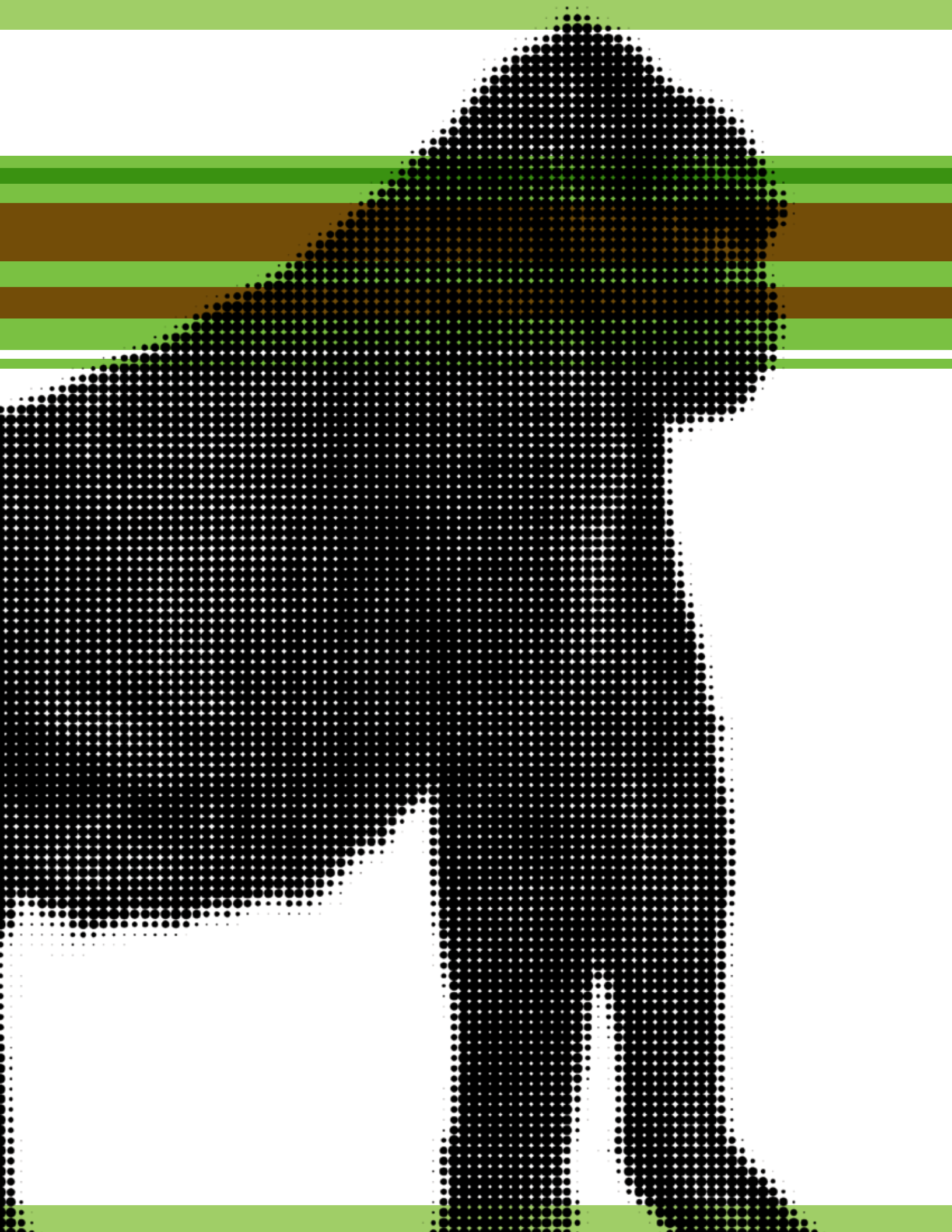


the 800 POUND GORILLA:

The Threat and Taming of Global Climate Change

by Jim Hansen

Animals are on the run. Plants are migrating too. The Earth's creatures, save for one species, do not have thermostats in their living rooms that they can adjust for an optimum environment. Animals and plants are adapted to specific climate zones, and they can survive only when they are in those zones. Indeed, scientists often define climate zones by the vegetation and animal life that they support. Gardeners and bird watchers are well aware of this, and their handbooks contain maps of the zones in which a tree or flower can survive and the range of each bird species.

Those maps will have to be redrawn. Most people, mainly aware of larger day-to-day fluctuations in the weather, barely notice that climate, the average weather, is changing. In the 1980s, I started to use colored dice that I hoped would help people understand global warming at an early stage. Of the six sides of the dice only two sides were red, or hot, representing the probability of having an unusually warm season during the years between 1951 and 1980. By the first decade of the twenty-first century, four sides were red. Just such an increase in the frequency of unusually warm seasons, in fact, has occurred.

ANIMALS AND PLANTS ARE ADAPTED TO SPECIFIC CLIMATE ZONES, AND THEY CAN SURVIVE ONLY WHEN THEY ARE IN THOSE ZONES.

Studies of more than one thousand species of plants, animals, and insects found an average migration rate toward the North and South Poles of about four miles per decade in the second half of the twentieth century. That is not fast enough. During the past 30 years, the lines marking the regions in which a given average temperature prevails ("isotherms") have been moving poleward at a rate of about 35 miles per decade. That is the size of a county in Iowa. Each decade the range of a given species is moving one row of counties northward.

As long as the total movement of isotherms toward the poles is much smaller than the size of the habitat or the ranges in which the animals live, the effect on species is limited. But now the movement is inexorably toward the poles and totals more than a 100 miles over the past several decades. If emissions of greenhouse gases continue to increase at the current rate—"business as usual"—then the rate of isotherm movement will double in this century to at least 70 miles per decade. If we continue on this path, a large fraction of the species on Earth, as many as 50 percent or more, may become extinct.

The species most at risk are those in polar climates and the biologically diverse slopes of alpine regions. These animals, in effect, will be pushed off the planet—though some like the polar bear may be "rescued" and allowed to survive in zoos.

If human beings follow a business-as-usual course, continuing to exploit fossil fuel resources without reducing carbon emissions or capturing and sequestering them before they warm the atmosphere, the eventual effects on climate and life may be comparable to those at the time of mass extinctions. Life will survive, but it will do so on a more desolate planet.

MELTING ICE AND HIGHER SEA LEVELS

The greatest threat of climate change for human beings, lies in the potential destabilization of the massive ice sheets in Greenland and Antarctica. As with the extinction of species, the disintegration of ice sheets is irreversible for practical purposes. Our children, grandchildren, and many more generations will bear the consequences of choices that we make in the next few years.

The level of the sea throughout the globe is a reflection primarily of changes in the volume of ice sheets and thus of changes of global temperature. When the planet cools, ice sheets grow on continents and sea level falls. Conversely, when the Earth warms, ice melts and sea level rises.

Future rise of sea level will depend, dramatically, on the increase of greenhouse gases, which will largely determine the amount of global warming. Sunlight enters the atmosphere and warms the Earth, and then is sent back into space as heat radiation. Greenhouse gases trap this heat in the atmosphere and thereby warm the Earth's surface as we are warmed when blankets are piled on our bed. Carbon dioxide (CO_2), produced mainly by burning fossil fuels (coal, oil, and natural gas), is the most important greenhouse gas made by human beings.

In order to arrive at an effective climate protection policy, we can project two different scenarios concerning climate change. In the business-as-usual scenario, annual emissions of CO_2 continue to increase at the current rate for at least 50 years, as do non-CO_2 warming agents including methane, ozone, and black soot. In the alternative scenario, CO_2 emissions level off this decade, slowly decline for a few decades, and by mid-century decrease rapidly, aided by new technologies.

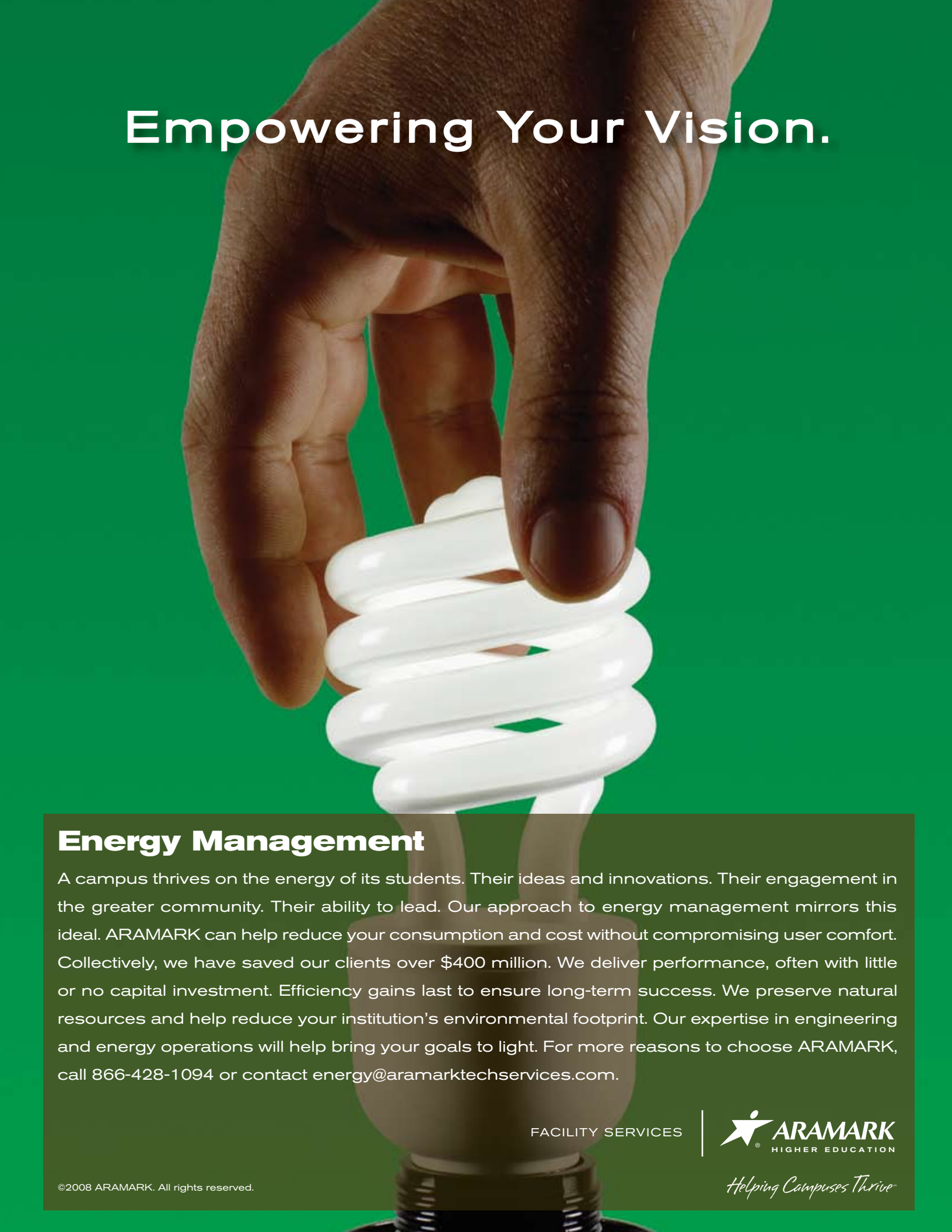
The business-as-usual scenario yields an increase of about five degrees Fahrenheit of global warming during this century, while the alternative scenario yields an increase of less than two degrees Fahrenheit during the same period. How much will sea level rise with five degrees of global warming? Our best information comes from the Earth's history. The last time that the Earth was five degrees warmer was three million years ago, when sea level was about 80 feet higher.

Eighty feet! In that case, the United States would lose most East Coast cities: Boston, New York, Philadelphia, Washington, and Miami; indeed, practically the entire state of Florida would be under water. Fifty million people in the United States live below that sea level. Other places would fare worse. China would have 250 million displaced persons. Bangladesh would produce 120 million refugees, practically the entire nation.

A rise in sea level, necessarily, begins slowly. Massive ice sheets must be softened and weakened before rapid disintegration and melting occurs and the sea level rises. It may require as much as a few centuries to produce most of the long-term response. Even if we kept global warming under two degrees Fahrenheit, there would still be a significant rise in the sea level, but its slower rate would allow time to develop strategies that would adapt to, and mitigate, the rise in the sea level.

ENERGY SCENARIOS AND RESPONSIBILITY

Both the U.S. Department of Energy and some fossil fuel companies insist that continued growth of fossil fuel use and of CO_2 emissions are facts that cannot be altered to any great extent. The danger is that their false prophecies will become self-fulfilling. In reality, an alternative scenario is possible



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THE GREATEST THREAT OF CLIMATE CHANGE FOR HUMAN BEINGS, LIES IN THE POTENTIAL DESTABILIZATION OF THE MASSIVE ICE SHEETS IN GREENLAND AND ANTARCTICA.

and makes sense for other reasons, especially in the United States, which has become an importer of energy, hemorrhaging wealth to foreign nations in order to pay for it.

The situation is critical because of the clear difference between the two scenarios I have projected. Further global warming can be kept within limits (under two degrees Fahrenheit) only by means of simultaneous slowdown of CO_2 emissions and absolute reduction of the principal non-CO_2 agents of global warming, particularly emissions of methane gas. Such methane emissions are not only the second-largest human contribution to climate change, but also the main cause of an increase in ozone—the third-largest human-produced greenhouse gas—in the troposphere, the lowest part of the Earth's atmosphere. Practical methods can be used to reduce human sources of methane emission, for example, at coal mines, landfills, and waste management facilities. However, the question is whether these reductions will be overwhelmed by the release of frozen methane hydrates—the ice-like crystals in which large deposits of methane are trapped—if permafrost melts.

If both the slowdown in CO_2 emissions and reductions in non-CO_2 emissions called for by the alternative scenario are achieved, release of "frozen methane" should be moderate, judging from prior interglacial periods that were warmer than today by one or two degrees Fahrenheit. But if CO_2 emissions are not limited and further warming reaches three or four degrees Fahrenheit, all bets are off. Greater warming could release substantial amounts of methane in the Arctic causing even more warming.

The United States has heavy legal and moral responsibilities for what is now happening. Of all the CO_2 emissions produced from fossil fuels so far, we are responsible for almost 30 percent, an amount much larger than that of the next-closest countries, China and Russia, each less than 8 percent. Yet, our responsibility and liability may run higher than those numbers suggest because we have persisted as the world's leading polluter of greenhouse gases while we were well aware of the consequences.

But it is not too late to redeem ourselves. The United States hesitated to enter other conflicts in which the future was at stake. But enter we did, earning gratitude in the end, not condemnation. Such an outcome is still feasible in the case of global warming, but just barely.

We have at most 10 years to alter fundamentally the trajectory of global greenhouse emissions. Our previous decade of inaction has made the task more difficult, since emissions in the developing world are accelerating. To achieve the alternative scenario will require prompt gains in energy efficiencies so that the supply of oil and natural gas can be sustained until advanced technologies can be developed. If instead we follow an energy-intensive path of squeezing liquid fuels from tar sands, shale oil, and heavy oil, and do so without capturing and sequestering CO_2 emissions, climate disasters will become unavoidable.

POLICY SOLUTIONS AND THE ROLE OF HIGHER EDUCATION

A good energy policy, economists agree, is not difficult to define. A carbon tax, involving a combination of a fuel tax and a cap-and-trade on carbon emissions, should encourage conservation, but with rebates to taxpayers so that overall levels of taxation and government tax revenue do not increase. The taxpayer can use his rebate to fill his gas-guzzler if he likes, but most people will eventually reduce their fuel use in order to save money and will spend the rebate on something else. With

An Unrecognizable World? Likely Consequences of Climate Change

- Higher temperatures, more frequent heat waves
- Greater warming at high northern and southern latitudes
- Loss of Arctic summer ice cover and melting of permafrost, possibly releasing methane and accelerating warming
- Melting of ice sheets, ice shelves, and glaciers, raising sea levels and inundating coastal areas worldwide
- Intensification of the hydrologic cycle, that is, stronger heat waves, droughts and fires, but also heavier downpours and flooding
- Decreased fresh water supplies, especially in subtropical regions and large areas dependent on runoff from mountain glaciers
- More powerful storms driven by latent heat, including hurricanes and thunderstorms, and thus increased storm damage
- Migration of tropical diseases and pests toward the poles
- Shifting of ecological niches poleward, threatening massive species extinction
- Disruption of agriculture and increased risk of famine
- Exacerbation of eco-refugee problem as millions abandon their homes in search of survival
- Increasing political strife and risk of war

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slow and continual increases of fuel cost, energy consumption will decline. The economy will not be harmed. Indeed, it will be improved since the trade deficit will be reduced; so will the need to protect U.S. access to energy abroad by means of diplomatic and military action. U.S. manufacturers would be forced to emphasize energy efficiency in order to make their products competitive internationally. Our automakers need not go bankrupt. Our quality of life need not decline.

Of course, the carbon tax should be complemented by other ways to encourage energy conservation and efficiency. Government policy should reflect a variety of strategies that include an appropriate mix of building codes, efficiency standards, incentives, and public education—all intended to significantly and quickly reduce the amount of fossil fuel we burn and consume. The carbon tax need not be large. The certainty that it will grow will be sufficient to drive innovations and technology development, assuring that consumers have options to minimize their costs.

An increasing carbon tax will promote a switch to renewable energies such as solar, wind, biomass, and other sources that do not produce CO_2. Nuclear power should be included among these options—but we must recognize that several serious issues have yet to be adequately addressed, including procedures for disposal of nuclear waste and assurance that weapons-grade nuclear material can and will be kept out of the hands of terrorists. Governments should address these issues with greater urgency than they have to date.

AN INCREASING CARBON TAX WILL PROMOTE A SWITCH TO RENEWABLE ENERGIES SUCH AS SOLAR, WIND, BIOMASS, AND OTHER SOURCES THAT DO NOT PRODUCE CO_2.

It has become clear, to scientists, that consumption of oil and gas alone will take global warming close to the dangerous level. And oil and gas are such convenient fuels (and located in countries where we can't tell people not to mine them) that they surely will be used. Thus the only way to keep CO_2 from going well above the dangerous level will be to enact a moratorium on the building of any more coal-fired power plants until we have the technology to capture and store the CO_2. The problem posed by carbon-intensive coal is so severe that old, dirty-coal power plants will also need to be shut down over the next few decades. This can be accomplished if we take advantage of the potential of energy efficiency and renewable energies.

Even with these two strong actions, a carbon tax and phase-out of dirty-coal, it is likely that CO_2 will reach and at least marginally pass the dangerous level. A way to combat an overshoot of the safe level of CO_2 is "negative CO_2 power plants" that generate electricity by burning biomass and then capture and store the carbon dioxide emissions. These power plants would take carbon dioxide recently removed from the atmosphere by growing biomass and sequester it deep beneath ocean sediments—thus producing a net reduction of atmospheric carbon dioxide. Improved agricultural practices—such as no-till —and reduced deforestation will also increase carbon storage in the soil and biosphere.

Science and policy implications are clear. Despite population growth and increasing demands for energy from developing nations, we must meet our energy needs while dramatically reducing greenhouse gas emissions. This challenge is huge. In order to stabilize climate and avoid the worst consequences of global warming and climate change, we must reduce annual greenhouse gas emissions by 2050 to a fraction of present emissions.

College and universities have a critical role to play. By demonstrating that their campuses can operate effectively while curtailing greenhouse gas emissions, institutions of higher learning can show what is possible and point the way for others. The American College & University Presidents Climate Commitment is a particularly hopeful development. By committing to achieve climate neutrality at the earliest possible date, signatories to the pledge are recognizing the urgency of the problem, not waiting for government to take actions. These efforts should inspire similar actions in other economic sectors and create momentum needed to get political leaders and government on all levels to act before it is too late.

Climatologist Jim Hansen is a director of the NASA Goddard Institute for Space Studies and Adjunct Professor of Earth and Environmental Sciences at Columbia University's Earth Institute. This article, Hansen's first for *Facilities Manager*, is an abridged version of his chapter in APPA's new publication *The Green Campus: Meeting the Challenge of Environmental Sustainability.*

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