

# Food & Health of a Full Earth

*David Tilman*

DAVID TILMAN, a Fellow of the American Academy since 1995, is Regents Professor and McKnight Presidential Chair in the College of Biological Sciences and Director of the Cedar Creek Ecosystem Science Reserve at the University of Minnesota. He is also a Professor at the Bren School of Environmental Science and Management at the University of California, Santa Barbara. He is the author of *Functional Consequences of Biodiversity: Empirical Progress and Theoretical Extensions* (with Ann P. Kinzig and Stephen Pacala, 2002), *Plant Strategies and the Dynamics and Structure of Plant Communities* (1988), *Resource Competition and Community Structure* (1982), and more than two hundred scientific papers.

The world is about to be full. Within two or three generations, our global population – currently seven billion people – will level off between ten billion and eleven billion. Although humanity steadily increased in size as it spread from Africa across the habitable lands of Earth, it was not until the 1920s that this growth turned explosive. In 1850, the global population was 1.1 billion people, on a trajectory to double every one hundred fifty years. This low growth rate held until World War I, after which the emergence of modern medicine and sanitation led to increasingly rapid annual growth rates. When this rate hit its peak in 1970, the global population was on course to double every thirty-five years. Now, our population growth rate – though still positive – is steadily slowing as we approach our maximum Earth density.

What will life be like on a full Earth? Can we provide eleven billion people with a secure supply of nutritious foods? Is it even possible for so many people to live on Earth without destroying its remaining natural ecosystems? Agriculture already accounts for more than 25 percent of global greenhouse gas emissions and occupies 55 percent of Earth's ice- and desert-free land area. Can we feed up to eleven billion people and still maintain a livable climate? Will the ethics, customs, rights, and laws established when the world had one billion or fewer people adequately guide a world that is ten times more populous? Or will new ethical principles be needed to live sustainably in this new context?

---

© 2015 by the American Academy of Arts & Sciences  
doi:10.1162/DAED\_e\_00349

The answers to these and related questions must also consider a second major way we fill Earth: our consumption. Many, but by no means all, of the less-developed nations of the world have rapidly growing economies. Based on current growth trajectories, citizens in developing nations are likely to gain three to five times more buying power within the next forty years. This is a continuation of a trend that began in earnest in the early 1900s: from 1900 to 2000, the buying power of the typical person on Earth increased 360 percent, while the global population increased 270 percent. What might the totality of global consumption look like in 2050?

Consider the World Bank forecasts of the global economy and the United Nations projections of the global population. Per capita inflation-adjusted incomes are on a trajectory to increase 140 percent from 2000 to 2050, while the global population should increase 50 percent. The cumulative effect of these global increases is a 260 percent increase in consumer buying power between 2000 and 2050. Urbanization also accompanies economic growth: in 1960, slightly less than one billion people lived in cities. By 2013, more than 3.5 billion people were urban. By the time that the great human expansion reaches its limit, the vast majority of the peoples of the world will be living in large cities and have incomes associated with middle-class lifestyles.

Because incomes determine how much an individual can consume, the full environmental impact of nine billion people in 2050, or ten to eleven billion by the end of the century, will be much greater than is suggested by the increase in population alone. Moreover, greater consumption does not necessarily lead to better lives. This is especially true for food. The world's two billion overweight or obese people would likely be harmed, rather than benefit, from increased caloric consumption. Indeed, increasing global incomes and urbanization

are strongly associated with dietary and lifestyle shifts that degrade health. However, the world's eight hundred million malnourished people would greatly benefit from increased incomes and better diets.

The future of humanity, including our ability to live on Earth in ways that would allow future generations to enjoy a quality of life at least as high as ours, will depend on the decisions we make in the coming decades. These decisions will impact our diets, our health, and the abilities of managed and natural ecosystems to supply us with vital services, and will also determine how many other species will share the planet with us. Some of these decisions will be pragmatic; others will be ethical. The world faces many unavoidable trade-offs. Actions that provide a net benefit or profit to one individual, such as a farmer applying more fertilizer to cropland to increase yields, may come at a cost to the environment and to the health of others. On a full Earth, the actions of any one person are likely to impact the well-being of someone else; just as the actions of any one nation may impact all other nations.

The essays in this issue of *Daedalus* address issues related to agriculture, diets, health, and the environment, as well as the ethics and value systems needed to assure equity and well-being within each generation and across all future generations. Our essays begin with a broad overview of the current environmental impacts of agriculture, how growth in incomes and population will influence the future of the environment, and how these environmental impacts may be avoided. In doing so, my essay with coauthor Michael Clark also briefly touches on many of the themes developed in depth in the rest of this volume.

Catherine Bertini highlights the central role that women play as the primary providers of food in most of the world, as well as their need for equity and voice if, especially in the developing world, women are

to be empowered to solve malnutrition, children's health, and other major problems related to food, diet, and agriculture. The essay by Jaquelyn Jahn, Meir Stampfer, and Walter Willett is an informative and insightful synthesis of decades of research on nutrition and health, addressing such global problems as undernutrition, obesity, and diet-dependent metabolic imbalances that lead to noncommunicable diseases such as diabetes and heart disease.

The next three essays all address agriculture, its sustainability, and the environment from different vantage points. Nathaniel Mueller and Seth Binder open the discussion with quantitative analysis of the increases in global food supplies that could be attained by intensifying agriculture in developing nations. Their analysis highlights the social, political, and economic barriers that have kept crop yields so low in these nations, and suggests how these might be overcome. Next, Andrew Balmford, Rhys Green, and Ben Phalan question if such intensification indeed is the best

way to meet food demand and preserve nature, or if conservation of endangered wildlife would be better achieved via low-intensity agriculture. G. Philip Robertson concludes this trio by discussing if agriculture could be made sustainable and still feed a full Earth. He does so in the context of the ethical assertion that sustainability requires current agricultural practices not to limit the ability of future generations to provide themselves with diets and a quality of life at least as good as exists now.

Our volume ends with Brian Henning's essay on the ethics of food, biofuels, and animal feed. His perspective as an ethicist adds a depth and nuance to all of the preceding contributions. Who, he asks, should have the greater right to consume the global food supply: people (who directly consume 60 percent of all crops), livestock (which consume 35 percent) or automobiles (which consume 5 percent)? Are livestock and cars more worthy of food than the eight hundred million undernourished people of Earth?

*David  
Tilman*