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## *'The Human Footprint- Has Civilization Gone Too Far?'*

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# The Law of Increasing Returns by Ronald Bailey

"Sustainable development," was defined by the 1987 U.N. report Our Common Future as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." This notion superficially echoes philosopher John Locke's proviso in his *Second Treatise on Government* that every person may remove resources from the state of nature by mixing his labor with them and making them his property as long as "there is enough, and as good left in common for others."

I will show that developed capitalist economies are precisely those economies that "meet the needs of the present without compromising the ability of future generations to meet their own needs." As history has amply shown, technological progress makes possible the economic growth that allows future generations to meet their own needs. There is only one proven way to improve the lot of hundreds of millions of poor people, and that is democratic capitalism. It is in rich democratic capitalist countries that the air and water are becoming cleaner, forests are expanding, food is abundant, education is universal, and women's rights respected. Whatever slows down economic growth also slows down environmental improvement.

At the heart of the debate over sustainable development lays concerns over human population growth and consumption. Two hundred years after Thomas Robert Malthus published An Essay on the Principle of Population, demographers, ecologists, economists, biologists and policymakers still debate his theory of population. Leading foundations spend scores of millions of dollars on population programs, while the United Nations holds international conferences on the topic and even has a specialized agency, the United Nations Population Fund, devoted to the issue. Every year, hundreds of weighty studies and books pour from the universities and think tanks discussing what is to be done.

Malthus advanced two propositions that he regarded as completely self-evident. First, that "food is necessary for the existence of man", and second, that "the passion between the sexes is necessary and will remain nearly in its present state." Based on these

propositions, Malthus famously concluded that "the power of population is indefinitely greater than the power in the earth to produce subsistence for man. Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will show the immensity of the first power in comparison with the second."

Malthus illustrated his hypothesis using two sets of numbers: "the human species would increase in the ratio of--1, 2, 4, 8, 16, 32, 64, 128, 256, 512, &c. and subsistence as--1, 2, 3, 4, 5, 6, 7, 8, 9, 10, &c." He further asserted that "population does invariably increase where there are the means of subsistence." Malthus' dismal summary of the situation in which humanity finds itself is that some portion of mankind must forever be starving to death; and, further, efforts to aid the starving will only lead to more misery, as those initially spared from famine bear too many children to feed with existing food supplies.

In his first edition of the Essay, Malthus argued that there were two "checks" on population, "preventive" and "positive." Preventive checks, those that prevent births, include abortion, infanticide and prostitution; positive checks include war, pestilence and famine. In later editions, he added a third check that he called "moral restraint", which includes voluntary celibacy, late marriage and the like. Moral restraint is basically just a milder version of the earlier preventive check. If all else fails to keep human numbers under control, Malthus chillingly concludes,

"Famine seems to be the last, the most dreadful resource of nature. The power of population is so superior to the power in the earth to produce subsistence for man, that premature death must in some shape or other visit the human race. The vices of mankind are active and able ministers of depopulation. They are the precursors in the great army of destruction, and often finish the dreadful work themselves. But should they fail in this war of extermination, sickly seasons, epidemics, pestilence, and plague, advance in terrific array, and sweep off their thousands and ten thousands. Should success be still incomplete, gigantic inevitable famine stalks in the rear, and with one mighty blow, levels the population with the food of the world."

Malthus' principle of population has proved to be one of the most influential and contested theories in history. It provided a crucial insight for Charles Darwin as he was developing his theory of natural selection. In his autobiography, Darwin wrote that in October 1838,

"I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on, from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved, and unfavourable ones would be destroyed. The result of this would be the formation of a new species. Here, then, I had at last got a theory by which to work."

Naturalists, biologists and ecologists have since applied Malthusian theory not only to animals and plants, but to humans as well. Undeniably, his principle of population has an

appealing simplicity, and has proved a fruitful hypothesis for ecology and population biology. It undergirds such biological concepts as carrying capacity, which is a measure of the population that a given ecosystem can support. The Kaibab Plateau deer, for example, is a famous case of an animal population outstripping its food supply. In the 1920s, the deer population expanded dramatically. In the absence of predators, a forage shortage ensued, which in turn led to a dramatic reduction of the deer population.

If the concept of carrying capacity can explain fluctuations in animal populations, some intellectuals have reasoned in the second half of the twentieth century, it should apply equally well to human populations. As Stanford University entomologist Paul Ehrlich has explained: "To ecologists who study animals, food and population often seem like sides of the same coin. If too many animals are devouring it, the food supply declines; too little food, the supply of animals declines. . . . Homo sapiens is no exception to that rule, and at the moment it seems likely that food will be our limiting resource."

In the late 1960s, Ehrlich was one of many biologists and agronomists who began to issue dire warnings about human "overpopulation", the most famous of which appeared in his book, The Population Bomb (1968). "The battle to feed all of humanity is over", Ehrlich wrote. "In the 1970s, the world will undergo famines--hundreds of millions of people are going to starve to death in spite of any crash programs embarked on now." Later, in an article for the first Earth Day in 1970, Ehrlich outlined a horrific scenario in which 65 million Americans and 4 billion other people would die of starvation in a "Great Die-Off" between 1980 and 1989. And in 1990 Ehrlich and his wife Anne published The Population Explosion, where they once again asserted that, "One thing seems safe to predict: starvation and epidemic disease will raise the death rates over most of the planet." In these gloomy forecasts, Ehrlich was far from alone. In 1967, William and Paul Paddock asserted in their book, Famine 1975!, that, "The famines which are now approaching . . . are for a surety, inevitable. . . . In fifteen years the famines will be catastrophic." Today, the Worldwatch Institute, a Washington, dc environmentalist advocacy group chaired by Lester Brown, still has a solid Malthusian focus.

Food is not the only resource said to be in short supply. In 1972 the Club of Rome, a group of politicians, businessmen and senior international bureaucrats, famously commissioned The Limits to Growth report, which concluded: "If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime in the next one hundred years. The probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity."

This is Malthus writ large: not only will humanity run out of food, but it will also run out of non-renewable resources like minerals and fossil fuels. . . .

The Primacy of Ideas

For decades, economists essentially used a two-factor model in which economic growth was accounted for by adding more labor and more capital to create more goods. The

problem with this model is that over time growth must halt when the marginal value of the goods produced equals the cost of the labor and capital used to produce them. This neoclassical model of economic growth was elaborated in the 1950s by Nobelist Robert Solow and his colleagues, and was later incorporated into The Limits to Growth computer model. Relying on it, MIT researchers predicted eventual collapse as the inevitable result of continued economic and population growth.

In the last two decades, economic forecasters, following the lead of economist Paul Romer, have made a conceptual breakthrough that has enabled them to describe more rigorously and accurately--and differently--how economic growth occurs and how, with the proper social institutions, it can continue for the foreseeable future. Romer explains this approach, which has come to be known as the New Growth Theory:

"New growth theorists now start by dividing the world into two fundamentally different types of productive inputs that can be called ‘ideas’ and ‘things. ’ Ideas are nonrival goods that could be stored in a bit string. Things are rival goods with mass (or energy). With ideas and things, one can explain how economic growth works. Nonrival ideas can be used to rearrange things, for example, when one follows a recipe and transforms noxious olives into tasty and healthful olive oil. Economic growth arises from the discovery of new recipes and the transformation of things from low to high value configurations."

Decoding the clunky economic terminology, "rival" goods are simply things that cannot be used by two or more persons at once, e.g., cars, drill presses, computers, even human bodies and brains. "Nonrival" goods can be used by any number of people simultaneously, e.g., recipes for bread, blueprints for houses, techniques for growing corn, formulas for pharmaceuticals, scientific principles like the law of gravity, and computer programs.

To understand the potency of ideas, consider that a few decades ago silicon was used primarily to make glass. Today it is a crucial component in microchips and optical fibers. Again, until fairly recently petroleum was known mainly as a nuisance for people engaged in drilling water wells; its use as a cheap lighting replacement for increasingly scarce whale oil only began in the 1890s, and soon after came the internal combustion engine.

We make ourselves better off, then, not by increasing the amount of resources on planet earth--that is, of course, fixed--but by rearranging resources we already have available so that they provide us with more of what we want. This process of improvement has been going on ever since the first members of our species walked the earth. We have moved from heavy earthenware pots to ultrathin plastics and lightweight aluminum cans. To cook our food we have shifted from wood-intensive campfires to clean, efficient natural gas. By using constantly improving recipes, humanity has avoided the Malthusian trap while at the same time making the world safer and more comfortable for an ever larger portion of the world’s population.

In fact, increasing, rather than diminishing, returns characterize many economic activities. For example, it may cost $150 million to develop the first vial of a new vaccine to prevent Lyme disease. Yet every vial after that is essentially free. The same is true for computer programs: it may cost Microsoft $500 million for the first copy of Windows 98, but each subsequent copy is merely the cost of the disk on which it is stored. Or in the case of telecommunications, laying a fiber optic network may cost billions of dollars, but once operational it can transmit millions of messages at virtually no added cost. And the low costs of each of these inventions make it possible for the people who buy them to be even more productive in their own activities--by avoiding illness, expediting word processing, and drastically increasing the tempo of information exchanges.

What modern Malthusians who fret about the depletion of resources miss is that it is not oil that people want; they want to cool and heat their homes. It is not copper telephone lines that people want; they want to communicate quickly and easily with friends, family and businesses. They do not want paper; they want a convenient and cheap way to store written information. In short, what is important is not the physical resource but the function to be performed; and for that, ideas are the crucial input. Robert Kates notes that technological discoveries have "transformed the meaning of resources and increased the carrying capacity of the Earth"; economist Gale Johnson concludes that history has clearly confirmed that "no exhaustible resource is essential or irreplaceable"; and economist Dwight Lee asserts that "the relevant resource base is defined by knowledge, rather than by physical deposits of existing resources."

With regard to using physical resources, no less an environmental advocate than Al Gore noted in 1999 in an address to the American Association for the Advancement of Science's annual convention that "throughout our economy, skills, intelligence, and creativity are replacing mass and money—which is why, in the past 50 years, the value of our economy has tripled, while the physical weight of our economy as a whole has barely increased at all." In other words, we got richer not just by using more stuff but by using it more intelligently.

Romer sums it up this way: "Every generation has perceived the limits to growth that finite resources and undesirable side effects would pose if no new recipes or ideas were discovered. And every generation has underestimated the potential for finding new recipes and ideas. We consistently fail to grasp how many ideas remain to be discovered. The difficulty is the same one we have with compounding. Possibilities do not add up. They multiply."

This, it should be noted, is the mirror image of Malthus' argument about exponential growth. Here, however, ideas grow much faster than population.

In fact there are two commons. Ideological environmentalists concentrate solely on the environmental commons and ignore another commons that addresses and solves problems that arise in the environmental commons. Let's call it the knowledge commons. We all draw from the knowledge commons, which consists of the growing pool of institutional, scientific, and technological concepts, and the wealth and capital they

create. It is true that the earth is finite, but it is also true that human creativity is not. Our ancestors, by creating the knowledge commons, have in most relevant respects honored Locke's proviso because they have left us much more than they took.

By using a number of simple calculations, Romer illustrates the point that the number of possible discoveries and inventions is incomprehensibly vast. Take, for example, the chemical combinations one can derive from the periodic table of elements. There are about 100 different elements and if one serially combined any four, one would get about 94 million combinations. Romer further assumes that these elements could be combined in differing proportions ranging from 1 to 10. This yields 3,500 proportions times 94 million combinations and provides 330 billion different recipes in total. At the rate of 1,000 recipes per day, it would take scientists nearly a million years to evaluate them all. What is more, this vastly underestimates the actual number of combinations available, since one could combine more than four elements, in different proportions, at different temperatures and pressures--and so on and on.

Again, consider the number of computer programs that could be installed on a single computer hard disk drive. Romer calculates that the number of distinct software programs that can be put on a one-gigabyte hard disk is roughly one followed by 2.7 billion zeros. By comparison, the total number of seconds that have elapsed since the beginning of the universe is only about 1 followed by 17 zeros, and the total number of atoms in the universe is equal to about 1 followed by 100 zeros.

In short, then, people possess a nearly infinite capacity to rearrange physical objects by creating new recipes for their use. Yet some committed Malthusians object that Romer and others who hold that economic growth is potentially limitless not only violate the law of diminishing returns but transgress an even more fundamental physical law: the second law of thermodynamics. According to the second law, in a closed system disorder tends to increase. Think of a droplet of ink as a highly ordered pigment that is diluted when it is dropped into a ten-gallon aquarium. When the pigment’s molecules spread evenly throughout the water, disorder is at a maximum--that is, it becomes virtually impossible to reconstitute the droplet. The idea, then, is that the maintenance of order in one part of the system (heating a house) requires an increase of disorder elsewhere (burning oil).

In fact, the solution to the puzzle of life and of a growing economy is that the earth is not a closed system--the energy that drives it comes principally from the sun. It is true that the sun’s energy is being dissipated. But it will not burn out for another four to five billion years. Hence, the recipes that humans could devise for obtaining and using energy are for all practical purposes limitless. Until medieval times, people inefficiently heated and cooked with open fires in their homes. Then someone in Europe invented the chimney, which dramatically increased the efficiency of heating and cooking. In the eighteenth century, Benjamin Franklin invented the cast iron stove, which again boosted efficiency--and so on, to today’s modern electric heat pumps and gas furnaces. And new ideas and designs continue to be developed all the time, among them passive solar homes, solar cells, fuel cells and nuclear power plants. It seems safe to conclude that so long as the sun shines, the second law of thermodynamics is not terribly relevant.

Indeed, trying to forecast today the energy mix for the next hundred years, especially given the current rate of technological innovation, is as fruitless as someone in 1900 trying to predict our current energy requirements. A person in 1900 would surely not have anticipated scores of millions of automobiles and trucks, thousands of jet planes, and millions of refrigerators. Because of this, the wisest course is for humanity to support institutions and incentive systems that will encourage future scientists, inventors and entrepreneurs to discover, finance and build the technologies that will supply human needs and protect the natural world in the coming century.

Reframing the Problems

Insights from New Growth Theory reframe many environmental problems and suggest some surprising solutions. For example, one of the global environmental problems most commonly attributed to population and economic growth is the loss of tropical forests. But is growth really to blame? According to the Consultative Group on International Agricultural Research, the chief factor that drives deforestation in developing countries is not commercial logging but "poor farmers who have no other option to feeding their families other than slashing and burning a patch of forest. . . . Slash-and-burn agriculture results in the loss or degradation of some 25 million acres of land per year."

By contrast, the United States today farms less than half of the land that it did in the 1920s but produces far more food now than it did then. The key, of course, is technology. In fact, available farming technology from developed countries could prevent, and in many cases reverse, the loss of tropical forests and other wildlife habitat around the globe. Unfortunately, institutional barriers, the absence of secure property rights, corrupt governments and a lack of education prevent its widespread diffusion and, hence, environmental restoration.

Another environmental problem frequently attributed to population growth is pollution. In 1972 The Limits to Growth computer model projected that pollution would skyrocket as population increased: "Virtually every pollutant that has been measured as a function of time appears to be increasing exponentially." But once again, the new Malthusians had things exactly backward. Since 1972, America’s population has risen 26 percent and its economy has more than doubled. Western Europe and Japan have experienced similar rates of growth. Yet, instead of increasing as predicted, the Environmental Protection Agency (EPA) reports that since 1976, when national measuring began, ambient air pollutants are way down. The levels of ozone in the air have dropped 31 percent, sulfur dioxides are down 72 percent, nitrogen dioxide was cut by 42 percent, carbon dioxide plunged 76 percent, and particulates (smoke and dust) fell by 31 percent. Air quality in the 10 largest metropolitan areas (four of the five most improved are in California) has improved an average of 53 percent since 1980. Also water use per capita in the United States has been going down for two decades

In fact, a growing body of literature suggests that in most cases there are thresholds of wealth at which the amount of a pollutant begins to decline. Department of Interior analyst Indur Goklany calls these thresholds the "environmental transition." What this

means is that when people rise above mere subsistence, they begin demanding amenities such as clean air and water. The first environmental transition is clean drinking water. Goklany has found that the level of fecal coliform bacteria in rivers, which is a good measure of water pollution, peaks when average per capita incomes reach $1,400 per year. The next transition occurs when particulates like smoke and soot peak at $3,200. And again, levels of sulfur dioxide peak at about $3,700. There even appears to be a threshold for forest expansion at about $15,000 per capita annual income.

Jesse Ausubel, director of the Program for the Human Environment at Rockefeller University notes that "forest regrowth appears part of modernity." He points out that U.N. Food and Agriculture Organization studies "of forest biomass for the decade of the 1990s in the boreal and temperate region in more than 50 countries show the forests expanding in every one of them." As global cropland and grazing area shrink, forests will continue to expand. Ausubel estimates that humanity will need to use 20 percent or less of the world's 3 billion hectares of forest to sustainably supply all of our wood needs in the 21st century.

Assuming that man-made global warming is a real problem, there are plenty of ways to handle it. One is to deploy technologies we already have to mitigate its effects on humanity: heating, air conditioning, seawalls, irrigation of farmland, crop switching, and so forth. We could also choose to sequester extra carbon dioxide by pumping it back into the ground whence it came, fertilizing the tropic ocean deserts so that they bloom with phytoplankton that absorbs it from the air, or planting more trees.

In any case, Ausubel doesn't think that carbon dioxide is a long-term problem because the world's energy system has been inexorably decarbonizing for the past two centuries. His research traces humanity's steady progress from wood to coal to oil to natural gas and, eventually, to hydrogen. At each stage, consumers, without being commanded to do so by regulators, have chosen fuels containing more hydrogen over fuels containing more carbon.

Ausubel sees that trend continuing until carbon-based fuels are eliminated by the end of the century. He expects that carbon dioxide concentrations, now about 360 parts per million (ppm), will peak at 450 ppm. That is 100 ppm less than the U.N.'s sometimes stated goal of "stabilizing" carbon dioxide at 550 ppm, and it would happen without draconian increases in energy prices or the creation of global bureaucracies aimed at regulating the atmosphere.

Not surprisingly, committed Malthusians reject such findings. Paul Ehrlich, for instance, stubbornly insists that, "Most people do not recognize that, at least in rich nations, economic growth is the disease, not the cure." [emphasis in original] To counteract the "disease" of economic growth, Maurice King recommends that people in the "privileged North" should engage in "the deliberate quest of poverty" to curb their "luxurious resource consumption."

The favored target of such critiques is the United States, whose citizens are supposedly consuming more than their fair share of the world's goods and causing more than their fair share of its ills. The average American, however, is not only a consumer but a producer of both goods and ideas. Americans and Europeans get more done with relatively less because of their higher levels of education, greater access to productive tools, superior infrastructure, democratic governments and free markets. As a consequence, output per hour of labor in the United States today is ten times what it was a hundred years ago. Thus, the average Westerner creates far more resources, especially knowledge and technology, than she or he consumes. Thus, too, both Western economies and environments are improving simultaneously.

All that said, if the right social institutions are lacking--democratic governance, secure private property, free markets--it is possible for a nation to fall into the Malthusian trap of rising poverty and increasing environmental degradation. The economies of many countries in Africa are declining, not because of high population growth rates or lack of resources, but because they have failed to implement the basic policies for encouraging economic growth: namely, widespread education, secure property rights and democratic governance.

Democratic governance and open markets have in fact proved indispensable for the prevention of famine in modern times. Nobel Prize-winning economist Amartya Sen notes that "in the terrible history of famines in the world, there is hardly any case in which a famine has occurred in a country that is independent and democratic, with an uncensored press." Why is this? Because, says Sen, "So long as famines are relatively costless for the government, with no threat to its survival or credibility, effective actions to prevent famines do not have the urgency to make them inescapable imperatives for the government."6 Along with Romer and other theorists, Sen also argues that general economic growth, not just growth in food output, is crucial to ending the threat of famine in Africa. He calls "for measures to encourage and enhance technical change, skill formation and productivity--both in agriculture and in other fields."

In article in the June 11, 2002 issue of the *Proceedings of the National Academy of Sciences* Ausubel concludes, "An annual 2-3% progress in consumption and technology over many decades and sectors provides a benchmark for sustainability." In other words, economic growth and technological progress are sustainable in the long run and make it less and less likely that humanity will overshoot any limits the biosphere may have.

We cannot deplete the supply of ideas, designs and recipes. They are immaterial and limitless, and therefore not bound in any meaningful sense by the second law of thermodynamics. Surely no one believes that humanity has already devised all of the methods to conserve, locate and exploit new sources of energy, or that the flow of ideas to improve houses, transportation, communications, medicine and farming has suddenly dried up. Though far too many of our fellow human beings are caught in local versions of the Malthusian trap, we must not mistake the situation of that segment as representing the future of all of humanity and the earth itself; it is, instead, a dwindling remnant of an

unhappy past. Misery is not the inevitable lot of humanity, nor is the ruin of the natural world a foregone conclusion.