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Reflections on Sustainability, Population Growth, and the Environment

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The related terms, "sustainable" and "sustainability," have become popular and are used to describe a wide variety of activities which are generally ecologically laudable. At the same time, the term "compromise" is heard more frequently because the needs of the environment often are in conflict with the needs of humans. A brief examination of the question of compromise shows that a series of ten compromises, each of which saves 70% of the remaining environment, results in the saving of only 3% of the environment. Judging from the ways in which the terms "sustainable" and "sustainability" are used, their definitions are not very precise, especially when compromises are involved. An attempt is made here to give firm definition to these terms and to translate the definition into a series of laws and hypotheses which, it is hoped, will clarify the implications of their use. These are followed by a series of observations and predictions that relate to "sustainability."

INTRODUCTION

In the 1980s it became apparent to thoughtful individuals that populations, poverty, environmental degradation, and resource shortages were increasing at a rate that could not long be continued. Perhaps most prominent among the publications that identified these problems in hard quantitative terms and then provided extrapolations into the future as well as recommendations for corrective actions, was the book *Limits to Growth*

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(Meadows et al, 1972) which simultaneously evoked admiration and consternation. The consternation came from traditional "Growth is Good" groups all over the world. Their rush to rebuttal was immediate and urgent, prompted perhaps by the thought that the message of *Limits* was too terrible to be true (Cole et al, 1973). As the message of *Limits* faded, the concept of limits became an increasing reality with which people had to deal. Perhaps, as an attempt to offset or deflect the message of *Limits*, the word "sustainable" began to appear as an adjective that modified common terms. It was drawn frgm the cgncept of "sustained yield" which had been used to describe agriculture and forestry when these enterprises were conducted in such a way that they could be continued indefinitely, i.e., they could be sustained. The use of the term "sustainable" provided comfort and reassurance to those who may momentarily have wondered if possibly there were limits. So the word was soon applied in many areas, and with less precise meaning, so that for example, "development" became "sustainable development," etc. One would see political leaders using the term "sustainable" to describe their goals as they worked hard to create more jobs, to increase population, and to increase rates of consumption of energy and resources. These terms seem to have been redefined flexibly to suit a variety of objectives and conveniences.

A sincere concern for the future is certainly the factor that motivates many who make frequent use of the word, "sustainable." But there are cases where one suspects that the word is used carelessly, perhaps as though the belief existed that the use of the adjective "sustainable" is all that is needed to create a sustainable society.

"Sustainability" has become big-time. University centers and professional organizations have sprung up using the word "Sustainable" as a prominent part of their names. In some cases, these may be illustrative of what might be called the "Willie Sutton school of research management."* For example, a governor recently appointed a state advisory committee on global warming. The charge to the committee was not to see what the state could do to reduce its contribution to global warming, but rather the committee was to work to attract to the state, companies and research grants dealing with the topic of global warming.

For many years, studies had been conducted on ways of improving the efficiency with which energy is used in our society. These studies have been given new luster by referring to them now as studies in the "sustainable use of energy."

In the extreme case, one reads about "sustainable growth."

*Willie Sutton was a legendary bank robber. When asked why he robbed banks, he is said to have responded, "That's where the money is!"

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"... the discussions have centered around the factors that will determine [a] level of sustainable growth of agricultural production" (Abelson, 1990).

If we accept the idea that "sustainable" means for long indefinite periods of time, then we can see that "sustainable growth" implies "increasing endlessly," which means that the growing quantity will tend to become infinite in size. Daly (1990) has set forth clearly the impossibility of "sustained growth," which he carefully contrasts with "sustainable development." The latter makes sense for the economy, but only if it is understood to mean "development without growth." The finite size of resources, ecosystems, the environment, and the Earth lead one to recognize that the term "sustainable growth" is an oxymoron. Yet the term is used by our leaders. In a recent report from the Environmental Protection Agency (EPA) we read that

President Clinton and Vice President Gore wrote in *Putting People First*,* "We will renew America's commitment to leave our children a better nation—a nation whose air, water, and land are unspoiled, whose natural beauty is undimmed, and whose leadership for sustainable global growth is unsurpassed." (EPA, 1993)

And so we have a spectrum of uses of the term "sustainable." At one end of the spectrum, the term is used with precision by people who are introducing new concepts as a consequence of thinking profoundly about the longterm future of the human race. In the middle of the spectrum, the term is simply added as a modifier to the names and titles of very beneficial studies in efficiency and so forth that have been in progress for years. Near the other end of the spectrum, the term is used as a placebo. In some cases the term may be used mindlessly (or possibly with the intent to deceive) in order to try to shed a favorable light on continuing activities that may or may not be capable of continuing for long periods of time. At the very far end of the spectrum, we see the term used in a way that is internally contradictory.

This wide spectrum of meanings is a source of confusion because people can ask, "Just exactly what is meant when the word 'sustainable' is used?" Is the use of the word "sustainable" sufficient to identify the user as one who is widely literate, numerate, and ecolate, in matters relating to the long-range problems of the human race?

Let us examine the use of the term "sustainable" in one of the major

**Putting People First: How We Can All Change America*. N.Y: Times Books, 1992, pp.94-95.

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global reports to see if we can gain a better idea of the intended meaning of the word.

SUSTAINABILITY

The terms “sustainable” and “sustainability” burst into the global lexicon in the 1980s as the electronic news media made people increasingly aware of the growing global problems of overpopulation, drought, famine, and environmental degradation that had been the subject of *Limits to Growth* in the early 1970s (Meadows, et al., 1972). A great burst of increased awareness came with the publication of the report of the United Nations World Commission on Environment and Development, the Brundtland Report, which is available in bookstores under the title *Our Common Future* (Brundtland, 1987).

In graphic and heart-wrenching detail, this Report places before the reader the enormous problems and suffering that are being experienced with growing intensity every day throughout the underdeveloped world. In the foreword, before any definition of “sustainable,” there is the ringing call,

What is needed now is a new era of economic growth—growth that is forceful and at the same time socially and environmentally sustainable (p.xii).

One should be struck by the fact that here is a call for “economic growth” that is “sustainable.” What is “economic growth?” Is it an increase in economic activity *per capita*, or is it an increase in total economic activity? Whatever the definition, one has to ask if it is possible to have an increase in economic activity without having increases in the rates of consumption of renewable and nonrenewable resources? If so, under what conditions can this happen? Are we moving toward those conditions today? As we have seen, these two concepts of “growth” and “sustainability” tend to conflict with one another, yet here we see the call for both. The use of the word “forceful” would seem to imply “rapid,” but if this is the intended meaning, it would just heighten the conflict. A few pages later in the Report we read,

Thus sustainable development can only be pursued if population size and growth are in harmony with the changing productive potential of the ecosystem (p.9).

One begins to feel uneasy. What does the Commission mean by the phrase “in harmony with . . . ?” It can mean anything. By page 11 the Commission acknowledges that population growth is a serious problem, but then

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The issue is not just numbers of people, but how those numbers relate to available resources. Urgent steps are needed to limit extreme rates of population growth.

The suggestion that "The issue is not just numbers of people" is alarming. Neither "limit" nor "extreme" are defined, and so the sentence gives the impression that most population growth is acceptable and that only the "extreme rates of population growth" ("extreme" is not defined) need to be dealt with by some undefined process of limiting. By page 15 we read that

A safe, environmentally sound, and economically viable energy pathway that will sustain human progress into the distant future is clearly imperative.

Here we see the recognition that energy is a major longterm problem and we see the important acknowledgment that "sustainable" means "into the distant future."

As the authors of the Report searched for solutions, they called for large efforts to support "sustainable development." The most commonly quoted definition of "sustainable development" appears in the first sentence of Chapter 2:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (p.43).

This definition, coupled with the earlier statement of the need to "sustain human progress into the distant future," should form the basis for our understanding of the use of the term, "sustainable development."

Unfortunately, the definition gives no hint regarding the courses of action that could be followed to meet the needs of the present, but which would not limit the ability of generations, throughout the distant future, to meet their own needs.

The Commission recognizes that there is a conflict between population growth and development:

An expansion in numbers [of people] can increase the pressure on resources and slow the rise in living standards in areas where deprivation is widespread. Though the issue is not merely one of population size, but of the distribution of resources, sustainable development can only be pursued if demo-

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graphic developments are in harmony with the changing productive potential of the ecosystem (p.44).

Can the Commission mean that population growth slows the rise of living standards *only* "in areas where deprivation is widespread?" This statement again plays down the role of population size in exacerbating resource and environmental problems. The Commission repeats the denial that the problems relate to population size and it shifts the blame to the distribution of resources. The Commission then speaks of "demographic developments," whatever that may mean, which must be "in harmony with . . .," whatever that means. If one accepts reports that the "global productive potential of ecosystems" is declining, due to deforestation, the loss of topsoil, pollution and so forth, then the "in harmony with . . ." could mean that population also will have to decline. But the Commission is very careful not to say this.

These quotations (above) are thought to be representative of the vague and sometimes contradictory messages that are in this important report. It seems that the Brundtland Commission Report's definition of "sustainability" is, with reason, both optimistic and vague. The Commission probably felt that the definition had to be optimistic, but given the facts, it was necessary to be vague in order not to appear to be pessimistic.

Straight talk about the meaning of "sustainability" is similarly avoided in a more recent report that came out of the 1992 Earth Summit in Rio de Janeiro, which was

. . . the largest gathering of world leaders in history [which] endorsed the principle of sustainable development (Committee for a National Institute for the Environment, 1993).

The report carries the impressive title, *Agenda 21, The Earth Summit Strategy to Save Our Planet* (Sitarz, 1993). The text discusses the relation between population growth and the health of the planet:

The spiraling growth of world population fuels the growth of global production and consumption. Rapidly increasing demands for natural resources, employment, education and social services make any attempts to protect natural resources and improve living standards very difficult. There is an immediate need to develop strategies aimed at controlling world population growth (p.44).

The first sentence is quite reasonable, but in the third sentence, what is meant by "controlling?" The dictionary suggests meanings such as, "To

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check or regulate; to keep within limits; to exercise directing, guiding or restraining power over. . . ." "Controlling world population growth" could mean, "hold the annual population growth rate at its present value of approximately 1.7%," which surely was not their intent. Why do they use the phrase "controlling world population growth" when one suspects that they know full well that the critical challenge is to "stop world population growth?" Having thus made a politically correct statement of the problem, the report then lists, under the heading, "Programs and Activities," the things that need to be done. Here we would expect that the authors would concentrate on the hard realities. Instead, it is all whipped cream. Perhaps their strongest recommendation is,

The results of all research into the impact of population growth on the Earth must be disseminated as widely as possible. Public awareness of this issue must be increased through distribution of population-related information in the media (p.45).

How are we going to increase public awareness of the problem of population growth if the crucial report that purports to give guidelines for the future will not talk frankly and honestly about the problem? How are we going to educate the public about the problem of population growth if we fail ourselves to give concrete details of "the impact of population growth on the Earth?"

Then, under the next heading of "National Population Policies" we read that,

The long term consequences of human population growth must be fully grasped by all nations. They must rapidly formulate and implement appropriate programs to cope with the inevitable increase in population numbers (p.45).

The authors indicate here that they know that there are serious "long term consequences of human population growth." These consequences could have been explored in simple, concrete, and illuminating detail, and yet the authors fail to do the exploring. The authors could have educated us about the "long-term consequences of continued population growth" and then could have identified for us the appropriate remedial courses of action which are necessary to achieve zero growth of population as rapidly as possible. By referring to the "inevitable increase in population numbers" the authors seem to say that there is nothing that can be done.

This book is loaded with admonitions suggesting that we all go out and embark on programs that are sustainable. In enumerating the things

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that the authors feel have to be done, the report has both the comprehensive scope and the literary style of the Yellow Pages. The book makes many references to sustainability, yet it artfully dodges the central issues relating to the meaning of "sustainability."

Distribution, harmony, and "improvement in the capacity to assess the implications of population patterns" are important, but it seems clear that improvements in the human condition cannot be achieved without understanding and recognizing the importance of numbers, and in particular, numbers of people. As we look here in the United States, and around the world, we can see that the numbers of people are growing, and we can see places where the problems associated with the growth are so overwhelming as to make it practically impossible to address the vitally important issues of distribution, equity, and harmony.

The failure of writers to address the population problem was underscored recently by Robert M. May (1993). May, who is Royal Society Research Professor at the University of Oxford and Imperial College, London, was reviewing a new book on biological diversity. He observes that the book,

says relatively little about the continuing growth of human populations. But this is the engine that drives everything. Patterns of accelerating resource use, and their variation among regions, are important but secondary: problems of wasteful consumption can be solved if population growth is halted, but such solutions are essentially irrelevant if populations continue to proliferate. Every day the planet sees a net increase (births less deaths) of about one quarter of a million people. Such numbers defy intuitive appreciation. Yet many religious leaders seem to welcome these trends, seemingly motivated by calculations about their market share. And governments, most notably that of the U.S., keep the issue off the international agenda; witness the Earth Summit meeting in Rio de Janeiro. Until this changes, I see little hope (p. 148).

THE ROLE OF COMPROMISE ON QUESTIONS OF THE ENVIRONMENT

Environmental conflicts are often portrayed in ways that pit the needs of humans against the needs of the environment, perhaps in the belief that most people feel that the environment is unlimited, and therefore how it is treated is irrelevant. This leads to calls for compromise. Humans will take

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a little of the environment, and some of the environment will be temporarily left untouched. It is urgent that we be aware that these compromises reduce the rate of destruction of the environment (which is good), but in most instances, the ultimate result of a succession of many compromises is the destruction of the environment. For example, instead of losing 60% of the local environment in some proposed development, a compromise might result in loss of only 30% of the environment, while 70% is saved. This is good; but one needs to know that a series of ten such compromises, each of which saves 70% of the remaining environment, will result in the loss of all but about 3% of the environment ($0.7^{10} = 0.03$). There have been situations where compromises have resulted in the preservation of large reserves in order to allow other critical areas to be set aside for human settlement and agriculture. It will be interesting to see how these compromises hold up in the face of the pressures of growing populations.

Preserving the environment can lead to frustrations. In contrast to the active promotion of population growth that is seen in most communities, a community can go to great effort and expense to purchase and to preserve open space for the benefit of generations yet to come. The result is predictable. People, industries, and businesses want to move to the communities that have preserved open space and have other environmentally sensitive programs and policies. Thus the effort to preserve a local environment helps to destroy the preservation that has been achieved.

Jerome B. Wiesner was President of M.I.T. (1971-1980) and was Special Assistant for Science and Technology for Presidents Kennedy and Johnson. He made a very sobering observation about the conflict between the needs of humans and the needs of the environment:

There are no clear-cut ways to reconcile economic growth with the measures needed to curb environmental degradation, stretch dwindling natural resources and solve health and economic problems (Wiesner, 1989, p.39).

CARRYING CAPACITY

The term "carrying capacity," long known to ecologists, has also recently become popular. It "refers to the limit to the number of humans the earth can support in the longterm without damage to the environment" (Giampietro et al, 1992). The troublesome phrase here is "without damage to the environment." One damages the environment when one kills a mosquito, builds a fire, erects a house, develops a subdivision, builds a power

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plant, constructs a city, explodes a nuclear weapon, or wages nuclear war. Which, if any, of these things takes place "without damage to the environment?" Although it is not stated explicitly, the term "can support" must mean "for a very long time."

There are two ways of viewing damage to the environment. At one extreme, one could hold the view that humans are apart from the environment, so that everything humans do damages the environment. At the other extreme, one could view humans as part of the environment, so that everything humans do is a part of the course of nature and hence, by definition, is not damaging to the environment.

Human activities have already caused great change in the global environment. May (1993) observes that

. . . the scale and scope of human activities have, for the first time, grown to rival the natural processes that built the biosphere and that maintain it as a place where life can flourish.

Many facts testify to this statement. It is estimated that somewhere between 20 and 40 percent of the earth's primary productivity, from plant photosynthesis on land and in the sea, is now appropriated for human use.

Giampietro and Pimentel (1993) estimate that "about 50% of all solar energy captured by photosynthesis worldwide is already used by humans." Perhaps the definition of carrying capacity means, "without further damage to the environment?" But then we note that growing populations need growing numbers of jobs and growing rates of consumption of resources. The satisfaction of these needs is almost always at the expense of the environment. So, if we do not want to do further damage to the environment, it seems logical that, as a minimum, we must stop population growth. When we talk about carrying capacity we must focus on population numbers and on the long term. This inevitably leads to a recognition of the need to stop population growth.

It is most probable that the term "carrying capacity" has to imply attaining a period of negative growth of populations, until populations and life styles reach a level that can be maintained indefinitely (sustained) by the world's biological and physical resources. The widespread rejection of this conclusion leads one to be certain that every estimate of the number of people that constitutes the carrying capacity of a country or of the Earth will be a subject of controversy. In some cases different scientists will interpret the data differently. In other cases the entire concept of carrying capacity will come under political and ideological attack. For example,

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when Jack Kemp, who was then the U.S. Secretary of Housing and Urban Development, was informed of a report from the United Nations that told of resource problems that would arise because of increasing populations, it was reported that he said, "Nonsense, people are not a drain on the resources of the planet" (Kemp, 1992). Malcolm Forbes, Jr., editor of *Forbes Magazine*, had a similar response to the reports of global problems resulting from overpopulation in both the developed and underdeveloped parts of the world; "It's all nonsense" (Forbes, 1992). This helps make the concept of "carrying capacity" contentious and hence an unpopular one for political leaders to embrace. Nonetheless, carrying capacity is a vitally important concept, and it must become central to our thinking.

POPULATION AND THE ENVIRONMENTAL PROTECTION AGENCY

The U.S. Environmental Protection Agency (EPA) has done many constructive and beneficial things. The policies, actions, and leadership of the Agency are crucial to any hope for a sustainable society. In a recent report we read,

In view of the increasing national and international interest in sustainable development, Congress has asked the Environmental Protection Agency (EPA) to report on its efforts to incorporate the concepts of sustainable development into the Agency's operations (1993, p.2).

The Report (EPA, 1993) is at once encouraging and distressing. It is encouraging to read of all of the many activities of the Agency which help protect the environment. It is distressing to search in vain through the Report for acknowledgment that population growth is at the root of most of the problems of the environment. Unlike the report of the Brundtland Commission, the EPA report avoids making the allegation that population growth is not the central problem. The EPA report makes only a very few minor references to the problems of urban population growth.

The Report speaks of an initiative to pursue sustainable development in the Central Valley of California,

where many areas are experiencing rapid urban growth and associated environmental problems. . . . A stronger emphasis on sustainable agricultural practices will be a key element in any long-term solutions to problems in the area.

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"A stronger emphasis on sustainable agricultural practices" will not stop "rapid urban growth and the associated environmental problems . . ." and hence, an emphasis on agriculture cannot solve the problem. If the EPA is to address the "associated environmental problems," it would seem to be more important to focus on stopping the "rapid urban growth" which causes the problems. Why focus on the development of "sustainable agricultural practices" when agriculture will be displaced by the "rapid urban growth"? However, if "A stronger emphasis on sustainable agricultural practices" means *protect agricultural land from any further loss to developments*, then perhaps there is logic to the statements quoted above.

In general, with our present social systems, agriculture, sustainable or otherwise, cannot be maintained in the face of urban population growth.

In speaking of the New Jersey Coastal Management Plan for the management of an environmentally sensitive tidal wetland, the Report says,

The project involves balancing the intense development pressures in the area with wetlands wildlife protection, water quality, air quality, waste management, and other environmental considerations.

Here we are "balancing" again. In many ways, a series of balances is a way to "sacrifice the environment in an environmentally sensitive way."

In the Pacific Northwest

The EPA . . . is an active participant in these discussions, which focus on sustaining high quality natural resources and marine ecosystems in the face of rapid population and economic growth in the area.

These quotations of minor sections of the EPA report make it clear that the EPA understands the origin of environmental problems. Thus it is all the more puzzling that the Agency so carefully avoids serious discussion of the fundamental source of so many of the problems it is supposed to address.

In this report of approximately 30 pages on the Agency's programs relating to sustainable development, the term "sustainable development" is mentioned hundreds of times, and population growth, the most important variable in the equation, is mentioned just the few times cited here. It is as though one attempted to build a one hundred story skyscraper from good materials, but one forgot to put in a foundation.

A proposal for the establishment of a "National Institute for the Environment" (Committee, 1993) is being advanced. If the proposed institute is

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to be effective, its mission and charge must include, "Studying the demographic causes and consequences of environmental problems."

A PERIOD OF TIME

The pertinent definition of "sustain" is "to maintain, or to cause to continue. . . ." The definition suggests that things can be sustained for long periods of time. Thus, when the Brundtland Report speaks of "future generations" and "into the distant future," it would seem to mean "for all future generations" or "forever."

Let us be specific and state that both "carrying capacity" and "sustainable" imply "for the period in which we hope humans will inhabit the earth." This means "for many millennia."

In what follows, "standard of living" is to be thought of in terms of the average annual *per capita* consumption of goods; "carrying capacity" refers to the number of people that can be sustained. The term "resources" refers to virgin resources, while "goods" can include both virgin and recycled materials.

LAWS, HYPOTHESES, OBSERVATIONS AND PREDICTIONS RELATING TO SUSTAINABILITY

The laws, hypotheses, observations, and predictions that follow are offered in order to define the term "sustainability," which must be understood to mean, "for many millennia." In some cases these statements are accompanied by corollaries that are identified by capital letters. They all apply for populations and rates of consumption of goods and resources of the sizes and scales found in the world in 1994, and may not be applicable for small numbers of people or to groups in primitive tribal situations.

These laws are believed to hold rigorously.

The hypotheses are less rigorous than the laws. There may be exceptions to some, and some may be proven to be wrong. Experience may show that some of the hypotheses should be elevated to the status of laws.

The observations may shed light on the problems and on mechanisms for finding solutions to the problems.

The predictions are those of a retired nuclear physicist who has been watching these problems for several decades.

The lists are but a single compilation, and hence may be incomplete. Readers are invited to communicate with the author in regard to items that should or should not be in these lists.

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In many cases, these laws and statements have been recognized, set forth, and elaborated on by others.

Garrett Hardin's Three Laws of Human Ecology

We start by repeating three laws of human ecology that are given by Garrett Hardin (Hardin, 1993). These are fundamental, and need to be known and recognized by all who would speak of sustainability.

First Law

"We can never do merely one thing." This is a profound and eloquent observation of the interconnectedness of nature.

Second Law

"There's no away to throw to." This is a compact statement of one of the major problems of the "effluent society."

Third Law

The impact (I) of any group or nation on the environment is represented qualitatively by the relation

$$I = P A T$$

where P is the size of the population, A is the *per capita* affluence, measured by *per capita* rate of consumption, and T is a measure of the damage done by the technologies that are used in supplying the consumption. Hardin attributes this law to Ehrlich and Holdren (Ehrlich and Holdren, 1971).

The suggestion may be made that the Third Law is too conservative. The Third Law suggests that I varies as p^n where $n = 1$. There are situations where the impact of humans increases more rapidly than linearly with the size of the population P so that $n > 1$.

Boulding's Three Theorems

These theorems are from the work of the eminent economist Kenneth Boulding (Boulding, 1971).

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First Theorem: "The Dismal Theorem"

"If the only ultimate check on the growth of population is misery, then the population will grow until it is miserable enough to stop its growth."

Second Theorem: "The Utterly Dismal Theorem"

This theorem "states that any technical *improvement* can only relieve misery for a while, for so long as misery is the only check on population, the [technical] improvement will enable population to grow, and will soon enable *more* people to live in misery than before. The final result of [technical] improvements, therefore, is to increase the equilibrium population which is to increase the total sum of human misery."

Third Theorem: "The moderately cheerful form of the Dismal Theorem"

"Fortunately, it is not too difficult to restate the Dismal Theorem in a moderately cheerful form, which states that if something else, other than misery and starvation, can be found which will keep a prosperous population in check, the population does not have to grow until it is miserable and starves, and it can be stably prosperous."

Boulding continues, "Until we know more, the Cheerful Theorem remains a question mark. Misery we know will do the trick. This is the only sure-fire automatic method of bringing population to an equilibrium. Other things may do it."

Abernethy's Axiom

Motivation, rather than differential access to modern contraception, is the primary determinant of fertility. Individuals respond to scarcity by having fewer children, and to perceived opportunity by having more children. Contrary to the demographic transition model, economic development does not cause family size to shrink; rather, at every point where serious economic opportunity beckons, family size preferences expand (Abernethy, 1993b).

- A) Foreign aid conveys to the recipients the perception of improving economic wellbeing, which causes an increase in the fertility of the recipients of the aid.
- B) Migrations from regions of low economic opportunity to

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places of higher economic opportunity result in an increase in the fertility of the migrants that persists for a generation or two.

LAWS RELATING TO SUSTAINABILITY

First Law

Population growth and/or growth in the rates of consumption of resources cannot be sustained.

A) A population growth rate less than or equal to zero and declining rates of consumption of resources are necessary conditions for a sustainable society.

B) Unsustainability will be the certain result of any program of "development," whether or not it is said to be "sustainable," that ignores the problem of population growth and that does not plan the achievement of zero or a period of negative growth of populations and of rates of consumption of resources.

C) The research and regulation programs of governmental agencies that are charged with protecting the environment and promoting "sustainability" are, in the long run, irrelevant unless these programs address vigorously and quantitatively the determination of optimal population sizes that can be carried indefinitely and unless the programs study in depth the demographic causes and consequences of environmental problems.

D) Societies, or sectors of a society, that depend on population growth or growth in their rates of consumption of resources, are unsustainable.

E) Persons who advocate population growth and/or growth in the rates of consumption of resources are advocating unsustainability.

F) Persons whose actions directly or indirectly cause increases in population or in the rates of consumption of resources are moving society away from sustainability. (Advertising your city or state as an ideal site in which to locate new factories indicates a desire to increase the population of your city or state.)

G) The term "sustainable growth" is an oxymoron.

Second Law

The larger the population of a society, and/or the larger its rates of consumption of resources, the more difficult it will be to transform the society to the condition of sustainability.

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Third Law

The response time of populations to changes in the total fertility rate is the length of time people live, or approximately fifty to seventy years. (The consequence of this is called "population momentum.")

A) If we want the population sizes to be reduced or at least stabilized by the mid-twenty-first century, we must make the necessary changes in the total fertility rates before the end of the twentieth century.

B) We live in a time of short time horizons.

C) It will be difficult to convince people to act now to change course, when the full results of the change may not be apparent in those people's lifetimes.

Fourth Law

The size of population that can be sustained (the carrying capacity) and the sustainable average standard of living of the population are inversely related to one another.

A) The higher the standard of living one wishes to sustain, the more urgent it is to reduce population size.

B) Reductions in the rates of consumption of resources and reductions in the rates of production of pollution can shift the carrying capacity in the direction of sustaining a larger population.

Fifth Law

Sustainability requires that the size of the population be less than or equal to the carrying capacity of the ecosystem for the desired standard of living.

A) Sustainability requires an equilibrium between human society and stable ecosystems.

B) Destruction of ecosystems tends to reduce the carrying capacity and/or the sustainable standard of living.

C) The rate of destruction of ecosystems increases as the rate of growth of the population increases.

D) Population growth rates less than or equal to zero are necessary, but are not sufficient, conditions for halting the destruction of the environment.

Sixth Law: (The lesson of "The Tragedy of the Commons") (Hardin, 1968):

The benefits of population growth and of growth in the rates of consumption of resources accrue to a few individuals; the costs of population

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growth and growth in the rates of consumption of resources are borne by all of society.

A) Individuals who benefit from growth will continue to exert strong pressures supporting and encouraging both population growth and growth in rates of consumption of resources.

B) The individuals who promote growth are motivated by the recognition that growth is good for them. In order to gain public support for their goals, they must convince people that population growth and growth in the rates of consumption of resources are also good for society. This is the Charles Wilson argument: If it is good for General Motors, it is good for the United States* (Yates, 1983).

Seventh Law

Growth in the rate of consumption of a non-renewable resource, such as a fossil fuel, causes a dramatic decrease in the life-expectancy of the resource.

A) In a world of growing rates of consumption of resources, it is seriously misleading to state the life-expectancy of a nonrenewable resource "at present rates of consumption," i.e., with no growth.

B) It is intellectually dishonest to advocate growth in the rate of consumption of a nonrenewable resource while, at the same time, reassuring people about how long the resource will last "at present rates of consumption."

Eighth Law

The time of expiration of nonrenewable resources can be postponed, possibly for a very long time, by (i) technological improvements in the efficiency with which the resources are recovered and used; (ii) using the resources in accord with a program of "sustained availability" (Bartlett, 1986); (iii) recycling; (iv) the use of substitute resources.

Ninth Law

When large efforts are made to improve the efficiency with which resources are used, the resulting savings are easily and completely wiped out by the added resource needs that arise as a consequence of modest increases in population.

*"What is good for the country is good for General Motors and vice versa!" Cited in Yates, 1983, p.123.

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A) When resources are used more efficiently, the consequence often is that the “saved” resources are not put aside for the use of future generations, but instead are used immediately to encourage and support larger populations.

B) Humans have an enormous compulsion to find an immediate use for all available resources.

Tenth Law

The benefits of large efforts to preserve the environment are easily canceled by the added demands on the environment that result from small increases in human population.

Eleventh Law: (Second Law of Thermodynamics)

When rates of pollution exceed the natural cleansing capacity of the ecosystems, it is easier to pollute than it is to clean up the environment.

Twelfth Law: (Eric Sevareid's Law)

The chief cause of problems is solutions (Sevareid, 1970).

A) This law should be a central part of higher education, especially in engineering.

Thirteenth Law

Humans will always be dependent on agriculture.

A) Supermarkets alone are not sufficient.

B) The central task in sustainable agriculture is to preserve agricultural land. The agricultural land must be protected from losses due to things such as (i) erosion; (ii) urbanization and development; (iii) poisoning by chemicals; (iv) salinization; and (v) waterlogging.

Fourteenth Law

If, for whatever reason, humans fail to stop population growth and growth in the rates of consumption of resources, nature will stop these growths.

A) Nature's method of stopping growth is cruel and inhumane.

B) Glimpses of nature's method of dealing with population that have exceeded the carrying capacity of their lands can be seen each night on the television news reports from places where large populations are experiencing starvation and misery.

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Fifteenth Law

Starving people do not care about sustainability. If sustainability is to be achieved, the necessary leadership and resources must be supplied by people who are not starving.

Sixteenth Law

The addition of the word “sustainable” to our vocabulary, to our reports, programs, and papers, and to the names of our academic institutes and research programs, is not sufficient to ensure that our society becomes sustainable.

Seventeenth Law

Extinction is forever.

HYPOTHESES RELATING TO SUSTAINABILITY

1) For the 1994 average global standard of living, the 1994 population of the Earth exceeds the carrying capacity of the Earth. The limiting factor is food (Brown, 1994).

2) For the 1994 average standard of living in the United States, the 1994 population of the United States exceeds the carrying capacity of the United States (Abernethy, 1993a; Giampietro & Pimentel, 1993). The limiting factor is the use of fossil fuels—particularly for the production of food.

3) The increasing sizes of populations that result from population growth are the single greatest and most insidious threat to representative democracy.

4) The costs of programs to stop population growth are small compared to the costs of population increases.

5) For society as a whole, population growth never pays for itself. (This is a consequence of the Tragedy of the Commons.)

(A) In the United States in general, the larger the population of a city, the higher are the municipal *per capita* annual taxes.

6) The time required for a society to make a planned transition to sustainability on its own terms, so it can live within the carrying capacity of its ecosystem, increases with increases in (i) the size of its population; (ii) the rate of growth of its population; and (iii) the society's average *per capita* rate of consumption of new resources.

7) The rate (*S*) at which a society can improve the average standard of living of its people is directly related to the rate of application of new technologies (*T*) and is inversely related to the rate of growth (*R*) of the size

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of the population (the fractional increase per unit time), by a relation with the general properties of the equation,

$$S = T - AR + B$$

where A and B are positive constants.

(A) In places in the world in 1994, the value of R (the rate of growth of population) is so large that it is causing S to be negative. Said in other words, (a) population growth competes with and slows down the rate of improvement of the average standard of living and may cause the average standard of living to decline. That is, (b) population growth interferes with economic growth.

8) Social stability is a necessary, but not a sufficient, condition for sustainability.

(A) Human freedoms depend on social stability.

(B) Armed conflict (war) cannot be a part of a sustainable society.

9) In some cases, social stability tends to be inversely related to population density (Kaplan, 1994).

10) The *per capita* burden of the lowered standard of living that generally results from population growth and from the decline of resources falls most heavily on the poor.

11) When populations are growing, the rate of growth of the fraction of the population that is poor exceeds the rate of growth of the fraction of the population that is wealthy.

12) Environmental problems cannot be solved or ameliorated by increases in population or by increases in the rates of consumption of resources. Probably all environmental problems would be easier to solve if the population were smaller and/or if the rates of consumption of resources were smaller.

13) Problems of shortages of nonrenewable resources cannot be solved or ameliorated by population growth.

14) In general, the environment cannot be enhanced or even preserved through compromises. Compromises and accommodations between the immediate needs of people and the longterm needs of the environment will generally be resolved in favor of people. For the most part, compromises only reduce the rate of destruction of the environment and/or they increase the elegance with which the environment is destroyed.

15) The fractional rate of destruction of the environment that results from human activities will always exceed the fractional rate of increase of our knowledge and understanding of the environment.

(A) Every decision affecting the environment will have to be made with less than full knowledge of the risks and consequences of the decision.

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(B) Much of our knowledge of the environment has come from the study of past mistakes.

16) By the time overpopulation and shortages of resources are obvious to most people, the carrying capacity has been exceeded. It is then almost too late to think about sustainability.

(A) It is difficult to know what to do once one realizes that the population is too large.

(B) Long-range thinking, planning, and leadership, carried out with a full recognition of the laws of nature, is most urgently needed.

17) Importing nonrenewable natural resources demonstrates unsustainability; exporting nonrenewable natural resources reduces the ultimate sustainable standard of living and/or the carrying capacity of the exporting country.

18) Because of the universal nature of world trade, the concept of "carrying capacity" is difficult to apply to a nation or region.

(A) Sustainability is a global problem.

(B) The approach to sustainability must be sought on the local and national levels.

(C) If a local official speaks of his/her community as being sustainable at present standards of living, it probably is not true.

19) Sustainable agriculture cannot be based on large annual energy inputs from fossil fuels, and in particular from petroleum. "The food system consumes ten times more energy than it provides to society in food energy" (Giampietro and Pimentel, 1993).

20) In many cases, irrigation of farmland cannot be sustained (Abernethy, 1993a, p.136). The lands become poisoned with salts.

21) Hydroelectric power generated from reservoirs created by construction of large dams cannot be sustained. The reservoirs fill with silt.

OBSERVATIONS RELATING TO SUSTAINABILITY

1) *The first and most important effort that must be made in order to move toward a sustainable society is to stop population growth.* This will require the initiation of major comprehensive educational, technical, and outreach programs in the areas of social responsibility, contraception, family planning, and immigration control. The greater the degree to which the carrying capacity has been exceeded, the more probable it is that coercion will become a factor in these programs.

2) The food chain and evolution are nature's equilibrium mechanisms. They function to prevent unlimited expansion of populations of flora and fauna. Primitive human societies were able to maintain approximately con-

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stant populations and to live within the carrying capacity of their ecosystems. The methods used were often cruel and inhumane. Technology has given many people the feeling that humans are exempt from the constraint of limited carrying capacities.

3) Ancient civilizations have vanished, in part because they grew too large. Their size exceeded the carrying capacity of the ecosystems on which they depended for support, and they did not have the technology to use large quantities of distant resources. Civilizations today show considerable tendency to repeat the mistakes of earlier civilizations, but on a much larger scale.

4) The complete era of the use of fossil fuels by humans will be a vanishingly short fraction of the span of human existence on the Earth.

5) The supplies of all non-renewable resources will effectively expire when the costs (in cash, in energy, in ecological and societal disruption) of making available a quantity of the resource exceed the value of the quantity of the resource.

6) Comprehensive educational, technical, and outreach programs in the areas of efficient use of resources will be needed in order to help achieve sustainability.

7) A major use of technology is, and has been, to accommodate the growth of populations, and to remove the recognition of the importance of living within the carrying capacity of the environment. (See Boulding's Utterly Dismal Theorem and Eric Sevareid's Law.)

(A) This use of technology has had the effect of encouraging population growth.

(B) This use of technology inhibits an approach to sustainability.

(C) An essential condition for sustainability is that technology be redirected toward the improvement of the quality of life and away from its use to increase the quantity of life.

8) Creating jobs increases the number of people out of work. In a city or state, creating jobs increases the population, of which 5% to 7% are always unemployed. It follows that the increase in population that is the result of the creation of jobs is always reflected as an increase in the number of people out of work. This is the direct consequence of the ease with which people can move from places with high unemployment to places with low unemployment. In this regard, the movement of people is like the movement of molecules of an ideal gas, that tend to move until they achieve a constant pressure throughout a closed vessel.

(A) If it is desired to maintain an "island" of low unemployment, in a nation, a state, or a community, one must erect barriers to prevent the immigration of unemployed people.

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TECHNICAL PREDICTIONS RELATING TO SUSTAINABILITY

- 1) Coal and/or oil shale may last 200 years, but they probably will not be in abundant supply throughout this time. Other fossil fuels probably will not be available in globally significant quantities for more than a few decades into the twenty-first century.
- 2) If replacements can be found for fossil fuels, especially for petroleum, it will require major technological breakthroughs.
- 3) Technological progress in the future is much more likely to be characterized by incremental advances than by breakthroughs, especially in the field of sources of energy.
- 4) The probability is very small that technological developments will produce new sources of energy in the next century, sources not already known in 1994, that will have the potential of supplying a significant fraction of the world's energy needs for any appreciable period of time.
- 5) The larger the global total daily demand for energy, the smaller is the probability that a new energy source or technology will be found that will have the potential of being developed sufficiently to meet an appreciable fraction of the global daily energy demand for any extended period of time.
- 6) The larger the global total daily demand for energy, the longer is the period of time that will be required for a new energy technology to be developed to the point where it might have the capacity of meeting an appreciable fraction of the global daily energy demand.
- 7) In the event that science and technology find a new source of large quantities of energy, the probability is high that the new source will be technologically very complex, with the result that it will be extremely costly to bring globally significant quantities of the new energy to the marketplace.
- 8) All use of fossil or nuclear energy results in the direct warming of the global environment, so the possible achievement of a new large-scale technology for the production of energy will speed the global warming now believed to be caused by chemicals being released into the atmosphere.
- 9) Children born in 1990 will not live to see 10% of the energy consumed in the United States generated by terrestrial nuclear fusion (Bartlett, 1990).
- 10) There will always be popular and persuasive technological optimists who believe that population increases are good, and who believe that the human mind has unlimited capacity to find technological solutions to all problems of crowding, environmental destruction, and resource shortages.
 - (A) These technological optimists are usually not biological or physical scientists.

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(B) Politicians and business people tend to be eager disciples of the technological optimists.

11) Because population growth is only one of the factors that drives up the cost of living, the rate of increase of the cost of living will probably be larger than the rate of increase of population.

POLITICAL PREDICTIONS RELATING TO SUSTAINABILITY

1) Local and regional business and political leaders will continue to spend much of their time trying to attract new industries and populations to their areas, and to spend a prominent few minutes a week complaining and wondering what to do about the increasing pollution, congestion, crime, costs, etc.

2) Local and regional political and business leaders will continue to use the circular arguments of self-fulfilling predictions in order to generate local population growth. These are the steps in the cycle.

- (i) Quantitative projections of future population growth in the area are made.
- (ii) Plans are made to expand the municipal or regional infrastructure to accommodate the predicted growth.
- (iii) Bonds are issued to raise money to pay for the planned expansions of the infrastructure, and the infrastructure is expanded.
- (iv) The bonds must be paid off on a schedule that is based on the projections of population growth.
- (v) The political and business leaders will do everything in their power to make certain that the projected population growth takes place, so that the bonds can be paid off on schedule.
- (vi) When this results in the needed population growth, the leaders will speak loudly of their foresight.
- (vii) Go back to i) and repeat.

3) Some political and business leaders will continue to want to throw away all manner of toxic waste by dumping it on the lands of low-income or underdeveloped people, in the United States or abroad.

4) Some business leaders will want to continue to manufacture hazardous materials whose sale in the United States is prohibited, so that these materials can be sold abroad.

5) Business and political leaders will continue to find it more attractive to promote growth than to promote sustainability.

(A) It is easy to talk about sustainability.

(B) It is difficult to make realistic constructive progress toward sustainability.

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(C) Business and political leaders are not attracted to the concept of a "carrying capacity."

6) In the United States, political "conservatives" will continue to be liberal in their policy recommendations in regard to rapid exploitation and use of the Earth's renewable and non-renewable resources, with complete confidence that technology will be able to solve all of the consequent problems of shortages, pollution, and environmental degradation. Political "liberals" will continue to urge people to be conservative, to conserve and to protect the environment, to recycle, to use energy more efficiently, etc.

7) Entrepreneurs and politicians will continue to use the term "sustainable" for their own personal advantage in promotion of enterprises and programs, whether or not these enterprises and programs are sustainable or contribute to the creation of a sustainable society.

SO WHERE DO WE GO FROM HERE?

The challenge of making the transition to a sustainable society is enormous, in part because there are so many aspects of the problem. If one glances through *Agenda 21, The Earth Summit Strategy to Save Our Planet*, one is overwhelmed by the sheer number of pages of recommendations, "We must do this," "We must do that," and so forth. The book avoids the population problem, even though the authors have to know that population growth is the central and most fundamental human problem. *Agenda 21* seems to be a diversion to keep people from recognizing the centrality of population growth to the enormous problems of the United States and the world. *The immediate task is to get the population program back at the top of the national and global agendas.*

The year 1992 was the year of the United Nations Conference on Environment and Development, the Earth Summit, that was held in Rio de Janeiro. The year also marked the end of a long period of dangerous withdrawal of the United States from its active support of family planning programs throughout the world. This long period was characterized by the belief that the human mind could use technology to overcome all limits, so that carrying capacity was not an issue, and population increases should be welcomed rather than avoided (Bartlett, 1985).

There are now a few signs that things may be changing for the better and that there is beginning to be recognition in the top echelons of governments that population is *the* problem. The Mid-Atlantic Preparatory Consultation meeting in Airlie, Virginia urged the 1994 International Conference on Population and Development in Cairo, Egypt to focus on a number of important topics, including

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A clear statement of the linkages between population, environment, economic growth and sustainable development (Popline, 1993).

President Fidel Ramos of the Philippines delivered the keynote address at a workshop for implementing the Rio Earth Summit's *Agenda 21* in the Philippines (Ramos, 1993).

I believe that . . . the serious imbalance that today threatens the sustainability of both our economy and our environment has arisen primarily from our pervasive and proliferating population growth.

There are many encouraging signs from communities around the United States that indicate a growing awareness of the local problems of continued unrestrained growth of populations. It has been noted that creating jobs increases the number of people out of work, and that population growth in our communities never pays for itself. Taxes and utility costs must escalate in order to pay for the growth. For example, in the United States, it costs on the order of \$15,000 per pupil to build a new school building. If each new home has, on the average, 0.4 school-age children, then each new house that is built creates the need for about \$6000 of tax money for school construction. In addition, growth brings increased demands on all municipal utilities and brings increased levels of congestion, frustration, and air pollution.

In recent years, several states have seen taxpayer revolts in the form of ballot questions that were adopted to limit the allowed tax increases. These revolts were not in decaying rust-belt states, the revolts have been in the states that claimed to be the most prosperous because they had the largest rates of population growth. Unfortunately, these limitations on taxation, that were made necessary by population growth, and that were intended to stop or slow the increase of taxes, have not stopped the population growth which was the root cause of much of the increase in taxes.

At the local or state levels, there is an interesting parallel between the promotion of growth and the promotion of war. The waging of war is the sole enterprise of large military establishments. Even the lowest mind knows what has to be done to win a war "One has to beat the opponent," after which one can have a large party to celebrate the victory, and then one starts preparing for the next war. Promoting community growth is quite similar. The promotion of growth is the sole enterprise of large municipal and state establishments. It does not take much of a mind to know that growth requires that you beat some competing community in the effort to

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get new factories to come to your community. Campaigns and battles are planned and, when a factory comes, you can have a large party to celebrate the victory, after which, you start looking for new factories. This "victory" results in higher taxes, more congestion, more pollution, etc. for the local residents. As in the case with war, the human costs are borne by the people, not by the leaders and promoters.

In contrast, winning the peace is quite different. Even the best minds do not know for sure what is the best way to "win the peace." There is no large public establishment that is devoted to or has a vested interest in maintaining the peace. There is no terminal point at which a party is in order where we can celebrate the fact that, "We won the peace!" Winning the peace takes eternal vigilance. Protecting the community environment is quite parallel. The best minds do not know for sure the best way to do it. There are few public establishments whose sole role is to preserve the environment. One can postpone assaults on the environment but, by and large, it takes eternal vigilance of concerned citizens, who, at best, can only reduce the rate of loss of the environment. There is no terminal time at which one can have a party to celebrate that, "We have saved the environment!"

How do we work on the local problem? Many years ago I was discussing population growth of Boulder with a prominent member of the Colorado Legislature. At one point he said, "Al, we could not stop Boulder's growth if we wanted to!" I responded, "I agree, therefore let's put a tax on the growth so that, as a minimum, it pays for itself, instead of having to be paid for by the existing taxpayers." His response was quick and emphatic. "You can't do that, you'd slow down our growth!"

His answer showed the way. *On the community level in the United States, we should work to make growth pay for itself.* The "tragedy of the commons" makes it clear that there will always be large opposition to programs of making population growth pay for itself. The promoters of growth will use their considerable resources to convince the community that the community should pay the costs of growth. In our communities, making growth pay for itself could be a major factor in slowing and possibly stopping the population growth.

On the local and national levels, we need to work to improve social justice and equity. The series of big city riots of the recent decades are symptoms of a deep-seated illness that we have ignored too long. The illness is certainly made worse by the rapid population growth that consumes public and private resources in order to give minimal accommodation to the growth. The resources that are used to support the growth are taken away from all manner of community programs that are essential for im-

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proving education, justice, and equity. Injustice and inequity breed unrest and discontent. When a condition of instability is reached, things can happen with surprising speed. We were all stunned by the swiftness of the fall of the Soviet Union.

On the national scale, we can hope for leaders who will recognize that population growth is a major problem in the United States. With a lot of work at the grassroots, our system of representative government will respond.

As we enter an era of expanded global trade, we need to know that the ease of international trade serves to block out our recognition of the concept of "carrying capacity." These other countries with which we trade with such ease seem to provide an "away" from which we can get resources and to which we can later throw things made from those resources. International trade interferes with our understanding of the concept of limits.

On the global scale, we need to support family planning throughout the world, and we should restrict our foreign aid and send it only to those countries that make continued demonstrated progress in reducing population growth rates. Kenneth Boulding observed that, "The economic analysis I presented earlier indicates that the major priority, and one in which the United Nations can be of great utility, is a world campaign for the reduction of birth rates. This, I suggest, is more important than any program of foreign aid and investments. Indeed, if it is neglected, all programs of aid and investment will, I believe, be ultimately self-defeating and will simply increase the amount of human misery." (Boulding, 1971, p.361)

If we work on the problem of population growth in our communities, counties, and states, it is possible that our leaders in Washington, D.C. will get the message and follow the people. There is reason to be optimistic.

In writing about the essay of Malthus on population, Boulding observes that the essay, ". . . punctures the easy optimism of the utopians of any generation. But by revealing the nature of at least one dragon that must be slain before misery can be abolished, its ultimate message is one of hope, and the truth, however unpleasant, tends 'not to create despair, but activity' of the right kind" (Boulding, 1971, p.142).

A THOUGHT FOR THE FUTURE

When competing "experts" recommend diametrically opposing paths of action regarding resources, carrying capacity, sustainability, and the future, we serve the cause of sustainability by choosing the conservative

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path. This is the path that would leave society in the less precarious position if the path we choose turns out to be the wrong path.

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