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Book 2
Part 2

A collection of papers by

John Cairns, Jr.

Eco-Ethics and Sustainability Ethics

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DEDICATION

The dedication of ESEP Book 2 to my wife Jean is printed in Part 1. Since Part 1 has no picture of Jean, I thought it appropriate to include one here. This photograph was taken in summer 1994 near Rocky Mountain Biological Station in Colorado, USA. Although neither of us could have known then, this summer was the last one that our health permitted us to hike in that area. Since we were just over 70 years old then, we were lucky to enjoy such a wonderful environment for so many years.

ACKNOWLEDGEMENTS

I am grateful to Mary Batson, Managing Editor, for valued help on this and other ESEP publications and to Sandra Hammer for typesetting duties. My editorial assistant Darla Donald acquired copyright permissions, collected manuscripts, and provided valuable editorial services. Individuals who helped with specific manuscripts are thanked in the acknowledgements of each article. Last, but not least, I am deeply indebted to the publishers of the separate articles for permitting me to use them in this volume. Particular sources are acknowledged at the beginning of each article.

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ABOUT THE AUTHOR

John Cairns, Jr.

University Distinguished Professor of Environmental Biology Emeritus, Department of Biology and Director Emeritus, University Center for Environmental and Hazardous Materials Studies, Virginia Polytechnic Institute and State University

A biographical sketch and photograph of the author are in ESEP Book 1, *Goals and Conditions for a Sustainable World*. Since that book's publication, Cairns has been made an Honorary Member of the World Innovation Foundation. ESEP Book 2 Part 1 lists representative organizations with which the author has associated as a consultant or researcher, his service on the US National Research Council, and his service on committees of national and international importance.

Over his lifetime, Cairns has chaired 74 graduate committees and been a member of over 100 more. Since 1948, John Cairns, Jr. has been author and editor of almost 1500 works, including books, bulletins, chapters, journal articles, abstracts and editorials. Cairns' work has appeared in 168 journals; his readership spans the globe.

Courses taught during Cairns' career include Ethics and Science; Protozoology; Limnology; Microbial Population and Community Dynamics; Ecology; General Biology; Stressed Ecosystems; Aquatic Ecology; Environmental Science—Water; Comparative Aquatic Ecology; Ecology of Polluted Waters; General Physiology; Environmental Science—Management; Extrachromosomal Inheritance; Generating a Scientific Data Base for Societal Decisions; Biological Testing of Hazardous Chemicals; Hazard Evaluation and Ecosystem Risk Analysis; Winning the Games Scientists Play; Politics, Economics, Science—Going Beyond Disciplinary Boundaries to Protect Natural Ecosystems; and Restoration Ecology.

PREFACE

I am deeply grateful to Professor Dr. Dr. h. c. Otto Kinne and Inter-Research for yet another opportunity to share my thoughts with ESEP readers. Neither the publishers nor I receive any monetary compensation for this book. We continue to believe that ethics and sound science will enable humankind to leave a habitable planet to posterity and to share the planet harmoniously with other life forms.

Article 18

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War and Sustainability

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KEY WORDS: Sustainability · Resource wars · Resources · Natural capital · Posterity · Sustainable use of the planet

SUMMARY

The purpose of war is to destroy, and, even with precision bombs and missiles, some collateral damage still occurs. Inevitably, natural capital and other types of capital are destroyed or impaired. In Vietnam, the foliage of forests was targeted. In the Gulf War, Iraq released crude oil into the Red Sea, which damaged marine life, and set Kuwaiti oil fields on fire, which produced both atmospheric and terrestrial damage. War co-opts natural resources (e.g. natural capital), destroys societal infrastructure, and interferes with a variety of natural cycles and ecosystem services. War is incompatible with sustainable use of the planet since modern technology, including nuclear capabilities, makes war an unsustainable practice. Instead of protecting resources as they become increasingly scarce, these wars (usually poorly masked as terrorist, religious, or cultural conflicts) use natural capital, such as oil, in an attempt to obtain more than would have been possible by peaceful means. The assumption that more will be obtained is weak since sabotage is often difficult to stop. Universal peace and sustainable use of the planet are both utopian visions, but failure to achieve them deprives posterity of a quality life, and even of life itself.

> *We must make clear to the Germans that the wrong for which their leaders are on trial is not that they lost the war, but that they started it. And we must not allow ourselves to be drawn into a trial of the causes of the war, for our position is that no grievances or policies will justify resort to aggressive war. It is utterly renounced and condemned as an instrument of policy.*
>
> U.S. Supreme Court Justice Samuel L. Jackson, America's Senior Representative at the 1945 Nuremberg War Crimes Trials and the Tribunal's Chief Prosecutor

THE TIPPING POINT

A tipping point occurs when the forces that create stability are overcome by the forces that create instability, and the ship, vehicle, or system tips into disequilibrium. Indications (e.g. continued

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human population increase, species extinction, depletion of natural capital, ever increasing human artifacts that displace natural systems, pollution) are that both natural systems and humankind may reach a tipping point in the twenty-first century if present unsustainable practices continue. Cairns (2000) remarks that, in order to achieve sustainability, humankind must be at peace with natural systems (i.e. cease destroying them).

A general principle of preserving natural systems is that maintenance is less environmentally costly than rebuilding or new growth. Cities destroyed by war (e.g. as in World War II) require more resources to rebuild than would have been used to maintain them. Similarly, a new growth forest requires more energy for building new biomass than an old growth forest requires in maintaining itself. Moreover, cultural development occurs primarily when basic needs (e.g. food, shelter, health care, warmth) have already been met. Even education suffers when people must use all their energies just to survive. Social capital (e.g. sense of community) requires time, which is less available when maintaining basic needs is a struggle. Cultural capital (e.g. museums, symphony orchestras, art galleries) can be badly damaged or destroyed by wars, either directly by explosives or indirectly by looters, when the social contract (e.g. respecting cultural organizations) has broken down.

The Athenian statesman Pericles praised the law that, although unwritten, was obeyed. Today, obeying such laws is called a social contract. At present, the intent to live sustainably and leave a habitable planet for posterity is the ultimate social contract, which encompasses vast spatial dimensions (e.g. Earth) and vast temporal spans (e.g. indefinite use of the planet). Humankind must reject short-term economic growth based on unsustainable practices in favour of sustainable practices, which should produce a habitable planet for posterity and reduce risks.

RISKS

If humankind is worried about risks of terrorism-caused death, some comparative figures from the November/December 2002 issue of *World Watch* (p. 40) should be enlightening:

In the United States:

430 700 killed by cigarette smoking, per year, on average
300 000 killed by obesity, per year, on average
110 000 killed by alcohol abuse per year
43 200 killed by motor vehicle accidents, per year, on average
2000 killed by terrorist attacks on September 11, 2001.

In other countries:

2 000 000 in Sudan: killed in the ongoing civil war
1 700 000 in Cambodia: killed by the Khmer Rouge massacre in 1975–78
1 700 000 in Congo: killed in the ongoing war
103 000 in Japan: killed by two atomic bombs dropped by US planes in 1945
20 000 in India: killed by the Bhopal chemical spill of 1985 and its aftermath.

The purpose of this information is to show that a better perspective on risks is needed. For example, in the United States, one is far more likely to be killed by cigarette smoking or obesity than by terrorists. If the primary goal is to protect human life, citizens of the United States should concen-

trate on cigarette smoking and obesity rather than terrorists. A person killed by cigarettes is just as dead as one killed by terrorists. The risks in many other countries are more severe; 2 million were killed in the ongoing civil war in Sudan and 103 000 by two atomic bombs dropped by the United States on Japan in 1945, a one time event. Yet the latter has received far more attention. Even the 20 000 deaths in India caused by the Bhopal chemical spill of 1985 and its aftermath received more attention than the civil war in Sudan. The deaths of all humans killed before their normal life span ends are horrific, but our efforts to protect humans should bear some relationship to the actual damage and risks. Reducing these risks and the consequent strain on natural systems and society can be accomplished by changes in human behaviour, although they will be most effective if done by large numbers of people. Preventing human deaths by war and other activities should be a part of the social contract. War is most destructive when waged by nation-states, but guerrilla activity can be very destructive as well. One common deleterious effect is the production of refugees who cause significant ecological damage to the areas in which they seek refuge. Refugees can also strain the societal infrastructure of the area in which they take refuge, even taking it past its maximum long-term carrying capacity.

THE DANGEROUS CONCEPT OF ZERO RISK

In the early days of the environmental movement, especially after the first Earth Day about three decades ago, discussion flourished on the idea of reducing to zero the risk from potentially toxic chemical substances. The concept of zero risk was eventually discarded, although some politicians and world leaders still believe it a reasonable goal. Ironically, this concept was even touted as an achievable goal in space flight. For example, before the American spaceship Challenger exploded, officials estimated the probability of malfunction to as few as 1 in 100 000 flights. This estimation was, in fact, just a euphemism for the idea of zero risk, i.e. the risk is so small it is essentially zero.

However, few activities in daily life are entirely without risk. The passengers on the three aircraft highjacked in the terrorist attack on the World Trade Center buildings in New York or the Pentagon in Washington, DC, did not anticipate the actual risk to which they were exposed. Actual risk is also not anticipated by a person driving an automobile who has the misfortune to encounter another driver filled with ‘road rage’. Absolute security is as elusive as zero risk. The irrational quest for zero risk and absolute security are major obstacles to achieving sustainable use of the planet, which should be humankind’s primary goal.

PREVENTATIVE WAR

The outmoded concepts of zero risk and absolute security are being used to justify preemptive military strikes to ‘prevent’ a serious threat (e.g. the war in Afghanistan to depose the Taliban and heighten the war on terrorism). The idea of preventative war replaces the concepts of containment and deterrence, which were the strategies used during the ‘Cold War’ and with Iraq following the Gulf War. The doctrine of preventative war was used by both Germany and Japan in World War II, but not by the nation-states that were attacked. Unilateral action (i.e. preventative war) and, to a lesser extent, measures associated with the war on terrorism represent a rejection of multilateralism, which is essential to the quest for sustainable use of the planet. Furthermore, the uncertainties involved in unilateral action will almost certainly result in larger expenditures for military purposes and more environmental damage, including societal infrastructure, when force is actually used.

Reaction to this new orientation (from multilateral to unilateral) will induce countervailing trends in the international system, which became evident in the actions of the United Nations when the

twenty-first century war in Iraq was proposed. Sustainable use of the planet requires the normative legitimacy of a planet ordered by law. Therefore, policy must be altered, even in powerful nation-states, in order to establish the international order required to achieve sustainability.

Some disturbing indications are that the American preemptive war strategy is emphasizing the role of nuclear weapons as battlefield tools rather than as the ultimate taboo weapons (Physicians for Social Responsibility [PSR], 2003). This possibility is especially troubling in the case of dual crises, such as North Korea and Iraq, even when preemptive strikes are theoretical exercises. Even moderate protective efforts, by any nation, against a preemptive strike would divert resources from efforts to achieve sustainability. The threat of a preemptive strike does not reduce proliferation of nuclear weapons. For example, when so threatened, North Korea withdrew from its Agreed Framework (abandoning nuclear weapons development in exchange for civilian nuclear power generation) [PSR, 2003]. Sustainability requires mutual trust at the global level and is hampered, even wrecked, by mutual suspicion. Consequently, the case for preventative war is weak.

The British philosopher Thomas Hobbes loved peace so much that he was willing to accept absolute monarchy as an alternative to civil war. In an era of globalization, a strong United Nations may be the only alternative to the eventual use of weapons of mass destruction, which would end, possibly forever, the possibility of achieving sustainable use of the planet. Hobbes believed that all humans had reason, which could be employed to reduce the possibility of violent death. Peace will not guarantee that humankind will achieve sustainable use of the planet; but, without it, the probability of doing so is problematic.

ENVIRONMENTALLY BENIGN WARS

Environmentally benign war is, of course, a hopeless goal. However, environmental harm can be limited, just as the military attempt to minimize civilian casualties and damage to the infrastructure (e.g. water supply, sewage treatment, power plants, hospitals, and other civil services) of the nation-state under attack. The United Nations is processing more than US$70 billion in claims for environmental damage in the invasion of Kuwait (the Gulf War). The less damage to environmental and other resources, the lower the cost will be for recreating Iraq. In the Gulf War, nearly a quarter of the Kuwaiti desert was encrusted with oil, which also contaminated aquifers that had produced as much as 40% of the water supply. Unexploded ordnance abounds. The churning of tank treads and truck tyres has accelerated erosion so that sand dunes are edging toward Kuwait City. Environmental damage by oil and oil fires is summarized in Youngquist (1997), which contains useful references on this topic.

DISTRESS AND EUSTRESS

Distress is an emotion that can overwhelm and prevent effective functioning. Distress warns of danger and impels the actions of fight or flight. In today's world, fight might merely be a letter to a local newspaper or peaceful picketing. Instead of running away from a rabid pit bulldog, which directly addresses a problem, 'flight' may manifest itself as limited denial, meditation, music, and the like. However, 'flight' can also mean suicide bombing, road rage, or actual war. Eustress (the prefix 'eu' from the Greek word meaning 'good') is the emotion that motivates and gives a sense of accomplishment when goals have been achieved.

The wars of the twenty-first century have not produced the elation that followed the end of World War II. No heads of nation-states surrendered and acknowledged defeat. In fact, victory was not announced as it was at the end of World War II. Instead, words such as 'cessation of hostilities' were used, even though significant portions of the populations of Afghanistan and Iraq have

remained hostile and many indigenous combatants have merely discarded their uniforms and hidden their weapons, almost certainly with the intention of using them at the first opportunity. Diplomatic relationships of long standing have been replaced with suspicion and lack of trust. The United Nations has, temporarily, ceased to function as intended. Most of humankind is still feeling distress, and the end of this emotion is not in sight—hardly an appropriate condition for embarking on a cooperative program to globalize sustainability, which requires implementation of euthenics (i.e. science concerned with bettering the condition of human beings through improvement of their environment).

The quest for sustainable use of the planet will be stressful because the shift from unsustainable to sustainable practices will require major, initially unpleasant, changes in both individual and societal behaviour. War itself is an unsustainable practice if humankind intends to leave a habitable planet for posterity. Humankind is already pushing the limits of environmental carrying capacity in food, water, fossil fuels, toxic chemical substances, radioactive wastes with a long half-life, and rate of climate change. For example, world production of petroleum will soon begin to decline (e.g. Deffeyes, 2001; Duncan, 2001).

The activities of humankind have placed nitrogen, potassium, and phosphates into the environment at a rate greater than that of natural systems. These chemicals degrade all types of water ecosystems, e.g. there is a 'dead zone' in the Gulf of Mexico and brown slime in the Adriatic. The consequences of these activities are uncertain, but, at present, they cannot be stopped because without commercial fertilizers billions of humans would die (e.g. Smil, 1991). The era of rising irrigation has ended (Postel, 1999), and even water rich areas of the United States have had to begin importing water by truck for growing populations (Grant, 2003). Such environmental crises could lead to resource wars if the human population continues to grow. However, if the human population was stabilized at present levels, or reduced, the funds that are being used to reduce these crises temporarily could be used to develop long-term sustainable practices. This more desirable state requires reexamination of war and growth, both demographic and economic, and the ethical relationships within human society and with the 30+ million other species with which humans share the planet.

A FUTURE WITHOUT HUMANS

On May 18, 2003, the television channel Discovery aired the program 'Future is Wild.' Scientists envisioned a future world in which humans are extinct and bizarre creatures inhabit the world. Many people would dismiss a world without humans as science fiction or fantasy. 'Future is Wild' illustrated climatic and geological changes that, if even partially accurate, will drive most extant species, probably including *Homo sapiens*, to extinction over the next 10 to 100 million years. If sustainable use of the planet truly means working toward human use of the planet indefinitely, humankind needs to demonstrate the capability of living sustainably under the present comparatively benign conditions. If this goal is not possible, sustainability is a denial of reality and a more suitable word to describe human activities should be selected.

One obvious beginning point of working toward sustainability is with energy (defined as the capacity to do work). Heniberg (2003) argues that global oil output will peak in 3–12 years. If an aggressive shift toward new energy sources, such as wind, solar, or fuel cells in the mix, is not achieved in the 3–12 year time period, there will be severe, even grim, consequences, such as economic collapse, resource wars, famine, disease, and despotism. If humankind reduces energy consumption, the transition period can be lengthened, but the basic problem must be addressed.

Heniberg (2003) stresses that a high growth rate in oil thirsty nation-states, such as China or India, increases the probability of calamity by increasing competition among nations for oil. Such a situation also increases the need for a decisive shift to alternatives.

An era of dwindling oil energy supplies, resource wars, economic collapse, and fragmentation of globalization is shocking. The global human population is expected to double in 50 years, and the population of the largest energy consumer, the United States, is expected to double in 70 years. All societal activities require energy, so a combination of conservation plus development of sustainable energy sources is essential. The societal consequences of lower energy availability could be devastating—food shortages, reduced and more expensive transportation, and less heating, cooling, and lighting. Energy efficiency should help on a short-term basis, but improving efficiency yields ever diminishing returns (i.e. vigorous and perpetual growth). Efficiency will not prevent long-term shortages. Unless alternative sustainable energy sources are developed, future resource wars are quite likely, which will further reduce energy available for civilian use.

The wars of the twentieth century occurred during a period of expanding resource extraction, and, thus, more resources were available for civilian use than will probably be true for the twenty-first century, which will be an era of declining resource availability and extraction. Replacing unsustainable practices with sustainable practices, if carried out with sufficient rapidity, should reduce the number and intensity of resource wars, but is unlikely to eliminate them. Dramatic energy conservation, giving high priority to developing alternative sustainable energy sources, population stabilization, and protection of natural capital and ecosystem services, will lessen the impact of downturns due to resource depletion. A planet with fewer people might make sustainability possible and improve the quality of life if resources are not diverted to war.

SUSTAINABILITY AND SECURITY

The ultimate security problem is sustainable use of the planet. Without ecological and technological life-support systems and the services they provide, human society as presently known is doomed, even possibly threatened with extinction. The beginning of the twenty-first century has provided persuasive evidence that neither war nor terrorism brings security, but diminishes both ecological and societal stability and integrity.

Chief security officers (CSOs) and senior security executives are concerned that the United States could be on its way to becoming a police state (according to a poll released May 12, 2003, by CSO magazine [www.cio.com]). Thirty six percent of the American public does not believe that changing Hussein's regime in Iraq will ultimately improve American national security, and 40% of CSOs do not believe the terror threat information provided by the U.S. Department of Homeland Security is timely and accurate (information provided by P. Ehrlich, personal communication, May 18, 2003). Only 3% believe another major physical attack on American soil by a terrorist organization or nation-state will ever happen.

The United States fought five major wars during the twentieth century: World Wars I and II, the Korean and Vietnam wars, and the 1991 Persian Gulf War. Four of these five wars gave the political party in the American White House victories and rejoicing when armistice peace was declared. However, situations deteriorated in the 1–5 years following these because of unwise peace terms, post-war stresses, broken promises, diplomatic disappointments, and war-related scandals (Phillips, 2003). Much uncertainty still exists in the world, despite the cost of these wars in money and lives. A popular definition of insanity is doing the same thing over and over again while expecting a different result.

WAR AND THE STOCK MARKET

The American stock market is commonly disturbed by uncertainty, and unsettled political conditions nationally and internationally have not inspired renewed investor confidence. Various fears, such as terrorism and SARS, have complicated the relatively simple process of attendance at major public events, decreased travel to once popular destinations, and even introduced fear into boarding an airplane.

The increased resistance to power (e.g. North Korea) may cause further uncertainty about the future and, thus, produce a decline in the stock market or even a recession. This situation offers a superb opportunity for a new global alliance, which would not be favorable to multi-national corporations or free trade. The effect on the stock markets of the world could be devastating, enough to cause global economic stagnation. Uncertainty would be heightened while new regional economic systems develop, which undoubtedly lead to new trade preferences and increased competition for the remaining resources in resource-poor areas. Worse yet, the vision of sustainable use of the planet may well be replaced by increased nationalism, even tribalism. The vision of sustainability based on universal peace and a new relationship with natural systems would fade. Any centrism based on a nation-state is unsustainable, especially with the emergence of a global Internet, but some alternatives to the nation-state, such as Bilderberg[1], are a cause for concern. Tucker and Bollyn (2003) reported that, until last year's meeting in the Washington, DC, suburb of Chantilly, Virginia, Bilderberg had a tradition of congeniality. Tucker and Bollyn (2003) assert that Bilderberg remains united on the common goal of establishing a world government under the United Nations while retaining control of the planet's wealth and all inhabitants. Tucker and Bollyn (2003) find that the remarkable concentration of wealth and power in Bilderberg is completely dissociated from its guesses of how globalization benefits 6.2 billion people. As the global population approaches or reaches 10 billion and fewer resources are available per capita, this disparity in wealth and power will become an even greater issue. As Durant and Durant (1968) caution, history shows that concentration of wealth is natural and inevitable and is periodically alleviated by violent or political partial redistribution.

Violence is increasingly the preferred solution to wealth concentration, but war damages both natural and human capital, limiting the global resources per capita. Sustainable use of the planet, including decreasing the disparity in ecological footprint size, appears to be the most promising alternative in achieving a fair and equitable distribution of resources, including the share needed to keep and increase the store of natural capital and the maintenance of ecosystem services.

WAR AND ECONOMICS

Wars appear to stimulate a nation-state's economy, but even the winner suffers a long-term ecological deficit. War, which damages both technological and ecological resources and uses additional resources in the process, is incompatible with steady-state economics. Daly (2003) remarks that the preanalytic vision from which steady-state economics emerges is that the economy, in its physical dimensions, is as an open subsystem of a finite, non-growing and materially closed total system — the Earth ecosystem or biosphere. The biosphere takes matter and energy from the environment in

[1]Depending on the ideological perspective, Bilderberg may be viewed as a club of an ultra-VIP lobby of the power elite of Europe and America capable of steering international policy from behind closed doors, or a harmless discussion group of politicians, adademics, and business tycoons, or a capitalist secret society operating entirely through self interest and plotting world domination (Escobar, 2003).

low-entropy form (raw materials) and returns it to the environment in high-entropy form (wastes). A closed system is one whose only energy flows through. A steady-state economy is one whose throughput (whatever enters a system as input and leaves as output) remains constant at a level that neither depletes the environment beyond its regenerative capacity nor pollutes it beyond its absorptive (i.e. assimilative) capacity (Daly, 2003). War requires man-made services and sacrifices natural capital services, and it ignores ecosystem service efficiency, which, together with the natural capital, comprises the planet's ecological life-support system. Damage to the ecological life-support system is irrational, yet, at present, all too much of humankind's resources (including natural resources) are devoted to war and the preparation for war (often termed defense), and comparatively trivial amounts are devoted to replacement of unsustainable practices with sustainable practices.

The most probable cause of this curious position is humankind's obsession with growth. On a finite planet with finite resources, continued growth induces scarcity. Then, scarcity leads to resource wars, mass migration, political instability and, arguably most importantly, competition for increasingly scarce resources (e.g. oil). Equitable and fair sharing of resources, including those needed to maintain the planet's ecological life-support system, will require both sharing and population control. Humankind is rapidly approaching the time when it will be attempting to manage the entire planet for sustainability.

Half the world's human population is living marginally or worse, and yet Renner (2003a) reports that military expenditures are on the rise. In 2001, a conservative estimate of world military expenditures was US$839 billion, of which the United States spends 36% and those states considered hostile to the United States spend 3% (Renner, 2003a). Even so, expenditures for the military are expected to continue rising (Stevenson and Bumiller, 2002; Dao, 2002). Even 25% of these funds would provide a much needed programme to develop alternative energy sources, which would also diminish the perceived need for resource wars.

Renner and Sheehan (2003) state that approximately 25% of the 50 wars and armed conflicts of recent years were triggered or exacerbated by resource exploitation. Hussein persisted as a political leader by using resource money (in this case, oil) to maintain power by a variety of methods, including murder. The use of resource funds to maintain power is all too common (e.g. Le Billon, 2001). Ending such misuse of power and the resultant conflicts has proven impossible because it is difficult to displace the power elite (e.g. United Nations Security Council, 2002).

THE ULTIMATE SECURITY

The recent wars in Afghanistan and Iraq were justified on the grounds of reducing terrorism and eliminating weapons of mass destruction. However, in the first half of the twenty-first century, humankind will probably find it essential to choose between war and a transition from unsustainable to sustainable practices. The pivotal issue is how to provide the 2 billion or more people who are living marginally with an opportunity to improve their quality of life without destroying the planet's ecological life-support system. Wars (particularly in Third World countries) exacerbate poverty, economic collapse, and damage to public health systems.

On the positive side, the number of armed conflicts declined slightly in 2002 because the number of conflicts ending surpassed those newly erupting. Additionally, there were 17 armed conflicts not sufficiently severe to qualify as war (Renner, 2003b). It seems likely that many wars and conflicts over resources are attributed to other causes, such as terrorism, ethnicity, weapons of mass destruction, and the like. As the population and material affluence increase per capita but resources do not, resource wars, however labeled, are likely to increase.

SECURITY AS A DEFINING MOMENT

The quest for sustainability will be one of humankind's defining moments, comparable to the agricultural and industrial revolutions. A defining moment is one that shapes our lives, even though, initially, it often appears to be insignificant. Both individuals and human society can have defining moments. The agricultural revolution began with a few plants and domesticated animals. Seemingly unimportant when it began, it shaped human society for generations and continues to do so. The same is true for the industrial revolution. The modest world stage appearance of sustainable development (United Nations World Commission on Environmental Development, 1987) initially made only a few ripples on the 'global pond'. My copy of the report, a thoughtful gift from a colleague, sat on my desk for over a week before I got around to reading it. Even when I read it, I did not recognize the enormous impact it would have on my life. Eventually, years later, I realized that reading that report had been a defining moment for both my professional and personal life. I realized that, on a finite planet, exponential growth of population and use of resources was unsustainable, even though some economists (e.g. Simon, 1981) asserted that humans are not limited by resources as are other species. Simon's book was a defining moment in the quest for sustainability because, if resources are not limiting, sustainable use had already been achieved. Daly (1985) has pointed out the fallacies in Simon's reasoning, but the controversy remains. Whenever one side prevails, it will be a defining moment.

Undoubtedly, there will be many defining moments on the path to sustainable use of the planet. Arguably, the most important is to accept that war and sustainability are incompatible, not only because of resource waste but because sustainable use of the planet requires the strong support of nearly all persons. A small number of non-violent dissidents can probably be tolerated, but terrorist destruction of resources cannot. If the planet is at full carrying capacity, this would mean falling below subsistence levels for some people. If not, then the quality of life would still be impaired. War disrupts the beneficial flow of matter through a closed system essential to sustainability. War is a false goal because, on a finite planet that is approaching or is already at carrying capacity, it wastes resources.

Individual cannot control defining moments, such as being born. Humankind cannot yet control earthquakes, hurricanes, and other episodic events, but it can make a significant difference about engaging in war, especially preemptive war.

Another positive defining event on the path to sustainability will be the recognition that the 'free lunch' at the expense of natural systems is over. Sustainable use of the planet requires stewardship of natural capital and ecosystem services, not exploitation. Positive, defining moments are those that result in long-term benefits. Negative, defining moments are those that result in long-term problems. War is definitely in this latter category.

CONCLUSIONS

War is an unsustainable practice on a finite planet with finite resources. Natural capital is diminishing at an unprecedented rate at a time when it is most needed. This reduction means the loss or reduction of the ecosystem services that natural capital provides. Arguably, loss of or damage to the planet's ecological life-support system is the greatest security threat of all time to humans. To provide a habitable planet for future generations, the ecological life-support system must be cherished and its health and integrity preserved. War is an unsustainable practice, which, if continued, will deplete natural capital to the point that famine, disease, and other factors will have an even greater effect on humankind. Sustainable practices defend humankind from these scourges to the degree that the human species stays within the planet's carrying capacity.

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Article 19

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Future of Life on Earth

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One lesson from the five great global extinctions is that species and ecosystems come and go, but the evolutionary process continues. In short, life forms have a future on Earth, but humankind's future depends on its stewardship of ecosystems that favor *Homo sapiens*. By practicing sustainability ethics, humankind can protect and preserve ecosystems that have services favorable to it. Earth has reached its present state through an estimated 4550 million years and may last for 15 000 million more years. The sixth mass extinction, now underway, is unique because humankind is a major contributor to the process.

Excessive damage to the ecological life support system will markedly alter civilization, as it is presently known, and might even result in human extinction. However, if humankind learns to live sustainably, the likelihood of leaving a habitable planet for posterity will dramatically increase. The 21st century represents a defining moment for humankind — will present generations become good ancestors for their descendants by living sustainably or will they leave a less habitable planet for posterity by continuing to live unsustainably?

In addition to humankind's relationship with natural systems, other ethical problems must be confronted. For example, how can society expect individuals who do not know where their next meal is coming from to be concerned about the future of civilization and life on Earth? How can humankind ensure a fair and equitable use of resources within its own species and with the 30+ million other life forms that share the planet? How can humankind preserve the integrity of natural systems and maintain human civilization?

This journal has the opportunity to open a dialogue on these and other crucial ethical issues to the benefit of all humankind. Some illustrative issues follow:

1. How can humankind meet the basic needs of its own species and the planet's ecological life support system upon which human lives depend?
2. How can humankind begin to live sustainably so that its descendants will inherit a habitable planet?
3. How can humankind focus more attention on 'social health' (i.e. social capital) when basic needs have not been met? Can humankind reduce poverty, wars, terrorism, suicide, and other undesirable attributes of the human condition as a step toward increased social health?
4. How can humankind be persuaded to purchase products from manufacturers who reclaim their used products for reuse and recycling?

5. How can developed nations reduce their ecological footprint size to reflect the world's average? Secondarily, how can the affluent keep their ecological footprint at a level that will not damage the integrity of natural systems so that the monetary savings can be used to aid those whose basic needs are not being met?
6. How can humankind persuade individuals to use native plants and grasses on their private property and use only natural rainfall for this vegetation?
7. How can humankind reduce the use of pesticides, artificial fertilizers, and other chemicals that contaminate water supplies in its households and on its personal properties?
8. How can citizens be persuaded to use public transportation whenever possible and to use energy efficient appliances, including automobiles?
9. How can individuals be persuaded to use fewer resources per capita in developed countries until the basic needs of the poor have been met?
10. How can humankind be persuaded to cease shrinking the planet's natural systems to accommodate human artifacts?
11. When will humankind give derelict ecosystems in each bioregion a high priority and begin to restore them?
12. How can humankind persuade governments (local to national) to cease environmentally harmful subsidies?

Many prophets, such as Robert Malthus and Garrett Hardin, have tried to convince humankind that it is dependent upon the resources of a finite planet and that failure to acknowledge that exceeding the planet's carrying capacity for humans will vastly increase human suffering and mortality. What has happened to natural systems in the last century is appalling and has probably disrupted evolutionary processes enough to produce ecological disequilibrium for a few centuries or more. Since humankind's basic life support system is ecological (as opposed to technological), this situation is high risk.

Terrorists can kill and/or maim millions, but change in climate, shortage of water, loss of topsoil, depletion of resources, and dominance of pest species beyond present levels could kill billions. When cultures and individuals forsake ethics or distort its overall aims, tragedy is the most likely result. In much of the world, success is measured by material possessions and wealth, which has made the world increasingly impersonal.

The profligate use of resources inflicts damage on natural systems and human society. Technological advances have produced some dramatic benefits; however, as Garrett Hardin notes, 'one can't only do one thing.' Technological advances have also produced unintended, unexpected, and hazardous results as well. These unexpected, hazardous results, in the aggregate, place humankind's future — and even its existence — at risk.

The complex interactions of biology/ecology, economics, and technological and social factors must be understood and coped with in an ethical, sustainable way to save both natural systems and humankind. Ethical views must not alienate humankind from the natural world. Science has documented much of what is at risk and some of the actions needed to reduce risk. Instead of denigrating the knowledge (e.g. global warming) and placing undue emphasis on the uncertainties (which always exist in science), leaders and citizens should give attention to those areas upon which mainstream science has reached a consensus. Unsustainable practices can be halted, but, even though remedies are known, they are not acted upon. It is not too late for a paradigm shift to occur.

Humankind has the information to improve the future of life on Earth, including the human species, but it lacks the leadership and the resolve to do enough. History judges civilizations by how

they cope with the challenges they face; however, if humankind fails this challenge, no judgment will be needed. If humankind succeeds in implementing sustainable practices, it will give posterity (of all species) a better life.

The economic disparities in *Homo sapiens* have been well documented, and humankind will not achieve sustainable use of the planet until these disparities are markedly reduced within the species. Similarly, humankind must not take such a disproportionate share of the planet's resources from other life forms. Ethos and ethics together with equity and fairness are essential to achieve sustainability. Life on Earth will almost certainly persist! Humankind must practice ethics to increase the probability of being part of the future!

Article 20

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Quaker website: preparingforpeace.org/cairnspeace_&_sust.htm

Peace and Sustainability: Nurturing Complex Systems

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ABSTRACT: Most wars are attempts to acquire more resources (e.g., oil, land, diamonds), although the justification for the war may be expressed quite differently. For the first time in human history, the world's population has doubled within a human lifetime—resources have not. In addition, human expectations for increased per capita consumption have increased dramatically. Finally, the range of per capita resource consumption worldwide has increased tremendously. These and related factors have markedly increased the likelihood of resource wars, which substantively deplete natural resources. All these trends are unsustainable. Living sustainably should reduce the probability of resource wars, benefit posterity, and provide hope for a quality future for all humankind. Sustainable living should also reduce the disparity between the "haves" and the "have nots." Both human population size (now 6.3 billion and rising) and distribution (increasingly urbanized) have increased dependence upon the technological/economic life support system which, as now managed, threatens the much older ecological life support system. The survival of human society now depends on the nurturing of both of these complex, multivariate systems so that they are mutualistic rather than antagonistic. Living sustainably should benefit both systems and reduce the probability of resource wars.

For every complex problem there is a simple, direct solution—and it is invariably wrong. H. L. Mencken

There is a lot wrong with our world. But it is not as bad as people think. It is actually worse.
Michael Meacher
Former Environmental Minister, United Kingdom

FOUNDATIONS OF SAND

Wars between humans are devastating, but the human war being waged on the environment will have a far greater effect on humankind. Peace for humankind is a superb vision. However, if humankind does not cease making war (i.e., destroying) on Earth's ecological life support system and the species that comprise it, peace will be built on a foundation of sand. Paul R. Ehrlich (Professor of population studies at Stanford University, Stanford, CA, USA) notes: "We're waging a war on the environment, a very successful one" (quoted in *The Guardian*, Friday, October 24, 2003). If natural capital is destroyed or impaired, ecosystem services will be lost (e.g., maintaining atmospheric gas balance). This loss will reduce the planet's carrying capacity for humans and per capita resources. The inevitable result is resource wars. Exponential population growth reduces per capita

resources such as water, forests, croplands, etc. Another cause for concern is mass migration from countries that have exceeded their carrying capacity to countries where resources appear to be more abundant.

Individuals who believe that humankind is immune from natural law need only become informed about the recent effects when Hurricane Isabel hit the 100+ miles of barrier islands (the "Outer Banks") on the east coast of North Carolina, USA. The hurricane washed out much of the main road for the islands, destroyed motels and million dollar houses, and even divided one island into several islets. A whole town, Hatteras Village, was cut off, temporarily at least, from the mainland.

One persistent belief, especially in the United States, is that nature can be vanquished. At the core of this belief is a conviction that there are no limits to growth. Proponents of unlimited growth consider certain ideas subversive: that limits exist, that finite limits exist on a finite planet, and that humans are subject to a finite carrying capacity (as with any other species). Peace is more than the absence of war. The probability of peace will be dramatically increased if Earth's life support systems are nurtured and natural capital is not squandered, thus markedly reducing the likelihood of resource wars. If humankind's war on nature continues, humankind will suffer grievous harm.

THE PIVOTAL ROLE OF PEACE

Peace is an essential precondition for sustainable use of the planet. However, to be truly effective, the word *peace* must include the 30+ million other life forms with which humankind shares the planet. The war on other life forms is transforming Earth at an exponential rate (e.g., McNeil 2000). This process is driven by rapid human population growth (e.g., Nelson 2003), corporate exploitation of natural resources, climate change, and an unjustified faith in technological solutions to ethical problems, such as the assertion by some economists that resources are infinitely substitutable. Humankind is waging resource war on natural systems by damaging habitat, which results in biotic impoverishment, including species extinction well beyond evolutionary replacement of lost species. Old growth forests, coral reefs, wetlands, and other important ecosystem categories are at risk worldwide. Waging war on the planet's ecological life support system is suicidal. If the 21st century wars in Afghanistan and Iraq are harbingers of future conflicts, the "shock and awe" attack by a major military power will be followed by a sabotage and anarchy campaign by a significant number of indigenous people that may be aided by volunteers from other countries.

In Iraq, occupying forces have cut down date trees, burned crops, drained wetlands, destroyed irrigation systems, and burned grassy knolls in areas thought to be harboring terrorists (Al-Atraqchi 2003, http://www.islamonline.net/English/In_Depth/Iraq_Aftermath/2003/10/article_13.shtml). Given the close association of local people with the land, reprisals appear inevitable.

Collateral environmental damage caused by humankind's life styles results in global climate warming (e.g., Usha Lee McFarling, 24 October, 2003, *Los Angeles Times*), desertification, water and air pollution, and changes in basic ecological cycles (e.g., nitrogen). Except possibly for a massive nuclear war, no war could be more devastating to natural systems.

Sustainable use is closely linked to the health and integrity of Earth's ecological life support system, which consists of natural capital (living systems) and the ecosystem services it provides. The condition of the ecological life support system depends, in turn, on a mutualistic, harmonious, coevolutionary relationship with humankind, its societies, and organizations. Above all, a positive coevolutionary relationship between these two complex systems based on eco-ethics and sustainability ethics (Cairns 2003a) and a transdisciplinary synthesis merging environmental monitoring information across large temporal and spatial scales is essential. Effective use of environ-

mental quality control data requires effective communication between and among the traditional disciplines and an enormous array of special interest groups. Coupling societal (including technological/economic) and natural systems to produce a sustainable, mutually beneficial relationship will require creativity, empathy, and the capacity to adapt quickly to the inevitable evolutionary changes in both of these complex multivariate systems. Humankind is so enamored with the technological/economic system that it needs neither explanation nor defense. However, the ecological life support system needs both an explanation and defense so that *both* systems are fully understood and a mutualistic relationship can be developed between them. Resource wars will not cease until use without abuse of natural systems is a sine qua non. Living sustainability does not ensure peace but living unsustainably will lead to resource wars.

Although synthesis has occurred within the traditional disciplines, transdisciplinary synthesis is rare. The term "interdependent web of life" recognizes the many connections in the environment. Humankind asserts that it respects the web, although human practices continue to cause grievous, possibly fatal, damage to the web. Although humans may become extinct long before life on Earth is extinguished if present unsustainable practices continue, severe damage to ecological and evolutionary processes is highly probable (e.g., Myers and Knoll 2001). This damage, in turn, will have deleterious effects on humankind.

Capra (2002) has undertaken to extend the new understanding of life that has emerged from complexity theory to the social demand, with particular attention to sustainability. As Capra (2002) remarks, humankind is surrounded by massively complex systems that increasingly permeate almost every aspect of human lives. The fact that these complex industrial systems and their unsustainable practices are the primary threat to the ecological life support system upon which sustainable use of the planet depends is alarming.

DOUBLETALK

As Hausman (2003) remarks, deception and doubletalk are common in advertising, politics, and the news media. Effective communication requires trust in the sources of the information (based on a reputation for accuracy, objectivity, and a systematic, orderly approach to issues important to sustainable use of the planet), which, in turn, requires a high level of literacy about nurturing humankind's life support systems. Special interest groups that are reaping profits from these unsustainable practices will regard high levels of literacy about current unsustainable practices with disfavor. War is also profitable to many special interest groups, so the path forward will be contentious and controversial. The issue of cigarette smoking in the United States often focuses on the economy and lost jobs. However, many of the costs (i.e., health and loss of working time) are predictably downplayed because of the pressure of special interest groups.

WORLD GOVERNANCE

Assuming that it is possible to diminish deception and doubletalk, which appears utopian at present, how can any world governance emerge that is capable of eliminating unsustainable practices that lead to resource wars? Capra (2002) believes that the present form of global capitalism is both ecologically and socially unstable in an era of economic instability. The ecological and social disequilibria are already quite apparent, and the global economic system is quite fragile. Badly needed is an organization capable of sustainably managing the global system so that it is protected from exploitation by nation-states, special interest groups, and individuals. Exploitation is an obstacle to both peace and sustainable use of the planet.

The United Nations has a broad mandate and transparent decision-making processes with prospects of giving guidance in implementing sustainable environmental practices and the social processes that support them. Enforcement powers, however, are well below the necessary level. There is hope that the information age will produce an unprecedented political movement. Capra (2002) postulates that use of the Internet by non-governmental organizations will foster development of a network capable of mobilizing members with unprecedented speed. Castells (1997) proposes that social change in the network will be a result of the rejection of present dominant values and, thus, will not originate within traditional institutions. Cairns (2003a) proposes a set of eco-ethics based on a sense of belonging to the interdependent web of life and a preliminary declaration of sustainability ethics based on a wish to leave a habitable planet for future generations of the human species and those of other life forms. Environmentalists usually assume that these two sets of ethics are identical—they are not. Peace within the human species will not be sustainable unless humankind makes peace with the interdependent web of life and the species that comprise it. Even though the two sets of ethics are not identical, they must be compatible.

Human aspirations change, but natural laws do not. Indefinite use of the planet by one species, *Homo sapiens*, does not conform to the paleontological record, which shows that species come and go, although some persist for considerable periods of time. The living network endures, but its component parts (i.e., species) do not. Without the system, the species cannot survive. The system is the aggregate of all living species, but not any particular one for an indefinite period of time. At present, humans are both inflicting major damage on the system and simultaneously expecting to persist as a species indefinitely. This war on nature will have consequences for humankind.

The glorification of materialphilia (love of material possessions, see Cairns 2003b) is now carried to the point of creating severe disequilibrium in the ecological life support system. An uncharitable person might understandingly conclude that humankind is suicidal. Ecological ethics is an attempt to establish a more harmonious relationship with natural systems and is clearly ecocentric (Cairns 2003c). Sustainability ethics attempts to be both homocentric and ecocentric (Cairns, 2003c), based on the assumption that they are compatible.

It is difficult to imagine protecting the global ecological life support system without a fair, equitable, effective system of world governance. As Hoffman (2003) remarks, the very complexity of the international scene makes it unlikely that such a system can develop. McNeil and McNeil (2003) assert that, to preserve what is here now, humankind and its successors must change their ways by learning to live simultaneously in a cosmopolitan web and in various and diverse primary communities. Reconciling such opposites is the defining question of the present time, and probably into the future. McNeil and McNeil (2003) conclude that humankind is living on the crest of a breaking web; however, with luck, intelligence, and tolerance, it may be possible to keep the web from breaking. I am convinced that a systems level approach, combined with compassion for local and regional issues, is essential to both peace and sustainability.

THE AGE OF SYNTHESIS

Sustainable use of the planet requires a level of synthesis unprecedented in human history. Arguably, humankind must accomplish synthesis in the first half of the 21st century because of both exponential population growth and rapid depletion of natural capital. Without peace, this transition will be exceedingly difficult, arguably impossible. Information about the components of sustainability (such as sustainable energy, agriculture, water use, and the like) has promise, but the connections between them at the system level are almost non-existent. In short, “bottom-up”

sustainability strategies are progressing satisfactorily, but "top-down" (i.e., system level) sustainability strategies are not. Furthermore, the connections between these two strategies are largely unexplored (Cairns 2003c). Worse yet, there is strong opposition to abandoning unsustainable practices. Sustainable practices are more favorable to maintaining peace because they diminish but do not eliminate resource wars.

POLICY ISSUES

The policy of expecting perpetual growth on a finite planet is no longer tenable and should have been abandoned in the 20th century. Although Ruth Patrick advocated "use without abuse" of natural systems in 1948, the concept of sustainability originated with Brown (1981). He defined a sustainable society as one that is able to satisfy its needs without diminishing the options of future generations. Years later the definition (somewhat modified) was used by the World Commission on Environment and Development (WCED 1987) in a report that received much international attention.

It is abundantly clear, however, that most individuals and their leaders the world over have little or no literacy in sustainability. Most people would probably endorse Brown's (1981) definition of sustainability. Many more, including corporations, would endorse the WCED (1987) definition, since the word *sustainable* is used as an adjective to define the noun *development* and this noun is strongly associated with growth, which is the world's dominant paradigm at present.

In the United States, a major belief is that present practices need only be modified to be sustainable—hence the term "smart growth." This conviction is usually accompanied by the concomitant belief that technology will provide the solution to even the most intractable problems, i.e., biotechnology will solve the food shortage and even the water shortages (e.g., treating unpotable water). As a consequence, few (if any) nation-states have in place and are implementing a broad, "top-down" sustainability strategy. Furthermore, effective implementation will require more knowledge of component parts (e.g., sustainable transportation) than is now available. Fortunately, there are a number of steps toward sustainability that could be implemented at once while a global, "top-down" sustainability policy is being developed.

ACHIEVING PEACE VIA SUSTAINABLE USE OF THE PLANET

- Diminish the probability of resource wars by moving toward a more fair and equitable allocation of resources.
- Preserve Earth's ecological life support system by allocating more than 12% of the total resource to this purpose.
- Cease immediately all environmentally perverse government subsidies (Myers and Kent 2001), but expect a fierce fight from the special interest groups that benefit from subsidy dollars.
- Stay within carrying capacity. The carrying capacity of ecoregions, nation-states, and the planet should be more precisely defined in terms of sustainable use, focusing on maximum capacity (low quality of life) and optimal capacity (high quality of life).
- Stabilize human population size and even reduce it if it exceeds carrying capacity. With regard to exponential growth of the human population size, one is reminded of the tale of an elephant in a small room—everyone sees it, but no one wants to talk about it.
- Achieve zero net immigration. Zero net immigration should be enforced by all nation-states (e.g., Browne 2002). Mass immigration, both legal and illegal, makes a mockery of attempts at population stabilization. Arguably, even more serious is that immigration encourages

nation-states to export people to avoid solving their population and sustainability problems internally.

– Control ecological footprint size. Careful analyses of ecological footprint size (Wackernagel and Rees 1996) should be made at all levels of social organization. (Useful websites on ecological footprint size are www.environment.govt.nz/footprint/input.html or www.bestfootforward.com/footprintlife.html or www.mec.ca.apps.ecoCalefood.jsp or www.lead.org/leadnet/footprint.default.html.) Important issues to consider are: (1) global disparity in ecological footprint size; (2) impact of the total human population on the ecological life support system is more important than related subissues of poverty, racism, and individual rights; (3) Biosphere II (Earth is Biosphere I), a 3.1-acre airtight mesocosm in Arizona, USA, illustrated quite well that an ecological life support system cannot be created and kept functional for a long period of time. Humankind should not think that an ecological life support system could be created with present knowledge. The lesson from Biosphere II is that the ecological life support system now functioning must be protected because a replacement is not possible at present; (4) ecological footprint size is not a robust measure of quality of life; (5) unsustainable practices damage the ecological life support system, which results in a per capita reduction in ecological footprint size; (6) incentives to overuse resources (large ecological footprint size) must be markedly diminished; (7) a sustainable quality life does not depend on material goods consumption. The United Nations Development Programme asserts that a sustainable quality of life is achieved by "creating an environment in which people can develop their full potential and lead productive, creative lives in accord with their needs and interests."

NURTURING THE TECHNOLOGICAL/INDUSTRIAL SYSTEM

Nurturing is exceedingly difficult without peace among humans and the other life forms with which they share the planet. The war on (destruction of) the world's ecosystems is, arguably, more important than wars between nation-states. Lasting peace requires inclusion of all life forms.

If humankind aspires to both lead the "good life" and leave a habitable planet for posterity, it is essential to preserve both the ecological life support system and the more recently developed technological/economic life support system. Present population size, demographic distribution, and level of affluence do not permit any other alternative. Cooperation of all humankind in this effort will only be possible if there is a vastly improved social equity and peace.

The definition of the "good life" is critical. If it is based primarily on acquisition of material goods, the ecological life support system will continue to be degraded. If based on a sense of community with both members of one's own and other species, the good life may be possible. Prugh and Assadourian (2003) believe that the survival of *Homo sapiens* is not in much danger from anything humankind might do to the global ecological life support system. This belief is dangerous because paleontological records show that the typical fate of a species is to become extinct. The assumption of indefinite survival for humans is probably untenable if there is both massive global climate change and a significant change in the evolution of new species more suited to new environmental conditions. It is not prudent to gamble with extinction while the alternative of living in a mutualistic relationship with the present ecological life support system appears possible.

Precautionary measures are always preferable to assumptions of invulnerability, as the passengers and crew of the Titanic discovered too late. On the other hand, as Prugh and Assadourian (2003) remark, most people would not choose a society in which a few people control resources. Mutiny is the likely outcome if the resources are disproportionately distributed, unless a totalitarian

state maintains the maldistribution by force. This situation is certainly not the scenario that most people would describe as the good life. Nurturing both the ecological life support system and the technological/economic life support system appears to offer the best prospect for living sustainably and achieving peace.

CULTURAL AND RELIGIOUS CONFLICTS, RESOURCE WARS AND TERRORISM

It seems probable that nation-states will endure for at least the 21st century. As a consequence, conflicts between them will occur and almost certainly increase as the global population increases and natural capital diminishes. The world's only superpower can defeat militarily countries such as Afghanistan and Iraq but cannot easily control terrorists and saboteurs, as the situations in Iraq and Afghanistan in 2003 illustrate.

In Iraq, the oil pipeline to Turkey was badly damaged, as were electrical and water supplies. In September 2003, there was no effective civil government in Iraq, nor is it likely that one will appear soon. Cultural and religious conflicts suppressed by Saddam Hussein are emerging as a major problem, and civil disorder is rampant. These situations are not satisfactory conditions for nurturing Earth's life support systems or achieving peace.

ETHICS AT THE CORE

The most basic ethical question is: Should humankind ignore the future of its descendants? Cultural evolution has expanded the ethical treatment of other species, first to domesticated species and then to other species of commercial or recreational value. However, extending ethical responsibility to the ecological life support system and posterity is not yet a major commitment for humankind. Meeting these responsibilities requires ensuring that the integrity of the ecological life support system is not impaired and that the condition of the technological/economic life support be maintained and preserved to the maximum degree possible without endangering the ecological life support system. There is robust justification for this position because natural capital is the ultimate source of all other capital. In addition, the ecosystem services provided by natural capital are essential to the ecological life support system. Without adequate resources per capita, peace is unlikely.

At present, nurturing the technological/economic life support system, even at the cost of severe damage to the ecological life support system, is called progress and economic growth. However, anything that compromises the ecological life support system is not sustainable. There is no justification for the statement "you can't stop progress" since, as defined at present, it damages the ecological life support system. Natural capitalism provides an economic alternative that nurtures the ecological life support system (i.e., natural capitalism consists of sustainable economic/technological practices), and unsustainable practices are poor management and unethical.

CATASTROPHES

Although much can be done to prevent anthropogenic short-term catastrophes, the long-term prospects are less encouraging. As Leakey and Lewin (1999, as quoted in Kosmicki 2001) note: "Since the Cambrian period the life on Earth has had its booms and catastrophes, the species developed and changed and then were all killed in global annihilation." Humankind has little likelihood of addressing these long-term issues until unsustainable practices are replaced with sustainable ones. Stacewicz (2001) believes the "turning point" in the creation of new cultural patterns of Western civilization has been evident for some time.

WILL REASON PREVAIL?

Great deeds require resolve, persistence, literacy, reason, and a strong commitment to ethics. Arguably, sustainable use of the planet is the ultimate great deed because it involves peace among humans and other life forms. Sustainability is probably the greatest experiment ever undertaken by humankind. It cannot succeed in an atmosphere of war, anarchy, or petty bickering between unilateralists and internationalists (and one might add between the academic disciplines). It cannot succeed if fear and force are the primary motivators. Sustainability cannot be achieved by force, even by a superpower whose leaders feel obligated to uphold world order. A consensual global set of values expressed through new international institutions is essential. Such a set of values will require the support of all of the powerful nation-states and the financial support of the wealthy, who cannot escape to another comparable planet if this one is damaged.

MOBILIZING BY CATASTROPHES

The worst-case scenario is that humankind will fail to respond adequately to the inevitable catastrophes that will result from continuing unsustainable practices (including war) on a large scale. One or more major catastrophes may be necessary to cause a global paradigm shift from unsustainable practices to sustainable practices. One hopes that the catastrophe will not exceed the resilience of the global life support system. Even then, an effective response will require world governance beyond what now exists.

This world governance, in turn, must be guided by shared ecological and sustainability ethics based on a much higher level of environmental literacy than now exists. Emerging world leaders must be well informed about how Earth's life support systems work and be able to communicate new paradigms to all humankind. As Paterson et al. (2003) note, governance has become one of the key themes in global environmental politics. They further state that much of the strength of this concept derives from its capacity to convey a sense of an overarching set of arrangements beyond the specificities of individual issue areas or thematic concerns that encompass a broad range of political foci.

ESTABLISHING FEEDBACK LOOPS FOR THE ECOLOGICAL LIFE SUPPORT SYSTEM

The suggestion that a nation-state, such as the United States, manage its economy without feedback loops providing information (e.g., inflation rates, consumer confidence, housing starts, and unemployment) would be ridiculed. The continual feedback of information enables economists to determine the health of the economy and nurture the system when its health is impaired. The level of detail required is impressive. However, no comparable feedback loops provide detailed, continuous information about the health of the ecological life support system, which is at least as important as the economy and, arguably, more important, since natural capital is the basis for all other forms of capital. The purpose of monitoring each system, either economic or ecological, is to confirm that pre-established quality control conditions are being met. If not, remedial measures should be taken quickly. The methods and procedures are available for monitoring the condition of the ecological life support system, but the motivation to do so at the level of detail provided for the economy is lacking. Nurturing the ecological life support system requires that a monitoring system be established. Without adequate feedback loops, the destruction of other species will continue.

NURTURING THE ECOLOGICAL LIFE SUPPORT SYSTEM WHILE NURTURING OLD PEOPLE

Achieving sustainability in an unsustainable world will not be possible if all unsustainable practices are not replaced with sustainable practices. Population stability in *all* nation-states and

eco-regions is essential to the quest for sustainable use of the planet. Humankind in developed countries faces two major problems: (1) an increased population of old people and (2) excessive consumption of material goods. These seemingly unrelated problems could be addressed concomitantly.

If the consumption of material goods were diminished, the ecological footprint of developed countries would be closer to the world average. The many workers who have two jobs to maintain a materialistic life style could reduce working hours and spend more time with their families (including caring for the elderly), on recreation, and volunteer social work. No nation-state or ecoregion should solve labor problems by encouraging immigration from nation-states and eco-regions that have exceeded their carrying capacity because these immigrants will age. If this practice continues, population problems will become even more acute globally since it permits nation-states and ecoregions to avoid facing the fact that they have exceeded their carrying capacity. Exporting humans to solve national and local problems is an unsustainable practice. The Middle East and North Africa have 6.3% of the world population and only 1.4% of the water and one of the world's highest birthrates. The region cannot export people indefinitely to avoid addressing carrying capacity problems since this will accelerate problems in the host countries.

In contrast, the United States has 4.6% of the world's population, but is responsible for nearly 25% of the world's anthropogenic carbon dioxide emissions. Both overdeveloped and third-world countries must address carrying capacity issues in a different way. Neither exporting nor importing people is a sustainable practice for either group. On a global scale, both overpopulation and over consumption of resources are severely damaging other life forms and driving some to extinction.

Iran's family planning initiatives, including contraceptive use, have reduced fertility rates from a high of 5.6 in 1985 to 2.0 in 2000. Regrettably, the United States, which should be a world leader in working toward population stabilization, has withheld US$34 million from the United Nations Population Fund and cut off aid to international family planning organizations whose services include (but do not use US funds for) informing women of legal abortion options. In an overcrowded world, a point has been reached where each population increase means less resources per capita, which will push more impoverished persons into starvation and even death. Earth can only support a finite number of people, beyond this point the primary issue is how people will die and at what age. These are not circumstances that favor peace.

Population stabilization will not be fully effective until urban sprawl is eliminated. Then, more space will be available for natural systems (i.e., natural capital and the services it provides). The policies espoused by "smart growth" proponents does reduce per capita land consumption but, unless coupled with population stabilization, merely saves land for the present generation that will be lost in succeeding generations (i.e., it is an unsustainable practice unless the reduction in per capita land consumption is coupled to population stabilization).

HOMO SAPIENS: AN ENDANGERED SPECIES?

Initially, a question about *Homo sapiens* being an endangered species appears preposterous, but the statement does have merit. Humans inherited a storehouse of natural capital that took 3 billion years to accumulate; they have greatly depleted it in just a few centuries. For most of their existence, humans were a small-group species spread thinly over Earth. However, recently in evolutionary time, they have become a large-group species living in high densities over a substantial part of the planet's land and exhausting the fisheries of the world's oceans, which cover a larger part of the surface. The planet has been turned into a common ground from which any individual

or corporation with sufficient money can extract resources, all too often in an unsustainable way. These activities have resulted in a biotic crisis that is likely, if these practices continue, to precipitate a sixth mass extinction of species. Extinction terminates lineages and removes genetic material valuable to the ecological life support system. Biodisparity (the biota's morphological and physiological variety) would be in serious decline (e.g., Russell et al. 1995).

The fossil record provides substantial evidence about extinction events that have covered various spatial scales and degrees of biotic impoverishment. It is quite clear that there is recovery from even major biotic impoverishment over geologic and evolutionary time. These are not time scales that human society has had experience planning for. Furthermore, disequilibrium conditions do not favor sustainable use of the planet by one species. Sustainability is more probable if human society had a peaceful, mutualistic relationship with natural systems upon which it is dependent.

Lessons from the past show that, when large numbers of individuals are weakened by famine, disease, emotional stress, and social disorder, the larger population of which they are a part is likely to experience severe disequilibrium. If this adversely affected the technological/economic life support system, recovery would be problematic since humankind has utilized much of the huge inventory of natural capital from which the present social system was built.

The most dramatic evolutionary effects of mass extinctions are that they remove successful incumbents (Jablonski 2001). Surely, *Homo sapiens* fits this description very well indeed for large species. Biotic consequences are not likely to be of major concern to species that have gone extinct.

THE PROSPECTS FOR PEACE

Resource wars will continue until humankind learns to live sustainably, which, in turn, requires peace with both the human species and with other life forms. Since resource wars are primarily caused by unsustainable resource consumption, much attention must be given to the ecological footprint size of both individuals and nations. Excessive resource consumption generates enormous profits for corporations and a few individuals on a short-term, unsustainable basis. These profits divert attention from protection of the resource to short-term benefits to the exploiters of the resource. The result is the extraction of resources as rapidly as possible and then shifting monetary capital to other resources. The power elite uses this procedure as a dominant paradigm; however, there are alternatives. Hawken (1993) has shown that corporate profits are possible even in the present global economy and are compatible with long-term benefits. Weston (1995) has produced an excellent overview of the situation that focuses on both environmental and corporate concerns. The US National Academy of Engineering (1996) addresses the pivotal issue of how to maximize the benefits of technological innovation with an emphasis on preventing environmental damage.

Prospects for peace with natural systems will be enhanced by: (1) not discharging or producing wastes that cannot be beneficially assimilated by natural systems, (2) taking nothing from Earth that is not renewable in quantities that can be extracted indefinitely (i.e., efficient use of resources), (3) anything that benefits neither consumers nor natural systems is unacceptable waste, (4) embracing natural capitalism (Hawken et al. 1999), which espouses an economic system that does not plunder Earth, (5) restoring damaged ecosystems at a higher rate than they are being damaged until there is sufficient natural capital for sustainable use of the planet, then, a balance between damage and repair should be adequate, (6) monitoring natural systems to confirm that previously established quality control conditions are being met. Present unsustainable practices

can be replaced now with practices available now! Thus, there is no excuse for not making peace with natural systems and the 30+ million species that inhabit them, including *Homo sapiens*.

SECURITY AND SUSTAINABILITY

Adams (2003) comments about the failure of the Natural Resources Defense Council (NRDC) to convince the US Congress not to approve the most far-reaching rollback of marine mammal protection in the last 30 years. The rollback exempts the US military from obeying core provisions of the Marine Mammal Protection Act and the Endangered Species Act. This change permits injuring and killing whales, dolphins, and other marine mammals with high intensity sonar and underwater explosives. It also permits the military to exempt itself entirely from all environmental review under the Marine Mammal Protection Act. In addition, the military can destroy the habitat of endangered birds and mammals that live on the 25 million acres of land under the military's jurisdiction.

These drastic steps were considered necessary because environmental laws were compromising combat readiness for the war on terror. Adams (2003) notes that even the administration in charge of the military cannot name a single training session anywhere in the country that had to be delayed or cancelled because of environmental restrictions.

These actions will clearly endanger Earth's ecological life support system, which is essential to sustainable use of the planet. This major threat to both national and global security will impair security far more than any act of terrorism. These unsustainable practices cannot continue indefinitely.

CONCLUSIONS

Nurturing complex systems for sustainable use of the planet requires a different perspective of humankind's identity, both as individuals and as nation-states. Since humans are dependent on Earth's ecological life support system, it is essential to ensure that the technological/economic life support system does not impair the health and integrity of the ecological life support system. Furthermore, the cumulative impact of individual decisions must also not damage natural systems. Unsustainable practices will be stopped either by changes in human behavior or, more brutally, by nature. Harsh penalties will be exacted by nature for disregarding nature's laws, such as exceeding the global or regional carrying capacity for humans.

Some older cultures regarded natural systems, such as water, as sacred, including the manner of use and the waste of water. In the 13th century, Sinran, a Buddhist priest, wrote, "Nature was not made by any outer forces but was made of its own accord. Buddha or all religious absolutes are means of understanding the state of nature. After real understanding is reached of nature and Buddha, it should not be open to discussion. If it becomes, then nature would not be made naturally and by its own accord. This understanding is the miracle of Buddhism" (as quoted by Kawanabe 2003).

The view of nature at present is nearly a polar opposite of the 13th century one. Nature is sacrificed to keep the economy growing or as a means of disposing of anthropogenic wastes. Respectful observation of nature still appears to be desired by many humans, but political leaders, both elected and appointed, fail to design projects in harmony with natural systems. Under the guise of progress and economic growth, humans destroy, bit by bit, the biospheric life support system for short-term benefits. The technological/economic life support, which supposedly benefits from unrestrained economic growth, is indeed a complex system, but it is merely a subsystem primarily designed for only one species—*Homo sapiens*. However, *Homo sapiens* and its complex technological/economic subsystem are embedded in a much more complex system of millions of species upon which, in the long term, its survival depends. As a consequence, it should be abundantly clear

that the subsystem and the species that created it cannot flourish unless the larger, more complex system is nurtured. Doing so will enhance the prospects for peace.

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Article 21

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Allocating Finite Resources on a Finite Planet

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Freedom is the recognition of necessity. Hegel

… the tender flower of objectivity is easily crushed by what is taken to be the necessity of the moment. Garrett Hardin

Humankind faces two major resource allocation decisions in the twenty-first century. (1) What percentage of the planet's resources are essential to keep Earth's ecological life support system (i.e. natural capital and the ecosystem services it provides) functioning? Empirical evidence on this issue is not robust, but persuasive evidence indicates that natural systems are being both degraded and replaced by human artifacts at a rate unprecedented in history. (2) The increasing disparity in resource allocation among members of the human species is shockingly large and still increasing. In a global community that worships economic growth, economists are failing to address the related questions of how long natural capital will last and whether ecosystem services provided by natural capital can be replaced by present technology in a cost-effective fashion. Persuasive evidence exists that both natural capital and the ecosystem services it provides will be seriously, possibly fatally, diminished in the twenty-first century.

Hardin (1974) used the lifeboat metaphor to approach the unresolved problem of the carrying capacity of the planet. An alternative metaphor is Earth as a spaceship (Boulding 1966). Both of these metaphors are useful in determining the sustainability ethics required for this finite planet with finite resources. Metaphorically, the approximately 2 billion comparatively wealthy people are in 'safe' lifeboats, while approximately 4 billion are in dangerously overloaded lifeboats. If one views each nation-state as a lifeboat, what should the occupants of the safe lifeboats do?

A number of important ethical decisions must be made when deciding what occupants of a particular lifeboat (i.e. citizens of a nation-state) should do. If the nation-states wish to invest in future generations, they should not consume natural capital at a greater rate than it is being regenerated. This decision may mean denying access to immigrants whose lifeboat sank. As Hardin (1974) notes, welcoming these immigrants would mean taking resources from posterity to assist strangers whose lifeboat failed to stay within its carrying capacity. If the persons whose lifeboat sank bring their unsustainable practices with them, then the assisting lifeboat will almost certainly sink; even if it does not, the quality of life for both the individuals in the receiving lifeboat and its descendents will decrease. Only two outcomes are available in this situation. (1) Humankind must exert the

moral and ethical disciplines of equity and fairness in resource allocation (i.e. live sustainably). (2) The natural laws that affect all other species will reduce the human population by famine and disease until it reaches a sustainable level. Economic growth has not been 'the tide that lifts all boats'. Economics has had a devastating effect upon natural systems that will, in the long term, reduce carrying capacity.

Both the lifeboat and spaceship metaphors are superb for acquainting people with the carrying capacity concept. Science fiction authors have even increased the carrying capacity of spaceships by using suspended animation of most of the passengers and crew. The expectation in the science fiction realm is that passengers and crew in suspended animation could be reactivated upon a new planet with more resources. This scenario is not a realistic means of long-term allocation of resources. For spaceship Earth, a better path is to reduce resource allocation per capita. The southern Indian state of Kerala has a much smaller ecological footprint per capita than the US; Kerala still has a life expectancy and literacy comparable to the US. Moreover, Kerala has a population of approximately 30 million, so it is not a small experimental group. Clearly the state has a high 'social capital' despite a modest per capita allocation of resources.

Agyeman et al. (2003) assert that the issue of environmental quality is inextricably linked to that of human equality. Torras & Boyce (1998) have provided evidence that nation-states with a more equal distribution of income, greater civil liberties, and higher levels of literacy tend to have higher environmental quality. However, Dobson (2003) reluctantly concludes that social justice and environmental sustainability are not always compatible objectives. He feels that rapprochements will only be temporary and transient. However, Dobson prudently notes that, although the view that environmental sustainability is generally regarded as a precondition for everything (including social justice), little empirical research supports this assumption.

Rees & Westra (2003) question the sustainability of the entire human enterprise. They focus on the troublesome interactions of conflicting economic, ecological, political, and social forces that humankind must confront and resolve in the twenty-first century. Wealthy individuals can shield themselves from the worst environmental degradation by living in or moving to areas where conditions are better. Special interest groups abound to protect the privileged status. Myers & Kent (1998) note the large number of lobbyists attempting (and often succeeding) to influence legislation favorable to them in the US legislature.

One of the crucial issues in resource allocation is how 'justice' is defined. The *Random House Dictionary, 2nd Edition*, has two definitions that seem appropriate in this regard: (1) the moral principle determining just conduct, and (2) the administration of deserved punishment or reward. The first definition is homocentric and, thus, determined by human moral and ethical principles. The second could be defined as ecocentric — the laws of nature predominate and humans are just part of the interdependent web of life. If one defines conduct that is just as including all life forms and ecosystem integrity, then sustainability ethics might serve because it aspires to be both homocentric and ecocentric. Ultimately violating nature's laws will result in severe penalties.

Nature usually gives quantity a high priority and from an abundance of individuals selects those with the highest fitness or the ability to fit into the present ecosystem. This viewpoint is not just in terms of the ethical stance professed by a part of human society, for example, professing the worth and dignity of each individual. If humankind wishes to leave a habitable planet for posterity (i.e. sustainable use of the planet), then obeying nature's laws must have the highest priority. Some individuals (e.g. Agyeman et al. 2003, pp. 3, 4) believe that 'more sustainable societies will only emerge if those societies begin to demonstrate greater levels of material, social, economic and political

equality.' The twenty-first century is likely to be a defining era for sustainability initiatives. If they are delayed too long, degraded natural systems may not have the resilience to return to the ecological conditions favorable to humankind.

The solution must begin with the recognition that Earth is finite and neither human population nor the amount of Earth's resources per capita can further increase substantially. The inescapable conclusion is that, to achieve both social and environmental justice, more equity and fairness must be present in Earth's resources used per capita globally. The next ethical decision is whether humankind wishes an optimum quality of life (somewhat more resources per capita) or a mere survival quality of life (barely adequate resources per capita). If quality of life is measured by such criteria as literacy, longevity, low infant mortality, and large social capital (i.e. benign social interactions) and small to modest material goods acquisition per capita, then each individual and nation-state will have an ecological footprint size that is sustainable. In addition, natural capital and the ecosystem services it provides will be protected and cherished. This protection is the sine qua non of sustainable use of the planet.

Fierce resistance will come from individuals with a large ecological footprint size and the few individuals and organizations who get a disproportionate share of Earth's resources. Justice may be achieved by stabilizing the population size of nation-states by enforcing zero net immigration (e.g. Cairns, in press) and limiting family size and resource allocation. The alternative is to let natural law determine both population size and resource allocation. This situation is even less attractive than the one just described.

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Article 22

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Sustainability Ethics Matter

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Some men have thousands of reasons why they cannot do what they want to, when all they need is one reason why they can. Mary Frances Berry

Free yourself from attachment to useless things. Buddhist Maxim

When I am asked what my major professional interest is, my reply frequently elicits a variety of stunned responses: 'Nobody cares about ethics anymore; ethics is not relevant'; 'I look out for #1. Let future generations look after themselves just as I do'; 'Exactly what do ethics and sustainable use of the planet mean?' However, I am reassured that an increasing minority shares in supporting the quest for sustainable use of the planet and sustainability ethics. Many people have heard about sustainable development, but they often assume the term applies to perpetual economic growth. Instead of reciting conventional definitions of the words, I usually tell people about my values and the areas of life that matter to me.

1. I care that humankind is destroying the planet's ecological life support system upon which it depends.
2. I care that future generations may not inherit a habitable planet.
3. I care that humankind is now in an epoch of species extinction mostly caused by humans.
4. I care that 1.2 billion people are living on US $1/day or less.
5. I care that cultures both fall (often quickly) as well as rise, with collapse triggered by one or more ecological events.
6. I care that humankind is a part of natural systems, not apart from them. Ignoring this relationship puts humankind at peril.
7. I care that humankind is not using its vaunted intelligence to replace unsustainable practices with sustainable ones.
8. I care that humankind does not recognize that a finite planet cannot tolerate exponential growth of *Homo sapiens*.
9. I care that human society is destroying the habitat of other life forms at an appalling rate in the name of economic growth.
10. I care that humankind is squandering increasingly scarce natural resources on war and the preparation for war (i.e. 'defense').

11. I care that economic capital is more highly valued than social capital (i.e. material possessions are replacing a sense of community).
12. I care that human society is depending on technology to solve the problems humankind has created rather than re-examining its value system.
13. I care that an abrupt global climate change could drastically reduce Earth's carrying capacity for humans.
14. I care that changing weather patterns will have adverse effects upon many of the planet's species, although eventually evolutionary processes will replace those species lost with others.
15. I care that misery and starvation are still factors reducing human population growth when other less brutal means are available.
16. I care that growth of human population and rate of material consumption will make the transition to sustainable use of the planet increasingly difficult.
17. I care that global climate change will adversely affect world economies, including insurance costs, retirement funds, food prices, and many other sectors of the economy.

The first color picture of Earth from the moon was a paradigm shifting experience for many people — a small, fragile, tiny blue globe containing the only life that has been found in the galaxy or even universe — not an overpowering picture of everyday life that often consists of hundreds of attention-grabbing television channels, the Internet, and multiple jobs for one person. Humans should be passionate about protecting Earth, both for themselves and the future generations of their own species and other life forms. A life without a passion for values (i.e. ethics) is a round of superficial events. Priorities that reflect obtaining money and material possessions trap an individual in an aimless existence in which goals are shaped by advertising, approval of others, and the accumulation of 'stuff.' An increase in material possessions, whose creation uses excessive amounts of increasingly scarce resources, is the result of being led by the profit motive of advertisers. Why have societies in developed nations 'sold out'? Lifestyles are being 'sold' to society for profit, which all too frequently is obtained from activities damaging to natural systems. In addition, corporations that profit from resource consumption and selling material possessions subsidize candidates and office holders who favor exponential growth. The life energy of humankind should not be drained by activities that are so harmful. As Socrates stated, 'The unexamined life is not worth living.'

Gandhi listed seven deadly social sins: (1) politics without principles, (2) wealth without work, (3) commerce without morality, (4) pleasure without conscience, (5) education without character, (6) science without humanity, (7) worship without sacrifice. Avoiding these 'sins' is an essential foundation for sustainability ethics.

What is humankind's justification for being on this planet as a part of and dependent upon natural systems? Surely, humankind's purpose is not to engage in consumerism at the expense of natural systems. Failure to consider the ethical components of defining moments,[1] which could either help human society to achieve sustainable use of the planet or cause failure, deserves serious attention. However, individuals attempting to survive one day at a time probably find the aspiration for sustainability meaningless, even insulting.

After population growth and demographic shifts, the next global sustainability crisis will almost certainly be the availability of freshwater, both quality and quantity. The eventual crisis is worsened by the probability that rainfall patterns will be altered by global climate change. Availability of fresh-

[1]A defining moment is one that causes a paradigm shift

water has been worsening for decades and is already badly in need of an application of sustainability ethics.

The situation involves freshwater resources. The basic evidence is readily available to politicians, world leaders, and any other inhabitants of Earth willing to make a modest effort. Only a small portion (4%) of the planet's water is of critical interest to humankind — approximately 70 million cubic kilometers. Water covers nearly three-quarters (71%) of the planet's surface. The hydrosphere is estimated at 1,420 million cubic kilometers (Source: FAO/World Water). All water benefits some life forms — humans extract resources from and travel on the vast oceans — but it is freshwater that is a limiting factor.

The residence time of a drop of water in human cells is a few hours, 8 days in the atmosphere, and only days to weeks in most flowing systems (i.e. streams, rivers, etc.). In contrast, the residence time of a drop of water in the oceans is estimated at 2,500 years and 1,400 years in underground aquifers (at least until extraction with pumps began). Some areas of the planet have abundant freshwater; others have very little. However, this essential component of all life forms is mismanaged nearly everywhere.

Flowing water has been used from Roman times to the present as a convenient means of transporting wastes away from the area in which they were produced. Even in Roman times, people usually lived downstream, so the practice has always been unethical. Even if no humans lived downstream, huge numbers of species with varying degrees of tolerance for anthropogenic wastes inhabit aquatic ecosystems. Aquatic ecosystems can assimilate limited quantities of waste and may even improve the water quality if the integrity and health of the ecosystem has not been impaired. Humans have an ethical responsibility for the condition of these ecosystems.

One cannot pollute aquatic ecosystems and be immune from the consequences. The capacity of aquatic ecosystems for self-purification must be retained for sustainable use of the planet. Vast amounts of freshwater are displaced from the normal hydrologic cycle for irrigation, as well as domestic and industrial use. Competition is high for finite amounts of water between domestic/industrial and agricultural special interest groups. Both uses endanger aquatic organisms by pollution and extraction.

The Third World Water Forum, Kyoto, Japan, 2003, discussed many of these issues. However, a defining moment for freshwater management was the 1977 International Water Conference, held in Mur de Plata, Argentina. Other meetings have been convened, but none have resulted in sustainable use of water.

In some areas of the world, the minimum flow needed to maintain the integrity of aquatic life forms is debated. Agricultural, municipal, and industry special interest groups with substantial funds are usually opposed in the debate by comparatively poorly funded environmentalists. Economic concerns usually win, which is not surprising since short-term economic issues usually get more attention than long-term sustainability ethics and issues. Sustainable use of the planet requires that unsustainable practices be replaced by sustainable practices.

The following statement on political cyclicity has been attributed to Professor A. Tyler, late 1700s, regarding the fall of the Athenian Republic (V. Abernethy, pers. comm., July 3, 2003):

> The average age of the world's greatest civilizations has been two hundred years. These nations have progressed through this sequence. From bondage to spiritual faith; from spiritual faith to great courage; from courage to liberty; from liberty to abundance; from abundancy to complacency; from complacency to apathy; from apathy to dependence; from dependence back into bondage.

The quest for sustainable use of the planet is an attempt to maintain a sustainable relationship with natural systems in which the desire for abundance is restricted by voluntary or involuntary alteration in human behavior so that the ecological life support system is not damaged and natural capital and ecosystem services are cherished and maintained in robust health. Moreover, intelligence and reason may be capable of dampening political cyclicity or ultimately eliminating it altogether. Sustainability ethics seems the most promising means of reaching this desirable goal. Sustainability cannot be achieved if world leaders, politicians, economists, and the citizenry as a whole espouse exponential growth on a finite planet, especially at the expense of posterity. Arguably, the most important achievement would be the ability of most of humankind to visualize the complex web of connections — ecological, social, and cognitive — that compromise the planet's life support systems. This recognition would acknowledge that no individual can exist in isolation from the life support system.

I believe in an essential goodness in all humankind that, if free from the advertising of greed, will preclude the horrendous damage to the planet's ecological life support system and concomitantly to posterity. If this expectation is not fulfilled, it will indicate that human intelligence and brain size was not the evolutionary success humans boast about. Mainstream scientists agree that the biotic crisis is likely to result in a major extinction of species.

Myers & Knoll (2001) believe that, probably more significant in the long term, the crisis will surely disrupt and deplete certain basic processes of evolution, with consequences likely to persist for millions of years. They speculate that distinctive features of future evolution could include a homogenization of biotas, a proliferation of opportunistic species, a pest-and-weed ecology, an outburst of speciation among taxa that prosper in human-dominated ecosystems, a decline in biodisparity, an end to the speciation of large vertebrates, the depletion of 'evolutionary powerhouses' in the tropics, and unpredictable emergent novelties. Almost certainly, even a few of these conditions will not favor sustainable use of the planet and might even reduce or eliminate *Homo sapiens*.

First order effects might well include: (1) elimination of between one-third and two-thirds of extant species (e.g. Wilson 1992); (2) a mega mass extinction of populations, with an impact proportionately greater than the mass extinction of species (e.g. Hughs et al. 1997); (3) probable crossing of ecosystem thresholds (e.g. Woodwell 1991); (4) invasions of exotic species and other alteration of biotas (e.g. Mooney & Hobbs 2000); and (5) major reduction and possible elimination of some biomes (e.g. Raup 1991).

Accelerating the pace of evolutionary change is a dangerous threat to sustainable use of the planet. How can one species, *Homo sapiens*, hope to thrive and persist when the planet's ecological life support system is experiencing major evolutionary change over a period likely to encompass millions of years? Sustainable use of the planet would be more probable if evolutionary change were at a slow pace to which humans could accommodate more readily. If sustainability models are to be truly long-term, they must include evolutionary processes and change as a major component. Morowitz (1992) notes that sustained life is a property of an ecological system rather than a single organism or species.

Almost certainly, any major disruption of Earth's ecological life support system will reduce the planet's carrying capacity for humans. Persuasive evidence already exists that the sixth great extinction of species is underway. Taking precautionary measures to enhance the probability of achieving sustainable use of the planet at once is justified since the tipping point (i.e. crucial ecological threshold) is not known. Humankind should engage in an ethical dialogue on these

issues while concomitantly improving predictive models of future events. One of the major benefits of this would be avoiding resource wars that could easily be triggered by reduced carrying capacity (carrying capacity refers to the ability of natural systems to support a finite number of people marginally or optimally depending on the resources per capita). Increased carrying capacity reduces the likelihood of resource wars. An abrupt decline in carrying capacity is likely to increase aggressive behavior of individuals and nations. At the very least, a dialogue on sustainability ethics would reduce human suffering and reduce the rate of biotic impoverishment. An ideal outcome would be to leave a habitable planet for posterity.

Above all the quest for sustainable use of the planet is an expression of optimism about the long-term future of humankind. Humankind can (1) reduce, perhaps even eliminate, abject poverty, (2) develop a mutualistic relationship with natural systems, and (3) leave a habitable planet for posterity. If I did not have confidence that humans could live sustainably, I would not, at nearly 81 years of age, be spending a very substantial portion of my remaining years espousing the ultimate quest of our time. I may not live to see a major transition from unsustainable to sustainable practices, but I am comforted that we have the means to do so and lack only the will.

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Article 23

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Taboos and Denials: Major Obstacles to Sustainable Use of the Planet

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ABSTRACT: A taboo is a (1) prohibition excluding something from use, approach, or mention because of its sacred and inviolable nature and (2) an object, work, or act protected by such a prohibition. Denial is a refusal to believe in the existence or reality of a fact or entity. Human society professes to believe sustainable use of the planet is a means of leaving it in a habitable condition for future generations. However, a taboo, especially among mainstream politicians, has been placed on the free and open discussion of present practices that are unsustainable. At the core of the taboo is the refusal to discuss the certainty that infinite growth on a finite planet is impossible. Reducing population growth and/or immigration to achieve a stable population is an example of a more specific taboo. Even in societies that profess to be liberal, there is either denial that the problems exist or a profession of excessive optimism about the future, even without substantive supporting evidence. Achieving sustainable use of the planet will require a free and open exchange of ideas on the present practices that are sustainable and which unsustainable practices should be eliminated or greatly modified to make them sustainable. Until then, the term *sustainable development* will be a placebo rather than a cure.

KEYWORDS: Sustainable development; Compassion; Value systems; Eco-ethics.

A man said to the universe: "Sir, I exist!"
"However," replied the universe,
"The fact has not created in me a sense of obligation." Stephen Crane, 1899

INTRODUCTION

The poet Stephen Crane recognized over a century ago that the human species has no special rights and its mistakes are not forgiven any more than those of any other species. If humans are to live sustainably on the planet, they must openly discuss the factors that are essential to this aspiration of sustainability. Making such discussions taboo or denying that major obstacles to sustainable use of the planet exist is not a productive approach!

Ryan and Durning (1997) give a "Warning to Readers" that reading too much STUFF at one time can be bad. Even reviewers (presumably, experienced people) of early drafts of journal articles reported feeling overwhelmed or depressed after learning the true stories of how things are made. I had the same response to *Material World* (Menzel, 1994)—the disparity in material goods from one family to another was shocking. Pessimism about what is being done is justified.

However, optimism is justified about what can be done to achieve sustainable use of the planet. For example, Hawken et al. (1999) describe an environmentally sensitive form of capitalism that protects and rehabilitates *natural capital* (e.g., top soil, old growth forests, wetlands) and provide case histories of such undertakings from both developed and developing countries. Raffensperger and Tickner (1999) also give case histories related to the general duty of precaution in environmental protection for governments and business. Nattrass and Altomare (1999) focus on the use of planetary resources by businesses in ways compatible with sustainable use. Quinn (1999) provides a philosophical/ethical justification for social solutions for an actively caring relationship with natural systems. While their observations are not limited to natural systems, the Dalai Lama and Cutler (1998) examine happiness (as distinct from pleasure) that, since it is not based on material possessions, would enhance the possibility of achieving sustainable use of the planet.

BENEFITS OF OPEN DISCUSSION

Open discussion of the consequences of promiscuity has definitely moderated the problem of AIDS in some countries, although the crisis is far from over. Similarly, societies that openly discussed the problem of driving automobiles while intoxicated have reduced the problem and almost eliminated it in countries with strict laws and considerable peer pressure. People who openly discussed the adverse consequences of these behaviors were not labeled "gloom and doomers" and were not commonly challenged with statements such as "I am optimistic about the future." How can one account for this difference in attitudes? One strong possibility is that only one primary behavior needed change, not a multidimensional array. Also, the consequences of driving under the influence were immediately apparent in many cases, and, in the case of AIDS, a single moment of carelessness could have devastating, although not immediately apparent consequences.

THE DOWNSIDE OF TARGETED COMPASSION

Just as most teenagers regard themselves as immortal and age proof, the case histories of the environmental collapse of ancient civilizations (e.g., Diamond, 1994, 1997) are ignored, as are contemporary parables such as that of Nauru Island (McDaniel and Gowdy, 2000) in the Pacific Ocean. Most people have never heard of Nauru, and many of those who have note that it is a quite different culture and "it couldn't happen here."

However, Hardin (1993) hits a more crucial aspect when he notes that society fails to mandate economic sanity because human brains are addled by compassion. High-powered lobbyists may have a major impact as well. Should all environmental protection be put on hold until every human on the planet has the same ecological footprint as wealthy individuals? Cairns (1998) believes that sustainability requires a balance of three types of compassion: (1) for those presently disadvantaged, (2) for other species with which humans share the planet, and (3) for future generations. These types of compassion are more difficult to achieve simultaneously and are less personally satisfying than targeted compassion. Future generations and other species cannot express gratitude, so one's personal efforts are difficult to distinguish from comparable efforts of other like-minded individuals. On the other hand, if one sponsors a starving child (targeted compassion), then

the child can write and send photos, and some beneficial results will probably be immediately apparent. Consequently, targeted compassion produces targeted gratitude—a very satisfying result.

Arguably, the solution to this dilemma of multidimensional versus targeted compassion is the development of a global environmental ethos or set of guiding beliefs that bring honor and status to exemplary practitioners of multidimensional compassion. The nomadic North American plains Indians did not accumulate material possessions, so the primary source of status was the "coup stick" on which a notch was cut for each notable achievement that benefited the tribe. In a small social group where others know each individual's actions, this type of recognition is not difficult to implement. In a larger arena where a harmonious relationship with natural systems is the key to the type of sustainable use of the planet generally envisioned, multidimensional compassion must somehow be rewarded.

THE UTOPIAN SOFT LANDING

Cairns (2001) speculates about the variety of scenarios that might lead to sustainability. The "soft landing," which causes no increased human suffering during and after the transitional period, is the scenario that receives the most media attention because it is optimistic and is what most people, and nearly all politicians, want to hear. Humans have had sustainable use of the planet for virtually their entire history. During this time, population numbers were low, kept so by high mortality and short life expectancy. Only in relatively recent times have exponential growth in population and remarkable per capita affluence for a few emerged. The exuberant optimists proclaim no limits to this growth. Others proclaim that further such increases are impossible on a finite planet. The outcome will probably become abundantly clear in this century!

THE EXTINCTION OF *HOMO SAPIENS*

For most of the planet's existence, the human species was not present. During that period, many species became extinct, and even mass extinctions occurred in some periods. The extinctions occurred because some species failed to adapt to changing physical/chemical/biological conditions, including competition from better adapted species. Most species do not survive for substantial periods of geological time. Why should the human species be one that does? The most commonly offered answers focus on human technology, economic prowess, creativity, and ingenuity. But these same attributes are creating problems faster than society can solve them. The least likely answers being suggested at present are societal ethics, ethos, sense of individual responsibility, and compassion for other species. Yet, it is the human value system that is the *sine qua non* of sustainability. How can this conclusion of the need for value systems be valid when a reasoned approach is essential to achieve sustainability with minimal trauma to humans and an actively caring relationship with natural systems? The answer, of course, is a free and open discussion of all issues and substantively reducing or even eliminating taboos and denials.

Even with a free and open discussion, a clash will probably occur between value systems and a reasoned approach. Still, value systems are essential because every problem cannot be resolved by evidence produced by reductionist and/or holistic or integrative science. The "least likely answer" mentioned previously is the least frequently used or offered because reexamination of value systems or societal ethos is usually a painful and contentious exercise. As a general rule, a catastrophic event is essential to have an entire society involved in the discussion. For example, some of the restrictions on individual freedom that were considered unthinkable before the

September 11 terrorist attacks in the United States are now being implemented with what appears to be fairly strong citizen approval—at least for the short term. Evidence and reason can often estimate risk rather well—only a value judgment can determine acceptable risk. It is also well to remember that, for a few people, prolonging the problem is profitable.

ETHICS IN ACTION AND INACTION

The National Research Council (NRC, 1992) recommended that U.S. wetlands be restored at a rate that offsets any further loss of wetlands and contributes to an overall gain of 10 million wetland acres by the year 2010, largely through reconversion of crops and pastureland and modification of existing water control structures. However, at the end of 2001, equilibrium has been reached between wetland loss and restoration. For rivers and streams, the NRC recommended restoration of 400,000 miles, approximately 12% of the 3.2 million miles of streams and rivers in the U.S. Excluding the Great Lakes and flood control and water supply reservoirs, the recommendation was to restore by the year 2000, 1 million of the 4.3 million acres of degraded lakes, with restoration increased to 2 million acres in the long run. Near the end of 2001, these goals are as distant as they were in 1992, yet the U.S. has enjoyed a period of remarkable prosperity and low unemployment. Arguably, more restoration was carried out during the Great Depression of the 1930s when the Civilian Conservation Corps revegetated many areas. Ironically, the economic boom of the 1990s was fueled by profligate use of natural capital, which was not being reversed at a rate essential for sustainable use of the planet. Even if resources were infinitely substitutable as some economists propose (e.g., Simon, 1981) and humans were not resource limited, as are other species, some daunting problems in eco-ethics would remain.

1. Even if humans were no longer dependent upon natural systems, would this independence free human society from an ethical responsibility toward the integrity and health of natural systems?
2. Many societies have abolished the death penalty for humans. Should this prohibition be extended to other species (i.e., take no action that leads to their extinction)?
3. Even if humans became free of resource limitations, their quest for substitute resources would deprive other species of resources (e.g., space, fiber, food). Since there are millions of species on the planet, what is the maximum equitable share for one species (*Homo sapiens*)?
4. What precautions should be taken to reduce the environmental impacts of genetic engineering?
5. Even if a wholly technological life support system were to be developed, would it not be prudent to retain the natural life support system (which has served humanity well for most of its existence) as a backup system? The failure of Biosphere II (Avise, 1994) shows how far society is from achieving a reliable technological life support system that replicates the ecological life support system.
6. If a more intelligent life form with a superior technology appeared from another planet, would humans expect treatment that is better than or comparable to the treatment they give “lower” life forms on this planet?

These are illustrative problems in eco-ethics that should elicit a free and open exchange of ideas in human society. Since they do not, society is either denying that the problems exist or feels that such discussion would degenerate into a greater polarization of opinions. As a consequence,

discussion can be considered taboo (e.g., Hardin), or the importance of the problem is denied (e.g., Orr and Ehrenfield, 1995).

Arguably, there is no human society so monolithic that every individual denies that a particular problem exists or does not feel upset about societal norms. Some remain silent or take covert action; others speak out and sometimes lose their lives or social status; still others may be highly honored after their deaths (e.g., in the environmental field, Rachel Carson and Aldo Leopold). However, both taboos and denials are powerful social forces and should be a matter of concern. In addition, there are always a few people who think they can beat the odds, however formidable they appear to be.

Hardin (1996) defines taboo as a prohibition excluding something from use, approach, or mention because of its sacred and inviolable nature or an object, word, or act protected by such a prohibition. Since the concept of sustainable development has been embraced by both organizations and people whose practices do not proclaim a reverence for natural systems, some very powerful taboos are preventing a free and open discussion of implementing sustainable use of the planet. Even if the taboos do not prevent people from talking about sustainable use, there is denial. If denial does not stop free discussion, calls for more studies muffle or suspend it.

ILLUSTRATIVE TABOOS ON SUSTAINABILITY

As Harding (1996) notes, those enthralled with a taboo not only resist discussion of it, but they even deeply resent the open naming of it. When scientific evidence has implications for the quest for sustainable use of the planet, implications must be communicated and discussed, and value judgments need to be made.

1. One must not question whether development or “smart growth” is compatible with sustainability.
2. Carrying capacity may be discussed for elevators and bridges, but not for humans on a finite planet.
3. The relationship between population size and quality of life is not open for discussion. In the United States, this taboo is so strong that policy goals include extending residency to illegal aliens (Grier and Chinni, 2001).
4. One must not discuss the “sixth great extinction”—the first biotic impoverishment primarily due to humans and their artifacts.
5. Redesigning human society for a better relationship with nature may only be discussed in the context of economic growth.
6. Human dependence upon natural capital, ecosystem services, and the planet’s ecological life support system is not open for discussion.
7. Restoring damaged ecosystems can be discussed, but when and how ecological destruction and repair are balanced cannot be discussed.

ILLUSTRATIVE DENIALS AFFECTING SUSTAINABILITY

Denials are merely the taboos of people who refuse to use the word *taboo*.

1. Human population growth is not a problem.
2. Highways and other human artifacts have no environmental impact.
3. Economic growth, as presently defined, improves the quality of life rather than diminishing it.

4. Placing trust in the managers of the global marketplace will protect the environment and enrich human lives.
5. The willingness to risk global disaster is essential to progress and job security.
6. Dominion over all other forms of life is a consequence of human superiority, and there is no reason to be concerned.
7. Humans are independent of nature and their intelligence, technology, and creativity free them from the natural laws that affect other species.

THE ENFORCERS

In 1777, the famous English explorer James Cook introduced his compatriots to the word *taboo*, which he had picked up in the South Pacific (Hardin, 1996). Of course, repressing speech or practices was not new to the western world—only the name was new. Arguably, the quest for sustainable use of the planet involving both science and value judgments is the most vulnerable aspiration of human society since it requires a free and open discussion of a multitude of concepts and beliefs. In Polynesia and other cultures, taboos (no matter what they were called) were enforced effectively, often brutally, by powerful people. How, one wonders, could taboos possibly be enforced in the 21st century in that bastion of rugged individualism and free speech—the United States of America? It can be done more easily than one might think.

In academe, where analysis and examination of all hypotheses and concepts should be subjected to rigorous validation and verification, there are speech codes. Much emotion is invested in speech codes, so a fearless discussion of them is difficult. In addition, politicians depend heavily upon funding from special interest groups for their increasingly expensive election campaigns. Support for one special interest group will cause countervailing effects in other areas (e.g., protection of endangered species, which has a tiny lobby compared to most economically important areas). As Keppler (1995) notes for the United States, special interest groups are adept at penetrating the political process and using their electoral influence to achieve their goals. In the U.S. capital of Washington, D.C., there are 90,000 lobbyists, in addition to 60,000 lawyers for back up, or 280 for every member of the U.S. Congress. The monthly cost for this is at least US$100 million and is increasing (Shuldiner and Raymond, 1998). The payoff can be immense: between 1993 and mid-1996, American oil and gas companies gave US$10.3 million to political campaigns and benefited from tax breaks worth US$4 billion (Roodman, 1996). Finally, television stations, newspapers, and magazines are not likely to offend their advertisers; one notable exception appears to be some radio talk shows. Who believes that taboos cannot be enforced in the land of the free and the home of the brave?

TABOOS THAT FACILITATE SUSTAINABILITY

From a different view, taboos may have benefits that facilitate sustainability. Taboos may be an effective method of achieving sustainability while environmental literacy remains low. This prospect is definitely not appealing. However, as one committed to reason guided by evidence and compassion, the following may be regarded as illustrative taboos enhancing sustainability. They are primarily drawn from Cairns (1997).

1. Human artifacts may not systematically increase on the planet.
2. The integrity of the planet's ecological life support system shall not be impaired for any reason.

3. Anthropogenic extinction of species is prohibited.
4. Large ecological footprints for both nations and individuals must be reduced.
5. Production of wastes not compatible with natural biogeochemical cycling may not be produced.
6. Ecological destruction may not exceed ecological repair.
7. Human society shall not co-opt so much of the planet's energy that ecosystem integrity is impaired and ecosystem services are disrupted or diminished.
8. Dependence upon yet undeveloped technologies to solve ecological problems is prohibited.
9. Failure to utilize precautionary practices to prevent catastrophic events, even if the scientific evidence is uncertain, is unreasonable. It is essential to remember that, if the outcome is uncertain, it could be catastrophic.

These illustrative taboos that might facilitate the quest for sustainable use of the planet will clearly be complex if human society is balancing the integrity of both economic/technological and ecological life support systems simultaneously. Since human society is now dependant upon both (Cairns, 1996), this balancing act must be done.

CONCLUSIONS

Taboos are not an adequate substitute for information but those favoring sustainability may be required to use them if human society as a whole remains ecologically illiterate. In addition, information is not knowledge and knowledge is not wisdom, but all will be needed to achieve sustainability. If people refuse to discuss a subject, how can they inform the unknowing what it is that is sacred? Thus, a word—*taboo*—held inviolate becomes a taboo on thinking itself. Ultimately, a word taboo held inviolate for a long temporal span becomes a thought taboo (how can one think of something one hears no words for?). In the United States and many other countries, discussion of unsustainable practices is taboo. Among the most sacred taboos is the free and open discussion of government subsidies for practices that adversely affect human health and the environment. Even some U.S. organizations that purport to favor the environment are wary of discussions about immigration policy, which is a key component of population policy that, in turn, strongly affects sustainable use of the planet.

Ultimately, it is not only what humans do that affects their lives, the lives of their descendants, and biospheric integrity but also what humans choose not to do. If humans choose not to discuss factors important to the quest for sustainable use of the planet, how can they possibly expect to achieve sustainability? The planet is finite, yet discussion of limits to growth of all kinds is increasingly taboo in centers of enlightenment (academic institutions), compassion (religious organizations), and even town councils.

Opposition is often silenced, but not persuaded, by use of terms such as smart growth. As James Thurber remarks, "A man convinced against his will is of the same opinion still." This situation masks a taboo rather than exposes it, which can be very dangerous to both individuals and organizations. Openness is essential to achieving sustainable use of the planet.

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Article 24

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Consilience or Consequences: Alternative Scenarios for Societal Acceptance of Sustainability Initiatives

John Cairns, Jr.

SUMMARY
Most people wish to leave a habitable planet for their descendants. Blocking the achievement of this goal are some powerful forces: (1) fragmentation of knowledge about the system, (2) unwillingness to change present behavior and practices, and (3) a belief that human ingenuity and technology can solve problems of resource depletion or scarcity. This discussion considers the necessary paradigm shift toward sustainability that will result from consilience (literally "a leaping together of ideas") or consequences (results of unsustainable behavior and practices). The consilience concept provides a hopeful indication that human society need not suffer horrendous consequences in order to make the paradigm shift toward sustainable use of the planet.

INTRODUCTION

Wilson (1998a, b) has resurrected the word *consilience*, a term introduced by William Whewell in his *The Philosophy of the Inductive Sciences*, published in 1840. Consilience (literally "the jumping together") means the alignment of knowledge from different disciplines. Wilson (1998a, b) notes that, since Whewell's time, the disciplines of physics, chemistry, and biology have been connected by a web of causal explanation organized by the induction-based theories that telescope into one another. He notes that the entire known universe, from the smallest subatomic particles to the reach of the farthest known galaxies (together spanning more than 40 orders of magnitude), is encompassed by consilient explanation. Wilson (1998a) notes that the unifying and highly productive understanding of the world that has evolved in the natural sciences owes its success to a fortunate combination of three circumstances: (1) the surprising orderliness of the universe, (2) the possible intrinsic consilience of all knowledge concerning it, and (3) the ingenuity of the human mind in comprehending both.

The quest for sustainability (e.g., World Commission on Environment and Development, 1987; Robèrt et al., 1997; Cairns, 1997a) essentially assumes that global human society is capable of altering its behavior by such actions as stabilizing population numbers, restraining the use of resources, and protecting the planet's ecological life support system so that a habitable planet will be left for future generations. My personal interpretation of sustainable use of the planet does not assume a steady set of conditions because the unexpected is bound to occur. Moreover, natural

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systems are dynamic but, nevertheless, retain their essential ecological integrity, except during the grossest insults. Sustainable use of the planet, therefore, should mean that human society holds natural systems in high esteem and is sufficiently literate about the conditions that enhance the well-being of natural systems to make the necessary adjustments in societal behavior to increase the probability of long-term, healthy condition of natural systems with robust integrity.

Wilson (1998a) notes that the expansion of consilient cause-and-effect explanations outward from the natural sciences towards the social sciences and humanities is calling the traditional division of knowledge into question. What has heretofore been taken as a series of discontinuities between the disciplines is, in Wilson's opinion, starting to look entirely different—a broad and largely unexplored terrain of phenomena bound up with the material origins and functioning of the human brain. In a sustainable use of the planet context, Wilson's (1998b, p. 17) key sentences are:

> At the heart of this borderland is the shifting concept of culture and its hitherto puzzling relation to human nature—and thence to the general inherited properties of individual behavior. In the spirit of the natural sciences, the matter can be expressed, I believe, as a problem to be solved. It is as follows: Compelling evidence shows that all culture is learned. But its invention and transmission are biased by innate properties of the sensory system and brain.

Wilson considers what the nature of the gene-culture coevolution might be and how it has affected the human condition today.

Wilson's consilience hypothesis is very persuasive and to take fragments of it (as I have done) is to trivialize a beautifully organized body of evidence and theory. It deserves a full and careful reading! Wilson's concepts provide the best foundation for hope in achieving some semblance of sustainable use of the planet and the multidimensional point of view necessary for achieving sustainability, and provides evidence (albeit not on sustainability itself) for reinforcing this belief. As Wilson (1998a) notes, it is becoming increasingly clear that the human brain and concomitant intelligence evolved as an instrument of survival rather than a device to understand itself, much less the underlying principles of physics, chemistry, and biology. Too few individuals and very few governments perceive the threats to the ecological life support system as threats to individuals, governments, or human society as a whole.

EVIDENCE FOR OPTIMISM ABOUT ACHIEVING SUSTAINABILITY

Ecotourism is a nature-based form of specialty travel defined by The Ecotourism Society (TES) as "responsible travel to natural areas which conserves the environment and sustains the well-being of local people." Ecotourism should be considered a specialty segment of the larger nature tourism market, which includes wildlife safaris, bird watching, whale watching, and the like. Not only is the ecotourism market alive and well, but it is expected to grow considerably in the future. Fillion et al. (1992) define ecotourism as "travel to enjoy and appreciate nature." They identified, through an analysis of inbound tourists' motivations to different worldwide destinations, that 40-60 percent of all international tourists are nature tourists and that 20-40 percent are wildlife-related tourists. Nature tourists can be defined as tourists visiting a destination to experience and enjoy nature, and wildlife-related tourists can be defined as tourists visiting a destination to observe wildlife (e.g., whale watchers). A United States Travel Data Center 1992 travel survey indicated that 7 percent (8 million) of United States travelers had taken at least one ecotourism trip and 30 percent (35 million) would take one by 1995; therefore, potentially some 43 million adults in the United States took an ecotourism trip between 1992 and 1995. In a 1994 study of North American travel

consumers, 77 percent had already taken a vacation involving activities related to nature, outdoor adventure, or learning about another culture in the countryside or wilderness. Of the 23 percent remaining who had not, all but one respondent were interested in doing so (Wight, 1996). One might reasonably conclude that individuals wish a more personal relationship with natural systems and would be distressed if their opportunities to achieve this were diminished.

CAN WE RELY ON EFFECTIVE GOVERNMENT ACTION?

One of the books I found most helpful on the question of relying on effective government action is by Salisbury (1969) on the siege of Leningrad in the then USSR during World War II. Despite overwhelming evidence to the contrary, Stalin (head of the then USSR) believed that the non-aggression pact with Hitler (head of Nazi Germany) would hold. Worse yet, high-ranking military officers, who had seen the evidence of a military build-up by Nazi Germany, presented a contrary view, literally at a risk to their lives. Even after the war had started, some common sense measures were not taken until after major suffering was evident; for example, women, children, the elderly, and invalids were not evacuated from Leningrad until much pain had occurred. Furthermore, foodstuffs such as sugar and flour were left in warehouses that were exceedingly vulnerable to air attack, rather than being placed for safekeeping in underground storage areas. I reread this 635-page book (admirably referenced) in order to examine the consequences of steadfast adherence to an inappropriate paradigm.

Both Lindsey's (1993) and Stevenson's (1976) books show similar inabilities of leaders and groups to focus on the important issues. Since I was in the Pacific during World War II, I have read some books about that conflict (e.g., Costello, 1969) and have found that both sides often had strongly held but inaccurate beliefs that caused substantial loss of life and material. The reason for reading these distressing publications is that the ease with which one holds on to paradigms to the extent that contrary evidence is rejected (as Kuhn, 1970, so aptly stated) is increased with distance from the problem. Some strongly held paradigms of the present time are: (1) economic growth is the solution to all the problems of human society, including poverty, overpopulation, destruction of natural resources, and the like; (2) any problem created by technology can be solved by technology; and (3) human intelligence, creativity, and technology exempt human society from the biophysical laws of nature that restrict other species.

For those who believe that present generations are so well informed that mistakes comparable to those of the past are simply impossible, it is worth re-examining the widespread collapse of the Asian economic system in 1997. Before it occurred, United States financial advisors and analysts worried that, if they did not emulate the Asian "tigers," they would be devoured. Investors were encouraged to invest in this rapidly expanding market, and the terrible fate of investors in stodgy United States stocks was described in extensive and lurid detail. The collapse of the Asian financial system involving many countries (Indonesia, South Korea, Japan, Thailand, Hong Kong and, to a lesser extent, others) seems to have taken financial advisors and analysts by surprise, although I have been looking in vain for an admission of error from those who were recommending stocks in the troubled countries, even up to the point of collapse. Governments in developed countries seem also to have been taken by surprise, although one would think the financial collapses in Asia would have been of military as well as economic significance.

The world is interconnected, which means that trouble in one part can easily result in trouble in other parts, particularly economic instability and political unrest. Even when the problem is fairly straightforward and obvious, such as the one in the United States Social Security System where

the finances and the demographics are comparatively clear, society seems unable to bring itself to make a decision until the unfavorable consequences are being endured by many.

ECOLOGICAL IMPAIRMENT OF ANCIENT CIVILIZATIONS

I first became interested in technological and ecological connectedness when invited in 1994 to write a chapter for a book to be published by the National Academy of Engineering (Cairns, 1996). A draft of this was completed in the first half of 1994, and, later that year, I was privileged to give the Abel Wolman Distinguished Lecture (Cairns, 1994, 1995) to the National Academy of Sciences. In both of these, I took the position that human society's life support system is both technological and ecological and that the former could seriously damage the latter if care is not taken in balancing the delivery of services from each. If human society repairs damage to ecological systems caused by technological systems, one of the primary forms of motivation would be an acknowledgment of a dependence upon the former. Furthermore, if human society can have a major effect upon natural systems (very well established) and natural systems can have major effects upon human society (hotly debated, but see Cairns and Bidwell, 1996a,b), then the two systems are coevolving (Cairns, 1997b).

One of the characteristics of coevolution is that failure to adjust to changes on either side can exact severe penalties on the component failing to do so, and even adversely affect the "innocent" partner. There is an interesting difference in coevolutionary relationships, partly influenced by level of organization and partly influenced by intelligence. For example, the hummingbird/flower relationship (in which the bill length of the bird is closely related to the structure of the flower and the bird gets nectar and the flower gets pollen distributed) is a "mindless" development where the individuals with inappropriate bill length or flower structure suffer severe consequences. What appears to be a beautiful, harmonious relationship is the result of severe penalties exacted on those individuals that did not meet specifications. The glorious result is highly visible; the penalties are not. Intelligence does not enter into the final result in any significant way, although consequences almost certainly did by eliminating the maladjusted.

In the human society/natural system coevolutionary relationship, the latter is merely following biophysical laws without regard to the consequences to either component. Human society, on the other hand, has the opportunity to use information, coupled with reasoning, to diminish the probability of deleterious consequences (such as loss of topsoil, contamination of the water supply, climate change, increased ultraviolet radiation because of depletion of the ozone layer). On the plus side, the maintenance of such ecosystem services as atmospheric gas balance, recycling of nutrients, transformation of solar energy into forms useful to living material, and providing food fiber and other useful materials to human society may be enhanced and sustained. The quest for sustainable use of the planet focuses on a mutually beneficial relationship, even though only one of the two systems is capable of awareness as a consequence of the development of intelligence. Failure to utilize this intelligence to nurture the coevolving system will probably result in the loss of those species unable to adjust to the present behavior of human society and will benefit those species highly resistant to the impact of human society (e.g., pests) and, often, its efforts to control them (Cairns, 1997b).

EXEMPTIONALISM

There are those who believe that human society, as a consequence of intelligence, ingenuity, and technology, has become exempt from the biophysical laws that affect other species. Others believe that humans are part of natural systems and subject to the same biophysical laws as other species,

although the attributes just mentioned protect human society from other species to some degree. For those unfamiliar with this debate, an excellent single source to examine both positions in detail is Myers and Simon (1994).

In developing my own position on the degree to which human ingenuity, intelligence, and technology exempt human society from biophysical laws, the writings of Jared Diamond have been exceedingly helpful. The Easter Island example is one of my favorites (Diamond, 1994) because: (1) the islanders were sufficiently organized to quarry stone, sculpt it into huge statues, and transport these to an area facing the sea some miles from the quarry; (2) the island was so small and remote that its human inhabitants could have an intimate contact with the entire land ecosystem and intimately observe changes in it, as well as being aware that outside help was far away; (3) the construction and transport of the huge statues is persuasive evidence of a central control, but the population was sufficiently small to have discussions about the consequences of its behavior upon the prospect for sustainable use of the island. Ecological mismanagement on the island led to the destruction of forests and concomitant loss of agricultural soils. The latter affected the food supply directly and the former indirectly by eliminating the raw material for construction of fishing canoes. The result was dramatically decreased population size, increased conflict, and eventual cannibalism.

Diamond (1997) discusses an equally intriguing situation based on three islands, Pitcairn Island (of *H.M.S. Bounty* fame) and less-known Henderson and Mangareva Islands. Mangareva, westernmost of the three islands, is still about 1,000 miles from the nearest habitable islands outside Southeast Polynesia and was the most abundantly endowed with natural resources important to humans (e.g., freshwater, fish and shellfish, and some land suitable for agriculture). It lacked high quality stone for making adzes and other tools, but suitable materials were available on Pitcairn Island, which was a smaller island of <2 square miles and, probably more important, 250 miles southeast of Mangareva. Henderson Island, the largest at 14 square miles, was 70 miles northeast of Pitcairn and 300 miles east of Mangareva. Despite its size, Henderson was the most marginal for human existence because it had no suitable materials for toolmaking, no trees sufficiently large to make canoes and, worse yet, no reliable freshwater supply. It did have abundant marine life and large colonies of nesting seabirds. Sailing canoes would probably have taken 3 or 4 days from Mangareva to Henderson and about 1 day from Pitcairn to Henderson. Much of the evidence used by Diamond in his analysis was generated by Marshall Weiseler, who spent 8 months on these islands as part of his graduate studies at the University of California at Berkeley during the early 1990s. Weiseler used modern methodology for analysis in dating materials and determining their origin, so the analysis by Diamond is based on robust evidence. I find the Pitcairn Island example intriguing because it involves interdependence and commerce, which could be clearly understood by the small populations inhabiting all three islands. Surely the islanders were in sufficiently close contact with their larger environment to recognize their dependence on an ecological life support system and the interdependence of the three islands. Despite this, they made inappropriate decisions, which adversely affected the natural systems on which they were dependent. This damage, in turn, caused severe consequences to their own societies, including serious decline in the human social system. Additional literature citations on the ecological collapse of ancient civilizations may be found in Diamond (1992, 1994) and Cairns (1994).

THE TRIUMPH OF CONSEQUENCES?

Although I remain optimistic about what human society could do, I remain pessimistic about what it will do to develop a set of goals and conditions toward sustainable use of the planet (e.g., Cairns, 1997a). When I found that the officers of the local Sierra Club were poorly informed about sustain-

ability issues, I began writing a series of commentaries on the subject in its local newsletter (e.g., Cairns, 1997c,d). Although some months have passed since the first commentary, I have received no comment, pro or con, on any of them.

A newly forming, local group that is purportedly interested in bioregional planning has failed to see the connection between bioregional planning and land trusts designed to preserve the ecological attributes of a particular piece or property in perpetuity. This lack of understanding is not an encouraging sign because it does not appear that major changes in societal behavior will occur on the basis of information alone. Still, the attempt must be made since the biophysical laws of nature will provide consequences if nothing is done beforehand. At the very least, discussions will likely leave society better prepared when the consequences do occur. A reasonable first step is speculation about possible scenarios.

(1) Significant action is taken towards sustainable use of the planet based on information alone, despite uncertainty about the precise outcome.

This scenario is, in a very real sense, a race between consilience and consequences. If severe environmental problems develop before any significant sustainability initiatives are undertaken, no one will ever know whether human society was capable of acting on the basis of information alone. Wilson's (1998a,b) consilience hypothesis indicates that a major dynamic leap forward might well occur, rather than painfully slow incremental advances. Whether the sort of synthesis of knowledge necessary to implement successful sustainability will occur is definitely uncertain, although the consilience hypothesis makes this seem more probable than it once did. Certainly, this outcome is the most desirable and is one advocated by a number of leaders in the field (Abernethy, 1997; Myers, 1997; Tullberg and Tullberg, 1997). Even though these authors might not be optimistic about the outcome, the time they have invested in defining the problem indicates they believe that a reasonable probability of successful implementation of sustainability is a hope. Such meetings as Industrial Ecology III of the Future 500 on April 24–26, 1998 in the Marin Headlands of Northern California indicate that scenario (1) is still possible.

(2) Human society is intellectually persuaded that sustainability is good, but it is emotionally incapable of making the necessary behavioral changes until a particular incident persuades it that postponement of change is no longer possible.

The spectrum of events to illustrate this situation is so broad that even a list would be extensive. One such happening would be the final loss of the Ogalala aquifer, extending from Texas to Canada, in which water is being pumped out at a rate greater than recharge. This loss would cause a major alteration of agricultural productivity in the United States. Another major alteration would be the melting of the polar ice caps, which would affect some of the low-lying islands, such as the Maldive Islands in the Indian Ocean, or sections of the United States such as Florida. This scenario is the second best option for reaching sustainable use of the planet because human society may suffer but may still have the resources to make effective changes toward sustainability in time.

(3) Multiple, severe consequences occur but human society is in a state of denial (e.g., Orr and Ehrenfeld, 1995) about the primary causes.

Clearly, doing nothing while waiting for better evidence of danger is not risk free.

(4) Technological solutions are attempted or explored instead of changing societal behavior.

Technological solutions may not appear in time (AIDS is a contemporary example). This scenario is especially true if severe consequences appear suddenly (e.g., major climate changes) and limit resources that might be available for research. I find this faith in a technological solution to all environmental problems particularly disingenuous in an era when research funds have diminished dramatically. A quality research establishment is slow to develop, but quickly disassembled. In contrast, recognition of collateral problems associated with new technologies may appear suddenly and have potentially devastating consequences. A contemporary example is hormone disruptors (e.g., Colborn and Clement, 1992; Colborn et al., 1996).

CHAOS, TERRORISM, AND SUSTAINABILITY

One of the ironies of the present is that a substantive level of global social stability is essential if the transition to sustainability is to be without major human suffering. Sustainable development during periods of widespread, armed conflict seems unlikely. Funding the transition period will require either new taxes or diversion of present tax funds. If the United Nations could diminish aggression, some of the funds could be reallocated from the military budget. At present, this seems highly unlikely. Even if aggressor states disappeared, attempts to control terrorists could still easily divert too much of the finite societal resources from the quest for sustainability. Last, but not least, Durant and Durant (1968) note: "leave men free, and their natural inequalities will multiply almost geometrically" (p. 20). The inequalities can be diminished by sacrificing liberty, as in Russia after 1917, or by redistribution of wealth through graded taxation, as many European and North American countries have done. Chaos in any form (earthquakes, economic upheavals, war, or epidemic diseases) is a threat to sustainability, but need not destroy it.

ETHOS, EQUITY, AND FAIRNESS

Technology has no value system, although it creates problems and sometimes provides solutions to the problems it created. Mercantile systems may focus too intently on a primary value (profit), although there is persuasive evidence that having other values (e.g., concern for employees) benefits the corporation as well. However, the quest for sustainability is based on a rather complex value system that covers large temporal and spatial spans. Robust value systems emerge as a result of extensive public discussion and debate (e.g., United States child labor laws). The tools to induce an appropriate social behavior for sustainability are few: (1) regulate, (2) litigate, and (3) enforce appropriate regulations that come from pressure exerted by citizen action groups. This achievement requires ethos (a set of guiding beliefs), equity, and fairness. However, if human society is not capable of achieving these, there will be consequences if, as I believe, humans are still subject to the biophysical laws of nature.

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Article 25

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The Unmanaged Commons
A Major Challenge for Sustainability Ethics

John Cairns, Jr.

Why another article on the commons when Garrett Hardin has covered all the major issues so superbly? There are new developments that did not exist in the many decades during which Hardin's writings became so famous: worldwide concern has heightened about the global environment since 1961 when Hardin wrote the classic "The Tragedy of the Commons" and sustainable development has attracted international interest, and even some implementation.

Economic globalization has turned the entire planet into common ground. Access to the commons need not be physical as originally envisioned by mathematician William Foster Lloyd in 1833. Economic access enables individuals and organizations to exploit far distant resources and avoid responsibility for the consequences even better than when the commons are exploited by local inhabitants. The global commons is unmanaged in an ecological sense and even in an economic sense if economic development ignores humankind's responsibility to its descendants and other species. The basic theorem of ecology is that it is impossible to do just one thing.

Exponential growth has some intended consequences (largely touted) and multitudinous unintended consequences (studiously ignored).

Sustainable use of the planet requires that humankind do nothing that seriously depletes and/or damages both natural capital and ecosystem services. In a less populated world, the need for a sustainability ethic was not as great as now. However, humankind now lives in a crowded world, so that leaving a habitable planet for future generations of humans and those of other species is problematic.

A tribe said to the universe,
"Sir, we exist!"
"So I see," said the universe,
"But your multitude creates in me
No feeling of obligation." Garrett Hardin

[Author note: Substitute "humankind" for "tribe" for a superb description of the present situation facing an unsustainable society.]

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A WIDER VIEW OF THE COMMONS

Environmental health is essential to human health since humans are embedded in the interdependent web of life. Two current developments justify additional attention to humankind's relationship to the global commons. The interest in sustainable development requires, at its core, informed and compassionate use of the global commons; and many more examples are available of the consequences of unsustainable practices.

On the negative side is the strong probability that the attractive word in the term *sustainable development* is *development*. Most people associate development with growth and the continuation of present lifestyles, with only a few minor adjustments and new technologies. It is clearly not accidental that the word *development* was chosen to describe ecological aspirations because the word goes quite well with *smart growth* and similar reassuring "buzzwords." It would be a pity to miss an opportunity to protect the global commons because of problems with semantics.

Hardin's (1968) "The Tragedy of the Commons" is, arguably, the key paper on ethical issues in the use of the commons. As of 1997, this seminal paper had been reprinted over 100 times in anthologies in the fields of biology, ecology, environmental sciences, law, economics, sociology, political sciences, philosophy, ethics, and English composition and is one of the most frequently cited articles in *Science*. A special issue of *The Social Contract* (Vol. XII, No. 1, Fall 2001) honoring Hardin provides a superb overview of his key topics and issues from 1968 to the present. Basically, tragedy is the inevitable price paid for unmanaged, unlimited freedom in use of the commons. The quest for sustainable use of the planet mandates responsibility for the commons. As Hands (1973) remarked, traditional ethics has almost entirely ignored the rights or claims of posterity; sustainability ethics focuses on leaving a habitable planet for posterity.

The reason for the emphasis on Hardin's publications is that he has addressed many of the important issues affecting sustainable use of the planet, yet they have not been given the attention they deserve in publications on sustainability. I have avoided discussion of population issues for many years because it seemed abundantly clear that all of the pivotal issues regarding human population size had been discussed, not only by Hardin but also by Paul R. Ehrlich, Lester Brown, and others. However, my avoidance of this issue was a serious error!

Not only human population issues but also those involving the 30+ million species with which humankind shares the planet must be continually discussed until action is taken about the addictive, unsustainable practices humankind perpetuates. As a student and early in my professional career, I was told that science and ethics should not be commingled. However, all environmental problems, arguably without exception, involve value judgments (i.e., ethics or ethos) that are best implemented with scientific evidence. Naturally, clear indications must be made of which category each component of the proposed solution belongs.

SUSTAINABILITY ETHICS

Catastrophes cannot be entirely eliminated because many are the result of natural forces, such as earthquakes. However, catastrophes resulting from human practices can be reduced both in frequency and magnitude. The question is how to reduce the misuse of the global commons. The impasse presently occurring over greenhouse gases illustrates the difficulty of nation-states being effective outside of their own borders, or, in some cases, even within their borders. In addition, the United Nations has neither the staff nor the power to become the global environmental police force. From a sustainability perspective, damaging the global commons damages natural capital, ecosystem services, and the interdependent web of life that constitutes the planet's ecological life

support system. No individual, organization, or nation-state has the "right" to damage these entities.

The illusion of an infinitely generous "Mother" Earth has masked the harsh reality that organisms without a suitable habitat die. The present use of the global commons is ruinous and unsustainable, and, in the long term, humankind does not benefit from damaging the global commons. In the short term, some individuals, organizations, and nation-states do benefit. The basic question becomes: how can human society best serve future generations of its own and other species while filling the basic needs of those now living? A truly socialized individual is ashamed to violate the social contract that aspires to sustainable use of the planet. However, the word *shame* is rarely used in this permissive era.

Cairns (2003) has produced a list of ten declarations that are focused on a mutualistic relationship between humankind and natural systems whose goal is leaving a habitable planet for human descendants and those of other species. Sustainability ethics differs from eco-ethics (e.g. Cairns, 2002, in press; Kinne, 2002)—sustainability ethics is both homocentric and ecocentric, while eco-ethics is entirely ecocentric. One might easily conclude that there is no substantive difference because humankind cannot survive without natural capital and ecosystem services. One should also recognize that nature is not designed to protect a single species, even if that species is capable of thinking it is the most important species on the planet. However, the implementation of sustainability ethics would, at worst, prolong humankind's stay on the planet.

Both sustainability ethics and eco-ethics deplore unsustainable practices that impair ecological integrity and increase biotic impoverishment. Both are expressions of deep concern about the exponential growth of the human population and consumption of material goods. Sustainability ethics is a consilience (literally, leaping together) of econ-ethics and eco-ethics (as revisited by Kinne, 2002).

Cairns (2003) also provides an illustrative list of ten sustainability ethics for nation states; they are even less likely to be accepted than either sustainability ethics or eco-ethics. All of the statements pledge that ensuring environmental integrity is the primary goal. The wide gap between these statements and the approach in the U.S. is illustrated by Walsh's (2003) recent analysis of President Bush's current policy on greenhouse gases. The basic problem is that the policy is based on how much reduction, if any, the industries that produce the gases can endure, rather than how much anthropogenic greenhouse gases the planet can tolerate. Such a policy does not include an ethical responsibility for the planet's biosphere.

Such attempts to "solve" environmental problems will not be successful in developing a harmonious relationship with the interdependent web of life. The U.S. greenhouse gas policy is based on voluntary agreements with industry to reduce global warming emissions. A number of industrial trade associations have announced that emissions goals were based on emissions per unit of output (i.e., intensity based). Voluntary commitments have not proven effective in the past, and, even if they were, nothing indicates that the biospheric life support system would be healthy, or even in good condition, as a consequence. As Walsh (2003) notes, even government projections show that U.S. greenhouse gases will continue to grow over the next 10 years. The result may be crossing a major ecological threshold that could place global climate at risk and seriously threaten the global commons.

The well-known Kyoto Protocol placed mandatory caps on emissions, which are vastly different than intensity goals that use the ratio of emissions to economic output. Environmental groups support a goal of reducing total emissions into the atmosphere, regardless of the size of the economic

output. In a growing economy, the actual emissions into the atmosphere might well increase. On a finite planet, the size of the atmosphere cannot be expanded to match the growth of the economy. Ethical use of the global commons requires recognition that it is both finite and vulnerable.

James Carville, aide to former President Bill Clinton, was fond of saying, "It's the economy, stupid!" To paraphrase Mr. Carville, "It's the planet, stupid!" In short, the global commons deserves tender, loving care. What is the benefit of energy production that also generates unacceptable levels of greenhouse gases if humankind lacks a habitable planet on which to use this energy? Sustainability ethics are essential to a perpetually habitable planet.

THE OCEAN COMMONS

This common ground covers over half Earth's surface. If this commons is seriously damaged, it probably will be impossible to restore it to the pre-industrial era condition. Unsustainable practices (e.g., over-harvesting fisheries stocks, toxic and sewage pollution, coral reef damage, littering with plastic and other solid wastes, and nuclear waste, etc.) have already caused serious ecological damage, and the situation is rapidly worsening. Using the oceans as an unmanaged commons has failed (e.g., Miles, 1999). Management on this scale is daunting, but essential to sustainable use of the planet.

Lindholm and Barr (2001) note that, in the US, a wide disparity exists between the total land and ocean under federal management. Of the total U.S. landmass, approximately 18 percent is included in some form of protected area. In contrast, of the total area of U.S. waters within the 200-mile Exclusive Economic Zone, only 0.4 percent is presently under Federal protection, with a much smaller percentage, 0.0004 percent, actually contained in non-extractive reserves.

Both land and oceans were once considered vast and limitless. However, even in the U.S., Australia, and Canada where "frontier" views persist to the present day, there is now a perception of a finite planet—Carl Sagan's "small blue dot" in a vast universe. Nevertheless, recognition of the need to cease unsustainable practices and to live sustainably is far from universal. Decades ago, Aldo Leopold perceived the need for a "land ethic." Now Safina (2002–2003) and Barr and Lindholm (2002–2003) propose a "sea ethic" using Leopold's land ethic as a model.

Although Aldo Leopold's land ethic has been widely acclaimed by those concerned with the environment, it has not been practiced widely, probably because most politicians and the average citizen have not even heard of the concept. The land ethic needs to be updated, especially with regard to sustainable use of the planet. Time is running out for humankind to implement either ecological ethics or sustainability ethics. If not implemented, nature's laws will become evident, whose consequences are not humane, as most people define this word.

NATION-STATE ENVIRONMENTAL TERRORISM

Hunt (2003) estimates the cost of Iraq's torching its oil fields at US$10 billion for only oil field repairs. Collateral effects, such as damage to human health and the environment, appear to be forgotten extras. Some useful information on environmental terrorism of this type comes from the Gulf War, which began when Iraq invaded Kuwait in 1990 and, in one day, gained control of 22 percent of the world's exportable oil. Had Iraq also successfully invaded Saudi Arabia, Iraq would have controlled 44 per cent of the exportable oil (Youngquist, 1997). This situation was clearly intolerable for the industrialized world, which responded promptly with massive, modern, military force. Even with this action, the Gulf Coalition aircraft did not strike Baghdad until the beginning of 1991.

Saddam Hussein had threatened to set fire to all of Kuwait's oil wells in retaliation for any invasion by coalition forces. Because of the rapidity of the invasion, not all the wells could be blown up and then set afire, but a large number were torched by the retreating Iraqi forces. At one time, about 4 million barrels of oil were burning each day (Hobbs and Radke, 1992). Some wells were blown up but not set afire, which resulted in large oil pools in the desert. Approximately 11 million barrels entered the Persian Gulf, with devastating environmental impact (e.g., Hawley, 1992). El-Baz (1992) predicted the effect would last for years; no robust evidence refutes this view.

This was nation-state environmental terrorism on a grand scale, and one that may be repeated in twenty-first century post-war Iraq. Despite the fact that the Gulf War spill was one of the largest oil spills in history, it did not attract media attention as did, for example, the Exxon *Valdez* spill in Prince William Sound, Alaska. This lack of attention is disturbing since, to protect the global commons, there must be worldwide indignation when the integrity of the commons is impaired.

PUBLIC OPINION: THE NEW SUPERPOWER?

Tyler (2003) asserts that two superpowers may exist on the planet: the U.S. and world public opinion. His theory is based on the sentiment of people around the world who felt that the evidence on which President Bush depended was not adequate for going to war against Iraq in 2003. The pivotal issue, in this case, for the United Nations Security Council was: what is the rationale for military operations? Tyler (2003) feels that, although the fresh outpouring of antiwar sentiment may not be enough to dissuade President Bush or his advisors from the preparations for war with other countries that appear to support terrorism, it is a persuasive reminder that any rush to war may have unfortunate political and environmental consequences for nations, organizations, and individuals who support a new war now. No war benefits the global commons.

What does public opinion have to do with protecting the global commons? Politics are affected by the psychology and momentum of public opinion. Even for a complex, multivariate issue such as the ecological integrity of the global commons, the majority of people now feel a sense of unease about how deteriorating ecological integrity could have adverse effects upon their lives (e.g., environmental refugees) and the lives of their descendants (e.g., depleted natural resources and ecosystem services).

Environmentally literate people, who are aware of adverse effects presented in well-documented studies in the publications of organizations such as Worldwatch and the United Nations, have a sense of barely controlled panic. However, these organizations also present persuasive evidence that sustainable alternatives are available to present unsustainable practices. For example, sustainable alternatives are biological controls for pests and wind power or solar power to replace the use of fossil fuels. Evidence also is available that ecological restoration can repair some of the damage to natural systems. Arguably, the cost of unsustainable practices mounting, often at an appalling rate, is evident everywhere on the planet.

Powerful economic forces defend the status quo. However, natural capitalism (e.g., Hawken et al., 1999) offers a competitive, economic alternative. Exceptional phenomena now occurring on the global commons, e.g., endocrine disruptors, biotic impoverishment, and melting glaciers, encourage the move toward sustainable use of the commons. Moreover, ethics is becoming an increasingly important piece of the decision making process. The term *carrying capacity* (a term well established in ecological literature) has been rejected as a pronouncement by "prophets of doom." Hardin (1976) has an excellent discussion of the ethical issues involved.

ECONOMICS AND THE GLOBAL COMMONS

Economic growth is a high priority goal for elected politicians, especially those with short terms of office. Not surprisingly, economic growth is the goal of all third world nations whose per capita wealth is shockingly low. Concomitantly, many mainstream scientists now consider the planet to be in the midst of the sixth great wave of animal extinctions. The fifth wave, 65 million years ago, was notable as the time of extinction of the seemingly invincible dinosaurs (e.g., Wilson, 1992).

The sixth wave of great extinctions is unique, being caused by humankind rather than natural causes. The twentieth century was a notable period of astonishing global wide habitat change. The human population exploded from 1.6 billion to over 6 billion. In three decades (1960–1990), 20 percent of the world's tropical forests were cut and burned; estimates of total deforestation rates vary from 50,000 to 170,000 square kilometers per year. Quality habitat (e.g., old growth forests) and other habitat losses (e.g., tall grass prairie) are responsible for many species extinctions.

From a sustainability standpoint, extinctions are only the final stage in the decline of a species. Species cease functioning as critical components of the ecological life support system long before they disappear entirely. Species can be saved if damaged ecosystems are restored in time. Restoring damaged ecosystems is a much more complex process than conserving them (e.g., National Research Council, 1992). In strong contrast to these views, Lomborg (2001) espouses the view that claims of environmental damage are exaggerated. Many powerful financial interests and media want to believe this "happy times" conclusion.

Those wishing unrestricted access to the global commons have enormous financial resources, some of which were acquired from resources obtained from the global commons. Those favoring limited access to the global commons are not without financial resources, but their finances are orders of magnitude less than those of organizations profiting from resources obtained from the global commons, discharging wastes into the global commons (e.g., air pollution), and producing hazardous products that are used on private property but end up, in part, in the global commons (e.g., pesticides, radioactive wastes).

The willingness to place short-term financial gains ahead of public safety in the attempts to circumvent the travel restrictions designed to restrict the spread of SARS is an example. Fears of loss of tourism and other revenues dependent on travel prevailed. Although China had belatedly taken significant steps to prevent spread of this disease, world financial interests pointed to the subsequent low numbers of deaths from SARS as justification for avoiding travel and following other restrictions designed to prevent a worldwide epidemic. In view of this disregard for human health, it seems wise not to count on major efforts by financial institutions to protect the global commons. Recreational or business travel during an outbreak of a transmissible disease does not represent a basic human need. The fact that many people are reluctant to travel until SARS is under control attests to the accuracy of this statement.

Other elements of economic theory are also a cause for concern. Arguably, the most contentious is the concept of resource substitutability. Simon (1981) and Simon and Kahn (1984) are the most outspoken advocates of the belief that resources are not limiting—when one resource becomes scarce, human creativity (the ultimate resource) will develop a substitute (e.g., alternative energy sources for fossil fuels). One problem of the concept of infinite substitutability is concentration on raw materials such as coal, metals, petroleum, marble, and the like. However, human ingenuity, creativity, and technology are unlikely to find substitutes for ecosystem services at a realistic cost. At present, almost all ecosystem services are free: maintenance of the atmospheric gas balance, decomposition and recycling of organic wastes, maintenance of water quality, biological pest and

disease control, pollination of agricultural and other plants, conversion of solar energy (photosynthesis) into food and raw materials that are readily recycled by natural systems, maintenance of the hydrologic cycle, production of fertile organic soils, moderation and regulation of global climate, models for pharmaceuticals, and nutrient recycling. The question of infinite substitutability has not been adequately phrased. Substitutes for copper fuel, fossil fuels, and the like divert the general public, economists, and ecologists from addressing the primary resource depletion.

The planet is running out of natural systems. The primary lesson of Biosphere 2 is that no amount of money can produce a self-regulating natural system that provides services favorable to humankind. In 1991, the US$200 million Biosphere 2 — a sealed, glass-enclosed, 3.15 acre structure — was designed to support eight scientists, the "bionauts," for 2 years in an environment suitable for them. It contained "miniature ecosystems," which, because of problems of scale, did not function like natural systems. Consequently, air quality declined (Recer, 1996); cockroaches flourished, and insect pollinators died. The estimated cost of supplying inadequate ecosystem services to the few inhabitants in Biosphere 2 was US$9 million per person per year. Clearly, human-made substitutes cannot reliably supply the diverse array of services natural systems supply at little or no cost. Is it reasonable to assume that these natural services should or can be replaced with human-designed ecosystems? The concept of infinite substitutability deserves more rigorous examination. Even if the science were robust and the technology sound and affordable, an ethical problem would still remain — should humankind replace natural systems with human-constructed systems?

Another interesting problem concerns intergenerational equity and fairness. Parfit (1982) wonders how obligations to posterity can be effectively met when present decisions may determine which people are born and even how many will survive. Since those now living do not know the preferences of posterity (Solow, 1993), humankind's primary obligation is to avoid impoverishing future generations through present overconsumption and undersaving.

The basic disagreement between ecologists and economists is with what effect damaging natural systems will have on posterity. In view of the rapid disappearance of natural systems, the probable outcome of endorsing either viewpoint becomes an ethical/moral decision. Globalization has made it virtually impossible to ensure the future of one's own children unless some provision is made for the children of others.

Ecological deficits should be of great concern to economists, ecologists, and everyone on the planet. Illustrative examples of ecological deficits are loss of old growth forests, loss of topsoil, disruption of the hydrologic cycle, depletion of brood stocks of oceanic fisheries, species impoverishment, depletion of fossil water, depletion of gene pools for models for pharmaceuticals, desertification, and fragmentation of ecosystems.

Basically, ecological deficits occur because natural capital is being used at a greater than replacement rate, which results in diminished ecosystem services (the "interest" on natural capital). Humankind has inherited natural capital that has been accumulating for billions of years. Only recently, in evolutionary time, has humankind had the technology to acquire natural capital at a rate greater than replacement. The assumption that it is a sound business practice to use more and more natural capital, processed by fewer and fewer people should be re-examined. Exponential growth of the human population and exponential depletion of natural capital are not sustainable strategies. The loss of natural capital (e.g., arable lands) is even now imposing severe costs (e.g., Postel, 1999; Brown, 2002a,b).

In Japan in the early 1950s, organic mercury produced a neurological disease (the Minimata disease) that resembled cerebral palsy. This disease was particularly affecting infants and children via

fetal development (e.g., Schettler et al., 1999). Schettler et al. (1999) cover damage to both the structure and the function of the human reproductive system by exposure to environmental chemicals. At present, the risks are mostly unknown and unstudied, but exposures continue. Unquestionably, economic and political forces influence both the nature of scientific research and level of public concern about risks. Clearly, these substances will have some, perhaps major, effects upon human health that, in turn, will affect the global economy. Although some exposures are highly site specific, most are sufficiently ubiquitous to be considered as having occurred in the global commons. Enlightened management should reduce these risks markedly, but zero risk is a utopian dream.

ETHICS FOR THE GLOBAL COMMONS

Problems resulting from an unmanaged global commons point out the need for developing a preliminary statement of ethics upon which management plans might be made. As Sophocles states: "One must learn by doing the thing; though you think you know it, you have no certainty until you try it." One thing is certain—an unmanaged global commons is a major threat to sustainable use of the planet. A statement of ethical responsibility is, arguably, a good way to develop an equitable, fair management program.

1. I pledge to oppose any activities that impair the integrity of the global commons, including actions of nation-states, corporations, and organizations.
2. I pledge to improve my environmental literacy so that I am aware of threats to the global commons.
3. I pledge to oppose any further increase of the human population on this finite planet.
4. I pledge to oppose a laissez faire market system ruled by conscience alone, since it rewards for lack of conscience.
5. I pledge to oppose all activities that diminish posterity's use of the commons.
6. I pledge to oppose any country that attempts to solve its population problems by exporting people to other countries.
7. I pledge to support social arrangements that enhance responsibility for the global commons, even if they involve arrangements that include coercion of some sort.
8. I pledge to acknowledge that the global commons is effectively limited in its capacity to accommodate use.
9. I recognize that the "right" to use the global commons must be matched by an operational responsibility to nurture and care for it.
10. I affirm that global tragedy is the price that will be paid for misuse of the commons. If humankind's laws do not protect the commons effectively, nature's laws will be activated, not only affecting the transgressors but all of humankind. Any disjunction between rights and responsibilities with regard to the global commons will result in tragic ruin for all of humankind.
11. I will not be misled by accusations of uncertainty and "unsound science" by those who benefit from the status quo. Precision of numbers is not as important as the relative size of the numbers (e.g., human population growth) or the direction of change (e.g., global warming).
12. I affirm that, on a planet with diminishing natural capital, humankind cannot be governed by ethics that ignore natural systems (ecosystems) and posterity.
13. I pledge to be guided by the basic theorem of ecology that one can never do merely one thing. This pledge is particularly important when exercising "rights" in the global commons.

14. I affirm that access to the resources of the global commons must be controlled (i.e., managed) so that the unscrupulous do not destroy them.
15. I affirm that food and other resources should never be sent to any population that has exceeded the carrying capacity, unless there is persuasive evidence that effective measures have been taken to stabilize the population and a firm time limit has been placed on the period of aid. Charity may often assume an austere and superficially unsympathetic aspect toward the population at risk. As Hardin (1972) remarks: "The morality of an act is a function of the state of the system at the time the act is performed—this is the foundation of situationist, ecological ethics."
16. I affirm T. H. Huxley's statement that every new truth begins as heresy. Management of the global commons now appears heretical, but, as the ecological collapse continues, it may increasingly appeal to common sense.

CONCLUSIONS

The health and integrity of the global commons is essential to the quest for sustainable use of the planet. An unmanaged global commons will permit unsustainable practices that may generate impressive short-term profits, but will generate even more impressive long-term losses. Literature on the use and misuse of the commons has existed for decades. However, the increasing evidence of the need to switch from unsustainable to sustainable practices has generated momentum for re-examination of this issue. Moreover, ethics is now becoming an increasingly important component of the decision-making process. Finally, the internet and international television have enabled average citizens to view environmental degradation, often while it is occurring.

Protests are not an ideal way to express opposition to unattractive decisions, but they may be all that is available for expressing dissent. Informed citizens can express both approval and dissent by their purchases in the global marketplace. Even a small shift to "green" purchases may make the difference between profit and loss for many companies.

Sustainable practices will benefit the global commons; unsustainable practices will damage it. The choice is basically based on different value systems and ethical motivation. A paradigm shift to sustainable practices might well occur at a breathtaking rate under these circumstances. An additional effort to protect the global commons is well worthwhile.

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Article 26

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Carrying Capacity, Exponential Growth, and Resource Wars: Ethical Dilemmas of Human Society

John Cairns, Jr.

"History is a vast early warning system." Norman Cousins

"… overpopulation can be avoided only if borders are secure; otherwise poor and overpopulated nations will export their excess to richer and less populated nations. It is time to turn our attention to this problem." Garrett Hardin

Biological carrying capacity is the number or biomass of organisms that a given habitat can support and involves two levels: (1) maximum or subsistence density—the maximum number of individuals who can eke out an existence in the habitat and (2) optimum or "safe" density—a lower density at which individuals are more secure in terms of food, resistance to predators, and periodic fluctuations in the resource base (Odum, 1996). Most humans would endorse the improved quality of life offered by the optimal density level, but they continue to use resources recklessly, which makes a subsistence lifestyle increasingly likely.

Exponential growth involves increases in such measures as population density and/or resource consumption. Global human population growth illustrates this point quite well. The first Earth Day in the United States included a major emphasis on human population problems at that time with a world population of 3.6 billion. The Earth Day celebration in 1990, 20 years later, saw a population that had increased by 1.7 billion to 5.3 billion. Near the end of the 20th century, global human population passed six billion. Moreover, per capita resource consumption had increased dramatically for a substantial portion of the human population. Benjamin Franklin (1775) remarked on population growth, as did Thomas Malthus (1798), so the concept is far from new. Despite these early warnings, societal use of resources has become increasingly unsustainable since resources are unlikely to expand exponentially, despite the exponential increase in population and consumption of resources.

Resource wars occur when a political entity decides to acquire resources that are unobtainable by conventional means. The two world wars and the Gulf War are good examples of resource wars. Hitler wanted "living room" and resource-poor Japan needed just about everything. The Gulf War was clearly a result of Saddam Hussein's intention to acquire control of even more of the world's oil

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reserves. Wars both consume and damage natural and other resources and, thus, lower carrying capacity and quality of life.

THE BASIC ISSUE

The basic issue is: why should an already crowded planet, on which the human population is destroying natural systems (its ecological life support system) at an unprecedented rate, be eager to continue exponential growth in both population and per capita resource consumption? Why, when half the world's population has inadequate food, shelter, education, and medical care, should the countries with the worst problems not receive major assistance to stabilize their populations until all citizens have at least subsistence levels of all four categories? Why should countries with optimal per capita resources permit immigration rates that will quickly push the countries beyond their carrying capacity? Additionally, why should these affluent countries enable poor countries to reduce temporarily the impact of exponential population growth by exporting people? These exports are often the most talented people in the poor country and are badly needed to help solve problems there. Inadequate resources cause resource wars. Why are badly needed resources being diverted to acquire resources by forceful means instead of using available knowledge to develop policies and practices appropriate for sustainable use of the planet? Why have we so little regard for posterity that we encourage the kinds of growth that exacerbate these unsustainable conditions?

REVISITING HARDIN

For much of my career (spanning more than half a century), I have avoided publishing on population problems. After all, Garrett Hardin eloquently discussed all major aspects in *Population, Evolution and Birth Control* (Hardin, 1969) and a variety of other books, journal articles, and pieces in the popular press. What more could I possibly add? Still, unsustainable practices not only persist but are worsening, and the prospects for the future of humankind are being seriously, arguably fatally, jeopardized. Nevertheless, one cannot avoid the personal responsibility for following one's conscience. As Hardin has remarked in many publications, the global political system is dedicated to worshiping the unmanaged commons, which is not compatible with sustainable use of the planet. No matter how many ways humankind finds to express an unpalatable truth, it is impossible to avoid natural law. It is abundantly clear that billions of people are not adequately fed and housed, and resources are being depleted at a rate far greater than they are being replenished.

Finally, the most important reason for keeping these issues alive is that, when a catastrophe does occur, there will be the usual responses from the world's leaders: "why wasn't I informed?", "the evidence was primarily junk science, I wanted to wait until the uncertainty was eliminated," "it would have had an adverse effect upon economic development," and the like. The resistance to these ideas is intensifying. At present, enough evidence has been accumulated to show the fallacy of believing in limitless resources on a finite planet. Ever increasing material wealth for an ever increasing human population is an illusion. Nature enforces limits on other species—technology and creativity do not exempt humankind from these laws of nature.

I have singled out Hardin for this discussion despite the number of other scientists and professionals who have made significant contributions to the study of the consequences of overpopulation. Hardin has focused on this problem far more than those of us with other academic interests. Moreover, he keeps expounding on the message, despite almost overwhelming, discouraging evidence. We must all remain optimistic that reason will prevail. Even if reason does not prevail, and one or more major cat-

astrophes occur, there must be evidence that alternatives to humankind's present unsustainable practices are readily available. Unmanaged use is driven by very powerful economic and political forces, but the laws and forces of nature always prevail. Ultimately, populations of all species, including humans, must remain within the planet's carrying capacity or suffer major declines.

ECO-ETHICS

As Ehrlich (2001) notes, there is no question that *Homo sapiens* is causing the sixth major era of biotic extinction but is also altering the course of evolution for millions of years into the future. He notes that the ethical questions about intervention are very similar to the closely related issue of the preservation of biodiversity (Ehrlich and Ehrlich, 1981). Plato (Honderich, 1995) and Kant (Gregor, 1996) believed that there exists a universe of ethics quite independent of the universe humankind inhabits. For these scholars, the question of the ethics of redirecting evolution already exists. Nitecki and Nitecki (1993) believe that ethics are a component of the evolutionary process and therefore "good." Ehrlich (2001) believes that the capacity to hold and share values is a component of human evolution. This view appears most congruent with: (1) sustainable use of the planet, (2) limiting human population size, and (3) severely reducing the rate of immigration from countries that have already exceeded their carrying capacity.

Ehrlich (2001) asserts that the evolution of ethics appears to be a product of a complex brain that evolved for, in part, interacting with other intelligent individuals living in small social groups (e.g., tribes). He notes that the genesis of ethics seems to trace to the appearance of empathy, which is "walking in another person's shoes." The capability of considering the mental processes of members of one's tribe or group and relating emotionally to their states probably resulted in a reproductive advantage and probably was a predisposition created by natural selection. Genetic components simply cannot incorporate adequate "instructions" into the brain's structure to program an appropriate reaction to every conceivable behavioral situation or even a very large number of them (Ehrlich, 2001). This description is appropriate for the situation for both carrying capacity and sustainable use of the planet. Achieving an operable level of consensus on both will be a monumental but essential goal for human survival.

A very carefully reasoned ethical argument for both carrying capacity and sustainable use of the planet should, at least, reduce the number of unsustainable practices that now make the planet less habitable for posterity. At present the choices between sustainable and unsustainable practices is difficult for most people. They are constantly being told that such choices need not be made. Worse yet, ethical evolution always lags behind technological evolution because the benefits are constantly touted while the environmental "surprises" are not.

As the human population continues to grow, the areas of the planet not already at full carrying capacity will reach that dangerous point. This situation will occur even with a falling birth rate if immigration is not severely limited or reduced to zero net immigration.

Ethics and science are interrelated and interactive and need to be integrated in a holistic way. Ethics is the sine qua non of human society, providing value systems for humankind's models for conduct. However, ethics can only expound on what to do—science is essential for illuminating what can be done. All the issues in this article involve viewing *Homo sapiens* as a part of nature and require a balanced co-existence with the 30+ million other species on the planet, which collectively constitute the biospheric life support system.

The development and implementation of eco-ethics is the most important prerequisite for attaining and maintaining a harmonious relationship between human requirements and ecosystem

carrying capacities and, thus, also for lengthening the span the human species can persist. Only through a development and application of eco-ethics can a catastrophe of gigantic dimensions be avoided (Kinne, 2001). The goal is to maintain Earth as a suitable habitat for humankind for many generations. However, this suitable habitat requires treating the interdependent web of life as inviolate and acknowledging humankind's dependence upon it.

WHY WORRY? WE HAVE PLENTY OF TIME

Since most people think linearly rather than exponentially, any type of exponential growth catches them unawares. A two percent growth rate seems harmless, but the resulting doubling time is 35 years. For a town, this growth means doubling housing, schools, utilities, police and fire protection, and roads every 35 years. Policy makers rarely plan for exponential growth in most areas of life, but are obsessed with it for the stock market, corporate earnings, and increased size of towns, cities, church congregations, and the like. The importance of exponential growth is that it causes populations to exceed carrying capacity through both size and increased depletion of resources. Nature levies brutal penalties for exceeding carrying capacity, such as famine, disease, and war. Regrettably, people are not alarmed by exponential growth because those with short-term memories regard present circumstances as normal. For example, the rate of human population increase is regarded as normal although, in terms of geologic or evolutionary time, it is aberrant.

The global extinction of species crisis is well known. But as Myers and Knoll (2001) note, probably more significant in the long term is that the crisis will disrupt and deplete certain processes of evolution, with consequences likely to persist for millions of years. This biotic crisis is the result of human activities that will be difficult to change. Tilman and Lehman (2001) believe that human-caused environmental changes are creating regional combinations of environmental conditions that, within the next 50 to 100 years, may fall outside of the envelope within which many of the terrestrial plants of a region evolved. Although mass extinctions probably account for the disappearance of less than five percent of all extinct species, the evolutionary opportunities they have created have had a disproportionate effect on the history of life (Erwin, 2001). Mass extinctions appear to cause a collapse of ecospace, which must be rebuilt during recovery (Erwin, 2001). A delay of about five million years has long been apparent in the Early Triassic, after the end of the Permian mass extinction (Erwin, 2001).

Invasive species are also a major factor in environmental disequilibrium. Elton (1958) was one of the pioneers to state that one of the great historical convulsions in the world's fauna and flora is occurring. This event is the result of a drastic breaching of biogeographic barriers that previously had isolated the continental biotas for millions of years (Mooney and Cleland, 2001). Invasive species alter the evolutionary pathway of native species by competitive exclusion, niche displacement, hybridization, introgression, predation, and ultimately extinction (Mooney and Cleland, 2001). These authors conclude that the biota of Earth is undergoing a dramatic transformation, and every indication is that these transformations will intensify as the human population continues to grow because of the global changes that have been set in motion that are affecting the atmosphere and the climate. Western (2001) remarks that ecosystem simplification is the ecological hallmark of humanity and the reason for humankind's evolutionary success. However, the side effects of human profligacy and poor resource practices are now so pervasive as to threaten the future, no less than that of biological diversity itself.

The changes just briefly described are consistent with mainstream ecological science. The conclusions are almost more than the mind can accept and far beyond the primary issues of the Kyoto

Conference on global climate change. There is a high probability that, if present unsustainable practices continue, humankind will disrupt certain processes of evolution with consequences likely to persist for millions of years. What little attention the carrying capacity of the earth has received has been focused on how many humans can be accommodated. It is now clear that the focus should be intent on Earth's carrying capacity for other life forms, which collectively constitute the ecological life support system. Life on Earth will doubtless continue. The major question is whether it will include humans and other large mobile animals or will it shift primarily to microbes as Jackson (2001) has predicted for the oceans, especially the coastal areas. Jonas (1997) discusses the ecological dominance of microbes at the expense of macro-organisms.

Additionally, humankind's technological assault on marine mammals has intensified. For example, the courtroom battle of the Natural Resources Defense Council (NRDC) to stop the United States Navy from deploying its low frequency active (LFA) sonar system (a new technology that blasts ocean habitats with noise so intense it can maim, deafen, and even kill marine mammals) was expected to begin June 30, 2003 (personal communication from John Adams, President NRDC, June 18, 2003).

STOCHASTIC EVENTS OCCUR

Droughts and other stochastic events, such as hurricanes, typhoons, floods, and earthquakes, almost always have some deleterious effect upon carrying capacity. The illustrative example that follows was chosen because final decisions have not been made. Furthermore, it occurs in the United States—a wealthy nation with a majority of citizens professing to respect the natural environment.

The headwaters of the Rio Grande River are in the state of Colorado, flow through the state of New Mexico, and then coincide with the border between the state of Texas and the country of Mexico. Water is not sufficient to meet the demands of a variety of special interest groups there. To further complicate the situation, an endangered fish, protected by the Endangered Species Act passed by the United States Congress, is indigenous to these waters.

The United States Bureau of Reclamation is charged with maintaining minimum continuous flows through the city of Albuquerque to protect the endangered fish (Soussan, 2002a). A slim majority of local voters support the Endangered Species Act (53%), but two thirds feel the act goes too far in this particular case (Soussan, 2002b), and both cities and farmers are fighting the situation. Water diverted from Colorado into New Mexico is transported via the Rio Grande. Additionally, the ground water aquifer from which the city of Albuquerque obtains quality water has only 25 years remaining; removing this water could cause subsidence of the land above it. Even if a final legal decision favors the endangered fish this time, the carrying capacity of the San Juan River is not meeting present demands, which are highly likely to increase and be worsened by the depletion of the underground aquifer. An already damaged ecosystem will be further damaged and of less use as an ecological life support system.

For arid Albuquerque, a significant part of the surface water flow during spring and summer months is from snowmelt in the mountains (Fleck, 2002). The dry mountain soil soaks up much of the snowmelt. The arid soil requires an *above average* (i.e., at least 20 percent) snow pack to maintain *average* stream and river flows the next year.

At present, it is not clear whether the final decision on diverting water will be at the local, state, or federal level. New Mexico's Governor Gary Johnson is considering calling on the rarely used and little known federal Endangered Species Committee, authorized by the Endangered Species Act. This committee consists of six high-ranking officials in the nation's capitol of Wash-

ington, D.C., plus one state resident, who will be appointed by the President when the committee is convened. The possibility of political bias in either direction should not be ignored. The committee is known in the press as the "God Squad," because it is authorized to make an exception to the Endangered Species Act in favor of humans. The court system does not have this authority.

This situation could have been avoided if the city of Albuquerque had a water budget and a drought plan (Hibbard, 2002). Individual behavior also plays an important role. For example, per capita water use in the cities of Tucson (Arizona), El Paso (Texas), and Santa Fe (New Mexico) is 140–160 gallons per day, while Albuquerque's per person per day average is 205 gallons. Simple measures could have helped the area stay within the carrying capacity of the local hydrologic system. A number of policy changes have been adopted by communities elsewhere to help alleviate such situations:

1. enforce mandatory restrictions on water use
2. landscape with plants that have low water requirements
3. restrict water use (e.g., car washing)
4. require phasing in of appliances (e.g., flush toilets, laundry washing machines, and dishwashers) with units that use water more efficiently
5. change water rate structures to reward those who conserve water and penalize those who waste it; some cities even have fines and/or jail times for flagrant misuse
6. use accurate water meters
7. cover swimming pools when not in use to prevent evaporative loss
8. avoid use of fountains and other systems with a high evaporative loss

As Linthicum (2002a) remarks, blaming the endangered species for the present unsustainable situation is unfair. Policies to enable sustainable use without abuse of the finite water supply are the only long-term solution. Driving a species to extinction to temporarily avoid policy issues and to avoid elimination of unsustainable practices is a poor management decision. Another important lesson from this case history is that, if local special interest groups cannot reach a consensus, the federal government will probably step in (Linthicum, 2002b). But what happens if there is no national consensus on the same issues?

The Albuquerque situation was chosen as an illustration because it has many of the important components of a carrying capacity crisis. Such crises exist worldwide, but this one is exceptional because of the thorough exploration of the issue in the *Albuquerque Journal*. Yet despite the fact that the *Journal* had fairly complete coverage, it was probably only read carefully by a small percentage of people. In contrast, the publicity from special interest groups is usually more intense and continuous. Even in the media, the issues of special interest groups receive more attention than public issues, which are usually poorly funded. Moreover, special interest groups often have a considerable economic stake that makes them more outspoken and aggressive. The general public is faced with a multitude of pressures: personal, work, social, and economic. Long-term issues, such as carrying capacity, tend to be brushed aside so that immediate problems, usually of minor long-term significance, receive the highest priority.

EXPONENTIAL GROWTH

The key to keeping within the carrying capacity of a finite planet is to address effectively the issue of exponential growth holistically. Exponential growth is the basic cause of the Albuquerque water problem — growth simply cannot continue without a concomitant increase in the resource

base: water. Typically, exponential growth is not mentioned, either because it is not understood or because of denial that human behavior must be drastically changed to avoid the consequences of exceeding carrying capacity. Resources are actually diminishing in many instances; they are certainly not increasing exponentially as growth is.

RESOURCE WARS

When a population exceeds the carrying capacity of the area it controls, a resource war to acquire additional resources is often the result, although another reason is usually given for the conflict. World War II was a resource war, although not usually described in those terms. As mentioned earlier, Hitler wanted "living room" and Japan needed almost every type of resource. The Gulf War occurred when Saddam Hussein of Iraq invaded Kuwait in an attempt to control an even larger share of the world's oil reserves. Countries, such as the United States that are greatly dependent on imported oil, simply could not tolerate this takeover, so Kuwait and its oil were liberated.

More recently, Smyth (2002) believes that a water war may be in the making over Wazzani Springs, in south Lebanon, where Lebanon is building a pumping station to supply drinking water to villages being rebuilt and repopulated after the Israeli military occupation ended several years ago. Water resources in this area are inadequate to meet ever increasing demands caused by population growth and inefficient use of water supplies. Pumping was expected to begin on October 15, 2002. Israeli officials threatened to attack the pumping station if water were diverted from the river, which flows into the Jordan and Lake Tiberius and contributes 138 m m 3 (millions of cubic meters per year) to Israel. Lebanon claims it only wants 3.6 m m 3 from the springs. Living sustainably, within the region's carrying capacity, is possible, but war is usually preferable to the changes that human society would have to make to live sustainably. War reduces resources by diverting them and is an unsustainable practice.

EXPONENTIAL POPULATION GROWTH, IMMIGRATION, AND LIVING SUSTAINABLY

Regrettably, the ecological messenger is usually blamed for a problem rather than the poor leadership and inept management that produced the problem. People who are happy with the status quo are not interested in changing it. Demonizing those who advocate lasting solutions to the crisis of carrying capacity is the way to become popular and to use force to acquire a disproportionate share of finite resources. Humankind can no longer focus on special interest groups or tolerate short-range damage control, especially when these are used as a substitute for developing sustainable practices. Living sustainably requires that all levels of social organization—individuals, nations, organizations, corporations, and ethnic and religious groups—embrace new thought patterns, behaviors, and policies that facilitate sustainability.

Proponents of perpetual economic and population growth carefully ignore the fact that humankind inhabits a finite planet. Living sustainably requires balancing population demands with resource availability. Populations will increase exponentially; resources will not. Additionally, the natural systems that produce these resources cannot be expected to do so if their integrity is damaged. However, population control is a subject that is rarely discussed by political leaders, religious groups, the general public, and the news media.

On August 20, 2002, Dr. Joseph Chamie, Director of the population division of the United Nations, stated that the United States has a population growth rate comparable to that of developing nations (as cited in *The New York Times*). It now ranks seventh in growth, but an astonishing

80 percent of the growth comes from immigration. Unless the per capita standard of living is reduced, more resources will be required for these additional people. This need comes at a time when the United States is already using a disproportionate amount of global resources. Regardless of the present position on immigration, the United States can neither have perpetual exponential population growth in a finite area nor continue to co-opt a disproportionate share of the planet's resources. As pressure on finite resources increases, per capita share of them will diminish. When this occurs, the United States will become less attractive to migrants, unless per capita resources world-wide are becoming depleted.

In areas such as Afghanistan and the Gaza Strip, exponential population growth continues despite an already low standard of living. In the United States, massive immigration, both legal and illegal, continues and many large families are still produced here, so the concept of carrying capacity is neither understood nor is it a major issue in national policy decisions. If this situation continues throughout the 21st century, arguably even the first half of the century, there will be a painful, possibly tragic, day of reckoning.

Reducing the per capita and national size of the ecological footprint will provide more time in which to make the transition from unsustainable to sustainable living. Examples of how this reduction may be implemented are given in Wackernagel and Rees (1996) and Hawken et al. (1999). These and other similar publications provide persuasive evidence that reducing the size of the ecological footprint does not produce a concomitant reduction in quality of life. In fact, social capital increases as a consequence of the group effort to live sustainably.

Living sustainably requires that humankind recognize that exponential growth of population and increased resource consumption are simply not possible on a finite planet. It also requires an eco-ethical relationship with natural systems, which avoids viewing natural systems as commodities. Eco-ethics will guide humankind toward sustainable behaviors. An ethical relationship with natural systems, which recognizes humankind's dependence upon them, will also increase the likelihood of leaving a habitable planet for future generations.

CONCLUSIONS

Until the end of the 20th century I would have thought referring to *Homo sapiens* as an endangered species was absurd. However, loss of habitat can drive a species to extinction and humankind is destroying its habitat on a global scale quite rapidly in evolutionary time. The primary illustrations used in this paper are the two interrelated concepts of carrying capacity and the major extinction of species both of which may disrupt some processes of evolution with consequences that might well persist for millions of years. Loss of resources per capita is likely to result in a resource war. Resource wars are increasingly likely because the human population is increasing exponentially while resources are not. The Albuquerque example was used because the situation could have been avoided if simple steps were taken in the framework of a water budget and a drought plan. However, the special interest groups have not been able to reach the necessary consensus.

If humankind used eco- and sustainability ethics, science-based decision making, and a systems level approach, there would be more incentive to replace unsustainable practices with sustainable ones. These latter practices must be integrated within human society if they are to persist (i.e., become sustainable). If the concept of carrying capacity is taken seriously, either subsistence or optimal human density and per capita ecological footprint size should be used to develop an immigration policy. Emigration should be discarded as a means of solving carrying capacity issues.

The issue of exponential growth on a finite planet must be considered holistically, especially when natural capital is diminishing.

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Article 27

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Is Human Society in Denial Regarding the Tough Questions About Sustainability?

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ABSTRACT: The news media report daily on unsustainable practices and events that impede progress toward sustainable use of the planet — production of greenhouse gases, biotic impoverishment, depletion of fossil waters (aquifers), human population growth, production of persistent toxic substances, loss of agricultural topsoil and land, rapid loss of old growth forests, and so on. Exponential economic growth both depletes natural capital more rapidly than it is regenerated and also gives an illusion of sustainable prosperity. Failure to act more expeditiously is almost certainly due to a number of factors; however, denial that a problem exists is, arguably, one of the most likely reasons. Just as an alcoholic or drug addict must first acknowledge that a problem exists before successful treatment is possible, so must those addicted to exponential growth on a finite planet.

KEY WORDS: Denial · Sustainability · Resource allocation · Depletion of natural capital · Memes · Eco-ethics

> *Facts do not cease to exist just because they are ignored.* Aldous Huxley

> *The growth ideology is extremely attractive politically because it offers a solution to poverty without requiring the moral disciplines of sharing and population control.* Herman Daly

I was first exposed to the dysfunctional relationship between human society and natural systems when Ruth Patrick became my mentor in 1948. Her goal was 'use without abuse' of natural systems. At that time, public awareness of environmental pollution was just beginning to increase. Leopold's (1949) *Sand County Almanac* provided a superb description of how natural systems functioned. Then, Carson's (1962) *Silent Spring* alerted me to the probable ecological damage of pesticides and also showed the intensity of the attacks likely to occur if the status quo were challenged. Next came Hardin's (1968) classic 'Tragedy of the Commons' and subsequent publications using the metaphors of lifeboats (Hardin 1974) and spaceships (Hardin 1972) to illustrate carrying capacity (Hardin 1976). Of course, there were many others, but these caused a major paradigm shift early in my career.

Mainstream science became much more interested in environmental science and studies, as evidenced by the first Earth Day in 1971. However, humankind still persisted in denying the extent of the problem. Denial is not new. Pliny the Elder stated, in the first century, that the stupid ostrich thrusts its head and neck into a bush and imagines that the entire body is concealed (Hardin 1999).

Other authors have espoused a no-need-for-concern attitude — everything is fine. Simon (1981) believed in unlimited growth. Naturally, this idea has critics (e.g. Daly 2003). Recently, Lomborg (2001) has created quite a stir, especially in the financial news (positive) (e.g. Cambridge University Press[1]) and the academic journals (negative) (e.g. Union of Concerned Scientists[2]). The Editors (Editorial 1997) of Scientific American have described some of this debate as science vs. antiscience.

Another form of denial may be the possibility of the deliberate production of disinformation so that science does not contradict political, religious, or corporate ideologies. In the 1930s, the USSR denigrated mainstream genetics in favor of a fraudulent theory of heredity, which was congruent with Communist ideology[3] (Sheehan 1993). A statement condemning misuse of science was signed by 62 leading scientists, including 20 Nobel laureates and 19 recipients of the National Medal of Science.[4] Time for resolving these issues is short. A very important factor is the 50–100 years available for humankind to achieve sustainability with an estimated population of 8–11 billion (Palmer et al. 2004).

Although there is cause for concern, cautious optimism is also justified. For example, Brown (2003) has produced a plan at the planetary level that including restructuring the economy, stabilizing population, and stabilizing climate. At subcomponent levels, the outlook is also positive: (1) studies on renewable energy (Odum & Odum 2001), (2) calls for behavior change (Green Week events[5]), (3) detailed studies of a hydrogen economy on the stratosphere, which will reduce uncertainty (Tromp et al. 2003), (4) plans for global climate monitoring are being discussed by scientists, although no robust plan has emerged so far, and (5) plans for preserving both land and the economy.[6]

An illustrative small town issue is ongoing in Blacksburg, Virginia, USA; a situation exists that is, in many ways, a microcosm of world environmental problems. The town has purchased a 169-acre, abandoned farm that shows exemplary ecosystem recovery (12 different habitats). One decision that must be made is whether this tract should be preserved as a nature park or turned into another mixed-use park (Browder et al. 2000). At a two-day workshop attended by about 500 residents, 80% of the citizens preferred that the land be used for nature preservation, environmental education, and passive recreation. Opponents favor an active-use plan (soccer fields, large parking lots for spectators, etc.) in which the concept of a nature park does not emerge as a guiding principle, i.e. protection and observation of wildlife, environmental education, and contemplation of nature

[1]See the 2004 review available online at http://uk.cambridge.org/economics/lomborg/reviews.htm

[2]See 'UCS examines the "Skeptical Environmentalist"' by Bjorn Lomborg, 2003, available online at www.ucsusa.org/global_environment/archive/page.cfm?pageID=533

[3]See the 2004 editorial 'Bush-league Lysenkoism: the White House bends science to its will'. Sci Am 26 Apr. Available online at www.sciam.com/article.cfm?articleID=0001E02A-A14A-1084-983483414B7F0000&ref=sciam&chanID=sa004

[4]See 'Restoring Scientific Integrity in Policy Making', PDF download at www.ucsusa.org/news/press_release.cfm?newsID=385

[5]For details, visit www.urbangreendays.org/index.php?id=1059

[6]See 'A deal is reached to preserve land and the economy in the Adirondacks', A de Palma, 22 April 2004, available online at www.nynjtc.org/externalnews/2004/adk1.html

are not primary goals. In addition, citizens have rejected a 'master plan' by a 3 to 1 margin that calls for mixing a nature park and active-use elements. This impasse is occurring in a town where educational levels are above average and the democratic process is continually praised. Is there a discontinuity between citizens and elected officials? Do most citizens favor a nature park in principle but not in practice? Is a mixed-use compromise likely to maintain any significant remnants of the present biological diversity? Another intriguing possibility may be at work: human society is in denial about certain aspects of the human condition.

THE CASE FOR DENIAL

The word *denial* is defined as 'an assertion that something said, believed, alleged, etc. is false' or 'disbelief in the existence or in the reality of a thing.'[7] Another definition is 'refusal to admit the truth or reality (as of a statement or charge), assertion that an allegation is false, negation in logic, a psychological defense mechanism in which confrontation with a personal problem or with reality is avoided by denying the existence of the problem or reality'.[8] Kuhn (1970) defined a *paradigm* as a belief so strongly held that, even when contrary evidence appears, the evidence is rejected. Dobzhansky (1945) stated that no evidence is powerful enough to force acceptance of a conclusion that is emotionally distasteful. The following few illustrative examples show that problems with denial do exist.

1. Cigarette smoking does not cause cancer or other adverse health effects.
2. Global warming is a myth not based on scientific evidence.
3. Biotic impoverishment (species extinction) will not affect human society.
4. Every environmental problem has a technological solution.
5. The human population can keep expanding indefinitely.
6. Resources are not limiting.

By denying that environmental problems exist, most people avoid considering precautionary measures until the adverse consequences are horrendous. Human society is facing an unprecedented environmental crisis on a global scale. However, the aggregate response to any evidence of a global crisis has been trivial, despite some heartening but uncommon case histories.

PERCEPTION OF RISK

World Watch magazine includes in each issue a page entitled 'Matters of Scale'. The Jan/Feb 2002 issue discusses 'Future of Risk', which is reproduced here.[9]

Number of people in Washington, D.C. who were murdered by anthrax poisoning between September 11 and November 9	2
Number of people murdered by other means in the same city during the same period	53
Number of U.S. residents who died of anthrax between October 1 and November 1	4
Approximate number of U.S. residents who died, during the same month, as a result of having smoked cigarettes	33,000
Number of U.S. residents who would die of anthrax in the coming year if the October 2001 rate (when anthrax became the top news story) continued	48

[7]From the *Random House Dictionary*, 2nd edn
[8]From *Merriam-Webster's Collegiate Dictionary*, 10th edn
[9]Reprinted with permission of World Watch Magazine, Vol. 15, No. 1, copyright 2002, www.worldwatch.org

Number of children in Afghanistan that the United Nations estimates may die this winter from pneumonia and diarrhea	100,000
Probability that someone who flies once a month will die in a commercial airplane crash in the coming year in the United States (where concern about terrorism has cut flying sharply), if terrorists hijack and crash one plane every month	1 in 540,000
Probability of dying of a heart attack in the United States (where tens of millions of people fail to exercise or maintain healthy diets despite the risk), in the same year	1 in 400
Odds of a U.S. resident being killed by terrorists in a shopping mall, in the coming year, if the person spends two hours a week in malls and if terrorists destroy one mall (and everyone in it) each week	1 in 1,500,000
Odds of the average U.S. resident being killed in that year by cancer	1 in 600

These examples illustrate that human society's response to risk is based more on emotion than evidence. The dangers of some risks are even being denied. The global risks from a major environmental disequilibrium would make these large numbers seem modest. Responses are not compatible with probable causes of harm, and the dangers of living unsustainably have not received the attention they deserve.

In the US, the 'baby boomer generation' (those in the age range of late thirties to mid-fifties) is concerned about retirement years and whether the Social Security and health care systems will continue to work as well as they did for previous generations. Most of the baby boomer generation believe these systems will not continue. Even though retirement and health care are great concerns, a greater concern exists: will the planet be as habitable for future generations? Health care for the planet's ecological life support system must be considered. Environmentally literate persons know of many reasons for concern. The ecological space available per capita on the planet has decreased from between 5–6 hectares to 1.5 hectares in the twentieth century (Wackernagel & Rees 1996). Natural capital, such as forests (e.g. Brown 2001), wetlands (National Research Council 1992), and fossil water (i.e. underground aquifers), are diminishing (Postel 1999) at rates far greater than replacement. In addition, the world sunshine has diminished 10% to 37% (Chang 2004); dead zones occur in marine ecosystems[10]; and the effects of the oil spill in Prince William Sound are still evident after 15 years.[11] These few examples illustrate the worsening environmental conditions.

Cultural changes are also important factors. In 1999, American gangs in the school systems were composed of these cultural proportions: white, non-Hispanic, 12%; black, non-Hispanic, 25%; Hispanic, 28%.[12] Arguably, major climate changes would produce both severe social and environmental stress. If the ice covering Greenland were to melt or slide into the sea, the oceans of the planet would rise. Barranger[13] describes a situation in the US national parks, particularly the Great Smokey National Park, in which a proposed federal 'clean-air' plan would actually reduce visibility to an unacceptable level.

[10]See 'Dead zones increasing in world's coastal waters,' 16 June 2004, from Earth Policy Institute, available from Environmental News Network online at www.enn.com/direct/display-release.asp?objid=D1D1366D000000FD2E251DE38084ED4A

[11]See '15 years later, Exxon Valdez oil spill lingers', by JR Pegg, from People and the Planet, 7 April 2004, available online at www.peopleandplanet.net/doc.php?id=2189

[12]See 'Indicators of school crime and safety', from the US Department of Education and US Department of Justice (Bureau of Justice Statistics), Oct 2000, Table 16-3. Available online at http://nces.ed.gov/pubs2001/2001017.pdf

[13]See 'Critics say clean air plan may be a setback for the parks,' by F Barranger, 31 May 2004, available online at http://home.earthlink.net/~cevent/5-31-04_clean_air_setback_for_parks.html

SPECIAL INTERESTS

The global environmental crisis, when considered at all, is almost always peripheral to the focus on individual and organizational special interests. Orr (2004) has persuasively argued that partisan wrangling is a symptom of a deeper dysfunction. Humans may not be denying so much the global environmental malaise (extinction, habitat destruction, ecosystem fragmentation, etc.), but rather they may be focusing so intently on their special interests that the larger events, which will markedly affect both any special interests and the quality of life, get little or no attention. For example, projections are that the current global population of over 6 billion humans might reach 9 billion in 50 years or less. Ninety percent of this growth is projected for developing nations. Even those aware of this situation are reluctant to limit population size to the planet's carrying capacity because such a limit would be tramping on 'individual rights', and sovereign nations (even those now dependent on imported food) would almost certainly not comply. However, very few people would hesitate to object if an elevator were occupied by more people than its carrying capacity. Is this because individual interests are likely to be immediately adversely affected, or because of the hope of making a difference, or both?

Humankind definitely wishes to escape vulnerability, whether from terrorists, aging, or intimate relationships. Denial of vulnerability does not erase the susceptibility. In the context of sustainable use of the planet, humankind is denying that it cannot transcend the iron laws of nature and the universe; this denial is a severe handicap. Indeed, the most striking example of this denial is the continued assertion that infinite growth on a finite planet not only is possible but also is desirable. Bartlett & Lytwak (1999) have noted that population momentum is either ignored or denied. If the 'normal' US life span of 70 years is considered, then lowering the fertility rate to 2.1 children per woman (replacement rate) would result in a gradual drop in population growth rate. However, the rate would not reach zero for 70 years, and, during this interval, the population would continue to grow.

Sustainability requires a willingness to accept the uncertainties of natural systems and to be exposed to natural law — after all, humankind is a component of the interdependent web of life rather than the centerpiece. In this view, humankind is more like the millions of other species (both plant and animal) on the planet, which means that much is beyond human control. Some natural events may severely disrupt or even end human lives. Humankind's denial of its dependence on the planet's ecological life support system and its vulnerability to the laws of nature is part of a larger pattern of denial.

Humankind is denying survival to a large array of species and leaving a less habitable planet for future generations when it damages planetary ecosystems. If humankind continues to act as it is presently, it is denying responsibility for actions that will have far reaching consequences.

Davidsen & Rees-Mogg (1997) predict the demise of the nation-state, primarily due to the rapid development of cyberspace. Local centers of power will reassert themselves as the state develops into fragmented overlapping sovereignties (e.g. Tilly 1993).[14] If the nation-states are indeed in decline, this event is very important since most nation-states espouse exponential economic growth, deny the reality of carrying capacity, and have routinely subsidized environmentally damaging activities (e.g. Myers with Kent 1998). Eliminating perverse subsidies is an obvious, major

[14]A detailed examination of these issues is available in a special issue of Global Environmental Politics, Vol. 4, No. 1, February 2004, edited by F Biermann and K Dingwerth. Interesting evaluations of these issues may also be found in Dalby (2004), Conca (2004), and Lipschutz (2004)

step toward achieving sustainable use of the planet. Myers with Kent (1998) estimate that subsidies of approximately US$1.5 trillion are larger than the economies of all but five countries in the world. Present and future generations are and will be markedly affected if these perverse subsidies continue.

DENIAL VERSUS IRRATIONAL EXUBERANCE

Most persons in 'developed countries', who are the largest consumers of planetary resources, also believe that human creativity, technology, and economic growth will solve all problems and continuously improve the human condition. The exponential growth and vastly increased affluence of many humans seem to support this assumption because, in the short term, they appear to indicate no limits to growth for *Homo sapiens*. This situation is particularly true in the 200+ years since Malthus (1798) published his still controversial book on population growth. However, exponential growth and increased affluence seems to be the result of unsustainable practices that may destabilize human society in the 21st century. At present, over half of the world's population is living in conditions that are far from enviable; global climate change, including changes in the hydrological cycle, could easily and rapidly worsen existing conditions.[15] Many environmental and ecological functions are non-linear; since doubling times (e.g. population, some types of climate change, and resource consumption) are non-linear as well, critical breakpoints and thresholds can be reached in far less time than expected by those who assume these activities are linear functions.

In general, social systems are slow to respond to environmental crises, especially when they involve large temporal and spatial spans. If decision makers and the general public must witness evidence of damage to human health and the environment before taking remedial action, the measures will be both less effective and more costly. However, taking precautionary action (while significant uncertainty still exists about the circumstances that will probably result in damage) requires a much higher level of environmental literacy than the level of most current decision makers and the general public.

A major, unanswered question concerns the degree that unmistakable damage to human health and the environment in one geographic area will influence decisions on similar problems in other geographic areas. Cultural differences, level of affluence, etc. will also probably affect the influence of case histories in other parts of the world. Clearly, sustainable use of the planet will require precautionary measures to avoid problems, not remedial action after the damage has occurred. Denial of the probable existence of problems until damage occurs is an ineffective way to resolve sustainability issues, especially when many more resources are required to repair environmental damage than to prevent it. The planet's biospheric life support system should have the highest priority for protection, maintenance, and repair since it is by far the most important factor in the quest for sustainable use of the planet. Both the future of humankind and the human economic system depend on its integrity and well-being. Humankind once acknowledged the necessity of a healthy biospheric life support system, but the technological and economic successes of the last few centuries, insignificant in geological time, have led to the belief that humans now transcend natural law. The evidence of this belief can be found throughout the globe, but humankind has become addicted to unsustainable practices that lead to an unhealthy biospheric life support system. Many of humankind's unsustainable practices are simple to state.

[15]See 'Heavy debt and drought drive India's farmers to desperation', by A Waldman. From the New York Times, 6 June 2004, available online at www.nytimes.com/2004/06/06/international/asia/06INDI.html?th

1. Denial that humankind inhabits a finite planet with limited resources and a finite carrying capacity for humans.

2. Denial of limits to growth, which enables humankind, for a short time at least, to continue present practices.

3. Denial that a human being is part of a whole called by many cultures 'the universe'. Humankind is part of an evolutionary system with participation possibly limited in time and space[16], even though individuals may perceive themselves as an entity separated from the interdependent web of life. This perception is a delusion. Sustainability requires that humankind free itself from this delusion by expanding its compassion from 'targeted' to 'generalized', embracing natural systems as well as future generations of its species with whom it shares planet Earth (Cairns 1998). Of course, this goal will remain, for the near future, an aspiration for both individuals and society, but it is essential to achieving sustainable use of the planet.

4. Denial that humankind is both a victim and a beneficiary of its cultural conditioning. Technologies (e.g. agricultural and industrial) have enabled humankind to modify some of nature's laws and adapt some habitats that were marginally habitable to make them moderately habitable. Domestication of a few species of plants and animals has resulted in additional security in food supply. As a consequence, awe of nature has been replaced by a feeling of dominance and control. However, nature still intrudes upon human lives (e.g. weather, disease, invasive species), so human society is not divorced from nature. Humankind has the power to improve the relationship between itself and natural systems. The current computer era and humankind's language-based cultural system provide an unprecedented opportunity to develop a mutualistic relationship with natural systems. However, at present, no persuasive evidence indicates that either of these tools will be used toward this end.

5. Denial that humankind has denigrated the value of the covenant with the natural systems on which humans are dependent for their survival. The covenant was established, confirmed, and reconfirmed by certain rites involving sacred tokens from the organisms themselves, a symbol that, when animals were slain or plants were consumed, their components should be returned to the mother source for rebirth (Eldridge 1991). As Eldridge (1991) notes, when such rites were performed and the mystery of the order of nature thus recognized, it was hoped that the food supply of the human community would be assured.

6. Failure to refute the distortions of scientific evidence by op-ed commentaries attacking the conclusions of mainstream science by those with far less impressive academic credentials (e.g. London 2002). As Cairns[17] remarks, life on Earth will endure — what needs to be saved are the conditions that support human life. In the long term, natural law will eradicate species that place natural systems in disequilibrium and impair their capacity for self-maintenance. Some people concerned about environmental problems are labeled 'environmental doomsayers' (e.g. London 2002). The people who use this label for environmentalists blithely ignore the fact that many more ways of living exist than the ones now used, no matter what they are (Quinn 1999). The people whom London (2002) labels 'environmental doomsayers' are concerned about humankind's future; they are not interested in preserving the status quo but only those components that are both sustainable and ethical.

[16]See 'Future of life on Earth', by John Cairns, Jr. ESEP 2004:1–2. Available online at www.esep.de/articles/esep/2004/E41.pdf

[17]See Footnote 16

7. Failure to remedy the maldistribution of resources. Nature gives up resources grudgingly; however, they are distributed fairly equitably among more than 30 million species. With finite resources on a finite planet, distribution among this huge number is no small achievement. This feat is accomplished by resource partitioning—each species has a competitive edge for a relatively small component of the total resources available. Species that exceed resource carrying capacity suffer famine and disease, which make many of them more vulnerable to predation. Some species exhibit strong territoriality. The waste products of one species may serve as resources for other species. Tribalism is the result of natural selection and has worked well for humans and other species. All members of a tribe or other biological, social community are involved in the success of the tribe. There is little compassion for misfits. Natural systems are characterized by substantial loss of individual lives.

Smail (2002a,b) has remarked upon the increasing tension between two, seemingly irreconcilable trends: (a) projections indicate that human population trends will reach or exceed 9 billion by the mid-to-late twenty-first century and (b) increasingly reliable scientific estimates indicate that Earth's long-term, sustainable carrying capacity may have already been exceeded (Wackernagel et al. 2002). To continue to deny that this dichotomy exists defies common sense. This statement is not 'gloom and doom', but rather a proposal acknowledging that humankind has an obligation to develop a harmonious and mutualistic relationship between humankind and natural systems that is sustainable. Goals and conditions must be provided to make the vision a reality (e.g. Cairns 1997). A belief that civilization as now practiced is unsurpassable is foolish, arguably fatal. One area that could be dramatically improved is eco-ethics, which should be the unifying theme of the vision. Making the planet more habitable for humankind and other species is the sine qua non of eco-ethics.

8. Failure to redefine *civilization* or to develop a new word to describe the vision of sustainable use of the planet. The word *civilization* is homocentric, and sustainability requires an ecocentric word. *Homo sapiens* has 'overrun' Earth and 'subjugated' nature. This result was perceived as inevitable, even ordained. Furthermore, substantial benefits have accrued to those who accept civilization as it is defined at present. Individuals who improve life for humankind are rewarded with power, wealth, and respect. However, the benefits that a few humans acquire are not widely distributed among humankind. At least 30% of the 6 billion people on the planet are poorly or marginally fed and housed. Consequently, a paradigm shift to a mutualistic relationship is at least possible since, for many, human society seems out of control. A number of scenarios could play out in this continuing, unsustainable relationship, from devastating effects upon humankind to moderately severe effects (Cairns 2000–2001).

TRANSCENDING DENIAL

Denial does not protect either individuals or societies. At best, denial temporarily postpones facing issues that persist until they are resolved with reason aided by intelligence. Denial can be lethal or, at best, damaging. Worse yet, denial can adversely affect both present and future generations. Even the best value system cannot stop the inevitable death of the planet, but a sustainable value system will enable humankind to persist much longer than denial will. Denial of reality (in this case, of the rule of natural law) can be fatal to both individuals and cultures.

Ehrlich (2000) gives a comprehensive overview of humankind's biological and cultural evolution. He discusses not only the processes that produced *Homo sapiens* but also the many facets of evolution that will markedly affect humankind's future. Humans began as a small tribal species that

was spread thinly over the planet with only primitive technology to extract resources from natural systems. Connections with natural systems were intimate, and severe penalties arose from inappropriate actions. Now the human population exceeds 6 billion and is still growing globally. Furthermore, massive technology allows extraction of resources from natural systems at a much greater rate. Expectations of material consumption are high and growing. To deny that these factors have not produced major problems will worsen the rapidly deteriorating environmental circumstances and will improve neither cultural evolution nor humankind's relationships with natural systems.

Before civilization as defined at present, each individual had to have a realistic view of the area of the planet s/he inhabited. Realistic survival techniques included avoiding predators, hunting and gathering food, selecting shelter, and ensuring adequate water. Modern *Homo sapiens* successfully persisted on Earth for 120 000 years before the agricultural revolution. Hunters/gatherers may have spent as little as 20% of their time securing adequate nourishment (2000 calories per day), at a cost of 400 calories.

DENIAL, MEMES, AND SILENCES

In *The Selfish Gene,* Dawkins (1990) states that memes (the replicating cultural units of transmission) are to cultures what genes are to bodies.[18] Memes can be both helpful and lethal to cultures. Especially dangerous are globally accepted beliefs such as the belief in perpetual economic growth or the belief that human technology and creativity free humankind from natural law. One important natural law is that a carrying capacity exists for each species that cannot be exceeded for long periods of time. When a lethal meme is widely accepted, catastrophe on a global scale becomes highly probable. Memes enable denial to continue despite substantial evidence to the contrary. For example, the US is resisting, arguably blocking, attempts to reduce greenhouse gases because of presumed adverse effects on the economy. Yet, global warming could destabilize civilization as known at present. Fortunately, some world leaders (e.g. UN Secretary General Kofi Annan [Annan 2002]) explicitly list the most important, potentially devastating environmental challenges, as well as a vision of green technologies, livable cities, and rising quality of life for a majority of humankind rather than just a fortunate minority. Most people accept the present situation both because they hope to be a part of the fortunate minority and because they have been acquiring more every year for decades (at least more of a few things — more food for less money, more clothes, and the perception of more tax relief). However, with resources becoming scarcer and the human population still growing, the prospects for joining the wealthy elite grow smaller every year. Further, the wealthy power elite has found that tranquility and happiness have generally remained elusive, although it appears to remain persuaded that more power and more wealth will correct this situation.

Ehrlich (2000) is not enamored with the meme hypothesis of cultural evolution, but does note that quantitative approaches to cultural evolution (e.g. Cavalli-Sforza & Feldman 1981) have been scientifically profitable. Ehrlich (2000) does believe that cultural and other environmental variations play a role in the evolution of humankind, compared to genetic evolution.

Nicholson (2002) believes that humans are reluctant to speak about important issues because openness makes them vulnerable and, thus, removes them from the 'enclosure' of privacy. Denial is probably not the word to use in this situation — Nicholson uses the word silence.

[18]Ehrlich (2000) has a superb and well-referenced book on both cultural and genetic evolution in humans

Orr (2004) believes that the whole political machinery that connects the values and ideals of American citizens with public policy has been severely damaged, possibly broken. Orr presents an unsettling evaluation of the environmental consequences humans will face unless citizens develop the political will to reverse current trends. He states that patriotism, heightened by fears of terrorism, is a major factor in this dysfunctional system and will adversely affect posterity. Despite Orr's disquieting analysis, he has both a positive view of the future of the human species and a plan for leaving a habitable planet for future generations. True patriotism may have severe penalties. For example, Thompson reports that a federal biologist and the team's advice were illegally ignored before a major fish kill in 2002 on the Klamath River.[19] The federal government was politicizing scientific decision making and misleading the public. Pegg reported another instance in which an attempt was made to time the release of information on the closure of an Oceans Commission report to occur before the US national elections.[20]

Another possibility is that, in some instances, uncertainty may appear to be denial. For example, some professionals have predicted an oil shortage (e.g. Editorial 2003, Goodstein 2004) and that the petroleum age is far from over (e.g. Maugeri 2004). Malakoff (2004) examines the possibility that some at-risk species (e.g. bluefin tuna and blue whales) appear to congregate along oceanic 'fronts' where cold and warm water masses meet. These fronts may exist for relatively long periods of time and may even result in areas rich in fisheries. However, much must still be learned about these areas. One thing is clear — this level of scientific uncertainty requires a high level of scientific literacy and may be ignored (not denied) because of both complexity and uncertainty. The same is true of such complex issues as the deterioration of world food security.[21]

In the US, alarm has increased over the number of overweight people (McGraw 2003). Is the silence in the US on an imminent food crisis due to denial, guilt, or a lack of awareness of the problem? A related issue (noted in Quigg 2004) is whether drought in the American West is a cyclic problem or a new trend.

In addition, ambivalence exists about repairing some of the ecological damage that humankind has done. Willott reported on a case in Tucson, Arizona, USA, of current riverbeds that are often dry; however, in the 1800s, they were often filled with water, but also malaria.[22] At present, malaria does not exist in the Tucson basin, but the West Nile virus does. The benefits of wetland restoration are numerous (e.g. National Research Council 1992), including ecosystem services such as water purification, removal of sediments, flood reduction, and use as major wildlife habitats. However, Willott noted that repair of nature in one area may mean an alteration in the social context.[23] To achieve sustainable use of the planet, humankind can neither assume an either/or attitude nor remain silent on the issues.

[19]See 'Federal whistleblower quits, alleges politicization of science', by D Thompson, 19 May 2004. Available online at www.sfgate.com/cgi-bin/article.cgi?file=/news/archive/2004/05/19/state1745EDT0118.DTL

[20]See 'Oceans Commission chair urges closure before election day', by JR Pegg, 25 May 2004. Available online at http://shiftingbaselines.org/blog/archives/000125.html

[21]See 'World food security deteriorating: food crunch in 2005 now likely', by LR Brown, 2004. From the Earth Policy Institute, available online at www.earth-policy.org/Updates/Update40.htm

[22]See 'Can we restore wetlands and leave the mosquitoes out?', by K Rogers, 25 May 2004. Available online at http://uanews.org/cgi-bin/WebObjects/UANews.woa/4/wa/SRStoryDetails?ArticleID=9253

[23]See Footnote 22

IDEALIZATION VERSUS REALITY

If humankind achieves sustainable use of the planet (or a close approximation thereof), it will be because billions of people share a new vision and use it to guide their practices. These billions can be amassed because thousands and/or millions who are living more sustainably should inspire other individuals. Individuals who live a life that is materially frugal, in harmony with nature, and yet have had an enriching, quality experience have caused many people to reexamine their lifestyle, including the satisfaction of developing a more harmonious relationship with natural systems (e.g. Wirzba 2003).

As a citizen of the US, which has the largest ecological footprint of all nations, I felt a personal responsibility to see how much of my personal footprint size could be reduced. Wackernagel & Rees (1996) provide a discussion of how the ecological footprint size is calculated. There are numerous Internet sites for determining personal ecological footprint size.[24] Figure 1 in Rees and Wistra (2003) graphically illustrates equitable (i.e. population-based) versus actual appropriation of global carrying capacity by selected countries. The US, with less than 5% of the global population, appropriates about 24% of global carrying capacity. Much can be done in the US to reduce footprint size. Residents of wealthy nations average 5–10 hectares/capita while residents of China require only 1.2 hectares (Wackernagel et al. 1999). If individuals realized that lifestyle changes could be incremental, they would be less likely to indulge in denial. Denial occurs most often if an entire lifestyle appears threatened. Furthermore, a modest change in a single component of a lifestyle (e.g. energy consumption) is likely to result in a significant improvement in sustainability. Denial appears more likely if individuals are told they will have to give up *everything* if they embrace sustainable use of the planet — 'back to the Stone Age' is a transparent but effective tactic for oppositionists. The quality of life appears threatened when, in fact, excessive consumption is the target. An obligation of giving up *cars* is more threatening than an appeal to *use* the car less. However, if a substantial number of people used cars less, greenhouse gases would diminish. Living comfortably without a car in most small US towns is difficult, but not impossible. However, if small towns had been designed with more neighborhood stores within walking distance, dependence on automobiles would be reduced and social capital would increase. Americans now drive to exercise facilities when walking to the local store would benefit both the individual and the environment.

On a finite planet with limited resources and a growing demand on them, a simpler, less materialistic lifestyle is inevitable. Exponential growth alone will ensure simplicity and less materialism. This crisis could come earlier than expected due to water shortages, climate change, terrorism, ethnic conflict, etc., which will worsen already troublesome conditions. Humankind is blessed with a sophisticated intellect, but denial of evidence that Earth's ecological life support system is being degraded at a rate unprecedented in human history results in stupid decisions that are harmful to both individuals and humankind. Dawkins (1990) asserts that individuals are temporary housing for genes from generation to generation. Presumably, human intelligence will have survival value when the environmental crisis intensifies, even if it does not seem to function effectively in eliciting precautionary measures that would lessen or avoid the crisis. Memes, both lethal and benign, are transmitted from mind to mind through cultures. Consequently, changing individual minds affects the survival value of memes. As a consequence, denial might be overcome rather rapidly. The future of humankind may depend on the validity of this hypothesis.

[24]See, for example, 'Calculate your ecological footprint,' at http://www.myfootprint.org

However, Dobson (2003) reluctantly concludes that social justice and environmental sustainability are not always compatible objectives. Rees and Wistra (2003) pose an equally challenging issue that must also be addressed before the loss of ecological resiliency occurs. Denial of serious sustainability issues is not prudent. Abernethy (e.g. 1994) has shown that motivation, rather than differential access to contraceptive methods and information, is the primary determinant of fertility.[25] Individuals respond to scarcity by having fewer children and to a perceived better future by having more children. In short, successful economic development does not reduce family size but, where perceived economic opportunity is good, family size increases.

The few selections from relatively recent publications that follow provide food for thought on the question of denial.

(1) The world's most populous country, China, has a significantly shrinking grain harvest, as do many other countries with large populations.[26]

(2) Oxygen deficient areas of the world's ocean, 'dead-zones', that are devoid of fish are spreading. The number has doubled since 1990 — 150 zones have been identified globally. Some are as large as 27,000 square miles.[27]

(3) It was once believed that hatchery salmon could help maintain wild populations but there is persuasive evidence that this is an unjustified expectation.[28]

(4) *The Los Angeles Times* notes that carbon dioxide levels have reached record high levels after growing at an accelerated pace last year.[29] This important greenhouse gas is a major factor in climate change.

(5) The human economy may well have overshot Earth's carrying capacity by exceeding its regenerative capacity (Wackernagel et al. 2002)

Many other examples of denial can be found in publications of the United Nations, The Earth Policy Organization, and Worldwatch. An important factor is accusations that US President Bush's administration has systematically distorted scientific fact and stacked technical advisory committees to advance favored policies on the environment (Glanz 2004). Dr. Charles M. Vest, president of the Massachusetts Institute of Technology, has cautioned against a very long-term trend toward selective use of scientific information driven by political and ideological motivations. Arguably, this trend is the most pernicious form of denial.

In the quest for sustainable use of the planet, humankind may be nearing a point of 'no return' (i.e. irreversible damage to the biospheric life support system). The closer this point is approached, the more difficult management becomes. Considerable uncertainty exists about the precise breakpoint of the biospheric system, but, clearly, much damage is being done to it. Denial that the problem exists will only result in being spectators to a tragedy that could have been avoided. As McNeill (2000) has documented, the rate of environmental deterioration seems to be accelerating.

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[25]See also Abernethy VD (2001) Fertility decline; no mystery. ESEP 2001:1–11, available online at www.esep.de/articles/esep/2001/article1.pdf

[26]See 'China's shrinking grain harvest' by LR Brown (2004). From the Earth Policy Institute, available online at www.earth-policy.org/Updates/Update36.htm

[27]See 'UN warns about ocean "dead zones"'; by H Greimel, 29 March 2004, available online at www.3reef.com/cgi-bin/yabb/YaBB.pl?board=Evironmental;action=display;num=1080578142

[28]See 'Hatchery salmon cannot replace disappearing wild fish', by JR Pegg. From the Environmental News Service, 26 March 2004, available online at www.flmnh.ufl.edu/fish/InNews/replace2004.html

[29]See 'Carbon dioxide levels rising faster; buildup sets record', 21 March 2004, available online at www.latimes.com/services/site/premium/access-registered.intercept (access limited to registered users)

The cult of hyperindividualism (i.e. focusing on the individual condition) appears to be accompanied by a belief that individual interests are divorced from the interests of humankind, including posterity. For example, mainstream science has been aware of the threat of global warming for more than a decade, but both nation-states and individuals all too often refuse to change their behavior to prevent exacerbating the problem. Sustainability is larger than the individual, and humankind cannot deny that an ethical behavior is required to transcend the individual. Still, the recognition of the need for ethical behavior could grow into a major political force globally. Regrettably, history indicates that major crises need to become painfully obvious before a paradigm shift occurs.

Why do people remain unconvinced and unconcerned despite increasing evidence that humankind is seriously reducing the chances of achieving sustainable use of the planet (Ehrlich & Ehrlich 2004)? Ehrlich & Ehrlich note that Americans, although major contributors to resource consumption and anthropogenic greenhouse gases, seem mostly oblivious to the potentially massive threats caused by excessive resource consumption (i.e. beyond regeneration or replacement capacity) and increasing pollution of the environment.

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Sustainability and Specialization

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ABSTRACT: Society depends heavily on its major universities and independent research organizations for new ideas. Arguably, sustainable use of the planet will require conceptual paradigms unprecedented in human history. Educational systems, especially major universities and research organizations, must produce students in all phases of the education continuum who are capable of transdisciplinary activities. A much larger group of such students will be required to implement these new undertakings. Until the perception of the need for transdisciplinary education becomes widespread, nothing significant is likely to happen. One major obstacle is the lack of employment for transdisciplinary individuals. A commitment to sustainable use of the planet will provide employment and make better use of increasingly scarce resources.

KEY WORDS: Sustainability · Academic specialization · Educational system · Transdisciplinary · Data integration · Co-evolutionary process · Environmental education

> *When environmental ethicists create a separate, distinct discipline with its own terms and assumptions, they disqualify themselves as the integrative contributors they could be if their disciplines were built in public discourse, the rich, highly textured language upon which we fall back when we are faced with a crisis or problem and must decide collectively what to do about it.* Bryan G. Norton, 2003

> *This well-meaning but narrow-minded nanny of an institution ensures that scientists work according to conventional wisdom and not as curiosity or inspiration moves them. Lacking freedom they are in danger of succumbing to a finicky gentility or of becoming, like medieval theologians, the creatures of dogma.* James Lovelock, 2000

> *The ongoing fragmentation of knowledge and resulting chaos in philosophy are not reflections of the real world but artifacts of scholarship.* Edward O. Wilson, 1998

INTEGRATION OF DATA

Sustainable use of the planet is a policy goal that requires input from all disciplines, professions, and special interest groups. The disciplines are essential for academic quality control; however, if they remain in the present degree of isolation from each other, sustainability is unlikely to be

achieved. The disciplines are the basic units of a *bottom-up* approach in which the components of sustainability are studied, but the *top-down* approach covers large temporal and spatial spans and is essential to the implementation of sustainability strategies. Specialization facilitates development of quality control practices for both data and personnel and is often referred to as the reductionist approach. The twentieth century was the age of specialization.

Integration of information and data is essential for the study of complex, multivariate systems. If sustainability is to be achieved effectively, integration of human society with all components of the planet's ecological life support system (i.e. both natural capital and ecosystem services) is mandatory. If humankind is fortunate, the twenty-first century will be known as the age of integrative knowledge and concepts.

THE ROLE OF ACADEME

The educational systems in the United States and elsewhere have made an exploratory effort toward integrating transdisciplinary data, but the effort may be too little, too late. After years of domination by specialization, adding a whole new structure will be extremely difficult, especially in a time of budgetary problems. In addition, the transformation to integrating transdisciplinary data must occur without impairing the integrity of the disciplines. Since major research universities are markedly dependent upon extramural funding, which is increasingly transdisciplinary, the rate of change will almost certainly be greater than if these universities were not so dependent upon outside funding.

In the United States, the amount of extramural funding is one of the most widely used ranking systems for universities. Naturally, ambitious administrators keep a vigilant eye upon those faculty who acquire major grants and contracts. Since some disciplines are more likely to acquire major extramural funding than others, each university experiences an imbalance as the more competitive disciplines are favored.

Inevitably, a division of the *haves* (well-funded) and the *have-nots* (little or no extramural funding) occurs. This imbalance can be diminished with endowment funds; however, a vast gulf which may negate cooperation may develop between the *haves* and the *have-nots*. Such a gulf is not a favorable condition for the exceptionally broad, transdisciplinary projects required to achieve sustainable use of the planet. Arguably, this lack of substantive interaction between disciplines is the most aggravating obstacle to developing sound sustainability strategies. Presumably, the dissimilarities in funding just mentioned will lessen as funding for sustainability projects increases. Even so, this issue deserves more attention than it is now receiving.

Many corporate and government grants and contracts are for a specific purpose. This specificity is to be expected because corporations must answer to stockholders and much government money comes from agencies with a specific mission. As a consequence, sustainable transportation, sustainable cities, sustainable energy sources, and sustainable agriculture are the typical categories of grants; however, specific grants and/or contracts may fall within even narrower disciplinary scopes. Funds to integrate these dissimilar fields into a comprehensive global, national, or regional strategy are far below probable needs.

CATASTROPHES

Issues important to sustainability probably will not be given serious attention at a global level until a major catastrophe occurs. Even then, a global response may not occur if the event is restricted to one or two nation-states. Of course, some components of sustainability may be addressed because, even at present, the need for more sustainable practices is evident (e.g. water

management) or because sustainable practices lower unit product cost for corporations (e.g. energy policy). In addition, the prospect of leaving a habitable planet for posterity and an increased compassion for other life forms are powerful ethical motives. Even in these instances, however, the need for sustainable practices is acknowledged more often than implemented.

In democratic societies, most politicians focus intently on re-election rather than on long-term strategies of any type. Since campaign costs are increasingly expensive and special-interest groups are a major source of funds, practicality motivates politicians to place emphasis on the interests of their contributors. However, if the general public gave responsibility for the well-being of posterity a high priority, these motivations could change rapidly. Lobbyists for special-interest groups are specialists in promoting their interests. Some pose less danger than others if their activities are directed in the general context of sustainable use of the planet. After all, society includes a variety of special-interest groups and probably always will. The danger occurs when special interests replace, rather than supplement, broad ethical responsibilities.

SPECIALIZATION

Arguably, the most intense experience in specialization occurs in the academic community. In academe, especially in the sciences, a highly motivated, intelligent individual can, in a few years, generate specialized information about a narrow area that is new even to the august members of the graduate advisory or tenure and promotion committee. The lesson is unmistakable — generation of robust, specialized information is the key to early recognition from one's mentors and peers. This process is accompanied by rites of passage that confer recognition of accomplishment; these rites of passage may also act as isolating mechanisms.

Specialized disciplinary terminology (an uncharitable person might use the word *jargon*) that is comprehensible only to a select group is another isolating mechanism used within the disciplines. International, national, and regional meetings of each discipline require use of this terminology to illustrate a specialist's knowledge of the field. Specialized terminology also isolates disciplines from each other since the terminology changes (i.e. addition of new terms) occur rapidly enough to require a significant effort to remain current. In academic institutions, promotion and tenure are dependent upon the recommendation of members of the disciplines to the college and/or university committee, which usually consists of still more disciplinary specialists.

I once collaborated for about a decade with an optical physicist, who specialized in laser holography, in developing a rapid biological information system based on species diversity (Almeida et al. 1978, Cairns et al. 1976). I never became an optical physicist and Sil Almeida never became a biologist, but we were able to communicate effectively to produce interdisciplinary research suitable for publication in peer-reviewed journals. This collaboration also provided valuable interdisciplinary experiences for graduate students and post-doctoral fellows. Finally, grant funding would not have been available to either discipline without the other. On the negative side, we were alienated from members of our own basic disciplines because both the terminology and the journals were unfamiliar to members of our disciplinary fields.

LIMITATIONS OF THE HUMAN BRAIN

Szent-Gyorgi (1962, p. 11) stated: 'Primarily the human brain is an organ of survival. It was built by nature to search for food, shelter, and the like, to gain advantage — before addressing itself to the pursuit of truth.' Heerwagen & Orians (1993) comment on the suitability of the human brain for both analyzing and responding effectively to the conditions of ancestral environments. Society

cannot reasonably expect the over 3 billion individuals living on US$3/capita/day or less to spend any significant amount of time on sustainability when their primary concern is survival. On the other hand, for the more affluent, time remaining in a busy schedule is often used to achieve status.

Economist Kenneth Boulding (1956) asserted that, beyond a certain degree of complexity, the human mind substitutes symbolic images for imagination. Environmental biologist Hardin advocated asking '*and then what'* questions to detect unexpected consequences of focusing too intently on a single goal (e.g. economic development or exponential growth).[1]

OBSTACLES TO TRANSDISCIPLINARITY

Remarkable progress has been made in overcoming the obstacles to transdisciplinary activities in the over 55 years I have been engaged in these activities. Both individuals and disciplines have experienced intellectual and financial benefits from this progress. Wilson (1998) believes this trend is irreversible and provides persuasive evidence to support his view. The major issue now rests on whether the rate of change will be adequate to enable humankind to have the information essential to achieve sustainable use of the planet. Unsustainable practices are still the norm, and natural capital is being depleted at a rate far in excess of its regeneration.

Most collaborations are still interdisciplinary and typically involve only two disciplines. *Interdisciplinary* is the appropriate term since the boundaries of the disciplines are quite evident, but the goal requires the participation of both. A major effort should be made toward synthesis of all phases of the relationship. This design is a distinct improvement over multidisciplinary studies in which each discipline has a separate approach toward a common goal, with synthesis or a series of feedback loops between or among the disciplines, so that information generated in [each] bears only token influence on the activities of the others. Transdisciplinary activities require that the research or problem-solving design not be dominated by the disciplines, that robust synthesis be a major goal, that disciplinary jargon be absent or kept to a minimum, that communication between and among the disciplines be sufficiently effective so that mid-course corrections can be made in all components because of information generated by others, and that the results be comprehensible to reasonably intelligent laypersons.

JOURNALS AND THE COEVOLUTIONARY PROCESS

A major contribution to this co-evolutionary process could come from journals that aspire to be truly transdisciplinary. These journals would provide an opportunity for transdisciplinary groups to publish their concepts and information without being hampered by the detailed knowledge base and complicated terminology essential to specialized journals. At the same time, transdisciplinary journals must adhere to rigorous quality control measures comparable to specialized journals. This undertaking is indeed a formidable task.

An important feature of producing these journals is the avoidance of endless repetition of information essential to understanding transdisciplinary papers so that the primary message of the manuscript is unmistakable. For example, the field of ethics comprises many subdivisions of great interest to ethicists but that are not essential to a manuscript for which a dictionary definition of ethics is adequate. Meeting the disciplinary requirements of a specialized journal on ethics is not appropriate for a transdisciplinary journal and may hamper communication with non-specialists.

[1]See www.garretthardinsociety.org/info/quotes.html

Sustainability has or should have a wide variety of information inputs. Most will be incomplete and some will be contradictory (e.g. as in the ecology/economics debate) and ambiguous. Regrettably, some data may be false (e.g. when prepared by a narrow-minded special interest group). Many people and a wide variety of special interest groups think sequentially (i.e. one item at a time), even when considering a multivariate issue covering large spatial and temporal spans. Results, especially in difficult international situations, may be presented as robust when they have not been confirmed or validated. Even when the data have been demonstrated to be either false or highly uncertain, humankind may be locked into an inappropriate course of action based on unreliable information. However, the human brain does not have predispositions resulting from biological evolution (Ehrlich 2000). Ehrlich (2000) notes that social evolution is important for the human species. Social evolution can be quite rapid while human biological evolution is comparatively slow. Transdisciplinary journals cannot solve this problem, but they can make readers aware of it. Each person only knows a tiny portion of the requirements for living sustainably, but is often too certain that the respective knowledge base is both correct and important.

REASON AWAKE REVISITED

In the foreword of *Reason Awake*, Dubos (1970, p. xiii) stated

> … all ecological systems, whether man-made or natural, must in the long run achieve a state of equilibrium and be self-regenerating with regard to both energy and materials. The ecology of highly industrialized nations has been in a state of disequilibrium for several decades. Furthermore, ecological instability is increasing at such an accelerated rate that disasters are inevitable if the trend continues.

People in denial in affluent countries will protest that Dubos was wrong — there is food in their stores, comfortable shelter, one or more automobiles in the garage, large television sets, at least one personal computer, and cell phones for every member of the family. At least two-thirds of the people on the planet would disagree with this complacent viewpoint.

If humankind ever achieves sustainable use of the planet, it will be the result of effective broad communication of the rationale and values essential to success. Arguably, the first step in this process will be to establish the scientific and ethical framework in transdisciplinary journals with a broad readership both geographically and professionally. The second step will require effective communication with the general public. Both will require a minimum of professional jargon and a willingness of participants to invest significant amounts of time in order to cope with the synthesis of many interactive components.

Most transdisciplinary, peer-reviewed journals are comparatively new; all new journals have three interrelated problems: (1) attracting authors with well-established reputations, (2) maintaining quality control via knowledgeable reviewers, editorial staff, and editorial board, and (3) obtaining an appropriate readership. Most transdisciplinary authors learned early in their careers that disciplinary publications were the fastest way to establish a professional reputation. The least aggravating means of publishing is in the disciplinary journals in which the reviewers and authors share a substantial knowledge base. However, reputations of some mid- and late-career individuals have been enhanced by transdisciplinary publications. Even so, a disciplinary orientation is the norm for both authors and reviewers for transdisciplinary journals. However, they are usually not from the same discipline and do not share a large knowledge base, including terminology.

Reaching an agreement on the adequacy of a transdisciplinary manuscript is not easy. The author is worried that colleagues in the author's original discipline will accuse him of needless

repetition, and reviewers insist on having details that would be unnecessary in a disciplinary journal. This requirement may be beneficial to the readers, especially of a new journal, but authors, reviewers, and readers must develop a more extensive shared knowledge base if the transdisciplinary journal is not cluttered perpetually with basics in a large array of disciplines. In short, a large base of common terminology and concepts would avoid boring regular readers. The large uncertainty is whether the rate of development of a transdisciplinary *language* will be adequate to cope with the rapidly developing environmental crises. Until these issues are resolved, sustainability will remain an aspiration rather than becoming a reality.

Since the educational system is the primary source of skilled, well-informed professions, what happens in it will have a major impact upon the prospects for achieving sustainable use of the planet. Institutions of higher learning are now proud of having a token amount of multidisciplinary and interdisciplinary activities on campus, but are using the word *transdisciplinary* rarely, if at all. Worse yet, a few educational institutions and individuals believe the terms are interchangeable. An examination of any college or university catalog will demonstrate how discipline-oriented these institutions are. As a caveat, disciplines are essential to educational institutions and sustainable use of the planet. This understanding must be reiterated continually in order to combat the common criticism that transdisciplinarity is hostile to the disciplines.

This academic structure is quite understandable since most educational budgets are allocated by discipline, and transdisciplinary activities are regarded as new programs, which, in an era of tight budgets, usually obtain funds by administrative reallocating of funds from the traditional disciplines. Incidentally, this strategy is often used for start-up funds for activities thought to have a high success rate for obtaining extramural funding.

Almost certainly, some academic institutions will find ways to surmount these obstacles and establish truly transdisciplinary programs devoted to sustainability. Most likely, these will be established with endowment funds and/or special gifts restricted for use for these purposes only. Students of some of these programs will undoubtedly become leaders in transdisciplinary fields, especially those focused on sustainable use of the planet. Since the twenty-first century will be an era of synthesis and integrative science, the graduates of these new transdisciplinary programs should have many employment opportunities not available to those lacking this experience. Additionally, as mentioned before, faculty members who have achieved transdisciplinarity should be very competitive for extramural funding that requires documented transdisciplinary education and experiences.

Since sustainable use of the planet requires both disciplinary and transdisciplinary viewpoints (both *top-down* and *bottom-up* sustainability strategies), the isolating mechanisms that kept the disciplines *pure* must be abolished so that this can take place. As Wilson (1998) noted, this breakdown is already occurring. However the rate may not be adequate to avoid environmental catastrophes during the twenty-first century. As a consequence, this inevitable co-evolution should be accelerated by removing or reducing some of the obstacles to the process. This change has begun in industries and corporations primarily for pragmatic reasons that also espouse a harmonious relationship with natural systems (e.g. Anderson 1998, Natrass & Altomare 1999).

Allen (2003) envisions an emerging ethnosphere (a planetary system of intercommunication based on a human value system that will produce new patterns of behavior), which might well be one of the keys to sustainable use of the planet. This behavioral change could be a major selective force on the educational system. Business and society should also be powerful forces in making this happen.

Humankind has been the only species that has escaped, at least temporarily, having an intimate survival relationship with local or regional ecosystems (Eldredge 1999). Now, if the relationship

becomes a global one as required by the quest for sustainable use of the planet, it is bound by the same constraints of other species — only the temporal and spatial scales differ. This scenario would require a more harmonious relationship between humankind and natural systems that would be co-evolving (i.e. each inextricably linked to the other in such a way that neither can survive in its present form without the other). At one time, if the local tribal (or other) cultures outgrew the carrying capacity of their local or regional ecosystems, excess population could migrate to other areas with a larger carrying capacity. Alternatively, in a technological age, resources could be extracted (e.g. petroleum) or produced elsewhere (e.g. food) and relocated to increase regional carrying capacity. However, in a global society, the technological component of humankind's life support system must be in balance with the ecological component (Cairns 1996). The old strategies used by populations that exceeded carrying capacity — migration and war — are neither suitable nor sustainable for a crowded planet.

REGAINING TRANSDISCIPLINARITY

Sustainable use of the planet requires that humankind examine natural systems from a dynamic, problem-solving perspective. Humankind still exists because its ancestors sought and used information about natural systems wisely. If posterity is to inherit a habitable world, humankind must interpret signals from the natural world and adjust its behavior so that Earth's ecological life support system is healthy. Humankind's interactions with nature have always been complex. For most of the time humans have been on the planet, there were no disciplines to fragment knowledge about natural systems. Only a comparatively few generations have passed since humans began to live in urban environments with a concomitant dependence upon mechanized technology. Distant ancestors were a small-group species, spread thinly over the landscape and having a minor effect upon it. Now humankind is trying to live in enormous groups, which mostly lack an intimate association with natural systems. Sustainable use of the planet requires that humans regain their holistic perspective of natural systems that they have had for most of the time they have existed on the planet.

CONCLUSIONS

Sustainable use of the planet requires a harmonious relationship between disciplinary specialists and transdisciplinary generalists. Despite illusions of humankind's freedom from the laws of nature, humans are just another species subject to all the selective processes that govern the survival and health of other life forms. The goal of sustainability is to achieve a sustainable relationship with natural systems (i.e. natural capital and ecosystem services), which constitute the basic life support system of *Homo sapiens* and 30+ million other species. Recently, in evolutionary time, humankind has created a technology upon which it is also dependent but which, as operated at present, constitutes the major threat to the integrity of natural systems.

The goal of sustainability is to retain the benefits of technology without endangering the planet's ecological life support system. This goal requires an integration and orchestration of knowledge unprecedented in human history. The nineteenth and twentieth centuries were the age of specialization, which provided a multitude of benefits to humankind without which the present level of population size (over 6 billion and likely to reach 10 billion in the first half of the twenty-first century) and affluence would not be possible. However, technology that uses natural capital at an unsustainable rate threatens the well-being of both present and future generations.

The goal of sustainable use of the planet is to protect and accumulate natural capital so that ecosystem services will be both dependable and abundant. In short, sustainability requires a

mutualistic relationship between two complex, dynamic, multidimensional systems — human society and natural systems of which *Homo sapiens* is a part. Since human society depends upon its educational system to produce citizens capable of a synthesis that will make sustainability possible, society must transform its structure (based on disciplines) so that reductionist science does not threaten or impede development of integrative science. This change must be accomplished rapidly since a resource crisis is likely in the first half of the twenty-first century, even if some remedial measures are taken (e.g. reduction of greenhouse gases), because recovery of natural systems takes time, often decades or longer.

Necessity usually results in new behavior patterns for individuals, new perspectives in government, and changed practices in those industries and corporations anxious to have a long-term market. Globalization creates problems but also opportunities for solutions. The global Internet provides both information and communication opportunities unprecedented in human history. Sustainable use of the planet will, if successful, represent a superb opportunity for humankind to cast off counter-productive unsustainable practices. This historic endeavor provides a wonderful opportunity to have a beneficial effect upon the future, which should produce great satisfaction even though the participants will not live to see it. I believe *Ethics in Science and Environmental Politics* has an opportunity to make a major contribution to this paradigm shift, which will represent a defining moment in human history. Due to globalization, survival, which has required a holistic perspective for most of human history, is more important now than ever.

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Sustainability Ethics: Tales of Two Cultures

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ABSTRACT: Two small, isolated Pacific islands colonized by Polynesians experienced quite different fates—Easter Island suffered a major ecological collapse, while Tikopia appears to have attained sustainability. Both events occurred before European contact and provide valuable evidence in the discussion of sustainability ethics.

KEY WORDS: Sustainability · Sustainable development · Carrying capacity · Human conscience · Sustainability ethics · Cultural norms · Individualism

> *We appear to be a species out of control, setting in motion processes that we do not understand with consequences we cannot foresee.* Lester R. Brown

> *To couple the concept of freedom to breed with the belief that everyone born has an equal right to the commons is to lock the world into a tragic course of action.* Garrett Hardin

CARRYING CAPACITY

Elevators, bridges, automobiles, ships, airplanes, lifeboats, and Earth have a finite carrying capacity for humans. *Carrying capacity* refers to the maximum, equilibrium number of organisms of a particular species that can be supported indefinitely in a given environment. A good illustration of experiencing carrying capacity can be related in the tale of two small, remote islands in the Pacific Ocean on which the human population encountered carrying capacity limits and responded in quite different ways. Much can be learned from their two case histories. The time period is after colonization by Polynesians and before European contact (Kirch 2000). Both islands had no landmass nearby that might furnish resources, nor could the people depend on outside help. The size of the islands allowed a physically fit person to view personally the terrestrial resources available as well as the nearby ocean.

Globalization has made humankind aware of how interconnected and interdependent society has become. Astronomy and space travel have shown that Earth is a small blue dot in a galaxy that appears lifeless, although life may exist elsewhere in the universe. Even if other parts of the universe

could help with carrying capacity problems, it would be foolish to expect assistance, at present, from outside Earth's solar system.

Humankind may have already passed the planet's long-term carrying capacity for humans since natural capital is being used more rapidly than it is being replaced. Even if this limit has not been reached, continued exponential growth of both population and rate of resource consumption ensures that humankind will soon reach or exceed it. Although the scale for Earth is much larger than in the two islands, the basic issues are quite similar.

EASTER ISLAND

The lesson from Easter Island has been discussed in detail in a variety of both popular and academic publications as well as on television (e.g. Flenly et al. 2003). Diamond (1994) has presented a concise discussion of the ecological collapse of ancient civilizations, including Easter Island.

Basically, the inhabitants of Easter Island exceeded their carrying capacity by over-harvesting trees that covered the island when it was colonized about 400 AD. Forests were cleared for agriculture, construction of canoes, and for the transport and leverage of the huge statues for which the island is renowned. The statues were moved several miles from the quarry to the coastal area, even though they weighed as much as 80 tons and were up to 37 feet tall. Clearly, the civilization of Easter Island was well organized in order to achieve the remarkable feat of erecting these statues.

Easter Island's peak population appears to have been reached in 1500 AD at 7,000 individuals or approximately 150 per square mile. By this time, about 1,000 statues had been carved and 324 erected. Deforestation resulted in the inability to make large canoes, thus effectively cutting off access to any marine fishery in deep water. Additionally, erosion resulted from the loss of forests that held soil in place and eventually depleted the terrestrial food resources, which led to resource wars and a population collapse. The inhabitants continued unsustainable practices despite evidence they were not sound. Alternatively, they may have realized the drawbacks of living unsustainably after it was too late to make a mid-course correction. An eventual population reduction to an estimated one-third of its peak level illustrates that the cost of exceeding carrying capacity is not trivial.

These events are even more poignant because the inhabitants no longer had the means to build the large canoes they needed for escape. Similarly, if Earth is regarded as an island in the galaxy, humankind currently does not have the means to escape, even if a refuge in the universe were available. In addition, transporting billions of people would pose a logistical nightmare.

TIKOPIA

The inhabitants of Tikopia Island also exceeded their carrying capacity (Firth 1983, Kirsch 2000), but took effective measures between 1000 and 1800 AD to stabilize their population at approximately 1,281 to 1,323 people. They accomplished their goal by infanticide, abortion, and decreeing that only first-born sons could have children. In addition, the inhabitants shifted to sustainable agriculture from 'slash and burn' practices. Finally, they eliminated pigs, despite the value Polynesians placed on them, because they damaged gardens and ate food the Tikopians could consume.

The precise processes that produced the dramatically different results for the two islands are not entirely clear. However, it is evident that the Tikopians better understood the concept of carrying capacity and that they possessed the leadership and will to achieve both a relatively stable population

and sustainable practices. Firth (1983) has listed some important factors relative to Tikopia that impact this present discussion of sustainability ethics.

1. Until about a century ago, the population of Tikopia was usually in a dynamic equilibrium with its food supply.
2. The relationship of population size to resource availability was expressed in terms of family equilibrium, rather than purely individual terms.
3. More radical methods of population stabilization included suicidal sea voyages and wars.
4. As a result of European contact and influence, the Tikopian limits to population expansion do not work to the same extent that they once did.
5. The consequence is that the carrying capacity of the lands of many families had been exceeded.
6. Technology, new foodstuffs, intensive cultivation, etc. resulted in a temporary expansion of resources that later ceased.
7. Migration does not appear to be a viable long-term solution to exceeding carrying capacity.
8. Sex education, plus contraceptives, would reduce the problem but, at present, is not practicable for economic and religious reasons.
9. Adequacy of the food supply is a very real fear among the chiefs and thoughtful natives.
10. Were it not for outside interference, the old checks and balances would still be working satisfactorily.
11. It may be necessary to eliminate life in the short term to preserve life in the long term.
12. Kinship relations are very strong, giving a real sense of community and the individual's responsibility to it.
13. Tikopians were living sustainably until outsiders converted them, in part, to new value systems, many of which have proved unsustainable. It is a pity that one of the best case histories for living sustainably has been altered, even if done with good intentions.

ISLAND EARTH

Of course, some significant differences exist between these two island case histories and ecological island Earth.

1. The spatial and temporal spans are much larger for Island Earth, and distance weakens resolve.
2. Communication on small islands is facilitated with only one language and an essentially homogeneous culture.
3. Religious diversity is far greater on Island Earth.
4. The inhabitants of Easter and Tikopia Islands were intimately associated with their resource base, while globalization of human society on Earth has increasingly dissociated people from their resource base.
5. Easter and Tikopia Islands can easily be seen as finite, while it is more difficult to visualize Earth as finite (despite pictures from space).
6. A persistent new belief for Island Earth is that modern technology can solve all problems.
7. One touching, but unjustified, belief for Island Earth is that economic growth will relieve most of the ills of humankind.
8. A vast advertising organization, often aided by governments, urges people on Island Earth to buy an increasing amount of material things.
9. A rapidly increasing, vast gap in resource use and acquisition is developing on Island Earth between wealthy and poor individuals. This difference was not as marked when humans were a small group species.

On the other hand, some important factors are now available on Island Earth to aid the quest for sustainable use of the planet.

1. Computers facilitate the gathering, storing, and communication of vast quantities of information.
2. Technology can be used to preserve and protect natural capital.
3. Literature and case histories are becoming available on sustainable use of the planet.
4. Restoration of damaged ecosystems is now possible, which will result in increased natural capital and ecosystem services.
5. More humane methods are available for population stabilization than infanticide (e.g. birth control). Regrettably, many persons in developing countries lack both necessary knowledge and funds to purchase contraceptives. Some nation-states and non-governmental organizations even effectively block both information dissemination and financial aid to assist people who wish to plan family size.
6. Nation-states, communities, eco-regions, etc. that encourage sustainable living have a better survival potential than those that favor unsustainable practices. However, these entities are likely to be increasingly vulnerable to groups that prefer the use of force and terrorism to a change in lifestyle to preserve resources.
7. Social systems are the result of numerous human decisions that can sometimes result in major paradigm shifts in a relatively short period of time.

HARDIN'S OSTRICH FACTOR

Hardin (1999) was an outspoken critic of those who ignore the dangers of overpopulation and irreversible environmental damage. He argued that rampant growth will inevitably force humankind to face many issues that are unpalatable — even discussion of them, at present, is often taboo. Hardin recalled that, in the first century AD, Pliny the Elder remarked that the stupid ostrich thrusts its head and neck into a bush, imagining 'that the whole of the body is concealed' (Bierens de Haan 1943, p. 11). In the 14th century, 'sand' was substituted for 'bush,' the form in which the myth still persists.

In short, if humankind avoids seeing something, it does not mean that the 'something' ceases to exist. This avoidance alone could explain the different results on Easter and Tikopia Islands: one culture turned a blind eye to the concept of carrying capacity; the other did not.

In contrast, Seidel (1998) believes that overpopulation, global warming, and other damage to natural systems are the results of individually sensible but uncoordinated efforts to better oneself. Seidel believes that failure to react to the threats to Earth's ecological integrity is not ignorance of what is wrong or not knowing what to do about it, but rather lies in humankind's failure to take this knowledge seriously enough to act on it.

Gazzaniga (1985) remarks that humans alter their beliefs to suit their needs or aspirations. Anyone who watches television in the United States is well aware that approximately one-third of the broadcast time is devoted to advertisements, which shape both individual 'needs' and aspirations. Given the enormous amount of time that both adults and children watch television, this shaping of individual wants and desires is indeed a powerful force. Consequently, the United States has an ecological footprint (Wackernagel & Rees 1996) that dwarfs most of the rest of the world.

THE FOLLY OF DEPENDING ON CONSCIENCE

Hardin (1968) agreed with Darwin's grandson that breeding of humankind, in the long run, cannot be controlled by an appeal to conscience. Even though some people will respond to a plea to reduce family size, those who fail to do so will have more children than those who do not. Feelings of guilt

will restrain exploitation of the commons by a few, while those who feel no guilt will continue this exploitation. Ultimately, nature's harsh penalties will reduce the population size, as they did on Easter Island. Intelligent choice, as on Tikopia Island, does blatantly restrict human 'rights,' but is beneficial to those making intelligent choices, as well as to posterity.

Crowe (1969) argues that the social myths are eroding at such a swift rate that the myths cannot be revitalized in time to prevent one or more environmental catastrophes. Three of these three myths follow: (1) a criterion of judgment can be developed that will render the incommensurables commensurable (i.e. having the same measure), (2) coercion can be mutually agreed upon, and (3) an administrative system can protect the commons from further desecration. In short, what proved effective for the Tikopians may not be successful for humans living in gigantic groups in an increasingly impersonal world. Ehrlich (2000) is optimistic about humankind's capability of learning to deal sensibly with both nature and human's nature, but he is pessimistic about whether humankind will use this capability. Clearly, the time to make a major paradigm shift is very short.

SUSTAINABILITY ETHICS AND CULTURAL NORMS

Estimates indicate that Earth has taken more than 4,550 million years to evolve from lifeless materials into the great diversity of life forms existing today. Life has probably existed on Earth for approximately 3,800 million years. Geological and paleontologic records show that these years have been dynamic, including such events as continental drift and ice ages. Earth may have another 15,000 million years remaining. Humans have existed only for a relatively short period of time (part of the Cenozoic era), but they are having a major influence on the sixth mass extinction now in progress. Most species ultimately become extinct, although the concept of sustainable use of the planet is based on the assumption that *Homo sapiens* will persist indefinitely.

If humankind intends to persist for 15,000 million years, cultural norms must change dramatically and must include a commitment to eco-ethics and sustainability ethics.[1] In fact, it will be a challenge for the human species to persist for merely 5 million years. As Boulding (1977, p. 292) remarked, 'It may be, therefore, that evolutionary sustainability is a different matter from the sustainability of any particular system (and one might add species) within the process, for though all particular systems may become extinct, the evolutionary process may go on.'

Until very recently, Earth had a large number of relatively isolated social systems. When one system failed, it became extinct or disappeared as an entity. Other social systems with more viable social norms have persisted, at least for a time. Globalization is changing Earth into a single social system in which the commitment of individuals to the system is weak or non-existent. The entire biospheric life support system is now threatened by human behavior, and no sense of community exists at a global level to protect and cherish its life support system. Professional organizations with international membership provide a means for reaching a consensus on global social norms that could make sustainable use of the planet possible.

INDIVIDUALISM AND SUSTAINABILITY

Renewable resources are those that have a self-regenerating capability and, if used properly, can function indefinitely. Carrying capacity of a particular eco-region, or even the planet, is defined as

[1]See Cairns J Jr (2003) Eco-ethics and sustainability ethics. Part 1. ESEP Book 2. PDF format (656kb) available for download at www.int-res.com/journals/esep/eb2cairns.html

'the maximum number of a species that can be supported indefinitely by a particular habitat, allowing for seasonal and random changes, without degradation of the environment and without diminishing carrying capacity in the future' (Hardin 1977, p. 113).

If Earth is regarded as a single ecosystem, major ecological damage in any area affects the entire system. Given the dangers of exponential growth on a finite planet, catastrophes are highly probable and possibly irretrievable. Without a sense of community, sustainability will not be achieved. Somehow the ability of individuals to view themselves as a part of a global community that is dependent upon a global biospheric life support system must be achieved. This is the sine qua non of sustainable use of the planet.

CONCLUSIONS

I believe that humankind can continue to persist on Earth for thousands of years, perhaps even longer. It seems improbable that the human species can persist indefinitely. At the very least, humankind should accept the responsibility of leaving a habitable planet for posterity. Behavior that is conducive to sustainability can be learned and passed to future generations. May it be so!

Tikopians were living sustainably until Europeans successfully changed parts of the Tikopian culture that resulted in replacing sustainable practices with unsustainable ones. Humankind should be learning to live sustainably from those who have some aptitude in this area. Some of the Tikopian methods are repugnant, but so is what unsustainable practices will do to posterity. The Easter Island tale shows that living sustainably is not inevitable.

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Article 30

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Numeracy and Sustainability

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ABSTRACT: Sustainable use of the planet is based on the assumption that humankind can maintain conditions suitable for inhabiting the planet indefinitely. No robust evidence supports this assumption nor rejects it, and adequate evidence on this issue may not be available for centuries. Numeracy is the ability to use or understand numerical techniques of mathematics. Even if adequate numerical data were available, the important decisions humankind makes regarding sustainable use of the planet should not be guided by numerical information alone, such as economic numbers, but by eco- and sustainability ethics, which provide a values framework that indicates how the numbers should be used and interpreted.

KEY WORDS: Sustainability · Numeracy · Eco-ethics · Sustainability ethics · Sustainable development

The trouble with our times is that the future is not what it used to be. Paul Valery

INTRODUCTION

Sustainable use of the planet is based on the assumption that humankind has the right to alter the planet so that human life can inhabit Earth indefinitely. In doing so, environmental conditions of the planet may be shifted so that they are optimal for one species, but not necessarily for all species or even a majority of species now alive. Clearly, humankind does not value all life equally. Sustainability is based on the assumption that acceptable environmental conditions can be maintained. The assumption has not been validated, nor is it likely to be for centuries, if ever. Numeracy is the ability to use or understand numerical techniques of mathematics (a useful introduction is available in Bartlett 1994). However, the important decisions humankind makes should not be based on numbers, even economic numbers, but rather on eco- and sustainability ethics, which provide a values framework that indicates how the numbers should be used and interpreted. The emphasis on severely limited numbers is a major weakness of the United Nations Commission on Environment and Development (1987) report, which focused on development (commonly

regarded as synonymous with growth). Development is just one metric valued by one species. Sustainability involves a variety of metrics for a complex, multivariate living system called the interdependent web of life.

Sustainability is the study of patterns involving all forms of life and the conditions necessary for them to flourish as a community. One can place an infinite value on human life and on other life forms as well. One can place an infinite value on one's own life but be willing to sacrifice it to protect one's offspring. This example illustrates that there can be more than one value for infinity. Sustainability involves a similar situation — humankind must place infinite value on personal life, on the lives of its future generations, and on those of other life forms. Balancing these seemingly incompatible values will never be fully achieved since life consists of dynamic and stochastic events that will frequently alter the factors affecting this precarious balance. Sustainability policies may be developed for individual components (e.g. agriculture, transportation, energy, communities, fisheries), but achieving sustainability will not be possible unless the policies are integrated into a master policy and plan that does not adversely affect other components. Numeracy will be helpful in establishing component balancing.

USING AVAILABLE NUMERICAL DATA

Numbers influencing sustainability are simple and straightforward but are either ignored or misunderstood by policy makers and the general public. As a consequence, unethical and unsustainable practices and behaviors are termed 'practical,' 'essential,' 'good for the economy,' 'compassionate,' and even 'religious.' Arguably, the greatest threat to sustainability is the misinformation on the dangers of human population growth (Bartlett 1998). As Bartlett (1998) notes, the more optimistic the prediction the greater the probability that the prediction is based on faulty arithmetic or no arithmetic at all. The human population cannot continue to grow exponentially and indefinitely on a finite planet. The debate on population growth began over 200 years ago with Malthus' (1798) insightful publication. At the root of this controversy is the denial of limits. Hardin (1993) provides a superb illustration (starting with a single lily pad of a specific size in a pond of a specific size and a specific rate of increase) of how rapidly a limit can be reached when exponential growth occurs even when no problem is apparent at present. This illustration could be applied to a population of any species on the planet — including humans. When will the pond be covered with lily pads? Assuming a daily doubling rate, the capacity will be reached on the 30th day. However, the pond would only be half covered on the 29th day. Seeking new resources will not avert reaching the limits since doubling the size of the pond will only postpone saturation (i.e. reaching the capacity) for one day; quadrupling the size of the pond would only add two days. In short, all appears well until the final doubling. After the 30th day, the lily pads produced would suffer seriously due to lack of space. Clearly, other life forms in the pond would also suffer at this stage. Emotional reasons that could lead to refusal to accept this reality for populations of humans may ultimately cost billions of lives.

This important issue of exponential growth can be examined by anyone with a pocket calculator or a pencil and a sheet of paper. For example, starting with one of anything, ten doublings will produce the astonishing number of 512. An estimate of doubling time can be calculated by dividing the growth rate into 70. A 2 % population growth rate per year (considered modest these days) results in a doubling time of 35 years. An island with a carrying capacity of 256 people would be in deep trouble with a single doubling. By ignoring simple numbers, humankind places itself at great risk.

ECOLOGICAL FOOTPRINTS

The average ecological footprint of a North American (essentially the amount of land that would be necessary to support a defined economy sustainably at its current material standard of living) is 4 to 5 hectares (Wackernagel & Rees 1996). At a 2 % annual human population growth rate, 8 to 10 hectares would be need in 35 years to maintain the footprint size. On a finite planet, unrestrained exponential growth is idiocy!

The Netherlands (National Institute for Public Health and Environmental Protection 1992) has a smaller ecological footprint (3.32 hectares per capita) than the US and Canada, but a standard of living above the average for the entire planet. However, even a small population growth rate can quickly reduce the available hectares per capita. At a 1 % annual human population growth rate, the doubling time would be approximately 70 years. The ecological footprint size would be reduced to 1.66 hectares per capita in the Netherlands (and consequently a much lower standard of living) if the resource base remained constant. This situation would result in halving the per capita resources if the resource base were not doubled. Obviously, humankind cannot send the entire population 'surplus' to other planets during the 70-year doubling time.

In stark contrast, the ecological footprint size in India is 0.38 hectares per capita (Wackernagel & Rees 1996). Worse yet, the estimated footprint size of the average person in India in the bottom 50% of income earners is roughly 0.2 hectares per capita (Wackernagel & Rees 1996). Thus, the present condition is already unsatisfactory. If the global carrying capacity for humans is reached or exceeded on a finite planet, then consumption by the rich must be markedly reduced to shift resources to the poor or the latter will suffer or die. This problem is one of eco-ethics, although numerical data provide useful information on how much needs to be done once it is decided what to do. Living at higher densities reduces the ecological impact because it does not require as much land for urban sprawl and, properly managed, has a lower energy consumption. Wackernagel & Rees (1996) provide an excellent illustration of comparative ecological footprint size for traveling 5 km each work day — bicycles, approximately 122 square meters/capacity; buses approximately 301 square meters/capacity, and automobiles; 1,442 square meters/capacity. In addition, food is also a major factor that determines ecological footprint size.

Brown (2000) estimates 1.1 billion hungry people on the planet. Since poverty and hunger are closely related, it should be no surprise that the World Bank (1997) estimates 1.3 billion people are living in poverty (defined as US $1.00/day or less). The precision of these numbers is important, but, for this article, the important issues are ethical. The numbers keep changing, but the ethical problems are constant.

The ethical question of resource distribution and allocation within the human species is of paramount importance. Before a systematic and orderly analysis of this issue of resource limits and allocation can be made, there are three important questions for which some numbers must be produced and some ethical issues addressed. First, how much of Earth's resources (10 %, 25 %, 50 %, 75 %) must be allocated to other species (i.e. natural systems) so that sufficient natural capital and ecosystem services remain for maintaining human society? Second, how can the size of humankind's ecological footprint be adjusted to a sustainable level? Third, since there will be considerable uncertainty about both numbers, what safety factor should be used as a precautionary measure? Vitousek et al. (1986) have estimated that human society is co-opting approximately 40 % of the photosynthetic energy of Earth (i.e. that energy converted by plants from sunlight to forms such as carbohydrates that are more suitable for use by humans). The percentage of the photosynthetic energy for the 'machinery' of nature to maintain natural capital and deliver the

ecosystem services necessary for sustainability is unknown. However, since the hunter/gatherer stage of human society probably used less than 1 %, we may now be approaching a critical ecological threshold or might even have passed it. Worse yet, we have not even the crudest estimate of how long deprivation of resources would result in disequilibrium of the interdependent web of life or what metrics to use in estimating long-term needs of natural systems. Obviously, numeracy is essential in selecting which numbers should be generated as well as analyzing the data. Earth is both finite and inhabited by other life forms. Humankind cannot treat natural systems as commodities rather than an essential life support system.

Many numbers can be used to estimate the health of the global economy and of most nations. Comparatively few numbers are available to estimate the health of the 'economies' of the 30+ million other species with which humans share the planet. Persuasive evidence indicates that some of these species have economic systems of their own (e.g. Tullock 1994). Yet these species, collectively called natural systems or the interdependent web of life, provide services upon which the survival of humankind and its economic system depend (e.g. Daily 1997). The combined value of these services has been estimated to be in excess of US $33 trillion per year (Costanza et al. 1997). The survival of both humankind and its unique economic system depend upon natural systems, yet human society is acting as if only the numbers related to economic systems are of primary importance. The two sets of numbers are related.

Brown (2001) notes that economists see the environment as a subset of the human economy, and environmentalists see the human economy as a subset of the environment. However, global policy and that of most nations is based on numbers focused on the human economy rather than the environment. Almost all trends in natural systems (e.g. loss of old growth forests, depletion of oceanic fisheries, and increased production of greenhouse gases) are toward crisis conditions. Brown (2001) further notes the existence of a stressed relationship between human economy and Earth's ecosystems which, at some point, could overwhelm the worldwide forces of progress and lead to human economic decline. Despite this catastrophic probable outcome, most economic data gathered are used for personal or corporate economic gain. Environmental data are most commonly gathered to demonstrate compliance with governmental regulations. In neither case is the integrity of natural systems the primary goal. It is unlikely that numbers gathered to protect natural systems will be generated until the health of natural systems and their component species becomes an ethical/moral responsibility of humankind.

Ignoring the stressful relationship between human society and natural systems has caused collapse of both, as evidenced in the decline or collapse of early civilizations (e.g. Tainter 1998). Causes include not only degradation of the environment but climate change, civil conflict, and foreign invaders. For example, the ancient Sumerian civilization almost certainly had an environment in which humans flourished. Now vegetation is sparse and virtually absent in many areas. One possibility is an environmental flaw in the hydrologic design of the irrigation system (Postel 1999). Mismanagement of water, plus soil erosion, appears to have caused a falling food supply in Sumeria. Another example of collapse is Easter Island (e.g. Diamond 1994) in the Pacific Ocean, where the island was small enough for each human to see the entire system. Carrying capacity was exceeded and followed by a steep decline in the number of people able to survive. Hard numbers were not needed to demonstrate the inhabitants were living unsustainably because the gross changes should have been evident to even unobservant people. What appears to have been lacking was an ethical responsibility for future generations and even those alive at the time. Since there was a social organization (and its leaders) capable of quarrying stone, sculpting huge statues, and trans-

porting them a considerable distance from the stone quarry, it is astonishing that there is no evidence of an attempt to live sustainably. The decline appears to have been precipitous, and its worst feature was cannibalism. Surely Easter Island's isolation obviated any chance for help from outside. However, Earth cannot expect help from elsewhere in the universe either.

Diamond (1997) describes an even more interesting situation involving three islands with a modest commerce between them, but which was essential to optimal use of all three. This interdependence is a small-scale model of the present global marketplace. Again, observant people should have realized they were not living sustainably. Still, the system collapsed. The spatial and temporal scales are much larger for the entire planet, but the basic problem remains unchanged — how does one use numeracy and eco-ethics to achieve sustainability?

THE LIMITS OF NUMERACY

The 'ancient' societies presumably did not have as much quantitative information as is available today, but each generally had fewer people per unit of area. They were probably as intelligent and may have been better informed about the entire system upon which they depended than modern people. They probably had a sense of the quantitative changes in the system upon which they depended. Today, food, fiber, and other resources come from a much larger area with which most individuals have minimal contact.

Situations involving complex natural systems require damage control without full proof of the consequences of doing nothing. Some individuals resist action until it can be based on objective evidence obtained by the scientific method. However, no single scientific method will suffice. An array of methods are available from which selections can be made, based on the nature of the problem, the amount of evidence already available, the complexity and variability of the system being studied, the consequences of an error in judgment, and the degree to which the chosen course of action is congruent with other established practices. The scientific method was developed to avoid mistakes that might lead to erroneous conclusions. However, biases exist at both the individual and collective levels. Given these circumstances, surprises will always be possible, so both science and public policy must be adaptive. Any monitoring system designed to detect error must provide early warnings in time for corrective action to be taken.

The comparative analysis of alternative courses of action should use quantitative data whenever it is available in a suitable form. The selection of the most suitable alternative should include the criteria used for the analysis and the realistic options that survived the process. It is also very important to state how the selected alternative will be implemented. Special interests will attempt to skew the selection process and will use every available political pressure to ensure an outcome that favors them. Furthermore, in the US (and presumably other countries as well), neither governmental nor non-governmental agencies/organizations have sufficient flexibility to cope with the complex problems of either sustainable use of the planet or the precautionary principle. To achieve this will require a much higher level of environmental literacy and a heightened sense of eco-ethics.

NUMERACY AND PREVENTATIVE ACTION

Sustainable use of the planet will require action to prevent significant damage to both natural capital and ecosystem services. In short, with the planet's huge human population, which is still growing, and equally rapid depletion of natural resources, mistakes and ecological 'surprises' could cost millions, even billions, of lives. Preventative action to avoid damage to natural capital and ecosystem services is essential. Not only should further damage be prevented, but lost natural

capital should be restored. Fortunately, methods and procedures for monitoring the restoration of natural capital are available (e.g. Cairns 2002a). The same monitoring techniques can be equally useful in providing an early warning of threats to natural capital so that preventative action can be taken before serious degradation occurs. Estimating the health and integrity of dynamic, complex, multivariate systems is a formidable task with fairly high levels of uncertainty. But, the important aspect, in terms of this article, is that the level of statistical literacy required for even determining the appropriate metric for each situation is rather high. The difficulties of explaining the process of analyzing and interpreting the data to legislators, policymakers, and the general public boggle the mind. An illustrative list of potentially useful analyses follows.

1. Uncertainty analysis — focuses on the effects of uncertainty of all components thought to be a factor affecting the outcome of an analysis as well as the outcome itself.
2. Uncertainty matrix — a matrix intended to identify the location, category, and level of uncertainty for the purpose of estimating the total uncertainty associated with the outcome of the analysis.
3. Power analysis — estimates the risk of being wrong and for determining the effects of false positives and false negatives.
4. 'Right' question analysis — have the right questions been asked in determining the components or issues to be analyzed?
5. Sensitivity analysis — estimates the effect a particular component has on the outcome of an analysis.

These are just a few examples of not only elements of a management plan to protect natural capital, but also the difficulty of assembling the analysis of each component so that the cumulative impact can be estimated.

NUMERACY AND ECOLOGICAL DEFICITS

An ecological deficit results when a significant deviation occurs from the nominative state or from a self-regulating ecological condition. Ecological deficits also have closely linked economic deficits. For example, deforestation and loss of old growth forests produce a variety of effects from shortage of fuel wood, increased erosion, major changes in the hydrologic cycle and the like. Excessive irrigation results in salinization of agricultural soils and consequent loss of productivity. Poor management practices result in expansion of deserts and deleterious effects of dust storms. Since a huge number of linkages exist in the complex system often referred to as the interdependent web of life, at some point these deficits act synergistically (combined effects greater than additive) and produce an ecological disaster of major proportions.

Ecological deficits must be calculated in ecological terms. Trying to frame deficits in monetary terms will not suffice. In one sense, ecosystems have infinite value since they constitute the planetary life support system without which humankind and its economic system could not survive. However, the size and extent of the deficit can be calculated. For example, the National Research Council (1992) has estimated the number of aquatic ecosystems (rivers, lakes, wetlands) that need restoration. The time and resources needed to accomplish this restoration can be calculated with reasonable precision. Since the rate of ecological damage greatly exceeds the rate of ecological repair, the deficit is increasing at a frightening rate. At some point, so many species will have been lost that restoration to predisturbance condition will no longer be possible. The task is already formidable and may already be beyond humankind's capacity to repair. The real danger to humankind is disequilibrium in the ecological life support system if conditions become intolerable. Even if

restoration to predisturbance ecological condition is not possible, a naturalistic community of plants and animals might well be assembled that would provide comparable natural capital and ecosystem services that would favor humankind.

ECOLOGICAL DEFICITS AND POLITICAL INSTABILITY

Ecological deficits could cause major disruption to both national and global political systems. A variety of ecological disequilibrium conditions could produce millions of environmental refugees (e.g. Cairns 2002b). Numbers on the health of national and global economics are available daily, even hourly; however, no comparable numbers are available on ecological health, although the two are interrelated.

Brown (2002a) lists the categories of ecological deficits in China, whose 1.3 billion people and geographic size make the country a major factor in global ecological, economic, and political arenas. In China, eroding croplands, disappearing forests, deteriorating rangelands, and failing underground aquifers are interacting to produce a dust bowl of historic dimensions. All nations have ecological deficits, but China's is of crucial importance because of its population size and strategic location. On April 12, 2002, South Korea was engulfed by a huge dust storm originating in China, which had a variety of detrimental effects ranging from human health to disrupted airline schedules (French 2002). Dust storms in China can even affect the US (Brown 2002b). A dust and sand storm that occurred on May 5, 1993, in the Hexi corridor of Gansu Province in China's northwest reduced visibility to zero. The storm destroyed 170,000 hectares of standing crops, damaged 40,000 trees, killed 6,700 cattle and sheep, blew away 27,000 hectares of plastic greenhouses, injured 278 people, and killed 49. Forty-two trains were canceled, delayed, or parked until the storm passed and the tracks were cleared of sand. The important lesson from this example is that an ecological deficit can cause additional deficits, sometimes very quickly. Even the modest data now available clearly demonstrate the need for corrective action.

THE ROLE OF ECO-ETHICS AND SUSTAINABILITY ETHICS

The global ecological deficit is enormous and rapidly growing. The problem is so spatially large and covers such a large range of time that securing adequate numbers in time will be virtually impossible. Preventing the deficit from increasing and gradually reducing the existing deficit are wise precautions that might well prevent a global catastrophe. Full use should be made of the numbers available, but the primary motivation must be ethics. A quote from Former US President Teddy Roosevelt fits the current situation beautifully: 'Far better to dare mighty things, to win glorious triumphs, even though checkered by failure, than to take rank with those poor spirits who neither enjoy much nor suffer much, because they live in the grey twilight that knows not victory nor defeat' (from *Bartletts Familiar Quotations*).

Leaders will be needed in every country and every region, and some nations will also have to become leaders. Ideally, the emerging leaders would primarily be from areas with the most abundant resources/capita since it is difficult for starving people to plan and think beyond their daily needs. And, if precautionary action is not taken soon, the majority of humankind will be starving. The US Department of Agriculture (2002) reported that the grain harvest in 2001 fell 40 million tons short of estimated consumption.[1] The US is the world's leading wheat exporter. As Brown (2002b)

[1]See also US Department of Agriculture (2002) Production, supply, and distribution. Electronic database, updated 10 May 2002 (as quoted in Brown 2002b)

notes, grain exports are, in reality, water exports, so food and water supplies are closely linked. The United Nations (2001) has already called attention to the need to restore the balance between water supply and human needs, which may depend on stabilizing population in water-deficit countries. Attempts to maintain the status quo on population increase and ever larger ecological footprints will eventually cause an ecological catastrophe so horrendous that even a fool will see it. This catastrophe can be avoided by shifting from exploitation of natural resources to sustainable use. Surprisingly, a major step in this regard can be taken at little cost to most of humankind.

ELIMINATING PERVERSE SUBSIDIES

Myers & Kent (1998) define *perverse subsidies* as subsides that exert adverse effects upon economies and environments alike. Total subsidies (both perverse and beneficial) are estimated to be roughly US $2 trillion worldwide per year (e.g. Panayotou 1993; United Nations Commission on Sustainable Development 1994). Many subsides, such as fostering overloading of croplands (e.g. erosion of topsoil), fossil fuel (e.g. air pollution, including greenhouse gases), road transportation (e.g. overuse of cars), water supply (e.g. overuse of water), fisheries (e.g. overharvesting), and forestry (e.g. excessive logging), are clearly perverse. Although this subject has been discussed (e.g. de Moor 1997; Roodman 1998), there is no general awareness of the extent to which subsidies damage the environment. From an eco-ethical standpoint, more numbers will not help answer the basic question — is it ethical to create more ecological deficits for future generations to reduce? From an eco-centric viewpoint — is it ethical to use other species as commodities, especially when they collectively constitute humankind's ecological life support system? In this case, the numbers are unambiguous — governments worldwide are subsidizing activities that harm the environment and often the economy as well. The US has numerous special interest groups that penetrate the political process. In the US capitol city, tens of thousands of lobbyists (as well as lawyers to keep them informed about various laws, loopholes, or about drafting new laws) attempt to affect laws. Between 1993 and mid-1996, American oil and gas companies gave US $10.3 million to political campaigns and received tax breaks worth US $4.0 billion. Meyer et al. (1992) report that depletion of soils, forests, and fisheries resulted in a 25-30 % reduction in potential economic growth. Thus, at best, subsidies may help produce a short-term economic gain but a long-term loss. This strategy is not the way to achieve sustainable use of the planet.

KNOWLEDGE AND COMPLICITY

In July 2002, a jury of citizens in the State of Florida, US, found two Salvadoran generals responsible for torture of leftist insurgents. The charge against the officers was not that they tortured with their own hands but that they knew about human rights abuses perpetuated by men they commanded and did nothing to stop them. The *sine qua non* of international law and human rights abuses is that they must be universally applied — not just applied when they coincide with policy goals. If this is true for human rights abuses, should it not also be true for environmental abuses? Complicity is a partnership or involvement in wrongdoing and is most commonly interpreted as harm to humans. However, degrading the planet's ecological life support system also harms humans, although a modest level of ecological literacy is required to make this connection. Recently, I read an excellent ecology book intended for students in the fifth grade of school (approximately age 11). Surely it is not unreasonable to expect our leaders and the general public to have a grasp of ecology expected of students in the fifth grade. Either they are ecologically illiterate or they have the knowledge to be aware of wrongdoing. If the latter

is true, they are guilty of complicity; if the former is true, they are not sufficiently literate to be either leaders or voters.

In a democratic state, it is the electorate that is ultimately responsible for this regrettable situation. Responsible citizenship requires focused attention. Alertness is essential, even if some of the details are boring. Affluent modern society appears to have chosen entertainment and other activities that diminish focused attention on environmental problems. Neil Postman (1986), in his book *Amusing Ourselves to Death*, remarks that 19th century farmers in the US turned out for hours-long debates between Abraham Lincoln (who subsequently became US President) and his opponent Stephen Douglas. The villagers were hardworking people who put in long, hard hours at work, but it did not affect their sense of responsibility. In the US, irresponsible acts such as 'road rage' are increasing. At the same time, voter turnout, financial support for education, retirement security, corporate accountability, and air quality are declining. This irresponsibility is not an appropriate condition for the world's only superpower, which one hopes would make sound decisions, especially on sustainability. Of course, sustainable use of the planet requires widespread ecological literacy and an informed citizenry in all the world's nations.

The present human population size and distribution is dependent upon both Earth's ecological life support system, consisting of natural capital and the ecosystem services it provides, and a technological/economic life support system. The metrics of the latter system are well known. Far less well known to elected and regulatory officials, as well as other decision makers, are the metrics of the ecological life support system. This system (the biosphere) operates at the global level with an array of subsystems of decreasing complexity, ranging from bioregions to ecosystems to communities to individual species. The type of decision being made will determine the specific metrics that are appropriate (e.g. Cairns & Smith 1989; Cairns et al. 1993). Moreover, for sound decision making at all levels of biological organization, the connections between the different levels must be made clear.[2]

Some illustrative metrics for ecosystem restoration are in National Research Council (1992) , Hoffman et al. (2003), and Holl & Cairns (2003). Long-term effects, such as climate change, will require trend analysis. The metrics will provide an estimate of the condition of the ecological life support system, but the ultimate decision will be based on value judgments and ethics. Both the metrics and the ethics will require critical judgment and the reasoning behind each decision should be explicitly stated.

ASSESSING & COMMUNICATING NUMERACY

In order to verify complicity, one needs to determine numeracy about sustainability. Some illustrative questions follow.

Assessing numeracy

1. What do leaders and the general public know about sustainability?
2. What level of numeracy do they have about sustainability?
3. What do government leaders and the general public think about these numbers?
4. What information (numbers) about sustainability do leaders and the general public understand?
5. What numbers still cause confusion?

[2]Cairns J Jr (2003) Integrating top-down/bottom-up sustainability strategies: an ethical challenge. ESEP 2003:1–6. Available at http://www.esep.de/articles/esep/2003/E26.pdf

Communicating numeracy

1. How can professionals communicate the issues of sustainability to leaders and the general public?
2. How can numbers that are important to the debate about sustainability be objectively introduced?
3. What can each person do to increase numeracy about sustainability so that effective implementation of the steps necessary to achieve this goal occurs?

OBFUSCATION

Special interest groups and the politicians indebted to them will often find ways to confuse the general public about the validity of even the most robust data. The attempt to obscure the primary issue is usually successful when the general public's literacy about sustainability is inadequate. Illustrative common tactics follow.

1. *Assert that the numbers are inadequate.* By asserting that the numbers were not derived by 'sound science,' the need to take action on important measures to achieve sustainable use of the planet is delayed or entirely blocked. Typically, no effort is made to describe why the numbers are inadequate. Why make the attempt when the accusation alone accomplishes the objective?

2. *Assert that more data are needed.* All science is probabilistic, so some uncertainty will always exist. Those asserting that more data are needed should at least describe the type of data needed and at what level of uncertainty a decision will be justified. If the outcome is likely to have severe or catastrophic consequences (e.g. global warming), precautionary measures are justified even when uncertainty is high.

3. *Urge that another committee be organized to 'study' the problem.* This tactic is very successful because, if committee members are selected who have trouble making a decision, the report will take a considerable amount of time and might well confuse the issue further rather than clarifying it.

4. *Use of irresponsible 'expert' witnesses*. All scientists should give every hypothesis a rigorous testing. Regrettably, some individuals will, for a substantial consulting fee, vigorously support the cause of a special interest group. All too often, such individuals are poorly qualified but get attention in courts of law, the news media, etc., so that all 'points of view' will be heard. Mainstream science may be totally against this view, but the contrary view of one individual will get a disproportionate amount of time. Mainstream science is occasionally wrong, but far fewer times than expert witnesses advocating the position of a special interest group.

5. *Inappropriate use of courts of law to make decisions on scientific evidence.* Courts of law are essential to any civilized society, but they are not equipped to evaluate scientific evidence. However, there are no comparable 'courts of science.' Courts of law have not functioned well on such varied issues as global warming, population control, preservation of biodiversity, restoration of damaged ecosystems, protection of ground water aquifers, preservation of wild areas, and a variety of related issues. Either the general public will have to acquire a higher level of numeracy or a court they trust will have to be established to make judgments requiring numeracy. Since elected leaders are unduly influenced by special interest groups making huge contributions to campaign funds, it is unlikely that numbers will routinely be used in an eco-ethical way. This dilemma can only be resolved by an informed electorate with a commitment to eco- and sustainability ethics. Leaders of non-democratic countries may be influenced by world opinion and the expectation that economic well-being requires sustainability.

CONCLUSIONS

Sustainability (sustainable use of the planet) requires a combination of numeracy and eco- and sustainability ethics. With increasing pressure on finite resources and humankind's dependence upon the planet's ecological life support system, both numeracy and eco- and sustainability ethics are essential to achieve sustainable use of the planet. A major ecological catastrophe that could have been avoided would probably suffice, but one hopes that intelligence guided by reason and eco- and sustainability ethics might help avoid major catastrophes, or at least reduce both their numbers and magnitude.

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Article 31

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Small Islands: Harbingers of Earth's Ecological Fate?

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How would you like your pain served? Michael Sutton, Packard Foundation

A colleague, P. Kullberg, sent me an article from *Le Monde Diplomatique* about the effects of climate change on the world's fragile islands.[1] In the approximately 600 islands of Micronesia in the South Pacific, about half of the 150,000 inhabitants have had houses damaged or destroyed by storms more frequent and violent than before. Sea level rise in the last half of the twentieth century and above normal high tides and unpredictable rain have exacerbated the intensity of the storms.

Arguably, Darwin was the first person to use islands to study speciation and other biological phenomena that occur more rapidly on islands than on large land masses. Islands are still very useful systems for observing the early effects of global warming. Low-lying islands are particularly vulnerable to sea level rise and climate change. Now, in the twenty-first century, islands may offer insights into ecological processes comparable to those discovered by Darwin. However, the insights will be at the systems level rather than the species level.

Since humankind persists in carrying out a global experiment (e.g. global warming) with the planet's ecological life support system, islands are already serving as an early warning of system level effects before the effects can be discerned readily in larger systems. The Alliance of Small Island States has been acutely aware of the problems of sea level rise and climate change on small islands. The problem is to communicate their distress to the global community. These small islands may be an important harbinger of Earth's ecological fate. Will a sufficient number of people, especially those with large ecological footprints, feel it is an ethical imperative to reduce markedly the production of greenhouse gases to arrest global warming?

The people of the Maldives are already preparing for worsening conditions.[2] They have started building an artificial island 2 m above sea level which eventually will serve 100,000 people. Rising water levels, increased surface water temperatures, and violent storms already threaten the coral reefs of the archipelago (Inter-Governmental Panel on Climate Change 2001). If the coral reefs are

[1]See Sinai A (2004) Climate change: the world's fragile islands. La Monde Diplomatique, available at http://mondediplo.com/2004/02/15climate
[2]See Footnote 1

seriously damaged, a major destabilization of coastal marine ecosystems is highly probable. Even though the Great Barrier Reef of Australia is endangered, Australia joined the United States and Russia in refusing to sign the Kyoto Protocol. However, ratification would be possible if Russia ratified the Protocol. Some heavily industrialized countries, mostly in the north, fear serious economic consequences if the Protocol is ratified. Some leaders of powerful nation-states are adamant in their opposition to ratifying Kyoto, which must be ratified by no fewer than 55 countries that account for at least 55% of global emissions in 1990. Powerful financial interests backing these leaders have a major influence through both corporate ownership and threats to withdraw political campaign contributions and advertising in the news media. Worse yet, rapidly developing countries, such as China, India, and Brazil, will substantially increase their production of greenhouse gases in the first half of the twenty-first century.

India and China refuse to consider reducing greenhouse gas emissions until the industrialized nations decrease their emissions. It is not clear how soon reduction in the output of greenhouse gases would reverse global warming trends, and, if a major ecological tipping point is passed, irreversible change will occur. Obtaining a technological solution to this problem has a much greater uncertainty than the uncertainties in the global warming predictive models; however, the scientific uncertainty has received much political attention, while the technological uncertainties have not.

A massive change in societal attitudes will be necessary to initiate a paradigm shift on greenhouse gases. Many people in wealthy countries have a large ecological footprint as a consequence of high energy use and consumption of material goods. If society altered its lifestyles and behavior to arrest global warming, humankind would not be rapidly approaching an ecological tipping point. The fate of these small islands and coral reefs indicates that a major ecological tipping point either has been or will soon be reached.

At present, it appears unlikely that an ethical tipping point (a majority acting on ethical rather than economic principles) will be reached in the near future. Reaching an ethical tipping point before reaching an ecological tipping point would, in the long run, be far less harmful to life on Earth, including humans. For much of the time *Homo sapiens* has been on the planet, comprehending the consequences of drastically altering complex, multivariate systems were not necessary. If society's ethics do not reflect what is happening to Earth, society can and almost certainly will make serious, possibly fatal, mistakes. Since an estimated 99% of all species have become extinct (R. Kaesler, pers. comm.), prudence dictates not stressing the planet's ecological life support system so that Earth stays well away from a major tipping point.

Hope exists, however. Late in 2003, the US Senate voted (43 for; 55 against) on the Climate Stewardship Act (CSA), Senate Bill 139. Although the bill did not pass, it received strong bipartisan support, and the bill's chief sponsors, Senators McCain and Leiberman, are committed to moving forward with the bill and hope for another vote in 2004. Regrettably, the US House of Representatives does not have a companion bill to the CSA. The CSA envisions a reduction by 2010 in emissions of heat-trapping gases to the levels of 2000. This aspiration is hardly a great leap forward but, if passed, would reverse the trend. Since the United States is the biggest contributor of greenhouse gases, legislation of this type is a major step toward arresting global warming if the bills are passed, the deadlines are met, and the legislation is enforced.

The so-called 'Pentagon Report' has warned against catastrophic consequences of global warming in the next 20 years. The British newspaper *The Observer* has warned that a suddenly warming climate is a threat to global political stability—a threat much greater than the one posed

by terrorism.[3] In Schwartz and Randall's 2003 report entitled 'An Abrupt Climate Change Scenario and Its Implications for United States National Security'[4] the authors note the situation that has been obvious to mainstream science for many years: once temperature rises above an ecological threshold or 'tipping point', adverse weather conditions could develop rather abruptly. The authors caution that the depicted scenario is extreme in that the effects noted may be regional rather than global and the magnitude may be substantively less. Still, even if the outcome is uncertain but major deleterious effects are likely, precautionary measures are justified. For example, formal ratification of the Kyoto Protocol seems justified since the economic effects of some of the consequences of global warming are likely to be much more costly than remedial measures. Three important tipping points exist in Schwartz and Randall's scenario.[5]

1. The economic tipping point — how much evidence is essential to show that the costs of unsustainable practices outweigh the benefits?
2. The ecological tipping point — how much stress can Earth's ecological life support system take before irreversible effects occur?
3. The unethical tipping point — when, if ever, will awareness of unethical behavior be sufficiently evident to induce ethical behavior?

The answers to these questions will have much to do with the long-term fate of humankind and the short-term fate of life on Earth. At present, judging from the relative amount of attention given these three issues in the United States and a number of other countries, the economic tipping point is the one most likely to invoke precautionary measures. The ecological tipping point would be second because a steadily increasing number of people are advocating precautionary measures based on increasingly persuasive evidence that going beyond the ecological tipping point will have serious, probably destabilizing, effects upon global economics (e.g. abrupt climate change). Exceeding the first two tipping points will result in destabilization of the two systems. Exceeding the tipping point of unethical behavior and replacing it with ethical behavior should go a long way towards protecting all three systems — economic, ecological, and ethical.

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[3]Available at http://www.ens-newswire.com/ens/feb2004/2004-02-23-09.asp#anchor1

[4]Full PDF report (917kb) available for download at http://www.ems.org/climate/pentagon_climate_change.html. Radio interview with author Peter Schwartz, 'On Point: Abrupt climate change', aired 3 March 2004, available at http://www.onpointradio.org/shows/2004/03/20040303_b_main.asp

[5]See Footnote 4

Article 32

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You and Earth's Resources

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> *The illusion of freedom will continue as long as it's profitable to continue the illusion. At the point where the illusion becomes too expensive to maintain, they will just take down the scenery, pull back the curtains, and you'll see the brick wall at the back of the theater.* Frank Zappa

The planet's human population, now at over 6 billion, is expected to increase to 10 billion by 2050. Earth is a finite planet with finite resources, so the decisions humankind makes in the first part of the twenty-first century will affect the lives of posterity as well as current generations. A major problem is that human society now considers exponential growth as normal. In the past, evolutionary selection, both biological and societal, has favored 'ecological fitness', which includes success in acquiring resources. Persuasive evidence indicates that some cultures have lived sustainably for many generations; however, equally persuasive evidence shows that cultures with too many unsustainable practices have collapsed.

Sustainable use of the planet is closely linked to individual behavior and societal practices. In the past, cultures lacking appropriate behaviors and practices collapsed without taking any, or only a few, other cultures with them. Now globalization has increased the probability that excessive individualism and modest levels of cooperation will fail on a finite planet with a finite carrying capacity. Hardin's (1968) classic article noted that individuals will exploit anything that is free in order to maximize their own advantage, which entails a cost to society as a whole. Hardin (1993) used a lifeboat as a metaphor to illustrate the concept of carrying capacity. A lifeboat has a finite capacity before it sinks. Hardin stressed that nations have carrying capacities as well. Catton (1980) asserts that exceeding or overshooting carrying capacity will result in a crash; however, an ecological understanding of the causes of the crash might halt a total loss of humanity. In addition, using reason coupled with intelligence and knowledge might make the crash avoidable.

During the twentieth century, life span and material affluence increased, but with concomitant massive ecological damage. The *ecological footprint* approach shows that humankind can live a fulfilled life in harmony with natural systems. 'The ecological footprint is a measure of the "load" imposed by a given population on nature. It represents the land area necessary to sustain current levels of resource consumption and waste discharge by that population' (Wackernagel & Rees

1996). The concept of the ecological footprint is a superb means of determining the disparity in the distribution of Earth's resources to both individuals and nations.

Arguably, the best way to approach the ethical issues involving humankind and Earth's resources is the calculation of an individual's ecological footprint (e.g. www.lead.org/leadnet/footprint/food.cfm, www.earthday.net/footprint/quiz.asp). In addition, factors that are most important in estimating the size of an ecological footprint are useful (www.redefiningprogress.org/programs/sustainabilityindicators/ef/faq/). The weighting of factors produces somewhat different footprint sizes. Calculation programs for estimating ecological footprint size are also available for communities, nations, and so on.

Most affluent individuals, especially those in wealthy nations, are shocked at what a large ecological footprint they have. The term *affluent* is relative. Middle-class Americans would deny being affluent, but even a casual perusal of the superbly illustrated book *Material World* (Menzel 1994) will quickly disabuse them of this illusion. The book's photographs show the material possessions of a cross section of families around the globe. For an American, these photographs are disturbing, especially the two on the book's cover. The text and statistics that accompany the pictures are equally revealing but lack the emotional impact of the photographs.

Rees (1996, his figure 2) provides another view of this critical situation. Essentially, the Netherlands depends on the ecological productivity of an area nearly 15 times larger than the country itself. In short, ecological footprint size is not determined by the area occupied, but by the area required to maintain the present consumption of resources.

Societal action on the ecological footprint information requires both ethics and science. In the middle of the twentieth century, the established dogma was that ethics and science should not commingle. I encountered this belief when I began research on water pollution in 1948. Those scientists with the temerity to deviate from 'pure science' were regarded with contempt by some, with amusement and pity by others. However, enough support was available to encourage us. Gradually over the next half century mainstream science increasingly accepted science and ethics as a construct. The crucial relationship between ethics and science began to be recognized, even applauded. However, the elation I felt was brief.

In some departments of American universities and colleges, science then began to be regarded as just another value judgment. The consilience (literally, leaping together) of ethics and science had been impaired. In addition, in the US, political efforts surfaced to disrupt the scientific process, including peer review; 'junk science' was given major attention. This situation has resulted in critical responses from such groups as the Union of Concerned Scientists (Meyer 2004) and the graduate students and faculty of Stanford University (see www.scienceinpolicy.org/, a document signed by a number of scientists worldwide and discussed in the news media [e.g. Revkin 2004]). The dangers of disrupting and denigrating the scientific process are already apparent. Fortunately, individuals can make ethical decisions based on the verifiable information used in determining ecological footprint size and by using voting and purchasing power to influence both political and corporate positions.

Some illustrative issues involving ecological footprint size follow.

1. If one's ecological footprint is significantly larger than the world average, what action should one take? (For the twentieth century, the available per capita ecological space has decreased from 5–6 hectares to approximately 1.5 hectares; the world average is about 1.8 hectares/person [Wackernagel & Rees 1996, pp. 85, their Table 3.4].)
2. Should all products and services be labeled to indicate how much they will increase one's ecological footprint size?

3. On a finite planet with finite resources, should there be a limit on ecological footprint size?
4. How can individuals, corporations, and nations with no conscience be limited in ecological footprint size?
5. Should ecological footprint size be regulated for transportation and other energy intensive activities?
6. The ecological footprint size of India is approximately 0.4 hectares/person. What should the response of nations with large ecological footprints (e.g. 5.1 hectares/person in the US) be if India's population continues to grow and the present tenuous carrying capacity is exceeded?
7. How should ecological deficits (the level of resource consumption and waste discharge by a defined economy or population in excess of locally/regionally sustainable natural production and assimilative capacity [Rees 1996]) be eliminated?
8. Since resources are finite on a finite planet and humankind is either approaching or has exceeded global carrying capacity, how can equity and fairness in resource distribution be achieved?
9. How can global consensus be reached on whether the goal is maximum number of people (lower quality life) or optimal number of people (higher quality life)?
10. What is the equitable and fair distribution of resources between one species (*Homo sapiens*) and the other 30+ million species with which humans share the planet?
11. If humankind overshoots global carrying capacity and causes a major ecological catastrophe resulting in decreased carrying capacity, how should this issue be addressed in terms of ecological footprint size?
12. Since some nations and cultures will live more sustainably than others because their population is more stable and more concerned about the size of their ecological footprint, what should they do when environmental refugees attempt to move into their ecosystem? Additionally, how will these comparatively prosperous, attractive countries avoid threats of resource wars and terrorism?

Excessive faith in technology and economics has fostered a belief that the planet's carrying capacity for humans is infinitely expandable. If this belief were true, the ecological footprint size would be a matter of academic interest, rather than a valuable concept for understanding sustainable use of the planet. However, the human population is still growing, as are expectations of more material goods per capita. Earth's resource base is simply not keeping up with expectations, and the present level of affluence is only possible because natural capital is being consumed at a greater than replacement rate. Even if the new technology does increase the resource base, the human population will expand to utilize the newly available resources, thus ensuring only a temporary increase in resources per capita.

In addition, new technologies may have undesirable side effects. For example, genetically modified potatoes may be able to immunize humans against hepatitis B and cholera, but uncertainty exists about the containment of the modified genes. In March 2004, voters in Mendocino County, California, US attempted to ban the propagation, cultivation, raising, and growing of genetically modified organisms. Whatever the outcome of this battle between concerned citizens and the biotechnological industry, this battle will probably be fought globally for many years to come. Whatever the outcome, a long-term increase of resources per capita is doubtful.

The twenty-first century represents a defining moment for humankind. This globally dangerous period of human history has two major threats: (1) overshooting global carrying capacity for humans and (2) major damage to Earth's ecological life support system as well as natural capital

and the ecosystem services it provides. Should humankind fail to replace unsustainable practices with sustainable practices before the middle of the twenty-first century, this irresponsibility and lack of concern for posterity will probably result in global catastrophe. Humankind must repudiate some beliefs and alter its attitude towards technology and exponential economic growth. Technology can be extremely useful, but it cannot develop ethics or values — humankind can. No robust evidence is available that technology can replace natural capital or that the remaining store of natural capital is adequate to meet indefinitely the demands placed upon it. Arguably, reduction of Earth's carrying capacity for humans may be the major problem of the twenty-first century.

Lotka (1925) remarked: 'It is not so much the organism or the species that evolves, but the entire system, species and environment. The two are inseparable.' All individuals are dependent upon this entire system, so it is prudent not to damage its processes for individual short-term gain.

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Article 33

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Choosing Model Nations to Set Examples for Achieving Sustainability

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At one time, the US would have seemed the best choice for a model nation to set the example for achieving sustainability. If Americans lived sustainably, more resources would be available for use by less developed countries. However, playing the famous game of 'What if?' makes the choice of the US as a model nation even less persuasive.

Increased life expectancies, births to American citizens, and legal and illegal immigration, if continued, will dramatically increase the population of the US in the 21st century. In addition, the number of Americans aged 65 and over is projected to increase from 35 million in 2000 to 78 million in 2050 (Schneider 1999), and the present 4 million American citizens at age 65 will expand to 18 million by 2050. Unfortunately, many demographers believe that these projections are underestimates (Schneider 1999).

The US Census shows that 139 million American citizens live in coastal zones. If Florida and other southern coastal areas are typical, a significant percentage of this number is older people. Where will additional retirees live, since the prime areas are already full? These issues are daunting ones that must be addressed during the transition to sustainability.

If future retirees choose coastal areas, the problem could worsen considerably. Over 50% of the American population would be living on 17% of the contiguous land mass. What if the sea level rises? Or worse yet, what if climate change were to cause both a sea level rise and markedly increased storm damage? Depending on the rate and amplitude of the sea level rise, between 10 and 40% of the population residing in the coastal areas could become environmental refugees. What if destroyed seaports cannot be quickly re-established? What if housing, electricity, medical care, etc. cannot be quickly re-established? What if, as seems likely, other nations (which could serve as 'lifeboats') are at or over capacity and cannot help the US? After all, a global sea level rise would create problems in all areas of the world. The time when migration could be used to solve carrying capacity problems is over. Even if other nations enforced zero net immigration and kept the birthrate at replacement level, they would still experience demographic shifts that would extend at least through the 21st century. This situation will also affect carrying capacity.

What if water supply availability worsens (Postel 1999)? What if the economies of 'lifeboats' are seriously weakened by one or more of the consequences of unsustainable practices?

These questions and many other ‘what ifs’ (e.g. pandemic disease outbreaks, global resource wars, major reduction of food supplies due to climate change) could indicate that no nation currently has enough sustainable practices to qualify as a model for the rest of the world. What, then, are the attributes of a nation that could serve as a model for achieving sustainability? A few illustrative characteristics follow.

1. The population must stabilize at or below carrying capacity.
2. Unsustainable practices must be replaced with sustainable practices at a rate of at least 5% per year.
3. The citizens and leaders must be both environmentally literate and committed to a well understood set of sustainability ethics.
4. Resources must be directed toward developing and implementing sustainable practices rather than toward war and/or preparation for war (i.e. ‘defense’).
5. The ecological footprint size should not be more than 20% above the global norm.
6. The use of fossil fuel should be heavily taxed; the proceeds should be used to repair ecological damage.
7. Purely industrial systems should be replaced by hybrid industrial/ecological systems on or before 2050.
8. At least 25% of the land mass must be allocated to the accumulation and protection of natural capital and the ecosystem services it provides; the area must be capable of supporting the biodiversity of the region.
9. Dependence on the natural capital and ecosystem services of other ecoregions must be avoided.
10. Neither the global commons (i.e. oceans and atmosphere) may be over-harvested or polluted; nations that exceed limits should suffer the consequences, including sanctions of other nations.
11. The practice of solving overpopulation problems by exporting people to other countries must be abandoned.
12. At least 25% of the natural systems must be self-regulating.
13. Ecosystems that are deliberately or accidentally damaged (e.g. oil spills) must be immediately repaired.
14. Ecosystem health and integrity must be monitored in a systematic and orderly fashion.
15. Persistent toxic or radioactive wastes requiring storage because they cannot be safely introduced into natural systems are banned.
16. Biodiversity is respected and maintained.
17. All human artifacts (including manufactured items) and waste products are designed so they can be recycled in both the technological and natural systems.
18. The well being of future generations of the human species and other life forms have a major influence on behavior.
19. The ultimate criterion for sustainable use of the planet is the preservation and accumulation of natural capital and the ecosystem services it provides.
20. If normal cyclic climatic or other episodic events increase stress on the planet’s ecological life support system, human society will alter its practices so as to reduce stress on natural systems to the degree necessary to protect their integrity.

It is probable that no country would qualify as a robust model of sustainable practices. Some evidence (Wackernagel & Rees 1996) suggests that Kerala State (in India) might be a satisfactory

candidate, but persuasive information about many of the attributes listed in this commentary (e.g. environmental monitoring, self-regulating ecosystems, ecosystem health and integrity) is extremely difficult to obtain, very likely because it is not commonly generated.

However, a test of congruency could compare the attributes that are ideal for achieving sustainable use of the planet and the actual attributes of a nation or ecoregion. The percentage of difference between the two could be determined:

$$\text{Sustainability Score} = \text{actual/ideal} \times 100 = \text{sustainability index} = \%$$

The list of sustainability attributes in this commentary is illustrative, but what if some type of measurement were a reality—i.e. actually measuring how far along the path of sustainability humankind really is? What if this resultant measurement accelerated the abandonment of unsustainable practices? What if people realized that sustainable use of the planet requires doing more than saying they favor it? Humankind would then know which, if any, nations might serve as models for achieving sustainability. What if progressing along the path to sustainable use of the planet became a primary goal? What if the citizens of each nation improved the illustrative list of sustainability attributes to fit their particular circumstances? What if humankind abandoned denial of the damage it is doing to the ecological life support system and the 30+ million fellow life forms with which it shares the planet?

However, in the far recesses of the mind, two sobering 'what ifs' remain. What if humankind continues its present unsustainable practices for the remainder of the 21st century? What if nature's laws stop the exponential growth of the human population and its concomitant destruction of natural capital and ecosystem services? If humankind continues unsustainable practices until it finds the answers to these last two 'what ifs,' this collapse will demonstrate that the human mind was an evolutionary failure. One hopes that reason guided by evidence, compassion, and ethics will make these two 'what ifs' merely speculative visions.

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Article 34

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Communication and Status: The Dilemma of an Environmental Scientist

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'Hard science' is quantitative and based on numbers, but 'soft science' requires qualitative judgment. The harder the science, the higher the status. There is, however, another aspect of assigning status: degree of independence. Environmental scientists typically study complex multivariate problems beyond the capabilities of a single discipline. They form interdisciplinary teams intended to interact and resolve problems. The connections and synthesis that environmental scientists regard as positive attributes of interdisciplinary work, 'hard scientists' judge as marks of incompetence and insecurity. This situation is remarkably analogous to the gender differences in communicating.

INTRODUCTION

The genesis of this article was a talk by the Reverend Catherine C. Snyder at the Blacksburg Unitarian Fellowship based on a book by sociologist Deborah Tannen.[1] As the talk progressed, I was struck by the correspondence between communication among women and communication among interdisciplinary team members, and by the correspondence between the problems of communicating from one gender to the other and those of interdisciplinary practitioners communicating to disciplinary practitioners. For women, being understood is [the] most important aspect of communication; for men, being understood is less important than establishing status. For interdisciplinary projects, it is essential that all team members understand what each is doing. A project that does not achieve at least some level of mutual understanding is doomed to failure. As in the case of 'communication' between men, within an area of specialization, status is achieved by making the listener struggle to comprehend the message, and, if the message is not understood, it is regarded as a deficiency not of the speaker but of the listener.

When the Reverend Snyder talked about communication in her address, I had a vivid flashback to a departmental seminar I attended several decades ago presented by an outside speaker on a rather esoteric area of genetics. On the way out of the seminar room, one of the senior faculty members commented on how scholarly and scientific the seminar had been. Since I had been thoroughly confused, I asked the senior member (not a geneticist) what the basic message had been. Not only was he unable to tell me, but he saw no contradiction between this inability to summarize the talk and his evaluation of the seminar. Intrigued by this response, I questioned two departmental geneticists about the 'take-home' message and found, to my glee, that neither had

understood the seminar, but both regarded it as profound and scholarly. Regrettably, I cannot find the reference for a much more quantitative study with the same results when a Dr S.L.Y. Fox (really a professional actor) gave a lecture with no content, but the formed attributes of a scholarly presentation to a very large audience at a major national professional meeting. The lecture was then judged on an evaluation form passed out to the audience as scholarly, scientific, brilliant, and the like.

COMMUNICATION, ACADEMIC FREEDOM, AND TEAM RESEARCH

An academic male's view of freedom is addressed in Tannen's book[1] from pages 40 to 42, titled "In Pursuit of Freedom". In a survey carried out by the Chronicle of Higher Education, men referred to independence as their main motive for joining academic institutions and regarded independence as freedom from being told what to do (page 42). Members of interdisciplinary teams in a sense lose freedom because, if they are to function effectively, the needs of the team will impose restrictions that might be regarded as a loss of freedom. Another way of looking at the team is as an enriching experience expanding each member's horizons to see how other disciplines regard a common problem.

My musings about communicating would have ended with these few thoughts had my wife Jean not pointed out an interview[2] of Deborah Tannen, entitled "Can We Talk?" The following question posed by the interviewer refocused my attention on the interesting parallels just mentioned: "In your book, you characterized the boy's world as dominated by a hierarchical social order where you're either one up or one down. Girls, on the other hand, live in a network of social connections, where intimacy and community are paramount. How does this affect our way of communicating?" In the answer, Deborah Tannen said, for males, "You use talk to preserve your independence. Females, on the other hand, use conversation to negotiate closeness and intimacy". An uncharitable person might substitute the term 'reductionist science' for the word males and interdisciplinary science' for females.

ARE TEAM INVESTIGATORS INFERIOR TO 'LONE WOLF' INVESTIGATORS?

I am told by people who study wolves that 'lone wolves' become solitary when food is abundant and easily acquired. The lone wolves quickly join teams when the abundant small food (rabbits, mice and the like) go underground, and larger prey, well beyond the capabilities of a lone wolf, must be attacked. What an interesting similarity the small food items have with the small problems chosen by reductionists (for more detail on this, see ref.3) and the large food items have with the larger, more complex, multivariate problems that require an interdisciplinary team.

Many years ago, I lost a valued assistant skilled in all aspects of interdisciplinary team management, including the acquisition of extramural funding. Although this colleague had impeccable academic credentials in both research and teaching, the tenure and promotion committee professed inability to 'see' this colleague's accomplishments due to the fact that the majority of his publications were multi-authored. Worse yet, many of the numerous publications were in 'other' fields such as physics, chemistry, and engineering. Physics and chemistry, of course, are among the hardest of sciences, and engineering enjoys a somewhat similar status since it deals with concrete data. When I am frustrated professionally, I invariably reduce the tension by writing. Since I had just received an invitation to address an international meeting on the Potomac/Thames Rivers, I chose to analyze the situation just described.[4] The published address proved to be a popular one with people facing the frustrations of establishing interdisciplinary teams in an age of lone wolf special-

ization. Not until I heard Rev. Snyder's talk did I realize that some key components had not been included in that discussion!

As I read Professor Tannen's book, I recalled serving on the College of Arts and Sciences Tenure and Promotion Committee at the request of the dean. Each committee member was assigned several candidates, but none from the department that we represented. One of the candidates I was assigned to review was a physicist who seldom was a sole author on a scientific paper. Moreover, on some of the key papers, six to eight authors were listed. In addition, the candidate was seldom listed as the first author. As part of my assignment, I called friends in the physics departments of several prestigious and nationally ranked universities. To my surprise, even though the telephone call had undoubtedly caught them unawares, they could not only identify the candidate's contribution to the team effort, but also all the other co-authors' contributions as well. That happened roughly a decade ago, but, in retrospect, it seems similar to male communication within a club (*i.e.* persons of very similar but not identical interests) and, unlike female communication, where connections and community are paramount. If this is true, it does not falsify the hypothesis that, on interdisciplinary teams, the purpose of communication is to be understood, and in the reductionist-oriented disciplines it is to establish status.

THE SECURITY OF SPECIALIZATION

One of the facts noted in the Tannen interview[2] is that men generally do not stop to ask for directions and women to [SIC]. For women, asking for directions means a fleeting connection with a stranger. As Tannen[2] notes, "That's a positive thing. You don't lose anything. But for a man, it means you're putting yourself 'one down' to a stranger, and that's very uncomfortable." As an extension of this, men often assume that if the person being asked does not know the answer that they person will answer incorrectly since admitting ignorance would put him 'one down'. Women assume that if the person does not know that she will simply say so.

A fascinating article by Jared Diamond[4] on the relationship between soft and hard sciences is particularly persuasive because some of his research is soft and some hard. Similarly, I have the advantage (or disadvantage) of having a lifetime of both research in a strictly reductionist disciplinary mode and a slightly less lengthy (but nevertheless considerable) period of working in the interdisciplinary mode. In fact, I often switch from one to the other, sometimes several times, in the course of a single day. The contrast is startling. In the disciplinary reductionist mode, I decide which problems to address, the boundary conditions (how much is manageable and how much seems unmanageable), and the time frame in which the project will be carried out. I do this with the certain knowledge that, if the timing proves to be poorly estimated, I can reschedule the various activities to suit my convenience. There is no compelling need to ask colleagues with a similar area of specialization for advice. However, if I choose to ask for assistance, it is not within a 'one up' or 'one down' situation as it would be if I were asking directions from a local inhabitant of a town who know much more about the town than I did. It is instead a situation similar to that of two explorers in territory unknown to either, deciding which of several routes would prove most satisfactory. If any of their judgments proved to be inaccurate, the explorers, if they survived, could choose whether to tell others about the mistake. Most importantly, since they are both specialists in the same field, they would have a variety of means for checking each other's judgment. Finally, if a mistake is made on the part of one explorer, the error in judgment is more likely to be forgiven by the other explorer, who knows the complexities and uncertainties leading to the judgment and is thus more likely to be sympathetic when error occurs.

In contrast, a member of a truly interdisciplinary team is certain to have his/her ignorance about a wide variety of subjects exposed on a regular basis. Most interdisciplinary team problems are externally generated by accidents—a spill of hazardous materials (*e.g*. the Exxon Valdez oil spill), by the unexpected consequences of a technological failure (*e.g.* the Three Mile Island nuclear plant situation), or by the compounded tyranny of a series of small decisions which individually made sense but were collectively disastrous (*e.g.* the multiple diversions of water en route to the Florida Everglades). The boundary conditions (the scope of the study), the time frame for generating information, and the level of detail are determined by external needs of some group(s) who requires a particular decision within a particular time frame for an area whose size is determined not by the investigators but by the problem. Additionally, because the problem is externally rather than internally generated, activities are carried out under a public spotlight where every action will almost certainly be questioned.

Probably the most upsetting factor for specialists is the apprehension that his or her specialty may be only poorly understood by the others. Also upsetting is the necessity for each team member to explain constantly his/her activities to those in other areas of specialization. Thus, the specialist is 'one down' in relation to the activities of other team members and intermittently but less often 'one up' when explaining his/her own area of specialization. Early in my professional career, I worked on a loosely organized interdisciplinary team (similar to that in the example in the tenure and promotion decision on a physicist) where a long working relationship permitted a gradual exchange of information, so that each member ultimately came to understand quite well what the other members of the team were doing.

Unfortunately, the mix of disciplines required for solving environmental problems is different in each instance, and most problems are dramatically different. Therefore, if the nature of the decision being made determines the array of information to be gathered and, consequently the structure of the team, a long working relationship cannot be expected for one team for the resolution of a particular problem. Specialists who fail to perform adequately as interdisciplinary team members may, and frequently do, return to their home discipline with the statement (to paraphrase Professor Tannen's book title), "They just don't understand discipline X". To illustrate how pervasive this point of view may be, I was once asked by an intermediate-level administrator to demonstrate how the activities of the interdisciplinary center, which I serve as a director, could be made congruent with the needs and activities of the discipline-based departments. In fact, just the opposite is necessary: the contributions of the discipline-based specialists must be congruent with the information needs of the decisions makers resolving a complex multivariate problem.

DEPENDENCE, INDEPENDENCE, AND INTERDEPENDENCE

Tannen[1] challenges the assumption that the alternative to independence is dependence. She claims that men's belief in this supposed dichotomy explains why many men are reluctant to become intimately involved with others: humiliating dependence is avoided by insisting on independence. But Tannen notes another possibility: interdependence. The major difference in these is symmetry. Dependence is an asymmetrical involvement, since only one person needs the other, so the needy person is 'one down'. Interdependence, on the other hand, is symmetrical, since both parties rely on each other, and neither is 'one up' or 'one down'. If interactions with colleagues is viewed from the standpoint of symmetry, an interdisciplinary team is superior to the reductionist, non-integrative, academic lone wolf approach.

I find the perception that a person is independent in a specialty but dependent on a field team unpersuasive. The specialist's supposed independence is not supported by observation. For

example, all faculty teaching introductory courses, especially those required as part of a core curriculum, must have a sense of theater if they are to keep students awake, much less appreciative. They faculty member of an institution devoted primarily to teaching ignores student response at his peril. Even at teaching/research institutions, failure to consider student response can be damaging. As the courses become more advanced, especially at the graduate level, competence alone may carry the day. The easiest way to retain student attention in introductory courses is a bit of humor from time to time. But as Tannen correctly notes, a faculty member's intention and a student's perception of a joke may be light years apart. All of us in academe have known teachers whose lecturing styles have had to change in an era of student evaluations, affirmative action offices on campuses, increased enrollment of women in what were formerly male courses, and the like. Considering this, the 'independence' of a lone wolf may not be so much greater than that of an interdisciplinary team member.

As for financial independence, even senior scientists depend on extramural funding (I recognize this is less so in fields that don't require instrumentation and the like, such as philosophy). My MS thesis studied the response of freshwater protozoan communities to pollution. This research led me to an interest in how these communities are structured and changed in sites unaffected by pollution and to a career-long interest in global transport systems, competition, mutualism and related ideas.

However, my priority list did not always coincide with the priority lists of funding agencies. As the woman (Dr Ruth Patrick of the Academy of Natural Sciences of Philadelphia), who became my mentor after I acquired the MS and PhD, once remarked, "People are much more likely to give you money to solve problems that interest them than problems that interest you". This remark seems obvious and almost platitudinous, if it were not for the large number of unfunded academicians waiting for their dissertation topics to become 'hot' again and liberally funded. Just as real life plots often outrun those of the most imaginative fiction writers, so the problems of the real world eclipse those of specialists, in both scope and complexity. As Will Rogers once put it much more effectively, "It's hard to make a living as a comedian when the US Congress is in session".

Since the Planet's major problems are beyond the capabilities of a single discipline, funding may be easier to obtain for solving problems of general interest than those of specialized interests. In science, at least, the 'haves' get money for instrumentation, travel, technical assistance, page charges, and the like, all of which makes them markedly more mobile than their colleagues among the 'have nots'. In the academic world, there is surely some close correlation between the degree of independence and the number of options open to an individual! Put in this way, perhaps the commonly held view of independence should be modified, as appears to be happening in this era of budget deficits where professional survival is more closely linked to performance than it has been in the past.

COMMUNICATION AND PROBLEM SOLVING

This discussion has focused on communication and status as the dilemma of an environmental scientist. The kind of communicating among the disciplines to resolve an environmental problem beyond the capabilities of a single discipline is a style attributed to women by Professor Deborah Tannen. I have noted the correspondence between the communication style of men, for whom being understood is less important than establishing status, and 'communication' between practitioners in a specialized discipline, who are achieving status within their own discipline. Tannen observed that men referred to a wish for independence as their primary motive for joining acade-

mic institutions, regarding this independence as freedom from being told what to do. I contrasted this with the requirements of an interdisciplinary team, the difficulty of achieving independence in the sciences without extramural funding, and the risk of ideas for research in a highly specialized discipline languishing unfunded because they don't coincide with the interests of funding agencies, which are concerned for interdisciplinary problems. 'Haves' with extramural funding are much more likely to publish in the sciences than the 'have nots', and publications enhance mobility and the choices an individual has in the academic arena. These considerations suggest that independence may be on the side of the interdisciplinary team worker, rather than the side of the specialist staying within his discipline.

In this period of financial hardship for most academic institutions in the United States and many other countries, administrators of academic institutions look quite favorably on faculty members who bring additional financial resources to the institution and reward them with a lighter teaching load, better research space, and additional staff assistance paid for by the institution. While the public and its elected representatives are continually reminded by those seeking research funding that all investment in science, however esoteric, eventually produces societal dividends, they are increasingly reluctant to fund purely theoretical research because it seems so remote from global problems.

It is clear that all of the major global problems, such as climate change, acid rain, environmental pollution, and loss of biodiversity, cannot be resolved within the confines of a single discipline. Interdisciplinary teams are needed to resolve these major environmental problems, and it is to interdisciplinary teams that large block grants are made available to deal with such problems. An environmental professional engaged in interdisciplinary work may have acquired a degree in any of the major classical disciplines, scientific or non-scientific, but the gate keepers (*i.e.* those who award status) predominantly identify themselves with a specific discipline. Although many academic institutions have a department of environmental science or some variation of this, the percentage of the total faculty in such a department is generally small. Rarely does such a department contain an adequate array of specialists to resolve a major environmental problem. In most academic institutions, the department organized according to discipline is still the dominant mode, and those working on broad-scale environmental problems must do so outside the disciplinary department. This results in a loss of status within the department and the discipline at a particular institution.

The same dilemma exists at the national and international levels. Most of the well-established journals represent a particular discipline or subunit of a discipline. For example, in biology, there are a large number of sub-disciplines such as molecular biology, fisheries, ecology, genetics, and by taxonomic unit. Certain short cuts can be taken within the discipline because of a correct assumption of a substantial base of commonly shared knowledge. In interdisciplinary activities, such as a base of commonly shared knowledge cannot be taken for granted. Communications, both in publications and presentations at professional meetings, must include details that appear elementary to highly specialized individuals. The highly specialized individuals within a discipline can more easily display unique research or insights to those sharing a common body of knowledge than can the individual attempting to do so within an interdisciplinary context where the common body of knowledge is far less substantial. Consequently, in the eyes of many professionals, there is a loss of status because of the mixture of basic and advanced information.

When individuals from two distinct disciplines collaborate in an area shared between the disciplines, it is extraordinarily difficult to get appropriate reviewers for the resulting manuscripts, even

for interdisciplinary journals. For many years, I collaborated with an optical physicist to develop instrumentation that would enable automated identification of diatoms.[5] Journals sent our papers to either optical physicists of biologists, each incapable of evaluating roughly half of the manuscript because this collaborative work ran contrary to the paradigm of what was appropriate to either field. Finally, one journal found a biologist and a physicist at the same institution to review the paper jointly, and it was accepted. Nevertheless, the difficulties in getting the paper published were considerably greater than would have occurred within an accepted area of specialization, and the status resulting from the publication was at least initially considerably less useful than it would have been had the publication been within the confines of a well-established discipline.

The shifts in funding now occurring will increasingly favor successful interdisciplinary collaborations. In the meantime, young and mid-career professionals must decide whether to communicate in ways that will result in status within the existing disciplinary-dominated system, without concern for being understood by those in other disciplines or to alter the style of communication to what is necessary for successful interdisciplinary collaboration, which makes extramural funding more accessible, but may endanger the careers of those housed in traditional specialized compartments of academic institutions (or even their counterparts in industry and government). It is encouraging that the difference in communicating styles of males and females described by Tannen appears to be dwindling, as does the contrast between disciplinary and interdisciplinary modes. During this transitional period, however, individuals differing too markedly from the communicating style of the gatekeepers are at risk in obtaining both status and security (*i.e.* tenure and promotion). The dilemma now faced by environmental professionals, especially those in early and mid-career, is determining how much to deviate from established norms for the sake of successful interdisciplinary collaboration and continued extramural funding and how much to conform to the requirements of strong disciplinary orientation for survival within their home institution.

Taking the long view, it appears that public pressure to solve global problems requiring an interdisciplinary approach will surmount disciplinary purity. Meanwhile, institutions that deal with this problem are more likely to attract competent professionals interested in solving problems of considerable societal interest that require an interdisciplinary approach, and that interdisciplinary approach will require a different style of communicating than is adequate within a discipline.

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Article 35

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Eco-ethical Issues: Self-regulating Versus Subsidized Ecosystems

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KEY WORDS: Sustainability · Eco-ethics · Subsidized ecosystems · Self-regulating ecosystems

SUMMARY

Sustainable use of the planet requires dependable delivery of ecosystem services at a level necessary to meet the needs of humankind. During the last two centuries, particularly in the twentieth century, ecosystems have been fragmented and stressed in a variety of ways, including biotic impoverishment. Self-regulating ecosystems are capable of maintaining nominative structure and function, including normal variability. Those ecosystems incapable of self regulation will require subsidies, which will divert resources from other activities that may also be important to sustainable use of the planet. If ecosystems are not subsidized, the loss of natural capital and ecosystem services will almost certainly impair the quest for sustainable use of the planet. Although most discussions of sustainability reflect an awareness of humankind's dependence on natural systems, ecosystem self regulation has not received an adequate amount of attention.

SELF-REGULATING ECOSYSTEMS

Self-regulating ecosystems should not be thought of as only technological systems. Regulate means to direct or control by means of a principle. Self regulation in nature is not a conscious effort, but rather the result of resource partitioning in which finite or limited resources are shared by an enormous number of species (30+ million). This distribution means that no single species gets a disproportionate share of the resources and that the wastes of one species are resources for another species. This allocation of resources per species is the result of resource partitioning achieved by a process of co-evolution by quite dissimilar species. For example, nectar is available in a wide variety of flowers of quite different structures. Hummingbirds have evolved an array of bill lengths so that each species is particularly suited to obtain nectar from a flower with a particular structure. As a con-

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sequence, a particular resource, nectar, is partitioned because some species are more suited to gathering nectar from certain flowers than others. Species diversity is maintained by conditions that permit the survival of substantial numbers of these co-evolutionary relationships. However, if a particular species of hummingbird disappeared, the nectar would still be available to other nectar gathering species less capable of exploiting the resources of a particular flower.

Furthermore, evolution is always moving toward increasing complexity, which results in finer and finer partitioning of resources. Complexity in nature results in an array of feedback loops, interrelationships, and, most important, use and reuse of resources. This dynamic system keeps everything (e.g. nutrients) moving, and species are also constantly being replaced in a successional process. However, species that disappear from one locale usually appear at another one. Despite this activity, the structure and function of the ecosystem remain remarkably stable, although the ecosystem does vary within limits. This dynamic stability is maintained by the interaction of an array of rate processes. One such interaction that results in an equilibrium number of species has been described by MacArthur and Wilson (1963). Another model of community structure that remains remarkably constant, although the kinds of species do not, is described by Patrick (1949). Illustrative functional attributes are described by Likens and Bormann (1995).

Nature favours quantity, from which it selects quality. Individual species and individual organisms have important roles, always in the context of the interdependent web of life in which all species, including humans, are a part. Often overlooked in the quest for sustainability are the changes required in the direction of humankind's financial investments, the orientation of its technology, the allocation of global resources, and, most important, in our mind set. Emulating the processes of nature is the most direct path to sustainability.

Nature ensures that its resource reserves are not readily available on demand. Furthermore, systematic recycling and reuse protects nature's inventory of both renewable and nonrenewable resources and keeps them from being pushed beyond critical limits needed for sustainable use. Societal and institutional change must be directed by the ability of natural systems to absorb the effects of human activities. Humankind is ethically responsible for present unsustainable practices and also for instituting the changes necessary to achieve sustainability.

The concept of viewing natural systems as sacred and inviolate will be a shocking or offensive idea to many people. Even acknowledging humankind's dependence upon natural systems will be difficult for many people. Asserting that both exponential and economic growth are unsustainable on a finite planet will be met by ridicule and sarcasm by those people reaping enormous wealth from these practices. However, if humankind lacks the courage and depth of ecological understanding necessary to eliminate unsustainable practices, nature will do so in ways that will cause both the wealthy and poor to suffer.

Earth is an ecosphere and the evolutionary source and support of life. A committee of the Ecological Society of America defined an ecosystem as a spatially explicit unit of Earth that includes all organisms, along with all components of the abiotic environment within its boundaries (Christensen *et al.* 1996). The term *ecosystem* was first used by Tansley (1935), who noted that organisms claim society's primary interest. He also stated that, even when research and thinking are on the basic level, organisms cannot be separated from the special environment with which they form one physical system. The National Research Council (1992) states that the goal of restoration is to emulate a natural, functioning, *self-regulating* (italics mine) system that is integrated into the landscape in which it occurs. It is almost platitudinous to state that a damaged ecosystem is not self regulating and that exemplary ecological restorations have restoring this capability as a major goal. During the

recovery phase, effective subsidies will assist the recovery process and reduce the time required to reach the desired state of self regulation. Complex ecosystem functions, with feedback loops and a variety of other attributes, are described in detail in ecology texts and journals. Most functions, arguably all, are involved in the delivery of ecosystem services and the accumulation of natural capital. Since ecosystems are dynamic, there is usually both colonization and decolonization of species as a consequence of seasonal cycles, long-term climatic changes, and the like. Despite all of these activities, ecosystems maintain a dynamic equilibrium and functional performance. It is especially important to remember that self regulation in water ecosystems is dependent upon inputs from the surrounding terrestrial ecosystems.

However, fragmentation of ecosystems by highways, power lines, and the like usually disrupt ecosystem conditions. Pollutants may both eliminate species and reduce their physiological function. Lovelock (1980) illustrated how important these interrelationships are by correctly predicting that no life could exist on Mars because of its inactive atmosphere.

The criteria for determining how many of the planet's ecosystems are self regulating are far from robust. Furthermore, as McNeill (2000) has remarked, in environmental history, the twentieth century qualified as a unique century because of the rapid acceleration of so many processes that bring ecological change. It is possible, arguably probable, that self-regulating systems may disappear before society has detailed knowledge of their attributes. On the other hand, ecosystems are able to recover from damage and, over time, return to a self-regulating state. Still, a prudent society would take precautions to avoid more ecological damage until more is known about both the subsidies needed by recovering ecosystems and those that are unable to recover fully.

EXAMPLES OF SUBSIDIES

Many species have disappeared or have reduced numbers in regulated rivers in which the flow regime has been altered, the water quality changed, or substantial amounts of water have been removed for irrigation, etc. Partial restoration of the hydrologic regime often restores a substantial degree of ecological integrity, and subsidies may restore some of the antecedent conditions. Of course, most widespread subsidies are applied to agroecosystems, which bear little resemblance to natural ecosystems partly because of the subsidies themselves. Since many agribusinesses favor monocultures, this situation is a golden opportunity for pests. To keep pests under some degree of control, large amounts of pesticides are usually used, as well as biological controls. Both are subsidies. Many of the world's agroecosystems are heavily subsidized by massive deliveries of water diverted from other areas or from fossil water (underground aquifers), which is being used at rates far greater than normal recharge rates. Postel (1999) discusses water subsidies, and a similar volume on water supply problems of the future has been produced by the US National Academy of Sciences *et al.* (1999). A superb book on perverse subsidies is Myers and Kent (2001). The book has a very extensive list of additional source materials.

It seems prudent to eliminate or reduce subsidies that have deleterious environmental effects and to prepare to increase further the beneficial environmental subsidies if, as seems quite likely, damage to natural systems continues at a rate equal to or greater than the present rate.

WHO PAYS?

Ideally, the person or organization that causes environmental damage should pay the costs of ecological restoration and any subsidies during the transition to whatever level of ecological recovery seems possible. In most cases, however, ecological damage is caused by a variety of events,

and the guilty party or parties are difficult to determine. In addition, much environmental damage has occurred in countries with very poor economies. If subsidies must originate outside the country where ecological damage has occurred, there will almost certainly be a requirement for persuasive evidence that convincing steps have been taken to prevent the damage from reoccurring. Doubtless, resistance will be strong to this type of subsidy even though there is already a precedent. The International Monetary Fund requires evidence of fiscal responsibility before granting or extending a loan to countries that cannot finance ecological restoration efforts. Why not require evidence of environmental responsibility before granting a subsidy?

The attempt by the United States to clean up hazardous waste sites ('Super Fund') provides ample evidence that assigning responsibility for damage to human health and the environment is very difficult. This situation may be due, in part, to the difficulty of evaluating scientific evidence in the American legal system and of determining the portion of the stress due to each source of pollution.

If the 'Super Fund' experience is representative of untangling a complex web of environmental stressors, where substantial sums (sometimes over half) of money to legal fees and costs rather than rehabilitating the environment, using tax dollars may be more cost-effective. Even if tax dollars were used, effective oversight would be necessary to reduce bureaucratic waste and inertia. This process need not increase an individual's tax burden—subsidies that benefit a few and lead to damage in the environment could be shifted to environmentally beneficial undertakings. The Myers and Kent book (2001) provides much evidence of how and where this could be done. It is highly improbable that, despite the effective analysis carried out by Myers and Kent, they have documented all perverse subsidies that are environmentally damaging.

REDUCING THE TAX BURDEN

Developing a more mutualistic relationship between human society and natural systems would not only be sound eco-ethics but would also increase the number of self-regulating ecosystems and, thus, the need for subsidies. Human society has become so accustomed to ecosystems having the capability of self regulation that the thought of having to subsidize them in order to maintain and increase natural capital and ecosystem services is shocking. There is no precedent for aiding ecosystem recovery in human history, so why worry about it now? The reason to be worried is the unprecedented assault on ecosystem integrity by human society. Humankind did not experience the ecological disequilibrium that accompanied the five great extinctions as evidenced in the fossil records. The important question becomes: must human society witness a major extinction period to realize that such a happening is plausible, or can intelligence and reason enable humankind to visualize what might happen and take precautions to avoid it? As the eco-ethical relationship improves, the cost of subsidies should ultimately be greatly reduced. One would also be justified in viewing this eco-ethical relationship as an act of enlightened self-interest by humankind, since the ecological life-support system would be self regulating. Ultimately, sustainable use of the planet requires a healthy biospheric (global ecology) life-support system.

LITERACY, REVERENCE, AND SACREDNESS

Increasing environmental literacy, having a reverence for natural systems, and regarding them as sacred should increase their health, integrity, and capability of self regulation. However, it is quite clear that none of the above are working well since environmental damage is occurring at a rate unprecedented in human history. How can literacy, reverence, and sacredness be improved since all three are essential for humankind to develop an optimal, mutualistic relationship with natural systems?

Environmental literacy

Since the United States and Canada have very large ecological footprints in hectares/person (USA 5.1; Canada 4.3) compared to the world (1.8) and India (0.4) (Wackernegel and Rees 1996, their Table 3.4, p. 85) one might reasonably ask 'Does environmental or ecological literacy affect the size of an individual's or country's ecological footprint?' Since the beginning of the twentieth century, the available ecological space per capita has decreased from about 6 ha to approximately 1.5. Kerala, a state in southern India, has a per capita income equivalent to US$1/day, but the life expectancy, infant mortality, and overall literacy rates are similar to those of the industrialized world. The difference appears to be the degree to which social capital is valued as opposed to manufactured capital (Alexander 1994). One rarely sees paid advertisements on the value of social capital while advertisements extolling the value of manufactured capital are ubiquitous—at least in areas where consumer purchasing power will likely result in sales and profit.

Clearly, a 'more is better' attitude confuses quantity of possessions with quality of life. Since there is a correlation between level of education (as presently defined) and affluence, environmental literacy has not been improved by formal education. As Robin (1994) notes, it is important to focus on personal fulfillment rather than on monetary wealth or acquisition of material possessions, and Menzel (1994) illustrates the poor correlation between material possessions and happiness. His photographs show stark contrasts in the amount of material possessions considered essential by an average family in a number of nations. Yet, despite the strong contrasts in material possessions and the consequent difference in the size of the ecological footprint, humankind still needs to aspire to sustainable use of the planet.

In terms of sustainable use of the planet, environmental literacy prospects are grim. The affluent have large ecological footprints, and the poor have large families. Neither practice is sustainable, but the means to persuade each group to move to more sustainable practices remain elusive. Sustainable use of the planet will require a strong focus on long-term goals that focus on quality of life for future generations.

Formulating and achieving long-term goals will require both overall scientific literacy and an ethos (set of values). However, Kosko (2002) summarizes the findings of a recent US National Science Foundation study in which overall scientific literacy remained fairly low: for example, only 54% of adults know that Earth takes one year to orbit the sun. At the same time, belief in pseudoscience continues to rise. In the United States, rule of law is prized; however, the study (Kosko 2002) suggests that most adults are not capable of serving on a jury that must decide questions of fact based on scientific or technical evidence. Worse yet, many judges will continue to let dubious 'experts' testify before scientifically incompetent jurors, and only one judge in 20 understands testability and error rate of scientific data.

Literacy was originally defined as the ability to read and write, and this definition is still a major measure of a country's standing (i.e. the number of people who can read and write). Many educational systems now add mathematics, computer science, and the like to the ancient skills. Hardin (1985) defines ecological literacy as the ability to ask 'What then?', and Orr (1992) notes that the failure to develop ecological literacy is both a sin of omission and of commission. Society is failing to teach the basics of how Earth works. As a consequence of the failure to include ecological perspectives in a variety of subjects (history, economics, politics, etc.), students form the impression that ecology is unimportant.

Environmental/ecological literacy, which is essential for taking the steps necessary to produce self-regulating ecosystems or to understand when ecological subsidies are needed and

what they should be, is seriously deficient. Moreover, no societies are sufficiently far advanced in sustainable practices to serve as role models for either ecological literacy or sustainable use of the planet. Environmental literacy must be developed to the point that it enables both sustainable development and protection of self-regulating ecosystems and provides adequate ecological subsidies when restoration to a self-regulating condition is not possible.

Reverence

Scientific results will always contain some uncertainty since they are probabilistic estimates based on evidence that is rarely perfect. If humankind revered (held in great regard) natural systems, it would be inclined to do everything possible to protect their health and integrity and restore them if evidence indicated this was desirable. Using good judgment, living responsibly, and feeling compassion for other life forms and living members of the human species and their descendants are the *sine qua non* of sustainable use of the planet. Humankind must have a reverence for these attributes because they are essential to the sound value judgments needed to complement scientific evidence. In short, humankind needs to stop managing the planet as if it were a multinational corporation and manage societal practices to protect something society reveres (i.e. natural systems). Humankind needs natural systems more than they need humans, although those who believe in no limits to growth, no such concept as carrying capacity, and no resource limits, think otherwise. The problem has been that replacing the failed systems with economic growth as the primary goal, rather than sustainable use of the planet, may not be very effective long term.

Part of the problem is confusion about sustainability. In 1948, my mentor Ruth Patrick described the ideal relationship of humankind with natural systems as 'use without abuse.' These three words say it all. Humans are part of the interdependent web of life, so it is inherent to interact, or 'use' it. Abusing the web will tear its fabric and harm humankind. Brown *et al.* (1990) described a sustainable society as one that satisfies its needs without jeopardizing the prospects of future generations. Although the authors clearly intend the protection and reverence for natural systems, this intent should have been explicitly stated in the primary definition. The quest for sustainability requires that humankind revere natural systems if only because it is dependent upon them. The widely cited Brundtland report (World Commission on Environment and Development 1987) states that development is sustainable if it meets the needs of the present without compromising the ability of future generations to meet their own needs. However, the report does not adequately stress humankind's dependence on the planet's ecological life-support system, nor such important ecological concepts as carrying capacity or a nonlinear response after an important ecological threshold has been crossed. Revering the needs of natural systems is a prerequisite for meeting the needs of future generations of the human species. As Orr (1992) remarked, the World Commission hedged its bets between two versions of sustainability: (1) technological sustainability (can human society achieve sustainability through better technologies and more accurate prices?) and (2) ecological sustainability (finding alternatives to the practices that harmed ecosystem integrity). The second, ecological sustainability, requires that humans revere (hold in great regard) both the structure and function of natural systems. There is no reason why a mutualistic relationship between the two systems cannot be developed, but the needs of the ecological systems must be given at least as much attention as the needs of the technological/economic system.

Sacredness

If Earth were regarded as holy, there would be more impetus to the quest for sustainability because the ecological life-support system would be regarded as sacred. Everything possible would be done to avoid profaning it.

ECO-ETHICALLY DRIVEN SUSTAINABLE USE OF THE PLANET

If there were increased literacy and a reverent and sacred attitude toward natural systems, then some straightforward steps that could be implemented immediately:

(1) Renewable resources would only be used at rates that ensure they would remain intact. Fisheries would not be over harvested, ground water aquifers would not be used at greater than recharge rates, and areas with depleted natural capital would be 'rested' until the natural capital could be restored.

(2) Ecological restoration would be carried out at rates at least equal to the rates of ecological damage. This view sounds utopian, but ecological destruction must stop sometime, why not now before nature's sanctions that enforce carrying capacity limits become very obvious? Still, an even more utopian idea is that economic/technological strategies, both extremely new in evolutionary time, will work despite a growing population and increased per capita material affluence. However, ecological restoration is often more swift than ecological restoration. Ecosystems can be damaged in hours, e.g. by oil spills and other hazardous materials; however, restoring damaged ecosystems may take years, decades, or centuries, and even then they may not resemble the predisturbance condition. Case histories of restoration sites furnish clear evidence of local civic pride in restoration efforts (National Research Council 1992). Ecological restoration is a global need that is the aggregation of local, regional, or national damage to ecosystems. However, effective solutions must occur at the local level, otherwise the integrity of the restored ecosystem will not be protected.

(3) Ecological restoration must be primarily local or regional. Berry (1989) believes that limits exist to the ability to comprehend and, thus, coordinate entities beyond a certain scale. He further asserts that humankind has a limited sense of good and any willingness to do it. How, then, will a constituency for ecological restoration develop? At present, at least half the planet's population lives in urban or suburban areas where frequent contact with natural systems is usually quite difficult. Persons who have become disengaged from nature must somehow become re-engaged—if not physically, then at least spiritually. Redclift (1987) believes that humankind must embrace the ways in which indigenous peoples structure their knowledge of their environment. Both the Natural Step Program (Robèrt *et al.* undated) and concepts of natural capitalism (Hawken *et al.* 1999) offer hope in this regard. A single model does not fit all ecoregions, and sustainable use of the planet requires both preservation and accumulation of natural capital, as well as the ecological and cultural practices that foster preservation and accumulation. Lovins and Lovins (1982) recommend using ecological concepts for the design of resilient technological systems. Both ecological and technological resilience is predicated upon the capacity to withstand both external disturbances and internal malfunctions. Ecological systems retaining resilience are not efficient as the term is used in modern industrial society (e.g. functional redundancy is common in self-regulating systems).

THE IMPORTANCE OF A SENSE OF PLACE

A strong sense of place and a reverence for local or regional natural systems is also mandatory for sustainable use of the planet. Developing a long-term commitment to the preservation of an

area one is familiar with is easier than caring for regions with which one has little contact. A classic literary example of this sense of place is Thoreau's Walden Pond.

With the inspired leadership of local high school teacher Tom Furrer, a group of Casa Grande High School students in Petaluma, California, raised money to clean up and restore Adobe Creek, which once had a salmon run (as described in Cairns 1999). Adopting a damaged ecosystem to restore would be a superb way for each community to develop a more harmonious relationship with natural systems. Such undertakings should involve all age groups, income levels and the like. In order to achieve sustainable use of the planet, all citizens must be able to understand the difference between self-regulating ecosystems, subsidized ecosystems, and damaged ecosystems. This knowledge alone will require massive participation and long-term commitment.

Of course, all these efforts will be virtually useless if people limit their dedication to one particular ecosystem while ignoring events in their bioregion. Of course, the interest level must not be trivial, e.g. one day a year is designated 'Earth Day,' in the United States—speeches are made, songs are sung, a few trees are planted; the next day is 'business as usual.' Ecosystem services are expected to continue, but public involvement to protect the ecosystems that provide these services is not exemplary. Since the ecosystems constitute the planet's ecological life-support system, this lack of involvement is a flagrant denial of reality.

CARRYING CAPACITY

The greatest peril to human society is seldom discussed. At its core is the concept of the planet's finite carrying capacity for humans. A related issue is what time human artifacts will displace natural systems to the point that they no longer furnish the ecosystem services essential to the survival of humankind. Reduction in ecosystem services will constitute a reduction in carrying capacity. However great the displacement of natural systems by human artifacts, there is a strong probability that natural systems will rediversify after an extinction, as has happened after previous mass extinctions. It is, therefore, not only an ethical responsibility to protect and restore natural systems, but it is also an act of enlightened self-interest since natural systems constitute humankind's life-support system. In short, humankind needs natural systems, but they do not need humans since natural systems existed for billions of years before humans arrived.

Surprisingly, although human society does not appear to be deeply concerned about the failure of its ecological life-support system (I am well aware of the many fine publications on this subject, but society as a whole either does not believe them or, more commonly, is unaware of them), it is almost obsessed with the health of its economic/technological system. It seems senseless to abandon concern for the biospheric life-support system when there is robust evidence that it can be self regulating if human assaults upon its integrity are restrained.

The economic/technological system has only been operative for about 10 000 years (beginning with the agricultural revolution) and has only been in major operation for the last two centuries—a tiny span of evolutionary time. The economic/technological system treats natural systems as commodities, not as the life-support system upon which human society is dependent.

Of course, both systems could fail and could even do so simultaneously. For example, a major climate change affecting agribusiness and changes in the hydrologic cycle will almost certainly affect both systems. Resiliency of both systems should be increased as a precautionary measure. Self-regulating ecosystems have equitable energy allocation, functional and structural redundancy, closed loops, and large numbers of species represented by low numbers of individuals. Thus, the temporary loss of a few, or even a significant number, of species can be

tolerated as a consequence of various redundancies. However, long-term stability of an ecosystem depends on a constant colonization by new species, which can be in a dormant stage at the site itself or an invader from other sites. Most ecosystems probably have a combination of these two phenomena to facilitate both cyclic and successional species turnover. Species invasion and successful colonization by the necessary number of species is enhanced for species from other sites if the travel distance is minimal and the travel route is tolerable (e.g. no pollution stress). This dynamic process is enhanced by a decentralization of the total species pool and obstructed by ecosystem fragmentation of species from one ecological 'island' to other 'islands.'

Sustainable use of the planet requires a significant number of self-regulating ecosystems that let colonization and natural selection maintain ecosystem integrity. If an ecosystem subsidy is necessary, there must be a better understanding of natural processes, a reverence for them, and a willingness to provide these subsidies for as long as they are necessary to keep ecosystems as functional as possible, including the delivery of ecosystem services. Since humankind at its present population size, distribution, and level of affluence is dependent on both technological and ecological life-support systems, it is important that the structure and function of natural systems be replicated as far as possible (Todd and Todd 1984).

ROLE OF BIODIVERSITY

Arguably, the greatest unknown is the role of biodiversity in ensuring self-regulating ecosystems. Succession or turnover of species in all ecosystems exists, although the temporal spans for the rate of turnover may differ dramatically from one ecoregion to another. Society does not yet know how many species are needed to preserve the integrity of self-regulating systems (Cairns 2002) or what species are being lost and at what rates. Even if financial support were available for determining the rate of replacement in temporal spans of a one-century monitoring system, not enough trained personnel exist to carry out this endeavor in a scientifically responsible manner, although a number could be educated and trained over a period of years.

BIOMONITORING

Biomonitoring is surveillance undertaken to ensure that previously established quality control conditions are being met (Cairns 2002). This definition of monitoring is common in hospital intensive care wards, industrial production lines, and a variety of other situations.

Since the number of species and structure of communities will be difficult to use in developing a monitoring strategy, an alternative strategy would be to monitor the integrity and health of ecosystems and to assume that, if the services they are providing remain fairly constant, the requisite number of species are present. One of the weaknesses of this assumption is that some greatly diverse systems appear to have a significant amount of functional redundancy; therefore, the ecosystem may continue to function so well that the monitoring system will not be able to distinguish between normal variability and a decline in trend. Of course, monitoring of species of particular interest to human society should be encouraged, particularly those threatened with or nearing extinction. One of the major drawbacks in the functional approach just mentioned (i.e. integrity, health, and ecosystem services) is that ecosystems may only need substantial levels of biodiversity for episodic periods of stress and may be able to function quite well under normal conditions without the species reserve. Thus, even if the ecosystem seems to be normal in terms of functional capabilities, it may not be normal in terms of biodiversity.

THE RELATIONSHIP BETWEEN STRUCTURE AND FUNCTION

Three major possibilities exist in the relationship between structure and function:

(1) Structure and function of natural communities are so closely interrelated that it is impossible to change one without changing the other,

(2) Structure (i.e. number and distribution of species) is more sensitive than function because functional redundancy will compensate for loss of species to a certain degree, and

(3) Function is more sensitive than number of species because it is possible, at least in the short term, to diminish species function and well being without actually killing the species.

The latter is common in ecotoxicological tests when endpoints (e.g. respiratory function, swimming ability, visual acuity, and the like) other than death are used.

FALSE NEGATIVES AND FALSE POSITIVES

Biological monitoring systems are generally designed to provide an early warning of change so that remedial measures may be taken as soon as possible. All monitoring systems are plagued with false positives and false negatives. A false negative is a signal indicating no deviation from the quality control norms has occurred when, in fact, change has occurred. A false positive is a signal indicating a definite deviation from the previously established norms, when none has occurred. False positives and false negatives should be expected when a monitoring system is being established unless normal variability is well understood. Trend analysis should be based on attributes that are not likely to demonstrate high variability, are not likely to disappear as a result of normal successional processes, have high predictive value for other attributes, and are likely to be persuasive to both the scientific community and policymakers. Use of inappropriate or unstable attributes for long-term trend analysis is most unfortunate since each shift causes a ‘down time’ during which the trend analysis is ineffective or partially so. Regrettably, this instance may be the time it is most needed.

THE ROLE OF EDUCATION

If both natural capital and ecosystem services are essential to sustainable use of the planet, then preserving self-regulating ecosystems and subsidizing those in need of help become an urgent matter. Educational systems must include sustainability as a part of each course. The task is not as formidable as it sounds. Years ago, several graduate students and I helped acquaint a high school teacher and his class with the fundamentals of ecological restoration. The particular ecosystem chosen as a class project was a landfill fairly close to a historic park and a scenic parkway. A landfill, for those not familiar with this particular word, is a place where all of the refuse of society is taken and buried. This includes all items not presently being recycled in some way and at some times classified in general as household waste, although many landfills contain industrial and municipal waste as well. In this particular landfill (seven or eight years ago), the wastes were compacted, baled, and stacked neatly. This refuse was then covered with clay or other materials to reduce water penetration and then a layer of topsoil to encourage revegetation. Not surprisingly, the students were horrified at the amount of waste arriving in truckload after truckload. We encouraged these students to determine how much refuse each of their households produced and what the average was for each household in the urban area. This awareness is, of course, one of the essential steps to achieving sustainable use of the planet.

The main purpose of the class project, however, was to determine what type of ecological restoration would be most appropriate once the landfill was sealed. The students conducted

individual component investigations on what kind of plants could survive the initial planting in the landfill soil and would hold the soil together and keep it from eroding. The lesson from this project was two-fold: students were appalled by the amount of the waste produced by a 'throwaway society' and were encouraged by the fact that they could do something to restore the ecosystem, if only partially, that had been removed to create the landfill.

Younger people are understandably apprehensive about their futures and enthusiastic whenever they have an opportunity to do something likely to improve their future quality of life. Although they may not know the term 'sustainable use of the planet,' they are well aware that humankind as a whole is living unsustainably, either by having large ecological footprints or large families or, in some cases, both. Educational systems can teach these young people about ecology and sustainable use of the planet. Ecological restoration, especially of a nearby damaged ecosystem, requires no highly technical equipment, although occasionally some regrading or redistribution of soil might be necessary. There are, in fact, no major obstacles to reestablishing an intimate relationship with natural systems at all levels in the educational system and, eventually, in all parts of society. The costs are minimal, except in personal time and energy. Achieving sustainable use of the planet will require a level of ecological literacy in every individual far greater than what now exists (Orr 1992), and universities and other institutions of higher learning need to practice what they teach, particularly with regard to concepts of ethics and social behavior (Filho and Wright 2002).

ECO-ETHICAL MOTIVATION

Although some students are highly motivated to restore damaged ecosystems, most are not; this lack of motivation is a serious barrier to achieving sustainable use of the planet. Navratil (2002) reports on a study to determine what it would take to get youth, aged 18–24, to vote in an American national election. The incentives offered in the study were: free beer, a few good speeches, a lottery ticket for a red Corvette (a sporty automobile), or another Vietnam war (which provoked major student resistance in its era). The red American classic automobile lottery ticket won. One student appears to have identified the problem—many issues do not affect you when you are 18–24. Caring about sustainable use of the planet is in the same category as voting. Clearly, the educational system has failed to instill the importance of long-term issues.

Of course, all age groups must be involved in the quest for sustainability. Lack of motivation is not a unique attribute of 18–24 year olds. Rather, it is a ubiquitous attribute. All age groups must be motivated toward sustainability, but it is essential that younger people be highly motivated because they have most of their lives ahead of them.

JUSTIFICATION FOR BOTH CONCERN AND OPTIMISM

Undertakings such as sustainable power, sustainable transportation, sustainable agriculture, sustainable cities, sustainable range management, and sustainable fisheries are all homocentric—they focus on human 'needs'. However, sustainable use of the planet requires an ecocentric perspective. At the present rate of ecological damage, many, possibly all, self-regulating ecosystems will be lost. The sort of subsidy that would be needed to assist enormous ecosystems, such as the oceans, boggles the mind. Even if enlightened subsidies were available, self regulation might not be restored in a time frame of interest to humans. Furthermore, the natural capital and ecosystem services might well diminish appreciably during this period.

The outlook for terrestrial systems is also not encouraging, but there are some grounds for optimism. More information is available on the restoration of terrestrial ecosystems, but not much

evidence is available on what self-regulating ecosystems look like. Information is not available for each ecosystem in each ecoregion; consequently, development of both theory and practice will require much time and energy on local, national, and global levels.

This massive undertaking (sustainable use of the planet) can only be successful if humankind's dependence on ecological life-support systems is widely recognized. Once the dependence of humankind on these ecological life-support systems is accepted, they should be treated as inviolate (i.e. sacred). The personnel and resources would then be dedicated to protect those ecosystems deemed self regulating and those requiring subsidies, including ecological restoration. Given the momentum of the present economic/technological system that preserves neither natural capital nor ecosystem services, it seems probable that some major catastrophic event will be necessary to initiate any change in attitude toward natural systems.

CONCLUSIONS

Humankind is dependent on both natural systems and the ecological services they provide for achieving sustainable use of the planet. The ecological services of natural systems have been free and constant, regardless of the encroachments and damage inflicted upon them by humans. However, a number of ecological thresholds and breakpoints, when crossed, often result in a nonlinear response that may occur with breath taking rapidity. Even though some systems have sufficient ecological resiliency to allow crossing some thresholds reversible, human social systems and their response times may not be adequate to this end. One of the basics for ensuring the continual availability of natural capital and ecosystem services is to protect self-regulating ecosystems wherever they exist. In addition, subsidies that will enable the accumulation of natural capital and the provision of ecosystem services for those ecosystems that are not now self regulating must be determined. Even if ecological restoration cannot produce a self regulating system for a variety of reasons, restoration should significantly reduce the subsidy requirements. Humankind is currently unprepared for this responsibility. Success in this endeavor will depend heavily on the development and practice of eco-ethics and on achieving a higher level of environmental literacy than now exists in human society, particularly in the case of its leaders. The planet's natural systems can handle only so much pressure, and time is growing short.

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Article 36

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Sustainability and the Anthropogenic Alteration of Evolutionary Processes

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ABSTRACT: Persuasive evidence indicates that Earth is now experiencing a major biotic crisis. Even if humankind ceases severe stress on natural systems, the crisis will probably disrupt the basic evolutionary processes that characterized the period preceding the agricultural and industrial revolutions. Proliferation of drug and pesticide resistant species and opportunistic species that thrive in human-dominated ecosystems will become increasingly common. The effect on humankind of altering basic evolutionary processes is uncertain because the understanding of these processes is not robust. The probable result will not be an environment as favorable to humans as the one that has existed for most of human history. Humans probably have altered the environment since *Homo sapiens* first appeared. However, only in the last two centuries has the degree and rate of change reached levels now considered by many people to be 'normal', even though the record shows they are not. Greatly improved technology has facilitated increased exploitation of natural resources to unsustainable levels. This exploitation, in turn, has led to exponential human population growth, which has depleted natural capital (living systems and the services they provide). Economic globalization has ensured that ecosystems far distant from consumers can be and are profitably exploited. Economic growth has become a universal mantra that is coupled with a conviction that such growth can continue indefinitely on a finite planet. A major paradigm shift is essential if sustainable use of the planet is to become a reality.

KEY WORDS: Evolution · Sustainability ethics · Destruction of natural capital · Human occupancy of Earth · Alteration of biosphere · Biotic extinctions · Economic globalization

… when we regard every production of nature as one which has had a history; when we contemplate every complex structure and instinct as the summing up of many contrivances, each useful to the possessor… how far more interesting, I speak from experience, will the study of natural history become!
Charles Darwin
(As quoted in Mayr 1977)

ILLUSTRATIVE EXAMPLES OF HUMAN IMPACT ON THE ENVIRONMENT

It is not the purpose of this discussion to provide an encyclopedic list of human impacts upon the environment (lists can be found in Brown et al. [2002] and Worldwatch Institute [2003a,b]), although some examples follow: fragmentation of ecosystems (e.g. Templeton et al. 2001), biotic impoverishment (e.g. Wilson 1992), disruption of the ozone layer, climate change from human production of greenhouse gases (e.g. Harte et al. 1992), acid rain, deforestation of old growth forests, disruption of the hydrologic cycle (e.g. National Research Council 1992), desertification (e.g. Eckholm 2000) due to overgrazing, excessive use of fossil water (underground aquifers, e.g. Postel & Vickers 2004), sea level rise due to melting of glaciers[1], soil erosion, declining ocean fisheries due to overharvesting, displacement of non-human species caused by exponential human population growth (e.g. Ehrlich & Ehrlich 1990), damage by exposure to hazardous substances (e.g. Hoffman et al. 2003), introduction of alien species (e.g. Cairns & Bidwell 1996), dramatic reduction of population size of many species, homogenization of biotas, and gross reduction of entire sectors of some biomes (e.g. Raup 1991). Unless human assaults on the environment are markedly diminished, the planet will be less habitable for both present and future generations of humans. What is lacking is major attention to the evolutionary consequences of these impacts.

THE EVOLUTIONARY FUTURE IS UNCERTAIN

Although scientists cannot reliably predict the species that will comprise ecosystems in the future, significant estimates can be offered about the ways in which human impacts will affect evolutionary processes. Although Myers gave attention to this issue as early as 1985, the first major attention occurred in 2000 at a US National Academy of Sciences Colloquium (Myers & Knoll 2000). The temporal and spatial spans of evolutionary processes are impressive (e.g. Ehrlich 2000). One factor is certain — evolutionary processes will affect humankind's quest for sustainable use of the planet.

Of course, evolutionary future, in every sense, is always uncertain. However, uncertainty can be reduced if humankind attempts to maintain the conditions favorable to *Homo sapiens*. Most discussions of evolution are ex post facto. However, as Hardin (1999) notes, doing nothing is not a viable option because nothing never happens. Various statistical approaches can determine uncertainty; consequently, means exist for determining practices that are likely to reduce uncertainty, i.e. means for determining which practices are unsustainable and which show promise of being sustainable. The introduction to the National Academy of Sciences Colloquium edited by Myers and Knoll (2000) provides many illustrations of alterations of evolutionary practices that pose major obstacles to achieving sustainability because they have precipitated a biotic crisis.

Despite the critical importance of evolutionary processes, little attention has been given to them in publications on sustainable development, sustainability, and sustainable use of the planet, although some literature does exist (e.g. Cairns in press). However, the precautionary principle (e.g. Tickner 2003, p. xiii–xiv) 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 1998 Wingspread statement listed four central components of the principle: (1) taking preventative action in the face of uncertainty, (2) shifting burdens

[1]See Lean G (2003) Melting ice 'will swamp capitals.' http://news.independent.co.uk/world/environment/story.jsp?story=470838

(of proof) onto proponents of potentially harmful activities, (3) exploring a wide range of alternatives to possibly harmful activities, and (4) increasing public participation in decision-making.

Some publications offer general guidance for reducing uncertainty and provide illustrations of attributes of both healthy and unhealthy ecosystems (e.g. National Research Council 2000) and trends that are likely to have both beneficial and adverse effects upon the environment (National Academy of Engineering 1997). The measurements of ecological footprint size for both individuals and societies (e.g. Wackernagel & Rees 1996) provide a means of reducing human impact on Earth. Anderson (1998) provides examples of moving toward a sustainable enterprise that should markedly reduce the human impact on evolutionary processes. The National Academy of Engineering (1996) provides insights on the reduction of engineering impacts upon ecosystems. Hawken et al. (1999) provide practical evidence that corporations that reduce environmental impact can still generate satisfactory profits. Clearly, much can be done now to reduce human impact on evolutionary processes by ensuring the maintenance of healthy ecosystems and restoring damaged ecosystems (e.g. National Research Council 1992).

EVOLUTIONARY ALTERATION OF HUMAN PROCESSES

Ancient Greeks believed the Earth was a living goddess named Gaia (Lovelock 1972, 1979). The Gaia hypothesis supposes Earth to be alive (Lovelock 1988) and assumes that the atmosphere, the oceans, the climate, and the crust of Earth are regulated at a state comfortable for life because of the behavior of living organisms. *Homo sapiens* happens to be one beneficiary of the processes that produce the conditions favorable to Earth's present species. However, drastic alteration of the biosphere may result in a different set of conditions that still may be favorable to life, but not necessarily to *H. sapiens*. Thus, the Gaia hypothesis proposes that the biosphere is a highly integrated and self-organized or controlled system. However, individual organisms and complex ecological systems have important differences. Odum (1997) notes that the organism has set-point controls that maintain steady states at limits (homeostasis), while ecosystems have no set-point controls. In the ecosystem, positive and negative feedback maintains pulsing states at limits (homeorhesis). The absence of set-point controls persuades many scientists that ecosystems and the biosphere do not function as cybernetic systems, although most acknowledge that organisms play major roles in the control of the chemistry of the atmosphere and the oceans (e.g. Kerr 1988). In short, as Odum (1997) remarks, although the biosphere has exhibited the resilience and stability to recover in past ages, this history is no reason to be complacent about the resilience of present life-support systems. Clearly, human abuse of natural systems will have consequences that will affect the benign conditions humans take for granted.

EARTH RIGHTS AND HUMAN RIGHTS

How ironic that some nation-states, that proclaim the necessity for human rights, have the largest ecological footprint and, therefore, the greatest impact on the living Earth. Continued unsustainable practices that damage Earth's ecological life support system will markedly affect human society and even human survival. Compassion for Earth is inextricably linked to compassion for posterity (i.e. sustainable use of the planet) for which humankind has an ethical responsibility.

Both the journals and books of the Eco-Ethics International Union provide information on the obligation of the present generation to future generations. In addition, Agyeman et al. (2003) also discuss sustainable practices and posterity.

The Random House Dictionary, 2nd edition, defines abuse as 'to use wrongly or improperly'. In this context, abuse refers to any practice or action that damages ecological integrity. Of course, any use will have an impact, but, preferably, the use will be mutualistic. Using without abusing is the sine qua non of sustainability. Fuller was the first to recognize that events in higher levels of organization are never predicted by examining the lower levels of complexity (e.g. Gerber 2001). Gaia is the whole of which humankind is an influential part.

Peacock (1990) writes of a continuity over time that the home place provides, including a love that extends not only to humans but between other beings as well. Surely this concept of interconnectedness is crucial to both Earth's rights and human rights. Lovelock (1979, 1988) visualized interconnectedness when he developed the Gaia hypothesis. Shepard (1973) focuses on humankind's interactions with natural systems and use of natural systems. Sustainability ethics is intimately associated with both the Gaia hypothesis and evolutionary processes, especially those favorable to the continued existence of *Homo sapiens* on the planet. Preserving the present environment that is so favorable to humans is essential to the preservation of the species. This preservation is both ethical and an act of enlightened self interest. Humankind should always have a compassion for posterity and avoid disrupting evolutionary processes in a way that might endanger the species.

THE PERSISTENCE OF EVOLUTIONARY PROCESSES

Whatever humankind does, life will probably persist on Earth until the sun dies. Humans may alter evolutionary processes, but they cannot stop them. The previous great extinctions and the recovery from them confirm the resiliency of evolutionary processes. However, paleontological records show that, while evolutionary processes persist, individual species may not. Earth may have 15,000 million years remaining before its end (Dixon & Adams 2003). The persistence of humans for this remarkable time span is by no means assured. Aided by a group of scientific consultants, Dixon and Adams (2003) speculate on the post-human inhabitants of Earth from 5 to 200 million years from now — following the sixth mass extinction for which humans are not entirely responsible, but to which they make a significant contribution. However, Dixon and Adams (2003) consider the removal of humankind's domineering presence — what might evolutionary processes then produce?

The overall diversity of life forms on Earth has increased despite five successive mass extinctions. The sixth, now in progress, is characterized by human-influenced destruction of natural capital. The loss of natural capital will almost certainly have major adverse effects upon both human society and evolutionary processes. The nature of future evolution will be determined by the species and evolutionary processes that survived human influence. In a world without anthropogenic stress, genetic variation and natural selection will decide the fate of life on Earth. Humankind must move from ecological and evolutionary theory to adopting sustainable practices (e.g. Hawken et al. 1999, Ehrlich 2000, Norton 2003).

CONCLUSIONS

By living sustainably, humankind is more likely to preserve evolutionary processes (and successful incumbent species) that have produced such a favorable environment. Living sustainably will not ensure that humankind will survive indefinitely, but it should prolong human occupancy of Earth. Eliminating unsustainable practices is an obvious first step. The second step is restoring and nurturing natural systems in an actively caring way.

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Article 37

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Coping with Ecological Catastrophe: Crossing Major Thresholds

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ABSTRACT: The combination of human population growth and resource depletion makes catastrophes highly probable. No long-term solutions to the problems of humankind will be discovered unless sustainable use of the planet is achieved. The essential first step toward this goal is avoiding or coping with global catastrophes that result from crossing major ecological thresholds. Decreasing the number of global catastrophes will reduce the risks associated with destabilizing ecological systems, which could, in turn, destabilize societal systems. Many catastrophes will be local, regional, or national, but even these upheavals will have global consequences. Catastrophes will be the result of unsustainable practices and the misuse of technology. However, avoiding ecological catastrophes will depend on the development of eco-ethics, which is subject to progressive maturation, comments, and criticism. Some illustrative catastrophes have been selected to display some preliminary issues of eco-ethics.

KEY WORDS: Ecological thresholds · Ecological catastrophes · Climate change · Eco-ethics · Overpopulation · Sustainability · Ecological deficits · Oceanic fisheries

> *If we could first know where we are, and whither we are tending, we could then better judge what to do, and how to do it.* Abraham Lincoln

> *We must prevent human tragedy rather than run around trying to save ourselves after an event has occurred. Unfortunately, history clearly shows that we arrive at catastrophe by failing to act when we should have acted. The opportunity passes us by and the next disaster is always more difficult and compounded than the last one.* Eleanor Roosevelt

ISSUE STATEMENT

Hardin, Ehrlich, Meadows, Brown, and others have covered many of the topics in this manuscript. One new development is public attention to sustainability. Despite some semantic differences, sustainable use of planet, sustainable development, and sustainability all have the primary goal of leaving a habitable planet for posterity, which includes not damaging the biospheric life support system. Another new factor is increasing recognition of the rapid massive changes in the

ecological, physical, and social world (e.g. McNeill 2000). This rate of change and the magnitude of the damage to ecological integrity of the planet are unprecedented in human history. A number of statements made at United Nations Conferences (e.g. Stockholm, Rio, and Johannesburg) recognize these new circumstances. Sustainable use of the planet is a vision that is simultaneously global, regional, and individual. This vision places the individual in a setting that has the potential to exist indefinitely. It differs from the egocentric vision all too common in the twentieth and twenty-first centuries of an individual or a nuclear family surrounded by material possessions. Each individual should have a vision beyond material possessions of the kind of world he/she wishes to inhabit and the one envisioned for one's descendants. *Material World* (Menzel 1994) contains intimate pictures of average families in different cultures surrounded by all their possessions. The disparity of possessions between families is enormous. Also conveyed by both pictures and text is how the family is defined by more than material possessions. Regrettably, it is impossible to depict the ecosystem each family depends upon because it is a larger area than the family inhabits; on the other hand, differences in the size of ecological footprints are easy to visualize. Even in affluent countries, the wishes of individuals for the future are for larger houses or specific material possessions, such as a larger television set, more sophisticated VCR, a different color refrigerator, and more home tools. These wishes are not the holistic vision needed for sustainable use of the planet, which, instead, asks how much material consumption by humankind can Earth's ecological life support system afford? This sustainability-ethics question is of increasing importance as the planet's human population increases and natural resources decrease.

The world is becoming more uniform due to the internet, economic globalization, mass migrations with interbreeding of individuals with different geographic origins, and the like. McNeill and McNeill (2003) describe human society as one huge web of cooperation and competition sustained by massive flows of information and energy (one might add natural resources). Globalization has vastly increased opportunities for invasive species (usually to the detriment of indigenous species) that reduce diversity. Decline of diversity leads to increased vulnerability, as agricultural monoculture has shown. Uniformity increases vulnerability to pests and diseases, which often quickly become resistant to pesticides and antibiotics. These changes increase the likelihood of both societal and ecological instability, which increases the potential for catastrophes to occur.

ECOLOGICAL DEFICITS

Ecological catastrophes are most likely to occur in areas or nations with existing ecological deficits. In a sense, this situation is comparable to the risk of a nation with a large financial deficit losing financial stability. Ecological deficit is defined here as a situation in which natural capital (e.g. Hawken et al. 1999) has been diminished; ecosystem services are lessened and, arguably most important, natural resources are not used in a sustainable way. In economic terms, natural capital may be regarded as monetary capital and ecosystem services as the interest on that capital. When natural capital is preserved and accumulated, ecosystem services will continue to be reliable and the more capital, the greater the services. In short, living sustainably diminishes the probability of catastrophes.

The remarkable advance of information systems, science, and technology has given humankind the ability to improve its relationship with the natural systems that constitute the ecological life support system, which maintains the conditions essential to human survival. Regrettably, having the ability to use reason and intelligence (in short, to act wisely) does not mean humankind will do so.

THE WHOLE VERSUS THE PARTS

As is the case with the human body and mind, health is best maintained with a holistic approach that will facilitate prioritization of those components most needing attention. In short, excessive preoccupation with the parts may result in missing the performance of the whole. Advocates of sustainable use of the planet emphasize the problem (unsustainable practices), the consequences of the problem (catastrophic events for both humankind and natural systems), and the solution to the problem (living sustainably). On a philosophical level, general agreement exists that humankind should leave a habitable planet for its descendants and those of other species. However, on the surface, the components of sustainability are not unique. On the basis of these surface components (e.g. population control, resource allocation, and avoiding such things as global warming), nations, ethnic groups, etc. have bitter arguments, even terrorism and/or war. Individuals and nations profess a commitment to the principles and goals of sustainable development but are often unwilling to change their practices and behaviors to meet the goals and conditions essential to sustainability (e.g. Agyeman et al. 2003).

A somewhat similar situation exists for the world's major religions (e.g. Islam, Judaism, and Christianity)—most favor peace but their disagreements block achieving true peace. In addition, there is crossfire between corporate fundamentalists and those of atavistic religious movements (e.g. Orr 2004), resulting in a polarization of views rather than mutualism. In such instances, differences in achieving and maintaining sustainability must be tolerated and the diversity of cultures honored. Sustainability and religious conflict may appear to be more isolated from each other than they actually are. It is highly probable that religious divisiveness will be used to exacerbate conflicts over sustainability issues.

ILLUSTRATIVE GLOBAL ECOLOGICAL CATASTOPHES

The use of natural resources (natural capital and the ecosystem services it provides) beyond their regenerative capacity, if continued, will cause catastrophes. Since the biosphere is an interactive system, cascading effects producing simultaneous catastrophes are probable. The illustrative global ecological catastrophes that follow are intended to persuade humankind to shift to sustainable practices that will reduce the risk of catastrophes.

Resource wars

Angola suffered a quarter-century of nearly uninterrupted civil war sparked by ideological differences (Swarms 2002). The United Nations' Children's Fund (Renner 2002) has described Angola as 'the worst place in the world to be a child.' The 2001 Human Development Index (United Nations Development Programme 2001), which is a broad gauge of social and economic progress, ranked Angola 161st out of 173 nations. Both the government and rebel forces (UNITA) used Angola's natural resource wealth (diamonds and oil), selling most of these resources for weapons and personal accumulation of wealth. Thus, resource-driven greed proved to be a powerful fuel for continuing the conflict, which left a million people dependent on foreign food aid (Renner 2002).

A significant number of resource wars continue on the planet (Renner 2002). Although Angola is an extreme case, in terms of the estimated revenue from a resource war, it might well portend the future, in that resource wars may be masked by claims of political oppression, denial of minority rights, or religious differences. If these wars were truly fought over ideological differences, large amounts of wealth from resource sales would not end up in the pockets of a few individuals.

In many instances, ethnic and religious conflicts are used as an opportunity to derive revenues by pillaging natural resources. This scenario is difficult to prove since the pillagers may claim to be driven by an unresolved grievance rather than greed. Natural resources are one of the few sources of wealth and the power derived from wealth in poorer societies. Of course, any nation can easily be diverted from protection of natural resources by war, terrorism, economic problems, and civil unrest. Unscrupulous individuals are quick to take advantage of such opportunities and to foster whatever improves or prolongs their access to natural resources. Either resource wealth or resource scarcity can result in resource wars (e.g. Cairns 2003) because wealth must be continually protected and scarcity may cause the 'have nots' to attempt to acquire resources by violence or threats of violence. English philosopher Thomas Hobbes believed that the only way out of this desperate state is to make a social contract and establish the state to keep peace and order. Hobbes subscribed to a very authoritarian version of the social contract.[1]

Renner (2002, his Table 2, p. 15) summarizes 16 cases of the impact of resource wealth on armed conflict. The duration, intensity, and key characteristics varied, as did whether or not the conflict was initiated by resource wealth. Unquestionably, the impact on the resources was unfavorable in all cases. In a number of cases, resource conflicts have led to UN sanctions (Renner 2002, Table 4, p. 55). Regrettably, in some cases, such as diamond smuggling, the activities have been reduced but not eliminated.

Who suffers — who gains?

If human society or the biosphere is destabilized, enormous suffering will occur in both humans and other species. However, as Hendrickson (2002) notes, two far-reaching political changes in the United States are: (1) a pronounced emphasis on unilateral methods in the conduct of American foreign policy and (2) the new American strategic doctrine of preventative war. As natural resources become scarcer and under increasing pressure, there is at least the possibility of moving toward the world envisioned by Hobbes of anarchy and power politics. These two are the most recent additions to the causes of ecological catastrophes.

The Florida Everglades

A good example of an ecological catastrophe supported by the US Congress and private enterprise and only weakly resisted by the general public is the exploitation of the Everglades in the southern part of Florida in the US. The original Everglades was not only a huge ecosystem, but it was (and still is) a unique subtropical ecosystem. It is rich in species that are characteristic of the subtropics and contains many 'ecological islands' and unique features, such as cypress domes. The area is also a major stop for migratory birds and a 'nursery ground' for many species of fish.

The Everglades originally began just below the area now occupied by the city of Orlando and extended south to the lower tip of Florida (Dovell 1947). Ecological damage to the Everglades began in the mid-1850s after Smith (1848, p. 68) reported to the US Congress that draining the Everglades by four to five feet would create a 'tropical breadbasket of no trifling advantage to the whole nation.'

Of course, protests began of 'senseless vandalism of the Everglades' (e.g. Simpson 1920, Small 1929), but it took many years for the warnings to be taken seriously. Although the park was established in 1934, lack of funding (the US was experiencing a depression at that time) meant that the

[1]See http://oregonstate.edu/instruct/phl302/philosopher/hobbes.html

Everglades National Park was not dedicated until 1947. By then, the park had been reduced to one third of the area contemplated in the original plan in order to accommodate private land holdings (Blake 1980).

Even at present, ecological restoration is almost entirely in the planning stage. Of course some restoration plans are quite a few years old. One example is the 'Re-Watering Plan' of the Florida Everglades, which addressed the problem of over-drainage and even advocated that some areas be permitted to revert to wetlands. A subsequent project involved installing a 100-mile-long perimeter levee to separate the Everglades from massive urban development. This plan eliminated 160 square miles of the Everglades (Lord 1993, Light & Dineen 1994). The US Congress passed the Everglades National Park Expansion Act in 1984 in an attempt to provide a more natural distribution and timing of water delivery and in 1990 passed the Everglades Protection and Enhancement Act to enable purchase of 107 600 acres of undeveloped land. The concept of sustainability was introduced in 1993 for the greater Everglades ecosystem.[2] Finally, Congress approved the Comprehensive Everglades Restoration Plan in 2000 as part of the Water Resources Development Act.

This brief overview of a very complicated situation is intended to illustrate how quickly an ecological catastrophe can develop and how entrenched the new status quo can become. This catastrophe is the basis for some important points involving both eco-ethics and environmental politics:

1. Alterations of ecosystems, which 'look good on paper,' may quickly become persistent problems that pose both major ethical and political problems.
2. Legislative bodies (in this case the US Congress and the State of Florida legislature) may pass legislation that raises expectations but often results neither in major ecological restoration nor in a widely supported political decision.
3. As the complexity, duration of time, and acceptance of the damage increases, so do the difficulties in restoring a self-regulating, naturalistic natural system. In some cases (e.g. wetlands), property rights became established, which were then difficult to expropriate.
4. The longer the damage continues, the fewer original species will be available for recolonization.
5. Even ecosystem restoration professionals have little experience restoring large, damaged ecosystems to self-regulating systems.
6. The general public and political leaders must have a strong sense of eco-ethics as well as a high degree of environmental literacy and commitment to the ecosystem being restored.
7. The State of Florida or the US federal government, or both, have the legal authority (jurisdiction) to repair the ecological damage. Since they condoned the actions that caused the problem, they both have an ethical responsibility to correct it.

Oceanic fisheries

The oceanic ecosystem covers 70% of Earth's surface, but most of this system is not under the control of any nation, although the UN could have the power of persuasion, if not the power of military force, to ensure the ecosystem is not overexploited. World demand for seafood is well beyond the sustainable yield. The evidence for this demand is the shrinking fishery stocks, declining catches, and collapsing fisheries (Brown 2001).

The world fish harvest in 2000, the last year for which global data are available, was reported to be 94.8 million tons. Some three-fourths of oceanic fisheries are fished at or beyond their sustain-

[2]See http://www.evergladesplan.org/about/rest_plan_02.cfm

able yields, and, in one third of these cases, stocks are declining.[3] Larsen also reports that some scientists, when correcting for suspected over-reporting by China, the world's leading fishing nation, believe the global catch has declined by 360,000 tons each year since 1988. Despite a tripling of fishing efforts, North Atlantic Ocean catches of a variety of fish popular with consumers have decreased by half. Larsen makes the important point that at least $2.5 billion of US government money is used to subsidize fishing in the North Atlantic each year.[4] These subsidies mask the fact that current fishing practices are both ecologically and economically unsustainable (Porter 2001). The vast extent of environmentally harmful government subsidies is well documented by Myers and Kent (1998).

Larsen makes two extremely important points: (1) it takes twice as much fuel to catch a ton of fish today as it did 20 years ago and (2) the world's fishing fleet has the capacity to catch fish at more than twice the sustainable yield of the fisheries.[5] Preventing an even greater ecological catastrophe in the oceanic fisheries than already exists is a major eco-ethical problem.

While oceanic fisheries are declining in many areas of the world, aquaculture of fish has grown about 10% annually and now accounts for approximately 27% of the world's edible fish supply. While agricultural technology has partially elevated the supply of fish, it has not solved the eco-ethical problem of preserving the oceanic ecosystems and their fisheries. Furthermore, some farmed oceanic fish, such as salmon, are fed with fish meal and oil obtained from oceanic sources. Thus, technology is still affecting oceanic fisheries (by harvesting small fish) and thus is still a major eco-ethical problem.

Fish farming has existed for thousands of years. In recent years, many hectares of rice paddies also have been used to raise fish. These fish are raised mostly in freshwater ponds, so they do not have an immediate effect upon oceanic ecosystems. However, fish hatcheries and, to a lesser extent, poly-culture of fish (with a grain crop) do produce wastes that will probably enter the hydrologic cycle and eventually reach the ocean.

The primary eco-ethical issues are quite clear: (1) a deliberate and world-wide reduction in harvesting oceanic fisheries until the harvest is clearly at a sustainable and ecologically sound level, (2) establishment of refugia (no-fishing zones) so that the stock can recover and provide a reservoir of species even if the management of larger areas is unsound, (3) contributions of individuals to this effort by greatly reduced consumption of oceanic fish and purchase of herbivorous aquaculture fish that are not fed on fish meal and oil from oceanic fisheries, (4) nations and individuals who go beyond sustainable harvesting of fisheries or do not respect refugia should suffer severe sanctions, as should all violators of sustainable practices, (5) a world science court should be established in the UN to ensure that the science used to implement the eco-ethical value judgments is robust, (6) in situations where the science is not robust and uncertainty exists about the outcome, precautions should be put in place to protect the oceanic fishery until robust information is available, and (7) in coping with any catastrophe, such as depleted oceanic fisheries, one should remember that sustainability is a multi-dimensional goal that will not be reached if component issues are examined in isolation from other eco-ethical issues related to sustainability.

[3]See Larsen J (2002) Fish catch leveling off. Eco-Economy Indicators, Earth Policy Institute, available online at http://www.earth-policy.org/Indicators/indicator3.htm
[4]See Footnote 3
[5]See Footnote 3

Global climate change

Robust evidence indicates that Earth's climate changed significantly even before humankind was present. Climate change from natural causes is difficult to manage, and it is possible to take the position that, even if humans could modify it to better suit their species, it might be prudent not to attempt doing so. However, persuasive evidence indicates that much of the recent climate change is markedly affected by anthropogenic activities of which, arguably, the most notable are those changes due to greenhouse gases (e.g. Brown 2001). The Goddard Institute for Space Studies of the US National Aeronautics and Space Administration (NASA) has shown that the 15 warmest years since record keeping began in 1867 have all occurred since 1980.

Although the thin envelope of atmosphere surrounding Earth is as important to the global commons as the oceanic fisheries, there are important differences: (1) the major problem for oceanic fisheries is removal of excessive amounts of stock, (2) the major problem for the atmosphere is the pollutants added from a variety of sources, (3) violators of the oceanic fishery are more likely to be seeking a profit and may have a sizable capital investment to recover, (4) violators of the atmospheric envelope are discharging pollutants into the atmospheric envelope to avoid spending money on waste treatment, (5) individuals contribute to the damage of both global systems, but, arguably, the aggregate of individual effects is greater for the atmospheric commons than for the oceanic commons, (6) by their actions, individuals can reduce the probability of a severe catastrophe in both arenas by reducing their own adverse effects, by letting corporations and governments know that they disapprove of their contributions to these adverse effects, and by boycotting products the corporations produce and the legislators who fail to protect these global systems.

While the increasing risk of a major atmospheric catastrophe is not fully appreciated by the general public, insurance companies are well aware of the risk. At the end of 2001, Munich Re (a company that helps spread risk among the various insurance companies) compiled a list of all the natural catastrophes on record with insured losses of US$1 billion or more (as quoted in Brown 2002). By the end of 2001, the list of catastrophes with *insured* damages of US$1 billion or more had reached 34. Brown (2002) also noted that Europe has experienced, in the last 15 years, an increased frequency of highly destructive winter storms. In Asia, rising sea levels could have a negative effect on rice production. The insurance industry is concerned about the effect of global warming on storm intensity. Even a seemingly insignificant increase of 0.5 to 1.0 degrees Celsius in the course of the next few decades could extend the hurricane season by several weeks, with a concomitant increase in the frequency and intensity of hurricanes. Melting of ice at the poles increases sea level rise (e.g. Brown 2001). Preparing for even a 1-m rise in sea level will require a very heavy investment in flood defenses worldwide. It is not clear either when such protection should be installed or who should pay for it. However, failure to provide protection will be very costly in human lives and property damage, but politicians are understandably reluctant to discuss the issue and most people, even the numerous residents of coastal areas, seem surprisingly unconcerned about the problem. Unless this situation is changed, coping will occur after the first major catastrophe — not before.

Death tolls due to heat waves have already been calculated.[6] However, the death toll is not yet sufficiently high to result in widespread, lasting concern. However, since there has been a rising trend from 1866 to 2000 (Brown 2001), there is cause for concern.

[6]See India heat deaths exceed 1,000. 3 June 2003, available online at http://news.bbc.co.uk/1/hi/world/south_asia/2956490.stm

Numerous books have been produced recently on global climate change, as well as much information in professional journals and internet sites of the UN, etc. (e.g. Olson 2004), and California even has an interfaith religious covenent to reduce global warming.[7] The reason for concern is that trends indicate a worsening of the situation. The justification for cautious optimism is that there are remedial measures available with existing technology. This possibility, together with a changed energy policy in the US and other nations that consume much fossil fuel, should markedly reduce the risk of catastrophic climate change while simultaneously increasing the prospects for sustainable use of the planet.

As was the case for the previous examples, the primary eco-ethical issues are quite clear: (1) a deliberate, systematic, and orderly reduction in the unsustainable practices that have adverse effects upon global climate and especially activities that cause global warming; (2) appropriate remedial measures can be taken at all these levels of organization (individuals, regions, nations, and planet), with a strong commitment to eco-ethics at all of these levels; (3) precautionary measures to prevent major global climate change are major eco-ethical issues; 'death' of the sun and being struck by a sizable object from outer space would both be major global catastrophes, but, since humankind does not at present have proven technologies to cope with these events, they are not eco-ethical issues; (4) cost to society of the complex, multivariate problem of global warming; since the indirect costs of some goods and services are far greater than the price fixed by the marketplace, economics will not prevent ecological and human health catastrophes, although econ-ethics[8] might do so; eco-ethics is more likely to value both ecosystem services and natural capital properly and place long-term sustainability above short-term profits and politics.

It is important to recognize that econ-ethics and eco-ethics are not mutually exclusive. Econ-ethics is homocentric (e.g. Daly 2003) and eco-ethics is ecocentric. Both are essential to sustainable use of the planet. The two are interactive as the efforts to market natural capitalism demonstrate (e.g. Daily & Ellison 2002).

Overpopulation

Sustainable use of the planet is based on the assumption that one species, *Homo sapiens*, can live in such a way that it can persist on the planet indefinitely. Despite this expectation, unsustainable practices are increasing at an alarming rate and are propelled by a human population growth of 74 million each year, unprecedented economic growth (driven by unprecedented consumption), and concomitant reduction in natural capital (natural systems). The increasing size of humankind's ecological footprint is already destroying habitats and species and threatening others. The inevitable consequence is shrinking per capita availability of resources for both humans and other species. The planet's ecological life support system is being severely damaged at a time when it is most needed. Grain production (which supplies food calories, both directly and indirectly), upon

[7]See also Intergovernmental Panel on Climate Change (2001) Climate change: impacts, adaptation, and vulnerability (summary for policy makers), available online at www.ipcc.ch/pub/wg2SPMfinal.pdf; Environmental News Service, Spiritual, scientific leaders unite in global warming action plea. 21 May 2004, available online at www.keepmedia.com/ShowItemDetails.do?itemID=472683&extID=10030&oliID-226; California Interfaith Power & Light, Congregational covenant, available online at www.interfaithpower.org/covenant.pdf; and Environmental News Service, Bank of America maps new climate change, forest policies. 18 May 2004, available online at www.forests.org/articles/reader.asp?linkid=31792

[8]Econ-ethics is defined by Professor Otto Kinne in Ethics in Environmental Science and Politics, ESEP 2002, p. 88–89

which humans depend, is not keeping pace with increased demand and is threatened by water shortages, loss of topsoil, desertification, and salinization of agricultural soils. All other species suffer greatly if they exceed the carrying capacity of their resource base. Technology and creativity can increase short-term carrying capacity for humans but cannot nullify natural law.

Extending the period of economic growth has resulted in ecological deficits. These mounting ecological deficits are taking an increasingly severe economic toll. One does not need to be a Nobel Laureate to realize that the relationship between economics and ecology (both derived from *oikos*) cannot continue to deteriorate without severe consequences to both. Desertification is already causing major demographic shifts and is likely to produce even more environmental refugees unless it is halted.

If sea level rise continues, the demographic problems that will occur boggle the mind. Both dust storms (resulting from desertification) and sea level rise will affect adjacent countries. Dust storms originating in China have already had major social and economic effects upon South Korea. Cairns (2002) has discussed the effects of environmental refugees upon both neighboring and even distant countries. Since agriculture is heavily dependent upon water supplies (1 000 tons of water are required to produce 1 ton of grain; Doorenbos & Kassam 1979), water and food shortages are the interrelated catastrophes most likely to get humankind's attention.

The eco-ethics question is how humankind will react when food/water shortages reach catastrophic levels. Iran, India and Yemen, Pakistan, and China already have water deficits, as do a number of other countries. World production of grain and other foodstuffs is threatened by a variety of factors. What is needed in both cases (food/water) is an ethical consensus on sustainable use of the planet, which I have termed *sustainability ethics*.[9]

Epidemiological catastrophes

Both globalization and increase in global population size increase the probability of epidemiological catastrophes. Globalization means an increase in transport of diseases to almost every area of the planet. Dense populations enhance local transmission of disease. Starvation, stress, etc., weaken resistance to disease.

Two types of epidemiological risks are relevant in an ecological context: (1) bioterrorism — either deliberate or inadvertent release of smallpox or other comparable 'weapons' of mass destruction and (2) rapid spread of a new virus, germ, etc. via the global transportation system, which could involve human carriers (e.g. AIDS), other biological transmitters (e.g. insects), transport on foodstuffs, and the like. Increasing human population densities, especially those billions of humans with inadequate nutrition, health care, sanitation facilities, potable water supplies, shelter, and the like, exacerbate the problem. For example, infectious diseases are spread by recent immigrants (e.g. Dorey 2003, Howard 2003).

Recently, another country with a high immigration rate, Canada, is providing similar evidence. Fayerman reported nearly 400 active tuberculosis cases in British Columbia last year, which represented a 35% increase and was the first time in at least a decade that such a marked increase has been recorded.[10] The British Columbia rate of 9.5 per 100 000 population is nearly double Canada's

[9]See Cairns J Jr (2003) A preliminary declaration of sustainability ethics: making peace with the ultimate bioexecutioner. ESEP 2003:43–48; available online at www.esep.de/articles/esep/2003/E30.pdf

[10]See Fayerman P (2002) Immigration fuels soaring TB rate: disease increases 35 percent in B. C. to nearly twice the rate across Canada. Times Colonist (Victoria, British Columbia, November 21), available online at http://stoptb.org/material/news/press/Times_Colonist_021121.htm

national rate of 5.5 per 100 000. Public health officials attribute this increase to the high number of cases among immigrants, aboriginals, and those who live in Victoria City's downtown eastside.

There is no 'magic bullet' to solve these problems, but they will be dramatically reduced by the same measures that will improve the likelihood of sustainable use of the planet. It is important to recognize that: (1) these are basically ethical problems, although both science and technology will help reduce them once the ethical foundation has been laid and (2) nature has been dealing with overpopulation problems for millions of species for billions of years. Most species produce more individuals than their habitat can hold, and, from this large quantity of individuals, quality is selected. This system is hard on the individuals who lose, but it does protect both the species and the ecological system.

ILLUSTRATIVE REGIONAL ECOLOGICAL CATASTROPHES

The commingling of human artifacts (e.g. shopping malls, cities, parking lots, roads, etc.) and natural systems increases the potential for catastrophes in both systems. As the final draft of this manuscript was being produced, eight separate fires near San Diego, California, were raging out of control, and the two largest ones had merged into a single 40-mile red wall of fire. Experts had seen the fire coming for months (P. R. Ehrlich, pers. comm.) since climate, ecology, and inappropriate urbanization practices set the stage for one of the 'most perfect' firestorms in history. The fire has already caused 14 human deaths (and certainly far more wildlife deaths), destroyed nearly 1,000 homes, and, as reported by National Public Radio on 29 October 2003, devastated an area approximately the size of the US state of Rhode Island. In addition, uncounted thousands packed their cars with family treasures and fled. With all the dry timber available, the question was not 'if' a fire would occur, but 'when.' This situation is not unique — a similar but less devastating fire occurred near Canberra in Australia in January 2003.

The 100 miles of barrier sand islands off the coast of North Carolina, USA, provide a similar example in a different type of ecosystem. Hurricanes regularly relocate and reshape these barrier islands. In recent years, the narrow strip of land behind the beaches has been an almost unbroken stretch of huge holiday homes whose values are as much as US$2 million each. However, Hurricane Isabel (September 2003) washed out most of the only road on the islands and tossed homes and motels around as if they were toys, and one island was cut into several islets.

Numerous cases worldwide show the folly of constructing houses and other human artifacts on the floodplains of rivers or other waterways. As is the norm for the previous examples, citizens who have suffered the consequences of commingling human artifacts and ecosystems not suited for that type of use usually appeal to the government to protect them from the penalties of their own injudicious decision. Human activities should be designed to be compatible with the ecosystems in which they occur since the practices just described are not sustainable.

ECO-ETHICS: MANAGING THE GLOBAL COMMONS

Economic globalization has converted the entire planet into a common ground. Access to it need not be physical, as originally envisioned by mathematician William Foster Lloyd in 1833. Economic access enables persons and organizations to exploit far distant resources and avoid responsibility for the consequences even better than when the commons are exploited by local inhabitants. The global commons is unmanaged in an ecological sense and even in an economic sense if economic development ignores humankind's responsibility to its descendants as well as those of other species. A widely accepted theorem of ecology is that it is impossible to do just one thing. Sustainable

use of the planet requires that humankind do nothing that seriously depletes and/or damages both natural capital and ecosystem services. In an uncrowded world, a sustainability ethic would be less needed than it is now. Humankind now lives in a crowded world where leaving a habitable planet for future generations and those of other species is increasingly problematic.

Obviously an unmanaged commons is more likely to produce catastrophes than a skillfully managed commons. However, a managed commons requires a 'social contract' that produces responsibility for the consequences of inappropriate (i.e. unsustainable) practices. This contract, in turn, will require an 'ethics of the commons' and some forms of coercion, such as severe penalties for damage to the commons whether deliberate or accidental. Coercion is unpalatable but essential for those with less susceptible consciences. Prohibiting murder is an action that is widely accepted. Damaging the integrity of the planet's ecological life support system by damaging the commons is less easily grasped, even though it also results in loss of health and life for huge numbers of humans and other species. Every effort to protect the global commons will be vigorously opposed as infringements on individual 'rights' and 'freedom.' However, individual 'rights' and 'freedom' do not include the right to adversely affect posterity or the ecological life support system.

Nation-states will view protection of the global commons as an infringement of their sovereign rights. However, as the complexity of the stresses on the global commons increases, so does the risk of catastrophes and the need to take precautionary measures to prevent them. Nation-states themselves infringe on individual 'rights' and 'freedoms' in a variety of ways. Individuals cannot refuse to pay taxes even if they disapprove of the way their money is being spent. Individual freedom to drive at any speed, in any vehicle, and to park the vehicle wherever it is convenient (e.g. a parking space restricted to the handicapped) is severely limited. Individuals cannot defecate or urinate anywhere they choose. Humankind tends to accept these restrictions because they are now part of the status quo. New restrictions are resisted because those now living can perceive their personal loss and resist it, sometimes violently.

Sustainable use of the commons at present human population densities and level of affluence involves infringement on everyone's personal 'rights' and 'liberties.' Nature does not recognize individual 'rights' and 'liberties' if they involve exceeding the carrying capacity of the region or the planet. For humans, mere maintenance of life requires about 1 600 kilocalories per day per individual. Any activities beyond maintenance (e.g. work, recreation) require additional calories. If humankind can figure out a way to increase resources without restricting the demand on them, an unmanaged global commons is at least theoretically possible and there is no need for infringement on individual freedoms. However, this possibility is remote and would not deserve attention if there were not a constant stream of assurances that an ever increasing supply of material goods for an increasing number of people would be available far into the future.

The assumption that there is a 'free lunch' underlies humankind's economic system at present, while resource limitations underlie nature's economic system. This discontinuity occurs because the economic system of humankind depreciates anthropogenic artifacts (e.g. vehicles, industrial plants, automobiles) but not nature's capital upon which the human economic system depends. If economic development solely has resulted in unsustainable practices, perhaps it is high time to give econ-, eco-, sustainability ethics a chance to be the basis for sustainable use of the planet. The problem is that the latter produces long-term rewards, while the former produces short-term rewards, which are much more attractive to the average person who is not particularly concerned with ecological and sustainability ethics. Acknowledgement that technology alone will not solve all the problems it creates is long overdue. Humankind can keep improving the quality of life in a

sustainable world. Sustainability is not stagnation! Co-evolving harmoniously with dynamic natural systems requires increased literacy about how they work and what paradigm shifts are necessary to maintain a harmonious relationship with them.

Some unpalatable realities, such as world poverty and consequent emigration and immigration, must be faced unflinchingly. At present the US, Canada, Australia, and a few other countries have a level of prosperity and social order unmatched in the rest of the world. Citizens of countries that cannot create comparable conditions are drawn to these countries as moths to a flame. The US, Canada, and Australia were mentioned because they were all recently colonized in evolutionary time, and their inhabitants are well aware that they are descendants of immigrants. Masters (2001) integrates ethics, ecology, and immigration into his discussion of this topic. It is repugnant to turn away new immigrants. However, countries with high immigration rates are also importing unsustainable practices (e.g. large families). Worse yet, they are being generous to immigrants with the resources that will be essential for a quality life for their descendants. If the same individuals had to decrease their personal resource use to accommodate immigrants, their enthusiasm for immigration would be markedly reduced. Even though corporations would still support immigration because of cheap labor, the citizens who would lose their employment would change their attitudes quickly. In fact, most citizens do not realize that there is no cornucopia from which resources will flow unceasingly in large quantities.

As Hardin (2001) describes the present situation, advocates of unrestrained immigration are proposing that the nation's citizens be figuratively thrown out of the 'lifeboat' to make room for strangers who are in the water because they could not manage their own 'lifeboat.' Hardin asserts that lifeboat ethics is merely a special application of the logic of the commons. However, the lifeboat analogy is much more understandable than an example involving the global commons. Yet, the paradigm is identical.

Turning the prosperous countries into a precarious human commons has already resulted in a high price in public health (e.g. Lutton 2003)[11], crime[12], civil conflict (Cincotta et al. 2003), welfare[13], and destruction of the existing culture[14]. Descendants in all parts of the planet will pay an even higher price if immigration continues at its present rate. Worse yet, the countries that have continually exported people to more affluent countries have not markedly benefited. One might view this remark as an elitist statement, so it clearly deserves elucidation. The Random House Dictionary, 2nd edition defines elitism as a practice of or belief in rule by an elite. Sociocultural selection has favored those cultures that have been most successful in acquiring resources. Living within the area or nation's carrying capacity is a basic need for humanity and the sine qua non of sustainable use of the planet. Confronting the challenges of overconsumption and poverty is also a major issue in achieving sustainability. Plato's carrying capacity (discussed by Durham 1994) was that the land must support a particular number of people in modest comfort. It is worth remembering that the available per capita ecological space on the planet has decreased, in the twentieth century, from between 5–6 hectares

[11]See also Camarota S (2000) Wrestling health care. Baltimore Sun, 22 August http://www.cis.org/articles/2000/sac8-22-00.html

[12]See Nunez P (2003) The deadly consequences of illegal alien smuggling. Testimony prepared for the US House of Representatives, Committee on the Judiciary, Subcommittee on Immigration, Border Security and Claims. 24 June http://www.cis.org/articles/2003/nuneztestimony062403.html

[13]See Krikorian M (1997) Will Americanization work in America? Freedom Review, fall issue. http://cis.org/articles/1997/freedom_review.html

[14]See Footnote 13

to 1.5 hectares (Wackernagel & Rees 1996). The fossil energy use (in gigajoules/year) was 287 per person per year (in 1991) and 5 per person per year (in 1991) for India (Wackernagel & Rees 1996, p. 85). One might well ask if greatly disproportionate use of Earth's resources is elitist. Some questions must be answered if immigrants are allowed to get aboard an ecological 'lifeboat.' Over half the world's population is living on US$3 per day or less (the latest figures are always available from the UN). If as many as 1 billion individuals wish to immigrate to a more affluent country, such as the US, Canada, and Australia, many aspects of this immigration must be considered. Which of the one billion should be admitted? Should entrance be 'first come, first served'? Should entrance be based on need? How is any distinction handled and what is said to those who are excluded? A more detailed discussion of these issues can be found in Hardin (2001).

The dramatic novel of Raspail (1973) has often been cited to support the view that 'restricting the poor and miserable will not maintain or increase the overall well being of the planet and its biosphere.' However, the main point of the novel is the consequences of the citizens of the impoverished countries attempting to get the wealthy nations to share more of the world's resources. One factor is very clear — Earth is a finite planet with finite resources and neither is infinitely expandable. Reaching population stabilization is an extremely complex issue that is not likely to be resolved in a single publication. However, taking more resources from the 30+ million other species with which humankind shares the planet is neither ecologically nor ethically sound.

As noted elsewhere in this journal, I advocate positive action to stabilize world population and ensure a fair and equitable distribution of resources.[15] These and other publications in ESEP recommend that wealthy nations assist less affluent countries in stabilization, as well as endorsing a fair and equitable distribution of resources. If the more affluent countries reduced the size of their ecological footprints and set an example by living sustainably, the world would have models to follow and more resources would be available to help other countries achieve sustainability.

CONCLUSIONS

Reducing catastrophes resulting from human activities is essential to sustainable use of the planet. Most societies are now sufficiently large, relative to their resource base, to preclude individuals from exercising complete control over their own destiny. Nation-states determine the fate of humankind. Thomas Jefferson's 1781 book *Notes on Virginia* warned of the dangers of importing peoples not literate in 'the freest principles of the English Constitution with others derived from natural right and natural reason.'

Catastrophes, resource wars, and political refugees will all probably increase (in rate, number, and severity) as humankind encounters resource limits. This statement then leads to coupling scientific knowledge with ecological and sustainability ethics as humankind addresses the central issue — population size and the natural resource base needed to support it cannot be separated. Migration of humans, including immigration, is generally viewed as an ethical issue, but there is a strong interconnection between human population size, both globally and locally, and the size and health of the natural resource base.

The fundamental issue of human survival (sustainable use of the planet) is how to develop a harmonious relationship between humankind and natural systems. Until this relationship develops,

[15]See Cairns J Jr (2004) Allocating finite resources on a finite planet. ESEP 2004:25–27, available online at http://www.esep.de/articles/esep/2004/E47.pdf; Cairns J Jr (2004) You and Earth's resources. ESEP 2004:9–11, available online at http://www.esep.de/articles/esep/2004/E45.pdf

catastrophes of anthropogenic origin will occur and humankind must learn to cope with them. Better yet, by taking the precautions espoused by ecological and sustainability ethics, humankind can help avoid many of these catastrophes. The emotional attachment humankind has to its unsustainable practices is placing billions of people at risk.

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