Companion to Environmental Studies

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Population numbers and global demography

7.15

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The importance of population in environmental problems

Each of the various environmental problems facing us, including global warming, air pollution, water pollution, deforestation, and species extinction, may be addressed by targeting relevant factors that are different for each problem. But population is a multiplicative factor common to all of them, so it deserves special attention. And it is a multiplier not only for the causes of environmental problems but also for their impacts. For example, the harm caused by sea-level rise depends on the number of people living in the coastal areas subject to flooding.

What exponential growth can do

Exponential growth occurs when the change of a quantity is proportional to the quantity itself. Populations (of plants, animals, and bacteria) are capable of exponential growth if the resources necessary for life are available, because the number of offspring in a population is proportional to the existing population. For humans, the "total fertility rate" (*TFR*) of a defined group (e.g. a nation) is the average number of children produced by a woman in her lifetime. The *TFR*, the population doubling time, and the annual growth rate, are all related by simple equations (Warren, 2015).

Two key examples (assuming for simplicity that all children live to reproductive age) are (a) *TFR* = 2 children per woman (cpw), resulting in a stable population and called "replacement-level fertility" because the number of children is just enough to replace their two parents; and (b) *TFR* = 4 cpw, for which the population doubles in one generation. At present, the highest *TFR*s are in Africa, 6–7 cpw (e.g. Niger, Angola, Congo), and the lowest are in Eastern Europe and East Asia, 1.2 cpw (e.g. Poland, Greece, Taiwan, Singapore).

If exponential growth continues for several generations, the population can grow by an astonishing amount. In 1900 the population of the Philippines was 7 million, but then it doubled every 28 years, reaching 100 million in 2014.

Recent population history

The world population doubled in 40 years, from 3 billion in 1960 to 6 billion in 2000 (now in 2016 it is 7.4 billion). This growth rate, a doubling in just 40 years, was unprecedented. Now the world is experiencing a slower growth rate in percent per year, but a constant number added per year, because the base population is growing. For example, in 1977 the population of 4.3 billion, growing at 1.9 per cent per year, meant an addition of 82 million people per year. In 2008 the growth rate was only 1.2 per cent per year, but building on a population of 6.7 billion it caused the population to grow, again, by 82 million per year.

Is our understanding of the demographic transition backwards?

At various times in the past two centuries the fertility rate in country after country declined dramatically, from ~6 to ≤2. In many developing countries, the fertility rate is inversely correlated with affluence and with education of girls, suggesting that the way to reduce *TFR* in poor countries is to promote economic and educational development; then women will choose to have fewer children. Expressing this view is the slogan "Development is the best contraceptive."

But in this correlation the causality could be in the other direction. In countries that recently transitioned from poor to rich and from high to low fertility, the fertility transition *preceded* the rapid economic development (O'Sullivan, 2015). In East Asia in 1970, Thailand and the Philippines both had high fertility (6 cpw) and similar per-capita GDPs. Because of differences in their family-planning policies, fertility declined more rapidly in Thailand than in the Philippines (now 1.6 and 2.9 cpw, respectively), and now Thailand's per-capita GDP is $6000, versus Philippines' $2400. With fewer children to support, resources are not spread so thin, and the children can be better educated. The outcome of this debate has implications for the focus of development aid; more attention might be paid to providing and promoting contraceptives, so as to reduce the fertility rate now rather than waiting for economic development to (hopefully) lead to smaller families. Currently, only 1 per cent of foreign development aid

is allocated to family planning; a doubling to 2 per cent has been advocated to slow population growth (Bongaarts, 2016).

Is immigration necessary to maintain a prosperous economy in low-fertility countries?

Many developed countries, particularly in Europe, now have below-replacement-level fertility, yet their populations are still growing because of immigration from nearby high-fertility countries. Immigration of young workers is widely seen as necessary to maintain public finances and standards of living in countries whose native populations are aging, such as Germany. This view has been challenged by Lee et al. (2014); their survey of 40 diverse countries found that, on the contrary, "Fertility below replacement, and modest population decline, favor higher material standards of living." Japan is taking this alternative path. Its fertility has been low for long enough that its population is already declining. But instead of bringing in immigrants, which now constitute only 2 per cent of Japan's population, alternative solutions are sought: recruiting women and retirees into the work force, and developing robots to lessen the demand for human workers. For example, robots in Japan are taking on some tasks in the nursing-home care of patients with dementia (Weisman, 2013).

Debates about population projections

The U.N. Population Division, in collaboration with the Statistics Department at the University of Washington (Gerland et al., 2014), projects world population reaching 11±1.3 billion at 2100 and still growing. Their work was challenged by Lutz et al. (2014), who expect world population to peak in 2075 at 9 billion and then decline. Both projections have *TFR* declining in the high-fertility countries; their debate is about how fast it will decline. For example, Gerland et al. assume Nigeria's *TFR* to drop from today's 5.5 cpw, down to 2.2 by 2100; this trajectory would result in growth of Nigeria's population from today's 182 million to 900 million in 2100. Lutz et al. expect a more-rapid drop in fertility, resulting in a smaller population in 2100.

Most of the projections have incorporated an assumption that all nations will eventually converge to a uniform value of $TFR \approx 2.1$ cpw, which is the replacement-level fertility for developed countries (it is slightly higher than 2.0 to account for childhood deaths). The U.N. has experimented with alternative limiting *TFR*s, but then returned to 2.1 for its most recent projections. But no stabilizing feedbacks have been found that can maintain *TFR* within a narrow range (Demeny, 1997), so why has this assumption, precise to two significant figures, been so persistent? We can get a clue by noting that any constant value of *TFR* greater than 2.1 leads to a population growing indefinitely toward infinity, and any value less than 2.1 results in the population declining eventually to zero (Figure 7.15.1). The assumption of 2.1 may therefore be based on the U.N.'s desire to avoid disaster.

What the projections do not incorporate is any increase in mortality (decrease of life expectancy) due to famine, disease, or war, that might result from overpopulation, and the projections have been criticized for this neglect.

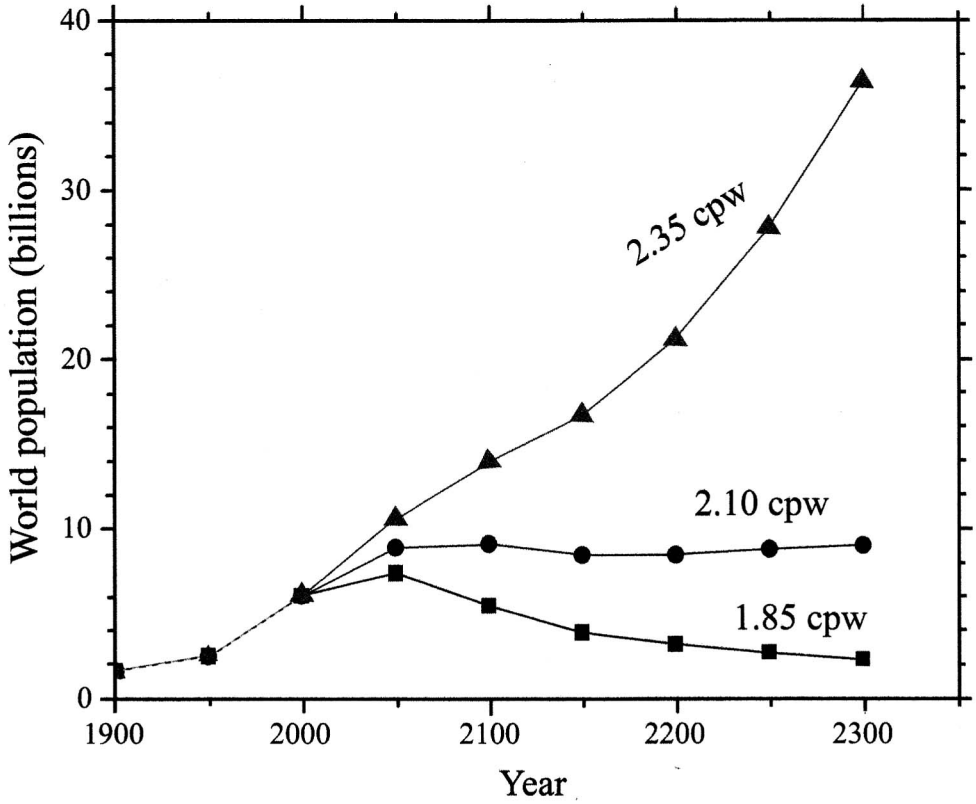

Figure 7.15.1 Projections of global population, assuming long-term fertility at the replacement level of 2.1 children per woman (cpw) as well as two variants of constant fertility, higher or lower than replacement level by 0.25 children.

Source: Redrawn from World Population to 2300, by Population Division, ©2004 United Nations. Reprinted with the permission of the United Nations.

The coming population decline *versus* the problem of outliers

The worldwide trend to smaller families has led many policy makers to conclude that "population will take care of itself", allowing them to focus efforts for environmental protection on other factors. This complacency has also been fostered by the projections of the U.N. and others that project fertility to stabilize at replacement level in all countries.

In opposition to this view is the expectation that the world will continue to exhibit cultural diversity, so that nations cannot all be expected to converge to identical social behavior. Even if most countries do limit their fertility to replacement level or below, the few that do not can grow to dominate numerically, because of the nature of exponential growth (Warren, 2015).

Women effectively control their own fertility, *versus* an "unmet need" for contraception

There is a widespread belief that women find ways to limit their fertility so that they in fact produce the number of children they say they want. This belief, along with the declining fertility projections of the U.N., has hindered efforts to make availability of birth control a priority in development aid. But if a woman in the Sahel has seven children and says that this is the number she desires, is she telling the truth? Women in patriarchal societies are often not free to choose; they may be married off in their early teens and then pressured by their parents and husbands to have more children than they desire. When contraceptives become available, these women eagerly start using them (Campbell et al., 2013).

The U.N.'s International Conference on Population and Development in 1994 resulted in diminished support for family planning, which led to a reversal of the ongoing fertility decline in East Africa, causing the projected 2050 population of Kenya alone to be 34 million more than if family planning had continued at its pre-1994 level (Figure 2 of Ezeh et al., 2009).

Is abortion necessary for fertility reduction?

The debate about legalizing abortion has mostly been between opponents who argue that abortion is murder, and proponents who argue for a woman's right to control her fertility and who are dismayed by the thousands of maternal deaths caused each year by unsafe illegal abortions. A different point of view is taken by those concerned about the environmental effects of overpopulation, who see abortion as an essential backup method of birth control for when contraception fails. It is rare to find a country whose fertility has dropped to replacement level without legal abortion.

Will birth control stop population growth, or will population be limited by the food supply?

The debate here is whether projections of human populations are useful if they do not include feedbacks from the Earth system. The projections by the U.N. and others assume that life expectancy will slowly increase everywhere but that fertility will decline so much that world population will eventually peak and then begin to decrease. Those projections do not consider possible resource shortages that would increase mortality, particularly by famine. Earth System models, by contrast, model the effects of population on environmental measures such as greenhouse gas emissions, and the resulting effects of climate change on agriculture, disease, and sea level, and then the feedback effects of this environmental damage on population and on national economies. Modeling of population as part of the Earth System began 40 years ago with the "Limits to Growth" study, but has only recently begun to attract renewed research effort.

Learning resources

The following are all insightful resources that allow exploration of key themes covered in this chapter:

Bongaarts, J. (2016) 'Development: slow down population growth', *Nature*, 530(7591): 409–412.

Cohen, J.E. (1995), *How Many People Can the Earth Support?* New York: Norton.

Population Reference Bureau (2016) *World Population Data Sheet*. Online. Available at: http://www.prb.org.

Rosling, H. (2016) *The Truth about Population*. Online. Available at: https://www.youtube.com/watch?v=eA5BM7CE5-8&feature=youtu.be.

Weeks, J.R. (1999) *Population: An Introduction to Concepts and Issues*. Belmont, CA: Wadsworth Publishing Co.

Weisman, A. (2013) *Countdown: Our Last, Best Hope for a Future on Earth?* London: Little, Brown and Company.

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Demeny, P. (1997) 'Replacement-level fertility: the implausible endpoint of the demographic transition', in Jones, G.W., Douglas, R.M., Caldwell, J.C. & D'Souza, R.M. (eds) *The Continuing Demographic Transition* (pp. 94–110). Oxford: Clarendon Press.

Ezeh, A.C., Mberu, B.U. & Emina, J.O. (2009) 'Stall in fertility decline in Eastern African countries: regional analysis of patterns, determinants and implications', *Philosophical Transactions of the Royal Society B*, 364: 2991–3007.

Gerland, P., Raftery, A.E., Ševčiková, H., Li, N., Gu, D., Spoorenberg, T., Alkema, L., Fosdick, B.K., Chunn, J., Lalic, N. et al. (2014) 'World population stabilization unlikely this century', *Science*, 346: 234–237.

Lee, R., Mason, A., Amporfu, E., An, C-B., Rosero-Bixby, L., Bravo, J., Bucheli, M., Chen, Q., Comelatto, P., Coy, D. et al. (2014) 'Is low fertility really a problem? Population aging, dependency, and consumption', *Science*, 346: 229–234.

Lutz, W., Butz, W., Samir, K.C., Sanderson, W. & Scherbov, S. (2014) 'Population growth: peak probability', *Science*, 346: 561.

O'Sullivan, J. (2015) 'The infrastructure dividend: conceptualising and quantifying the cost of providing capacity for additional people'. Seventh African Population Conference, Johannesburg, South Africa, December 2015. Online. Available at: http://uaps2015.princeton.edu/abstracts/150981.

United Nations Population Division (2004) *World Population to 2300*. New York: UN Department of Economic and Social Affairs.

Warren, S.G. (2015) 'Can human populations be stabilized?', *Earth's Future*, 3: 82–94.

Weisman, A. (2013) *Countdown: Our Last, Best Hope for a Future on Earth?* London: Little, Brown and Company.