Bibliography

Boulding, Kenneth E., 1964. *The Meaning of the 20th Century: The Great Transition.* New York, NY, Harper and Row, p. 126.

Cohen, J., 1995. *How Many People Can the Earth Support?* W.W. Norton and Co.

Daily, Gretchen C., Anne H. Ehrlich, and Paul R. Ehrlich, 1994. *Population and Environment* 15 (6), 469-475.

Diamond, J., 2005. *Collapse: How Societies Choose to Fail or Succeed*. Penguin Books.

Ferguson, Andrew R.B., 2005. *Intractable Limits to a Sustainable Human Population, Medicine, Conflict and Survival,* 21:2, 142-151, DOI: 10.1080/13623690500073463 <doi.org/10.1080/13623690500073463>.

Firth, R., 1936. *We, the Tikopia*. London: George Allen and Unwin.

Frejka, Tomas, Gavin W. Jones, and Jean-Paul Sardon, 2010. East Asian Childbearing Patterns and Policy Developments. *Population and Development Review*, 36 (3): 579-606.

Footprint. <footprintnetwork.org/our-work/ecological-footprint>.

Good, D.H., and R. Reuveny, 2006. The Fate of Easter Island: The Limits of Resource Management Institutions. *Ecological Economics* 58(3):473-490.

Kirch, P.V., 1997. Microcosmic Histories: Island Perspectives on "Global" Change. *American Anthropologist, New Series*, 99(1):30-42.

Kolbert, Elizabeth, 2014. *The Sixth Extinction: An Unnatural History.* New York NY: Henry Holt and Co.

Lianos, Theodore P., and Anastasia Pseiridis, 2016. Sustainable Welfare and Optimum Population Size. *Environ. Dev. Sustain* 18:1679-1699.

Malthus, T.R., 1798. *An Essay on the Principle of Population*. Printed by William Pickering, London 1986.

McDonald, Charlotte, 2015. How Many Earths Do We Need? *BBC News <bbc.com/news/magazine-33133712>.*

Meadows, Donella H., Dennis L. Meadows, Jørgen Randers, and William W. Behrens III, 1972. *The Limits to Growth; A Report for the Club of Rome's Project on the Predicament of Mankind. New York: Universe Books <donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf>.*

Pimentel, David, Michele Whitecraft, Zachary R. Scott, Leixin Zhao, Patricia Satkiewicz, Timothy J. Scott, Jennifer Phillips, Daniel Szimak, Gurpreet Singh, Daniela Gonzalez, and Tun Lin Moe, 2010. Will Limited Land, Water, and Energy Control Human Population Numbers in the Future? *Human Ecology* 38 (5): 599-611.

Turner, Graham. M., 2012. On the Cusp of Global Collapse? Updated Comparison of *The Limits to Growth* with Historical Data. *GAIA* 21/2 (2012): 116 – 124.

United Nations Population Division, Interactive data available at: <population.un.org/wpp/DataQuery>.

Vermeulent, P.J., and D.C.J. De Jongh, 1977. Growth in a Finite World—A Comprehensive Sensitivity Analysis. *Automatica* 13: 77-84.

Considering Limits to Human Population Size

Population Working Group, Quaker Earthcare Witness, 2019

QEW Population Pamphlets

- *A Friend's Witness on Population*
- *Seeking Clearness on Childbearing in a Crowded World*
- *Adoption: An Earth-Friendly Alternative*
- *A Witness on Sexuality of Friends*
- *Immigration in a Crowded World*
- *Friends Seeking Clearness on Abortion*
- *Empowering Women: The Link to Population*
- *Human Reproduction Is in the Commons: The Case for Smaller Families*

Quaker Earthcare Witness works to integrate into the beliefs and practices of the Religious Society of Friends the Truth that God's creation is to be respected, protected, and held in reverence in its own right, and the Truth that human aspirations for peace and justice depend upon restoring Earth's ecological integrity. Some Friends may choose different language to describe their personal reasons for supporting or sharing in the work of Quaker Earthcare Witness. All are welcome who seek to further QEW's programs and activities.

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Contributions to QEW are welcome.

What Can Friends Do?

- Support education of girls, empowerment of women, reproductive health services, and organizations, such as, Population Connection, Population Media Center, and Planned Parenthood.
- Discuss these matters with family, F/friends and colleagues.
- Consider the material in other QEW population publications on subjects of childbearing, sexuality, immigration, abortion, adoption, especially "Seeking Clearness on Child-bearing in a Crowded World" and "Human Reproduction in the Commons: The Case for Smaller Families".[20]
- Have a forum on population concerns in your Meeting or invite a speaker from QEW Population Working Group to speak at your Quarterly or Yearly Meeting.

Endnotes

1) Daily, Ehrlich, and Ehrlich, 1994; Ferguson, 2005; Pimentel *et al*. 2010; Lianos and Pseiridis, 2015.
2) Boulding, 1964.
3) United Nations Population Division World Population Prospects <*population.un.org/wpp/Graphs/Probabilistic/POP/TOT/900*>.
4) Malthus, 1798.
5) Meadows, *et al*, 1972.
6) Vermeulent and De Jongh, 1977.
7) Turner, 2012.
8) Frejka, *et al*, 2010.
9) Diamond, 2005.
10) Good and Reuveny, 2006.
11) Firth, 1936.
12) Kirsh, 1997.
13) Sustainable Fisheries Partnership, University of Washington <sustainablefisheries-uw.org/fact-check/how-many-fisheries-are-overfished>.
14) NASA, 2019 <climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide>.
15) Kolbert, 2014.
16) Footprint Network <footprintnetwork.org/en/index.php/GFN/page/world_footprint>.
17) McDonald, 2015.
18) Quaker Earthcare Witness, Population Working Group, 2015. Empowering Women: The Link to Population <quakerearthcare.org/sites/default/files/pamphlet/empoweringwomen-final.pdf>.
19) IPCC Press Release, October 18, 2018. <ipcc.ch/site/assets/uploads/2018/11/pr_181008_P48_spm_en.pdf>.
20) Quaker Earthcare Witness, Population Working Group, 2018. <quakerearthcare.org/article/population-resources>.

Providing comprehensive sex education and free contraceptive services are essential first steps. Education gives women opportunities other than early marriage and childbearing. Studies consistently show that women's educational level is one of the most important determinants of levels of fertility.[18] China's goal in the late 20th century for a one-child family did help slow population growth significantly and brought about improvements in daily life, but it was highly coercive, which is against human rights standards.

Simultaneous reduction in material consumption in developed countries and among the burgeoning middle and upper classes of developing countries is clearly another goal. "Worldwide net human-caused emissions of carbon dioxide would need to decline by about 45 percent from 2010 levels by 2030."[19] Attaining these goals will require concerted efforts and societal pressures with a major argument being "for the sake of future generations." These are monumental challenges.

One major impediment to bringing about reduced population by lowering fertility is the economic system based on continual growth. For example, to see more diapers sold next year than this year, and thereby increase profits, marketers would like there to be an increasing number of babies each year. However, studies have shown that population growth is negatively correlated with economic growth. On a finite planet with economic growth dependent on the extraction of non-renewable resources, limits will be reached sooner or later. The vision of a "no growth" economy is one that would provide for the sustenance of the population, but stops the overuse and destruction of the natural environment. And, while not the whole answer, population stabilization is necessary as we move toward a global "no growth" economy.

Adapting to a world with average families having fewer than two children for several generations will be very difficult personally, communally, and spiritually, but no more difficult than living in a world with increased premature deaths of billions of people suffering famine, poverty, disease, and violence. It can be an opportunity to live with much less, not expecting continual economic growth forever, not using up the Earth's fossil fuels, but enjoying clean water and air, and the abundance of vibrant species all around us. Above all, it could be a time for spiritual transformation, to live lightly on the land, to cherish and treasure family all around us. Let us embrace the challenge.

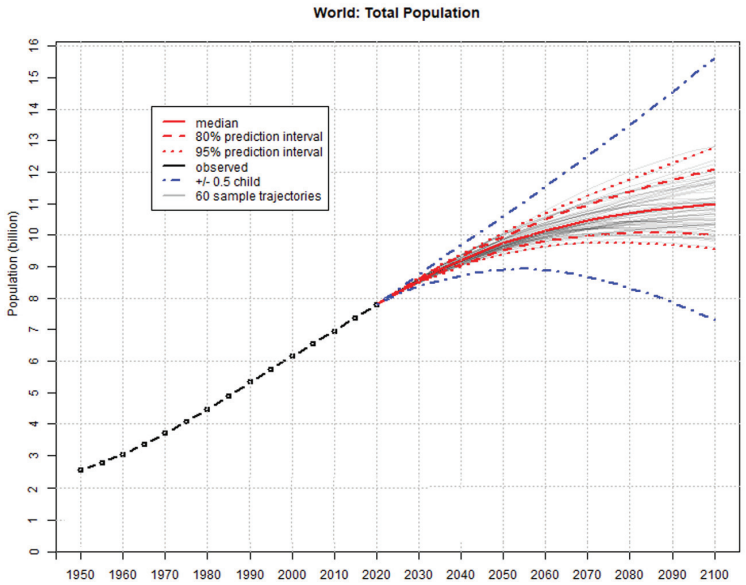
Considering Limits to Human Population Size

Friends have long been concerned about how we live on our Earth and how we can best support a good life for everyone and all species. Sustainability requires that we use Earth's resources at a level that provides a reasonable life for all now and maintains the capacity to provide such a life for all coming generations. An existing population must not use up resources needed to sustain human and other life in the future. Ultimately this means we as a people must consider what are the limits to human population size. The question is: what is a sustainable human population on Earth?

Researchers employing different methods have estimated that the maximum sustainable human population size on Earth ranges between 1.5 and 3.5 billion persons.[1] This raises several questions. Does this mean that the human population is in overshoot already? What does historical research tell us about human behavior under overshoot conditions? What mechanisms can be used to bring the human population back to a sustainable size?

As Quaker Economist Kenneth Boulding wrote more than 50 years ago, "[t]he arithmetic is simply this: any positive rate of growth whatever eventually carries a human population to an unacceptable magnitude, no matter how small the rate of growth may be, unless the rate of population growth can be reduced to zero before the population reaches an unacceptable magnitude."[2] In short, the only sustainable population growth rate in the long term is 0.0 percent per year.

There has been very rapid growth of global population from two billion in 1930, three billion in 1960, four billion in 1974, five billion in 1987, seven billion in 2011, to 7.7 billion as this booklet goes to print. The United Nations projects that world population will reach 9.8 billion by 2050 and 11.2 billion by 2100. Figure 1 (*p. 4*) shows their probability projections to 2100 with estimates of the median, as well as 80 and 90 percent probabilities. Also shown is outlier fertility—if it is increased by 0.5 (upper curve) or decreased by 0.5 births (lower curve) from the median level.



There are two major problems with such UN projections. First, projection of population up to 20-30 years in the future can be quite accurate as many of the people alive today will be alive then. However, for the year 2100, very few people alive today will be alive then. Thus the projections to 2100 depend almost entirely on assumptions of future fertility, since mortality is normally a minor component.

Ecological Limits to Human Population

The other major limitation of these UN projections is that they do not take into account any ecological limitations. For example, the country of Niger, which is landlocked and mostly desert, has a level of fertility of about six births per woman now and the UN projects that it will decline to about 4.4 births per woman by 2050. The population of Niger is now 23 million and the UN projects that it will be 66 million in 2050. But Niger is having great difficulty feeding its present population, so how will it feed 66 million persons?

Based on his experience in Europe, Thomas Malthus proposed in 1798 that food could only increase arithmetically each year (by the same amount) while the human population seemed to grow geometrically (by the same rate). If this continued for very

resources at a rate that would require two Earths to sustain the current population into the future. It would take nearly four Earths to support the present population if everyone lived like the average person in the U.S. A few countries use more than the U.S., but most are well below the consumption of the U.S. Overall, we are overshooting the carrying capacity of Earth now and will overshoot even more if population and consumption continue to grow.[17]

So how we live is an important determinant of a population size that can be supported. If everyone were vegetarian, Earth could support a larger population than is possible for a population of meat-eaters. Similar arguments extend to our mobility using fossil fuels for cars and airplanes, and our other uses of non-renewable resources, for example heating our homes with natural gas. Fossil fuels are nonrenewable, and burning them has led to the crisis of climate change.

Because we are using up Earth's resources, we cannot sustain the global human population of 7.7 billion in 2019. We may be able to attain a very large population before a crash occurs, but a maximum sustainable population (sometimes called an optimum population) is the population size that could continue indefinitely.

Reducing Population Size

Given the current standard of living and its effects on the Earth, human population size definitely appears to be in overshoot now. The question becomes, how can population be brought back down to around three billion without increasing mortality? Fortunately, a decline need not be a crash, but rather an opportunity through lower fertility.

Some countries in Europe (*e.g.* Russia, Latvia, and Hungary) and Japan, have had below replacement fertility (average of 2.1 babies per woman) for so long that there are actually population declines now, that is, more deaths than births in a given year. The aging of the population which accompanies such trends of below replacement fertility is a challenge that must be addressed. To the extent these countries welcome immigrants, it could be a win-win situation for both sending and receiving countries. In recent years, some of these countries, however, have been making efforts to increase fertility due to fears of a national population decline.

To reach a population of three billion worldwide without a crash involving major increases in mortality due to famine, pestilence, and war, as Malthus wrote, will require widespread acceptance of a family norm below two children per family for several generations.

population grew rapidly from about 1,200 in 1929 to 1,753 in 1952," which "exceeded the capacity of the production system to respond to periodic environmental disasters...and famine ensued."[12]

Overshoot

Since the time of Malthus, in part due to improvements in agriculture and the green revolution, the food supply of the world has grown more rapidly than Malthus envisioned, and the population continues to grow by about 80 million persons a year. Signs of population overshoot, however, are appearing. Specifically:

1) The most productive arable land is already under cultivation and the limits of agricultural yield per acre appear to have been reached.
2) Population increase is outpacing increase in food production in many countries.
3) Water scarcity, overused soils, and topsoil losses all indicate challenges for further increases in food production.
4) Nearly one-third of commercial fish species are over-fished and some have already experienced crashes.[13]
5) The amount of carbon dioxide in the atmosphere has surpassed 400 ppm for the first time in recorded history.[14]
6) Millions of persons have become internally displaced or international climate refugees as droughts destroy crops in some parts of the world and sea levels rise.
7) Anti-immigrant political movements have increased throughout the world.
8) Quality of life for many in the U.S. is decreasing as children cannot expect to be better off than their parents; suicide rates are increasing; and opiate addiction is epidemic.

What is a Sustainable Human Population?

The sustainable human population size depends on Earth's resources that are used, that is, on the lifestyles of the human population and how much of Earth's resources are left for future generations and the other creatures with whom we share Earth. We are extinguishing other species at an astonishing rate, called the "Sixth Extinction" and climate change exacerbates this.[15]

Many in the developing world are adopting the equivalent of a U.S. middle class lifestyle, which includes eating more meat, and other aspects that use more of Earth's resources. Ecologists insist that with our current (2019) average lifestyle, we have surpassed the sustainable population size. In fact, the ecological footprint experts have estimated that we passed the sustainable population on planet Earth in about 1970.[16] Worldwide we are now using up

long, population would outstrip food supply, and population would then stop growing because of famine, war, and/or pestilence—by increasing the death rate. Malthus later recognized that human populations also controlled their fertility to respond to ecological limits through celibacy, delayed marriage, and controlled fertility within marriage—thus lowering the birth rate.[4]

Food is limited by the productivity of arable land and the efficiency of the agricultural technology used to produce it, as well as the productivity of the rivers, lakes, and seas. Another limiting factor to food production is the availability of fresh water, which will change with a changing climate.

In the 1972 book, *Limits to Growth,* Meadows, Meadows, Randers, and Behrens reported the results of a study commissioned by the Club of Rome to gain insights into the limits of Earth's resources, the constraints they put on human populations, and their interactions. Population, food production, industrialization, pollution, and material consumption of non-renewable natural resources were considered in the model used. Figure 2 shows their predictions of resources, population, food, pollution, and industrial output. As can be seen, they predicted a significant decline in human population because of a substantial rise in mortality, that is, a ***crash*** in the size of the population of the world.[5]

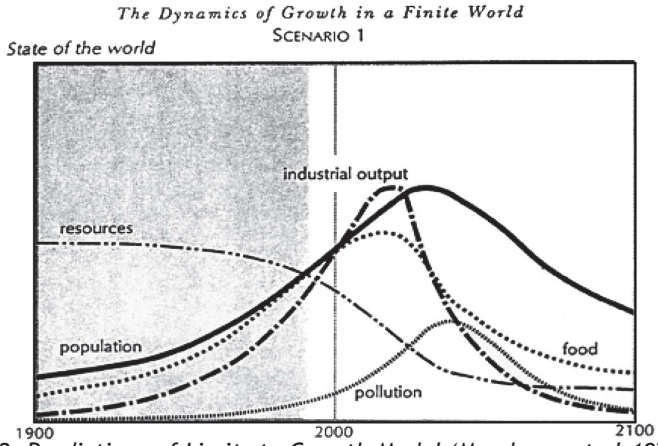


Figure 2. Predictions of Limits to Growth Model (Meadows, et al,1972)[5]

The study was criticized immediately as the results were very sensitive to input parameters, some of which were largely guesses.[6] However, a study in 2012 showed that the trends since 1970 have so far closely matched their simulations from 40 years before.[7]

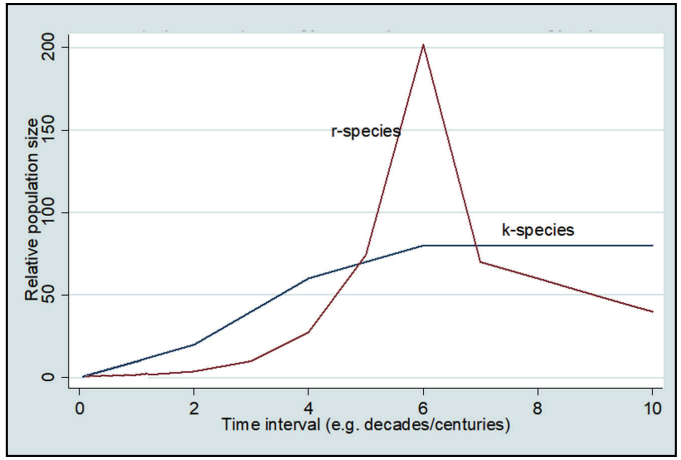


Figure 3. Theoretical population trends of r and k species

Biologists classify species as having an r-strategy for reproduction or a k-strategy. Species with an r-strategy reproduce fast and overshoot their resource base and then the population crashes. In this category are deer, rabbits, and many insects. For k-strategy species, before the population outstrips the resources available to it, reproduction slows and population stabilizes at the carrying-capacity of the environment, at some fixed level that can be supported indefinitely. Most bird and mammal species have a k-strategy and will not breed when their population density passes a certain point (*Figure 3*).

In some places and times, humans have behaved as a "k" species. For example, among the earliest countries to have fertility decline to replacement level (2.1 births per woman), were the city-states or islands Hong Kong (1980-85), Singapore (1975-80), and Taiwan (1985-90). In those cases, when available land was clearly a limiting factor that everyone knew, adjustments to fertility were made.[8] Half the population of the world now lives in countries with fertility at or below the replacement level but because of population momentum the populations of most of these countries will continue to grow for many years. Just as a car does not stop as soon as the brakes are applied, so it is with population. Because of past growth in the world's human population, each age group entering childbearing age will increase in size from one year to the next for quite some time. Even after fertility reaches two children per couple, we can expect the population will continue to grow for about 70 years because of population momentum.

Given the extent to which many current human populations overuse non-renewable resources and pollute Earth's air, water, and soil, sacrificing the wellbeing of future generations and leading to the extinction of large numbers of plant and animal species on Earth, are humans now behaving as an "r" species? One wonders if we are in population overshoot and headed for a crash.

Does Human Population Overshoot and Crash?

There are examples of overshoot and collapse of human societies. In his book *Collapse*, Jared Diamond gives details of five societies that have collapsed due to population overshoot as a function of the available resources. Perhaps the most famous case is Easter Island.[9]

Easter Island is 2,100 km east of the closest Polynesian Island and 3,700 km west of the coast of Chile. About 400 CE a few Polynesians arrived on Easter Island (170 km^2 in size). They created a thriving agrarian society and built huge statues. Over the centuries, the population increased to about 10,000, and then declined rapidly. The island was originally covered with a lush forest but when Europeans arrived in the 18th century, it was nearly barren of trees, with about 2,000 people living in extreme poverty and fighting over the few remaining resources. Archaeologists have documented extinctions of 21 species of trees, 24 species of seabirds and evidence of cannibalism after 1650.[10]

As a counter-example, consider another small volcanic island (Tikopea, 4.6 km^2) in the South Pacific. It had the same challenge (very limited space) as Easter Island but was able to control its population. In the early 20th century, Raymond Firth went to Tikopea and interviewed residents.[11] One thing he wanted to understand was how they controlled population. The stories he heard were: celibacy, prevention of conception (coitus interruptus presumably or periodic abstinence), abortion (they placed hot rocks on the abdomen of a pregnant woman to induce abortion), infanticide, and sea-voyaging by which young males were put in a canoe and sent off to find another island—likely amounting to suicide. However, "when the Christian missionaries prevented the application of the more stringent of these measures, the Tikopea