

Malthus Revisited

Sustainability and the denial of limits

by John Cairns, Jr.

Abstract

In the bicentennial year of Malthus' seminal paper, human society is still debating whether the evidence of biophysical limits on population growth (which applies to other species) also applies to *Homo sapiens*. In terms of evolutionary or geological time, 200 years is a trivial span to test such a hypothesis.

Human ingenuity and technology appear to invalidate Malthus' hypothesis, although the present living conditions of at least 2 billion people support Malthus' idea. However, the emerging debate on sustainable development or sustainable use of the planet has again raised questions about whether infinite growth in any species can occur on a finite planet. No other habitable planets are known and, even if they are discovered, shipping 95 million people annually to another location might exhaust Earth's resources more quickly than sustaining the population here. As many others have noted, human society is engaged in a global experiment with no "control" planet. Unlike changing from an airplane that may be in poor condition, humans do not have the option of catching another planet. This paper analyzes some of the issues raised by Malthus in a sustainability context.

What Hasn't Changed in the Last 200 Years?

(1) Human society still views complex, interactive systems in terms of special interest components (i.e., those of obvious interest personally or to an applicable group). The failure in

this view is not realizing that affecting the components affects the system, and the system affects the components and, ultimately, human society.

(2) Human society looks for single connections rather than patterns. Those who look at patterns are disregarded because the short-term uncertainty is usually higher than for simple, even limited, multiple connections.

(3) Human society rarely acknowledges the programmatic futility of single-interest, lobby- (i.e., money-) dominated politics.

(4) A touching but dangerous belief is that problems caused by technology can be solved by more technology, rather than by changes in societal behavior.

What Has Changed in the Last 200 Years?

(1) The power of individuals, especially terrorists, to place the social order in disequilibrium has vastly increased and is becoming worse.

(2) Ecological capital (e.g., old growth forests, etc.) has decreased dramatically. The per capita decrease is even more dramatic due to increased numbers of humans.

(3) Economic and, arguably, ecological disparities for individuals have markedly increased, thus providing disincentives for the average human to work for the common good.

(4) Natural systems are highly manipulated parts of industrial society. As Holmberg and Robert (draft) state: "The industrial society can be said to be a highly manipulated part of the natural ecosystem, but its dependence on, and influence on, the natural ecosystems are determined by the same basic laws of nature that are in operation in nature itself."

Uncertainties Associated with Human

A wrongdoer is often a man who has left something undone, not always someone who has done something.

— Marcus Aurelius

All man's troubles arise from the fact that we do not know what we are and do not agree on what we want to be.

— Vercors (Jean Bruller)
You Shall Know Them (1953)

John Cairns, Jr. is University Distinguished Professor of Environmental Biology Emeritus in the Department of Biology at Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. He retired in 1995 but maintains an office and continues to do research and to write.

Society's Largest Experiment

As Schneider and Londer (1984) note, climate both influences and is influenced by life on Earth — the two appear to have coevolved. Unquestionably, the interactions are intricate and profound. Persuasive evidence also indicates that human society and natural systems are coevolving (e.g., Janzen, 1984; Cairns, 1994, 1997a). Cairns (1996) notes that this type of coevolution can be either hostile or benign (the relationship leading to sustainability). The harmonious aspects of coevolution in natural systems are often the result of harsh penalties exacted on those individuals or components that do not respond adequately or with sufficient rapidity to alterations in other components. In more blunt terms, global experiments with climate and ecological life-support systems can result in extremely harsh penalties to human society. If significant uncertainties about the outcomes of various courses of action (such as crossing an ecological threshold without realizing it or relying on human ingenuity and technology to replace all exhausted resources) are in error, human society may cease to exist as it is now known.

Non-renewable resources, such as fossil fuels, are being exhausted at a substantial rate, as are renewable resources/ecological capital such as topsoil, old growth forests, and fossil water. Population is still increasing despite birth rates that are less than replacement rates in some parts of the world, and the disparity in per capita resource use and living standards is increasing at the individual and national levels as well. Equitability and fairness for the entire planet's human population will be resource-use intensive, and efforts to increase standards of living for the billions now deprived will almost certainly be a final blow to Earth's ecological life support system.

The Uncertainty/Risk Paradox

The absence of certainty is not synonymous with the absence of risk. The statement is platitudinous, but 200 years of inaction since Malthus' seminal publication indicates that this statement is not commonplace for a number of societies. The December 1997 Climate Summit in Kyoto, Japan, indicates a reluctance by human societies to accept that their unwillingness to change their behavior does not suspend

consequences of biophysical (i.e., natural) laws. The next "Kyoto Summit," whenever and wherever it is held, will almost certainly be convened to discuss ways to minimize the consequences of climate change. At the time of the 1997 summit, the news media reported that increased ultraviolet radiation from depletion of the protective ozone layer may be responsible for the demise of salamanders and other amphibians. Even before such evidence became available, amphibians were suffering despite the uncertainty/risk dilemma, even 200 years after Malthus' publication.

One of the major consequences of the increasing temporal, spatial, and intensity scales of environmental problems is an increase in the

"...increasing standards of living for the billions now deprived will almost certainly be a final blow to Earth's ecological life support system."

uncertainty of predictions of environmental outcome and consequences. Tolerance of scientific uncertainty and tolerance of risk are both appropriate subjects for debate before decisions are made that will affect environmental health and condition. However, they are linked — acting with an intolerance of uncertainty usually demands a high tolerance for risk. If the consequences of inaction are likely to be severe, even though not certain, one should be willing to act even in the face of high uncertainty.

Cairns (1992) notes a vast difference between the response to perceived personal risk as opposed to risk to ecosystems. Chemicals may kill a few people and take a few years off the lives of others, but the collapse of Earth's life support systems may kill billions, or at best, cause billions to suffer. In an interesting article in *Science* (January 19, 1990), asbestos abatement costs versus the budget for the National Institutes of Health (NIH) were covered, as well as asbestos risks in the perspective of other hazards, such as long-term smoking, home accidents, motor vehicle accidents, high school football, and the like. For some reason, a chemophobia exists for both certain chemicals and the perceived risks from them, however improbable

according to the evidence. These fears are greater than the much more probable, though not certain, risks from the collapse of Earth's life support systems. Human society will not be able to address crucial societal problems until it comes to grips with the uncertainty/risk paradox and realizes that uncertainty does not permit it to evade the laws of nature (nor do economic and social needs).

Rights versus Responsibilities

In order to avoid the suffering predicted by Malthus, human society would either have: (1) to practice mutually agreed coercion to limit population size and utilization of resources to fit the planet's carrying capacity or (2) to depend on an enlightened citizenry with sufficient compassion for future generations and other species to impose these restrictions voluntarily. However, a strong distrust of government and an increasingly vocal, militant stress on perceived individual rights exist at present. In his forthcoming book *You're Driving Me Crazy*, Scott Geller (personal communication) gives much attention to aggressive automobile driving. This situation is just one of many examples of decreased civility and lack of concern for others. To offset this trend, Geller, (1994, 1996) espouses an "actively caring model," which stresses the positive benefits of appropriate behavior rather than the dire consequences of inappropriate behavior.

In the United States, and likely in other countries as well, many grandparents are caring for their grandchildren because the grandparents feel more responsibility for these children than their actual parents. Many others of the same age as the grandparents or younger have had adult children return to their home so that these adult children can continue the lifestyle they previously enjoyed, without earning enough money to do so on their own. These adult children feel they have a "right" to these services, whether it means asking someone else to care for children they have produced but are incapable of caring for, or whether it is a lifestyle to which they have become accustomed but which

they are incapable of achieving on their own. The reason for introducing these depressing circumstances is to illustrate the point that some people feel an intense responsibility and others are almost polar opposites, despite being members of the same extended family. Given the shocking display of irresponsibility of large segments of society, even when their own offspring or close family members are involved, is it realistic to expect a feeling of responsibility for passing on a habitable planet to future generations? In addition, is it reasonable to expect those so insistent on the exercise of their own perceived "rights" (to the extent that they neglect or ignore the rights of blood relatives) to show restraint that will permit future generations of their own species

and other species to survive or, better yet, thrive? Ecologist Kinne (1997) feels that modern societies are preparing the scene for suicide by destroying the basis of life on Earth. Wilson (1993) expresses a similar view in a *New York Times* Sunday magazine supplement.

One wonders how Malthus would analyze the present situation, except that he might state that there is no "right" to survive, either as individuals or societies! The opportunity to survive exists if human society pays careful attention to the

biophysical laws of nature. However, this acknowledgment is only the first step. Ehrlich (1997) discusses what professional ecologists should be doing about the world's plunge toward ecocatastrophe. He notes that increasing numbers of ecologists are beginning to understand that the major thrust in saving the world will occur in the realm of the social sciences—especially in ecological economics. This scenario will mean venturing into areas that make most ecologists, and scientists in general, exceedingly uncomfortable. However, Wilson (1998a) believes that now is the time for "hard" sciences and the social sciences to come together. Not too long ago, an applied ecologist was considered a second-rate citizen by the theoretical ecologists. This hierarchy still exists, and there are vestiges of this relationship remaining to this day.

What in the 1990s Would

“Given the shocking display of irresponsibility of large segments of society ... is it realistic to expect a feeling of responsibility for passing on a habitable planet to future generations?”

Surprise Malthus?

Leopold (1966), who effectively expressed the joy of ecology, was acutely aware of its pain, as shown by the statement:

One of the penalties of an ecological education is that one lives alone in a world of wounds... An ecologist must either harden his shell and make believe that the consequences of science are none of his business, or he must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise.

Ehrlich (1997) recounts personal observations of wounds developing in healthy ecosystems in numerous and widely scattered portions of the planet. Malthus was primarily concerned with the ability of *Homo sapiens* to produce offspring well beyond the replacement rate, even in his era, and about the limitations of resources, particularly food, on a finite planet. He was not concerned, nor was there then reason to be, about the dramatic assault on the environment that has caused the present problems of biotic impoverishment, fragmentation of habitat, ozone holes, global warming, and loss of topsoil well beyond the replacement rate.

How would Malthus feel about these situations in the bicentennial year of his remarkable article? Clearly, sustainable use of the planet was on his mind but, of course, the current phrase "sustainable development" was not. The following are a few of the issues I think would have startled Malthus if he had available a fast-forward time machine permitting access to 1998.

(1) *Even 200 years later, the basic issue is still being debated — are there too many people with too high expectations for a finite planet?*

Despite extensive analyses of the ethical problems (Hardin, 1972, 1993) and population issues (Ehrlich, 1968; Ehrlich and Ehrlich, 1996; Ehrlich et al., 1995) involved, most people are either unaware of the problem or are in a state of denial (Orr and Ehrenfeld, 1995).

(2) *The degree of isolation still continues in the academic disciplines.*

While scientists are more numerous today than in Malthus' time, they are more isolated from each other and far more specialized. The reductionist approach has certainly accomplished much, but the

resulting isolation of the disciplines has resulted in a paucity of synthesis as to how the world works.

(3) *A global economy makes resource depletion possible.*

The existence of a global economy makes resource depletion in an area far removed from one's living space quite possible. Thus, Australian forests may supply Japan; the Arabian Peninsula and other areas far distant from the United States supply some of its oil; and many nations deplete ocean resources, which are "common grounds," except, of course, for the areas adjacent to particular nations and claimed by them.

(4) *Some nations have achieved a birth rate below replacement level (e.g., Italy, at 1.35 or so children per woman) and others are still far above replacement rate (e.g., Nigeria).*

Zero population growth is possible, but not universal. I am ambivalent about whether Malthus would be surprised by the legal and illegal immigration into such countries as the United States and Canada. He would probably be surprised that individuals from developing countries could so easily colonize developed countries, given the territoriality of most nations and individuals. For a "nation of immigrants" such as the United States, there is a lack of awareness regarding the effect this will have on long-range demographics (e.g., Lutton and Tanton, 1994), and there is sympathy for immigrants since American ancestors were in this category.

(5) *Malthus would probably be astonished that, with an environmental crisis unprecedented in human history and a human population far larger than even at the beginning of the century, there is so much "business as usual" in the academic community, which might be expected to address these issues more vigorously.*

Harold Mooney, once president of the Ecological Society of America, is quoted by Ehrlich (1997) as stating (to Ehrlich) that one could read an entire year of the journal *Ecology* and not be made aware that an ecological crisis exists. How can ordinary citizens be expected to believe in an ecological crisis if the ecological journals do not proclaim this continually? In recent years, the Ecological Society of America has begun producing a second journal, *Ecological Applications*, which does indicate the existence of an environmental crisis. Is this enough? If there is, in fact, a severe ecological crisis (and I believe there is)

it should be proclaimed in every professional journal of ecology as an indication that ecologists have shifted their priorities. The public perceives academics as studying questions and issues that are important for scholarly reasons, but which may be shockingly irrelevant to “real world problems.” If scientists were making everyone aware of the ecological situation, Lubchenko (1997) would not have had to exhort the entire scientific community to mount “a more effective, interdisciplinary ... effort on the environment.” Lubchenko asks scientists to redirect their efforts and form a new social contract to this end. Presumably, the effort would include all those who signed the World Scientists’ Warning to Humanity (Union of Concerned Scientists, 1992), even though they are not allocating a large amount of their professional time to addressing environmental issues, but rather continue in almost complete absorption with their areas of specialization. Since over 1600 scientists signed the warning, I am assuming that at least a substantial

may achieve in the short term. While this is not always the case, it is true often enough to substantiate the point that the growth of money and the enhancement of human welfare are not coincident.

(7) *Many people still believe that the planet has enough resources to last indefinitely if human ingenuity and technology are coupled with economic development and allowed to proceed unhampered by environmental activists.*

Malthus clearly believed in limits and would almost certainly be appalled by both human society’s indifference to limits and, even more troublesome, denial that they exist. Rohe (1997) eloquently reaffirms a finite planet and a world of limits. He admits as unknown how many people the planet can accommodate — but maintains that limits exist. The central hypothesis of the Reverend Malthus was the question “Will human numbers eventually outstrip the carrying capacity of the landmass?” The Carrying Capacity Network (CCN), a non-profit organization in Washington, D.C., defines carrying capacity as “the number of individuals who can be supported without degrading the physical, ecological, cultural, and social environment, i.e., without reducing the ability of the environment to sustain the desired quality of life over the long term.” Although phrased somewhat differently, this definition is the goal of sustainable development (e.g., World Commission on Environment and Development, 1987),

sustainable use of the planet (e.g., Cairns, 1997b,c), or leaving a habitable planet for future generations. The United States has seen, in just two centuries, the fallacy of maintaining the illusion of unending, inexhaustible resources. Has this obviously naive faith of the frontier society merely been replaced by a faith in unlimited, inexhaustible human creativity and technology, or is there something more?

Orr and Ehrenfeld (1995) believe that willful blindness to ecological/environmental crisis has reached epidemic proportions. Ehrlich and Ehrlich (1996) observe a betrayal of science and reason and have coined the term “brownlash” to describe the propaganda campaign designed to create skeptics who believe that ecologists (or anyone else) are unnecessarily taking the threat of deteriorating life support systems seriously. Ehrlich (1997) notes a major effort in the United States, both within the

“Has the obviously naive faith [in exhaustible resources] of the frontier society merely been replaced by a faith in unlimited, inexhaustible human creativity and technology...?”

number of them, arguably even a majority, are still primarily preoccupied with the specialized area of research that resulted in a “world class” status.

(6) *Companies and, frequently, individuals externalize the costs of doing business and, thus, reap a disproportionate share of benefit, while disseminating the cost throughout society or substantial portions of society.*

Hardin’s (1968) classic paper is arguably the most concise and effective examination of this problem of cost shifting. More recently, Hawken (1993), a businessman deeply concerned about environmental problems, described the situation very effectively:

The more able a company is to externalize its cost of doing business and to be ruthless in its practices, the greater return on capital it

government and without, to roll back regulations for environmental protection.

An equally daunting obstacle hinders the attainment of sustainability. Durant and Durant (1968) surmise from their study of history that a large gap in per capita income between the wealthy and the poor always demands a redistribution of wealth, either by revolution or government action. Quite clearly, if mechanisms needed to attain sustainability are perceived as creating more hardship for the poor, who vastly outnumber the wealthy, this faction of society will, at the very least, be hesitant to support sustainable use of the planet because they will not view it as being beneficial to either them or their descendants. Since Malthus was attacked for his views in his lifetime, he probably would not be surprised by the shifting defense tactics designed to avoid admitting there are limits.

Denial of Limits

Malthus would find the denial of limits stronger in 1998 than 200 years ago. The frontiers of the planet are essentially gone — certainly those that would be hospitable to long-term human residence. Population growth on the planet in the last 200 years has followed Malthus' expectations. Almost certainly, the view of Earth from outer space, Sagan's (1994) *Pale Blue Dot*, put an end to the idea of unlimited space and resources for most rational people. True, the oceans are viewed as an unexplored frontier, but they are not as easily colonized by humans as the relatively uninhabited parts of Earth were in Malthus' time. Some also claim that resources are available on the moon, but the difficulties in summer 1997 with the MIR space station indicate that utilizing these resources will not be easy and may not be cost effective. Even if the oceans could be colonized and resources could be obtained from the moon, human capacity for reproduction would still, in a few hundred years at most, encounter a new set of limits.

In Malthus' time, the ecological collapse of ancient civilizations (e.g., Diamond, 1994, 1997) was not as well known as today. Monitoring of environmental conditions, while not all it could be,

is enough to provide warnings of serious declines in ecosystem quality. A number of studies have been provided in the literature on resource depletion and overutilization (Postel et al., 1996; Carson, 1962; Hardin, 1968, 1993). Without question, the opportunity to become environmentally literate is far greater than it was in Malthus' time. Despite this, the acknowledgment of limits seems to be no greater.

Wilson (1993) feels that humans are smart enough and have time enough to avoid an environmental catastrophe of civilization-threatening dimensions. However, he acknowledges that the technical problems are sufficiently formidable to require a redirection of much of science and technology, and that the ethical issues are so basic as to force a reconsideration of the human self-image as species. People who write on the environmental crisis, sustainability, and ecological limits must be optimistic about what human society could do, or why bother to publish on this subject? Most, however, are apprehensive about what human society will do. It seems inescapable, given the conditions of poverty and hunger today, that a large part

of humanity will suffer even more in the future because of the glacial slowness of social change. The longer the recognition of limits is postponed, the greater the suffering and societal disruption will be.

Ecological restoration partially reverses the damage to a naturalistic assemblage of plants and animals, but it can only occur while the species exist to recolonize the damaged area. Biotic impoverishment is now occurring at a much greater rate than in Malthus' time, and, if it is not now at a crisis level (and there is persuasive evidence that it is), it soon will be. The next three to five decades will tell whether restoration ecology is merely a "body and fender shop" that repairs damaged ecosystems at an inadequate rate or whether restoration ecology is one of the keys to sustainable use of the planet.

“[E.O.] Wilson feels that humans are smart enough and have time enough to avoid an environmental catastrophe of civilization-threatening dimensions.”

Waiting Until the Last Day Hardin (1993) gives a marvelous illustration of exponential growth — starting with a single lily pad of a specific size in a pond of a specific size and a specific rate of increase. When will the pond be half-covered with lily pads? This growth will be accomplished on the 29th day, assuming a daily doubling rate. The pond will be fully covered with lily pads on the 30th day, or the next day. The pond's carrying capacity for lily pads, which was only half reached on the 29th day, was fully reached on the 30th day. After the 30th day, half the lily pads produced would suffer seriously because of lack of room, or all the pads would have less surface area to share in collecting photosynthetic energy. These two conditions presumably would result in a declined quality of life for lily pads or, in fact, for the entire plant. Not mentioned in Hardin's example, but quite obvious to an ecologist with his background, is the detrimental effect upon other members of the pond's community of having even half the pond covered with lily pads. Photosynthetic organisms would be deprived of sunlight; organisms eating these would be deprived of nourishment; the pond would be deprived of oxygen produced by organisms such as algae; and nutrient and energy transfer systems would be dramatically altered.

Malthus identified with the problem of carrying capacity over 200 years ago when Earth was far short of reaching these limits. Limits have been expanded by increasing the amount of agricultural land (thus depriving other species of their habitat) and by technological advances, but these increases do not mean that limits have disappeared, but only that their effects have been postponed. When a population with exponential growth crosses a threshold, it usually does so with amazing rapidity, as in the lily pad example.

Why Malthus' Message Is Still Not Received Loud and Clear

Either empirical evidence, plausible speculation about how the situation can be relieved, statements that if the free market economy were given a chance the problem would not exist, or outright denial that there is a problem exist on every issue that appears to illustrate the existence of limits. A selection of illustrative examples follows.

(1) *The world is running out of food.*

Brown (1995) has an extensive and relatively recent analysis of the food situation in China. In contrast, Prosterman et al. (1996), in *Scientific American*, asserted that China's food problems could be met if three conditions were implemented. One of these concerned agricultural development of "waste" land. Presumably this land is now in ecosystems undeveloped by humans, but which furnish services benefitting humans. Such a condition is a short-term, unsustainable solution to a long-range problem. The surprising consequences of exponential growth are not the sole province of population biologists, but results of unbridled growth have been in folktales and the like for centuries. Meadows et al. (1993) use an old Persian legend about an astute courtier who gave a splendid chessboard to his king. The courtier suggested that in exchange the king give him one grain of rice for the first square on the board, two grains for the second square, four grains for the third, etc. Marveling at his good fortune, the king agreed and ordered the rice to be brought from the storehouses. The fourth square in the chessboard required 8 grains, the tenth took 512 grains, the fifteenth 16,384, and the twenty-first square gave the courtier more than a million grains of rice. By the time

"When a population with exponential growth crosses a threshold, it usually does so with amazing rapidity..."

the counting had reached the fortieth square, a million million grains of rice had to be piled up. The payment could never have continued to the sixty-fourth square because it would have taken more rice than was available. Given the ubiquity of both folktales and peer-reviewed scientific literature, it is difficult to understand how oblivious policymakers remain regarding the consequences of exponential growth.

(2) *Homo sapiens is not exempt from the iron biophysical laws of nature that limit other species.*

An obituary of recently-deceased optimistic economist Julian Simon (Anon., 1998) notes that he "challenged the popular (and still widely held) view

that there were limits to growth; in particular that the earth's natural resources were becoming so scarce that they would become even costlier." Simon (Myers and Simon, 1994) also stated that "we now have in our hands the technology to feed, clothe, and supply energy for the next seven billion years." If human ingenuity, creativity, and technology free human society from limiting factors that affect other species, clearly Malthus was wrong. It seems premature to have so much faith in human ingenuity while "poverty, misery, vice, selfishness, famine, disease, and war" (Malthus, as quoted by Himmelfarb, 1998) are so frequently in the news. To this list one might add: terrorism, AIDS, worldwide economic problems, climate change, biological/chemical warfare agents, and aggressive drivers.

(3) *Human society is in ecological denial.*

Orr and Ehrenfeld (1995) believe that human society is in a state of denial about ecological problems. Since denial exists in many forms these days, one more addition to the list is not surprising.

(4) *Society's approach to multidimensional problems is compartmentalized and fragmented.*

Leopold (1990) notes that each government agency often acts as if it were "the only flower facing the sun." Regrettably, the same accusation all too often applies to academic disciplines (e.g., Cairns, 1993). Even a holistic problem such as sustainable use of the planet is fragmented into sustainable-energy, -transportation, -agriculture, and the like. Wilson's (1998a, in press) consilience (literally "leaping together") of a presently fragmented system provides persuasive grounds for optimism.

Perceived Societal versus Personal Risk

A number of possible explanations could be given for the general view on societal risk. The first is the fatalistic view that could be expressed: if one is sailing on the Titanic, one might as well go first class.

A second view is that "everyone else is doing it," why should I suffer? This perspective is especially true in societies where irresponsible, but sexually active, persons have children without being able to support them. Society is then placed in the regrettable position of protecting the child from suffering. In some areas, competition for control is

leading groups to increase their own population in the hope of freeing themselves from domination by some other cultural or ethnic group.

The third view relates to the use of credit cards — gratification is immediate and consequences are postponed, although not for long. A number of other views of societal risk are possible, but these three are highly probable and not mutually exclusive.

The matter becomes more puzzling where individual risk is concerned. Geographer Charles M. Good (personal communication) is studying the incidence of sexually transmitted diseases (STDs) in Africa and in Southeast Asia. He finds that even when the risks are apparent, risky behavior continues. Many inhabitants of more developed countries continue to smoke cigarettes despite mounting evidence about the consequences. If individuals ignore warnings about personal risk, are they likely to pay much attention to Malthus?

Virtual Reality Graveyards

On December 22, 1997, the English language broadcast from Radio Japan carried a fascinating news item that space for burial could be acquired on the Internet. The Japanese respect and honor their ancestors and their final resting places, but burial sites in Japan are becoming extraordinarily expensive and, even then, difficult to acquire because of the aging population, the large size of Japan's population, and shortage of space. Apparently the Internet offers the ability to call up an image of the gravestone and grave site, together with a biographical sketch of the ancestor. One can also have one's own Internet tombstone, apparently with the names of the living color-coded differently from the names of the deceased. Additionally, the caring rituals, such as cleaning, leaving flowers, and other marks of respect, could be carried out on the Internet as in traditional graveyards on traditional gravestones. Furthermore, the burial site could be visited at any time, regardless of time of day, inclement weather, or amount of time available. One wonders whether the computer screen can produce the same aura evoked by real tombs and real graveyards and whether the location in one's home will have the same effect as a particular geographic location with real burial sites. Japan and other Asian countries have already led the way in producing virtual reality pets, and one wonders whether the relationship of humans with nature will suffer the same transformation. The difference, however, is that human society may reverse and

respect its ancestors, may cherish its pets, but it is dependent on natural systems and their services. A computer screen may substitute, to some degree, in the emotional part of the relationship (although even this is questionable), but not in terms of the biophysical services provided. If human society cannot provide space for its deceased ancestors, held in much respect, is it likely that space for living individuals of other species will get serious attention if human society does not admit an interdependent relationship with these other species?

Economists

As a regular viewer of Rukeyser's *Wall Street Week in Review* on public television, I am frequently reminded that economists are often far off target; however, as Rukeyser himself notes, this shortcoming does not seem to diminish their followings appreciably. A healthy economy is necessary, and the general public seems to accept this claim universally. However, comparable statements about the well-being of ecosystems and their influence on human society are rarely made and generally not believed by the general public. Both economics and ecology have their share of individuals who, according to the ancient Chinese saying, "watch the sky from the bottom of the well" — referring to those having a very limited outlook or who are narrow-minded. As Wilson (1998b) notes, scientists often learn what they need to know in their specialized area, often remaining poorly informed about the rest of the system they inhabit. Doubtless, every profession has its share of highly specialized persons who are remarkably well informed about a very narrow area. Their research is often unintelligible to people in their own general field, except for a few kindred spirits. Most professionals are extremely reluctant to venture outside their area of high competence, either because the other areas are, in their view, less important or because they fear being less well informed and, thus, vulnerable to criticism. Certainly, making connections with other parts of their profession, other parts of science, and even, for some, with the rest of the world they live in, is considered professionally risky and, therefore, unacceptable.

Ecologists

Although the field of ecology as a formally recognized entity did not exist in Malthus' time, his

writings have enormous ecological implications. Since ecology is a scientific field, it seems appropriate to examine Malthus' model with a scientific perspective — namely, an organized systematic enterprise that gathers knowledge about the world and condenses the knowledge into testable hypotheses and principles. Wilson (1998b) concisely states that some diagnostic features of science are useful in distinguishing it from pseudoscience.

(1) *Repeatability.*

Numerous instances have been documented of population crashes (resulting from exceeding carrying capacity) for other species. Diamond (1994) and Ehrlich and Ehrlich (1990) cite cases for human society also. Of course, at the global level, repeatability is out of the question — no control series of planets is available for testing, as would be necessary for many scientific experiments. However, microcosms and mesocosms can be used for some experiments. Island biography is especially instructive, which is why Diamond's writings are so persuasive.

(2) *Economy.*

Certainly Malthus attempted to synthesize information into a form that is both simple and aesthetically pleasing by using mathematics that could be followed by almost any literate person. Although his concept did not take into account the mechanization of agriculture and other components of the agricultural revolution, it was not invalidated by them.

(3) *Mensuration.*

Mensuration is the feasibility of being properly measured, using universally accepted scales. Since Malthus' time, particularly in the last century, the ability to study human population dynamics has improved enormously, and the numbers are rarely disputed. The consequences of the rate of population growth, rather than the actual numbers themselves, remain in dispute. Sewage treatment systems have become overloaded, water supply is short, schools are overcrowded, transportation systems are clogged, and cost of land for housing in populous areas has risen. The only way to ignore such consequences is to assert that the carrying capacity for humans is unlimited, even though biophysical laws show that limits exist for other species.

(4) *Heuristics.*

Heuristics is the ability to stimulate additional research often in unpredictable new directions that, in

turn, provides additional tests of the original hypothesis. The quest for goals and conditions that will facilitate sustainable use of the planet (which has received increased attention over the last decade) is one such new "direction." However, the effort is in such early developmental stages that it lacks substantive implementation for providing evidence of robust analysis because of too many fragmented viewpoints (e.g., discrete initiatives for sustainable energy, sustainable agriculture, sustainable transportation, sustainable cities, and the like).

(5) *Consilience*.

The explanations of different phenomena most likely to survive are those that can be connected and proved consistent with one another. This area is the least satisfactory and, arguably, the most crucial feature. Regrettably, as temporal and spatial scales and the level of complexity increase, the degree of uncertainty also increases appreciably. This scenario leads to challenges of experimental error, faulty science, political views masquerading as science, and the like. The fact that uncertainty exists about the consequences of particular courses of action does not mean that human society is free of risks until the uncertainties are diminished! Waiting for reduction in uncertainty could produce risks that, with 20/20 hindsight, would be clearly unacceptable. This area is probably the core of the population problem resolution. Any one who is intolerant of uncertainty must necessarily have a high tolerance for risk because the two are connected. Those who dispute Malthus focus on the uncertainty and minimize the risk. However, ignoring risk does not eliminate it, as human society has demonstrated over and over again. Perhaps this acknowledgment is why the film *Titanic* is so popular — it shows clearly the consequences of denying risk.

Conclusion

If humans are not exempt from the biophysical laws that limit other species, and they seriously impair the planet's ecological life support system beyond repair, then Malthus will be proven right at great cost to human society. Ecosystems are difficult to restore when many of the species that inhabited them have been driven to extinction. Even if Malthus is proven wrong, staying within ecologically sound limits will lead to the kind of life-quality that most people want. The rise in eco-

tourism and other related activities (e.g., bird watching) indicate that many humans derive great satisfaction from a close relationship with natural systems. At the very least, human society should wait for more persuasive evidence that it is exempt from some natural laws before committing itself irreversibly to acting on the belief that it is so exempt. This stance requires paying more than token attention to limits of ecosystem abuse on a finite planet. **TSC**

ACKNOWLEDGMENTS

I am deeply indebted to Eva Call for skillful transcription of my dictation and incorporation of many revisions into this manuscript. As ever, my long-term editorial assistant Darla Donald has been extremely proficient in preparing the manuscript for publication. I thank my colleagues Alan Heath, John Tanton, and Bruce Wallace for comments on an early draft of this manuscript. John and MaryLou Tanton brought the Durants' book to my attention.

REFERENCES

- Anonymous. 1998. Obituary: Julian Simon. *The Economist*, February:87.
- Brown, L. R. 1995. *Who Will Feed China?: Wake-Up Call for a Small Planet*. New York: W. W. Norton & Co.
- Cairns, J., Jr. 1992. "Ecosystem peril vs. Perceived, personal risk." *CHEMTECH* 22:24-27.
- Cairns, J. Jr. 1993. "The intellectual electric fence." *Annals of the Earth*, XI(3): 17-18.
- Cairns, J. Jr. 1994. "Ecological restoration: Re-examining human society's relationship with natural systems." The Abel Wolman Distinguished Lecture. Water Science and Technology Board, National Research Council, Washington, DC.
- Cairns, J. Jr. 1996. "Determining the balance between technological and ecosystem services. In Schulze, P. C., ed. *Engineering Within Ecological Constraints*. Washington, DC: National Academy Press, pp.13-30.
- Cairns, J. Jr. 1997a. "Global coevolution of natural systems and human society." *Revista de la Sociedad Mexicana de Historia Natural* 47:217-228.
- Cairns, J. Jr. 1997b. "Commentary: Defining goals and conditions for a sustainable world." *Environmental Health Perspectives*, 105(11): 1164-1170.
- Cairns, J. Jr. 1997c. "Sustainability, ecosystem services, and health." *International Journal of Sustainable Development and World Ecology*, 4:153-165.
- Carson, R. 1962. *Silent Spring*. Boston: Houghton Mifflin.
- Diamond, J. 1994. "Ecological collapse of ancient civilizations: The golden age that never was." *Bulletin of the American Academy of Arts and*

- Sciences* 47(95): 37-59.
- Diamond, J. 1997. "Paradises lost." *Discover* 18(11):68-78.
- Durant, W. and Durant, A. 1968. *The Lessons of History*. New York: Simon and Schuster.
- Ehrlich, P. R. 1968. *The Population Bomb*. New York: Ballantine Books.
- Ehrlich, P. R. 1997. *A World of Wounds: Ecologists and the Human Dilemma*. Oldendorf/Luhe, Germany: Ecology Institute.
- Ehrlich, P. R. and Ehrlich, A. H. 1990. *The Population Explosion*. New York: Simon and Schuster.
- Ehrlich P. R. and Ehrlich, A. H. 1996. *Betrayal of Science and Reason: How Environmental Anti-science Threatens Our Future*. Washington, DC: Island Press.
- Ehrlich, P. R., Ehrlich, A. H., and Dailey, G. C. 1993. *The Stork and the Plow: The Equity Answer to the Human Dilemma*. New York: Putnam.
- Geller, S. E. 1994. "The human element in integrated environmental management." In J. Cairns, Jr., T. V. Crawford and H. Salwasser, eds. *Implementing Integrated Environmental Management*. Blacksburg, VA: Virginia Polytechnic Institute and State University.
- Geller, S. E. 1996. *The Psychology of Safety*. Radner, PA: Chilton Book Company.
- Hardin, G. 1968. "The tragedy of the commons." *Science* 162:1243-1247.
- Hardin, G. 1972. *The Voyage of the Spaceship Beagle*. New York: Pelican Books.
- Hardin, G. 1993. *Living Within Limits*. New York: Oxford University Press.
- Hawken, P. 1993. *The Ecology of Commerce*. New York: Harper Business.
- Himmelfarb, G. 1998. "The ghost of Parson Malthus." [London] *Times Literary Supplement*, January 23, pp.4-5.
- Janzen, D. H. 1984. "The most coevolutionary animal of them all." Craaford Prize Lecture. The Royal Swedish Academy of Sciences, Stockholm, Sweden.
- Kinne, O. 1997. Introduction. Page XI, in P. R. Ehrlich, *A World of Wounds: Ecologists and the Human Dilemma*. Oldendorf/Luhe, Germany: Ecology Institute.
- Leopold, A. 1966. *A Sand County Almanac, with Essays from Round River*. New York: Ballantine Books.
- Leopold, L. B. 1990. "Ethos, equity, and the water resource." *Environment* 32(2): 16-42.
- Lubchenko, J. 1997. "Entering the Century of the Environment: A New Social Contract with Science." Presidential address, February 15. American Association for the Advancement of Science, Seattle, WA.
- Lutton, W. and Tanton, J. 1994. *The Immigration Invasion*. Petoskey, MI: The Social Contract Press.
- Meadows, D. H., Meadows, D. L., and Randers, J. 1993. *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future*. White River Junction, VT: Chelsea Green Publishing.
- Myers, N. and Simon, J. 1994. *Scarcity or Abundance: A Debate on the Environment*. New York: W. W. Norton.
- Orr, D. W. and Ehrenfeld, D. 1995. "None so blind: the problem of ecological denial." *Conservation Biology* 9(5): 985-987.
- Postel, S. L., Daily, G. C., and Ehrlich, P. R. 1996. "Human appropriation of renewable fresh water." *Science* 271:785-788.
- Prosterman, R. L., Hanstad, T. and Ping, L. 1996. "Can China feed itself?" *Scientific American*, Nov:90-96.
- Rohe, J. F. 1997. *A Bicentennial Malthusian Essay: Conservation, Population and the Indifference to Limits*. Traverse City, MI: Rhodes and Easton.
- Sagan, C. 1994. *Pale Blue Dot: A Vision of the Human Future in Space*. New York: Random House.
- Schneider, S. H. and Londer, R. 1984. *The Co-Evolution of Climate and Life*. San Francisco, CA: Sierra Club Books.
- Union of Concerned Scientists. 1992. *World Scientists' Warning to Humanity*. Cambridge, MA.
- Wilson, E. O. 1993. "Is Humanity Suicidal?" *The New York Times Magazine*, May 30:24-29.
- Wilson, E. O. 1998a. "Resuming the enlightenment quest." *The Wilson Quarterly*, Winter:16-27.
- Wilson, E. O. 1998b. "Scientists, scholars, knaves and fools." *American Scientist* 86:6-7.
- Wilson, E. O. In press. *Consilience: Unity of Knowledge*. New York: Alfred A. Knopf Publishers.
- World Commission on Environment and Development. 1987. *Our Common Future*. Oxford: Oxford University Press.