If climate change can raise the threat of civil war, the press of population and technology on resources is driving its own dynamic for conflict. Rare minerals essential for advanced technology will be increasingly the focus of competition in the coming decades, as they are now to different degrees in the Congo, South America, and China. China itself has been seeking to command new resources on near and far frontiers. Its efforts to control Tibet and the eastern Uighur autonomous region have explicitly been efforts to settle ethnically Han people, particularly military veterans, outside the Chinese core, and the Chinese government has launched a series of efforts to secure resources in sub-Saharan Africa. And on the other hand, despite arguments that oil supplies are plentiful, the industrial West has been extremely aggressive in securing access to oil; protecting the global flow of oil from the Persian Gulf has been a central tenet of United States foreign and military policy since the close of World War I.[23]

* * *

Deniers, Pessimists, and Pragmatists

On a broad front, then, climate change, population growth, and energy resources all are already directly shaping the context of global struggle in the decades to come. Some already claim that the wider impact of climate change is the vehicle of a genocide by the north being perpetrated against the global south.[24] Put more scientifically, or more delicately, by E. O. Wilson and William McKibben, we are at a "bottleneck" or a "special moment."[25] The question is how to get through this bottleneck. Answers to this question run across a wide gamut of public opinion. In the end they lead us to domains beyond the formal purview of this book: politics and governance.

and Conflict," *Political Geography* 26 (2007), 627–38; Jon Barnett and W. Neil Adgerb, "Climate Change, Human Security, and Violent Conflict," *Political Geography* 26 (2007), 639–55 offer an overview of a research agenda. See also the essays in Paul F. Diehl and Nils Petter Gleditsch, eds., *Environmental Conflict: An Anthology* (Boulder, CO, 2000).

[23] Jeffrey Gettleman, "Rwanda Stirs Deadly Brew of Troubles in Congo," *NYT*, Dec. 3, 2008; William J. Broad, "Plan to Carve Up Ocean Floor Riches Nears Fruition," *NYT*, March 29, 1994; David Barbosa, "China Starts Investing Globally," *NYT*, February 21, 2009; Edward Wong, "Clashes in China Shed Light on Ethnic Divide," July 8, 2009; Daniel Yergin, *The Prize: The Epic Quest for Oil, Money and Power* (New York, 1992), 396–403, 430–98, 588–613, 633–52, 769–79; Klare, *Resource Wars*, 27–137; Carolyn Pumphrey, ed., *Global Climate Change: National Security Implications* (Carlisle, PA, 2008); John M. Broder, "Climate Change Seen as Threat to U.S. Security," *NYT*, Aug. 9, 2009.

[24] Gideon Polya, "Climate Criminals and Climate Genocide," July 2, 2007 at http://www.countercurrents.org/polya010807.htm, accessed August 8, 2012. See also Naomi Klein, *The Shock Doctrine: The Rise of Disaster Capitalism* (New York, 2007).

[25] Wilson, *The Future of Life*, 22–49; Bill McKibben, "A Special Moment in History," *Atlantic Monthly* (May 1998), 55–78.

Until recently, public opinion on the ecological future of the earth and its people has been described in the terms framed by the debate between Paul Ehrlich and Julian Simon, alarmist Malthusians and optimistic Cornucopians. With the shift of the center of the debate from resources to climate change, new frameworks and positions have emerged. Simon's cornucopianism, with its fundamental free-market-driven assumption that a business-as-usual pursuit of economic growth could continue forever, has shifted toward a posture of denial. The active "deniers," about 7 percent of the American public according to surveys, simply refuse to accept any of the evidence that human activity has had an impact on natural climate systems. Strongly conservative and individualistic in their worldview, deniers call the evidence of climate change "junk science," "a false theory," a conspiracy, or media hype, or they argue that any changes are simply driven by natural forces. The deniers are supported by extremely powerful and wealthy interests entrenched in an old technology, especially the oil industry, which had its origins more than a century ago in the Second Industrial Revolution. And their voices have been wildly amplified by a small group of well-financed and well-connected right-wing ideologues who have worked assiduously to move public opinion against scientific evidence on cancer and tobacco, acid rain, and the ozone layer, before ginning up the campaign against climate change science.[26]

At the other end of the spectrum, separated from the deniers by a broad body of the public inclined to see climate change as a significant if somewhat abstract issue, the environmental "alarmists" have divided into two camps. The time for sounding the alarm is over, and environmentalists and their allies have had to decide on the best course of action. Very broadly they have divided into positions of angry pessimism and concerned pragmatism.

A mood of angry pessimism hangs like a dark cloud over the scientific world. For decades, scientists have been increasingly concerned about the planetary future, and frustrated by the roadblocks to mitigation thrown up by the partisans of denial in the political arena. With politicians and entrenched interests standing in the way of change, the evidence about the deep past and the unfolding present has mounted to support the premise that the earth is on the brink of nonlinear catastrophic change.[27] At this late juncture, the pessimists fear, intervention is just too little too late. This angry pessimism does not often find its way into the scientific literature, but it has found its most powerful expression in the words of James Lovelock, whose

[26] Anthony A. Leiserowitz, "American Risk Perceptions: Is Climate Change Dangerous?" *Risk Analysis* 25 (2005), 1433–42; Naomi Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth in Issues from Tobacco Smoke to Global Warming* (New York, 2010).

[27] A recent poll indicates the massive consensus among climate scientists on the human causes of recent climate change and their probable consequences: http://visionprize.com/results, accessed August 8, 2012.

insights forty years ago about the interconnections of life, atmosphere, and the solid, moving earth have underpinned the earth systems approach that drives modern environmental science. In *The Revenge of Gaia*, published in 2006, Lovelock describes the future of the earth in apocalyptic terms:

> [N]ow the evidence coming in from watchers around the world brings news of an imminent shift in our climate toward one that could easily be described as Hell: so hot, so deadly that only a handful of the teeming billions now alive will survive. We have made this appalling mess of the planet, and mostly rampant liberal good intensions. Even now, when the bell has started tolling to mark our ending, we still talk of sustainable development and renewable energy as if these feeble offerings would be accepted by Gaia as an appropriate and affordable sacrifice.[28]

Lovelock closes his book with the image of future survivors on camelback making their way through horrific deserts to refuges north of the Arctic Circle. But Lovelock cannot help but toy with the technological solutions that have captured the attention and efforts of many of his environmentalist peers and their new allies among the ranks of economists. This new body of pragmatists, all concerned and some hopeful, are poised on the classic pivot between Malthus and Boserup: Will the press of human numbers overwhelm the planet, or will it drive another technological revolution bringing those numbers into balance with the earth system? Can economic growth be detached from demographic numbers, attached as it has been for millennia? And can growth be detached from the environmental impacts that have followed from human activity for those same millennia?

Paltry as they might seem to Lovelock and the pessimists, the efforts of the pragmatists seeking a way through the bottleneck at times have seemed to fill the news. Fully aware of the timeline of predictions of tipping points and points of no return and the threats of abrupt change, the pragmatic approach is driven by a calculation that many discrete efforts will add up to the necessary course correction in the trajectory of the earth and its people. They are increasingly attuned to the idea that the earth will have to be managed by human action for a sustainable future, and that this will require the acceptance of a certain level of risk. And they are self-consciously thinking through a model of human social resilience in the face of sudden climatic change.[29]

[28] James Lovelock, *The Revenge of Gaia: Earth's Climate Crisis & the Fate of Humanity* (New York, 2006), 147–8, 159; see also Tim Dyson, "On Development, Demography and Climate Change: The End of the World as We Know It?" *Population and Environment* 27 (2005), 117–49; John D. Cox, *Climate Crash: Abrupt Climate Change and What It Means for Our Future* (Washington, DC, 2005), 177–90; Eugene Linden, *The Winds of Change: Climate, Weather, and the Destruction of Civilizations* (New York, 2006), 247–69; Anthony Barnofsky, *Heatstroke: Nature in an Age of Global Warming* (Washington, DC, 2009), Naomi Oreskes and Erik M. Conway, "The Collapse of Western Civilization: A View from the Future," *Daedalus* 142 (2013), 40–58.

[29] Smil, *Global Catastrophe and Trends*, 219–53; Scheffer, *Critical Transitions*, 265–325; Andrew C. Revkin, "Middle Stance Emerges in Debate over Climate," *NYT*, January 1,

The best established of these pragmatic programs, and perhaps the model for others in other arenas, is the effort to improve living conditions in the developing world. In a line that runs back to the nineteenth-century reformers and responding to the consequences of the control of mortality, the first pragmatist turn came in response to the earliest Malthusian concerns about population in the postwar years. In this effort they had after 1945 a ready-made global institution, the United Nations, which since its founding has devoted a large percentage of its budget to addressing pressures on the developing world, through programs and agencies devoted to population, health, economic development, food, refugees, women and children, and human settlements. Outside of the U.N., institutions such as the World Bank and the International Monetary Fund have also had a global reach, though often with the effect of advancing the interests of the developed world. Private philanthropic foundations established by the beneficiaries of the Second and Third Industrial Revolutions have also played a increasingly important role, the long-established Rockefeller and Ford Foundations now overshadowed by the Bill and Melinda Gates Foundation, which is putting vast resources into innovative development projects aimed at the world's poorest populations, and especially into health initiatives involving malaria, AIDs, and childhood diseases. The U.N.'s Millennium Development Goals, adopted in 2001, establish well-articulated plans to move aggressively to help the poorest countries, and the poorest billion of the world's population, out of poverty, challenging the world's richest nations to fund this effort with .7 percent of their GDP, less than what has been promised – but not delivered – in international aid.[30]

Over the past ten to twenty years, entrepreneurs and engineers have joined climate scientists in a similar pragmatic coalition to address global warming

2007; Stephen Pacala and Robert Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies," *Science* 305 (2004), 968–72. For an early manifesto of the need for pragmatic earth system management, see Daniel B. Botkin, *Discordant Harmonies: A New Ecology for the Twenty-First Century* (New York, 1990); –, *Shaping Climate-Resilient Development: A Framework for Decision-Making* (The Economics of Climate Adaptation Working Group, 2009); Rob Atkinson et al., *Climate Pragmatism: Innovation, Resilience, and No Regrets* (The Hartwell Group, 2011). The rise of the environmental pragmatists has attracted the attention of certain skeptics (if not hardcore deniers), who advocate action or adaptation: Gregg Easterbrook, "Some Convenient Truths," *Atlantic Monthly* (September 2006), 29–30; Bjorn Lomborg, *Cool It: The Skeptical Environmentalist's Guide to Global Warming* (New York, 2007). For a very optimistic pragmatism, see Ramez Naam, *The Infinite Resource: The Power of Ideas on a Finite Planet* (Hanover, NH, 2013).

[30] Jeffrey D. Sachs, *Commonwealth: Economics for a Crowded Planet* (New York, 2008); –, *The End of Poverty: Economic Possibilities for our Time* (New York, 2005), esp. 288–308; Paul Collier, *The Bottom Billion: Why the Poorest Countries are Failing and What Can Be Done about It* (New York, 2007); Jean Strouse, "How to Give Away $21.8 Billion," *NYT*, April 16, 2000.

and the energy systems that have driven it. The technology required to reduce greenhouse gases is advancing, driven by patriotic and pocketbook concerns about energy independence, energy efficiency, and potential profit as much as environmental impact. Efforts to bring this transition to the private automobile are now advancing, with hybrid gasoline-electric vehicles well established in the market, and electric cars beginning to hit the streets.[31] Bus fleets are being converted to cleaner-burning natural gas, and hydrogen fuel systems could be in cost-effective production in a decade or two. Solar and wind energy have suddenly emerged as real possibilities. While Europe and particularly Germany are now the world leaders in solar energy supply, solar panel arrays are being installed throughout the hotter regions of the United States, and China has begun to dominate the world solar market through a major, heavily subsidized campaign.[32] Enormous fields of wind turbines are an increasingly common sight across the United States, and are becoming a significant part of the employment picture in some rural regions. Whether these weather-dependent systems can provide the steady high volume of sustained electric power remains to be seen, however.

These efforts to limit emissions may well come up short, too little too late, or simply fail. The result is a growing if contested interest in more aggressive interventions into the workings of the earth system. One idea being developed is to literally scrub CO_2 out of the air with chemical machinery that would convert the carbon to quicklime. Such CO_2 scrubbers have been constructed in laboratories, and efforts are under way to see if they can be manufactured on a real-world scale.[33] Other approaches are more controversial, because they involve more radical geoengineering interventions that might well lead to widely ramifying unintended consequences. One solution would be to dump many tons of iron fillings into the south Pacific to encourage blooms of algae that would ingest and sequester

[31] The transition to new automotive fuels may – or not – be driven by new resources shortages. If the weight of the environmental debate shifted from sources to sinks in the 1980s and 1990s, the sudden entry of China and India into the world economy after the year 2000 drove the massive spike in oil prices that ran from the summer of 2007 into 2008. This price increase clearly drove the biofuels enthusiasm that has diverted huge volumes of corn from foodstocks to fuel, driving a worldwide increase in food prices. But the price of oil fell in 2008 as the financial crisis began to unfold, and has been held down by the recession. As the world economy recovers, oil prices should rise again, and the eagerness of American consumers to dump "clunkers" for fuel-efficient Toyotas in the summer of 2009 seems to have been a strategic hedge against a projected price increase. But if indeed oil supplies themselves are not really limited, the constriction point is refinery capacity.

[32] Keith Bradsher, "China Racing Ahead of U.S. in the Drive to Go Solar," *NYT*, August 25, 2009; Associated Press, "GM Rolls Past 1 Million Miles in Fuel Cell Demo," reported in the *NYT*, Sept. 11, 2009.

[33] Nicola Jones, "Sucking it Up," *Nature* 458 (2009), 1094–7; Wallace S. Broecker and Robert Kunzig, *Fixing Climate: What Past Climate Changes Reveal about the Current Threat – and How to Counter It* (New York, 2008), 198–233.

CO_2. Another proposal is to inject sulfate aerosols into the stratosphere to simulate the effect of volcanic eruptions, thus cooling the earth; another would have special ships spraying seawater to whiten stratospheric clouds. Yet another involves positioning enormous reflectors above the atmosphere, which would deflect solar radiation. The most extreme model so argues that the hiatus in warming in the 1950s and 1960s was not caused by industrial sulfates but by pulverized rock put into the atmosphere by surface testing of nuclear weapons; the article quantifies the cost of sending daily flights to the top of the atmosphere to spread tons of powdered limestone. The first objection to these concepts, some of which are seen as borderline feasible, are the unintended consequences. Overshooting the dumping of iron filings could cool the earth climate suddenly, while imitating volcanic emissions runs the risk of further interfering with global precipitation patterns. As important, these technological interventions could well encourage global powers to accept a solution of continuing high greenhouse emissions offset by technological fixes. Such a "solution" would require century after century of careful maintenance because shutting down such technologies while inflated levels of greenhouse gases remain in the atmosphere would indeed set off a hellish surge of catastrophic warming. On the other hand, having these technologies in reserve might well be a prudent policy, because they could be deployed in a worst-case scenario.[34]

Policy, however, requires politics. Shaping these technical fixes are the political decisions that will direct the flow and structuring finances necessary to effect change. These involve complex negotiations between global institutions and sovereign nations, which have as yet not arrived at a workable solution, given the deeply entrenched interests at stake. As in development and population, the center of efforts to address questions of global environment and climate change are institutions framed by the United Nations. First, the Intergovernmental Panel on Climate Change was established in 1988, the hot year that suddenly brought the question of global warming to public attention, as a global consortium of scientists assessing the evidence for climate change. Formed on the initiative of the World Meteorological Organization and the U.N. Environmental Programme, which dated back to 1873 and 1972 respectively, the IPCC thus has roots in the late nineteenth-century institutionalization of science and the launch of the environmental movement after the first Earth Day. Publishing its first report in 1995, the IPCC was formally made the advisory arm to the U.N.'s negotiating body,

[34] William J. Broad, "How to Cool a Planet (Maybe)," *NYT*, June 27, 2006. For skeptical views, see the articles by Stephen Schneider and James Lovelock in Brian Launder and J. Michael T. Thompson, eds., *Geo-Engineering Climate Change: Environmental Necessity or Pandora's Box?* (New York, 2010), 3–26, 84–92; Gabriele C. Hegerl and Susan Solomon, "Risks of Climate Engineering," *Science* 325 (2009), 955–6. For the nuclear model, see Yoshiaki Fugii, "The Role of Atmospheric Nuclear Explosions on the Stagnation of Warming in the Mid-20th Century," *Journal of Atmospheric and Solar-Terrestrial Physics* 73 (2011), 643–52.

the Framework Convention on Climate Change (UNFCCC), established at the Earth Summit at Rio de Janeiro in 1992. The Framework convention has met annually since 1995, but the negotiations have never reached on a consensus on how the leading and established economies might disproportionately cut their emissions, leading toward green technology while developing countries continue energy- and emission-intensive economic development. The Kyoto Protocol of 1997 established a global plan to bring greenhouse emissions 6 percent to 8 percent below 1990 levels by 2008–12; the U.S. target of 7 percent was blocked by the U.S. Senate during the Democratic Clinton administration and explicitly rejected by the Republican Bush administration in 2001. In June 2009, the U.S. House of Representatives passed the Waxman-Markey Clean Energy and Security Act, which established a cap-and-trade system aimed at reducing U.S. greenhouse emissions by 17 percent (from 2005) in 2020, and 80 percent in 2050, mandated the modernization and increased efficiency of electrical systems, and advanced support for renewable energy and electric vehicles. Under the relentless pressure of the economic recession and a drumbeat of opposition from the American Republican Party, this bill has disappeared from the national agenda, as the debate over health care and then the slow economic recovery from the 2008 crash have stifled any political momentum toward action on climate.[35]

The central and obvious roadblock to a comprehensive global agreement lies in the perceived trade-off between economy and environment. As we have seen, the modern history of economic expansions and interruptions has demonstrated so far that flourishing economies – producing and consuming increasing volumes of electricity – produce equivalent emissions. The United States has refused to control emissions if that would interfere with an "American lifestyle," and developing countries such as China have been equally unwilling to slow their development for the sake of the environment. While the evidence from the 1987 Montreal Protocol, which banned CFCs, has shown how effective global controls can be implemented without serious economic consequences, the largest greenhouse contributors stand against decisive action.

Thus a worldwide debate on practical, pragmatic solutions for the next century hinges on the balance between economic growth and projected climate change. The Fourth Assessment Report of the IPCC, issued early in 2007, stands at the institutional and intellectual center of this debate. Working Group III of IPCC was assigned the task of assessing the range of mitigation strategies, and presenting a graduated series of options for the Framework Convention and its member nations to consider and act upon. The core of their report is a review of the costs of investments in technology,

[35] Weart, *The Discovery of Global Warming*, 32–3, 142–59, 168–9, 174–5, 187–90; John M. Broder, "House Passes Bill to Address Threat of Climate Change," *NYT*, June 27, 2009.

infrastructure, and behavior modification that would be required to bring greenhouse gas emissions to within certain stabilization targets. They estimate that keeping CO_2 concentrations in 2030 in the 440–485 ppm range might shave off perhaps 1 percent of global GDP, and keeping it within 350–440 ppm range might cost 2 to 3 percent. Estimates for the years 2050 are considerably higher, as much as 5.5 percent. On the other hand, the Working Group does not assess the costs of *not acting*, but suggests that action might even *increase* GNP slightly, by as much as 1 percent by 2050. New estimates posit that the costs of inaction against global warming are much higher than previously expected; it remains to be demonstrated directly that they would be much higher than those of action.[36]

The IPCC Report, and the Stern Review issued by Nicholas Stern, climate adviser to the United Kingdom in 2006, both present relatively cost-free plans for addressing climate change. As revised in a 2009 book, the Stern report is now the core of a pragmatic solution. He proposes a 50 percent cut in 1990 emissions by 2050, with a target of ~450 ppm CO_2 (or 500 ppm CO_2 in total greenhouse gas equivalents). Developed countries would agree immediately to reductions by 2020 and 2050, totally 80 percent of 1990 emissions; developing countries would agree to reductions in 2020. The entire process would be governed by a global system of cap and trade in "carbon credits" that would grow increasingly costly through time, driving emitters to adopt improved technologies. Essential elements include success in stopping tropical deforestation, subsidies by developed countries for the necessary technology, and serious efforts to provide a wide range of assistance to the developing world.[37]

The Stern position is the essence of pragmatism. It addresses the deniers by arguing that the costs of climate mitigation would not be too high, and it warns the pessimists to not "disrupt the possibility of agreement in the very near future."[38] But its premises have been strongly challenged. James

[36] IPCC, "Summary for Policy Makers," and Brian Fisher et al., "Ch. 3: Issues Related to Mitigation in the Long-Term Context," in B. Metz et al., eds., *Climate Change 2007: Mitigation: Contribution of Working Group III to the Fourth Assessment Report of the Inter-governmental Panel on Climate Change* (Cambridge, 2007), 11, 18; 197–200, 203–6, 231–3. For an assessment of the literature on the costs of inaction, see Richard S. J. Tol, "The Social Cost of Carbon: Trends, Outliers and Catastrophes," *Economics: The Open-Access, Open-Assessment E-Journal* 2 (2008); and –, "Why Worry about Carbon? A Research Agenda," *Environmental Values* 17 (2008), 437–70; Martin Parry et al., *Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC and other Recent Estimates* (London, 2009).

[37] Nicholas Stern, *The Global Deal: Climate Change and the Creation of a New Era of Progress and Prosperity* (New York, 2009), 144–80. Originally published in the United Kingdom as *A Blueprint for a Safer Planet*. See also Fred Krupp and Miriam Horn, *Earth the Sequel: The Race to Reinvent Energy and Stop Global Warming* (New York, 2008). Fred Krupp is the president of the Environmental Defense Fund.

[38] Stern, *The Global Deal*, 150–1.

Hansen, the director of the NASA Goddard Institute for Space Science and one of the leading climate scientists in the United States, opened the public climate change debate in his 1988 report to Congress. He earned his spurs as a pragmatist during the last decade, arguing that a low-cost mitigation could be achieved through focusing on reducing methane and black soot emissions to zero, while allowing CO_2 emissions to continue relatively unabated for several decades.[39] But in the past few years, following his own review of the entire sweep of Cenozoic climate history, he has rejected the 450 ppm target advanced by the IPCC and the Stern report, and strongly advocated for a goal of reducing CO_2 to 350 ppm as soon as possible. His position is supported by new studies focusing on the long-range impacts of highly persistent atmospheric CO_2. Hansen's analysis hinges on the "tipping point" toward a glaciated planet 35 million years ago during the late Eocene, when he argues that CO_2 dropped below a range of 450–600 ppm. In this analysis, a planet with an atmospheric CO_2 count of higher than 450 ppm, "if long maintained would push Earth toward an ice-free state," the extreme, apocalyptic picture of the "angry pessimists." Thus Hansen – with a distinguished group of coauthors – argues strenuously that we need to return as soon as possible to a "safe" 350 ppm level. To achieve this goal, he reiterates his recommendations on eliminating methane and black soot emissions, recommends serious efforts at reforestation, the elimination of biomass burning, and demands that all coal emissions be sequestered or phased out. Then he takes an initial step toward geoengineering, proposing the industrial production of the CO_2 air scrubbers that now exist as prototypes. His fellow NASA scientist Drew Shindell has advanced the argument for black carbon reductions, combining the evidence for its unique greenhouse impact with its adverse effects on agricultural productivity and human health.[40]

In the final analysis, our current circumstance needs to be seen both as a crisis in the relation of humanity and the earth system, and as a moment in the long-term transformation of economic systems on a scale with any of the

[39] James Hansen et al., "Global Warming in the Twenty-First Century: An Alternative Scenario," *PNAS* 97 (2000), 9875–80; James Hansen and Larissa Nazarenko, "Soot Climate Forcing via Snow and Ice Albidos," *PNAS* 101 (2004), 423–8; James Hansen and Makiko Sato, "Greenhouse Growth Rates," *PNAS* 101 (2004), 16109–14; James Hansen, "Defusing the Global Warming Time Bomb," *SA* (March 2004), 70–7.

[40] James Hansen et al., "Target Atmospheric CO_2: Where Should Humanity Aim?" *The Open Atmospheric Science Journal* 2 (2008), 217–31, and suppl. i–xxi. See also Myles R. Allen et al., Warming Caused by Cumulative Carbon Emissions toward the Trillionth Tonne," *Nature* 458 (2009), 1163–6; J. A. Lowe, "How Difficult Is It to Recover from Dangerous Levels of Global Warming?" *Environmental Research Letters* 4 (2009), 014012; Malte Meinshausen, "Greenhouse-Gas Emission Targets for Limiting Global Warming to 2°C," *Nature* 458 (2009), 1158–62; Susan Solomon et al., "Irreversible Climate Change Due to Carbon Dioxide Emissions," *PNAS* 106 (2009), 1704–9; Drew Shindell et al., "Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security," *Science* 335 (2012), 183–9.

great ruptures of the human past. Scientists, engineers, and entrepreneurs, the core of the pragmatic coalition, are mapping a possible path to a sustainable future. Quite simply, it can go one way or another. What is needed is a new legal framework to shape the transition to a new system of energy and the market. If an earth system crisis is averted, it will be because the politics of economic transformation was able to unfold quickly enough to make a difference.

Over the past 500 years, all significant epochs of economic transformation have had a fundamentally political dimension. In each case, the state's role in the determination of the course of economic action made the decisive difference. European states set the conditions that launched the age of empire; the resolution of the English Revolution in 1689 and eventually British victories over Napoleon framed the conditions of the First Industrial Revolution; the legal, institutional, and financial initiatives of European governments and the United States set the conditions for the Second Industrial Revolution.[41] In each of these transitions there was a heated political struggle between the established order and the advocates of change. It can be argued that we currently sit stalled in the midst of the Third Industrial Revolution, but that the tools needed to address the earth system crisis are those of that third revolution: an explosion of innovation and investment in an energy-technology economy that will drive the human condition forward while maintaining the essential integrity of the earth system. The critical lever to launch and sustain this transformation must be the collective action of democratic governance at the national and the international levels. There are strong indications that the American public is beginning to understand the case for action.[42]

What is necessary, what all of the pragmatists are working for, what the pessimists despair of, and what the deniers reject in antihistorical, antiscientific ideological animus, entrenched interest, and a good bit of wishful thinking, is a global solution. We hold it in our collective capacity to address the earth system crisis that is now upon us. That capacity must be mobilized by an informed political will.

[41] Here see Carlota Perez on the role of politics and law in the turning points of long waves, in *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Cheltenham, UK, 2002), 52–3, 120–1; and Robert U. Ayres, "Resources, Scarcity, Technology, and Growth," in Simpson et al., *Scarcity and Growth Revisited*, 144–54.

[42] The public support for taking climate change seriously is stronger than much of the media coverage would indicate. See Anthony Leiserowitz et al., *Climate Change in the American Mind: Public Support for Climate & Energy Policies in March 2012: Yale University and George Mason University* (New Haven, CT, 2012); University of Texas Energy Poll, reported in Mark Drajem, "Record Heat Wave Pushes U.S. Belief in Climate Change to 70%," *Bloomberg News*, July 18, 2012.