Reflections...

On sustainability, population growth, and the environment – revisited

by Albert A. Bartlett

This is a revised version of the paper that was first published in *Population & Environment*, Vol. 16, No. 1, September 1994. Since then, reprints have been widely distributed and the author has received no communications suggesting that this paper contained errors. This could indicate that either readers have found the paper to be reasonable, or that they believe it is so completely wrong as to be unworthy of criticism.

The main message of the paper is contained in the first two Laws of Sustainability, which point out that in any society, population growth cannot be sustained, and that the larger the population, the more difficult it will be for the society to achieve sustainability.

The Brundtland Report (Brundtland 1987) is, in 1998, more than a decade old. The definition of sustainability given in that report remains the definition that is frequently cited by persons writing and speaking of sustainability.

Many parts of the original paper have been revised and updated, but the Laws, Hypotheses, Observations and Predictions relating to sustainability have had only minor revisions and additions.

Abstract

The related terms, "sustainable" and "sustainability" are popularly used to describe a wide variety of activities which are generally ecologically laudable but which may not be sustainable. An examination of major reports reveals contradictory uses of the terms. An attempt is made here to give a firm and unambiguous definition to the concept of sustainability and to translate the definition into a series of laws and hypotheses which, it is hoped, will clarify the implications of the use of the concept of sustainability. These are followed by a series of observations and predictions that relate to "sustainability." The laws should enable one to read the many publications on sustainability and help one to decide whether the publications are seeking to illuminate or to obfuscate.

Albert A. Bartlett, Ph.D., *is Emeritus Professor of Physics at the University of Colorado at Boulder.*

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, was the book *Limits to Growth* (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 from the concept of "sustained yield" which is used to describe agriculture and forestry when these enterprises are conducted in such a way that they could be continued indefinitely, i.e., their yield could be sustained. The introduction of the word "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, with little visible change, "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. In the manner of Alice in Wonderland, and without regard for accuracy or consistency, "sustainability" seems to have been redefined flexibly to suit a variety of wishes and conveniences.

The Meaning of Sustainability

First, we must accept the idea that "sustainable" has to mean "for an unspecified long period of time."

Second, we must acknowledge the mathematical fact that steady growth (a fixed percent per year) gives very large numbers in modest periods of time. For example, a population of 10,000 people growing at 7 percent per year will become a population of 10,000,000 people in just 100 years (Bartlett 1978).

From these two statements we can see that the term "sustainable growth" implies "increasing endlessly," which means that the growing quantity will tend to become infinite in size. The finite size of resources, ecosystems, the environment, and the Earth, lead one to the most fundamental truth of sustainability:

When applied to material things, the term "sustainable growth" is an oxymoron.

(One can have sustainable growth of non-material things such as inflation.)

Daly has pointed out that "sustainable development" may be possible if materials are recycled to the maximum degree possible, and if one does not have growth in the annual material throughput of the economy. (Daly 1994)

The Use of the Term 'Sustainable'

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 exists that the frequent 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. Politicians have gotten into the act. 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. The governor's charge has the effect of increasing the state's production of greenhouse gases (a move away from sustainability) and thus increasing the state's contribution to global warming. In some cases, these big-time operations may be illustrative of what might be called the "Willie Sutton school of research management" (Sutton).

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."

The term "sustainable growth" is used by our political leaders even though the term is clearly an oxymoron. In a recent report from the Environmental Protection Agency 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).

We even find a scientist writing about "sustainable growth":

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

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 long-term 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, etc. 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 oxymoronic.

This wide spectrum of uses 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? Unfortunately, the answer seems to be "No."

Let us examine the use of the term "sustainable" in some major environmental reports.

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 increase of 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, the 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 there was any definition of "sustainable," there was 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". One has to ask if it is possible to have an increase in economic activity (growth) without having increases in the rates of consumption of non-renewable resources. If so, under what conditions can this happen? Are we moving toward those conditions today? What is meant by the undefined terms, "socially sustainable" and "environmentally sustainable?" Can we have one without the other?

As we have seen, these two concepts of "growth" and "sustainability" are in 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. "Population size and growth" are vaguely identified as possible problem areas, but we don't know what the Commission means 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:

> *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.* [emphasis added]

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 undefined "extreme rates of population growth" 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 long-term problem: we see no recognition that enormous technical and economic difficulties can reasonably be expected in the search for an "environmentally sound and economically viable energy pathway." Most important here is the 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 Report's definition has been widely used by others. It appears in the first sentence of Chapter 2, (p. 43):

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition, coupled with the earlier statement of the need to "sustain human progress into the distant future," are crucial for an understanding 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, even though it is obvious that non-renewable resources consumed now will not be available for consumption by future generations. The Commission recognizes that there is a conflict between population growth and development: (p. 44).

> *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 demographic developments are in harmony with the changing*

productive potential of the ecosystem.

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 for the problems 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 of the decline of "global productive potential of ecosystems" due to deforestation, the loss of topsoil, pollution, etc., (Kendall and Pimentel 1994) then the "in harmony with…" could mean that population also will have to decline. But the Commission is very careful not to say this.

"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 won't talk frankly and honestly about the problem?"

These quotations are thought to be representative of the vague and contradictory messages that are in this important report. As the Report seeks to address severe global problems, it clearly tries to marginalize the role of population size as an agent of causation of these problems.

The Brundtland Commission Report's discussion of "sustainability" is both optimistic and vague. The Commission probably felt that the discussion had to be optimistic, but given the facts, it was necessary to be vague and contradictory in order not to appear to be pessimistic.

Straight talk about the meaning of "sustainability" was 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 published version of 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?" "Controlling world population growth" could mean, "hold the annual population growth rate at its 1993 value of approximately 1.6 percent per year," which surely was not their intent. Why does the Report use the phrase "controlling world population growth" when one suspects that the Report's authors 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 won't talk frankly and honestly about the problem? How are we going to educate the public about the problem of population growth if we fail to set forth clearly the known concrete details of "the impact of population

growth on the Earth?" Then, under the Report's 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 Report indicates a recognition of the fact 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 Report fails to do the exploring. The Report could have educated its readers about the "long-term consequences of continued population growth" and then could have identified for the readers the appropriate remedial courses of action which are necessary to achieve zero growth of population as rapidly as possible. But to negate it all, the Report refers to the "inevitable increase in population numbers." Thus the Report seems to say that nothing can be done. This leads to the question, "If nothing can be done, why bother to educate people about the 'long-term consequences of continued population growth'?"

This Report is loaded with admonitions suggesting that we all go out and embark on programs that are sustainable. In enumerating the things that the Report suggests have to be done, the Report has both the comprehensive scope and the literary style of the Yellow Pages. The Report 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 education of women, distribution of resources, justice, and simple equity.

The failure of the Report to address the population problem was underscored by Robert May (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.*

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 long term 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 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?"

The concept of carrying capacity is central to discussions of population growth. Since the publication of the original paper, the concept has been examined by Cohen in a book *How Many People can the Earth Support?* (Cohen 1995) Cohen makes a scholarly examination of many past estimates of the carrying capacity of the Earth, and concludes that it is not possible to say how many people the earth can support. Furthermore, any calculated estimate of the carrying capacity of the earth may be challenged and will certainly be ignored.

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

> *…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.

An impact on the global environment of this magnitude is properly the cause for alarm.

We note that growing populations require growing numbers of jobs and growing rates of consumption of resources, and the satisfaction of these requirements is almost always at the expense of the carrying capacity of the environment.

The inevitable and unavoidable conclusion is that if we want to stop the increasing damage to the global environment, as a minimum, we must stop population growth.

It won't be easy. 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 if we are to maintain the carrying capacity of Earth (Wiesner 1989).

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.

So, instead of trying to calculate how many people the earth can support, we should instead focus on the question: why should we have more population growth? This is nicely framed in the challenge:

Can you think of any problem, on any scale, from microscopic to global, whose long-term solution is in any demonstrable way, aided, assisted, or advanced, by having larger populations at the local level, the state level, the national level, or globally?

Denial of the Population Problem

There are prominent political leaders who believe that there is no population problem.

For example, when Jack Kemp, who was then the U.S. Secretary of Housing and Urban Development, was informed of a report from the United Nations which 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)

Here are two presidential aspirants who reject the notion of limits that are implied by the concept of sustainability. Their expressions are consistent with a prominent refrain in presidential politics: "We can grow our way out of the problems."

Contrast these two statements with the words of the biologist E.O. Wilson who has written that:

The raging monster upon the land is population growth. In its presence, sustainability is but a fragile theoretical construct. To say, as many do, that the difficulties of nations are not due to people but to poor ideology or land-use management is sophistic.

Population and the Environmental Protection Agency

The U.S. Environmental Protection Agency 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 from the Agency, 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.

The Report (EPA 1993) is both 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. While the Brundtland Report says that population growth is not the central problem, the EPA report avoids making this allegation. But the EPA report makes only a very few minor references to the environmental problems that arise as a direct consequence of population growth.

The EPA 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.

There is no way that "A stronger emphasis on sustainable agricultural practices" can stop the "rapid urban growth" that is destroying farmland! An emphasis on agriculture cannot solve the problem. To solve the problems, one must stop the "rapid urban growth" which causes the problems. It is pointless to focus on the development of "sustainable agricultural practices" when agriculture will soon be displaced by the "rapid urban growth." However, if "A stronger emphasis on sustainable agricultural practices" means "stop the conversion of agricultural land to urban or other developments," then there is logic to the second of the statements.

With our present social and value systems, it is almost impossible to maintain agriculture 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 EPA 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.

"Balancing" sounds nice, but it needs to be recognized that "balancing" generally means "yielding to."

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 puzzling that the Agency so carefully avoids serious discussion of the fundamental source of so many of the problems it is called on to address.

In this thirty-page report on the Agency's programs, the term "sustainable development" is mentioned hundreds of times, and population growth, the most important variable in the equation, is mentioned just these few times. It is as though one attempted to build a 100-story skyscraper from good materials, but forgot to put in a foundation.

A proposal for the establishment of a "National Institute for the Environment" (1993) is being advanced. If the proposed institute is to be effective, its mission and charge must include, "Studying the demographic causes and consequences of environmental problems." This means "look at the numbers!"

The Marginalization of Malthus

We have seen how major national and international reports misrepresent and downplay (marginalize) the quantitative importance of the arithmetic of population sizes and growth. The importance of quantitative analysis of population sizes was pioneered by Thomas Malthus two hundred years ago, (Appleman 1976) but the attempted marginalization of Malthus goes on today at all levels of society.

In an article, "The Population Explosion is Over," Ben Wattenberg finds support for the title of his article in the fact that fertility rates are declining in parts of the world (Wattenberg 1997). Most of the countries of Europe are (1997) at zero population growth or negative population growth, and fertility rates in parts of Asia have declined dramatically. Rather than rejoicing over the clear evidence of this movement in the direction of sustainability, Wattenberg sounds the alarm over the "birth dearth" as though this fertility decline requires some immediate reversal or correction.

The most extreme case is that of Julian Simon who advocates continued population growth long into the future. Writing in the newsletter of a major think tank in Washington, D.C., Simon says:

We have in our hands now – actually in our libraries – the technology to feed, clothe, and supply energy to an ever-growing population for the next 7 billion years... Even if no new knowledge were ever gained… we would be able to go on increasing our population forever. (Simon 1995)

It has been noted that a spherical earth is finite, but a flat earth can be infinite in extent. So if Simon is correct, we must be living on a flat earth (Bartlett 1996).

Living at the Limit

As populations grow and demands on resources increase, an aspect of the problem that is often overlooked is the fact that there are major fluctuations in the ability of the environment to satisfy our needs. In the

case of municipal water, if we build new subdivisions sufficient to consume the limiting maximum output of our municipal water supply in wet years, then in dry years we will be seriously short. When one is living at the limit of a renewable resource, small fluctuations in the annual yield of the resource can cause major dislocations. Prudence dictates that one should plan to consume no more water annually than the water supply can deliver during the dryest years. This problem is even more critical with world food supplies, which are very dependent on the vagaries of global weather patterns.

The World's Worst Population Problem

Echoing a view expressed earlier by the Ehrlichs (Ehrlich 1992), Bartlett points out that because of the high per capita consumption of resources in the U.S., we in the U.S. have the world's worst population problem! (Bartlett 1997) Many Americans think of the population problem as being a problem only of "those people" in the undeveloped countries, but this serves only to draw attention away from the difficulties of dealing with our own problems here in the U.S. It is easier to tell a neighbor to mow his/her yard than it is for us to mow our own yard. With regard to other countries, we can offer family planning assistance on request, but in those countries we have no jurisdiction or direct responsibility. Within our own country we have complete jurisdiction and responsibility, yet we fail to act to help solve our own problem. In a speech at the University of Colorado, then U.S. Senator Tim Wirth observed that the best thing we in the U.S. can do to help other countries stop their population growth is to set an example and stop our own population growth here in the U.S.

There can be no question about the difficulty that we will have to achieve zero growth of the population of the U.S. An examination of the simple numbers makes the difficulty clear. In particular, population growth has "momentum" which means that if one makes a sudden change in the fertility rate in a society, the full effect of the change will not be realized until every person has died who was living when the change was made. Thus it takes approximately 70 years to see the full effect of a change in the fertility rate. (Bartlett & Lytwak 1995)

Population Growth Never Pays for Itself

There are many encouraging signs from communities around the U.S. that indicate a growing awareness of the local problems of continued unrestrained growth of populations, because population growth in our communities never pays for itself. Taxes and utility costs must escalate in order to pay for the growth. In addition, growth 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. These limits on taxes were felt to be necessary to stop the tax increases that were required to pay for the growth. Unfortunately the growth has managed to continue, while the schools and other public agencies have suffered from the shortage of funds.

"There are many encouraging signs from communities around the U.S. that indicate a growing awareness of the local problems of continued unrestrained growth of populations."

How do we work on the local problem? Many years ago I was discussing population growth in 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, the growth 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: communities can slow their population growth by removing the many visible and hidden public subsidies that support and encourage growth.

"The Tragedy of the Commons" (Hardin 1968) makes it clear that there will always be large opposition to programs that make population growth pay for itself. Those who profit from 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 tool to use in stopping the population growth.

PSEUDO SOLUTIONS: GROWTH MANAGEMENT – SMART GROWTH

From the highest political and planning circles come various suggestions that are intended to address the problems caused by growth and thus to improve the quality of life. Many of these suggestions are "pseudo solutions" to the problems. At first glance, these sophistic solutions seem logical. A moment's thought will show that, in fact, they are false.

The terms "growth management" and "smart growth" are used interchangeably to describe urban developments that are functionally and esthetically efficient and pleasing. Sometimes these planning processes are advocated by those who believe that we cannot stop population growth, therefore we must accommodate it as best we can. Other times they are advocated by those who are actively advancing population growth. The claim is made that growth management and smart growth "will save the environment." They don't save the environment. Whether the growth is smart or dumb, the growth destroys the environment. "Growth management" is a favorite term used by planners and politicians. With planning, smart growth will destroy the environment, but it will do it in a sensitive way. It's like buying a ticket on the Titanic. You can be smart and go first class, or you can be dumb and go steerage. In both cases, the result is the same. But given the choice, most people would go first class.

PSEUDO SOLUTIONS: CREATING JOBS

The favorite rallying cry of community leaders and politicians is, "We must create jobs." One must respond to this cry by asking: " Did you know that in your community creating jobs increases the number of people out of work?"

Most people don't understand this, even though it can be explained easily. If the equilibrium unemployment rate is 5 percent, and a new factory moves into town, the hiring at the new factory may lower the unemployment rate to 4 percent. But then new people move into the town to restore the unemployment rate to the equilibrium value of 5 percent. But this is 5 percent of a larger population, so the number of unemployed people has increased. Every time 100 jobs are created in a community one can look for about five more unemployed people in the community.

The only possibility for having permanently low unemployment in a region is to build a wall around the region so that people can't move in to take the jobs. The constitutionally acceptable way to "build exclusionary walls" around a region is to be so successful in promoting your region that you drive up real estate prices to a very high level so that people can't afford to move into the community. This is the case in many popular recreational areas.

PSEUDO SOLUTIONS: BUILDING HIGHWAYS

It is frequently said that we can reduce congestion and air pollution by building high-speed super highways. This can be proven false by noting that if this were true, the air in Los Angeles would be the cleanest in the nation. The fallacy arises because of the fact that the construction of the new highways generates new traffic, not previously present, to fill the new highways to capacity. (Bartlett 1969)

PSEUDO SOLUTIONS: REGIONAL PLANNING

As populations of nearby cities grow, the call is made for "regional solutions" to the many problems created by growth. This has two negative effects:

1.) Regional planning dilutes democracy. A citizen participating in public affairs has five times the impact in his/her city of 20,000 as he/she would have in a region of 100,000 people.
2.) The regional "solutions" are usually designed to accommodate past and predicted growth and hence they foster and encourage more growth rather than limiting it. In the spirit of Eric Sevareid's Law (below), regional "solutions" enlarge the problems rather than solving them.

One concludes that regional solutions to problems already caused by growth will work only if the growth is stopped.

Population Growth Destroys Democracy

In an interview (Moyers 1989) Bill Moyers asked Isaac Asimov: "What happens to the idea of the dignity of the human species if this population growth continues at its present rate?" Asimov responded:

> *It will be completely destroyed. I like to use what I call my bathroom metaphor: if two people live in an apartment and there are two bathrooms, then both have freedom of the bathroom. You can go to the bathroom anytime you want to stay as long as you want for whatever you need. And*

everyone believes in freedom of the bathroom; it should be right there in the Constitution.

But if you have twenty people in the apartment and two bathrooms, no matter how much every person believes in freedom of the bathroom, there is no such thing. You have to set up times for each person, you have to bang on the door, "Aren't you through yet?" and so on.

Asimov concluded with the profound observation:

In the same way, democracy cannot survive overpopulation. Human dignity cannot survive [overpopulation]. Convenience and decency cannot survive [overpopulation]. As you put more and more people onto the world, the value of life not only declines, it disappears. It doesn't matter if someone dies, the more people there are, the less one person matters. [emphasis added]

War and Peace

At the local or state levels, there is an interesting parallel between the promotion of growth (unsustainability) and the promotion of war, both of which can be very profitable for high level people but are very expensive for everyone else.

The waging of war is the sole enterprise of large military establishments. Even the meanest 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, pass out the medals, and then start 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, both public and private. It does not take much of a mind to know that victory in the growth war requires that your community beat competing communities to become the location of new factories. Campaigns and battles are planned and, when a factory comes, there is a large party to celebrate the victory and pass out the awards. Then the community warriors start fighting for even more new factories.

In contrast, winning the peace is quite different. Even the best minds don't know for sure the best way to "win the peace." Compared to the groups that promote war, the public agencies that are devoted to maintaining peace are minuscule. In the effort to maintain peace, there is no terminal point at which a party is in order where all can celebrate the fact that, "We won the peace!" Winning the peace takes eternal vigilance. Protecting the community environment from the ravages of growth is quite parallel. The best minds don't 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 the fact that, "We have saved the environment!"

A Healthy Economy

For some time, the economy in the U.S. has been said to be "healthy." During this time studies shown that the economic gap between the well-to-do and the poor has been increasing. This allows us to say that "healthy economy" is one in which people with large incomes find that their incomes are rising more rapidly than their costs, while people with low incomes find that their incomes are rising less rapidly than their costs.

Injustice and Inequity

The series of big city riots of the recent decades are symptoms of a deep-seated illness (injustice and inequity) 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 generous returns to investors, with minimal benefits going to help the low income people who are adversely affected by the growth. The public financial resources that are needed to pay the costs of population growth come at the expense of all manner of community programs that are essential for improving 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.

Global Trade

As we enter an era of expanded global trade, we need to know that technology has made it easy to conduct trade over long distances, and this ease of trade serves to block out our recognition of the concept of "carrying capacity." This is especially true if their peoples are unsophisticated, these other places with which we trade with such ease are used to provide an "away" from which we can get the resources we need, and to which we can later throw our trash. Technology and trade combine to interfere with our understanding of the concept of limits.

Laws Relating to Sustainability

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."

Many prominent individuals have given postulates and laws relating to population growth and sustainability.

THE TWO "POSTULATA" OF THOMAS MALTHUS

The reverend Thomas Malthus used these two assumptions as the basis of his famous essay two hundred years ago.

First, That food is necessary to the existence of man.

Secondly, That the passion between the sexes is necessary and will remain nearly in its present state. (Appleman, 1976)

GARRETT HARDIN'S THREE LAWS OF HUMAN ECOLOGY

These three laws of human ecology were 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 is 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. Here P is the size of the population, A is the per-capita affluence, measured by per-capita annual 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 Hardin's Third Law is too conservative. The Third Law suggests that I varies as Pn where n = 1. There are situations where the impact of humans increases more rapidly than linearly with the size P of the population. In these cases, n 1.

BOULDING'S THREE THEOREMS

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

> *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 <u>may</u> do it.*

In another context, 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)

ABERNETHY'S AXIOM

Motivation, rather than differential access to modern contraception is a major determinant of fertility. Individuals frequently respond to scarcity by having fewer children, and to perceived improved economic 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 is followed by an increase in the fertility of the recipients of the aid.

B) Migrations from regions of low economic opportunity to places of higher economic opportunity result in an increase in the fertility of the migrants that persists for a generation or two.

Laws, Hypotheses, Observations and Predictions Relating to Sustainability

The Laws, Hypotheses, Observations, and Predictions that follow are offered to define the term "sustainability." 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 1998, 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.

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

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 a necessary, but not a sufficient, condition for a sustainable society.

B) Unsustainability will be the certain result of any program of "development" that does not plan the achievement of zero (or a period of negative) growth of populations and of rates of consumption of resources. This is true even if the program is said to be "sustainable."

C) The research and regulation programs of governmental agencies that are charged with protecting the environment and promoting "sustain ability" are, in the long run, irrelevant, unless these programs address vigorously and quantitatively the concept of carrying capacities 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 who suggest that sustainability can be achieved without stopping population growth are misleading themselves and others.

G) 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.)

H) The term 'Sustainable Growth" is an oxymoron.

Second Law: In a society with a growing population and/or growing rates of consumption of resources, the larger the population, and/or the larger the rates of consumption of resources, the more difficult it will be to transform the society to the condition of sustainability.

Third Law: The response time of populations to changes in the human fertility rate is the average length of a human life, or approximately 70 years. (Bartlett and Lytwak 1995) [This is called "population momentum."]

A) A nation can achieve zero population growth if: a) the fertility rate is maintained at the replacement level for 70 years, and b) there is no net migration during those 70 years. During that period the population continues to grow, but at declining rates until the growth finally stops.

B) If we want to make changes in the total fertility rates so as to stabilize the population by the mid- to late

21st century, we must make the necessary changes before the end of the 20th century.

C) The time horizon of political leaders is of the order of two to eight years.

D) It will be difficult to convince political leaders to act now to change course, when the full results of the change may not become apparent in the lifetimes of those leaders.

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. [This must be true even though Cohen asserts that the numerical size of the carrying capacity of the earth cannot be determined.] (Cohen 1995)

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

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 dynamic but 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. This is true locally and globally.

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; the costs of population 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 non-renewable resource "at present rates of consumption," i.e., with no growth. More relevant than the life-expectancy of a resource is the expected date of the peak production of the resource, i.e. the peak of the Hubbert curve. (Hubbert 1974)

B) It is intellectually dishonest to advocate growth in the rate of consumption of non-renewable resources while, at the same time, reassuring people about how long the resources will last "at present rates of consumption." (zero growth)

Eighth Law: The time of expiration of non-renewable resources can be postponed, possibly for a very long time, by:

A) technological improvements in the efficiency with which the resources are recovered and used

B) using the resources in accord with a program of "Sustained Availability," (Bartlett 1986)

C) recycling

D) 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 resources consumed as a consequence of modest increases in population.

A) When the efficiency of resource use is increased, 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.

"The addition of the word "sustainable" to our vocabulary, to our reports, programs, and papers ... is not sufficient to ensure that our society becomes sustainable."

Eleventh Law: (Second Law of Thermodynamics) When rates of pollution exceed the natural cleansing capacity of the environment, 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. [This is the first of Malthus' two postulata.]

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:

1. Urbanization and development

2. Erosion

3. Poisoning by chemicals

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) By contemporary western standards, Nature's method of stopping growth is cruel and inhumane.

B) Glimpses of Nature's method of dealing with populations 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.

Fifteenth Law: In every local situation, creating jobs increases the number of people locally who are out of work.

Sixteenth Law: Starving people don't care about sustainability.

A) If sustainability is to be achieved, the necessary leadership and resources must be supplied by people who are not starving.

Seventeenth Law: The addition of the word "sustainable" to our vocabulary, to our reports, programs, and papers, to the names of our academic institutes and research programs, and to our community initiatives, is not sufficient to ensure that our society becomes sustainable.

Eighteenth Law: Extinction is forever.

HYPOTHESES RELATING TO SUSTAINABILITY

1) For the 1998 average global standard of living, the 1998 population of Earth exceeds the carrying capacity of Earth. (Pimentel 1994) [Cohen (1995) would probably debate this.]

2) For the 1998 average standard of living in the United States, the 1998 population of the United States exceeds the carrying capacity of the United States. (Abernethy 1993a), (Giampietro and Pimentel 1993)

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 U.S. in general, the larger the population of a city, the higher are the municipal per-capita annual taxes.

B) Sales taxes generated by a large shopping center in a small town may make it appear that growth of the shopping center has earned more than its public costs, but these earnings are at the expense of the areas surrounding the town.

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

1) the size of its population

2) the rate of growth of its population

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

$$S = T - A R + B$$

where A and B are positive constants.

A) In places in the world in 1998, 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. In other words:

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) Social stability tends to be inversely related both to population size and density.

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.

A) 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 non-renewable resources cannot be solved or ameliorated by population growth.

14) Regional efforts to solve problems caused by population growth will only enlarge the problems if population growth in the region is not halted.

15) In general, neither the environment nor agriculture can be enhanced or even preserved through compromises.

A) Compromises and accommodations between the immediate needs of people and the long-term needs of the environment will generally be resolved in favor of people at the expense of the environment, as though people can exist independent of the environment. For the most part, compromises only reduce the rate of destruction of the environment or they increase the elegance with which the environment is destroyed.

B) Compromises between the demands of urban/industrial growth and agriculture will always result in the conversion of agricultural land to urban and industrial uses. The reverse conversion never happens.

16) 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.

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

C) It will always be possible for persons to argue for the delay of the implementation of corrective measures to save or preserve the environment, by claiming that our information about the problems is incomplete.

17) 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 of a society 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.

18) For countries with large populations, importing non-renewable natural resources demonstrates

unsustainability: exporting non-renewable natural resources reduces the ultimate sustainable standard of living and/or the carrying capacity of the exporting country.

19) When a society is living at the limit with regard to renewable resources such as food or water, small fluctuations in the supply can have large negative effects on the society.

20) Because of the growing 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) However, the approach to stainability must be sought on the local and national levels.

C) If a local official speaks of his/her community being sustainable, it probably is not true.

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

22) Irrigation of farmland, as it has been practiced throughout history and up to the present time, cannot be sustained (Abernethy 1993a, p. 136) – the lands become poisoned with salts.

23) Hydroelectric power generated from reservoirs created by construction of large dams, cannot be sustained – the reservoirs fill with silt.

OBSERVATIONS RELATING TO SUSTAINABILITY

1) In order to be moved toward a sustainable society, the first and most important effort that must be made is to stop population growth. This will require the initiation of major comprehensive educational, technical, and outreach programs in the areas of social responsibility, family planning, contraception, immigration, and resource use. To get things right, these programs must focus on the goal of stopping population growth and should not be diluted by omitting references to the numbers involved in understanding population growth. 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 is nature's equilibrium mechanism. It functions to prevent unlimited expansion of populations of flora and fauna. Primitive human societies were able to maintain approximately constant populations and to live within the carrying capacity of their ecosystems. The methods they used to maintain approximately constant populations were often cruel and inhumane. Technology has given many people the feeling that, through our own efforts, we are exempt from the cruel constraints of limited carrying capacities.

3) Ancient civilizations have vanished, in part because they grew too large and their size exceeded the carrying capacity of the ecosystems on which they depended for support.

A) Education notwithstanding, civilizations today show considerable tendency to repeat the mistakes of earlier civilizations, but on a much larger scale.

B) Growing international trade allows the developed countries to draw on the carrying capacity of the entire earth, often at the expense of underdeveloped countries.

4) The complete era of the use of fossil fuels by humans will turn out to be a short fraction of the span of human existence on the earth. (Hubbert 1974)

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, especially for those whose quality of life is now low, and away from its present use to increase the quantity of life.

TECHNICAL PREDICTIONS RELATING TO SUSTAINABILITY

1) Peak world production of petroleum will

probably happen before the year 2020. Peak production of coal and oil shale, may occur in the 21st Century. Other fossil fuels probably will not be available in globally significant quantities for more than a few decades into the 21st 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 1998, 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 will 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) Children born in 1990 will not live to see 10 percent of the energy consumed in the U.S. generated by terrestrial nuclear fusion. (Bartlett 1990)

9) 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.

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

10) 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.

11) The rate of increase of the cost of living will be greater than the rate of increase of family income for a majority of families. This is what is called a "healthy economy."

POLITICAL PREDICTIONS RELATING TO SUSTAINABILITY

1) Local and regional business and political leaders will continue to spend much of their working 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 consequent increases in taxes, 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. The circular argument proceeds as follows:

a) Quantitative projections of the "inevitable" future population growth in the area are made.

b) Plans are made to expand the municipal or regional infrastructure to accomodate the predicted growth.

c) Bonds are issued to raise money to pay for the planned expansions of the infrastructure, and the infrastructure is expanded.

d) The bonds must be paid off on a schedule that is based on the projections of population growth.

e) 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.

f) When this results in the needed population growth, the leaders who predicted the population growth will speak loudly of their foresight.

g) Go back to (a) and repeat.

3) Some political and business leaders will continue to want to throw away all manner of toxic waste by dumping the waste on the lands of low-income or

underdeveloped people, in the U.S. or abroad.

4) Some business leaders will want to continue to manufacture hazardous materials whose sale in the U.S. 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

C) Business and political leaders are not attracted to the concept of limits as implied by the term "carrying capacity."

6) In the U.S., 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 conserve and to protect the environment, to recycle, to use energy more efficiently, etc., i.e., to be conservative.

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.

8) Many members of the academic research and education programs that focus on sustainability issues such as air pollution, global warming, etc. will continue their old ways of generating high per capita levels of pollution.

9) Many Americans will continue to deny the seriousness of the population problem in America and will focus their attention on population problems elsewhere. They may be motivated in this by their reluctance to accept the fact that immigration accounts for roughly half of the present growth of the population of the United States.

10) Many Americans will continue to believe that the environment in the U.S. can be preserved without the need of addressing the population growth in the U.S.

11) Many people who are active in matters relating to population problems will continue their efforts to ignore and to urge others to ignore the quantitative aspects of the population problem. They will continue to claim that the problems will be more effectively addressed if we focus our efforts on such worthy causes as population growth in other countries, foreign aid, human rights, justice, equity, education of women, the consumption of resources, the distribution of food, etc. Some will even claim that slow growth and sustainability are compatible.

12) Reports containing the word "sustainable" in their titles will continue to be produced at all levels of government, and these reports will continue to ignore population growth as the greatest threat to sustainability.

13) There will always be those who reject all limits to growth.

So Where Do We Go from Here?

The challenge of making the transition to a sustainable society is enormous, in part because of a major global effort to keep people from recognizing the centrality of population growth to the enormous problems of the U.S. and the world.

The immediate task is to restore numeracy to the population programs in the local, national and global agendas.

On the local and national levels, we need to work to improve social justice and equity

On the community level in the U.S., we should work to make growth pay for itself.

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

On the global scale, we need to support family planning throughout the world, and we should generally restrict our foreign aid to those countries that make continued demonstrated progress in reducing population growth rates.

Boulding on Malthus

In writing about Malthus' essay on population, Kenneth Boulding observed:

> *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 path, which is defined as the path that would leave society in the less precarious position if the chosen path turns out to be the wrong path.

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