

This discussion of the history of global population growth is excerpted from *A Scientist Searches for Life* (in preparation), by Curtis D. Mobley.

World Population

It is difficult to estimate the population of the world at the pre-dawn of civilization some ten or twelve thousand years ago. The last ice age was just ending in Europe and North America. Nomadic hunter-gatherers followed herds of wild game. There were few villages to leave remains for archaeologists. Not surprisingly, then, estimates of the earth's population in 10,000 BCE¹ are highly uncertain. Various studies have placed the global population anywhere from one to ten million. The actual population probably fell somewhere in the middle, say five million persons. In any case, the human population of the entire world would not fill even a single large city of today.

Agriculture was “invented” around 7,000 or 8,000 BCE with the domestication of wild plants and animals. The cutting-edge technology of that time consisted of hand planting of crops using sticks for plows and flint-bladed scythes to harvest the grain. Primitive as it was, the development of farming nevertheless triggered the rise of what we now call civilization, with permanent settlements in areas such as the “fertile crescent,” which stretched from the Nile valley to the Tigris and Euphrates river valleys in modern Iraq. The population increased to perhaps ten million (estimates range from 5 to 20 million) by 5,000 BCE, a doubling time of 5,000 years.

I have found nine estimates of the world population at the time of Christ, two thousand years ago. These estimates range from 170 to 400 million, with an average of 269 million. That is roughly the population of the United States today. At that time, agriculture was still subsistence farming, but did use metal hand tools, wooden plows pulled by horses or oxen, manual irrigation in river flood plains, and fertilization with animal manure. The associated increases in food production enabled the growth of cities such as Rome, which had an estimated population as large as one million.

Not until the mid-1600s was metal added to plows. Jethro Tull invented the seed drill in the early 1700s, Cyrus McCormick invented the reaper in 1831, and John Deere invented the self-cleaning steel plow in 1837. These new technologies enabled farmers to plant and harvest much more than before, even though horse power was not replaced by steam power on the farm until the end of the nineteenth century. Food production increased greatly, with the population following close behind.

My own lifetime has seen the “green revolution” based on manufactured chemical fertilizers and pesticides, farm mechanization, genetically engineered crops, and enormous irrigation projects. Grain production correspondingly increased by a factor of ten from 1950 to 1990 (14 million to 144 million tons).

¹Before the Common Era, the politically correct replacement for BC, or Before Christ.

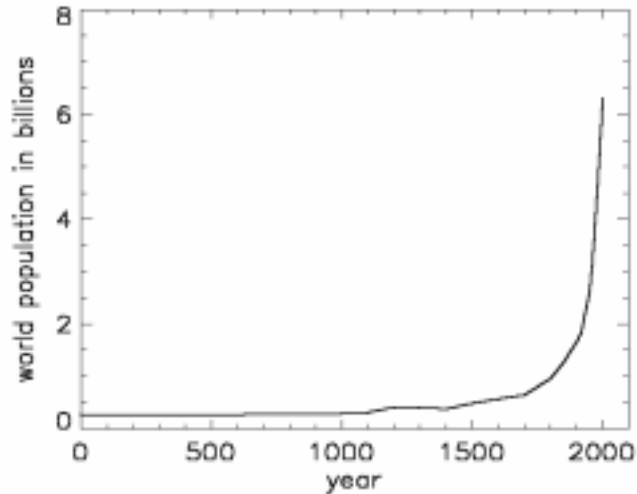


Fig. 1. The greatest problem the earth faces: out-of-control population growth.

Each of these revolutions in agriculture easily could have resulted in a world without hunger, had the population remained steady, or grown only slowly, after the introduction of the new technologies. Needless to say, that is not what happened.

Figure 1 shows the rise in the global population since the time of Christ. There is much to be learned from this simple curve, so I wish to examine it in detail. First, note the slight dip around 1400. This is the impact of the “black death” (bubonic and pneumonic plague) that killed approximately one third of all the people in Europe beginning with its arrival in Constantinople in 1347. But catastrophic as it was to Europe, the plague generated only a minor hiccup in the earth’s population statistics when viewed from afar.

Figure 2 replots the population data beginning with the year 1000. As shown by the dotted line, the earth’s population from 1000 to 1700 can be nicely described as exponential growth with a doubling time of approximately 650 years. That is to say, at this growth rate, the population would double every 650 years. Had this growth rate continued, the earth would today have fewer than one billion persons, and today’s actual population of 6.2 billion would not be reached until around the year 3,900.

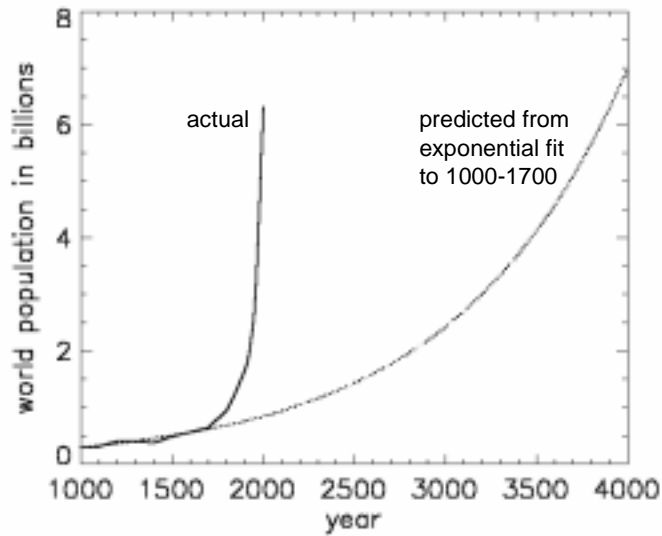


Fig. 2. Actual global population (solid line) versus what the population would be if the growth rate from 1000 to 1700 had continued (dotted line).

The rapid increase in population beginning around 1700 reflects the rise of modern agriculture—the improved plowing, planting, and harvesting techniques, new crops, farm-to-city transportation, etc. mentioned above. The population grew quickly as soon as the land could support more people. Ireland provides the classic case study. Before the introduction of the potato to Europe in the late sixteenth century, it was often the case that a young man did not marry until he owned a plot of land sufficiently large to support a family. Many women never married, or did not marry and have children until their late twenties. However, potatoes can feed far more people per acre of land than can barley or wheat. Thus, when potatoes became a major crop in Ireland by the end of the 1600s, it became possible for a man to support a family on a much smaller plot of land than before. Marriage ages decreased and family sizes increased. The population of Ireland consequently grew from four to 8.2 million from 1781 to 1841, a doubling time of less than sixty years.

Potato-induced population growth was not just an Irish phenomenon. Much the same thing happened, for example, in Nepal. Potatoes, introduced there by the British, were ideally suited to the high, cold Himalayan mountain valleys that were unsuitable for barley, the major Nepalese food crop at the time. The Nepalese quickly occupied previously unfarmable mountain regions and the population exploded.

The same story could be repeated for other crops or technologies and other countries. Most importantly, there is a common human behavior in every instance. Never once did the Irish, or the Nepalese, or anyone else collectively say to themselves, “You know, I can now feed my wife and two children with ease. I’ll stop reproducing now, and we’ll all live comfortable lives with full stomachs and spare time for education, golf, and sleeping late on Saturday morning.” Without fail, the thought (or lack of thought) was, “This is great. Fifty years ago, my father could barely support two half-starved children. I can now support six or eight or maybe a dozen. By the time I die, I can have dozens of grandchildren.” The inevitable result was that the population always outran technology’s ability to provide food. Where there were four hungry people before, there were a dozen a century later.

Figure 3 shows that the same behavior continues today. From 1900 to 1950, the population grew exponentially with a doubling time of approximately 90 years. But starting around 1950, the growth rate exploded again. From 1960 to the present, the doubling time has been around 35 years. What happened in 1950?

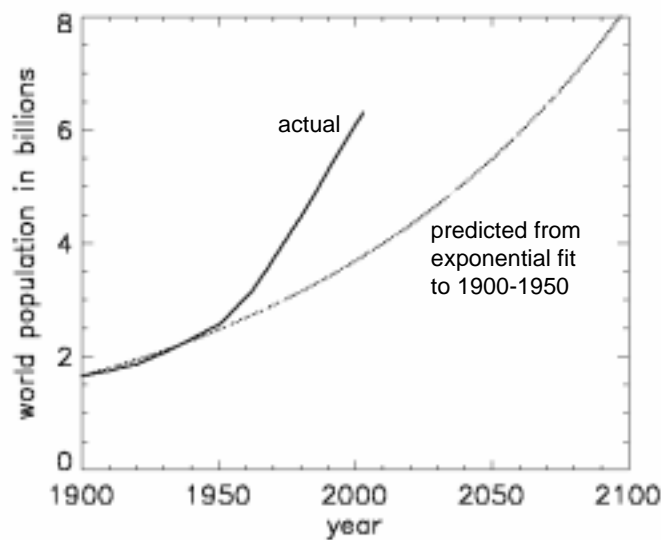


Fig. 3. Actual global population versus what it would be if the growth rate from 1900 to 1950 had continued.

The Second World War resulted in sixty million deaths in Europe. Yet that was less than three per cent of the world's population in 1940, not even enough to cause a noticeable dip in the population curve of Fig. 3. The war effort also resulted in the establishment of scientific research as an important foundation of any advanced society. Conducting science for the sake of discovery soon became just as important a driver of a nation's economic well being as raising food, manufacturing, energy production, military defense, or other traditional undertakings. The technological fruits of basic medical research, for example, soon reached society in the form of antibiotics and other improvements in health care, ranging from diagnostic x-rays to vaccines for polio. Farm mechanization, fertilizers, and pesticides allowed more food to be produced from less land and fewer farmers. The world was again able to support a greatly increased number of people, and the population boomed.

The optimist views this history of parallel increases in food production and population as confirming that things always work out OK. Don't worry—luck, science, or God will take care of us. Just when the Germans finished logging all of their original forests for firewood, coal was discovered in the Ruhr valley. That coal fueled Germany's industrial growth far better than wood ever could have. So no problem, log that last patch of old growth. Just when the future of oil production in the United States was starting to look shaky, new fields were discovered on the North Slope of Alaska. So no problem, keep commuting in your gas guzzling land yacht. Just when virtually all of the arable land on the planet had been plowed, the green revolution increased production. See, no problem, we don't need any more land. Go ahead and have another cute baby. Global warming, insatiable demand for oil, drying aquifers, worldwide spread of AIDS? No problem, something will save the day.

I do not see the situation in the same light. Exponential growth never, ever continues forever. It does not matter if it the growth refers to the number of maggots feeding on a dead cow or the number of persons feeding on the earth. Simple mathematics guarantees an end to growth when resources are finite. As Fig. 3 shows, the population doubled from three to six billion between 1960 and 2000. If exponential growth with that doubling rate could continue, the population would double fifteen more times in the next six hundred years. That would give $2^{15} = 32,768$ times the present population. The result would be that each person on earth would have less than one square yard of room on land. After a couple more doublings during the following century, people literally would be standing shoulder to shoulder from the south pole to the top of Mt. Everest. I suppose, at that time, growth would finally cease because people would be so jammed together that they would not be able to position themselves for mating.

But long before that day, of course, necessary resources will become depleted and the growth will stop. It is often the case in nature that a rapidly growing population crashes quite suddenly, just like the price of an overhyped stock when the pool of gullible investors finally dries up. For humans, the crash could come over a century or two from starvation, over a few years from the rapid spread of a new disease, or perhaps over days from a nuclear war triggered by competition for dwindling natural resources. There is no question that the world's rapid population growth will come to an end. The only uncertainty is how soon and in what manner.

What, then, are the most likely prospects for future population growth? The U. S. Census Bureau projects that the global population will be 9.2 billion in 2050. That is a billion less than the number obtained by a linear extrapolation of the curve in Fig. 3, and three billion less than would result from another doubling of today's population. This slowing down of the growth rate is unprecedented in human history. (The decrease in population during the black death in Europe was due to an increase in the death rate, not to a decrease in the birth rate.) The cause lies primarily in decreasing birth rates in Japan, Europe and North America. The fertility rate, the average number of births per woman during her lifetime, is currently 2.01 in the United States. This is not quite enough to replace the existing population when account is made for babies born who themselves never reproduce. In Italy and Spain the rate is less than 1.2. (Apparently couples in these supposedly Catholic countries have either perfected the rhythm method or chosen to ignore the Pope's strictures against artificial means of birth control.) However, in sub-Saharan Africa the average is still almost six births per woman. It is four in North Africa and the middle East, and almost three in Latin America and Asia. The consequence is that the less developed countries of the third world today account for ninety-nine percent of the global population growth. Indeed, some European countries are even experiencing slight decreases in population due to emigration.

...much more to come...