Carrying Capacity, Exponential Growth, and Resource Wars

Ethical dilemmas of human society

by John Cairns, Jr.

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

> *"History is a vast early warning system."*
> — Norman Cousins

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

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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 catastrophes 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.

> *"...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

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 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 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.

"Driving a species to extinction to temporarily avoid policy issues and to avoid elimination of unsustainable practices is a poor management decision."

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 Washington, 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 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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LITERATURE CITED

Ehrlich, P. R. 2001. "Intervening in evolution: ethics and actions." In *The Future of Evolution*, N. Myers and Knoll,

A. H., eds. Washington, DC: Proceedings of the National Academy of Sciences 98(10):5477-5480.

Ehrlich, P. R. and Ehrlich, A. H. 1981. *Extinction: The Causes and Consequences of the Disappearance of Species*. New York: Random House.

Elton, C. S. 1958. *The Ecology of Invasions by Plants and Animals*. London, England: Methuen Publishers.

Erwin, D. H. 2001. "Lessons from the past: Biotic recoveries from mass extinctions." In *The Future of Evolution*, N. Myers and Knoll, A. H., eds. Washington, DC: Proceedings of the National Academy of Sciences 98(10):5399-5403.

Fleck, J. 2002. "Much of snow won't make it to rivers." *Albuquerque Journal* 268:A1, A2.

Franklin, B. 1755. *Observations Concerning the Increase of Mankind, People of Countries*. Boston, MA: S. Kneeland.

Gregor, M. 1996. Translation of Kant, I, *The Metaphysics of Morals*. Cambridge, United Kingdom: Cambridge University Press.

Hardin, G. 1969. *Population, Evolution and Birth Control, 2nd Ed*. San Francisco, CA: W. H. Freeman.

Hawken, P., Lovins, A., and Lovins, H. 1999. *Natural Capitalism: Creating the Next Industrial Revolution*. New York: Little Brown & Co.

Hibbard, D. 2002. "City suffers leadership drought." *Albuquerque Journal* 270:A13.

Honderich, T. 1995. *The Oxford Companion to Philosophy*. Oxford, United Kingdom: Oxford University Press.

Jackson, V. B. C. 2001. "What was natural in coastal oceans?" In *The Future of Evolution*, N. Myers and Knoll, A. H., ed. Washington, DC: Proceedings of the National Academy of Sciences 98(10):5411-5418.

Jonas, R. B. 1997. "Bacteria, dissolved organics and oxygen consumption in salinity stratified Chesapeake Bay: an anoxia paradigm." *American Zoologist* 37:612-620.

Kinne, O. 2001. *Eco-Ethics Further Developed Text*. Eco-Ethics International Union.

Linthicum, L. 2002a. "Minnow allies say don't fault fish." *Albuquerque Journal* 269:A1, A2.

Linthicum, L. 2002b. "Fed 'God Squad' may decide minnow's fate." *Albuquerque Journal* 268:A1, A2.

Malthus, T. 1798. "An Essay on the Principle of Population." From the *Norton Critical Edition*, Philip Appelbaum, ed. New York: W. W. Norton & Company.

Mooney, H. A.. and Cleland, E. E. 2001. "The evolutionary impact of invasive species." In *The Future of Evolution*, N. Myers and Knoll, A. H., eds. Washington, DC: Proceedings of the National Academy of Sciences 98(10):5446-5451.

Myers, N. and Knoll, A. H. 2001. "The biotic crisis and the future of evolution." In *The Future of Evolution*, N. Myers and Knoll, A. H., eds. Washington, DC: Proceedings of the National Academy of Sciences 98(10):5389-5392.

Nitecki, M. H. and Nitecki, D. V. 1993. *Evolutionary Ethics*. Albany, New York: State University of New York.

Odum, E. P. 1996. *Ecology: A Bridge between Science and Society*. Sunderland, MA: Sinnauer Associates, Inc.

Smyth, G. 2002. "Israel 'may use Iraq' to push regional ambitions." *London Financial Times* Oct 3(http:llnews.ft.com/servlet/ContentServer?)Pagename=FT.com/StoryFT/FullStory=StoryFT cid=1031119869048p=1012571727172).

Soussan, T. 2002a. "Judge orders water released for minnow." *Albuquerque Journal* 262:A1, A3.

Soussan, T. 2002b." Most say act goes too far." *Albuquerque Journal* 262:A1, A3.

Tilman, D. and Lehman, C. 2001. "Human-caused environmental change: impacts on plant diversity and evolution. Proceedings of the National Academy of Sciences 95(10):5433-5440.

Wackernagel, M. and Rees, W. 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, British Columbia, Canada: New Society Publishers.

Western, D. 2001. "Human-modified ecosystems and future evolution. Proceedings of the National Academy of Sciences 95(10):5458-5465.