



## The impact of ecological limits on population growth

Demographers are predicting that world population will climb to 10 billion this century. But with increasing pressure on water and food supplies will this projected population boom turn into a bust?

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This year marks the arrival of the seven billionth human. But with increasing pressure on water and food supplies will this projected population boom turn into a bust? Photograph: Ace stock Ltd/Alamy/Alamy

The hard part about predicting the future, someone once said, is that it hasn't happened yet. So it's a bit curious that so few experts question the received demographic wisdom that the Earth will be home to roughly 9 billion people in 2050 and a stable 10 billion at the century's end. Demographers seem comfortable projecting that life expectancy will keep rising while birth rates drift steadily downward, until human numbers hold steady with 3 billion more people than are alive today.

What's odd about this demographic forecast is how little it seems to square with environmental ones. There's little scientific dispute that the world is heading toward a warmer and harsher climate, less dependable water and energy supplies, less intact ecosystems with fewer species, more acidic oceans, and less naturally productive soils. Are we so smart and inventive that not one of these trends will have any impact on the number of human beings the planet sustains? When you put demographic projections side by side with environmental ones, the former actually mock the latter, suggesting that nothing in store for us will be more than an irritant. Human life will be less pleasant, perhaps, but it will never actually be threatened.

Some analysts, ranging from scientists David Pimentel of Cornell University to financial advisor and philanthropist Jeremy Grantham, dare to underline the possibility of a darker alternative future. Defying the

optimistic majority, they suggest that humanity long ago overshot a truly sustainable world population, implying that apocalyptic horsemen old and new could cause widespread death as the environment unravels. Most writers on environment and population are loathe to touch such predictions. But we should be asking, at least, whether such possibilities are real enough to temper the usual demographic confidence about future population projections.

For now, we can indeed be highly confident that world population will top 7 billion by the end of this year. We're close to that number already and currently adding about 216,000 people per day. But the United Nations "medium variant" population projection, the gold standard for expert expectation of the demographic future, takes a long leap of faith: It assumes no demographic influence from the coming environmental changes that could leave us living on what NASA climatologist James Hansen has dubbed "a different planet."

How different? Significantly warmer, according to the 2007 assessment of the Intergovernmental Panel on Climate Change — as much as 10 degrees Fahrenheit more than today on average. Sea levels from two to six feet higher than today's — vertically, meaning that seawater could move hundreds of feet inland over currently inhabited coastal land. Greater extremes of both severe droughts and intense storms. Shifting patterns of infectious disease as new landscapes open for pathogen survival and spread. Disruptions of global ecosystems as rising temperatures and shifting precipitation patterns buffet and scatter animal and plant species. The eventual melting of Himalayan glaciers, upsetting supplies of fresh water on which 1.3 billion South Asians and Chinese (and, of course, that number is rising) depend for food production.

And that's just climate change, based on the more dramatic end of the range the IPCC and other scientific groups project. Yet even if we leave aside the likelihood of a less accommodating climate, population growth itself undermines the basis for its own continuation in other ways. Since

1900, countries home to nearly half the world's people have moved into conditions of chronic water stress or scarcity based on falling per-capita supply of renewable fresh water. Levels of aquifers and even many lakes around the world are falling as a result. In a mere 14 years, based on median population projections, most of North Africa and the Middle East, plus Pakistan, South Africa and large parts of China and India, will be driven by water scarcity to increasing dependence on food imports "even at high levels of irrigation efficiency," according to the [International Water Management Institute](#).

The world's net land under cultivation has scarcely expanded since 1960, with millions of acres of farmland gobbled by urban development while roughly equal amounts of less fertile land come under the plow. The doubling of humanity has cut the amount of cropland per person in half. And much of this essential asset is declining in quality as constant production saps nutrients that are critical to human health, while the soil itself erodes through the double whammy of rough weather and less-than-perfect human care. Fertilizer helps restore fertility (though rarely micronutrients), but at ever-higher prices and through massive inputs of non-renewable resources such as oil, natural gas, and key minerals. Phosphorus in particular is a non-renewable mineral essential to all life, yet it is being depleted and wasted at increasingly rapid rates, leading to fears of imminent "peak phosphorus."

We can recycle phosphorus, potassium, nitrogen, and other essential minerals and nutrients, but the number of people that even the most efficient recycling could support

may be much less than today's world population. In 1997, Canadian geographer Vaclav Smil calculated that were it not for the industrial fixation of nitrogen, the world's population would probably not have exceeded 4 billion people — 3 billion fewer than are alive today. It's likely that organic agriculture can feed many more people than it does currently, but the hard accounting of the nutrients in today's 7 billion human bodies, let alone tomorrow's projected 10 billion, challenges the hope that a climate-neutral agriculture system could feed us all.

Food production also requires many services of nature that conventional agronomy tends to ignore in projecting future food supplies, and the dependability of these services appears to be fraying. Roughly one out of every two or three forkfuls of food relies on natural pollination, yet many of the world's most important pollinators are in trouble. Honeybees are

succumbing to the tiny varroa mite, while vast numbers of bird species face threats ranging from habitat loss to housecats. Bats and countless other pest-eaters are falling prey to environmental insults scientists don't yet fully understand. And the loss of plant and animal biodiversity generally makes humanity ever-more dependent on a handful of key crop species and chemical inputs that make food production less, rather than more, resilient. One needn't argue that the rising grain prices, food riots, and famine parts of the world have experienced in the past few years are purely an outcome of population growth to worry that at some point further growth will be limited by constrained food supplies.

As population growth sends human beings into ecosystems that were once isolated, new disease vectors encounter the attraction of large packages of protoplasm that walk on two legs and can move anywhere on the planet within hours. In the last half-century, dozens of new infectious diseases have emerged. The most notable, HIV/AIDS, has led to some 25 million excess deaths, a megacity-sized number even in a world population of billions. In Lesotho, the pandemic pushed the death rate from 10 deaths per thousand people per year in the early 1990s to 18 per thousand a decade later. In South Africa the combination of falling fertility and HIV-related deaths has pressed down the population growth rate to 0.5 percent annually, half the rate of the United States. As the world's climate warms, the areas affected by such diseases will likely shift in unpredictable ways, with malarial and dengue-carrying mosquitoes moving into temperal zones while warming waters contribute to cholera outbreaks in areas once immune.

To be fair, the demographers who craft population projections are not actively judging that birth, death, and migration rates are immune to the effects of environmental change and natural resource scarcity. Rather they argue, reasonably enough, that there is no scientifically rigorous way to weigh the likelihood of such demographic impacts. So it makes more sense to simply extend current trend lines in population change — rising life expectancy, falling fertility, higher proportions of people living in urban areas. These trends are then extrapolated into an assumedly surprise-free future. The well-known investor caveat that past performance is no guarantee of future results goes unstated in the conventional demographic forecast.

Is such a surprise-free future likely? That's a subjective question each of us must answer based on our own experience and hunches. Next to no research has assessed the likely impacts of human-caused climate change, ecosystem disruption, or energy and resource scarcity on the two main determinants of demographic change: births and deaths. Migration related to climate change is a more common subject for research, with projections ranging from 50 million to 1 billion people displaced by environmental factors — including climate change — by 2050. The mainstream projections cluster around 200 million, but no one argues that there is a compelling scientific argument for

any of these numbers.

The IPCC and other climate-change authorities have noted that extremely hot weather can kill, with the elderly, immune-compromised, low-income, or socially isolated among the most vulnerable. An estimated 35,000 people died during the European heat wave of 2003. The U.S. Centers for Disease Control and Prevention cites research projecting that heat-related deaths could multiply as much as seven-fold by the century's end.

In the past few years, agronomists have lost some of their earlier confidence that food production, even with genetically modified crops, will keep pace with rising global populations in a changing climate. Already, weather-related disasters, from blistering heat waves to flooded farm fields, have contributed to widening gaps between food production and global consumption. The resulting price increases — stoked also by biofuels production encouraged in part to slow climate change — have led to food riots that cost lives and helped topple governments from the Middle East to Haiti.

If this is what we see a decade into the new century, what will unfold in the next 90 years? "What a horrible world it will be if food really becomes short from one year to the next," wheat physiologist Matthew Reynolds told *The New York Times* in June. "What will that do to society?" What, more specifically, will it do to life expectancy, fertility, and migration? Fundamentally, these questions are unanswerable from the vantage point of the present, and there's a lesson in this. We shouldn't be so confident that the demographers can expertly forecast what the world's population will look like beyond the next few years. A few demographers are willing to acknowledge this themselves.

"Continuing world population growth through mid-century seems nearly certain," University of California, Berkeley, demographer Ronald Lee noted recently in *Science*. "But nearly all population forecasts... implicitly assume that population growth will occur in a neutral zone without negative economic or environmental feedback. [Whether this occurs] will depend in part on the success of policy measures to reduce the environmental impact of economic and demographic growth."

It's certainly possible that ingenuity, resilience and effective governance will manage the stresses humanity faces in the decades ahead and will keep life expectancy growing in spite of them. Slashing per-capita energy and resource consumption would certainly help. A sustainable population size, it's worth adding, will be easier to maintain if societies also assure women the autonomy and contraceptive means they need to avoid unwanted pregnancies. For anyone paying attention to the science of climate change and the realities of a rapidly changing global environment, however, it seems foolish to treat projections of 10 billion people at the end of this century as respectfully as a prediction of a solar eclipse or the appearance of a well-studied comet. A bit more humility about population's path in an uncertain and dangerous century would be more consistent with the fact that the future, like a comet astronomers have never spotted, has not yet arrived.