Sea Change: Afterword to the Paperback Edition

Global warming first hit the political agenda in 1988. Since then the Kyoto Treaty has been drafted, ratified, and, at least on paper, gone into force. There have also been calls to action too numerous to mention, but for most people global warming has remained a side show. Then came 2006, and with it some real signs of change.

First off, 2006 was hot! How hot was it? In January 2007 some New Yorkers kicked off the New Year by going to see the cherry blossoms blooming in Central Park. In the coming years Florida beach tourism might join the ski industry as a casualty of a warmer globe as Canada's snowbirds shorten their winter migration and drive to New York to bask in the warm January sun on the grass in Central Park's Sheep's Meadow. New York has already taken on some col-

oration of more southerly climes. As the winters warm, the *New York Times* reports that flora are migrating north: southern trees such as catalpa and white poplar are moving in, while paper birch and black spruce retreat north. Who knows where this all ends? Temperatures set record highs in Canada, too.

Is this additional evidence for global warming? No, no more than the severe January cold snap in India and Bangladesh provides evidence of global cooling. At the risk of sounding cute, though, even if an AWOL winter in eastern North America cannot be used as evidence of global warming, it is symptomatic of a warming globe.

That's the rub. Nobody will ring a bell to announce that a climate-change event has begun, and it's easy to ignore the signals that climate is changing. After two decades of pondering the issue, I still have a hard time envisioning how we will know when a rapid climate-change event is upon us. After all, we've always had extreme weather, and during abrupt climate changes in the past the transitions were marked by normal as well as abnormal years, as the climate system struggled to find a new equilibrium. It's also possible that the message that we have passed the point of no return will come from the financial markets or the world's food system even before we've sorted out what's happening to the weather.

That's not to say that some future dramatic event—for instance, the Greenland ice sheet sliding into the ocean—won't happen (though it's very unlikely), but rather that it's far more likely that global warming will creep up on us as the weather gradually unmoors from its normal patterns. Single events will be explained away—just as this warm winter is dismissed as the product of an El Niño. At some point, though, the frequency, severity, and ubiquity of the unusual

weather will produce a sense of foreboding, a sense that something is happening beyond our control.

Second: The public finally seems to be awakening to the threat. Since the issue first arose there has been a catch-22 to taking action on climate change: In order to avert dangerous climate change we need to be scared into doing something before it is upon us, but at the same time ordinary people and policy makers alike have insisted on irrefutable evidence that climate change is upon us before agreeing to do anything. For the world to act, we need a collective leap of imagination similar to the fears that produced agreements to control nuclear arms. Those of us who were children in the 1950s remember having nightmares after Ed Sullivan unveiled a cobalt bomb on his Sunday night show that he claimed could end life on earth. Now *that* was alarmism, but it served a noble purpose by cloaking nuclear weapons with a special horror. It may not say much about human progress since the Stone Age that it still takes deep fear rather than reasoned argument to get us to act on potential threats, but the heartening development of the past year is that more and more people are making that imaginative leap.

Looking back, it's astonishing how much the climate for climate action has changed in just one year. When *Winds of Change* came out in 2006, the leader of the Senate environment committee's position on climate change was that it was a "hoax" perpetrated by grant-hungry scientists. Now, the United States has a new Congress, led by politicians who take the threat seriously.

Ordinary people are waking as well. The public has been aware of the threat of climate change for more than a decade, but few have felt that it was an urgent issue. Indeed, a simple survey of polling data suggests that more people believe

that aliens have already visited the planet or that they have personal angels looking out for them than agreed in 2005 that the threat of climate change merited immediate action. It's both funny and frustrating that people who dismiss science when it contradicts their fantasies suddenly become diehard empiricists when a threat might disrupt business as usual. Now, it's dawning on Americans that changing climate is already costing them money, such as when insurers have pulled out of providing home insurance in coastal areas as far north as Cape Cod, Massachusetts.

One sure indication of global warming's rising status as an issue has been a flood of initiatives by state and local governments and corporations. For all their talk, few politicians are going to risk their future on an issue that doesn't concern the voters. Whether or not politics translates into meaningful action, more than 200 American cities have committed to meeting the requirements of the Kyoto Treaty to reduce greenhouse gasses, and dozens of states are pushing their own aggressive climate initiatives. These efforts have taken root despite the stance of the Bush administration on the issue, which has ranged from indifference to hostility.

Even here though, there are faint signs of change. In his 2007 State of the Union address President Bush offered a plan for energy independence and then, in a tacked-on phrase, said that his proposed measures would also help deal with the challenge of climate change. While this tepid acknowledgement is a far cry from assuming leadership on the issue, it is indicative of the pressures building on the administration.

On the other hand, the perfunctory nature of this mention suggests that he cannot get over his distaste for the issue and its advocates. I expect that someday President Bush will recognize that his failure to address expecations in this speech was an enormous missed opportunity for him as well

as the world. Had he been nearly as detailed and passionate about the costs of our failure to act on global warming as he was in defending his strategy for the war in Iraq, he might have galvanized the nation and redefined his presidency. While he might find the analogy uncomfortable, he need only look back to the example of President Nixon. Long after memories of Watergate and his nickname "Tricky Dick" have faded, Nixon will be remembered and thanked for signing sweeping legislation that has helped clean up the nation's air and water, protected endangered species, established agencies that monitor pollutants, and set guidelines for the stewardship of the landscape.

Part of the pressure on the president has come from major U.S. corporations. Just before his speech a coalition that included GE, Alcoa, and several major utilities called on the administration to cap greenhouse gas emissions, among other measures. Wall Street firms and a lengthening list of corporations including Wal-Mart, the world's largest retailer, have pledged to battle the threat—in part because of pressure from stakeholders, in part because it has dawned on them that there is real money to be made by being part of the solution, and in part because they are realizing that real money can be lost by being part of the problem. When global warming becomes a pocketbook issue, that's progress!

Third: the real climate seems to be changing faster than the political climate. Globally, 2006 ranked fifth or sixth as the warmest year on record, but in the United States, 2006 topped the charts. Up north, melting has accelerated. Greenland is shedding ice faster than climate models predicted, an ancient ice shelf cracked off of Canada's Ellesmere Island, and satellite readings showed near-record low levels of Arctic sea ice.

The retreat of the sea ice may be feeding upon itself. As the sea ice decreases, the dark ocean absorbs more heat, fur-

ther accelerating the retreat of the ice. A NASA-funded study led by Marika Holland estimated that sea ice could disappear as early as the middle of this century, decades faster than earlier predictions, which would likely spell doom for polar bears and other arctic creatures that evolved in concert with the ice. The ice is an issue for those of us in the mid-latitudes since such a profound change in the energy budget of the far north would also accelerate the melting of permafrost, which would release huge amounts of the powerful greenhouse gas methane, further accelerating climate change.

Also in 2006 scientists found further confirmation that increased carbon dioxide in the atmosphere is making the oceans more acidic. Carbon dioxide combines with seawater to form carbonic acid, but as this acid accumulates it decreases the ability of the oceans to absorb more CO_2. The acidic water also makes it more difficult for tiny armored algae called coccolithophores to form shells. Apart from comprising an important part of the oceanic food chain, these skeleton-forming algae also help sequester atmospheric carbon. They take carbon from the oceans to form their skeletons, and then when they die they drift to the sea floor, entombing carbon in seabed sediments. The oceans have long been the sleeping giant of global warming, and the findings of 2006 suggest that this giant is getting irritated by the extra billions of tons of carbon forced on it year after year.

One tributary of our growing sense of foreboding is uncertainty: we can't be sure of where we now sit on the arc of climate change or what we face. A debate now going on down under typifies the uncharted territory we are entering. Australian scientists and commentators have been arguing about whether a fifth year of intense drought is related to global warming, the persistent and expanding ozone hole, or none of the above. (One theory is that the retreat of the polar

vortex to the south has shifted the geometry of atmospheric flows in ways that contribute to persistent drought conditions.) Contrarians argue that it is hard to see any statistical signal that this drought is materially different than regularly recurring dry cycles. This may say more about statistics than the ongoing drought conditions since Australia's rivers and streams, now at all time lows, are screaming out a message that something is different about this drought.

Closer to home, Richard Seager of Lamont Doherty recently published a study in *Science* that suggests that large parts of the western United States (as well as Mexico, the Mediterranean region, and other areas) are entering a drying period that could last more than a century. Using nineteen different climate models, he looked to see how well the models replicated historical precipitation in these regions, and he then looked forward. With extraordinary consistency, the models show that a drought commenced around 1998 and that this drying will continue for many decades before stabilizing at precipation levels will below those of the recent past. As Seager puts it, drought rivaling the 1930s Dust Bowl will become the new climatology, as the southwest enters "perpetual drought."

Whether or not current drought will end shortly or represent the beginning of a great drying out, Australians, those in the American West—or for that matter New Yorkers witnessing the incongruous blossoming of cherry trees in January—must wonder whether they are seeing a portent of a climate gone haywire. While some of the drumbeat of unusual weather events may be unconnected to global warming, we can't dismiss the linkages out of hand. In that respect, we are all now like the fugitive holed up in a hotel who must worry about every knock on the door.

Fourth: The naysayers have regrouped around a new mantra. The swelling flood of evidence that climate is chang-

ing has forced the contrarians, who until recently denied that climate was changing at all, to admit that yes, earth is warming, but they now argue that it's not our fault. One champion of this position is Senator James Inhofe of Oklahoma, who until January 2007 served as chair of the Committee on Environment and Public Works. The logic of this strategic retrenchment seems to be that if changing climate is not our fault, then we needn't worry about it. Before breathing a sigh of relief, think for a minute about the implications of that concept. Here's my question: If we are already seeing alarming changes in climate, wouldn't it be *better* if we knew that human-sourced emissions were the cause?

If we started this round of climate change, then presumably we can stop it. If Inhofe is correct, however, we can't do anything about it because we don't know what is causing the changes. Either the effects of greenhouse-gas emissions have yet to be felt (a terrifying prospect given the startling shifts we are already seeing) or the entire scientific community has been wrong about the role of carbon dioxide emissions. It's as if 6 billion people were entering rapids on a raft without paddles or a rudder and with no knowledge of waterfalls that might lie ahead. Is this supposed to be a comforting image?

Regardless, Inhofe is wrong. There is plenty to debate about climate change, both in policy and in science, but the consensus among scientists that humans have contributed to the current warming has only strengthened during the past year. Changes, such as higher nighttime, temperatures, indicate that the atmosphere is trapping more heat, while lowered stratospheric temperatures rule out increased solar radiation as the cause of the warming. (More heat coming from the sun would warm the upper atmosphere as well as air closer to earth.) Moreover, solar radiation hasn't really changed in more than fifty years.

Fifth: Scientists are pushing back and the contrarians are in retreat. Those in Congress who still dismiss scientific consensus have the flimsy but credible excuse of scientific stupidity (credible since they are members of one of the few remaining forums where evolution remains a subject of debate), but the few scientists in the naysayer camp have no cover for debating in bad faith. Bad faith? Yes. Serious climate scientists have become so frustrated by the misinterpretation of their data that they have taken to tacking on public disclaimers that their findings should not be used to contradict the consensus on global warming.

For instance, Peter Doran, a scientist whose study about cooling in the interior of Antarctica was cited by so many naysayers as evidence that the world isn't warming, wrote an op-ed for the *New York Times* publicly aligning himself with the global-warming consensus. Global-warming skeptics also trumpet that Mount Kilimanjaro's glaciers started shrinking before industrial-era greenhouse gas emissions really began in earnest. (The earlier shrinkage probably resulted from a Victorian-era drought, but the mountain's glaciers have kept shrinking even as the surrounding lakes recovered when the drought ended.) Here again, Douglas Hardy, one of the authors of the paper cited, complained in an email to colleagues that "Using these preliminary findings to refute or even question global warming borders on the absurd."

And then there is the finding by Frank Keppler of Germany's Max Planck Institute, who published a paper in *Nature* in January 2006 reporting that plants emit methane. Contrarians immediately blamed plants for global warming, letting humans off the hook. An exasperated Keppler was moved to issue a press release in which he rebutted this "misinterpretation" of his study and noted, "It is the anthropogenic emissions which are responsible for the well-

documented increasing atmospheric concentrations of methane since pre-industrial times. Emissions from plants thus contribute to the natural greenhouse effect and not to the recent temperature increase known as 'global warming.'" What frustrates Doran, Hardy, Keppler, and many others is the skeptics' tendency to cherry-pick data and take findings out of context.

Lately, the naysayers have been taking a serious drubbing. The British Royal Society, a much older (340 years) analog of America's National Academy of Sciences, publicly demanded that Exxon stop funding scientifically spurious ads put out by the Competitive Enterprise Institute and other organizations. Some of these ads approached self-parody with lines such as, "they call it [CO_2] pollution, we call it life!"

It is not capitalism's finest hour when the largest and most profitable corporation on the planet stoops to funding propaganda and casuistry. On the other hand, it looks as though the shellacking by the Royal Society, a similar scolding by the Union of Concerned Scientists, and knocks from U.S. senators Snowe and Rockefeller have had an effect. Exxon did stop funding these egregious ads and has joined in discussions on limiting carbon emissions. In mid-January 2007 the company issued the following statement: "we recognize that the accumulation of greenhouse gases in the Earth's atmosphere poses risks that may prove significant for society and ecosystems. We believe that these risks justify actions now, but the selection of actions must consider the uncertainties that remain."

Unless some other deep-pocketed naysayer steps up to replace Exxon's millions, it's possible that we are in the final days of a nearly twenty-year campaign to derail action on climate. While comical to anyone with passing acquaintance to the science, the ads and disinformation campaign were effective at muddying the waters. After all, to win the skep-

tics don't have to disprove global warming, they just have to convey the notion that it's still under debate so that the public says, "I'll wait until the scientists sort it out before I start worrying." The scientists, of course, have sorted it out, and they've done so despite being natural contrarians themselves.

Sixth: Old champions have been reinvigorated and new constituencies for action have emerged. With mother nature continuing her saber rattling, the public finally seems to be sorting things out for themselves. Two thousand six turned out to be the year that ordinary people tuned in to what scientists had been saying for years. Proof of this is that Al Gore, who scarcely mentioned his earlier outspoken views on global warming during his campaign for president, has found his voice again. While in 2000 he downplayed the issue on the advice of his advisors, now he has pundits calling for him to run in 2008 precisely because he is loudly sounding the alarm on the threat. Even more astonishing, a documentary on Al Gore and global warming, *An Inconvenient Truth,* has pulled in $24,000,000 so far, out-grossing such big-budget movies as *The Wicker Man* and *The Black Dahlia*. That may not sound like much in this era of blockbusters, but keep in mind that the Gore movie was a documentary about a slide show—about as wonky as you can get—and that it opened in four theaters, not the 2,000-plus screens of its feature-film peers. It says something when more than 3 million viewers choose to spend their evening getting a tutorial on global warming from Al Gore.

Support for action on climate change has been popping up in surprising places. I had always believed that Wall Street firms would be late to the party on climate change, if only because very few firms will eschew a profit-making opportunity or alienate the giants of the energy business. That doesn't seem to worry Goldman Sachs or Morgan Stanley,

two of a number of firms that have promised to hew to climate-friendly policies.

Equally surprising, calls for action have been coming from the evangelical community, which counts upward of 40 million Americans in its ranks, depending on how their numbers are tallied. While by no means monolithic, more and more evangelical leaders are speaking up on climate change. In February 2006, eighty-six prominent evangelical leaders and the presidents of thirty-nine Christian colleges took out a full-page ad in the *New York Times* committing their energy to solving the global warming "crisis." Fundamentalist concerns flow from the view that human-caused global warming represents an affront to God's creation. This is not the first time that the evangelical community has found itself in uneasy alliance with environmentalists. In the early 1990s, evangelical leaders helped prevent the overturning of the Endangered Species Act.

Seventh: The leaders of the biggest nation on earth may be getting it. This change is particularly timely since China will become the world's largest emitter of greenhouse gasses in as little as three years (a decade earlier than projected just a few years ago). While, the conventional wisdom was that China would need inducements from the developed world to limit its carbon dioxide emissions, there are signs that it has dawned on China's leaders that global warming will not distinguish between industrial and emerging economies when it begins to wreak havoc. An official government report released in January predicts that climate change could cut deeply into agricultural production and further reduce water supplies in a country that has been suffering from acute water shortages for more than a decade.

On occasion China has acted decisively once it recognized the consequences of an environmental threat. When devastating floods killed thousands during the powerful El Niño

of the late 1990s, China clamped down on deforestation in the watersheds of the flood-prone rivers. If China follows up on its report on climate change with equal seriousness, there may be some hope to stabilize and then reduce the carbon burden in the atmosphere. As a nation very dependent on foreign oil, China has many incentives to pursue alternatives to fossil fuels.

Eighth: The task ahead becomes more clear every year, but it also becomes more daunting. While mounting public concern is a precondition for action to halt emissions, there remains the question of whether it is realistic to assume that anything can be done to stop the slide toward climate chaos. Is it even possible to cut back greenhouse-gas emissions sufficiently to relieve the pressure on the climate system given our dependence on fossil fuels? At first the numbers look daunting.

Working in concert with physicist Robert Socolow, Steven Pacala, an ecologist at Princeton University, developed a simple way of thinking about the problem. Present concentrations of CO_2 in the atmosphere are roughly 380 parts per million, about 40 percent higher than preindustrial levels. This represents more carbon in the atmosphere than at any time since humans first emerged as a species, but still there is no chance that we can halt these concentrations at these levels. With tremendous global commitment, though, we have a chance to stabilize CO_2 at between 500 and 550 parts per million over the next fifty years. Or, to put this another way, with concerted global effort we have a chance of halting concentrations somewhere in the neighborhood of a doubling of preindustrial levels.

No one can say whether this is sufficient to avert a climate calamity, but it is certainly better than the tripling of preindustrial levels of CO_2 that will come about if we do nothing. To stop at a doubling would require the world to

eliminate several billion tons of carbon each year that would otherwise be emitted. Socolow and Pacala call these billion-ton units wedges and identify fifteen different technologies available today (ranging from renewables and natural sinks, to nuclear and coal-to-gas) that could help get us there. So far so good, but let's see what that would entail.

To stabilize emissions at 500 PPM by 2056, they argue that the U.S. burden would involve eliminating two of the seven wedges that have to be offset. Sounds easy enough, but one wedge is equivalent to doubling the gas mileage of all the cars in the world, doubling nuclear generating capacity instead of building coal-fired plants, or halting all deforestation in the world. Clearly the task is enormous, but given that we have five decades to get there, it is also doable. A world that shifted from wood to coal to oil can shift from oil to something else. To argue otherwise would be to admit that the engine of prosperity of the past 100 years was not technological prowess, but the liquidation of one fossil fuel—not a particularly noble obituary for the most powerful civilization yet to appear.

Pacala and Socolow also detail the costs of delay. Given the lasting nature of carbon in the atmosphere and ever-increasing global emissions, every year of delay means that we have to use that much less fossil fuels later on. For instance, if the world delayed five years, it would mean taking 7.7 wedges out of carbon emissions rather than the 7 that would be required if we started now.

This is precisely why a public prepared to act is so important. Consumer spending accounts for about 70 percent of GDP in the United States. If shoppers had an easy way to make climate-friendlier choices, and if companies could deliver on those choices, I think that economists would be surprised by the speed at which the United States could stabilize and then lower greenhouse-gas emissions. Consumers shifted

from getting their music from CDs to iPods in just a few years. If consumer interest emerges in climate-friendly products, businesses will enable that shift, too. The key is that when consumer demand arises, companies have to be prepared to deliver. There are plenty of ways that government could help, such as gradually imposing some form of carbon tax, but here again, it will be consumers/voters who put pressure on politicians to act.

Obviously, addressing the threat of global warming involves much more than an aroused citizenry, but over the past eighteen years it has become clear that nothing is going to happen without the energy of an aroused citizenry to force the issue. For this reason alone, 2006 will stand as a year to remember in the battle to avert climate chaos. Past civilizations that fell victim to climate change were blindsided by a fatal turn in the weather. We have the great good fortune of being able to see what is coming, why it is happening, as well as what we might do to stop it. To put it bluntly, we have no excuses if we become the next victim of this ancient serial killer.