholds that correspond to their many component structures and functions. It is also true that, in seeking significant thresholds for risk assessment for every potentially important response that is monitored, many more are not examined. Errors of omission and errors of extrapolation occur.

Most known thresholds were established by crossing them in designed experiments, including small-scale laboratory experiments, microcosms, mesocosms, and field enclosures. However, as the spatial and temporal scales increase, the system of interest may be too large for the testing methods available. If the goal is to preserve the integrity or health of a large system (e.g., a landscape or even the biosphere), present methodology is helpful but often indirect.

The hierarchical biologic scale from submolecular to molecular to cell to ecosystem to planet requires that the diagnostic attributes change with each level of biologic organization. Concerns may range from mortality in a population to nutrient export in an ecosystem or disturbance propagation in a region. However, information is often extrapolated from one hierarchical level to another with only the most primitive of models. For example, in a toxicity test with fish exposed to a chemical substance, one often determines the point at which half the organisms expired and half did not. One then multiplies the concentration thus derived by some fraction known as the "application factor" or some similar term to derive a presumably "safe" concentration. A major danger is that single disciplines will focus intently on their area of specialization and “keep the blinders on” to other aspects of environmental issues.

In small-scale, designed experiments, considerable replicability is possible. The same test will yield the same threshold again and again. However, any resulting assessment of risk has considerable uncertainty due to untested assumptions inherent in the extrapolation from the test result to a prediction of harm in the real world. Even a modest extrapolation from a fish lethality test to a prediction of community effects in a river receiving waste would be compromised by the necessarily small number of test specimens used, the inability to include even a small fraction of all conditions under which exposure might occur, and the small number of species tested compared to the large number of species exposed. Each extrapolation from the effect observed to the effect of interest in the larger world engenders errors and uncertainty (Mayer et al. 1987; Mayer and Ellersieck 1986).

The dose response has been a major component of toxicology and was once the crux of predictive strategy in many environmental areas. Most dose-response strategies are developed from single species laboratory toxicity tests with low environmental realism. Replication of single species toxicity tests is common, and usually there is a close correspondence. This is even true for multispecies tests using microcosms, mesocosms, and field enclosures. But these are not miniature ecosystems, but rather one or a few of the multitude of interlocking cause-and-effect pathways that characterize an ecosystem. Because of the complex, dynamic, multivariate systems involved (ecosystems), validation of predictions of effects in natural systems from any laboratory

test is problematic. As a consequence, thresholds are to ecosystem studies what the dose response is to laboratory toxicity tests. When a threshold is crossed, disequilibrium conditions usually develop in ecosystems. Thresholds are difficult to determine both in laboratory tests and in ecosystems (Cairns 1992). The dose response is important in estimating where the thresholds are, but not in estimating the ecologic consequences if the threshold is crossed. Holistic science requires the use of both in predictive strategies.

Thresholds may sometimes even be an artifact of the experimental practice (Cairns 1992). Still, the determination of a threshold, despite all the weaknesses and difficulties involved in determining how to use it, does provide a rough index of relative risk that can be used early in planning to include environmental concerns in initial design decisions for any activity related to sustainability. In contrast, the absence of any evidence regarding the location of critical thresholds and breakpoints is analogous to walking blindfolded in the dark near the edge of a cliff.

The analogy has some strengths, but is weak in several respects. Most important, because of various lag times or insensitivity of measuring methods and procedures, a critical environmental threshold can be crossed without being aware of it, at least immediately. Like the coyote in the roadrunner cartoons, we may run off the cliff and hang in midair long enough to contemplate our fate before plummeting. Second, ecologic thresholds are rarely static because they are altered by a wide variety of cyclic and episodic phenomena. Although ecosystems do not have the homeostatic mechanisms present in humans and many other creatures, which assist in keeping attributes like temperature or oxygen content of the blood within the nominative state, ecosystems may establish a new threshold rather than returning to the predisturbance condition. Ecosystems are dynamic, and consequently, management goals must be adaptive to be congruent with both normal variability and long-term trends.

Biologic monitoring. Biologic monitoring is intended to provide a feedback loop of information about the integrity and condition of natural systems so that remedial action can be taken when necessary. Biologic monitoring is surveillance undertaken to ensure that previously established quality control conditions are being met. Ideally, biologic monitoring is accompanied by chemical/physical monitoring. When properly designed, biologic monitoring can deliver useful information about the integrity and health of ecosystems (Cairns 2000, 2002; Cairns et al. 1982). Basically, in ecosystem biomonitoring, one is determining that crucial ecologic thresholds have not been crossed. The precautionary principle is intended to prevent a significant ecologic threshold from being crossed. In short, monitoring is both an early warning system for early detection of potential harm to ecosystems and validation (or invalidation) of prediction models. But early warning information has little or no effect without a management system capable of taking immediate corrective action. However, this management group must be literate in both toxicology and ecosystem structure and function. Biomonitoring, properly carried out, protects both natural capital and ecosystem services. Ecosystems provide economically valuable services at no direct cost. Biologic monitoring costs are justified to protect these economically valuable services.

Conclusions

The concept of the “commons” is rooted in the practices of the inhabitants of a group of privately owned houses surrounding an area for common use, but for which no individual is responsible. A simple example is a grazing area capable of supporting 100 head of cattle, so each of 100 families could have one cow without damaging the commons. However, if one family puts a second cow on the commons, they double their benefits but at the loss (damage to the commons) of all 100 fami-

lies. The classic paper on this subject is Hardin (1968). For the purpose of this discussion, damage to the global commons will occur if anthropogenic stress (e.g., pollution) reduces both natural capital and ecosystem services. Freedom to use the commons (e.g., the water, air, and land of Earth) must be accompanied by a responsibility to protect them. Thresholds and biologic monitoring are useful, especially when used in conjunction with the precautionary principle. Their effective use requires a clear statement of what human society is attempting to optimize. If sustainable development is the goal, a redefinition of the word "development" is in order. If sustainable use is the goal, it is essential to determine what present uses are unsustainable. Both terms may be too homocentric, that is, give inadequate attention to ethical obligations to life forms other than our own. If the goal is optimization of a mutualistic relationship between human society and natural systems, it is essential to begin discussions on just how this coevolutionary relationship will work. Some of the requirements that would be placed on human society will be unwelcome. As Hardin (Hardin 2001) noted, tragedy is the price of freedom in the commons. Unless freedom is coupled with responsibility, the tragedy of the commons will continue. However, one of the consequences of acting irresponsibly may be loss of individual freedom, if continuing environmental damage erodes quality of life.

Because most theories are eventually proven to be incorrect, limited to special situations, irrelevant, or inadequate, the quest for sustainability is probably just another transitional stage. Still, emphasis on a harmonious relationship between human society and natural systems appears more useful than merely preventing harm to natural systems. This premise is not intended to denigrate preventative strategies but merely to assert that what worked in the past may not be entirely adequate for the future.

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APPENDIX
ADDITIONAL READING

For those not well acquainted with the literature on sustainable use of the planet (also called sustainability and sustainable development), the following reading list should be helpful.

Cairns J Jr. 2002. Goals and Conditions for a Sustainable World. Oldendorf/Luhe, Germany:Eco-Ethics International Union.
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Article 14

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Repairing the Country's Ecological Infrastructure: The Cumulative Impact of Small Decisions

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KEY WORDS: Ecological infrastructure, Sustainable development, Sustainability, Biotic impoverishment, Environmentally benign decisions

INTRODUCTION

Aggregate small decisions exert a tyranny on the personal lives of individuals. Large numbers of people decide to drive on a particular highway at a particular time, and the result is a traffic jam. A hurricane, ice storm, or snowstorm is predicted and stores are depleted of flashlight batteries, foodstuffs, and the like. On a global scale, aggregate small decisions on the use of fossil fuels (particularly petroleum) substantially increases greenhouse gases (particularly carbon dioxide). Aggregate driving decisions, each insignificant on its own and generally localized, cause smog problems in Los Angeles and respiratory problems in Mexico City. Practically no attention is given to the serendipitous, beneficial effects of large numbers of environmentally benign decisions, which collectively might well result in a sustainable world and, at worst, will leave a more habitable planet for future generations.

Many citizens, even many biologists, are not particularly knowledgeable about the Atlantic white cedar. Even those well acquainted with the Atlantic white cedar may justifiably wonder if their efforts to restore it to some semblance of its former range and to improve management practices in its existing range will have a lasting, beneficial effect upon the bioregion in which it occurs and contribute significantly to the quest for global sustainable use of the planet and the desire to leave a more habitable planet for future generations. The answer to both questions is a resounding "yes" — if large numbers of similar groups concerned with the preservation and enhancement of ecological integrity of a wide variety of species and ecosystems contribute to an aggregate bioregional improvement and if sufficient aggregate bioregional improvements occur throughout the planet. The obstacles are unquestionably daunting because achieving such goals requires an enormous paradigm shift in human society's relationship with natural systems, which constitute human society's life support system and provide such services as maintaining the atmospheric gas balance. The consequences of a failure of the ecological life support system are appalling. For example, the Great Dismal Swamp is a unique and valuable ecosystem; failure to protect and enhance its ecological integrity in combination with large numbers of similar decisions elsewhere will have unfortunate, arguably catastrophic, effects on future generations of humans and millions of other species.

THE ATLANTIC WHITE CEDAR

If each generation accepts an additional amount of environmental degradation and loss of natural capital beyond the inherited state, the world will soon be biologically impoverished and inhospitable, and the biospheric life support system will cease to function adequately! Before the Civil War in the United States, the Atlantic white cedar was a favorite choice for roofing shingles, and boat builders were very fond of it because of its light weight and resistance to decay. At present, commercial uses are limited to specialty wood products, possibly because of short supply. One central issue then becomes: should society cease to protect a species because its commercial value has declined, because no immediate commercial use is foreseeable in the future, or because the biodiversity of species in the planet's ecological life support system is not appreciated as it should be? The white cedar requires nearly full sun and saturated soils. Ecological perturbations, such as catastrophic canopy fire and stress from saturated peat, are thought to be requirements for regeneration. Although clear-cutting does partially mimic natural environmental perturbations and allows some degree of regeneration, the ecological similarities between catastrophic fire and clear-cutting are minimal. No species should be considered in isolation from the ecosystem it inhabits, and while commercial value is assessed one species at a time, this approach is not sound for ecosystems because they have value both as a source of natural capital and as a provider of ecosystem services. While individual species may provide identifiable ecosystem services, the interdependent web of life is responsible for the particularly valuable services such as maintenance of atmospheric gas balance and transformation of nonhazardous wastes into additional natural capital. Ecosystem services are best considered by looking at the system that the Atlantic white cedar inhabits — swamps. One of the important ecosystem services that Atlantic white cedar swamps provide is storage of carbon as peat. Other services are discussed in more detail elsewhere in this symposium through the three prime focuses: (1) what strategies should be employed to ensure the continuation of the ecosystem services that are the basis of the planet's ecological life support system? (2) if each generation accepts the amount of ecological destruction that present generations are accepting, how long will the planet remain habitable and the quality of life acceptable? and (3) does human society have an ethical responsibility toward the other species on the planet beyond treating them as commodities and respecting them only for their commercial value?

THE SERENDIPITY OF ENVIRONMENTALLY BENIGN DECISIONS

The late William T. Odum (1982) of the University of Virginia produced a world-class paper entitled "Environmental Degradation and the Tyranny of Small Decisions." It was inspired by a paper from economist Alfred E. Kahn (1966) based on the economic impact of aggregate, small decisions. Both of their observations are based on the same phenomenon — the aggregate impact of seemingly insignificant, small decisions. Collectively, these small decisions (taken in the aggregate) tyrannize people by stealing time, fraying nerves, and disrupting schedules. Road rage merely increases the tyranny and the personal risks resulting from aggregate small decisions. Similarly, it is possible to drive a species to extinction one tree at a time. Should society become upset about the loss of one American white cedar? Becoming enraged is a difficult position to justify if only one particular tree is considered rather than the aggregate loss caused by large numbers of similar decisions to ignore the loss of one tree.

A flip side exists to the tyranny of small decisions — there is a serendipity of aggregate, environmentally benign decisions, each seemingly trivial and unimportant on its own, but in sufficient num-

bers the collective ecological protection and improved integrity of natural systems can be enormous. Society must keep this viewpoint constantly in mind when confronted with seemingly unmanageable environmental problems such as global warming. The collective impact of numerous, environmentally benign decisions at a particular place and time can reverse seemingly irreversible trends. This consequence is particularly evident in the case histories discussed in the National Research Council's (1992) book *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy.* When large numbers of people support environmental protection and ecological restoration, they usually are successful, even against seemingly overwhelming odds and obstacles. This support is being successful elsewhere in the world as well. The Chinese are revegetating the upper drainage basin of the Yangtze River, which will reduce erosion of soils and increase the life expectancy of the Three Gorges Reservoir by reducing the silt load being deposited behind the dam. The densely populated Netherlands has restored an ecosystem, including reintroduction of large mammals, in an area quite close to sizable population centers. Mass marketing revolutionized the industrial world, and mass concern about the fate of natural systems will revolutionize human society's relationship with them. At symposia such as this one, we must never lose sight of this possibility.

CONNECTIONS

People who consider themselves environmentalists are fond of affirming their "respect for the interdependent web of life" of which they are a part. This step is the first one on the long path toward environmental literacy — only a first step, not the final destination! The use of the word *respect* implies that the decision is optional. However, if humans are part of the interdependent web of life, then damage to the web threatens and impairs an individual's well being, ultimately even survival. Respect in this context is a weak, unsuitable word! If humans are part of the interdependent web of life, then they are dependent upon it! In short, there is no technological substitute for the biospheric/ecological life support system. If there is no technological substitute for the planet's ecological life support system, and if lives depend upon its functional well being, why not come directly to the point and acknowledge dependence upon it? Human activities are causing extinction of species, damaging the interdependent web of life, and threatening the life support systems by producing persistent toxic chemicals that disrupt endocrine systems and have a multitude of other deleterious effects. Anthropogenic artifacts (shopping malls, highways, etc.) are also displacing natural systems at an unsustainable rate.

Connections are the key factor in the interdependent web of life and the quest for sustainable use of the planet requires that human society examine these connections and become increasingly literate about them. Of course, absolute literacy is far beyond the capabilities of an individual, nation, or even of most organizations. For the Atlantic White Cedar Management and Restoration Ecology Symposium, establishing as many of these connections as possible has another component — it will draw in people who were unaware that their special interests are interlocked with the Atlantic white cedar management program. The downside is that it will inevitably be attacked by those who perceive their interests are threatened by the Atlantic white cedar management program. The overriding factor is that anything that threatens the integrity of the planet's ecological life support system threatens everyone, regardless of their special economic or other interests. None of these considerations seemed important during the frontier society or eras when vast unexplored territories existed in the United States. Then, the planet seemed infinite. At present, however, anyone who has failed to find a parking space realizes all too vividly that a finite planet with finite

resources and a finite ecological life support system is being damaged or destroyed at a rate unprecedented in human history.

Almost certainly, critical connections of the Atlantic white cedar, Great Dismal Swamp, etc. to other parts of the bioregion will be disclosed at this symposium. A few illustrative examples follow.

(1) Connections to other parts of the Americas

Many species of birds, particularly migratory birds, have enormous routes from their summer nesting grounds to their wintering grounds with stopovers in between. Twice annual migratory flights are especially stressful, not only with regard to the distance involved but also the hazards encountered en route. The elimination or degradation of habitat at any component of this system, including the beginning and the end, vastly increases the already hazardous journey. Bird watchers are particularly sensitive to migratory route damage, and it would be enlightening and educational for those interested in the Atlantic white cedar management to develop ties with citizens of other components of the migratory route of at least one representative bird species. This connection would be a particularly valuable experience for students at all levels of the educational system.

(2) Water and air sheds

Air and water pay no attention to political boundaries. The extensive, deliberately set fires of the last few years in Indonesia have adversely affected not only their own country but areas such as Thailand, well beyond its borders. Water management practices on the Colorado River have seriously diminished both the quantity and quality of the water reaching the Sea of Cortes. According to the British Broadcasting Corporation (BBC), land management practices in Mozambique have exacerbated the flooding problems, as have similar bad practices in the neighboring countries of Zimbabwe and Zaire from which water flows into Mozambique. If Sudan decided to dam the Blue and White Nile Rivers to provide water for irrigation to supply additional arable land and the consequent agricultural products for a growing population, Egypt would be deprived of water badly needed for its agricultural irrigation and the nutritional needs of an ever-growing population. The likelihood of war will be vastly increased if this scenario develops; war would increase the refugee problem in Africa and elsewhere. Food shortages will produce environmental refugees if the food supply does not keep pace with the population growth. Distant as these places are, Virginia is connected to them and the fate of its residents is linked to theirs, and all the connected human fates are linked to the fate of the environmental life support system.

HUMAN POPULATION SIZE AND PER CAPITA ECOLOGICAL FOOTPRINTS

The United Nations estimates that the population of the planet will double in the next 40 years. During my lifetime (77 years), the population of the world has more than doubled. Exponential growth simply cannot continue on a finite planet! Odum (1996) asks a key question: “Does human population growth spur economic development or strain it?” One might reasonably assert that rapid population growth has no economic or other benefit because social and environmental problems are created faster than they can be solved. Odum (1996) uses Egypt as a Malthusian microcosm in which the promise of technology (such as dams, high-yielding cultivars, and the like) simply discourages any attempts to limit population growth. Biwas (1993) notes that, between 1900 and 1990, arable land in Egypt increased from 5.5 to 7.5 million acres as a consequence of the construction of the Aswan dam, which permitted irrigation of dry land. However, during the same period, Egypt’s population increased from 10 million to 50 million; thus, per capita arable land decreased from 0.5 to 0.1 acres. Even though increased yield, which provided more food per acre, was a factor, Egypt still has to import food to provide its people with even the barest essential diet.

Exponential growth "won" over technological advances, as it usually does. In fact, on a finite planet, it is difficult to visualize ways in which exponential growth can ever be ignored or beaten in the long term.

Arguably, simple population size is less important than the size of the per capita "ecological footprint." Wackernegel and Rees (1996) have developed a method of calculating the environmental impact of an individual (or country) in terms of consumption of energy, material goods, and the like. For example, the United States, with a fraction of the world's total population, uses approximately 25% of the energy and material resources of the planet. The U.S. per capita ecological imprint is very large indeed, as is that of Canada and, to a lesser extent, developed countries in Europe and Asia, such as Japan. One might think that the size of the ecological footprint is directly correlated with the quality of life, but this is simply not true. The state of Kerala in India has a tiny per capita ecological footprint compared to the per capita footprint in the United States and Canada, yet the life expectancy is only slightly below that of the U.S. and the literacy rate is fractionally higher. A very important point exists in these statistics. When the world resource crises begin to be severe, it will be easy to denigrate the importance of preserving the integrity of the Atlantic white cedar ecosystem. One can almost write the statements: "Of course I support the preservation of the Atlantic white cedar in principle, but is it as important as _____?" Fill in the blank: economic development, creation of X number of new jobs, providing a site for a new industry, a new shopping mall, etc. However, the Atlantic white cedar ecosystems are an integral part of Virginia's ecological heritage. They are "umbrella species" whose protection inadvertently protects a host of less visible but essential species that inhabit the same ecosystem. Sacrificing an ecosystem to provide a simple way to address short-term emergencies is simply bad management. It requires little or no administrative skills and is unquestionably a zero sum game where there are always winners and losers. Skilled management requires more effort, multidimensional management skills, and, ideally, leads to a win-win situation in which both natural systems and human society benefit. Make no mistake, the Atlantic white cedar ecosystem will be repeatedly threatened by single-dimensional, one-objective managers who are becoming increasingly obsolete in a multidimensional global society. This situation will persist until a paradigm shift occurs in which natural capital is acknowledged as the primary source of human society's wealth without which technological development would not be possible (Diamond 1997).

RESTORING THE NATION'S ECOLOGICAL INFRASTRUCTURE: AIR, LAND, WATER, AND WILDLIFE

Most individuals take the delivery of potable drinking water for granted, as they do the ability to move from one spot to the other without paying tolls or enduring interminable delays. The American society expects enormous quantities of solid wastes to be removed from households (where it would soon constitute a health and space problem) and placed in some remote spot, preferably "not in my backyard" and more preferably far distant from the household. American society also expects a wide variety of food to be delivered in fresh condition, even in densely packed cities thousands of miles from where the food was produced. These and many other services are the result of having a very extensive series of pipes, transportation systems, etc., which collectively are termed *infrastructure.* This system is, in a sense, a technological infrastructure because much of it depends on engineer-designed and operated facilities. Former President George Bush, when he signed a national transportation bill, focused attention on the need to repair the country's crumbling infrastructure. At the end of the last century and the beginning of the present century, Vir-

ginia's legislative system has focused much attention on the need to repair and maintain the public highway system. However, preserving, maintaining, and restoring the state's and country's ecological infrastructure has not received comparable attention. This neglect has happened despite the fact that the well being of human society, particularly in the United States, has been based upon *natural capital,* namely the natural resource infrastructure that provides life-sustaining ecosystem services (such as maintaining a breathable atmosphere, nutrient cycling, waste transformation, water purification, solar energy capture, materials for bioengineering, and production of food, fiber and other raw materials so essential to the economy). Natural ecosystems have been providing such services free since the beginning of human history and, as a result, the ecological infrastructure is less noticed and less appreciated than the technological infrastructure, although both represent human society's life-support systems. Although much has been made about the declining birth rate in many countries (e.g., Eberstadt 2000), the world's population continues to grow (in 1999, it passed 6 billion) and will continue to rise until the middle of the present century for complex demographic reasons. Even a particular state or country with a birth rate well below replacement rate will probably not see a marked population decline because of increased human longevity, immigration, decreased infant and other mortalities, and the like. The United States, for example, is particularly accessible to inhabitants of countries with birth rates far higher than replacement rates, and the longevity of American citizens has increased dramatically over the last century.

A growing population, for whatever reasons, means less ecosystem services per capita unless ecosystems are better repaired and maintained than they are today. Furthermore, as Hawken et al. (1999) have shown, natural capitalism is the basis for the new emerging sustainable economy and practically all future economic growth, which they describe as the next industrial revolution. Fortunately, most industry, engineering, and many business persons are taking sustainable use of the planet seriously. For example, Hawken's (1993) book *The Ecology of Commerce* shows how environmental sensitivity can be coupled with substantial profits. The National Research Council (1996), which is the operating arm of the US National Academy of Sciences and the US National Academy of Engineering, has linked science and technology to society's environmental goals. *Time* (2000) magazine published a special edition commemorating Earth Day 2000 in which Ford Motor Company's advertisements focus on explicit environmental issues such as going solar, air quality, making parts for cars from soybeans, environmental consciousness, and the like. In addition, Nattrass and Altomare (1999) provide a persuasive discussion of how profit can go hand-in-hand with sustainable development. And last, but far from least, Anderson's (1998) book provides superb leadership in persuading the business community to operate more sustainably. Courageous books such as Common's (1995) show the limits to conventional economics in considerable detail, and books such as Luhrs' (1997) are increasingly popular on college campuses and among a significant minority of the general population. Raffensperger and Tickner (1999) have extensive discussions of the idea that when an activity raises threats of harm to human health and/or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically. Stated simply, the precautionary principle challenges human society to use reason and intelligence to act wisely and well when the consequences of not doing so may be catastrophic for human society, even though scientific "proof" as interpreted in courts of law is not robust. In a very real sense the precautionary principle shifts the burden of the proof to those making profits by exploiting the common grounds to prove that they are doing no harm rather than requiring persons who question their actions to do so. As is often the case in major paradigm shifts,

adopting the precautionary principle has been difficult, arguably negligible, despite an increasing body of rhetoric showing justification for it. Some governments, particularly in Europe, and the United Nations have adopted the precautionary principle in principle but have not implemented it in any significant way.

Natural systems do not care if humans live or die, and natural systems do not seek to make a connection with them. Humans must take the responsibility of making a connection with their life support system because the consequences of not doing so will, at best, cause much human suffering and at worst result in a horrendous reduction of human numbers, even extinction of the species. Some discussions (*Time* 2000) provide a general status report on various components of the environment showing, for example, that the situation for freshwater is grim, while the impetus in other cases for remedial action is strong but somewhat less than urgent. Nevertheless, it is foolish to choose a part of the environment that is in dire need of attention and neglect the rest because the parts are all interconnected. Water quality and quantity is, in large part, a reflection of the surrounding land use management, and disruption of the hydrologic cycle by means of human artifacts, such as dams, canals, transfer pipelines and the like, can produce many unintended and largely unforseen deleterious effects.

The big question is whether human society can facilitate a paradigm shift without first suffering horrendous consequences. Birth rates are falling over much of the developed world, but, even so, the world's population will keep growing until at least mid-century, possibly beyond. Many of the world's peoples, arguably as many as half, are living on such marginal incomes that getting to the next day, let alone getting to the next decade, is their primary focus. In affluent societies, materialism is dominant, although sustainable use of the planet is receiving increasing support. Human health and ecosystem health are closely coupled. Human society is dependent on ecological support systems and will suffer if they are not in robust condition.

Ultimately, the health of the country's ecological infrastructure will depend on a huge number of local and regional decisions. The future of the Atlantic white cedar is a prime example of the "small" decisions which, in the aggregate, will determine whether human society can develop a sustainable, harmonious relationship with the planet's ecological life support system. A biologically impoverished world with an unhealthy ecological life support system will be neither sustainable nor desirable. However, not taking local and regional responsibility for the Atlantic white cedar and its counterparts elsewhere could produce such a world.

GLOBAL BIOTIC IMPOVERISHMENT

Worldwide biological systems are in decline, which is clearly the result of the aggregate effects of a vast multitude of small regional and local decisions. In mid-year 2000, Mayor Giuliani of New York City was reported by the news media as advocating use of pesticides to control mosquitoes that transmit the West Nile virus, which has proven fatal to some humans. His statement reportedly included the admission that he values humans above fish, worms, and other creatures. However, some of the species that will almost certainly be adversely affected by applications of pesticides will be ones that prey on mosquitoes and reduce their numbers substantially. Without the natural biological controls that will be eliminated by the pesticides, even more pesticide control for mosquitoes will be necessary.

People regularly express empathy for their fellow humans, even if the expression of this empathy results in the destruction of other creatures. Willingness to destroy biological components of the environment is just another part of a multitude of actions resulting in biotic impoverishment and

which are generally justified either in terms of progress, economic development, empathy for other humans, or all of these together.

THE INDEPENDENCE FROM NATURE MODEL

All humans and all societies behave as they do because they have a certain mental model about how one should act and how things should be. In its simplest form, the most dangerous mental model is that humans are independent from natural systems and that they can domesticate or dominate the parts of nature that are important to them. Domination is certainly not true for the many disease-causing organisms that are becoming ever more resistant to antibiotics; AIDS; the gypsy moth in eastern United States; the Asian clam throughout the United States and many other parts of the world; the zebra mussel; cockroaches, house flies; mice; rats; fruit flies; and a long, long list of other organisms.

White-tailed deer were not a serious problem in the eastern United States in the middle of the 20th century and were, in fact, unknown in some areas where they are now considered pests. However, human society eliminated their predators, and they are now a problem on highways and are eating vegetation at Gettysburg National Memorial Park and in most suburban areas. Human society creates pests by reducing or eliminating their biological controls and by providing habitats that enhance the well being of the pests. Unlike human society, "pest societies" do not have unemployment. Human dominance and control are an illusion, which is why the pesticide manufacturers flourish, but the pests do not disappear.

A dangerous component of this mental model is that, because of creativity, technology, and ingenuity, humans no longer depend on nature's services. Preliminary estimates of the monetary value of ecosystem services (such as a breathable atmosphere, etc.) are in the trillions of dollars (e.g., Costanza et al. 1997). However, attempts to convert ecosystem services into conventional economic valuing and terminology miss the primary point: there are no substitutes for most of these services and how does one truly value something that is irreplaceable? The misconception is that nature's services will continue to human society at no cost, no matter what humans do to natural systems.

The mental model of an independence from nature is difficult to disprove. On a global scale, an ecological threshold would have to be crossed that would result in ecological disequilibrium and disruption of ecosystem services which, in turn, would cause enormous human suffering as well as suffering of other life forms. McNeill (2000) discusses in considerable detail the giant, uncontrolled experiment on planet Earth that the human race has undertaken in the 20th century. During the 20th century, environmental transformations have occurred at both a rate and a scale unprecedented in human history. One or more crucial environmental thresholds may have already been crossed that are placing ecosystems into disequilibrium and disrupting the delivery and reliability of ecosystem services. Many of the effects of human society upon natural systems are nonlinear, and, additionally, many thresholds and breakpoints exist. The likelihood of crossing one or more thresholds under these conditions is quite high and will require close observation to reduce the number of surprises. Since both individual and institutional behaviors are resistant to change, remedial action will probably be tardy, reluctant, and often fiercely resisted. Every area of the planet has one or more symbolic species, such as the Atlantic white cedar, and, if society's empathy for symbolic species is heightened, the consequences of crossing an ecological threshold will almost certainly be significantly reduced. There are three sets of conditions that are likely to produce unexpected crossings of critical thresholds.

Discontinuities

Humans can drastically alter nature, but less well recognized is that nature can disrupt human society. Cairns and Bidwell (1996a,b) discuss some abrupt shifts (discontinuity) in previously stable states in which nature has adverse effects on human society. The abruptness will not necessarily be apparent on scales to which humans are accustomed but rather may be on geological, evolutionary, or other quite different and larger scales that apply to natural systems.

Sometimes discontinuity appears to be extremely abrupt, such as the rapidity with which many disease-causing organisms develop resistance to antibiotics. The AIDS epidemic has made behaviors once regarded as acceptable (at least in some human societies) as now life threatening and is causing major demographic discontinuities in Africa. The scale of the discontinuities may also vary from a worldwide climate shift resulting from anthropogenic greenhouse gases to a regional increase in pollution levels that threatens the Atlantic white cedar.

Synergistic Effects

Environmental toxicologists have known for many decades that interactions of heavy metals and other toxicants can produce an effect significantly greater than their individual additive toxicities. However, these synergistic effects are not limited to toxicants. For example, increasing the temperature of the tundra may cause additional release of methane, which is a much more powerful greenhouse gas than carbon dioxide. This release could increase the greenhouse effect, leading to even greater release of methane and further increasing the temperature. Synergistic effects are particularly difficult to cope with because they are difficult to predict until they are observed. Once they occur, conditions that were “safe” in isolation from other conditions often have severe consequences synergistically.

Undetected or Unnoticed Trends

Most natural systems are both cyclic and highly variable, thus making early detection of a new trend difficult. As a consequence, early warning systems designed to detect changes from normal condition are likely to produce both false positives (indicating a change is occurring when it is not) or false negatives (indicating no change is occurring when in fact one is). Experience reduces but does not eliminate the number of false positives and false negatives. A limited number of false positives are beneficial because, like fire drills, they discover imperfections in the drill. However, if their frequency is too great, a signal of danger may not produce action because it is viewed as another false alarm. The old folktale of the boy who cried wolf so frequently that the villagers ignored his cry and, thus, were unprepared when the real wolf appeared remarks on this danger. False negatives are arguably far worse than false positives because they signal that everything is normal when it is not.

EXTERMINATING OUR RELATIVES

Various groups of indigenous peoples the world over refer to other species as their relatives. This conceptual model is an appropriate one because it demonstrates empathy for other species separate from economic calculations of species as commodities or, to use the more common term, natural resources. Expressed in terms possibly more appropriate to the present, it is acceptable to use ecosystems in a sustainable way but not to abuse them in a non-sustainable way. The three most basic human needs are food, warmth (in the form of shelter or clothing or both), and water. Restrained harvesting for food and warmth on a sustainable basis is acceptable, but overharvesting that leads to extermination of species is not. Similarly, destroying habitat that leads to the extermination of a species has the same consequences as directly exterminating a species. Last, but

not least, as Cousteau (2000) states, “There is only one body of water on our planet Earth, constantly traveling from one river, to one lake, to one ocean . . . The sea is a bonus to us all, soothing climates, washing beaches, feeding animals and people, connecting nations together, pregnant with resources of all kinds, but still sensitive and vulnerable.” Water ecosystems are not just fluids; they are living systems that can be impaired, injured, and transformed into debits rather than assets. Cousteau (2000) notes that convincing people to protect the environment by reasoning alone is essential but not sufficient: “... but now we need a more active army of people who love the sea, who understand that there is no life without water. And that we have to put all our efforts in saving whatever we can for future generations.”

The quality of life is not determined by material possessions once the basic needs have been satisfied. Destroying other creatures to accumulate material wealth, if done by everyone on the planet, will leave future generations with an inadequate ecological life support system and a quality of life dramatically diminished from the present one. What is needed is a paradigm shift that respects and honors the white cedar and the habitat it requires. Replacing it and its habitat with human artifacts, if done for other species and habitats on a worldwide basis, will eliminate any realistic chance for sustainable use of the planet and for a quality life for future generations. In a worst possible case scenario, the ecological life support system could be placed in such a degree of disequilibrium that the planet becomes inhospitable to humans.

CONCLUDING STATEMENT

Just as an inappropriate conceptual model of the relationship between human society and nature can lead to numerous individual acts that are seemingly insignificant in isolation from others but will collectively still further damage natural living systems, a series of different individual acts, seemingly insignificant in isolation from others, can in the aggregate preserve natural systems and the integrity of the biospheric life support system. This conceptual model will give the current and future generations an opportunity to develop a sustainable relationship with natural systems.

There will almost certainly never be a court trial for the crimes of human society against the biosphere, but the consequences of the actions of human society will be more severe than any court judgment could be. Empathy for natural systems begins with those habitats that are best known, such as the habitat of the Atlantic white cedar. With good fortune, the empathy will extend to habitats worldwide with the hope that the human societies associated with them will develop a strong empathy to protect their integrity and condition. Respect and esteem for habitats worldwide will result in sustainable use of the planet. Disrespect and disregard for habitat integrity and well being will likely result in an inhospitable planet and will definitely lower quality of life for present and future generations.

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Article 15

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The Re-emergence of Multidimensional People: A Consilience of the Disciplines

John Cairns, Jr.

Sustainable use of the planet by humanity is an admirable goal that may be achieved if a sufficient unity of knowledge is reached and acted upon with reason and intelligence. Wilson (1998) has resurrected the word *consilience*, literally "a leaping together of knowledge," as used by William Whewell in his synthesis *The Philosophy of Inductive Sciences*, published in 1840. In this vein, one need only look at the stationery of the Renewable Natural Resources Foundation to find persuasive evidence that a wide variety of professional disciplines can function effectively when they have a worthwhile unifying theme. Regrettably, such multidimensional organizations are rare. However, to achieve sustainable use of the planet, they must become more common.

To function effectively, multidimensional organizations must have multidimensional people who excel at synthesizing the evidence from a variety of sources. Interdisciplinary activities require a free and open exchange of information and ideas among the disciplines. However, the interdisciplinary group must do more than exchange information — it must synthesize it. This goal, in turn, requires feedback loops among the disciplines that both affects the program design of each component and facilitates the integration of information as well.

Academic disciplines are artifacts of the age of specialization, but are in reality narrow views of a seamless continuum. A charitable person will call attention to the effective role of the disciplines in controlling the quality of both practitioners and hypotheses. An uncharitable person might well describe them as a series of petty fiefdoms, each with its own tribal language (i.e., technical jargon), rites of passage, professional journals, space on campus, budget, and other isolating mechanisms that impede effective interactions with other disciplines. In stark contrast to this fragmented system, it is impossible to find a single, major problem of the global society that does not transcend the capabilities of a single discipline. As a consequence, academic institutions have reluctantly accepted (at best) and fiercely resisted (at worst) the emergence of interdisciplinary teams on their campuses.

Arguably, the most important role of the disciplines in interdisciplinary efforts is quality control. It is unlikely that any individual can be proficient in every area; however, confidence in the evidence provided is essential. Without an enormous effort at quality control in every component, the final product will be misleading or worthless. The quality control of the synthesis must be a joint effort carried out both by interdisciplinary team members and several multidimensional individuals with integrative experience.

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Being on an interdisciplinary team is hard work. One must maintain high standards in one's discipline and be acutely aware of the operational prerequisites of other disciplines as well. One must also ensure that the results are presented in a form intelligible to policy and decision makers, who often will not be skilled in any of the disciplines represented on the team. Many such professionals now exist, but not nearly enough to implement goals and conditions for sustainable use of the planet. Society usually depends on the educational system (especially public universities) to fulfill such needs, but tax dollar support has been decreasing, and public universities are increasingly dependent upon two sources of revenue — student fees and extramural funding (Slaughter and Leslie 1997). Ideally, students should participate in interdisciplinary activities for educational credit. Two of the most important lessons are: (1) transcending disciplinary boundaries and (2) how much uncertainty can be tolerated in each component in order to make an informed professional judgment. Most professional positions now require some interaction with other disciplines, and students who are headed for the work force must be educated on this interaction before they enter the job market. The focus on the problems created from unsustainable practices is accelerating the development of an interdisciplinary perspective, although progress is still glacially slow on all of the world's critical environmental issues.

In 1948, my mentor Ruth Patrick ventured into interdisciplinary activities after years of specializing in diatom taxonomy. I was a member of one of her two teams. My "elementary education" consisted entirely of observing her. I ventured into the interdisciplinary arena, with the blessing of my major professor Dr. David Wenrich and my graduate committee, before acquiring the PhD. But the joy and excitement of interacting with colleagues in other disciplines has increased over the years to the point where I have difficulty responding to the question, "And what field are you in Professor Cairns?"

I applaud the appearance of the many interdisciplinary journals and the close association and interaction of the professional societies that constitute the Renewable Natural Resources Foundation! These organizations are superb examples of what must be done to achieve sustainable use of the planet. I believe the Renewable Natural Resources Foundation is on the cutting edge of the path toward sustainability and am honored that an organization that has been engaged in activities I admire has given me this award! Receiving the 2001 Sustained Achievement Award from the Renewable Natural Resources Foundation is a moving experience because it comes from colleagues who share my belief that sustainable use of the planet is a worthwhile goal. Thank you from the bottom of my heart!

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Article 16

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Philosophical reviews: introduction

The following paper is the first in a new series of invited philosophical reviews from international leaders in the field of toxicology and industrial health. These papers are intended to raise questions and evoke new ideas. It was further agreed that the topic and how it is addressed should be left only to the author, with review of the article limited to a panel of peers who would judge only readability and editorial accuracy. The information presented is based on the authors' individual expertise and experience. We hope our readers will enjoy this new, insightful approach in addition to the traditional laboratory and epidemiological reports provided in Toxicology and Industrial Heath*. The following paper by Dr John Cairns is the first in this series. It is thought-provoking, stimulating and holistic in nature, consistent with Dr Cairns and his numerous contributions to science and humankind.*

Ron Hart, Editor

Ecotoxicology and Sustainable Use of the Planet

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The goal of sustainable use is indefinite use of the planet by humankind. This objective, in turn, requires that the planet's ecological life support system, consisting of natural capital and ecosystem services, remains healthy for an indefinite period. Achieving sustainability will require a new view of the responsibilities of professionals, such as ecotoxicologists, to ensure a healthy ecological life support system. Because both human society and natural systems are complex and multivariate, a high degree of uncertainty will remain. Therefore, sound judgment will be needed in determining what, if any, precautionary measures should be taken until more robust information has been gathered.

The role of ecotoxicologists in the quest for sustainable use of the planet is quite varied: 1) shifting goals and endpoints from an absence of harm to persuasive evidence of health; 2) increasing both temporal and spatial scales of ecotoxicological studies; 3) achieving a critical mass of qualified personnel, 4) including demographic change in ecotoxicological analysis and judgment, 5) developing new ecological thresholds, 6) being prepared for environmental surprises, 7) focusing on design for a quality environment, 8) developing ecosystem services as endpoints in ecotoxicological studies, and 9) being prepared for climate change and other events that might destabilize the biosphere and require major adjustments in the process of ecotoxicological testing. Both sustainable use of the planet and the field of ecotoxicology are rapidly developing fields that are mostly evolving in isolation from each other. To be successful, they must co-evolve.

Key words: *ecological thresholds; ecosystem services; ecotoxicology; industrial ecology; natural capital; role of ecotoxicologists; sustainability*

Personal background

While still a graduate student in 1948, I was employed as a protozoologist on one of Dr. Ruth Patrick's two aquatic survey teams studying the effects of pollution on aquatic organisms in the Conestoga River Basin in Pennsylvania. The teams were evaluating the effects of pollution upon aquatic organisms, from bacteria to fish, as well as water quality. When summer ended, I was offered a permanent position in the Academy of Natural Sciences in Philadelphia.

Since free-living protozoans do not preserve well and other groups do (except bacteria), especially in low densities with much debris, I had free time while the other members of the crew were identifying preserved specimens. I minored in chemistry and physics in college, so when Dr W Hart (Atlantic Refining Research) offered the equipment with which he, Doudroff and Greenbank had developed one of the first standard methods for toxicity testing with fish, I accepted with alacrity, but with some apprehension about my ability to master this strange new field. Since then, I have worked on toxicity testing and benefited greatly: I was connecting field and laboratory studies; tests were extended to include algae and invertebrates, which provided some insights into differential responses and the need to modify testing procedures for different groups of aquatic organisms; I was in contact with chemists, engineers, and other waste treatment personnel,as well as industrial executives and regulatory professionals; and since the most interest in this research was expressed by engineers and chemists, I published research results extensively in their journals, which broadened my perspective considerably.

As the survey team examined polluted areas of the Conestoga River Basin, the idea of repairing ecological damage was always present. Patrick had diverted water from Ridley Creek, Pennsylvania, to a newly dug channel of about 300 meters, which had riffles, pools, and 'slack' water similar to the main creek. This water was quickly colonized by organisms from the main stream, although it took a few months for it to resemble the diversity and community structure of the main stream. This experiment showed that, in the absence of stress from chemical substances, industrial waste discharges, and the like, natural recovery could be quite rapid if sources of recolonizing organisms were in close proximity. This exercise illustrated quite well the connection between ecotoxicology and restoration ecology (e.g., Cairns, 2002a), which, regrettably, have not developed the close relationship one might expect.

This research also stimulated my interest in aquatic community colonization dynamics (Cairns *et al.*, 1969; Dickson *et al.*, 1971), which was extremely helpful in ecological restoration. Eventually, community colonization dynamics also became useful in ecotoxicology. The research used polyurethane artificial substrates to study colonization in streams and lakes, so that the time the substrate had been in the water was precisely known. Using naturally colonized substrates from aquatic ecosystems permitted testing of entire communities of protozoans (e.g., Niederlehner *et al.*, 1990), algae, and macroinvertebrates (e.g., Dickson *et al.*, 1971). Placing uncolonized substrates in with colonized substrates enabled colonization rate to be used as an ecotoxicological endpoint. It was even possible to place a container with a substrate in a stream, with a means of delivering minute (compared to stream volume) amounts of substrate and also let researchers study processes with natural variations of light and temperature (Arnegard *et al.*, 1998). These methods helped validate results of laboratory tests under more environmentally realistic conditions.

Another form of validation of laboratory tests was development of a monitoring information system designed to provide an early warning of deleterious effects occurring in natural systems. Rapid information systems were important, so computer interfacing (Almeida *et al.*, 1978) with biological and chemical test systems was developed (Cairns *et al.*, 1970), laser holography was used to iden-

tify diatoms very rapidly. The primary purpose of these monitoring systems was to determine if previously established quality control conditions were being met. The goal of these monitoring systems was to enable humankind to use natural systems without abusing them. Theoretically, use without abuse could go on indefinitely — that is, sustainable use of the planet was at least possible, but required replacing unsustainable practices with sustainable ones. Easier said than done!

During the last part of my career, especially after age 65, I have spent much time seeking a concept that would provide a framework to which my entire life's work could be attached and linked. The concept of sustainable use of the planet is the ideal framework. At first, I favored the term *sustainable development* to describe this concept, until it became evident that its quick acceptance was the result of associating development with growth (i.e., highways, shopping centers, parking lots, and the like). This type of development is clearly impossible on a finite planet since this growth has already caused a dramatic loss of natural capital. If humankind succeeds in using the planet for an indefinite period (i.e., by using but not abusing natural capital), it will be because unsustainable practices are abolished. *Sustainable use* is a much better term because it focuses on appropriate use rather than development. I expect to spend the remainder of my professional life investigating sustainable use of the planet.

Connections

Both the policies and practices of sustainable use of the planet commonly encounter substantial difficulties and obstacles in implementation as a consequence of the involvement of many special-interest groups. Exacerbating this difficulty is the fact that sustainability is not simply a question of preserving the planet's ecological life support system and developing sustainable technologies, but the issues involve socio-cultural systems or political components that expect to optimize their component. Thus, the cultural context (often multi-cultural), social organizations, and societal learning processes must be understood and taken into account. The inevitable tensions between various groups require integrated social science approaches as well as classical science. The goal is balancing public and private responsibilities, such as balancing economic and technological development with the protection of the planet's ecological life support system. I have described the goals and conditions for a sustainable world in a free internet book (Cairns, 2002b) and have provided a preliminary evaluation of the ethical components of sustainability (Cairns, 2002c,d; 2003a).

Sustainable use of the planet envisions perpetual use of a large multivariate system (the world). This objective simply cannot be accomplished in a fragmented way — special-interest groups, individual disciplines and professions, or political components cannot expect optimization of their component. To be effective, connections, communication, and teamwork must be present among and between the components. This situation is not one-time-only, but rather a situation that must become the norm for sustainability to be achieved.

Top-down/bottom-up strategies

The basic assumption of any holistic, interdisciplinary approach is that, by examining large systems, one assesses attributes not observable in the components or fragments of the system and concomitantly gains critical insights into which components are 'key' and thus worthy of more detailed study than non-key components. This method is commonly referred to as the top-down approach (Cairns, 2003a). Its counterpart, the bottom-up approach or reductionist strategy, assumes that, the more restricted the field of study, the more fundamental it is and that, by robust understanding of the fundamentals or components, the nature of the system will become evident.

The top-down strategy is often considered less effective due to a reductionist bias on the part of scientists who generally began as specialists and also to institutional barriers resulting from an organization dominated by individual disciplines (Cairns, 1993a). It is becoming increasingly clear that an effective consilience (literally leaping together; Wilson, 1998) of the disciplines is especially essential for sustainable use of the planet.

Co-evolution

As humankind progresses toward sustainability, major changes must occur in both human society and the field of ecotoxicology. Since these two entities must work together effectively, they must co-evolve so that all interactions are mutually beneficial. Furthermore, mutualistic interactions must occur between and among the multitude of important component professions and special-interest groups. This type of interaction is unprecedented in human history, but so is sustainable use of the planet. At the same time, the disciplines, such as ecotoxicology, must maintain the quality control of methods, procedures, personnel education, and data analysis that are the backbone of any scientific discipline.

The role of ethics

Ethics or ethos is a set of guiding values and/or moral principles. The primary values for sustainability are: 1) a dedication to posterity (i.e., leaving a habitable planet for future generations); 2) a commitment to preserve and enhance the health and integrity of the planet's ecological life support system (i.e., consisting of natural capital and ecosystem services); 3) a promise of use of natural systems without abusing them; 4) a policy expressing the determination to prevent environmental damage before it occurs (i.e., the precautionary principle).

The precautionary principle is a policy statement based on a value judgment that the uncertainty inherent in a scientifically based assessment of risk should not negate management action. Precautionary measures will clearly depend on accurate information about ecological thresholds and breakpoints that, if exceeded, would result in disequilibrium. Regrettably, societal ethics (or set of values) have not been widely articulated (Cairns, 2003a).

Ethical or value judgments are made constantly, but usually they are not labeled as such: giving money to this or that organization, spending time repairing or building for the disadvantaged, etc. Sustainable use of the planet will require ethical decisions at all levels, from individual to community to eco-region to nation-state to all of humankind at the global level. The inescapable situation is that growth in continuing human population size and the use of natural resources are unsustainable on a finite planet.

Natural capital and ecosystem services

Natural capital and ecosystem services are at the heart of the role of ecotoxicology in sustainable use of the planet. Nature's wastes are used, with some exceptions, by some part of the natural system other than the component that produced them (Hawken, 1993). Although some species produce particularly toxic materials, they are not commonly or widely distributed and are not usually persistent. Other species have evolved a variety of means of avoiding exposure. Industrial wastes are not likely to have value to other species and may be deleterious, even fatal, to them.

The concept of industrial symbiosis (or mutualism) with natural systems involves modeling industrial systems along the lines that are characteristic of natural systems. This concept requires that the industrial system be viewed in harmony with natural systems rather than in isolation from

them (e.g., Graedel and Allenby, 1995). If waste products from anthropogenic activities are beneficial to natural systems, then society has no need to bury wastes or transport them from the site of generation. This challenge will greatly expand the role of ecotoxicologists and require many new methods and procedures. As a consequence, wastes become an economic asset cycled through a system that consists of a web of previously isolated components. A frequently cited example of this new industrial ecology is in the Danish industries of Kalundborg (e.g., Tibbs, 1992; Hawken, 1993; Gradel, 1999). Instead of discharging waste water into the environment, other beneficial uses are found for it by other organizations. This system is both economically and environmentally beneficial. The agreements between the discharger and the second-use organization are worked out voluntarily by the institutions involved.

Natural capital consists of resources, living systems, and ecosystem services. Natural capitalism recognizes the critical interdependency between the production and use of human-made capital and the maintenance of natural capital (Hawken *et al.*, 1999). Traditional definitions of capital deal with accumulated wealth in the form of investments, factories, and equipment. The present industrial system uses human capital (in the form of labor, intelligence, culture, and organization), financial capital (cash, investments, and monetary instruments), and manufactured capital (infrastructure, machines, tools, and factories). These three forms of capital are used to transform natural capital into the material goods humankind takes for granted, such as televisions, food, highways, power plants, and the like.

The present concept of economic growth places the development of human artifacts at a much higher priority level than the preservation of natural capital. The price of destruction of natural capital is becoming increasingly high. A new goal for ecotoxicologists will be to maintain and accumulate natural capital and ecosystem services (e.g., Cairns 2003b).

A useful metaphor is to regard natural capital as money in the bank and ecosystem services as interest on this capital. Reduce the capital and accumulation of interest is lost. Increase natural capital and these services (i.e., interest) increase. Their monetary value is staggering (e.g., Costanza *et al.*, 1997). Dailey (1997) provides a comprehensive discussion of ecosystem services, and Cairns (1994) makes the case for using ecosystem services as toxicological endpoints. Even at present, the effects of toxicants upon ecosystem services can be estimated (Cairns and Niederlehner, 1994; Cairns, 1995).

A major component of natural capitalism is the hybrid industrial-ecological system (Tibbs, 1992). These systems are designed as interlocking artificial ecosystems that interface harmoniously with natural systems. Rather than view industrial and ecological systems as separate and minimally related, these hybrid systems encourage changes in industrial processes so that they are more congruent with ecological processes. Because this approach is based on mimicking natural cycles, it can also serve as an early warning signal when industrial components are not congruent with ecological processes. Using such information effectively will require a flexible approach from regulatory agencies. Inherent in both natural capitalism and industrial ecology (hybrid systems) is the premise that humankind will benefit from preventing damage to environmental systems before it occurs. Thus, the methods and procedures used in environmental management to predict and prevent environmental damage become critical.

Who pays?

Humankind has received ecosystem services free for all of human history. Despite the damage done to natural systems, it will be difficult for most people to imagine paying for ecosystem ser-

vices. There is now no means of estimating with high confidence where critical thresholds and breakpoints in natural systems are. Some people, probably most people, will not believe these thresholds exist until some important ones have been crossed with severe consequences. In the past, great difficulties were encountered in persuading citizens and government officials that cigarette smoke harmed human health. In that case, individuals who smoked cigarettes suffered, and, later, some evidence indicated that even secondhand cigarette smoke had deleterious effects. However, if the global ecological life support system (GELSS) malfunctions, all humankind will suffer, and individuals will find it impossible to avoid the consequences. During this transition period between taking the GELSS for granted and acknowledging humankind's dependence upon it, ecotoxicologists should be developing methods and procedures so that they will be partially prepared when they are called upon to maintain the health of the GELSS. At present, there is little realization that the planet's ecological life support system is at risk.

Self-preservation is a powerful motivator, but the idea of leaving a habitable planet for posterity should also be compelling. Science, including toxicology, is supposed to be value-free in order to be considered scientific. However, there is nothing unscientific about determining the conditions that facilitate sustainable use of the planet and those that undermine it. Even selecting ecotoxicological endpoints/thresholds is not value-neutral. Regrettably, it has been fashionable in recent years to regard values in a relativistic way. In short, saying that values are "good" and others "bad" is considered, by some people, to be inappropriate. A society that favors sustainable use of the planet is not a value-neutral one that leaves to the individual the decisions about which practices are unsustainable and which are not. Sustainable use of the planet will depend more on informal processes than on law. Adaptive management cannot be based on coercion but must depend on a consensus about values and goals. In the USA, prohibition of alcoholic beverages between the first world ware and the second failed because most members of society did not regard prohibition as a social norm. A society relying on a social norm does not need the coercive measures of the nation-state. The relativistic position, the view of not judging others, especially the conduct of those in other cultures, is not defensible in a finite world with more and more people and rapidly decreasing resources.

Ecotoxicological goals

One standard business school faculty statement is 'the corporation belongs to all who invest in it.' How should ecotoxicologists invest in the quest for sustainable use of the planet?

1) Ecotoxicologists should examine their value system (i.e. ethical position) and agree, as a profession, on the shared values. For example, do humans value leaving a habitable planet for future generations (Cairns, 2003c)?
2) If sustainable use of the planet is an important goal, some means of integrating top-down (system level) and bottom-up (component level) strategies must be developed. A well thought out ethical position will provide a good framework for this process (Cairns, 2003d).
3) Since both natural capitalism and industrial ecology are important components of sustainability, the role of ecotoxicologists in these areas must be well developed (Cairns, 2003b).
4) Ecotoxicology studies the effects of anthropogenic stress upon complex, multivariate natural systems. Ecological restoration, a developing field, studies the process of rehabilitating natural systems that have been altered by anthropogenic stress (Cairns, 2002e). Although these fields have developed essentially in isolation from each other, they must be integrated if sustainable use of the planet is to become a reality (Cairns, 2003e).

5) Once ecotoxicological goals have been set and steps taken to achieve them, a monitoring system must be in place to determine the degree to which the goals have been met. Monitoring is defined as surveillance undertaken to ensure that previously established quality control conditions have been met. Monitoring should be closely linked to the endpoints and thresholds in ecotoxicology. This system will be the acid test of the predictive capabilities of ecotoxicology.
6) The goal of developing a natural systems level capability will require ecotoxicologists to add extensive research in landscape level systems to the existing methods and procedures (i.e., microcosms, mesocosms, and field enclosures). One of the inevitable consequences will be a marked reduction in replicability due primarily to the increased number of variables involved. Landscape level systems research will also involve working continuously with a variety of other professions, special-interest groups, and governmental agencies. An additional complication will be the need to use hybrid industrial/ecological systems being operated for a profit. Each of these will have some unique attributes, but there should be a large number of similarities as well. Some case histories are provided in Hawken (1993) and Hawken *et al.* (1999). Such case histories are not yet common, but those available do illustrate that natural resource savings can be impressive. Furthermore, employees appear to favor these systems because of their naturalistic atmosphere.
7) Ecotoxicologists must learn more about the planet's ecological life support system. For example, until natural pollinators of agricultural and other plants had a significant decline, most US citizens had no idea what an important ecosystem service they provided. If ecotoxicologists are to play an informed role in the quest for sustainable use of the planet, they must learn more about the planet's ecological life support system. Since most professionals began and persisted in carrying out research with system components, rather than with the entire system, the transition period will be difficult. At the same time, research on the components should not be neglected, because sustainable use of the planet requires both top-down/bottom-up sustainability strategies.
8) Ecotoxicologists should begin research on how hybrid industrial/ecological systems and buffer zones can be used to determine threshold responses at the systems level. Inevitably, some accidents will occur at such sites (such as equipment failure, chemical spills, and errors in predictive models), which will, if properly studied and monitored, provide information not available from the single species laboratory tests low in environmental realism and high in replicability.
9) All disciplines, including ecotoxicology, must engage in transdisciplinary communication. This communication means not only informing other disciplines about the fundamentals of ecotoxicology, but also finding out about the fundamentals of other disciplines. Additionally, decision makers, legislators, and the general public must be informed as well. This necessitates hard work but does provide a multitude of benefits. Since most of the world's major problems, including achieving sustainability, cannot be addressed by a single discipline, there will be many opportunities for those familiar with transdisciplinary work. However, a penalty may be attached for engaging in transdisciplinary activities and communicating with other disciplines. Some individuals will charge that, unless one knows everything in one's discipline, one should not attempt to carry out transdisciplinary activities. While this argument may well be true for some highly specialized persons, top-down sustainability strategies will not be successful unless some professionals develop a holistic view. On a personal note, it seems advisable to me to remain active in one's original discipline because pure generalists are not well accepted by specialists. There is justification for this strategy because, without considerable understanding of the specialists' problems, generalists will not use their data effectively.

Another important downside exists to attempting transdisciplinary activities — per-unit-of-effort status is more quickly achieved by placing all one's effort into a single, highly specialized area. A major contribution to some field of science is always essential, but is more readily appreciated by other specialists in the same field. Effective transdisciplinary communication involves a less focused effort over a broad area, including not only other disciplines but non-scientific special-interest groups as well (e.g. Cairns, 1993b).

The twentieth century was characterized by specialization and divergence within and between the traditional disciplines. Economic growth, as practiced at present, is embraced without properly estimating the costs of degrading the planet's ecological life support system or even caring much about the situation. Humankind's activities are not viewed in a holistic way, nor has there been, until recently, any inquiry into which activities are not sustainable. For example, natural systems cannot be destroyed at the present rate, or, all too soon, none will be left except a few token nature preserves and natural parks.

The twenty-first century will be one of integrative science and knowledge of activities that affect the ecological life support system. A global economy promotes efficiency and cheaper material goods and enables some countries, such as the USA and Japan, to expand beyond the limits of indigenous resources. Theoretically, the global economy gives nation-states a stake in each other's political stability. However, the free movement of capital and material resources tends to drive the benefits of labor toward the lowest global level. Worse yet, some nation-states sacrifice natural resources in order to remain competitive.

Assistance must be given to nation-states that lack adequate numbers of ecotoxicologists and other environmental professionals. Additionally, ecotoxicologists must go beyond avoiding the symptoms of toxic stress on natural systems and focus on maintaining them in a healthy condition for optimal function for reliable delivery of ecosystem services. In a very real sense, ecotoxicologists will be going beyond preventing symptoms of environmental stress to being environmental quality control professionals whose goal will be robust ecosystem health. This strategy will favor accumulation of natural capital and reliable delivery of ecosystem services.

For the first time in history, humankind dominates ecosystems worldwide and affects all of them. Ecotoxicologists must not only reduce stress on these systems, but must also help redesign societal wastes so that they can be recycled into natural systems in ways that enhance their integrity. Hybrid industrial/ecological systems should be very useful in achieving this desirable goal.

Humankind has been creating a future that has never been rigorously discussed or debated. A robust debate about sustainable use of the planet should remedy this regrettable situation.

Sustainability opportunities for ecotoxicologists

The following suggestions are not intended to replace existing ecotoxicological methods and procedures, but to expand ecotoxicological capabilities so that ecotoxicologists can make an even greater contribution to the quest for sustainable use of the planet.

1) Develop methods and procedures to determine ecosystem health and function;
2) Develop a quality control monitoring system to provide an early warning of a decline in ecosystem health and to validate the robustness of predictions of ecosystem health and condition;
3) Improve the integration of viewpoints (i.e., individuals, communities, landscapes, eco-regions, and nation-states) that differ significantly in terms of scale (e.g., temporal and spatial). Cairns (2003d) proposes ethics as a way to use words at different organizational levels, such as scale, in a consistent way;

4) Assist in the development of protocols that optimize the self-regulatory capabilities of natural systems;
5) Develop protocols that increase the compatibility of humankind's economic system and the natural economics system to facilitate sustainable use of the planet. The human free market economic system is self-regulating, as are natural economic systems. Despite this important similarity, attempts to integrate the two systems have been minimal. Ecotoxicologists can help in this process by focusing on long-term assimilative capacity issues;
6) Improve the use of their information by indicating the scale at which it was generated and how it influences issues at other scales;
7) Play a major role in determining the assimilative capacity of natural systems for anthropogenic wastes and by reconfiguring these wastes so that they benefit natural systems;
8) Require that no materials be produced that are harmful to natural systems. Without healthy natural systems, sustainable use of the planet by humankind is not a realistic goal. Ecotoxicologists must play a major role in achieving this goal. The disincentives for continuing use of unsustainable practices must be more clearly communicated to the general public.

Conclusions

Sustainable use of the planet provides a superb opportunity for ecotoxicologists to interact with other professions and interest groups and to develop a dynamic relationship with two other dynamic systems that must achieve a harmonious relationship. This challenge will mean an unprecedented growth rate, even for a very rapidly developing field. At stake, however, is the future of human society as it is known. The urgent need of change to achieve sustainability is not yet generally appreciated. Ecotoxicologists should remember that they have a responsibility to educate those not familiar with ecotoxicology with the use of the information they generate.

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Article 17

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Sovereignty, Individuality, and Sustainability

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ABSTRACT: Humans must acknowledge that the biosphere is the essential support for all living organisms. In order to achieve sustainable use of the planet, humans must proceed beyond egocentrism, ethnocentrism, homocentrism, and biocentrism to ecocentrism. National states, with present policies, are a major obstacle to sustainable use of the planet. However, there is some evidence that the individual has increasing sovereignty at the expense of both nation states and the environment. Still, the primary obstacle to sustainability is inherent in the present system of sovereign nation states. The basic question is how much sovereignty must nation-states and individuals relinquish to preserve the health of Earth's biospheric life support system. A free and open exchange of thoughts on this subject is long overdue. To achieve sustainable use of the planet, humankind must view its identify within the context of the interdependent web of life.

KEY WORDS: Sustainability · Sovereignty · Individuality · Eco-ethics · Natural systems

> *The universe rewards us for understanding it and punishes us for not understanding it. When we understand the universe, our plans work and we feel good. Conversely: if we try to fly by jumping off a cliff and flapping our arms the universe will kill us.* Cohen & Stewart, 1994

> *We like to believe that if we secure adequate data bearing on a scientific problem, then anybody with normal intelligence who takes the trouble to become acquainted with these data will necessarily arrive at the same conclusion regarding the problem in question. We like to speak of conclusions demonstrated, settled, proved and established. It appears, however, that no evidence is powerful enough to force acceptance of a conclusion that is emotionally distasteful.* Dobzhansky, 1945

INTRODUCTION

Earth's carrying capacity for humans may well be exceeded in the 21st century due to both population growth and rapidly increasing use of resources. Sovereignty of both individuals and nation states is destructive of the interdependent web of life of which humans are a part. Sustainable use of the planet will probably require rethinking the autonomy of both individuals and nation states, as well as the acknowledgment of interdependence. Humankind can survive only if a new concept called eco-ethics is generally accepted (Kinne 2003).

The planet contains a large number of nation states, each with its own idiosyncratic history, stage of technological development, biogeochemical identity, and relationship with natural systems. All must orchestrate sustainable use of the planet in ways that are congruent with the rest of the world. Efforts to assist or coerce laggard nation states are likely to have a perverse effect and provoke resentment instead of gratitude. There are many reasons why a major global crisis may result in continuation of unsustainable practices as powerful nation states attempt to maintain the status quo. Any nation state that believes itself capable of 'going it alone' is likely to resist any major global undertaking such as sustainable use of the planet. Most nation states persist in a secular view of the world because joining a global community effort is perceived as a loss of identity and national prerogatives. This exacerbates the problem because there is a tendency to focus on 'urgent' (from its perspective) short-term problems and ignore long-term problems (from a global perspective). This euphoric arrogance ignores the fact that the planet is too complex and multidimensional to focus on one issue as if it were independent from other issues. In sustainable use of the planet, interconnectedness must be central to all decisions and the implementation of these decisions. The present world is one in which advanced technology is being used in an ethical framework that is, at best, two or three centuries behind the technology. This is a very dangerous paradox in an era when economic and technological growth are worshipped and ethics or ethos rarely mentioned. The Random House Dictionary, 2nd edition, defines sovereign as 'a person who has sovereign power or authority or a monarch; a king, queen or other supreme ruler.'

Clearly, most people associate sovereignty with nation states and rarely with individuals, although the latter have acquired more independence in recent years. It is difficult to visualize increased individual sovereignty in an era of resource scarcity since humans are dependent upon Earth's ecological life support system, and, on an increasingly urbanized planet, most people are dependent on outside sources of food, energy, and materials.

Davidson & Rees-Mogg (1997) describe a new revolution of power, which they feel is liberating individuals at the expense of nation states. They make a case for this fourth stage of human society, preceded by three earlier stages of economic life: (1) hunting-gathering societies, (2) agricultural societies, and (3) industrial societies. Despite negative reviews by some prominent newspapers (e.g. The Wall Street Journal) and other news media of this and other publications, I found this book well researched and well reasoned. However, their vision was difficult to reconcile with sustainable use of the planet. Humans evolved as a small group species, and the analysis of Davidson & Rees-Mogg (1997) is compatible with this viewpoint, but not with the gigantic groups that exist today.

Sustainable use of the planet is based on the assumptions that:

— a harmonious, mutualistic relationship can be developed between human society and natural systems
— individuals will not abuse the commons (i.e. natural capital) but use it equitably and fairly, including sharing of resources with other species in the planet's ecological life support system
— sustainable resource allocation and partitioning will continue indefinitely and, thus, leave a habitable planet for future generations
— the taboo common to most social orders, which forbids thinking about how they will end and the degree to which present practices will affect the end, will be banished
— society will abandon an outmoded cultural paradigm rather than retain a facade that gives the illusion of continuity

— natural capital will be preserved and accumulated even at the cost of human privation during 'hard' times because it constitutes the ecological life support system essential to the well being and survival of human society
— some group or organization must transcend what economists term 'public goods dilemmas' (e.g. Ledyard 1994) to protect natural capital in the commons and on private property, including restraining and punishing individuals who impair the ecological life support system
— violence (i.e. terrorism, war, ethnic and religious conflict, etc.) must be kept to a minimal level. The advent of biological weapons of mass destruction has made violence prevention extremely difficult, arguably impossible. Durant & Durant (1968, p. 81) noted that, in the last 3,421 years of recorded history, only 268 have seen no war. Of course, war is not the only manifestation of violence
— human society must more closely resemble natural systems in which the most productive individuals do not subsidize the less productive, especially if the latter have an exponential rate of population increase and the former (productive) do not.

THE TYRANNY OF CUMULATIVE, SMALL DECISIONS

Individuals make a series of small, seemingly insignificant decisions daily. However, the cumulative impact of these decisions can destabilize both human society and the planet's ecological life support system and affect happenings from global warming to congested traffic. In the context of this discussion, the important outcome is the reduction or loss of sovereign power by both individuals and nation states. The resulting tyranny is clearly beyond the control of individuals unless they act in concert and probably beyond effective control by nation states because they lack the power to police such a multitude of individually small decisions. The concept of carrying capacity is a perfect example of cumulative impact at a global level. The basic issue is the carrying capacity of the planet for *Homo sapiens*. However, each nation state must stay within its carrying capacity, as must each of the political and ecological subdivisions within it. At present, there is a misapprehension that the problem is only global, and the subunits have no major role. This erroneous assumption is one of the major obstacles to achieving sustainable use of the planet.

CARRYING CAPACITY — A COMMUNAL EFFORT

Immigration, both legal and illegal, affects carrying capacity. Kavanaugh (2002) notes that illegal immigrants number at least 7 million, possibly 8 million, and are growing by 500,000 per year according to the US 2000 Census. More than 7 million tourists, business visitors, foreign students, and temporary workers arrived in 2001 as non-immigrants. However, the US Immigration and Naturalization Service acknowledges that it lacks a reliable tracking system to determine how many of these visitors left the country after their visas had expired. Under these circumstances, i.e. the US cannot reliably determine how many people are in the country or control the number of illegal immigrants or how this number will increase in the future, determinations of carrying capacity are exceedingly difficult, arguably impossible. Furthermore, in an exponentially growing population, the indigenous peoples can exceed the carrying capacity in a century or less. Reference is made to indigenous peoples to emphasize that carrying capacity is both a global and local problem. The global problem cannot be resolved unless the geographic, political, and ecological subunits solve the carrying capacity problem. Immigration into the US is a major factor in global carrying capacity for two reasons — (1) if present rates are continued and the immigration birth rate is higher than that of the general population, the US will be quickly pushed beyond its carrying capacity, and

(2) the US and Canada have the largest ecological footprints on the planet, that is, per capita use of resources is very high; if immigrants reach a comparable level of use, there will be a much greater effect on the planet's carrying capacity than now exists. Thus, a large number of seemingly insignificant decisions to migrate or have a large family can adversely affect carrying capacity and endanger, even tyrannize, an entire population.

A number of countries have a birth rate below replacement rate (e.g. Russia, Italy), but world population continues to increase by approximately 80 million per year. On a finite planet with a finite carrying capacity, this growth is not conducive to sustainability. The most populous nation, China, is approaching population stabilization by means of peer pressure and sanctions.

THE MYTH OF RUGGED INDIVIDUALISM

The term 'rugged individualism' is used to illustrate the myth that individuals are self-sufficient and not dependent upon the planet's ecological and technological life support systems. This myth is very dangerous since it fails to recognize the marked interdependence at all levels of organization from individual to community to state or province to nation state to planet.

Cultural dogmas impede the quest for sustainable use of the planet, for example, the belief that humans have conquered nature. The tremendous technology developed in the last century has deliberately or inadvertently destroyed or degraded ecosystems worldwide. On the other hand, numerous species (called pests) defy attempts to eliminate them or control them, and other species have been domesticated to serve humans. Culture has placed humankind on a higher plane than the brutish 'lower' organisms. However, as Ehrlich (2000) has noted, the evolutionary processes that created humans also created an astonishing array of other organisms that both surround humans and support them. More important, these other life forms were responsible for generating the most important features of the environments that in turn have shaped the evolution of humankind. During the quest for sustainability, humankind will shape nature and it, in turn, will shape human culture. As Kahneman (1980) remarks, 'The increase in man's power over his environment has not been accompanied by a concomitant improvement in his ability to make rational use of that power.' Thus, errors in judgment during the quest for sustainability will shape human culture as well as sound judgment.

THE COMPOSITION OF ETHICAL SYSTEMS

Usually, ethical systems are focused on the values of one species — *Homo sapiens*. Generally, ethical concerns are extended beyond the human species if other life forms are perceived as valuable to humans. Species other than human are perceived as valuable because they collectively constitute the planet's ecological life support system. As ecological literacy increases, sentient organisms are recognized as valuable in and for themselves. The next step is to go beyond organisms, and affection and concern may be extended to special places and/or systems such as landscapes, old growth forests, coral reefs, or prairies. The major weakness of ethics at present is that humans get the most attention while the ecological life support system gets the least. Fortunately, publications have been formulated that will facilitate this transition. Daily & Ellison (2002) provide a superb documentation of the utility of nature. Wilson (2002) espouses quick and decisive action to save Earth's biological heritage and explores the ethical and religious basis for doing so. Orr (1992) analyzes what governments, corporations, utilities, international agencies, and individuals can do to facilitate the transition to sustainable use of the planet. Particular attention is given to what schools, colleges, and universities can do to assist in the transition from unsustainability to sus-

tainability. In short, what should people know and how should they learn it? Odum (1997) discusses how the field of ecology has matured enough to be viewed as the basic science of the total environment. Since ecology is an integrative science, it can serve as a communication 'bridge' between science and society.

Three books have influenced my thoughts about the quest for sustainable use of the planet. Torrance (1998) has produced a superb compendium of ways in which humankind has understood and represented the natural world. The unifying theme is the ethic resulting from the possible relationships with nature. Hauser (2000) provides some excellent insights that should markedly reduce anthropomorphosis. It illustrates how animals are adapted to their ecological niches and provides information that should increase the empathy of humans for other life forms. Brown (2001) depicts an environmental revolution that could follow the industrial revolution and that is driven by humankind's instinct for survival. Central to his model is discarding the paradigm that views the environment as a subset of the economy and replacing it with the view that the economy is a subset of the environment.

WE ARE DEFINED BY THE QUESTIONS WE ASK

Both individuals and societies are defined by the questions they ask, the questions they avoid, and how they respond to stochastic events. Among the questions are 'Can an individual or species be sovereign?' and 'What should the role of humankind be in the interdependent web of life and how dependent are humans upon it?'

Plato said 'The life which is unexamined is not worth living.' Psychologist PC McGraw (2001) wrote 'You need to know your highest best use in this world, and then to pursue it.' He further states 'You cannot change what you do not acknowledge.' The Random House Dictionary states that 'to define' is 'to explain or identify the nature or essential qualities of'. The questions we ask define us, not nation states or rugged individuals. Illustrative, defining questions about sustainable use of the planet are: (1) How can I learn to live sustainably? (2) Which of my present practices are unsustainable?

Is an individual ever sovereign? The US is regarded as the world's only superpower, yet it cannot control either the illicit flow of large amounts of drugs or immigrants into its country. This situation fits the hypothesis of Davidson & Rees-Mogg (1997) in which individuals are liberated at the expense of the nation state. However, even the most liberated individuals are still vulnerable to stochastic events such as earthquakes and global climate change. Wealth is often associated with power, but even the wealthiest individuals are dependent on other individuals for food and protection and on the planet's ecological life support system for a favorable maintenance of atmospheric gas balance and other ecosystem services.

Illustrative unasked questions

The questions that follow are rarely asked by nation states, rugged individuals, businesses, or most of human society. Failure to ask appropriate questions will ensure the continuation of unsustainable practices. The questions are a response to the failure to live sustainably. It is important to recognize that the time frame for these questions is whatever length of time humans expect to live on habitable planet.

— How will finite Earth's carrying capacity be determined? Two obvious means of doing so are: (a) exceeding the carrying capacity and increasing human misery and (b) estimating the carrying capacity using quality of life indices.

— How will the conditions necessary for sustainable use of the planet be enforced? Since sustainability is both a local and a global issue, enforcement will be a major problem unless individuals accept a major responsibility for implementing the quest for sustainability.
— How will individual 'rights' be affected by the quest for sustainable use of the planet?
— If the planet's carrying capacity for humans is exceeded, what organization will be responsible for the return to sustainable use?
— How much of the planet should be set aside for natural ecosystems?
— How will the health of the biospheric life support system be monitored?
— How will planetary biodiversity be maintained?
— If the human population size and level of affluence keeps changing, how will the resources needed by humankind's descendants be estimated? If both population size and level of affluence (i.e. use of resources) continue to increase and the disparity between the wealthiest and poorest individuals continues to widen, what remedial measures should be taken? Durant & Durant (1968, p. 57) conclude that the concentration of wealth is both natural and inevitable and is periodically alleviated by violent or peaceable partial redistribution. The distribution of resources questions may be one of the major obstacles to sustainable use of the planet.
— What organization will be responsible for confirming that the conditions for sustainability are being met? Individuals respond best to meeting conditions that will favor themselves, their family, and their state or nation. The further the issue is removed in either time or cultural ties (i.e. family and friends), the less attention it gets. A strong dedication to eco-ethics is essential since sustainable use of the planet is supposed to continue for an indefinite period of time, benefit future generations, and preserve natural capital (including millions of species other than humans) and the condition of Earth's ecological life support system. An important subsidiary question concerns how this organization will be supported.
— How will disputes about the conditions of sustainability be met? Science and technology are important factors in achieving sustainable use of the planet, but ethical and moral values are also important in determining both the planetary and human condition. In addition, the system must respond quickly to any and all changes in the conditions needed for sustainability.
— How will the social capital[1] essential to sustainable use of the planet be preserved and increased? The extreme, sovereign individual may view the self as independent of or in control of human society. In a less extreme form, the sovereign individual may feel no need to foster and accumulate social capital.

Illustrative asked questions

Understandably, most of the asked questions have short time horizons, often only hours or days: What should I wear today? What should I have for lunch and dinner? For those in the US, will Social Security be financially sound when I retire? Some of these questions are important in the temporal scale for which they are made — e.g. should I pass the vehicle ahead of me on a curve in the road where the visibility is poor? Should I get nursing home care insurance for my old age? What should I do to make life better for my descendants?

[1]Social capital is the aggregate of the positive interactions between individuals and cultures. The 1995 Wealth Index of the World Bank (see pp. 57–66 on the internet site of the 1995 edition or the more recent 1997 report) estimated that the sum value of human capital (social and cultural systems) is three times larger than all the financial and manufactured capital reflected on the global balance sheet

Short-term or small-distance questions are usually egocentric or homocentric. Long-term or large-distance questions are most commonly either homocentric or ecocentric. Almost all of these questions are, of course, a mixture of egocentric, homocentric, and ecocentric. The important question is how to balance these three views of life. Humankind has never faced a problem on this temporal and spatial scale. Since the evidence base for achieving sustainable use of the planet is small and since we must achieve sustainability to be confident what methods and procedures are essential, the effort must be flexible. However, it would be a mistake to change practices too suddenly because there is often a considerable lag time before ecosystems adjust to new conditions. Human society also takes time to adjust to new conditions. As a consequence, it seems advisable to be patient when a response seems to be favorable so that much validating evidence can be accumulated. On the other hand, the response should be rapid when deleterious effects upon ecosystems are evident. Both false negatives and false positives are virtually certain to occur, especially in the early stages of the quest for sustainable use of the planet. False negatives occur when the monitoring system fails to detect deleterious effects and false positives signal deleterious effects when there are none.

SUBSIDIES

Subsidies are primarily given by nation states to special interest groups that have argued for them persuasively. The funds usually come from taxes and other similar revenues. Subsidies also come from such organizations as the World Bank and also from individuals. One of the prime goals of subsidies is economic growth, but this does not ensure that the resulting practices are sustainable. For example, one nation state may hope to gain an economic advantage over one or more other nation states. However, this competition may result in loss of natural capital (bad for sustainability) rather than the accumulation of natural capital (good for sustainability). It is essential to recognize that government subsidies to special interest groups probably will not result in improvement of the human condition.

A major obstacle to achieving a balance is the powerful special interest groups that are often subsidized with tax dollars (Myers & Kent 2001). Some subsidies (i.e. education) benefit the entire society while others benefit special interest groups and may simultaneously have adverse environmental effects (e.g. Roodman 1996, Drew 1999). Subsidizing special interest groups that damage the environment is neither eco-ethical nor a sound business practice. Furthermore, using tax monies for subsidies diminishes the sovereignty of the individual citizen by collecting funds in the form of taxes that subsidize a select group and may harm the individual (e.g. pollutants, etc.).

REQUIEM FOR SOVEREIGNTY

The Davidson & Rees-Mogg (1997) discussion of the loss of power of the 20th century nation state to the individual has already been described. This essay speculates that individual sovereignty is an illusion. However, Scott (1982, p. 33) notes that, for global systems to work reasonably well, a large number of subsystems must consistently function effectively.

Failure or inappropriate functioning of any one of these will cause problems. Risk is inherent in the system and would exist even if all individuals attempted to cooperate. Scott (1982, p. 203) further remarks that, since the international or global system now creates problems faster than solutions, increased cooperation and coordination are essential. Orr (1992, p. 45) notes that the ultimate expression of sovereignty — war — has become too destructive for both victor and vanquished. Over a decade after Orr's book was published, human society has ample evidence of

terrorism and other displays of individual power. Also, weapons of mass destruction, including biological warfare, have further strengthened Scott's view on nation state power and the likelihood of lose/lose results.

INTERDEPENDENCE

Clearly, sustainable use of the planet requires both a recognition of interdependence of all individuals within the human species and an acknowledgment that it is dependent upon the interdependent web of life. Ehrlich (2000) believes that biological evolution is not sufficiently rapid to make the necessary changes. However, he feels that cultural evolution might do so, despite the evidence that it has led many past civilizations to extinction. He further states that humans are essentially small-group animals attempting to live, with increasingly rare exceptions, in gigantic groups — trying to maintain health, happiness, and a feeling of connectedness in an increasingly impersonal world in which individual natures are based on even smaller fractions of society's culture. One might easily conclude, if these assumptions are accepted, that sovereignty is outmoded at all levels of organization — individual, nation state, bioregional, and global.

Even if all these adjustments are made, there is no guarantee that *Homo sapiens* can exist indefinitely on this planet. What is highly probable is that failure to attempt these transitions will shorten the time humankind can persist on the planet.

CONCLUSIONS

Individuals may believe they are sovereign (supreme ruler of Earth), but no organisms exist as separate entities. All are part of Earth's geoecosystem, without which nothing could exist. Common sense and research in ecology provide persuasive evidence that organisms, even humans, are not self-sufficient. Given the dependence of humankind on the biospheric life support system, the concept of individuals as sovereign is not only counterproductive but may even be fatal. Sustainable use of the planet requires humility and a greater sensitivity for the health of the planet's biosphere.

This article covers only one aspect of the quest for sustainable use of the planet — sovereignty. It is clear that sustainability requires replacement of all unsustainable practices, especially those that damage the integrity of the planet's ecological life support system. One hopes that the ethical imperatives congruent with this goal will be discussed at length in ESEP by individuals from all parts of the planet. Focusing on ecologically destructive practices is the responsibility of all humankind. One alternative is to practice sustainability at the individual level by an informed, ecologically literate global community. If this appears hopeless, a less satisfactory alternative is a transnational organization (e.g. such as the UN) to provide sustainability polices and enforce global compliance. The latter alternative will be unattractive to many individuals, but the alternative of continuing to live unsustainably will leave a less habitable, even uninhabitable, planet for posterity. The quest for sustainable use of the planet is a complex, multivariate goal. Each individual can become literate about sustainability, think about and act on this information — live up to the species descriptor *Homo sapiens*, and communicate thoughts and ideas to EEIU and ESEP. Alternatively, one can deny reality, take an anti-depression medication, and live for the moment. This is clearly unethical behavior.

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