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A Special Moment in History: The Challenge of Overpopulation and Overconsumption

BILL MCKIBBEN

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In this essay he argues that, because of the environmental crisis we face, we are living in a special time, which could determine the near—and long-term—future of the planet. With the world's population heading for another doubling and with more people consuming more resources and creating more pollutants—and with fewer sinks into which to throw them—the decisions we make in the next few decades may well determine the fate of Earth and the prospects for future generations.

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... We may live in a special time. We may live in the strangest, most thoroughly different moment [of history] since human beings took up farming, 10,000 years ago, and time more or less commenced. Since then time has flowed in one direction—toward *more*, which we have taken to be progress. At first the momentum was gradual, almost imperceptible, checked by wars and the Dark Ages and plagues and taboos; but in recent centuries it has accelerated, the curve of every graph steepening like the Himalayas rising from the Asian steppe. We have climbed quite high. Of course, fifty years ago one could have said the same thing, and fifty years before that, and fifty years before *that*. But in each case it would have been premature. We've increased the population fourfold in that 150 years; the amount of food we grow has gone up faster still; the size of our economy has quite simply exploded.

But now—now may be the special time. So special that in the Western world we might each of us consider, among many other things, having only one child—that is, reproducing at a rate as low as that at which human beings have ever voluntarily reproduced. Is this really necessary? Are we finally running up against some limits?

To try to answer this question, we need to ask another: *How many of us will there be in the near future?* Here is a piece of news that may alter the way we see the planet—an indication that we live at a special moment. At least at first blush the news is hopeful. *New demographic evidence shows that it is at least possible that a child born today will live long enough to see the peak of human population.*

Around the world people are choosing to have fewer and fewer children—not just in China, where the government forces it on them, but in almost every nation outside the poorest parts of Africa. Population growth rates are lower than they have been at any time since the Second World War. In the past three decades the average woman in the developing world, excluding China, has gone from bearing six children to bearing four. Even in Bangladesh the average has fallen from six to fewer than four; even in the mullahs' Iran it has dropped by four children. If this keeps up, the population of the world will not quite double again; United Nations analysts offer as their mid-range projection that it will top out at 10 to 11 billion, up from just under six billion at the moment. The world is still growing, at nearly a record pace—we add a New York City every month, almost a Mexico every year, almost an India every decade. But the rate of growth is slowing; it is no longer "exponential," "unstoppable," "inexorable," "unchecked," "cancerous." If current trends hold, the world's population will all but stop growing before the twenty-first century is out.

And that will be none too soon. There is no way we could keep going as we have been. The *increase* in human population in the 1990s has exceeded the *total* population in 1600. The population has grown more since 1950 than it did during the previous four million years. The reasons for our recent rapid growth are pretty clear. Although the Industrial Revolution speeded historical growth rates considerably, it was really the public-health revolution, and its spread to the Third World at the end of the Second World War, that set us galloping. Vaccines and antibiotics came all at once, and right behind came population. In Sri Lanka in the late 1940s life expectancy was rising at least a year every twelve months. How much difference did this make? Consider the United States: If people died throughout this century at the same rate as they did at its beginning, America's population would be 140 million, not 270 million.

If it is relatively easy to explain why populations grew so fast after the Second World War, it is much harder to explain why the growth is now slowing. Experts confidently supply answers, some of them contradictory: "Development is the best contraceptive"—or education, or the empowerment of women, or hard times that force families to postpone having children. For each example there is a counterexample. Ninety-seven percent of women in the Arab sheikhdom of Oman know about contraception, and yet they average more than six children apiece. Turks have used contraception at about the same rate as the Japanese, but their birth rate is twice as high. And so on. It is not AIDS that will slow population growth, except in a few African countries. It is not horrors like the civil war in Rwanda, which claimed half a million lives—a loss the planet can make up for in two days. All that matters is how often individual men and women decide that they want to reproduce.

Will the drop continue? It had better. UN mid-range projections assume that women in the developing world will soon average two children apiece—the rate at which population growth stabilizes. If fertility remained at current levels, the population would reach the absurd figure of 296 billion in just 150 years. Even if it dropped to 2.5 children per woman and then stopped falling, the population would still reach 28 billion.

But let's trust that this time the demographers have got it right. Let's trust that we have rounded the turn and we're in the home stretch. Let's trust that the planet's population really will double only one more time. Even so, this is a case of good news, bad news. The good news is that we won't grow forever. The bad news is that there are six billion of us already, a number the world strains to support. One more near-doubling—four or five billion more people—will nearly double that strain. Will these be the five billion straws that break the camel's back?

BIG QUESTIONS

We've answered the question *How many of us will there be?* But to figure out how near we are to any limits, we need to ask something else: *How big are we?* This is not so simple. Not only do we vary greatly in how much food and energy and water and minerals we consume, but each of us varies over time. William Catton, who was a sociologist at Washington State University before his retirement, once tried to calculate the amount of energy human beings use each day. In hunter-gatherer times it was about 2,500 calories, all of it food. That is the daily energy intake of a common dolphin. A modern human being uses 31,000 calories a day, most of it in the form of fossil fuel. That is the intake of a pilot whale. And the average American uses six times that—as much as a sperm whale. We have become, in other words, different from the people we used to be. Not kinder or unkinder, not deeper or stupider—our natures seem to have changed little since Homer. We've just gotten bigger. We appear to be the same species, with stomachs of the same size, but we aren't. It's as if each of us were trailing a big Macy's-parade balloon around, feeding it constantly.

So it doesn't do much good to stare idly out the window of your 737 as you fly from New York to Los Angeles and see that there's *plenty* of empty space down there. Sure enough, you could crowd lots more people into the nation or onto the planet. The entire world population could fit into Texas, and each person could have an area equal to the floor space of a typical U.S. home. If people were willing to stand, everyone on earth could fit comfortably into half of Rhode Island. Holland is crowded and is doing just fine.

But this ignores the balloons above our heads, our hungry shadow selves, our sperm-whale appetites. As soon as we started farming, we started setting aside extra land to support ourselves. Now each of us needs not only a little plot of cropland and a little pasture for the meat we eat but also a little forest for timber and paper, a little mine, a little oil well. Giants have big feet. Some scientists in Vancouver tried to calculate one such "footprint" and found that although 1.7 million people lived on a million acres surrounding their city, those people required 21.5 million acres of land to support them—wheat fields in Alberta, oil fields in Saudi Arabia, tomato fields in California. People in Manhattan are as dependent on faraway resources as people on the Mir space station.

Those balloons above our heads can shrink or grow, depending on how we choose to live. All over the earth people who were once tiny are suddenly growing like Alice when she ate the cake. In China per capita income has doubled since the early 1980s. People there, though still Lilliputian in comparison with us, are twice their former size. They eat much higher on the food chain, understandably, than they used to: China slaughters more pigs than any other nation, and it takes four pounds of grain to produce one pound of pork. When, a decade ago, the United Nations examined sustainable development, it issued a report saying that the economies of the developing countries needed to be five to ten times as large to move poor people to an acceptable standard of living—with all that this would mean in terms of demands on oil wells and forests.

That sounds almost impossible. For the moment, though, let's not pass judgment. We're still just doing math. There are going to be lots of us. We're going to be big. But lots of us in relation to what? Big in relation to what? It could be that compared with the world we inhabit, we're still scarce and small. Or not. So now we need to consider a third question.

HOW BIG IS THE EARTH?

Any state wildlife biologist can tell you how many deer a given area can support—how much browse there is for the deer to eat before they begin to suppress the reproduction of trees, before they begin to starve in the winter. He can calculate how many wolves a given area can support too, in part by counting the number of deer. And so on, up and down the food chain. It's not an exact science, but it comes pretty close—at least compared with figuring out the carrying capacity of the earth for human beings, which is an art so dark that anyone with any sense stays away from it.

Consider the difficulties. Human beings, unlike deer, can eat almost anything and live at almost any level they choose. Hunter-gatherers used 2,500 calories of energy a day, whereas modern Americans use seventy-five times that. Human beings, unlike deer, can import what they need from thousands of miles away. And human beings, unlike deer, can figure out new ways to do old things. If, like deer, we needed to browse on conifers to survive, we could crossbreed lush new strains, chop down competing trees, irrigate forests, spray a thousand chemicals, freeze or dry the tender buds at the peak of harvest, genetically engineer new strains—and advertise the merits of maple buds until everyone was ready to switch. The variables are so great that professional demographers rarely even bother trying to figure out carrying capacity. The demographer Joel Cohen, in his potent book *How Many People Can the Earth Support?* (1995), reports that at two recent meetings of the Population Association of America, exactly none of the more than 200 symposia dealt with carrying capacity.

But the difficulty hasn't stopped other thinkers. This is, after all, as big a question as the world offers. Plato, Euripides, and Polybius all worried that we would run out of food if the population kept growing; for centuries a steady stream of economists, environmentalists, and zealots and cranks of all sorts have made it their business to issue estimates either dire or benign. The most famous, of course, came from the Reverend Thomas Malthus. Writing in 1798, he proposed that the growth of population, being "geometric," would soon outstrip the supply of food. Though he changed his mind and rewrote his famous essay, it's the original version that people have remembered—and lambasted—ever since. Few other writers have found critics in as many corners. Not only have conservatives made Malthus's name a byword for ludicrous alarmism, but Karl Marx called his essay "a libel on the human race," Friedrich Engels believed that "we are forever secure from the fear of overpopulation," and even Mao Zedong attacked Malthus by name, adding, "Of all things in the world people are the most precious."

Each new generation of Malthusians has made new predictions that the end was near, and has been proved wrong. The late 1960s saw an upsurge of Malthusian panic. In 1967 William and Paul Paddock published a book called *Famine—1975!*, which contained a triage list: "Egypt: Can't-be-saved. . . . Tunisia: Should Receive Food. . . . India: Can't-be-saved." Almost simultaneously Paul Ehrlich wrote, in his best-selling *The Population Bomb* (1968), "The battle to feed all of humanity is over. In the 1970s, the world will undergo famines—hundreds of millions of people will starve to death." It all seemed so certain, so firmly in keeping with a world soon to be darkened by the first oil crisis.

But that's not how it worked out. India fed herself. The United States still ships surplus grain around the world. As the astute Harvard social scientist Amartya Sen points out, "Not only is food generally much cheaper to buy today, in constant dollars, than it was in Malthus's time, but it also has become cheaper during recent decades." So far, in other words, the world has more or less supported us. Too many people starve (60 percent of children in South Asia are stunted by malnutrition), but both the total number and the percentage have dropped in recent decades, thanks mainly to the successes of the Green Revolution. Food production has tripled since the Second World War, outpacing even population growth. We may be giants, but we are clever giants.

So Malthus was wrong. Over and over again he was wrong. No other prophet has ever been proved wrong so many times. At the moment, his stock is especially low. One group of technological optimists now believes that people will continue to improve their standard of living precisely *because* they increase their numbers. This group's intellectual fountainhead is a brilliant Danish economist named Ester Boserup—a sort of anti-Malthus, who in 1965 argued that the gloomy cleric had it backward. The more people, Boserup said, the more progress. Take agriculture as an example: the first farmers, she pointed out, were slash-and-burn cultivators, who might farm a plot for a year or two and then move on, not returning for maybe two decades. As the population grew, however, they had to return more frequently to the same plot. That meant problems: compacted, depleted, weedy soils. But those new problems meant new solutions: hoes, manure, compost, crop rotation, irrigation. Even in this century, Boserup said, necessity-induced invention has meant that "intensive systems of agriculture replaced extensive systems," accelerating the rate of food production.

Boserup's closely argued examples have inspired a less cautious group of popularizers, who point out that standards of living have risen all over the world even as population has grown. The most important benefit, in fact, that population growth bestows on an economy is to increase the stock of useful knowledge, insisted Julian Simon, the best known of the so-called cornucopians, who died earlier this year. We might run out of copper, but who cares? The mere fact of shortage will lead someone to invent a substitute. "The main fuel to speed our progress is our stock of knowledge, and the brake is our lack of imagination," Simon wrote. "The ultimate resource is people—skilled, spirited, and hopeful people who will exert their wills and imaginations for their own benefit, and so, inevitably, for the benefit of us all."

Simon and his ilk owe their success to this: they have been right so far. The world has behaved as they predicted. India hasn't starved. Food is cheap. But Malthus never goes away. The idea that we might grow too big can be disproved only for the moment—never for good. We might always be on the threshold of a special time, when the mechanisms described by Boserup and Simon stop working. It is true that Malthus was wrong when the population doubled from 750 million to 1.5 billion. It is true that Malthus was wrong when the population doubled from 1.5 billion to three billion. It is true that Malthus was wrong when the population doubled from three billion to six billion. Will Malthus still be wrong fifty years from now?

LOOKING AT LIMITS

The case that the next doubling, the one we're now experiencing, might be the difficult one can begin as readily with the Stanford biologist Peter Vitousek as with anyone else. In 1986 Vitousek decided to calculate how much of the earth's "primary productivity" went to support human beings. He added together the grain we ate, the corn we fed our cows, and the forests we cut for timber and paper; he added the losses in food as we overgrazed grassland and turned it into desert. And when he was finished adding, the number he came up with was 38.8 percent. We use 38.8 percent of everything the world's plants don't need to keep themselves alive; directly or indirectly, we consume 38.8 percent of what it is possible to eat. "That's a relatively large number," Vitousek says. "It should give pause to people who think we are far from any limits." Though he never drops the measured tone of an academic, Vitousek speaks with considerable emphasis: "There's a sense among some economists that we're *so* far from any biophysical limits. I think that's not supported by the evidence."

For another antidote to the good cheer of someone like Julian Simon, sit down with the Cornell biologist David Pimentel. He believes that we're in big trouble. Odd facts stud his conversation—for example, a nice head of iceberg lettuce is 95 percent water and contains just fifty calories of energy, but it takes 400 calories of energy to grow that head of lettuce in California's Central Valley, and another 1,800 to ship it east. ("There's practically no nutrition in the damn stuff anyway," Pimentel says. "Cabbage is a lot better, and we can grow it in upstate New York.") Pimentel has devoted the past three decades to tracking the planet's capacity, and he believes that we're already too crowded—that the earth can support only two billion people over the long run at a middle-class standard of living, and that trying to support more is doing great damage. He has spent considerable time studying soil erosion, for instance. Every raindrop that hits exposed ground is like a small explosion, launching soil particles into the air. On a slope, more than half of the soil contained in those splashes is carried downhill. If crop residue—cornstalks, say—is left in the field after harvest, it helps to shield the soil: the raindrop doesn't hit as hard. But in the developing world, where firewood is scarce, peasants burn those cornstalks for cooking fuel. About 60 percent of crop residues in China and 90 percent in Bangladesh are removed and burned, Pimentel says. When planting season comes, dry soils simply blow away. "Our measuring stations pick up Chinese soil in the Hawaiian air when ploughing time comes," he says. "Every year in Florida we pick up African soils in the wind when they start to plough."

The very things that made the Green Revolution so stunning—that made the last doubling possible—now cause trouble. Irrigation ditches, for instance, water 17 percent of all arable land and help to produce a third of all crops. But when flooded soils are baked by the sun, the water evaporates and the minerals in the irrigation water are deposited on the land. A hectare (2.47 acres) can accumulate two to five tons of salt annually, and eventually plants won't grow there. Maybe 10 percent of all irrigated land is affected.

Or think about fresh water for human use. Plenty of rain falls on the earth's surface, but most of it evaporates or roars down to the ocean in spring floods. According to Sandra Postel, the director of the Global Water Policy Project, we're left with about 12,500 cubic kilometers of accessible runoff, which would be enough for current demand except that it's not very well distributed around the globe. And we're not exactly conservationists—we use nearly seven times as much water as we used in 1900. Already 20 percent of the world's population lacks access to potable water and fights over water divide many regions. Already the Colorado River usually dries out in the desert before it reaches the Sea of Cortez, making what the mid-century conservationist Aldo Leopold called a "milk and honey wilderness" into some of the nastiest country in North America. Already the Yellow River can run dry for as much as a third of the year. Already only two percent of the Nile's freshwater flow makes it to the ocean. And we need more water all the time. Producing a ton of grain consumes a thousand tons of water—that's how much the wheat plant breathes out as it grows. "We estimated that biotechnology might cut the amount of water a plant uses by ten percent," Pimentel says. "But plant physiologists tell us that's optimistic—they remind us that water's a pretty important part of photosynthesis. Maybe we can get five percent."...

I said earlier that food production grew even faster than population after the Second World War. Year after year the yield of wheat and corn and rice rocketed up about three percent annually. It's a favorite statistic of the eternal optimists. In Julian Simon's book *The Ultimate Resource* (1981), charts show just how fast the growth was, and how it continually cut the cost of food. Simon wrote, "The obvious implication of this historical trend toward cheaper food—a trend that probably extends back to the beginning of agriculture—is that real prices for food will continue to drop.... It is a fact that portends more drops in price and even less scarcity in the future."

A few years after Simon's book was published, however, the data curve began to change. That rocketing growth in grain production ceased; now the gains were coming in tiny increments, too small to keep pace with population growth. The world reaped its largest harvest of grain per capita in 1984; since then the amount of corn and wheat and rice per person has fallen by six percent. Grain stockpiles have shrunk to less than two months' supply.

No one knows quite why. The collapse of the Soviet Union contributed to the trend—cooperative farms suddenly found the fertilizer supply shut off and spare parts for the tractor hard to come by. But there were other causes, too, all around the world—the salinization of irrigated fields, the erosion of topsoil, the conversion of prime farmland into residential areas, and all the other things that environmentalists had been warning about for years. It's possible that we'll still turn production around and start it rocketing again. Charles C. Mann, writing in *Science*, quotes experts who believe that in the future a "gigantic, multi-year, multi-billion-dollar scientific effort, a kind of agricultural 'person-on-the-moon project'" might do the trick. The next great hope of the optimists is genetic engineering, and scientists have indeed managed to induce resistance to pests and disease in some plants. To get more yield, though, a cornstalk must be made to put out another ear, and conventional breeding may have exhausted the possibilities. There's a sense that we're running into walls.

We won't start producing *less* food. Wheat is not like oil, whose flow from the spigot will simply slow to a trickle one day. But we may be getting to the point where gains will be small and hard to come by. The spectacular increases may be behind us. One researcher told Mann, "Producing higher yields will no longer be like unveiling a new model of a car. We won't be pulling off the sheet and there it is, a two-fold yield increase." Instead the process will be "incremental, torturous, and slow." And there are five billion more of us to come.

So far we're still fed; gas is cheap at the pump; the supermarket grows ever larger. We've been warned again and again about approaching limits, and we've never quite reached them. So maybe—how tempting to believe it!—they don't really exist. For every Paul Ehrlich there's a man like Lawrence Summers, the former World Bank chief economist and current deputy secretary of the Treasury, who writes, "There are no . . . limits to carrying capacity of the Earth that are likely to bind at any time in the foreseeable future." And we are talking about the future—nothing can be *proved*.

But we can calculate risks, figure the odds that each side may be right. Joel Cohen made the most thorough attempt to do so in *How Many People Can the Earth Support?* Cohen collected and examined every estimate of carrying capacity made in recent decades, from that of a Harvard oceanographer who thought in 1976 that we might have food enough for 40 billion people to that of a Brown University researcher who calculated in 1991 that we might be able to sustain 5.9 billion (our present population), but only if we were principally vegetarians. One study proposed that if photosynthesis was the limiting factor, the earth might support a trillion people; an Australian economist proved, in calculations a decade apart, that we could manage populations of 28 billion and 157 billion. None of the studies is wise enough to examine every variable, to reach by itself the "right" number. When Cohen compared the dozens of studies, however, he uncovered something pretty interesting: the median low value for the planet's carrying capacity was 7.7 billion people, and the median high value was 12 billion. That, of course, is just the range that the UN predicts we will inhabit by the middle of the next century. Cohen wrote,

> The human population of the Earth now travels in the zone where a substantial fraction of scholars have estimated upper limits on human population size. . . . The possibility must be considered seriously that the number of people on the Earth has reached, or will reach within half a century, the maximum number the Earth can support in modes of life that we and our children and their children will choose to want.

EARTH2

Throughout the 10,000 years of recorded human history the planet—the physical planet—has been a stable place. In every single year of those 10,000 there have been earthquakes, volcanoes, hurricanes, cyclones, typhoons, floods, forest fires, sandstorms, hailstorms, plagues, crop failures, heat waves, cold spells, blizzards, and droughts. But these have never shaken the basic predictability of the planet as a whole. Some of the earth's land areas—the Mediterranean rim, for instance—have been deforested beyond recovery, but so far these shifts have always been local.

Among other things, this stability has made possible the insurance industry—has underwritten the underwriters. Insurers can analyze the risk in any venture because they know the ground rules. If you want to build a house on the coast of Florida, they can calculate with reasonable accuracy the chance that it will be hit by a hurricane and the speed of the winds circling that hurricane's eye. If they couldn't, they would have no way to set your premium—they'd just be gambling. They're always gambling a little, of course: they don't know if that hurricane is coming next year or next century. But the earth's physical stability is the house edge in this casino. As Julian Simon pointed out, "A prediction based on past data can be sound if it is sensible to assume that the past and the future belong to the same statistical universe."

So what does it mean that alone among the earth's great pools of money and power, insurance companies are beginning to take the idea of global climate change quite seriously? What does it mean that the payout for weather-related damage climbed from $16 billion during the entire 1980s to $48 billion in the years 1990–1994? What does it mean that top European insurance executives have begun consulting with Greenpeace about global warming? What does it mean that the insurance giant Swiss Re, which paid out $291.5 million in the wake of Hurricane Andrew, ran an ad in the *Financial Times* showing its corporate logo bent sideways by a storm?

These things mean, I think, that the possibility that we live on a new earth cannot be discounted entirely as a fever dream. Above, I showed attempts to calculate carrying capacity for the world as we have always known it, the world we were born into. But what if, all of a sudden, we live on some other planet? On Earth2?

In 1955 Princeton University held an international symposium on "Man's Role in Changing the Face of the Earth." By this time anthropogenic carbon, sulfur, and nitrogen were pouring into the atmosphere, deforestation was already widespread, and the population was nearing three billion. Still, by comparison with the present, we remained a puny race. Cars were as yet novelties in many places. Tropical forests were still intact, as were much of the ancient woods of the West Coast, Canada, and Siberia. The world's economy was a quarter its present size. By most calculations we have used more natural resources since 1955 than in all of human history to that time.

Another symposium was organized in 1987 by Clark University, in Massachusetts. This time even the title made clear what was happening—not "Man and Nature," not "Man's Role in Changing the Face of the Earth," but "The Earth as Transformed by Human Actions." Attendees were no longer talking about local changes or what would take place in the future. "In our judgment," they said, "the biosphere has accumulated, or is on its way to accumulating, such a magnitude and variety of changes that it may be said to have been transformed."

Many of these changes come from a direction that Malthus didn't consider. He and most of his successors were transfixed by *sources*—by figuring out whether and how we could find enough trees or corn or oil. We're good at finding more stuff; as the price rises, we look harder. The lights never did go out, despite many predictions to the contrary on the first Earth Day. We found more oil, and we still have lots and lots of coal. Meanwhile, we're driving big cars again, and why not? As of this writing, the price of gas has dropped below a dollar a gallon across much of the nation. Who can believe in limits while driving a Suburban? But perhaps, like an audience watching a magician wave his wand, we've been distracted from the real story.

That real story was told in the most recent attempt to calculate our size—a special section in *Science* published last summer. The authors spoke bluntly in the lead article. Forget man "transforming" nature—we live, they concluded, on "a human-dominated planet," where "no ecosystem on Earth's surface is free of pervasive human influence." It's not that we're running out of stuff. What we're running out of is what the scientists call "sinks"—places to put the by-products of our large appetites. Not garbage dumps (we could go on using Pampers till the end of time and still have empty space left to toss them away) but the atmospheric equivalent of garbage dumps.

It wasn't hard to figure out that there were limits on how much coal smoke we could pour into the air of a single city. It took a while longer to figure out that building ever higher smokestacks merely lofted the haze farther afield, raining down acid on whatever mountain range lay to the east. Even that, however, we are slowly fixing, with scrubbers and different mixtures of fuel. We can't so easily repair the new kinds of pollution. These do not come from something going wrong—some engine without a catalytic converter, some wastewater pipe without a filter, some smokestack without a scrubber. New kinds of pollution come instead from things going as they're supposed to go—but at such a high volume that they overwhelm the planet. They come from normal human life—but there are so many of us living those normal lives that something abnormal is happening. And that something is so different from the old forms of pollution that it confuses the issue even to use the word.

Consider nitrogen, for instance. Almost 80 percent of the atmosphere is nitrogen gas. But before plants can absorb it, it must become "fixed"—bonded with carbon, hydrogen, or oxygen. Nature does this trick with certain kinds of algae and soil bacteria, and with lightning. Before human beings began to alter the nitrogen cycle, these mechanisms provided 90–150 million metric tons of nitrogen a year. Now human activity adds 130–150 million more tons. Nitrogen isn't pollution—it's essential. And we are using more of it all the time. Half the industrial nitrogen fertilizer used in human history has been applied since 1984. As a result, coastal waters and estuaries bloom with toxic algae while oxygen concentrations dwindle, killing fish; as a result, nitrous oxide traps solar heat. And once the gas is in the air, it stays there for a century or more.

Or consider methane, which comes out of the back of a cow or the top of a termite mound or the bottom of a rice paddy. As a result of our determination to raise more cattle, cut down more tropical forest (thereby causing termite populations to explode), and grow more rice, methane concentrations in the atmosphere are more than twice as high as they have been for most of the past 160,000 years. And methane traps heat—very efficiently.

Or consider carbon dioxide. In fact, concentrate on carbon dioxide. If we had to pick one problem to obsess about over the next fifty years, we'd do well to make it CO_2—which is not pollution either. Carbon *mon*oxide is pollution: it kills you if you breathe enough of it. But carbon *di*oxide, carbon with two oxygen atoms, can't do a blessed thing to you. If you're reading this indoors, you're breathing more CO_2 than you'll ever get outside. For generations, in fact, engineers said that an engine burned clean if it produced only water vapor and carbon dioxide.

Here's the catch: that engine produces a *lot* of CO_2. A gallon of gas weighs about eight pounds. When it's burned in a car, about five and a half pounds of carbon, in the form of carbon dioxide, come spewing out the back. It doesn't matter if the car is a 1958 Chevy or a 1998 Saab. And no filter can reduce that flow—it's an inevitable by-product of fossil-fuel combustion, which is why CO_2 has been piling up in the atmosphere ever since the Industrial Revolution. Before we started burning oil and coal and gas, the atmosphere contained about 280 parts CO_2 per million. Now the figure is about 360. Unless we do everything we can think of to eliminate fossil fuels from our diet, the air will test out at more than 500 parts per million fifty or sixty years from now, whether it's sampled in the South Bronx or at the South Pole.

This matters because, as we all know by now, the molecular structure of this clean, natural, common element that we are adding to every cubic foot of the atmosphere surrounding us traps heat that would otherwise radiate back out to space. Far more than even methane and nitrous oxide, CO_2 causes global warming—the greenhouse effect—and climate change. Far more than any other single factor, it is turning the earth we were born on into a new planet.

Remember, this is not pollution as we have known it. In the spring of last year the Environmental Protection Agency issued its "Ten-Year Air Quality and Emissions Trends" report. Carbon monoxide was down by 37 percent since 1986, lead was down by 78 percent, and particulate matter had dropped by nearly a quarter. If you lived in the San Fernando Valley, you saw the mountains more often than you had a decade before. The air was *cleaner*, but it was also *different*—richer with CO_2. And its new composition may change almost everything.

Ten years ago I wrote a book called *The End of Nature*, which was the first volume for a general audience about carbon dioxide and climate change, an early attempt to show that human beings now dominate the earth. Even then global warming was only a hypothesis—strong and gaining credibility all the time, but a hypothesis nonetheless. By the late 1990s it has become a fact. For ten years, with heavy funding from governments around the world, scientists launched satellites, monitored weather balloons, studied clouds. Their work culminated in a long-awaited report from the UN's Intergovernmental Panel on Climate Change, released in the fall of 1995. The panel's 2,000 scientists, from every corner of the globe, summed up their findings in this dry but historic bit of understatement: "The balance of evidence suggests that there is a discernible human influence on global climate." That is to say, we are heating up the planet—substantially. If we don't reduce emissions of carbon dioxide and other gases, the panel warned, temperatures will probably rise 3.6° Fahrenheit by 2100, and perhaps as much as 6.3°.

You may think you've already heard a lot about global warming. But most of our sense of the problem is behind the curve. Here's the current news: the changes are already well under way. When politicians and businessmen talk about "future risks," their rhetoric is outdated. This is not a problem for the distant future, or even for the near future. The planet has already heated up by a degree or more. We are perhaps a quarter of the way into the greenhouse era, and the effects are already being felt. From a new heaven, filled with nitrogen, methane, and carbon, a new earth is being born. If some alien astronomer is watching us, she's doubtless puzzled. This is the most obvious effect of our numbers and our appetites, and the key to understanding why the size of our population suddenly poses such a risk.

STORMY AND WARM

What does this new world feel like? For one thing, it's stormier than the old one. Data analyzed last year by Thomas Karl, of the National Oceanic and Atmospheric Administration, showed that total winter precipitation in the United States had increased by 10 percent since 1900 and that "extreme precipitation events"—rainstorms that dumped more than two inches of water in twenty-four hours and blizzards—had increased by 20 percent. That's because warmer air holds more water vapor than the colder atmosphere of the old earth; more water evaporates from the ocean, meaning more clouds, more rain, more snow. Engineers designing storm sewers, bridges, and culverts used to plan for what they called the "hundred-year storm." That is, they built to withstand the worst flooding or wind that history led them to expect in the course of a century. Since that history no longer applies, Karl says, "there isn't really a hundred-year event anymore . . . we seem to be getting these storms of the century every couple of years." When Grand Forks, North Dakota, disappeared beneath the Red River in the spring of last year, some meteorologists referred to it as "a 500-year flood"—meaning, essentially, that all bets are off. Meaning that these aren't acts of God. "If you look out your window, part of what you see in terms of the weather is produced by ourselves," Karl says. "If you look out the window fifty years from now, we're going to be responsible for more of it."

Twenty percent more bad storms, 10 percent more winter precipitation—these are enormous numbers. It's like opening the newspaper to read that the average American is smarter by 30 IQ points. And the same data showed increases in drought, too. With more water in the atmosphere, there's less in the soil, according to Kevin Trenberth, of the National Center for Atmospheric Research. Those parts of the continent that are normally dry—the eastern sides of mountains, the plains and deserts—are even drier, as the higher average temperatures evaporate more of what rain does fall. "You get wilting plants and eventually drought faster than you would otherwise," Trenberth says. And when the rain does come, it's often so intense that much of it runs off before it can soak into the soil.

So—wetter and drier. *Different.*

In 1958 Charles Keeling, of the Scripps Institution of Oceanography, set up the world's single most significant scientific instrument in a small hut on the slope of Hawaii's Mauna Loa volcano. Forty years later it continues without fail to track the amount of carbon dioxide in the atmosphere. The graphs that it produces show that this most important greenhouse gas has steadily increased for forty years. That's the main news.

It has also shown something else of interest in recent years—a sign that this new atmosphere is changing the planet. Every year CO_2 levels dip in the spring, when plants across the Northern Hemisphere begin to grow, soaking up carbon dioxide. And every year in the fall decaying plants and soils release CO_2 back into the atmosphere. So along with the steady upward trend, there's an annual seesaw, an oscillation that is suddenly growing more pronounced. The size of that yearly tooth on the graph is 20 percent greater than it was in the early 1960s, as Keeling reported in the journal *Nature*, in July of 1996. Or, in the words of Rhys Roth, writing in a newsletter of the Atmosphere Alliance, the earth is "breathing deeper." More vegetation must be growing, stimulated by higher temperatures. And the earth is breathing earlier, too. Spring is starting about a week earlier in the 1990s than it was in the 1970s, Keeling said....

[It's] not clear that the grain belt will have the water it needs as the climate warms. In 1988, a summer of record heat across the rain belt, harvests plummeted, because the very heat that produces more storms also causes extra evaporation. What *is* clear is that fundamental shifts are under way in the operation of the planet. And we are very early yet in the greenhouse era.

The changes are basic. The freezing level in the atmosphere—the height at which the air temperature reaches 32°F—has been gaining altitude since 1970 at the rate of nearly fifteen feet a year. Not surprisingly, tropical and subtropical glaciers are melting at what a team of Ohio State researchers termed "striking" rates. Speaking at a press conference last spring, Ellen Mosley-Thompson, a member of the Ohio State team, was asked if she was sure of her results. She replied, "I don't know quite what to say. I've presented the evidence. I gave you the example of the Quelccaya ice cap. It just comes back to the compilation of what's happening at high elevations: the Lewis glacier on Mount Kenya has lost forty percent of its mass; in the Ruwenzori range all the glaciers are in massive retreat. Everything, virtually, in Patagonia, except for just a few glaciers, is retreating.... We've seen ... that plants are moving up the mountains.... I frankly don't know what additional evidence you need."

As the glaciers retreat, a crucial source of fresh water in many tropical countries disappears. These areas are "already water-stressed," Mosley-Thompson told the Association of American Geographers last year. Now they may be really desperate.

As with the tropics, so with the poles. According to every computer model, in fact, the polar effects are even more pronounced, because the Arctic and the Antarctic will warm much faster than the Equator as carbon dioxide builds up. Scientists manning a research station at Toolik Lake, Alaska, 170 miles north of the Arctic Circle, have watched average summer temperatures rise by about seven degrees in the past two decades. "Those who remember wearing down-lined summer parkas in the 1970s—before the term 'global warming' existed—have peeled down to T-shirts in recent summers," according to the reporter Wendy Hower, writing in the *Fairbanks Daily News-Miner*. It rained briefly at the American base in McMurdo Sound, in Antarctica, during the southern summer of 1997—as strange as if it had snowed in Saudi Arabia. None of this necessarily means that the ice caps will soon slide into the sea, turning Tennessee into beachfront. It simply demonstrates a radical instability in places that have been stable for many thousands of years. One researcher watched as emperor penguins tried to cope with the early breakup of ice: their chicks had to jump into the water two weeks ahead of schedule, probably guaranteeing an early death. They (like us) evolved on the old earth....

The effects of that warming can be found in the largest phenomena. The oceans that cover most of the planet's surface are clearly rising, both because of melting glaciers and because water expands as it warms. As a result, low-lying Pacific islands already report surges of water washing across the atolls. "It's nice weather and all of a sudden water is pouring into your living room," one Marshall Islands resident told a newspaper reporter. "It's very clear that something is happening in the Pacific, and these islands are feeling it." Global warming will be like a much more powerful version of El Niño that covers the entire globe and lasts forever, or at least until the next big asteroid strikes.

If you want to scare yourself with guesses about what might happen in the near future, there's no shortage of possibilities. Scientists have already observed large-scale shifts in the duration of the El Niño ocean warming, for instance. The Arctic tundra has warmed so much that in some places it now gives off more carbon dioxide than it absorbs—a switch that could trigger a potent feedback loop, making warming ever worse. And researchers studying glacial cores from the Greenland Ice Sheet recently concluded that local climate shifts have occurred with incredible rapidity in the past—18° in one three-year stretch. Other scientists worry that such a shift might be enough to flood the oceans with fresh water and reroute or shut off currents like the Gulf Stream and the North Atlantic, which keep Europe far warmer than it would otherwise be.... In the words of Wallace Broecker, of Columbia University, a pioneer in the field, "Climate is an angry beast, and we are poking it with sticks." But we don't need worst-case scenarios: best-case scenarios make the point. The population of the earth is going to nearly double one more time. That will bring it to a level that even the reliable old earth we were born on would be hard-pressed to support. Just at the moment when we need everything to be working as smoothly as possible, we find ourselves inhabiting a new planet, whose carrying capacity we cannot conceivably estimate. We have no idea how much wheat this planet can grow. We don't know what its politics will be like: not if there are going to be heat waves like the one that killed more than 700 Chicagoans in 1995; not if rising sea levels and other effects of climate change create tens of millions of environmental refugees; not if a 1.5° jump in India's temperature could reduce the country's wheat crop by 10 percent or divert its monsoons....

We have gotten very large and very powerful, and for the foreseeable future we're stuck with the results. The glaciers won't grow back again anytime soon; the oceans won't drop. We've already done deep and systemic damage. To use a human analogy, we've already said the angry and unforgivable words that will haunt our marriage till its end. And yet we can't simply walk out the door. There's no place to go. We have to salvage what we can of our relationship with the earth, to keep things from getting any worse than they have to be.

If we can bring our various emissions quickly and sharply under control, we *can* limit the damage, reduce dramatically the chance of horrible surprises, preserve more of the biology we were born into. But do not underestimate the task. The UN's Intergovernmental Panel on Climate Change projects that an immediate 60 percent reduction in fossil-fuel use is necessary just to stabilize climate at the current level of disruption. Nature may still meet us halfway, but halfway is a long way from where we are now. What's more, we can't delay. If we wait a few decades to get started, we may as well not even begin. It's not like poverty, a concern that's always there for civilizations to address. This is a timed test, like the SAT: two or three decades, and we lay our pencils down. It's *the* test for our generations, and population is a part of the answer....

STUDY QUESTIONS

1. Explain why McKibben thinks we live in a special moment of history. Do you find his arguments cogent and convincing?
2. Doomsdayers have been wrong before in their prediction that the sky is falling. How does McKibben respond to this charge that he and others, like Paul Ehrlich, are unduly pessimistic?
3. What evidence does McKibben bring to bear on the global warming thesis—that humans are responsible for the greenhouse effect, which is having dramatic effects on Earth's climate? How serious is the greenhouse effect?

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The Tragedy of the Commons

GARRETT HARDIN

Garrett Hardin (1915–2003) was a professor of human ecology at the University of California, Santa Barbara, and the author of many works in biology and ethics, including Exploring New Ethics for Survival *(1972) and* Living within Limits *(2000). He was and remains a polarizing figure in environmental thinking. He advocated many controversial positions: against food aid to famine victims, in favor of abortion, against reproductive freedom, against immigration, and against "multiethnic societies." He received many awards from environmental and academic organizations but is also listed as a white nationalist extremist by the Southern Poverty Law Center. He had four children.*

This reading contains Hardin's classic formulation of the "tragedy of the commons," which would become influential in environmental philosophy, economics, and other fields. He argues that individual rationality and self-interest lead to the overexploitation of commonly shared resources. Technical solutions cannot solve this problem, since those solutions increase the size of the resource but do not change individuals' incentives to continually increase their use of it. The only solution to a tragedy of the commons, Hardin contends, is to change what it is in each individual's self-interest to do—through privatization, legal penalties, and the like. Population growth, he thinks, is an example of a commons problem. We cannot rely on voluntary restriction of population by families, Hardin argues, since many will not respond to voluntary procreation limitations. The only solution to overpopulation, he claims, is "mutual coercion, mutually agreed upon by the majority of the people affected."

At the end of a thoughtful article on the future of nuclear war, Wiesner and York[1] concluded that: "Both sides in the arms race are . . . confronted by the dilemma of steadily increasing military power and steadily decreasing national security. *It is our considered professional judgment that this dilemma has no technical solution.* If the great powers continue to look for solutions in the area of science and technology only, the result will be to worsen the situation."

I would like to focus your attention not on the subject of the article (national security in a nuclear world) but on the kind of conclusion they reached, namely that there is no technical solution to the problem. An implicit and almost universal assumption of discussions published in professional and semi-popular scientific journals is that the problem under discussion has a technical solution. A technical solution may be defined as one that requires a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or ideas of morality.

In our day (though not in earlier times) technical solutions are always welcome. Because of previous failures in prophecy, it takes courage to assert that a desired technical solution is not possible. Wiesner and York exhibited this courage; publishing in a science journal, they insisted that the solution to the problem was not to be found in the natural sciences. They cautiously qualified their statement with the phrase, "It is our considered professional judgment. . . ." Whether they were right or not is not the concern of the present article. Rather, the concern here is with the important concept of a class of human problems which can be called "no technical solution problems," and, more specifically, with the identification and discussion of one of these.

It is easy to show that the class is not a null class. Recall the game of tick-tack-toe. Consider the problem, "How can I win the game of tick-tack-toe?" It is well known that I cannot, if I assume (in keeping with the conventions of game theory) that my opponent understands the game perfectly. Put another way, there is no "technical solution" to the problem. I can win only by giving a radical meaning to the word "win." I can hit my opponent over the head; or I can drug him; or I can falsify the records. Every way in which I "win" involves, in some sense, an abandonment of the game, as we intuitively understand it. (I can also, of course, openly abandon the game—refuse to play it. This is what most adults do.)

The class of "No technical solution problems" has members. My thesis is that the "population problem," as conventionally conceived, is a member of this class. How it is conventionally conceived needs some comment. It is fair to say that most people who anguish over the population problem are trying to find a way to avoid the evils of overpopulation without relinquishing any of the privileges they now enjoy. They think that farming the seas or developing new strains of wheat will solve the problem—technologically. I try to show here that the solution they seek cannot be found. The population problem cannot be solved in a technical way, any more than can the problem of winning the game of tick-tack-toe.

WHAT SHALL WE MAXIMIZE?

Population, as Malthus said, naturally tends to grow "geometrically," or, as we would now say, exponentially. In a finite world this means that the per capita share of the world's goods must steadily decrease. Is ours a finite world?

A fair defense can be put forward for the view that the world is infinite; or that we do not know that it is not. But, in terms of the practical problems that we must face in the next few generations with the foreseeable technology, it is clear that we will greatly increase human misery if we do not, during the immediate future, assume that the world available to the terrestrial human population is finite. "Space" is no escape.[2]

A finite world can support only a finite population; therefore, population growth must eventually equal zero. (The case of perpetual wide fluctuations above and below zero is a trivial variant that need not be discussed.) When this condition is