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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?

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These things mean, I think, that the possibility that we live on a new earth cannot be discounted entirely as a fever

forum of Post & Riposte.

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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."

From the archives:

- **"Mideast Oil Forever?" by Joseph J. Romm and Charles B. Curtis (April, 1996)**
Congressional budget-cutters threaten to end America's leadership in new energy technologies that could generate hundreds of thousands of high-wage jobs, reduce damage to the environment, and limit our costly, dangerous dependency on oil from the unstable Persian Gulf region.

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 *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 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 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 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 degrees Fahrenheit by 2100, and perhaps as much as 6.3 degrees.

From the archives:

- **"The Great Climate Flip-flop," by William H. Calvin (January, 1998)** "Climate

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

change" is popularly understood to mean greenhouse warming, which, it is predicted, will cause flooding, severe windstorms, and killer heat waves. But warming could lead, paradoxically, to drastic cooling -- a catastrophe that could threaten the survival of civilization.

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 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 degrees 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 degrees 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."

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Bill McKibben 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.

Illustrations by Brian Cronin

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