# Optimum Human Population Size

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Although the tremendous size and rate of growth of the human population now influence virtually every aspect of society, rarely does the public debate, or even consider, the question of what would be an optimum number of human beings to live on Earth at any given time? While there are many possible optima depending on both the criteria defining "optimum" and on prevailing biophysical and social conditions, there is a solid scientific basis for determining the bounds of possibilities. All optima must lie between the minimum viable population size, MVP (Gilpin & Soulé, 1986; Soulé, 1987) and the biophysical carrying capacity of the planet (Daily & Ehrlich, 1992). At the lower end, 50-100 people in each of several groups, for a total of about 500, might constitute an MVP.

At the upper end, the present population of 5.5 billion, with its resource consumption patterns and technologies, has clearly exceeded the capacity of Earth to sustain it. This is evident in the continuous depletion and dispersion of a one-time inheritance of essential, nonsubstitutable resources that now maintains the human enterprise (e.g., Ehrlich & Ehrlich, 1991; Daily & Ehrlich 1992). Numerous claims have been made that Earth's carrying capacity is much higher than today's population size. A few years ago, for example, a group of Catholic bishops, misinterpreting a

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thought exercise by Roger Revelle (1976), asserted that Earth could feed 40 billion people (Anonymous, 1988); various social scientists have made estimates running as high as 150 billion (Livi-Bacci, 1989). These assertions are based on preposterous assumptions, and we do not deal further with them here.

Nonetheless, we are left with the problem of determining an optimum within wide bounds. Above the minimum viable level and within biophysical constraints, the problem becomes a matter of social preference. Community-level, national, and international discussions of such social preferences are critical because achieving any target size requires establishing social policies to influence fertility rates. Human population sizes have never, and will never, automatically equilibrate at some level. There is no feedback mechanism that will lead to perfectly maintained, identical crude birth and death rates. Since prehistoric times, societies have controlled fertility and mortality rates to a substantial degree, through various cultural practices (Harris & Ross, 1987). In the future, societies will need to continue manipulating vital rates to reach desired demographic targets. Most important, societies must reach a rough consensus on what those targets should be as soon as possible because the momentum behind the growth of the present population ensures at least a doubling before any decline is possible (UNFPA, 1992).

This commentary, given at the First World Optimum Population Congress (convened in London, U.K., 1993) is a contribution to that necessary dialogue. What follows is a brief statement of our joint personal views of the criteria by which an optimum should be determined (in no particular order).

1. An optimum population size is not the same as the maximum number of people that could be packed onto Earth at one time. The maximum would have to be housed and nurtured by methods analogous to those used to raise battery chickens, and the process would inevitably reduce the planet's longterm carrying capacity. Many more human beings could exist if a sustainable population were maintained for thousands to millions of years than if the present population overshoot were further amplified and much of Earth's capacity to support future generations were quickly consumed. Thus, an optimum size is a function of the desired quality of life and the resultant per-capita impacts of attaining that lifestyle on the planet's life support systems.

2. An optimum population size should be small enough to guarantee the minimal physical ingredients of a decent life to everyone (e.g., Ehrlich *et al.*, 1993), even in the face of an inequitable distribution of wealth and

resources and the uncertainty regarding rates of longterm, sustainable resource extraction and environmental impacts. We agree with Nathan Keyfitz (1991): "If we have one point of empirically backed knowledge, it is that bad policies are widespread and persistent. Social science has to take account of them." The grossly inequitable distribution of wealth and basic resources prevailing today is highly destabilizing and disruptive. While it is in nearly everyone's selfish best interest to narrow the rich-poor gap, we are skeptical that the incentives driving social and economic inequalities can ever be fully overcome. We therefore think a global optimum should be determined with humanity's characteristic selfishness and myopia in mind. A further downward adjustment in the optimum should be made to insure both against natural and human-induced declines in the sustainable flow of resources from the environment into the economy and against increases in anthropogenic flows of wastes, broadly defined, in the opposite direction.

3. Basic human rights in the social sphere (such as freedom from racism, sexism, religious persecution, and gross economic inequity) should be secure from problems generated by the existence of too many people. Everyone should have access to education, health care, sanitary living conditions, and economic opportunities; but these fundamental rights are difficult to assure in large populations, especially rapidly growing ones. Political rights are also related to population size, although this is seldom recognized (Parsons, 1977). Democracy seems to work best when populations are small relative to resource bases; personal freedom tends to be restricted in situations of high population density and/or scarce resources.

4. We think an optimum population size should be large enough to sustain viable populations in geographically dispersed parts of the world to preserve and foster cultural diversity. It is by no means obvious that the dominant and spreading "western" culture has all the secrets of longterm survival (Ehrlich, 1980)—to say nothing of cornering the market on other values. We believe that cultural diversity is an important feature of our species in and of itself. Unfortunately, many cultures borne by small groups of people are in danger of being swamped by the dominant culture with its advanced technologies and seductive media, or worse, of being destroyed deliberately because of social intolerance or conflicts over resources.

5. An optimum population size would be sufficiently large to provide a "critical mass" in each of a variety of densely populated areas where intellectual, artistic, and technological creativity would be stimulated. While creativity can also be sparked in sparsely populated areas, many cultural endeavors require a level of specialization, communication, and

financial support that is facilitated by the social infrastructure characteristic of cities.

6. An optimum population size would also be small enough to ensure the preservation of biodiversity. This criterion is motivated by both selfish and ethical considerations. Humanity derives many important direct benefits from other species, including aesthetic and recreational pleasure, many pharmaceuticals, and the very basis and security of agricultural production. Furthermore, the human enterprise is supported in myriad ways by the free services provided by healthy natural ecosystems, each of which has elements of biodiversity as key working parts (Ehrlich & Ehrlich, 1992). Morally, as the dominant species on the planet, we feel *Homo sapiens* should foster the continued existence of its only known living companions in the universe.

In general, we would choose a population size that maximizes very broad environmental and social options for individuals. For example, the population of the United States should be small enough to permit the availability of large tracts of wilderness for hikers and hermits, yet large enough to create vibrant cities that can support complex artistic, educational, and other cultural endeavors that lift the human spirit.

Innumerable complexities are buried in this short list of personal preferences, of course. But with the world's population size now above any conceivable optimum and (barring catastrophe) destined to get much larger still (UNFPA, 1992), it appears that many decades are available in which to debate alternative optima before even stopping growth of the population, much less approaching an optimum. During that time, human technologies and goals will both change, and those changes could shift the optimum considerably.

It is nonetheless instructive to make a tentative, back-of-the-envelope calculation of an optimum on the basis of present and foreseeable consumption patterns and technologies. Since the human population is in no imminent danger of extinction due to underpopulation, we focus here on the upper bound of an optimum. We begin by using humanity's energy consumption as a rough, indirect measure of the total impact civilization inflicts on Earth's life-support systems (Holdren & Ehrlich 1974). Energy, especially that provided by fossil fuel and biomass combustion, directly causes or underpins many of the global environmentally damaging activities that are recognized today: air and water pollution, acid precipitation, land degradation, emissions of carbon dioxide and other greenhouse gases, and production of toxic and hazardous materials and wastes.

At present, world energy use amounts to about 13 terawatts (TW; $10^{12}$ watts), about 70% of which is being used to support somewhat over a billion people in rich countries and 30% to support more than four billion people in developing countries. This pattern is both ethically undesirable and biophysically unsustainable, because of the gross disparity between rich and poor societies, and because of the environmental damage that results. The consumption of 13 TW of energy with current technologies is leading to the serious ecological impacts indicated above, all of which contribute to several forms of deleterious global change, including a continuous deterioration of ecosystems and the essential services they render to civilization (Ehrlich & Ehrlich, 1991; Ehrlich et al., 1993).

An examination of probable future trends leads to dismal conclusions. The world population is projected to increase from 5.5 billion in 1993 to somewhere between 10 and 14 billion within the next century. Suppose population growth halted at 14 billion and everyone were satisfied with a per-capita energy use of 7.5 kilowatts (kW), the average in rich nations and about two thirds of that in the United States in the early 1990s. A human enterprise that large would create a total impact of 105 TW, eight times that of today and a clear recipe for ecological collapse.

A scheme that might possibly avoid such a collapse was proposed by John Holdren of the Energy and Resources Group at the University of California, Berkeley. The Holdren scenario (Holdren, 1991) postulates expansion of the human population to only 10 billion and a reduction of average per-capita energy use by people in industrialized nations from 7.5 to to 3 kilowatts (kW), while increasing that of the developing nations from 1 to 3 kW. The scenario would require, among other things, that citizens of the United States cut their average use of energy from almost 12 kW to 3 kW. That reduction could be achieved with energy efficient technologies now in hand and with an improvement (by most people's standards) in the standard of living.

While convergence on an average per-capita consumption of 3 kW of energy by 10 billion people would close the rich-poor gap, it would still result in a total energy consumption of 30 TW, more than twice that of today. Whether the human enterprise can be sustained even temporarily on such a scale without devastating ecological consequences is unclear, as Holdren recognizes. This will depend critically on the technologies involved in the future as reserves of fossil fuels, especially petroleum, are depleted. Perhaps through further development and widespread application of more benign technologies (such as various forms of solar power and biomass-derived energy), environmental deterioration at the peak of human activities could be held to that of today.

Against that background, what might be said about the upper limits on an optimum population size, considering present attitudes and technologies? In view of the environmental impacts of a civilization using 13 TW today, to say nothing of the threats to the future prospects of humanity, it is difficult to visualize a sustainable population that used more than 9 TW with present and foreseeable technologies.

One might postulate that, with careful choices of energy sources and technologies, 9 TW might be used without degrading environmental systems and dispersing nonrenewable resources any more rapidly than they could be repaired or substituted for. Under similar assumptions, a 6 TW world would provide a 50% margin for error, something we deem essential considering the unexpected consequences that often attend even very benign-appearing technological developments (the invention and use of chlorofluorocarbons being the most instructive case to date). A more conservative optimum would be based on a 4.5 TW world, giving a 100% margin for error. Which upper limit one wished to choose would depend in part on some sort of average social risk aversion combined with a scientific assessment of the soundness of the 9 TW maximum impact.

In the real world, the maximum sustainable population might well be determined in the course of reducing population size and overall impact—by discovering the scale of the human enterprise at which ecosystems and resources seemed to be holding their own. For our thought experiment, let us consider a 6 TW world. If we assume a convergence of all societies on 3 kW percapita consumption, that would imply an optimum population size of 2 billion people, roughly the number of human beings alive in 1930. Such a number seems at first glance to be reasonable and well above the minimum number required to take advantage of both social and technical economies of scale. In the first half of the twentieth century, there were many great cities, giant industrial operations, and thriving arts and letters. A great diversity of cultures existed, and members of many of them were not in contact with industrializing cultures. Large tracts of wilderness remained in many parts of the world. A world with 1.5 billion people using 4.5 TW of energy seems equally plausible and would carry a larger margin of safety. This is about the same number of people as existed at the turn of the century.

To summarize this brief essay, determination of an "optimum" world population size involves social decisions about the life styles to be lived and the distribution of those life styles among individuals in the population. To us it seems reasonable to assume that, until cultures and technologies change radically, the optimum number of people to exist simultaneously lies in the vicinity of 1.5 to 2 billion people. That number, if achieved reasonably soon, would also likely permit the maximum number of *Homo sapiens* to live a good life over the long run. But suppose we have underestimated the optimum and it actually is 4 billion? Since the present population is over 5.5 billion and growing rapidly, the policy implications of our conclusions are still clear.

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