

A special moment in history: the future of population

(Cover Story) *Bill McKibben.*

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Abstract: The human population on Earth is growing at an alarming rate, despite the decision by most women to have fewer children. The planet can only support a certain number of people. Questions about what will happen if that number is exceeded are discussed.

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Beware of people preaching that we live in special times. People have preached that message before, and those who listened sold their furniture and climbed up on rooftops to await ascension, or built boats to float out the coming flood, or laced up their Nikes and poisoned themselves in some California sub-division. These prophets are the ones with visions of the seven-headed beast, with a taste for the hair shirt and the scourge, with twirling eyes. No, better by far to listen to Ecclesiastes, the original wise preacher, jaded after a thousand messiahs and a thousand revivals.

One generation passes away, and another generation comes; but the earth abides forever. . . . That which has been is what will be, that which is done is what will be done, and there is nothing new under the sun. Is there anything of which it may be said, "See, this is new"? It has already been in ancient times before us.

And yet, for all that, we may live in a special time. We may live in the strangest, most thoroughly different moment 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 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 unkind, 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 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. Most 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 percent- age have dropped in recent decades, thanks mainly to the successes of the Green Revolution. Food production has tripled since the Second World War, out- pacing 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 con- tinue 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 prob- lems: compacted, depleted, weedy soils. But those new problems meant new solu- tions: 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 produc- tion.

Boserup's closely argued examples have inspired a less cautious group of popu- larizers, 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 popu- lation growth bestows on an economy is to increase the stock of useful knowl- edge, 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 peopleskilled, 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 experi- encing, might be the difficult one can begin as readily with the Stanford biologist Peter Vitousek as with anyone else. In 1986 Vitousek decided to cal- culate 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 over- grazed 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 corn stalks, 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 corn stalks 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."

What these scientists are saying is simple: human ingenuity can turn sand into silicon chips, allowing the creation of millions of home pages on the utterly fascinating World Wide Web, but human ingenuity cannot forever turn dry sand into soil that will grow food. And there are signs that these skeptics are right that we are approaching certain physical limits.

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 top-soil, 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.

Earth 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 area--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 waste-water 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 CO₂--which is not pollution either. Carbon monoxide is pollution: it kills you if you breathe enough of it. But carbon dioxide, carbon with two oxygen atoms, can't do a blessed thing to you. If you're reading this indoors, you're breathing more CO₂ 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 CO₂. 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 CO₂ 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 CO₂ 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, CO₂ 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 CO₂. 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.

Sowetter 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 CO₂ 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 CO₂ 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.

Other scientists had a hard time crediting Keeling's study; the effect seemed so sweeping. But the following April a research team led by R. B. Myneni, of Boston University, and including Keeling, reached much the same conclusion by means of a completely different technique. These researchers used satellites to measure the color of sunlight reflected by the earth: light bouncing off green leaves is a different color from light bouncing off bare ground. Their data were even more alarming, because they showed that the increase was happening with almost lightning speed. By 1991 spring above the 45th parallel--a line that runs roughly from Portland, Oregon, to Boston to Milan to Vladivostok--was coming eight days earlier than it had just a decade before. And that was despite increased snowfall from the wetter atmosphere; the snow was simply melting earlier. The earlier spring led to increased plant growth, which sounds like a benefit. The area above the 45th parallel is, after all, the North American and Russian wheat belt. But as Cynthia Rosenzweig, of NASA's Goddard Institute for Space Studies, told *The New York Times*, any such gains may be illusory. For one thing, the satellites were measuring biomass, not yields; tall and leafy plants often produce less grain. Other scientists, the *Times* reported, said that "more rapid plant growth can make for less nutritious crops if there are not enough nutrients available in the soil." And 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 grain 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.

You don't have to go to exotic places to watch the process. Migrating red-winged blackbirds now arrive three weeks earlier in Michigan than they did in 1960. A symposium of scientists reported in 1996 that the Pacific Northwest was warming at four times the world rate. "That the Northwest is warming up fast is not a theory," Richard Gammon, a University of Washington oceanographer, says. "It's a known fact, based on simple temperature readings."

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. (See "The Great Climate Flip-flop," by William H. Calvin, January Atlantic.) 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.

The arguments put forth by cornucopians like Julian Simon that human intelligence will get us out of any scrape, that human beings are "the ultimate resource," that Malthusian models "simply do not comprehend key elements of people" all rest on the same premise: that human beings change the world mainly for the better.

If we live at a special time, the single most special thing about it may be that we are now apparently degrading the most basic functions of the planet. It's not that we've never altered our surroundings before. Like the beavers at work in my back yard, we have rearranged things wherever we've lived. We've leveled the spots where we built our homes, cleared forests for our fields, often fouled nearby waters with our waste. That's just life. But this is different. In the past ten or twenty or thirty years our impact has grown so much that we're changing even those places we don't inhabit changing the way the weather works, changing the plants and animals that live at the poles or deep in the jungle. This is total. Of all the remarkable and unexpected things we've ever done as a species, this may be the biggest. Our new storms and new oceans and new glaciers and new springtime these are the eighth and ninth and tenth and eleventh wonders of the modern world, and we have lots more where those came from.

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.

Changing "Unchangeable" Needs

when we think about overpopulation, we usually think first of the developing world, because that's where 90 percent of new human beings will be added during this final doubling. In *The Population Bomb*, Paul Ehrlich wrote that he hadn't understood the issue emotionally until he traveled to New Delhi, where he climbed into an ancient taxi, which was hopping with fleas, for the trip to his hotel. "As we crawled through the city, we entered a crowded slum area. . . . the streets seemed alive with people. People eating, people washing, people sleeping. People visiting, arguing, and screaming. . . . People, people, people, people."

We fool ourselves when we think of Third World population growth as producing an imbalance, as Amartya Sen points out. The white world simply went through its population boom a century earlier (when Dickens was writing similar descriptions of London). If UN calculations are correct and Asians and Africans will make up just under 80 percent of humanity by 2050, they will simply have returned, in Sen's words, "to being proportionately almost exactly as numerous as they were before the European industrial revolution."

And of course Asians and Africans, and Latin Americans, are much "smaller" human beings: the balloons that float above their heads are tiny in comparison with ours. Everyone has heard the statistics time and again, usually as part of an attempt to induce guilt. But hear them one more time, with an open mind, and try to think strategically about how we will stave off the dangers to this planet. Pretend it's not a moral problem, just a mathematical one.

* An American uses seventy times as much energy as a Bangladeshi, fifty times as much as a Malagasi, twenty times as much as a Costa Rican.

* Since we live longer, the effect of each of us is further multiplied. In a year an American uses 300 times as much energy as a Malian; over a lifetime he will use 500 times as much.

* Even if all such effects as the clearing of forests and the burning of grasslands are factored in and attributed to poor people, those who live in the poor world are typically responsible for the annual release of a tenth of a ton of carbon each, whereas the average is 3.5 tons for residents of the "consumer" nations of Western Europe, North America, and Japan. The richest tenth of Americans the people most likely to be reading this magazine annually emit eleven tons of carbon apiece.

* During the next decade India and China will each add to the planet about ten times as many people as the United States will but the stress on the natural world caused by new Americans may exceed that from new Indians and Chinese combined. The 57.5 million Northerners added to our population during this decade will add more greenhouse gases to the atmosphere than the roughly 900 million added Southerners.

These statistics are not eternal. Though inequality between North and South has steadily increased, the economies of the poor nations are now growing faster than those of the West. Sometime early in the next century China will pass the United States as the nation releasing the most carbon dioxide into the atmosphere, though of course it will be nowhere near the West on a per capita basis.

For the moment, then (and it is the moment that counts), we can call the United States the most populous nation on earth, and the one with the highest rate of growth. Though the U.S. population increases by only about three million people a year, through births and immigration together, each of those three million new Americans will consume on average forty or fifty times as much as a person born in the Third World. My daughter, four at this writing, has already used more stuff and added more waste to the environment than most of the world's

residents do in a lifetime. In my thirty-seven years I have probably outdone small Indian villages.

Population growth in Rwanda, in Sudan, in El Salvador, in the slums of Lagos, in the highland hamlets of Chile, can devastate those places. Growing too fast may mean that they run short of cropland to feed themselves, of firewood to cook their food, of school desks and hospital beds. But population growth in those places doesn't devastate the planet. In contrast, we easily absorb the modest annual increases in our population. America seems only a little more crowded with each passing decade in terms of our daily lives. You can still find a parking spot. But the earth simply can't absorb what we are adding to its air and water.

so if it is we in the rich world, at least as much as they in the poor world, who need to bring this alteration of the earth under control, the question becomes how. Many people who are sure that controlling population is the answer overseas are equally sure that the answer is different here. If those people are politicians and engineers, they're probably in favor of our living more efficiently--of designing new cars that go much farther on a gallon of gas, or that don't use gas at all. If they're vegetarians, they probably support living more simply--riding bikes or buses instead of driving cars.

Both groups are utterly correct. I've spent much of my career writing about the need for cleverer technologies and humbler aspirations. Environmental damage can be expressed as the product of Population x Affluence x Technology. Surely the easiest solution would be to live more simply and more efficiently, and not worry too much about the number of people.

But I've come to believe that those changes in technology and in lifestyle are not going to occur easily and speedily. They'll be begun but not finished in the few decades that really matter. Remember that the pollution we're talking about is not precisely pollution but rather the inevitable result when things go the way we think they should: new filters on exhaust pipes won't do anything about that CO₂. We're stuck with making real changes in how we live. We're stuck with dramatically reducing the amount of fossil fuel we use. And since modern Westerners are practically machines for burning fossil fuel, since virtually everything we do involves burning coal and gas and oil, since we're wedded to petroleum, it's going to be a messy breakup.

So we need to show, before returning again to population, why simplicity and efficiency will not by themselves save the day. Maybe the best place to start is with President Bill Clinton--in particular his reaction to global warming. Clinton is an exquisite scientific instrument, a man whose career is built on his unparalleled ability to sense minute changes in public opinion. He understands our predicament. Speaking to the United Nations early last summer, he said plainly, "We humans are changing the global climate. . . . No nation can escape this danger. None can evade its responsibility to confront it, and we must all do our part."

But when it comes time to do our part, we don't. After all, Clinton warned of the dangers of climate change in 1993, on his first Earth Day in office. In fact, he solemnly promised to make sure that America produced no more greenhouse gases in 2000 than it had in 1990. But he didn't keep his word. The United States will spew an amazing 15 percent more carbon dioxide in 2000 than it did in 1990. It's as if we had promised the Russians that we would freeze our nuclear program and instead built a few thousand more warheads. We broke our word on what history may see as the most important international commitment of the 1990s.

What's important to understand is why we broke our word. We did so because Clinton understood that if we were to keep it, we would need to raise the price of fossil fuel. If gasoline cost \$2.50 a gallon, we'd drive smaller cars, we'd drive electric cars, we'd take buses and we'd elect a new President. We can hardly blame Clinton, or any other politician. His real goal has been to speed the pace of economic growth, which has been the key to his popularity. If all the world's leaders could be gathered in a single room, the one thing that every last socialist, Republican, Tory, monarchist, and trade unionist could agree on would be the truth of Clinton's original campaign admonition: "It's the economy, stupid."

The U.S. State Department had to send a report to the United Nations explaining why we would not be able to keep our Earth Day promise to reduce greenhouse-gas emissions; the first two reasons cited were "lower-than-

expected fuel prices" and "strong economic growth." The former senator Tim Wirth, who until recently was the undersecretary of state for global affairs, put it nakedly: the United States was missing its emissions targets because of "more prolonged economic activity than expected."

America's unease with real reductions in fossil-fuel use was clear at last year's mammoth global-warming summit in Kyoto. With utility executives and Republican congressmen stalking the halls, the U.S. delegation headed off every attempt by other nations to strengthen the accord. And even the tepid treaty produced in Kyoto will meet vigorous resistance if it ever gets sent to the Senate.

Changing the ways in which we live has to be a fundamental part of dealing with the new environmental crises, if only because it is impossible to imagine a world of 10 billion people consuming at our level. But as we calculate what must happen over the next few decades to stanch the flow of CO₂, we shouldn't expect that a conversion to simpler ways of life will by itself do the trick. One would think offhand that compared with changing the number of children we bear, changing consumption patterns would be a breeze. Fertility, after all, seems biologicalhard-wired into us in deep Darwinian ways. But I would guess that it is easier to change fertility than lifestyle.

perhaps our salvation lies in the other part of the equation--in the new technologies and efficiencies that could make even our wasteful lives benign, and table the issue of our population. We are, for instance, converting our economy from its old industrial base to a new model based on service and information. Surely that should save some energy, should reduce the clouds of carbon dioxide. Writing software seems no more likely to damage the atmosphere than writing poetry.

Forget for a moment the hardware requirements of that new economy--for instance, the production of a six-inch silicon wafer may require nearly 3,000 gallons of water. But do keep in mind that a hospital or an insurance company or a basketball team requires a substantial physical base. Even the high-est-tech office is built with steel and cement, pipes and wires. People working in services will buy all sorts of things--more software, sure, but also more sport utility vehicles. As the Department of Energy economist Arthur Rypinski says, "The information age has arrived, but even so people still get hot in the summer and cold in the winter. And even in the information age it tends to get dark at night."

Yes, when it gets dark, you could turn on a compact fluorescent bulb, saving three fourths of the energy of a regular incandescent. Indeed, the average American household, pushed and prodded by utilities and environmentalists, has installed one compact fluorescent bulb in recent years; unfortunately, over the same period it has also added seven regular bulbs. Millions of halogen torchere lamps have been sold in recent years, mainly because they cost \$15.99 at Kmart. They also suck up electricity:those halogen lamps alone have wiped out all the gains achieved by compact fluorescent bulbs. Since 1983 our energy use per capita has been increasing by almost one percent annually, despite all the technological advances of those years.

As with our homes, so with our industries. Mobil Oil regularly buys ads in leading newspapers to tell "its side" of the environmental story. As the company pointed out recently, from 1979 to 1993 "energy consumption per unit of gross domestic product" dropped 19 percent across the Western nations. This sounds goodit's better than one percent a year. But of course the GDP grew more than two percent annually. So total energy use, and total clouds of CO₂, continued to increase.

It's not just that we use more energy. There are also more of us all the time, even in the United States. If the population is growing by about one percent a year, then we have to keep increasing our technological efficiency by that much each yearand hold steady our standard of livingjust to run in place. The President's Council on Sustainable Development, in a little-read report issued in the winter of 1996, concluded that "efficiency in the use of all resources would have to increase by more than fifty percent over the next four or five decades just to keep pace with population growth." Three million new Americans annually means many more cars, houses, refrigerators. Even if everyone consumes only what he consumed the year before, each year's tally of births and immigrants will swell American consumption by one percent.

We demand that engineers and scientists swim against that tide. And the tide will turn into a wave if the rest of the world tries to live as we do. It's true that the average resident of Shanghai or Bombay will not consume as lavishly as the typical San Diegan or Bostonian anytime soon, but he will make big gains, pumping that much more carbon dioxide into the atmosphere and requiring that we cut our own production even more sharply if we are to stabilize the world's climate.

The United Nations issued its omnibus report on sustainable development in 1987. An international panel chaired by Gro Harlem Brundtland, the Prime Minister of Norway, concluded that the economies of the developing countries needed to grow five to ten times as large as they were, in order to meet the needs of the poor world. And that growth won't be mainly in software. As Arthur Rypinski points out, "Where the economy is growing really rapidly, energy use is too." In Thailand, in Tijuana, in Taiwan, every 10 percent increase in economic output requires 10 percent more fuel. "In the Far East," Rypinski says, "the transition is from walking and bullocks to cars. People start out with electric lights and move on to lots of other stuff. Refrigerators are one of those things that are really popular everywhere. Practically no one, with the possible exception of people in the high Arctic, doesn't want a refrigerator. As people get wealthier, they tend to like space heating and cooling, depending on the climate."

In other words, in doing the math about how we're going to get out of this fix, we'd better factor in some unstoppable momentum from people on the rest of the planet who want the very basics of what we call a decent life. Even if we airlift solar collectors into China and India, as we should, those nations will still burn more and more coal and oil. "What you can do with energy conservation in those situations is sort of at the margin," Rypinski says. "They're not interested in fifteen-thousand-dollar clean cars versus five-thousand-dollar dirty cars. It was hard enough to get Americans to invest in efficiency; there's no feasible amount of largesse we can provide to the rest of the world to bring it about."

The numbers are so daunting that they're almost unimaginable. Say, just for argument's sake, that we decided to cut world fossil-fuel use by 60 percent--the amount that the UN panel says would stabilize world climate. And then say that we shared the remaining fossil fuel equally. Each human being would get to produce 1.69 metric tons of carbon dioxide annually--which would allow you to drive an average American car nine miles a day. By the time the population increased to 8.5 billion, in about 2025, you'd be down to six miles a day. If you carpooled, you'd have about three pounds of CO₂ left in your daily ration--enough to run a highly efficient refrigerator. Forget your computer, your TV, your stereo, your stove, your dishwasher, your water heater, your microwave, your water pump, your clock. Forget your light bulbs, compact fluorescent or not.

I'm not trying to say that conservation, efficiency, and new technology won't help. They will but the help will be slow and expensive. The tremendous momentum of growth will work against it. Say that someone invented a new furnace tomorrow that used half as much oil as old furnaces. How many years would it be before a substantial number of American homes had the new device? And what if it cost more? And if oil stays cheaper per gallon than bottled water? Changing basic fuel to hydrogen, say--would be even more expensive. It's not like running out of white wine and switching to red. Yes, we'll get new technologies. One day last fall The New York Times ran a special section on energy, featuring many up-and-coming improvements: solar shingles, basement fuel cells. But the same day, on the front page, William K. Stevens reported that international negotiators had all but given up on preventing a doubling of the atmospheric concentration of CO₂. The momentum of growth was so great, the negotiators said, that making the changes required to slow global warming significantly would be like "trying to turn a supertanker in a sea of syrup."

There are no silver bullets to take care of a problem like this. Electric cars won't by themselves save us, though they would help. We simply won't live efficiently enough soon enough to solve the problem. Vegetarianism won't cure our ills, though it would help. We simply won't live simply enough soon enough to solve the problem.

Reducing the birth rate won't end all our troubles either. That, too, is no silver bullet. But it would help. There's no more practical decision than how many children to have. (And no more mystical decision, either.)

The bottom-line argument goes like this: The next fifty years are a special time. They will decide how strong and healthy the planet will be for centuries to come. Between now and 2050 we'll see the zenith, or very nearly, of human population. With luck we'll never see any greater production of carbon dioxide or toxic chemicals. We'll never see more species extinction or soil erosion. Greenpeace recently announced a campaign to phase out fossil fuels entirely by mid-century, which sounds utterly quixotic but could if everything went just right happen.

So it's the task of those of us alive right now to deal with this special phase, to squeeze us through these next fifty years. That's not fair--any more than it was fair that earlier generations had to deal with the Second World War or the Civil War or the Revolution or the Depression or slavery. It's just reality. We need in these fifty years to be working simultaneously on all parts of the equation on our ways of life, on our technologies, and on our population.

As Gregg Easterbrook pointed out in his book *A Moment on the Earth* (1995), if the planet does manage to reduce its fertility, "the period in which human numbers threaten the biosphere on a general scale will turn out to have been much, much more brief" than periods of natural threats like the Ice Ages. True enough. But the period in question happens to be our time. That's what makes this moment special, and what makes this moment hard. S

Bill McKibben ("A Special Moment in History") is the author of several books about the environment, including *The End of Nature* (1989) and *Hope, Human and Wild* (1995). His article in this issue will appear in somewhat different form in his book *Maybe One: A Personal and Environmental Argument for Single-Child Families*, to be published this month by Simon & Schuster.

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