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AS I SEE IT

How many people will nature permit?

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Every 'shortage' of supply is equally a 'longage' of demand. Garret Hardin

'How many people will nature permit' is not a simple question, such as 'How many people will fit in an automobile? elevator? or life boat?' First global consensuses must be reached on some crucial issues because, without them, sustainable use of the planet will be problematic. Following are illustrations of some of these crucial issues.

(1) How much of Earth's resources, including space, is essential for keeping the biospheric life support system in robust condition?

(2) How can humankind maintain an accurate record of global and regional natural capital, especially in terms of accumulation or loss?

(3) How can the vastly disproportionate per capita distribution of Earth's resources be made fairer and more equitable?

(4) What type of organization is needed to ensure that commitments to maintain adequate natural capital and ecosystem services meet the agreed upon human carrying capacity?

(5) What organization decides which sanctions are appropriate for nations or regions that exceed carrying capacity?

(6) Can third world countries reasonably be expected to stabilize their populations when the United States, a technologically advanced country, adds 3.3 million people annually (Pimentel & Pimentel 2005)?

(7) How can balance be attained between energy that is captured through contemporary photosynthesis and that which is used as fossil fuel? For example, Americans are using twice as much fossil energy annually as the total solar energy captured by all plants through photosynthesis in the United States (Pimentel & Pimentel 2005).

(8) How can the disparity in national use of agricultural products be reduced? For example, the average US citizen uses 908 kg per year, while the world average is 567 kg (Pimentel & Pimentel 2003).

(9) How can humankind ensure that the biospheric life support system receives adequate resources to continue functioning in a manner favorable to humans?

As Diamond (2005) notes, Western lifestyle is flirting with the same sudden ruin that resulted in the collapse of entire societies. Especially appropriate, in terms of this manuscript, is Diamond's discussion of the deleterious effects of change-resistance in human social systems. This concept is particularly relevant in terms of the present resistance to reduction of anthropogenic greenhouse gases, particularly by the United States, the nation that produces the most. Another of Diamond's major points is that a society's precipitous decline may occur just decades after it reaches its peak numbers, power, and wealth.

Ehrlich & Ehrlich (2004) analyze the reasons for Assyria's collapse. Assyria had a powerful, professional army with war chariots and giant siege engines that produced a flow of resources from a wide area. However, the remarkably developed Assyrian Empire lasted only from 744 to 612 BC — just over a century (Healy 1991). Did the leaders and citizens of these ancient societies realize the serious, long-term, ecological threat they faced? Archeological ruins testify to what happened, but not why. Was the ecological collapse a result of hubris or ignorance or a combination of the two? In more recent times, the loss of the steamship Titanic suggests hubris — a classic illustration of an unwarranted faith in technology.

Easter Island (e.g. Diamond 1994, Kirch 2000) is a superb test case in determining whether the ecological collapse of previous human societies has been due to hubris or ignorance. Easter Island is so small that a moderately active person can view the entire ecosystem in a relatively short time, which indicates the possibility of personal knowledge of the natural systems. The society on the island was sufficiently well orga-

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nized to quarry, sculpt, and transport huge statues from the quarry to an area with a superb view of the ocean. The population was small, permitting significant exchange of ideas among the inhabitants.

A few centuries ago, small island populations had far more control of their fates, but the situation at present is dramatically different. Furthermore, the aggregate landmass of the largest 125 islands is equal to the size of Europe (Silverstein 2005). At present, sea level rise due to global warming is a threat to all of the world's more than 100 000 islands. Globalization has led to difficulty for these island societies to protect themselves since they have neither major political nor economic power. If, as seems likely, inhabitants of the islands become environmental refugees, they could still constitute a major global social problem. Assuming that the continents are immune to the effects of sea level rise is a serious error. A significant, e.g. a third of a meter, further rise in sea level will produce millions of more environmental refugees.

Peer-reviewed scientific information about the worsening problems of global warming and about agricultural problems (e.g. desertification, loss of topsoil and salt contamination, depletion of oceanic fisheries) is continuously available. Continuation of any one of these trends will almost certainly reduce Earth's carrying capacity for humans. As if these problems were not enough, the United Nations estimates a 40% rise in world population by 2050 (The Globe and Mail 2005). However, no trend continues indefinitely. Japan has acknowledged the serious national demographic problem (Faiola 2005) of finite space and finite resources. Any prudent government should be exploring ways to cope with the inevitable age-structure shift necessary to accompany any humane solution to the exponential population growth characteristic of the twentieth century. Although Japan's problems are more tractable than those of many other countries, 3 or 4 generations will probably be needed to reach a sustainable population size.

I believe Earth is rapidly approaching an array of ecological and societal tipping points. A 'tipping point' is a threshold beyond which the system goes into a disequilibrium from which return to the original condition is problematic (Cairns 2004). Gladwell (2000) discusses societal tipping points and asserts that an entity is at the verge of a tipping point if people are stimulated to reframe an issue. At present, although many people favor replacing unsustainable practices with sustainable ones, the tipping point, globally, has not been previously determined for most of the practices. However, an ecological tipping point has already been reached in many oceanic fisheries. Earth may have reached a tipping point for global warming, but, due to huge time lags in ecological systems, robust information may not become available for decades. Since the consequences of a major climate change will be severe, precautionary measures to reduce anthropogenic greenhouse gases would be prudent.

Both human society and the biospheric life support system are complex, multivariate, interactive systems with a vast number of tipping points, many unknown to humankind. The location and/or threshold of these unknown tipping points can only be approximated. In a very real sense, humankind is carrying out a vast global experiment involving a host of variables that humans cannot, or will not, control. A few illustrative societal problems follow.

(1) The gap in income is widening between the very rich and the very poor. This problem is already serious in the US, but China is concerned about the current economic situation that increases the disparity in the world's most populous nation (Kahn 2005). When the gap becomes too great (reaches the tipping point), a partial redistribution of wealth occurs through revolution or nation-state action.

(2) China is rapidly replacing the US as the world's leading consumer (Brown 2005). On a finite planet with finite resources, this change will increase the probability of resource wars. This danger could be significantly reduced if nation-states rapidly replace unsustainable practices with sustainable ones.

(3) The population problem is worsening, particularly in third world countries. Nevertheless, the US disrupted an important United Nations conference on advancing women's equality with a burst of anti-abortion zealotry (NYT Editorial 2005). Disrupting a conference on advancing women's equality to forward a political ideology was an act of irresponsibility. Fortunately, the attempt failed. I found Raspail's (1975) fictional account of the consequences of the Third World forcing wealthy countries to share more of the world's resources both shocking and memorable because the logic is even more applicable today than when the book was first written.

I chose the title of this discussion to emphasize that natural law is the ultimate determiner of how many people can live on the planet. Technology permits temporary modification of natural laws, but *Homo sapiens* is affected, as are the 10 to 100 million species with which humans share the planet (Wilson 1992). For approximately 4.5 billion years, nature produced individuals in each species in quantities far in excess of the replacement rate. From these populations, the most ecologically fit were selected (i.e. quality).

Humankind cannot be assured that it is living sustainably until human society has done so for at least 3 generations. Since billions of people at present lack adequate food, shelter, education, and clothing, a 40% increase in human population size by 2050 seems sui-

cidal. The 2 following scenarios illustrate the challenges humankind faces.

(1) Best case scenario: World food resources are distributed equitably — to add a safety factor, most calories are from cereal grains rather than meat. World population is stabilized well before 2050.

(2) Worst case scenario: Exponential growth of population and resource consumption continues at present rates. Since growth of resources is linear, then starvation, pandemic diseases, and resource wars destabilize human societies globally, damaging the technological life support system as well as the biospheric life support system. Massive reduction of human population size eventually brings the human population into equilibrium with Earth's altered carrying capacity for humans.

Many more scenarios could be offered, but they all depend upon the answer to one question: Will humankind use intelligence guided by science and reason to determine how many people natural systems can support or will humankind continue its present unsustainable practices and let famine, disease, and resource wars control population numbers as is the fate of other species? How humankind responds to these questions and issues will have a major impact on global security (Worldwatch Institute 2005).

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