How Many People Can the Earth Support?

By JOEL E. COHEN

How many people can the Earth support? This question crosses the boundaries of academic disciplines in which experts are trained. The longer we examine it, the more complicated it becomes. Answers turn on human choices as well as natural constraints. Markets, laws, social institutions, technology, war, politics, trade agreements, changes in values and customs, and natural ecological and geophysical constraints all play a role in determining the Earth's human carrying capacity.

Unfortunately, it is often difficult for people in different disciplines to talk about global population issues. Some environmentalists and natural scientists bring a sense of hard upper limits to discussions of human carrying capacity. Most demographers and economists do not talk much about questions of scale—such as factors that determine whether a population is large or small, and the consequences of large or small population size. The scale of the human population, though little treated in conventional demography, is basic to the questions posed in this article.

Wanted: A balanced view

Any population question must be considered from four angles: population dynamics, economics, the natural environment, and culture (including politics). Many discussions of population and development leave out environmental and cultural factors. Many discussions of the impact of population on the environment leave out economic and cultural factors.

The famine in Sudan in 1993 provides a good case study. First, there was a crop failure, in part as a result of natural events (in this case, drought), but also in part due to economic factors (inadequate capital investments to supply water for irrigation and inadequate markets and transportation to supply food from other regions). In addition, there was an important political factor: civil war. The Sudanese government refused to admit international relief workers, with food supplies, into the rebel area. Thousands of people starved to death because of a combination of environmental, economic, political, and cultural forces. The famine was no proof that the region had exceeded its carrying capacity in some biological or environmental sense, because economic and political factors also played important roles.

How many people?

Rapid population growth is a modern phenomenon. Before the industrial revolution, world population doubled at the rate of once in about 1,650 years. The most recent doubling occurred in just 40 years. World population has tripled since 1920—during the lifetime of some readers of this article.

Given this unprecedented growth, some people fear that the number of Earth's inhabitants will reach or surpass a ceiling on human numbers. But what is the carrying capacity of the Earth? As many as 65 estimates have been published over the past 350 years. These are graphed along a timeline and on a logarithmic scale of population size (see Speaking Graphically, page 6). Also shown are three projections, prepared by the United Nations, of world population growth through 2150. Population has entered, and is rapidly moving deeper into, the zone where the majority of these 65 estimates of "ceilings" fall.

One striking feature of the graph is that there has been no clear increasing or decreasing trend in the upper bounds of the various estimated "ceilings." Antoni van Leeuwenhoek's 1679 estimate of 13.4 billion is not strikingly different from the estimates of 7.7 billion by Donella Meadows and her colleagues in 1992, or the 12 to 14 billion estimate by Gerhard K. Heilig in 1993. Recent estimates seem to be diverging, not converging, however. In 1994 alone, five published estimates ranged from less than 3 billion to more than 44 billion. If there is a right answer to the question, "How many people can the Earth support?" then not all of these answers can be right. In fact, the wide range of estimates shows the diversity of assumptions that can be made in trying to answer the question. Here is a sample of some of these estimates.

On April 25, 1679, in Delft, Holland, Leeuwenhoek recorded what may be the first estimate of the maximum number of people the Earth can support. In a letter to the Royal Society of London, Leeuwenhoek, who invented the microscope, set out to show that the 150 billion "little animals in the milt of a cod" greatly exceeded the maximum possible number of people on the Earth. He estimated the Earth's habitable land area and assumed that the population density of Holland at that time was the maximum possible. He came up with a potential total of 13.4 billion human beings on Earth.

Two centuries later, in 1891, E.G. Ravenstein presented an estimate before the British Association for the Advancement of Science in Leeds. Leaving aside the sparsely settled polar regions, Ravenstein estimated the proportions of each continent that were "fertile," "steppes," and "desert" and then applied various maximal population densities to the different types of land. He came up with a total

possible population of just under 6 billion—a bit higher than world population is today.

An estimate by Albrecht Penck, published in the 1924 proceedings of the Prussian Academy of Sciences, set the highest conceivable number of inhabitants of the Earth at 15.9 billion.

In 1967, near the high-water mark of the world's population growth rate, C.T. De Wit calculated how many people could be fed if photosynthesis—and nothing else—were the limiting process. De Wit, from the Institute for Biological and Chemical Research on Field Crops and Herbage in Wageningen, the Netherlands, concluded that 1,000 billion people could be supported by the Earth (although not necessarily live on the planet) if photosynthesis were the sole constraint.

Three years later, in 1970, as world population passed 3.6 billion, H.R. Hulett of the Department of Genetics of the Stanford University Medical School estimated that optimal world population must be less than 1 billion. He took the production of food, forest products, and certain nonrenewable resources as fixed and estimated how many people could consume those resources at the current American consumption level.

This difference of more than 1,000-fold between Hulett's and De Wit's guesstimates testifies to the radically different approaches and assumptions they used.

Also in 1967, the Australian economist Colin Clark estimated the Earth could feed 157 billion people. Clark based his estimate on climate—making no deductions for poor soils, mountains, or swamps. His estimates of consumption were based on two lifestyles, which he characterized as "American" and "Japanese"—the "Japanese" having lower requirements for meat and timber.

In 1974 and 1976, the eminent oceanographer Roger Revelle published two widely read estimates of how many people the Earth could feed: one of 38 to 48 billion people and another of 40 billion people. Revelle's optimism assumed increases in cereal yields and massive new investments in irrigation in the developing world. These investments have not materialized as he anticipated.

In 1983, the United Nations Fund for Population Activities (UNFPA) asked the Food and Agricultural Organization (FAO) and the International Institute for Applied Systems Analysis (IIASA) to examine the "potential population-supporting capacities of different regions." The estimates included many factors but emphasized soil types, length of growing seasons, and production systems. Researchers made different estimates for high and low inputs of technology, power sources, capital, and infrastructure. They concluded that, in the year 2000, in the developing regions excluding China, 5.6 billion people could be fed with low inputs and 33.4 billion with high inputs.

Refining the question

These various estimates, with their differing assumptions, illustrate how a seemingly straightforward question becomes many smaller questions of definition. When we ask "how many people can the Earth support?" we need to define:

How many at what average level of well-being? What type of diet, transportation, and health infrastructure do we provide?

How many with what distribution of material well-being? It may be easier to support a vast number of poor people and a few rich than the same number with the same statistical average of income.

How many with what technology? The way people grow food, manufacture goods, and provide services affects the Earth's carrying capacity.

How many with what kinds of domestic and international political institutions? The way countries resolve conflicts—at home and internationally—makes a huge difference. Organized violence is wasteful of human life and resources.

How many with what domestic and international economic arrangements? Trade enables regions to benefit from complementary resources in other regions.

How many with what domestic and international demographic arrangements? How much do people want fertility to go up or down? What will be an average family size? What structures and supports will be provided for children and elderly?

How many with what physical, chemical, and biological environments? Do people want to live in a world populated by just humans and wheat (or rice)? How much clean air and water and wilderness do we want?

How many with what risk or robustness? How many people the Earth can support depends on how much risk of natural or human disaster people want to accept. If you settle in a flood plain, you must accept a higher risk of catastrophe.

How many for how long? How fast oil stocks are consumed matters little if one cares only about the next five years. In the very long-term, technology can change the definition of resources, or convert what was once free goods, such as air and water, into valuable or scarce commodities.

How many with what values, tastes, and fashions? Do we eat a vegetarian or meat diet? Wear cotton or polyester shirts? Commute to work by car, mass transit, or bicycle? Spend tax money on elementary schools or nursing homes? Values determine whether we judge our economic well-being by the average level or the minimum.

Three basic approaches have been advocated to ease future tradeoffs among population, economic well-being, environmental quality, and cultural values. The "bigger pie" school says: develop more technology. The "fewer forks" school says: slow, stop, or reverse population growth. The "better manners" school says: improve the terms under which people interact (for example, by removing economic irrationalities and improving governance).

How many people the Earth can support will be determined not only by natural constraints but also by human choices. The choices we and our children have made and will make—about everything from food and the environment to liberty, styles of life, and other dearly held values—will in turn influence which natural constraints will matter. ■

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