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How Many People Can the Earth Support?

Introduction:

At the time of Christ, there were about a quarter billion people in the world, and it took more than one thousand six hundred years for the population to double. The next doubling to one billion people took about 200 years; the next took about one hundred years, until around 1930, and the next doubling took about forty-four years. Population growth rate reached a high of 2.1% per year in the late 1960s and has declined since then to about 1.6% per year, a rate sufficient to double the present world population of 5.7 billion in about forty years.

We spoke with Joel Cohen about the consequences of the unprecedented increase in the number of people on the Earth. Professor Cohen received two doctorates, one in applied mathematics and a second in population sciences and tropical public health, both from Harvard University. In 1992 Professor Cohen received the Sheps Award from the Population Association of America for outstanding contributions to mathematical demography. He was a MacArthur Fellow from 1981 to 1986, is now a trustee of the Russell Sage Foundation, a member of the committee on selection of the John Simon Guggenheim Foundation and serves on various other boards.

Dr. Cohen has been a professor of populations and head of the laboratory of populations at Rockefeller University since 1975. As of 1995 he was also jointly appointed a professor at Columbia University. He has published eight books in various fields including *How Many People Can the Earth Support?* published in December 1995 by W.W. Norton & Co. His comments are based on that book, which can be ordered direct from the publisher. Telephone 1/800/233/4830 (voice) or 1/800/458/6515 (fax). Copyright 1995 by Joel E. Cohen.

ER: Professor Cohen, why are people so excited about human population growth?

JC: Two thousand years ago, the number of people on Earth was about a quarter of a billion people, roughly the population of the United States today. The estimates range from 130 to 330 million. A quarter of a billion is a round number which is probably correct within a factor of two.

Apart from a fall in the 14th century at the time of the plague, the population increased slowly and reached about half a billion around 1650. So it took sixteen and a half centuries to double.

At that point, the New and the Old Worlds began to exchange foods, people and other resources. The rate of growth of the population accelerated tremendously so that the doubling time dropped from sixteen and a half centuries to only two centuries. The population grew from half a billion around 1650 to about a billion around 1830.

Then, with the industrial revolution and changes in hygiene and increases in food production, the rate of growth doubled. I am not talking about the population size alone; the rate of growth increased, and the next doubling from one billion to two billion people took only one century between 1830 and roughly 1930.

Then the growth rate increased even further, and the next doubling from two billion to four billion people took about forty-four years. Instead of 1,650 years, it took forty-four to double. Roughly a forty-to fifty-fold increase in the rate of increase. It was like having an interest bearing account in which your rate of interest increases with your balance. That is an explosive situation.

Anybody now alive who is forty years old or older has lived through a doubling of the human population. Never before the second half of the

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twentieth century had any human being lived through a doubling of the human population. And there are some people who are now alive who have lived through a tripling of the human population. The population growth that took from the beginning of time until 1830, namely, an increase of one billion people is now proceeding in twelve years. Both the relative and the absolute increases in the numbers of people are without precedent.

The world population growth rate peaked at 2.1% per year around 1965 to 1970, and has since slowly declined to about 1.6% per year. And that is maybe the most important change in all of human demographic history. Nevertheless, it leaves us with a growth rate today that was never experienced globally before World War II. So even with the decline in the growth rate, the absolute numbers are increasing at 85 to 90 million people a year. That is one reason why some people are excited.

ER: It's not just the number of people on Earth but the technology they use, that must be considered.

JC: When you multiply the increase in human numbers by the impact per person on the planet, you see that humans have become a geological force. For example, around 1860 the average person was able to use or had available 0.9 megawatt hours per year of inanimate energy from all sources. By 1991 that had risen to about 18 megawatt hours per year. The consequence is that the total inanimate energy used by the human species rose from about 1 billion megawatt hours per year in 1860 to about 94-95 billion megawatt hours per year in 1991, almost a hundred fold increase in energetic impact.

ER: Why did energy use go up a hundred fold while the population only increased four-or five-fold?

JC: Because people discovered ways of extracting energy from fossil fuels and from other sources and found ways of putting that energy to work economically.

The average person puts into the atmosphere about 1.1 metric tons of carbon per year. In the U.S., carbon burning is about five metric tons per person per year.

ER: Where does the carbon come from?

JC: It comes from burning gasoline, coal, oil, wood, natural gas. It comes from burning fossil fuels.

That means that the rest of the world must have an average of about 0.9 tons of carbon per person per year if the world average works out to 1.1. So we Americans are burning quite a bit more per person than the rest. But if you supposed that the rest of the world succeeded in catching up with the carbon burning per person per year of the U.S., the 95% of the world that is not America would go from 0.9 ton to 5 tons, and the aggregate amount of carbon being put into the atmosphere would be very substantial. With the same size population we have now, it would be about 28 billion tons rather than 6.4 billion tons, roughly a four-or five-fold increase. And we think that would have somewhat unpredictable but probably not very good effects on the atmosphere, on warming. There is scientific uncertainty about it but a lot of people think, with some justification, that this could be a very bad thing.

ER: There was a report in *Science* magazine last week that an Academy panel has decided that global warming has been discerned. This is a breakthrough for a very conservative scientific establishment.

JC: I am aware of that. I also have a book published in 1970 called *Forecasts, Famines and Freezes*, by John Gribbin in which the concern is the coming ice age. If you look at these discussions over the last fifty years, there have been tremendous swings in scientific opinion. I may be more agnostic on this climate change than many people, but I think that the size of the atmospheric perturbation is itself cause for concern, whether or not we know exactly what the consequences are going to be. I do not consider that this is necessarily going to wind up one way or the other, but if you kick the atmosphere as hard as we are kicking it, you can be sure there are going to be some surprises.

ER: The point to draw from Gribbin's book is that we don't know what we are doing.

JC: Quite right. That is the point I draw from it.

ER: What is meant by the carrying capacity of the Earth?

JC: The concept is much older than the term, and people have been concerned about how many people the earth can support for centuries before there was a

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science of ecology. In fact, the Babylonians, around 1600 BC, had a myth, an epic poem called the Atrahasis epic. According to the myth, the gods created human beings to do the work that they didn't want to do. People became so numerous and so noisy that they prevented the gods from sleeping. The gods didn't like this so they decided to bring a pestilence on humankind, a plague, and get rid of the excess of people. That didn't work so the gods then tried to flood the whole Earth with the largest rainstorm ever experienced. Only one man, Atrahasis, survived this flood, and the gods repented and allowed humans to flourish again. If this sounds familiar, it should be, because this was a model for other, later texts. People have for nearly 4,000 years interpreted disasters as a divine retribution against humans for overpopulating.

In 1679, Antoni van Leeuwenhoek — who was the inventor of the microscope — wrote down in a letter to the Royal Society in London, what I believe is the first quantitative estimate of the maximum number of people the Earth could support. He said it is impossible that the world could be more densely peopled than Holland at that time, which had about a million people, and he said the area of Holland is one part in 13,400 of the habitable area of the Earth, so the maximum population of the Earth must be 13.4 billion.

I have collected sixty-five published estimates of how many people the Earth can support, starting from 1679 and going through 1994. The lowest of these numbers is less than one billion, meaning that the Earth in the long run, whatever that means, cannot support the numbers it already has. The highest of the numbers I have found is well over 1,000 billion. So there is a range of a thousand-fold from less than one to more than a thousand billion.

That should raise in your mind some questions: Can all these estimates be right? No. Why do they all differ? They differ because they are making different assumptions about how people will choose to live. They are making different assumptions about technologies that are available. And in general, the question how many people can the Earth support, is an incomplete question. So let me give you some of the things that must be considered to make the question complete.

...growth rate peaked at 2.1% per year around 1965... and has since slowly declined to about 1.6% per year.

You have to ask how many people can the Earth support at what average level of material well being? Do people want to have a lot of food, with animal foods included, or just vegetarian food? Do people want their clothing to be cotton or wool or synthetic fibers? Do people want to drink river water or Perrier water? Do people want to live in shacks or do they want to live in Monticello like Thomas Jefferson? What average level of well-being?

Second, with what distribution of material well-being? Do you want everybody to be equally well off or would you be willing to have millions of people living in poverty as they do now?

How many people with what technology now and in the future?

How many people with what domestic and international political institutions? If political conflict is resolved by negotiation, you have many more resources than when it is resolved by force. Political institutions that give people incentives to work for themselves have a different effect on their productivity and therefore on the carrying capacity of the Earth than political institutions where there are no incentives for individual initiative.

How many people with what domestic and international economic arrangements? Economic arrangements make a tremendous difference to how many people the Earth can support. If you have land and I have phosphates and you and I can trade, then I can sell you phosphates, you can fertilize your land and I can buy your food. So we can both be better off than if we don't trade.

How many people with what domestic and international demographic arrangements? Your country has mines but few people. My country

has many people. Are people allowed to migrate from where they are to where they are needed for work? It makes a difference in what can be produced. How will families be structured? Who will be responsible for taking care of old people? These demographic arrangements will have a major effect on carrying capacity.

How many people in what physical, chemical and biological environments? For example, which is going to cause more problems, global warming or global limitation on fossil fuel consumption? Which is going to cause more problems, dumping toxic or nuclear wastes or ordinary sewage sludge in the deep ocean, where it may come back when deep currents well up in biologically productive off-shore zones, or dumping those same wastes on land, where they may enter aquifers? These are choices we have to make about physical and chemical and biological environments.

How many people with what variability or stability? Do we want to have the population of the world fluctuate or do we want to hold it at a steady level? If we want to hold it at a steady level then we have to hold it at the lowest level that we can be sure to maintain. If we are willing to ride up and down depending on the decadal weather patterns and long-term shifts in climate then the average population size could be higher.

How many people with what risk or robustness? For example, if you settle in a previously uninhabited zone, such as the flood plain of the Mississippi River, or the hurricane-prone coast of the southeastern U.S., you demand a higher carrying capacity of the hazardous zone, but you have to accept a higher risk of catastrophe.

How many people for how long? If you are only concerned about five years, you don't have to worry about oil resources. But in the long term, technology can change the very definition of resources. Technology can convert what used to be a useless, greasy slick coming out of the ground in Pennsylvania, into oil that has many uses. If the time and capital available are sufficient — a very big "if" — then technology can do the same thing for other kinds of rocks. Of course, no one knows whether the technology and capital will be available when, and in the amounts, they are wanted.

Finally, and I think most importantly, how many people the Earth can support depends on their fashions, tastes, and values. How many people the Earth can support depends on what people want from life. Do people prefer a high average wage and low employment, or low average wage and high employment, if they can't have both? Should industrial economies seek to develop renewable energy resources now, or should they keep burning fossil fuels and leave the transition to other energy sources to future generations? Should women work outside their homes? These are moral and value questions and they have a tremendous impact on carrying capacity.

So carrying capacity is determined jointly by human choices and natural constraints. Consequently, the question, how many people can the Earth support, does not have a single numerical answer, now or ever. Human choices about the Earth's human carrying capacity are constrained by facts of nature which we understand poorly. So any estimates of human carrying capacity are only conditional on future human choices and natural events. If people make certain choices in the future, then the human carrying capacity is likely to be thus and so. And nobody can predict the constraints or possibilities that lie in the future.

...many of the estimates of the Earth's carrying capacity fall right within the ... present or projected population...

ER: Surely we can make a reasonable estimate of the limits to human numbers.

JC: Demographers used to make population predictions. They used to say that the number of people on Earth will be so and so or the number of people in the U.S. will be so and so. When they turned out to be wrong, they fell back to a much safer and intellectually much sounder position of making conditional predictions; that is, if birth rates do this, and if death rates do that, and if migration rates are so and so, then the population will change in this way. That kind of

conditional prediction or projection is fine. It leaves to the user a judgement about how plausible these assumptions about birth, death and migration are. I think that is appropriate because it is really impossible for me to predict, for example, how many children my nineteen-year-old daughter is going to have. I don't know and I don't know if she knows. To predict fertility on a global basis is really out of the question. You can make estimates but they are only estimates.

The same argument I believe, applies to calculations about how many people the Earth can support. If people use such and such a technology, and if they settle their political differences by peaceful means, and if the world has open trading, and if we want to preserve a decent quality of atmosphere, soils and water, and if people choose to live modestly, then we can support such and such a number.

In my new book, one chapter analyzes in great detail eight case studies of how this has been done. In another chapter I discuss how many people can be fed at different levels from 2,000 kilocalories per day up to 3,000 kilocalories per day or more, depending on how much water is used for irrigated agriculture. I derive not a single number but what is called a response surface. In other words, for each choice of number of calories per day, and for each fraction of the water available that will be used for irrigation, and for each choice of how much of the food grown will be wasted by rodents, and how much will be wasted by the consumer, for all of these choices you get one number of people who can be fed. For other choices, you get other numbers of people who can be fed.

I am trying to change the way people think about the question. People see the title, *How Many People Can the Earth Support?* and they ask me "What is the answer?" And my answer is: we have to understand the question better. What choices do we want to make? How well do we understand the natural constraints?

Some people say: Who cares? I answer that many of the estimates that have been made of the Earth's carrying capacity fall right within the same ranges as the present or projected population for the next few decades.

...if you kick the atmosphere as hard as we are kicking it, you can be sure there are going to be some surprises.

That should be a cause of concern. I think we have to take seriously the likelihood of confronting, now and in the coming half century, difficult choices. These choices would probably be easier if the population grew more slowly or not at all. It seems prudent to seek constructive ways to slow rates of population growth.

Many of the means that have been suggested for voluntarily slowing population growth are worth doing in themselves. So I think there are quite clear action consequences that follow from these estimates of how many people the Earth can support, not because we are going to run into a stone wall of some hard and fast limit to the number of people, but because we are driving in the dark, when it is foggy.If you don't know where the road is turning, and you don't know where the cliffs at the side of the road are, it behooves you to travel slowly and cautiously. That is my argument. Not that there is a hard and fast limit that we are going to smash into, but that there could be surprises and it is easier to steer the car if it is going slowly, easier to foresee problems and respond appropriately if you are not doing sixty.

ER: Once the population starts growing rapidly there is a momentum to it. Is that important?

JC: Yes. Even if all women, from today on, had just the 2.1 children required to replace themselves and a partner, the population would still increase by several billion, maybe up to around eight billion over the coming century or so. The population has a tremendous momentum like a huge truck or ocean liner. It takes a long time to bring population growth to a halt.

ER: Is that because there are so many people of child bearing age alive now?

JC: About thirty-five percent of the people of the developing regions of the world today — almost one of three people on Earth — are aged under fifteen years old. Those young people have not even begun to have their children. When they have their children, that will add to the numbers that we have.

ER: The current population explosion is occurring in the developing world, but the developing world does not have the agriculture, the schools, the jobs to support a growing population.

JC: The less developed countries have average gross national product per person of about one thousand dollars. The more developed countries, with only twenty percent of the world's people, have an annual average GNP of about seventeen thousand dollars per person as of 1995. Yet the population growth rate in the less developed

countries is about 1.9 percent a year and in the more developed countries it is one-tenth of that, 0.2 percent per year. In other words, the less developed countries are doubling every thirty-six years at current rates; the more developed countries are doubling every 430 years. So ninety-five percent of all the people who are being added to the world's population are being added in the poorer countries.

The population density in the poor countries is about fifty people per square kilometer whereas in the more developed, richer countries it is about twenty per square kilometer. Worldwide, it is little bit in excess of about forty per square kilometer. So the poorest countries have the most rapid growth, they already have the highest population density, they have the least income, they have the highest number of young people and they are going to double in thirty-six years at current rates, if these rates are maintained. Most likely the current rates will not be maintained, fortunately.

A big question is, are people reducing their fertility as rapidly as they would if they understood the consequences of continuing high fertility? I think that the prospects are not gloomy, but they are potentially dangerous unless people rapidly learn to behave in their own self interest by reducing their fertility.

To give an analogy: when I cross a highway, there is a lot of traffic there and it is dangerous. But I am not afraid, I am just careful. And the same thing applies to population I think. If people could understand that making the wrong move can get you into trouble, but behaving prudently can save you trouble, then people would begin to behave prudently.

It is in the self interest of the rich countries not only to encourage the dissemination of contraceptive materials and services, but also to help educate women all over the world, to improve child survival, to promote economic development, to invest in better workers in poor countries so that they get paid more, to promote peace and democracy and freedom, and to help the world find a better balance between economic efficiency and economic equality. All these lofty goals, good in themselves, will also help solve problems of population growth.