The Collapse of Western Civilization: A View from the Future

Naomi Oreskes & Erik M. Conway

Authors' note: Science fiction writers construct an imaginary future; historians attempt to reconstruct the past. Ultimately, both are seeking to understand the present. In this essay, we blend the two genres to imagine a future historian looking back on a past that is our present and (possible) future. The occasion is the tercentenary of the end of Western culture (1540 – 2073); the dilemma being addressed is how we – the children of the Enlightenment – failed to act on robust information about climate change and knowledge of the damaging events that were about to unfold. Our historian concludes that a second Dark Age had fallen on Western civilization, in which denial and self-deception, rooted in an ideological fixation on "free" markets, disabled the world's powerful nations in the face of tragedy. Moreover, the scientists who best understood the problem were hamstrung by their own cultural practices, which demanded an excessively stringent standard for accepting claims of any kind – even those involving imminent threats. Here, our future historian, living in the Second People's Republic of China, recounts the events of the Period of the Penumbra (1988 – 2073) that led to the Great Collapse and Mass Migration (2074).

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In the prehistory of "civilization," many societies rose and fell, but few left as clear and extensive an account of what happened to them and why as the twenty-first-century nation-states that referred to themselves as *Western civilization*. Even today, two millennia after the collapse of the Roman and Mayan empires and one millennium after the end of the Byzantine and Inca empires, historians, archaeologists, and synthetic-failure paleoanalysts have been unable to agree on the primary causes of those societies' loss of population, power, stability, and identity. The case of Western civilization is different because the consequences of its actions were not only predictable, but predicted. Moreover, this technologically transitional society left extensive records both in twentieth-century-style paper and in twenty-first-century electronic formats, permitting us to reconstruct what happened in extraordinarily clear detail. While analysts differ on the details, vir-

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tually all agree that the people of Western civilization knew what was happening to them but were unable to stop it. Indeed, the most startling aspect of this story is just how much these people knew, yet how little they acted upon what they knew.

For more than one hundred years, *physical scientists*[1] in the Western world had known that carbon dioxide (CO_2) and water vapor absorbed heat in the planetary atmosphere. A three-phase Industrial Revolution led to massive release of additional CO_2, initially in the United Kingdom (1750 – 1850); then in Germany, the United States, and the rest of Europe (1850 – 1950); and finally in China, India, and Brazil (1950 – 2050). At the start of the final phase, some scientists recognized that the anthropogenic increment of CO_2 could theoretically warm the planet, but few were concerned; total emissions were still quite low, and in any case most scientists viewed the atmosphere as an essentially unlimited sink. Through the 1960s, it was often said that "the solution to pollution is dilution."

Things began to change as planetary sinks approached saturation. Some effects occurred because of the extreme power of certain chemical agents even at very low concentrations, such as organochlorine insecticides (most famously the pesticide dichlorodiphenyltrichloroethane, or DDT), and chlorinated fluorocarbons (CFCs). The former were shown in the 1960s to disrupt reproductive function in fish, birds, and mammals; scientists correctly predicted in the 1970s that the latter would deplete the stratospheric ozone layer. Other saturation effects occurred because of the huge volume of materials being released into the planetary environment. These materials included sulfates from the combustion of coal as well as CO_2 and methane (CH_4) from fossil fuels, concrete manufacture, deforestation, and then-prevalent agricultural techniques such as growing rice in paddy fields and producing cattle as a primary protein source.

In the 1970s, scientists began to recognize that human activities were changing the physical and biological functions of the planet in consequential ways – giving rise to the Anthropocene Period of Geological History.[2] None of the scientists who made these early discoveries was particularly visionary: many of the relevant studies were by-products of nuclear weapons testing and development.[3] It was the rare man (in those days, sex discrimination was still widespread) who understood that he was in fact studying the limits of planetary sinks.[4] (Along with these findings, scientists also highlighted the phenomenon of *market failure*, a discussion of which appears below.) Major research programs were launched and new institutions created to acknowledge and deal with the issue. Culturally, celebrating the planet was encouraged on an annual Earth Day (as if every day were not an Earth day!), and in the United States the establishment of the Environmental Protection Agency formalized the concept of *environmental protection*. By the late 1980s, scientists had recognized that concentrations of CO_2 and other *greenhouse gases* were having discernible effects on planetary climate, ocean chemistry, and biological systems, threatening grave consequences if not rapidly controlled. Various groups and individuals began to argue for the need to control greenhouse gas emissions and begin a transition to a non-carbon-based energy system.

Historians view 1988 as the start of the Penumbral Period. In that year, scientists created a new hybrid scientific/governmental organization, the Intergovernmental Panel on Climate Change (IPCC), to communicate relevant science and form the foundation for international

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governance to protect the planet and its denizens. A year later, the Montreal Protocol to Control Substances that Deplete the Ozone Layer became a model for an international framework to control greenhouse gases. In 1992, world nations signed the United Nations Framework Convention on Climate Change (UNFCCC) to prevent "dangerous anthropogenic interference" in the climate system. But there was backlash. Critics claimed that the scientific uncertainties were too great to justify the expense and inconvenience of eliminating greenhouse gas emissions, and that any attempt to solve the problem would cost more than it was worth. At first, just a handful of people made this argument, almost all of them from the United States, although in time, the arguments spread to Canada, Australia, and parts of Europe as well. In hindsight, the self-justificatory aspects of the U.S. position are obvious, but they were not apparent to many at the time. Some nations used inertia in the United States to excuse their own patterns of destructive development. Others tried but failed to force the United States into international cooperation.

By the end of the millennium, denial had spread widely. In the United States, political leaders – including the president of the United States, members of Congress, and members of state legislatures – took denialist positions. In Europe, Australia, and Canada, the message of "uncertainty" was promoted by industrialists, bankers, and some political leaders. (Meanwhile, a different version of denial emerged in non-industrialized nations, which argued that the threat of climate change was being used to prevent their development. The claims had little effect, though, because these countries produced few greenhouse gas emissions.)[5]

By the early 2000s, dangerous anthropogenic interference in the climate system was under way. Fires, floods, hurricanes, and heat waves began to intensify, but these effects were discounted. Those in what we might call *active denial* insisted that the extreme weather events reflected natural variability, despite a lack of evidence to support that claim. Those in *passive denial* continued life as they had been living it, unconvinced that a compelling justification existed for broad changes in industry and infrastructure. Scientists became entangled in arcane arguments about the "attribution" of singular events; however, the threat to civilization inhered not in any individual flood, heat wave, or hurricane, but in the overall shifting climate pattern, its impact on the cryosphere, and the increasing acidification of the world ocean.

The year 2009 is viewed as the "last best chance" the Western world had to save itself, as leaders met in Copenhagen, Denmark, to try, for the fifteenth time since the UNFCCC was written, to agree on a binding, international law to prevent disruptive climate change. Two years before, scientists involved in the IPCC had declared anthropogenic warming to be "unequivocal," and public opinion polls showed that a majority of people – even in the recalcitrant United States – believed that action was warranted. But shortly before the meeting, a massive campaign (funded primarily by fossil fuel corporations, whose annual profits at that time exceeded the GDPs of most countries[6]), was launched to discredit the scientists whose research underpinned the IPCC's conclusion.[7] Public support for action evaporated; even the president of the United States felt unable to move his nation forward.

Meanwhile, climate change was intensifying. In 2010, record-breaking summer heat and fires killed more than 50,000 people in Russia and resulted in over $15 billion (in 2009 USD) in damages. The following year, massive floods in Australia

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affected more than 250,000 people. In 2012, which became known in the United States as the "year without a winter," winter temperature records, including for the highest overnight lows, were shattered – something that should have been an obvious cause for concern. A summer of unprecedented heat waves and loss of livestock and agriculture followed. The "year without a winter" moniker was misleading, as the warm winter was largely restricted to the United States, but in 2021, the infamous "year of perpetual summer" lived up to its name, taking 500,000 lives worldwide and costing nearly $500 billion in losses due to fires, crop failure, and the deaths of livestock and companion animals.

The loss of pet cats and dogs garnered particular attention among wealthy Westerners, but what was anomalous in 2021 soon became the new normal. Even then, political, business, and religious leaders refused to accept that the primary cause was the burning of fossil fuels. A shadow of ignorance and denial had fallen over people who considered themselves children of the Enlightenment. For this reason, we now know this era as the Period of the Penumbra.

It is clear that in the early twenty-first century, immediate steps should have been taken to begin the Great Energy Transition. Staggeringly, the opposite occurred. At the very time that the urgent need for an energy transition became palpable, world production of greenhouse gases *increased*. This fact is so hard to understand that it calls for a closer look at what we know about this crucial juncture.

In the early Penumbral Period, scientists were accused of being "alarmist" in order to increase financial support for their enterprise, gain attention, or improve their social standing. At first, the accusations took the form of public denunciations; later they included threats, thefts, and the subpoena of private correspondence.[8] Then legislation was passed (particularly in the United States) that placed limits on what scientists could study and how they could study it, beginning with the notorious "Sea Level Rise Denial Bill," passed in 2012 by the government of what was then the U.S. state of North Carolina (now part of the Atlantic Continental Shelf)[9] and the Government Spending Accountability Act of 2012, which restricted the ability of government scientists to attend conferences to share and analyze the results of their research.[10]

Though ridiculed when first introduced, the Sea Level Rise Denial Bill would become the model for the U.S. National Stability Protection Act of 2022, which led to the conviction and imprisonment of more than three hundred scientists for "endangering the safety and well-being of the general public with unduly alarming threats."[11] By exaggerating the threat, it was argued, scientists were preventing the economic development essential for coping with climate change. When the scientists appealed, their convictions were upheld by the U.S. Supreme Court under the Clear and Present Danger doctrine, which permitted the government to limit speech deemed to represent an imminent threat.

Had scientists exaggerated the threat, inadvertently undermining the evidence that would later vindicate them? Certainly, narcissistic fulfillment played a role in the public positions that some scientists took, and in the early part of this period, funds flowed into climate research at the expense of other branches of science, not to mention other forms of intellectual and creative activity. (It is remarkable how little these extraordinarily wealthy nations spent supporting artistic production; one explanation may be that artists were among the first to truly grasp the

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significance of the changes that were occurring.[12]) However, by 2010 or so, it was clear that scientists had been *underestimating* the threat, as new developments outpaced early predictions of warming, sea level rise, and Arctic ice loss, among other parameters.[13]

It is difficult to understand why humans did not respond appropriately in the early Penumbral Period, when preventive measures were still possible. Many have sought an answer in the general phenomenon of *human adaptive optimism*, which later proved crucial for survivors. Even more elusive to scholars is why scientists, whose job it was to understand the threat and warn their societies – and who thought that they *did* understand the threat and that they *were* warning their societies – failed to appreciate the full magnitude of climate change. To shed light on this question, scholars have pointed to the roots of Western natural science in religious institutions.

In an almost childlike attempt to demarcate their practices from those of older explanatory traditions, scientists felt it necessary to prove to themselves and the world how strict they were in their intellectual standards. Thus, they placed the burden of proof on novel claims, including those about climate. Some scientists in the early twenty-first century, for example, had recognized that hurricanes were intensifying, but they backed down from this conclusion under pressure from their scientific colleagues. Much of the argument surrounded the concept of *statistical significance*. Given what we now know about the dominance of nonlinear systems and the distribution of stochastic processes, the then-dominant notion of a 95 percent confidence limit is hard to fathom. Yet overwhelming evidence suggests that twentieth-century scientists believed that a claim could be accepted only if, by the standards of Fisherian statistics, the possibility that an observed event could have happened by chance was less than 1 in 20. Many phenomena whose causal mechanisms were physically, chemically, or biologically linked to warmer temperatures were dismissed as "unproven" because they did not adhere to this standard of demonstration.

Historians have long argued about why this standard was accepted, given that it had no substantive mathematical basis. We have come to understand the 95 percent confidence limit as a social convention rooted in scientists' desire to demonstrate their disciplinary severity. Just as religious orders of prior centuries had demonstrated moral rigor through extreme practices of asceticism in dress, lodging, behavior, and food – in essence, practices of physical self-denial – so, too, did natural scientists of the twentieth century attempt to demonstrate their intellectual rigor through intellectual self-denial.[14] This practice led scientists to demand an excessively stringent standard for accepting claims of any kind, even those involving imminent threats.

Western scientists built an intellectual culture based on the premise that it was worse to fool oneself into believing in something that did not exist than not to believe in something that did. Scientists referred to these positions as "type I" and "type II" errors, and established protocols designed to avoid type I errors at almost all costs. One scientist wrote, "A type I error is often considered to be more serious, and therefore more important to avoid, than a type II error." Another claimed that type II errors were not errors at all, just "missed opportunities."[15] So while the pattern of weather events was clearly changing, many scientists insisted that these events could not yet be attributed with certainty to anthropogenic climate change. Even as lay citizens began to accept this link, the scientists who stud-

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ied it did not.[16] More important, political leaders came to believe that they had more time to act than they really did. The irony of these beliefs need not be dwelt on; scientists missed the most important opportunity in human history, and the costs that ensued were indeed nearly "all costs."

By 2012, more than 365 billion tons of carbon had been emitted into the atmosphere since 1751. Staggeringly, more than half of these emissions occurred *after* the mid-1970s – that is, *after* scientists had built computer models demonstrating that greenhouse gases would cause warming. Emissions continued to accelerate even after the UNFCCC was established: between 1992 and 2012, total CO_2 emissions increased by 38 percent.[17] Some of this increase was understandable, as energy use grew in poor nations seeking to raise their standard of living. Less explicable is why, at the very moment when disruptive climate change was becoming apparent, wealthy nations dramatically increased their production of fossil fuels. The countries most involved in this enigma were two of the world's richest: the United States and Canada.

A key turning point was 2005, when the U.S. Energy Policy Act exempted shale gas drilling from regulatory oversight under the Safe Drinking Water Act. This statute opened the floodgates (or, more precisely, the wellheads) to massive increases in shale gas production.[18] U.S. shale gas production at that time was less than 5 trillion cubic feet (Tcf, archaic imperial units) per annum. By 2035, it had increased to 13.6 Tcf. As the United States expanded shale gas production and exported the relevant technology, other nations followed. By 2035, total gas production had exceeded 250 Tcf per annum.[19]

In the late twentieth century, Canada was considered an advanced nation with a high level of environmental sensitivity. This changed around the year 2000, when Canada's government began to push for development of huge oil sand deposits in the province of Alberta. While these deposits had been mined intermittently since the 1960s, the rising cost of conventional oil had made sustained exploitation economically feasible. The fact that 70 percent of the world's known reserves were in Canada explains the government's new denialist position on climate change: in 2011, Canada withdrew from the Kyoto Protocol to the UNFCCC.[20] Under the protocol, Canada had committed to cut its emissions by 6 percent, but its actual emissions increased more than 30 percent during this period.[21]

The massive increase in shale gas led to a collapse in the price of natural gas, driving out nascent renewable energy industries everywhere except China. Then the United States implemented laws forbidding the use of biodiesel fuels – first by the military, and then by the general public – undercutting that emerging market as well.[22] Bills were passed to restrict the development and use of other forms of renewable energy, maintaining the lock that fossil fuel companies had on energy production and use.[23]

How did these wealthy nations – rich in the resources that would have enabled an orderly transition to a zero net-carbon infrastructure – justify the deadly expansion of fossil fuel production? Certainly, they fostered the shadow of denial that obscured the link between climate change and fossil fuel production and consumption. They also entertained a second delusion: that natural gas from shale could offer a "bridge to renewables." Believing that conventional oil and gas resources were running out (which they were, but at a rate insufficient to avoid disruptive climate change), and stressing that natural gas, when combusted, produced only half as much CO_2 as coal, political and

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economic leaders persuaded themselves and their constituents that promoting shale gas was an environmentally and ethically sound approach.

This line of reasoning, however, neglected three crucial factors. First, *fugitive methane emissions* – CH_4 that escaped unburned into the atmosphere – greatly accelerated warming. (Again, scientists had foreseen this phenomenon, but their predictions were buried in specialized journals.) Second, the argument presupposed that net CO_2 emissions would fall, which would have required strict restrictions on coal and petroleum use.[24] Third, and most important, the sustained low prices of fossil fuels, supported by continued subsidies and a lack of external cost accounting, undercut efficiency efforts and weakened emerging markets for solar, wind, and biofuels (including crucial liquid biofuels for aviation).[25] Thus, the bridge to a zero-carbon future collapsed before the world had crossed it. The bridge to the future became a bridge to nowhere.

The net result? Fossil fuel production escalated, greenhouse gas emissions increased, and climate disruption accelerated. In 2001, the IPCC had predicted that atmospheric CO_2 would double by 2050.[26] In fact, that benchmark had been met by 2042. Scientists had expected a mean global warming of 2 to 3 degrees Celsius; the actual figure was 3.9 degrees. Though originally merely a benchmark for discussion with no particular physical meaning, the doubling of CO_2 emissions turned out to be significant: once the corresponding temperature rise reached 4 degrees, rapid changes began to ensue.

By 2040, heat waves and droughts were the norm. Control measures such as water and food rationing and Malthusian drills had been widely implemented. In wealthy countries, hurricane- and tornado-prone regions were depopulating, putting increased social pressure on areas less subject to those hazards. In poor nations, conditions were predictably worse: rural portions of Africa and Asia were already experiencing significant depopulation from out-migration, malnutrition-induced disease and infertility, and starvation. Still, sea level had risen only 9 to 15 centimeters around the globe, and coastal populations were mainly intact.

Then, in the Northern Hemisphere summer of 2041, unprecedented heat waves scorched the planet, destroying food crops around the globe. Panic ensued, with food riots in virtually every major city. Mass migration of undernourished and dehydrated individuals, coupled with explosive increases in insect populations, led to widespread outbreaks of typhus, cholera, dengue fever, yellow fever, and, strangely, AIDS (although a medical explanation for the latter has never been forthcoming). Surging insect populations also destroyed huge swaths of forests in Canada, Indonesia, and Brazil. As social order broke down, governments were overthrown, particularly in Africa, but also in many parts of Asia and Europe, further decreasing social capacity to deal with increasingly desperate populations. The U.S. government declared martial law to prevent food riots and looting, and the United States and Canada announced that the two countries would form the United States of North America in order to begin resource-sharing and northward population relocation. The European Union announced similar plans for voluntary northward relocation of eligible citizens from its southernmost regions to Scandinavia and the United Kingdom.

While governments were straining to maintain order and provide for their people, leaders in Switzerland and India – two countries that were rapidly losing substantial portions of their glacially sourced water resources – convened the First

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International Emergency Summit on Climate Change, organized under the rubric of Unified Nations for Climate Protection (the former United Nations having been discredited and disbanded over the failure of the UNFCCC). Political, business, and religious leaders met in Geneva and Chandigarh to discuss emergency action. Many said that the time had come to make the Great Energy Transition. Others argued that the world could not wait the ten to fifty years required to alter the global energy infrastructure, much less the one hundred years it would take for atmospheric CO_2 to diminish. In response, participants hastily wrote and signed the Unified Nations Convention on Climate Engineering and Protection (UNCCEP), and began preparing blueprints for the International Climate Cooling Engineering Project (ICCEP).

As a first step, ICCEP launched the International Aerosol Injection Climate Engineering Project (IaICEP, pronounced ay-yi-sep) in 2042.[27] IaICEP had widespread support from wealthy nations anxious to preserve some semblance of order, poor nations desperate to see the world do something to address their plight, and frantic low-lying Pacific Island nations at risk of being submerged by rising sea levels.

IaICEP began to inject submicrometer-size sulfate particles into the stratosphere at a rate of approximately 2.0 teragrams per year, expecting to reduce mean global temperature by 0.1 degrees Celsius annually from 2042 to 2062. (In the meantime, a substantial infrastructural conversion to renewable energy could be achieved.[28]) Initial results were encouraging: during the first three years of implementation, temperature decreased as expected and the phaseout of fossil fuel production commenced. However, in the project's fourth year, an anticipated – but discounted – side effect occurred: the shutdown of the Indian Monsoon. As crop failures and famine swept across India, IaICEP's most aggressive promoter now called for its immediate cessation.

IaICEP was halted in 2047, but a fatal chain of events had already been set in motion. It began with *termination shock*: that is, the abrupt increase in global temperatures following the sudden cessation of IaICEP. Once again, this phenomenon had been predicted, but IaICEP advocates had successfully argued that, given the emergency conditions, the world had no choice but to take the risk.[29] In the following eighteen months, temperature rapidly rebounded, regaining not just the 0.4 degrees Celsius that had been reduced during the project but an additional 0.6 degrees. This rebound effect pushed the mean global temperature increase to nearly 5 degrees Celsius.

Whether it was caused by this sudden additional heating or would have happened anyway is not known, but the greenhouse effect then reached a global tipping point. By 2050, Arctic summer ice was completely gone. Scores of species perished, including the iconic polar bear, the dodo bird of the twenty-first century. While the world focused on these highly visible losses, warming had meanwhile accelerated a less visible but widespread thawing of Arctic permafrost. Scientists monitoring the phenomenon observed a sudden increase in permafrost thaw and CH_4 release. Exact figures are not available, but the estimated total carbon release from Arctic CH_4 during the next decade may have reached over 1,000 gigatons, effectively doubling the total atmospheric carbon load.[30] This massive addition of carbon led to what is known as the Sagan effect (sometimes more dramatically called the Venusian death): a strong positive feedback loop between warming and CH_4 release. Planetary temperature increased by an additional 6 degrees Celsius

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over the 5 degree rise that had already occurred.

The ultimate blow for Western civilization came in a development that, like so many others, had long been discussed but rarely considered as a serious threat, at least not in the twenty-first century. Technically, what happened in West Antarctica was not, in fact, a collapse. The ice sheet did not fall in on itself, and it did not happen all at once. The collapse was more of a rapid disintegration. Post hoc failure analysis shows that extreme heat in the Northern Hemisphere disrupted normal patterns of ocean circulation. This sent exceptionally warm surface waters into the southern ocean, which destabilized the ice sheet from below. As large pieces of ice shelf began to separate from the main ice sheet, removing the bulwark that had kept the sheet on the Antarctic mainland, sea level began to rise rapidly.

Social disruption hampered scientific data-gathering, but some dedicated individuals – realizing the damage could not be stopped – sought, at least, to chronicle it. Over the course of the next decade, approximately 90 percent of the ice sheet broke apart, disintegrated, and melted, driving up sea level approximately three meters across most of the globe. Meanwhile, the Greenland Ice Sheet, long thought to be less stable than the Antarctic Ice Sheet, began its own disintegration. As summer melting reached the center of the Greenland Ice Sheet, the east side began to separate from the west. Massive ice breakup ensued, adding another two meters to mean global sea level rise.[31]

Analysts had predicted that a five-meter sea level rise would dislocate 10 percent of the global population. Alas, their estimates proved low: the reality was closer to 20 percent. Although records for this period are incomplete, it is likely that 1.5 billion people were displaced around the globe, either directly from the impacts of sea level rise or indirectly from other impacts of climate change, including the secondary dislocation of inland peoples whose towns and villages were overrun by eustatic refugees. Dislocation contributed to the Second Black Death, as a new strain of the bacterium *Yersinia pestis* emerged in Europe and spread to Asia and North America. In the Middle Ages, the Black Death killed as much as half the population of Europe; this second Black Death had similar effects.[32] Disease also spread among stressed nonhuman populations. Although accurate statistics are scant because twentieth-century scientists did not have an inventory of total global species, it is not unrealistic to estimate that 60 to 70 percent of species were driven to extinction.

There is no need to rehearse the details of the human tragedy that occurred; every schoolchild knows of the terrible suffering. Survivors' accounts make clear that many thought the end of the human race was near; had the Sagan effect continued, warming would not have stopped at 11 degrees. However, when a key species of lichen evolved to use atmospheric CO_2 more efficiently,[33] this adaptation, coupled with a fortuitous shift in Earth's orbit, reversed the warming trend. Survivors in northern inland regions of Europe, Asia, and North America, as well as inland and high altitude regions of South America, were able to begin to regroup and rebuild. The human populations of Australia and Africa, of course, were wiped out.

To the historian studying this tragic period of human history, the most astounding fact is that the victims *knew what was happening and why*. Indeed, they chronicled it in detail precisely *because* they knew that fossil fuel combustion was to blame. Historical analysis also shows that Western civilization had the technological know-how and capability to effect

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an orderly transition to renewable energy, yet the available technologies were not implemented in time.[34] As with all great historical developments, there is no easy answer to the question of why this catastrophe occurred, but key factors stand out. The thesis of this analysis is that Western civilization became trapped in the grip of two inhibiting ideologies: namely, *positivism* and *market fundamentalism*.

Twentieth-century scientists saw themselves as the descendants of an empirical tradition often referred to as *positivism* – after the nineteenth-century French philosopher Auguste Comte, who developed the concept of "positive" knowledge (as in, "absolutely, positively true") – but the overall philosophy is more accurately known as *Baconianism*. This philosophy held that through experience, observation, and experiment, one could gather reliable knowledge about the natural world, and that this knowledge would empower its holder. Experience justified the first part of the philosophy (we have recounted how twentieth-century scientists anticipated the consequences of climate change), but the second part proved less compelling. Although billions of dollars were spent on climate research in the late twentieth and early twenty-first century, the resulting knowledge had little impact on the crucial economic and technological policies that drove the continued use of fossil fuels.

A key attribute of the period was that power did not reside in the hands of those who understood the climate system, but rather in political, economic, and social institutions that had a strong interest in maintaining the use of fossil fuels. Historians have labeled this system the *carbon-combustion complex*: a network of powerful industries comprised of primary fossil fuel producers; secondary industries that served fossil fuel companies (drilling and oil field service companies, large construction firms, and manufacturers of plastics and other petrochemicals); tertiary industries whose products relied on inexpensive fossil fuels (especially automobiles and aviation); and financial institutions that serviced their capital demands. Maintaining the carbon-combustion complex was clearly in the self-interest of these groups, so they cloaked this fact behind a network of "think tanks" that issued challenges to scientific knowledge they found threatening.[35] Newspapers often quoted think tank employees as if they were climate researchers, juxtaposing their views against those of university-based scientists. This practice gave the public the impression that the science was still uncertain, thus undermining the sense that it was time to act.[36] Meanwhile, scientists continued to do science, believing, on the one hand, that it was inappropriate for them to speak to political questions (or to speak in the emotional register required to convey urgency) and, on the other hand, that if they produced abundant and compelling scientific information (and explained it calmly and clearly), the world would take steps to avert disaster.

Scientists, to their credit, recognized some of the difficulties they were facing, and were grappling with how to communicate their knowledge effectively.[37] While they were making some headway, a large part of Western society was rejecting that knowledge in favor of an empirically inadequate yet powerful ideological system. Even at the time, some recognized this system as a quasi-religious faith, hence the label *market fundamentalism*.

Market fundamentalism – also known as free market fundamentalism, neoliberalism, laissez-faire economics, and laissez-faire capitalism – was a two-pronged ideological system. The first prong held that societal needs were served most efficiently in a free market economic system. Guided by the "invisible hand" of the marketplace, individuals would freely respond

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to each other's needs, establishing a net balance between solutions ("supply") and needs ("demand"). The second prong of the philosophy maintained that free markets were not merely a good or even the best manner of satisfying material wants: they were the *only* manner of doing so that did not threaten personal freedom.

The crux of this second point was the belief that marketplaces represented distributed power. Various individuals making free choices held power in their hands, preventing its undue concentration in centralized government. Conversely, centrally planned economies entailed not just the concentration of economic power, but of political power as well. Thus, to protect personal liberty – political, civic, religious, artistic – economic liberty had to be preserved. The philosophy, called *neoliberalism*, hearkened back to the liberalism of the eighteenth- and nineteenth-century Enlightenment, particularly the works of Adam Smith, David Hume, John Locke, and, later, John Stuart Mill. Reacting to the dominant form of Western governance in their time – that is, monarchy – these thinkers lionized personal liberty in contrast to control by unjust and arbitrary despots. At a time when some political leaders were imagining alternatives to despotic monarchy, many viewed the elevation of individual rights as a necessary response. In the late eighteenth century, these views influenced the architects of the American Republic and the early, "liberal" phase of the French Revolution. Even then, however, such views were more idealistic than realistic; slavery persisted in the United States, and in Europe, the French Revolution collapsed in a wave of violence and the restoration of autocratic rule under Napoleon Bonaparte.

In the nineteenth century, power became concentrated in the hands of industrialists (the "robber barons" of the United States and elsewhere), challenging liberal conceptions of the desirability of weak political governance.[38] In Europe, the German philosopher Karl Marx argued that an inherent feature of the capitalist system was the concentration of wealth and power in a ruling class that siphoned off the surplus value produced by workers. Industrialists not only employed workers under brutal and tyrannical conditions (the nineteenth-century "satanic mills"), they also corrupted democratic processes through bribery and extortion, and distorted the marketplace through a variety of practices. A powerful example is the development and expansion of American railroads. Supply of these "roads to nowhere" was heavily subsidized, and the demand for them was manufactured at the expense of the native peoples and natural environment of the American West.[39]

Marx's analysis inspired popular leaders in many nation-states then in existence – for example, Russia, China, Vietnam, Ghana, and Cuba – to turn to Communism as an alternative economic and social system. Meanwhile, the capitalist United States abolished slavery and made adjustments to remedy power imbalances and losses of liberty due to the concentration of wealth. Among other reforms, the federal government introduced *antitrust laws* to prevent monopolistic practices, established worker protections such as prohibitions on child labor, and introduced a progressive income tax. By the early twentieth century, few could argue that capitalism in its theoretical form was a functional social and economic system: the failures were too obvious. Intellectuals came to see the invisible hand, akin to the hand of God, as the quasi-religious notion that it was. The Great Depression of the 1930s – from which Europe and the United States emerged only through the centralized mobilization of World War II – led scholars and political leaders to view the idea of self-regulating markets as unwork-

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able. After the War, most non-Communist states became "mixed" economies with a large degree of individual and corporate freedom as well as significant government involvement in markets, including extensive systems of taxes, tariffs, subsidies, and immigration control.[40]

Communism, which had spread throughout Eurasia and to some parts of Africa and Latin and South America, was revealing even worse failures than capitalism. Communist economies proved grossly inefficient at delivering goods and services; politically, early ideas of mass empowerment gave way to tyrannical and brutal dictatorship. In the Soviet Union under Joseph Stalin (1878 – 1953; ruled 1941 – 1953), tens of millions died in purges, forced collectivization of agriculture, and other forms of internal violence. Tens of millions died in China as well during the "Great Leap Forward" – the attempt by 毛泽东 (Mao Zedong, 1893 – 1976; ruled 1949 – 1976) to force rapid industrialization.[41]

Following World War II, the specter of Russian Communism's spread into Eastern (and possibly even Western) Europe – thus affecting U.S. access to markets and stoking fears that the West could sink back into economic depression – led the United States to take a strong position against Soviet expansion. Conversely, the Soviet Union's desire to control its western flanks in light of historic vulnerability led to the political occupation and control of Eastern Europe. The resulting Cold War (1945 – 1989) fostered a harshly polarized view of economic systems, with "communists" decrying the corruption of the capitalist system and "capitalists" condemning the tyranny and violence in Communist regimes.[42] Perhaps because of the horrible violence in the East, many Western intellectuals came to see everything associated with Communism as evil, even – and crucially for our story – modest or necessary forms of intervention in the marketplace, such as progressive taxation and environmental regulation, and humanitarian interventions, such as effective and affordable regimes of health care and birth control.

Neoliberalism was developed by a group of thinkers – most notably, Austrian Friedrich von Hayek and American Milton Friedman – who were particularly sensitive to the issue of repressive centralized government. In two key works, von Hayek's *Road to Serfdom* and Friedman's *Capitalism and Freedom*, they developed the crucial "neo-" component of neoliberalism: the idea that free market systems were the only economic systems that did not threaten individual liberty.

Neoliberalism was initially a minority view. In the 1950s and 1960s, the West experienced high overall prosperity, and individual nations developed mixed economies that suited their own national cultures and contexts. Things began to shift in the late 1970s and 1980s, when Western economies stalled and neoliberal ideas attracted world leaders searching for answers to their countries' declining economic performance, such as Margaret Thatcher in the United Kingdom and Ronald Reagan in the United States. Friedman became an advisor to President Reagan; in 1991, von Hayek received the Presidential Medal of Freedom from President George H.W. Bush.[43]

The end of the Cold War (1989 – 1991) was a source of celebration for citizens who had lived under the yoke of oppressive Soviet-style governance; it also ignited a slow process of overdue reforms in the First People's Republic of China. But for many observers in the West, the Soviet Union's collapse gave rise to an uncritical triumphalism, proof of the absolute superiority of the capitalist system. Some went further, arguing that if capitalism was a superior system, then the best system

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was capitalism in its purest form. While it is possible that some academic economists and intellectuals genuinely held this view, it was industrialists and financiers, who perceived large opportunities in less regulated marketplaces, who did the most to spread and promote it. As a result, the 1990s and 2000s featured a wave of deregulation that weakened consumer, worker, and environmental protections. A second Gilded Age reproduced concentrations of power and capital not seen since the nineteenth century, with some of the accumulated capital used to finance think tanks that further promoted neoliberal views. Most important for our purposes, neoliberal thinking led to a refusal to admit the most important limit of capitalism: market failure.

When scientists discovered the limits of planetary sinks, they also discovered market failure. The toxic effects of DDT, acid rain, the depletion of the ozone layer, and climate change were serious problems for which markets did not provide a spontaneous remedy. Rather, government intervention was required: to raise the market price of harmful products, to prohibit those products, or to finance the development of their replacements. But because neoliberals were so hostile to centralized government, they had, as Americans used to say, "painted themselves into a corner." The American people had been persuaded, in the words of President Reagan, that government was "the problem, not the solution." Thus, citizens slid into passive denial, accepting the contrarian arguments that the science was unsettled. Lacking widespread support, government leaders were unable to shift the world economy to a net carbon-neutral energy base. As the implications for market failure became indisputable, scientists came under attack, blamed for problems they had not caused but merely documented.

These physical scientists were chief among the individuals and groups who tried to warn the world of climate change, both before and as it happened. (In recognition of, and gratitude for, what they tried to achieve, millions of survivors have taken their names as middle names.)[44] In addition, social scientists introduced the concept of "late lessons from early warnings" to describe a growing tendency to neglect information. As a remedy, they promoted a *precautionary principle*, whereby early action would prevent later damage.[45] Yet the idea of managing energy use and controlling greenhouse gas emissions was anathema to the neoliberal economists whose thinking dominated at this crucial juncture. Thus, no planning was done, no precautions were taken, and no management ensued until it was disaster management.

Discerning neoliberals acknowledged that the free market was not really free; interventions were everywhere. Some advocated eliminating subsidies for fossil fuels and creating "carbon" markets.[46] Others recognized that certain interventions could be justified. Von Hayek himself was not opposed to government intervention per se; indeed, as early as 1944, he rejected the term *laissez-faire* as misleading because he recognized legitimate realms of government intervention: "The successful use of competition as the principle of social organization precludes certain types of coercive interference with economic life, but it admits of . . . and even requires [others]," he wrote. In his view, legitimate interventions included paying for signposts on roads, preventing "harmful effects of deforestation, of some methods of farming, or of the noise and smoke of factories," prohibiting the use of poisonous substances, limiting working hours, enforcing sanitary conditions in workplaces, controlling weights and measures, and preventing violent

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strikes.[47] Von Hayek simply (and reasonably) believed that if the government was to carry out such functions, and particularly if doing so *selectively* limited the freedom of particular groups or individuals, then the justification for intervention should be clear and compelling. Given the events recounted here, it is hard to imagine why anyone in the twentieth century would have argued against government protection of the natural environment on which human life depends. Yet such arguments were not just made, they dominated the discussion.[48]

As the devastating effects of the Great Collapse began to appear, the nation-states with democratic governments – both parliamentary and republican – were at first unwilling and then unable to deal with the unfolding crisis. As food shortages and disease outbreaks spread and sea level rose, these governments found themselves without the infrastructure and organizational ability to quarantine and relocate people.

In China, the situation was somewhat different. Like other post-socialist nations, China had taken steps toward liberalization but still retained a strong, centralized government. When sea level rise began to threaten coastal areas, China rapidly built new inland cities and villages and relocated more than 250 million people to higher, safer ground.[49] The relocation was not easy; many older citizens, as well as infants and young children, could not manage the transition. Nonetheless, survival rates exceeded 80 percent. To many survivors – in what might be viewed as a final irony of our story – China's ability to weather disastrous climate change vindicated the necessity of centralized government, leading to the establishment of the Second People's Republic of China and inspiring similar structures in other, reformulated nations. By blocking anticipatory action, neoliberals did more than expose the tragic flaws in their own system: they fostered expansion of the very system of government that they most abhorred.

Today, we remain engaged in a vigorous intellectual discussion of whether, now that the climate system has finally stabilized, decentralization and redemocratization may be considered. Many academics, in the spirit of history's great thinkers, hope that such matters may be freely debated. Others consider that outcome wishful, in light of the dreadful events of the past, and reject the reappraisal that we wish to invite here. Evidently, the Penumbra falls even today – and likely will continue to fall for years, decades, and perhaps even centuries to come.

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ENDNOTES

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1 For convenience, I use the historical categories of *physical science* and *physical scientists*, recognizing the Western convention at that time of studying the physical world in isolation from social systems. I also use the nation-state terms of the era. For the reader not familiar with the physical geography of Earth prior to the Great Collapse, the remains of the United Kingdom can be found in present-day Englascotland; Germany in the Nordo-Scandinavian Union; and the United States and Canada in the United States of North America.

2 http://www.quaternary.stratigraphy.org.uk/workinggroups/anthropocene/.

3 Ronald Doel, "Constituting the Postwar Earth Sciences: The Military's Influence on the Environmental Sciences in the USA after 1945," *Social Studies of Science* 33 (2003): 535 – 666; Naomi Oreskes, *Science on a Mission: American Oceanography from the Cold War to Climate Change* (Chicago: University of Chicago Press, forthcoming).

4 A notable exception was the futurist Paul Ehrlich, whose book *The Population Bomb* (New York: Ballantine Books, 1968) was widely read in the late 1960s but was considered to have been discredited by the 1990s.

5 China took steps to control its population and convert its economy to non-carbon-based energy sources. These efforts were little noticed and less emulated in the West, in part because Westerners viewed Chinese population control efforts as immoral, and because, in the short run, greenhouse gas emissions were increasing dramatically in China. However, by 2020, China's emissions were falling rapidly. Had other nations followed China's lead, the history I am recounting here might have been very different. On the various forms of Chinese population control, see Susan Greenhalgh, *Just One Child: Science and Policy in Deng's China* (Berkeley: University of California Press, 2008).

6 At the time, most countries still used the archaic concept of a *gross domestic product*, a measure of consumption, rather than the Bhutanian concept of gross domestic happiness to evaluate well-being in a state.

7 http://unfccc.int/meetings/copenhagen_dec_2009/meeting/6295.php.

8 Michael Mann, *The Hockey Stick and the Climate Wars: Dispatches from the Front Lines* (New York: Columbia University Press, 2011). A less known but crucial incident was the seizing of scientific notes from scientists who had documented the damage caused by the 2011 BP Deepwater Horizon oil spill. Though leaders of the scientific community protested, scientists yielded to the demands, thus helping set the stage for further pressure on scientists from both governments and the industrial enterprises that governments subsidized and protected. See http://www.wired.com/wiredscience/2012/06/bp-scientist-emails/.

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9 Seth Cline, "Sea Level Bill Would Allow North Carolina to Stick Its Head in the Sand," *U.S. News & World Report*, June 1, 2012, http://www.usnews.com/news/articles/2012/06/01/sea-level-bill-would-allow-north-carolina-to-stick-its-head-in-the-sand. One comedian at the time made a satire of the law; little did he know what impact it would later have. See Stephen Colbert, "The Word – Sink or Swim," *The Colbert Report*, June 4, 2012, http://www.colbertnation.com/the-colbert-report-videos/414796/june-04-2012/the-word---sink-or-swim.

10 Government Spending Accountability Act of 2012, 112th Cong., 2012, H.R. 4631, http://oversight.house.gov/wp-content/uploads/2012/06/WALSIL_032_xml.pdf.

11 *Hansen et al. v. United States*, 1025 U.S. 722 (2032). Hansen was deceased when the case reached the Supreme Court, nine years after the original conviction. In a speech following the ruling, co-defendant Kevin Trenberth stated, "There is nothing good to be said about this decision, except that I am relieved that James Hansen is not here to witness it"; http://www.independentscientificvoice.org.

12 The most enduring literary work of this time is a science "fiction" trilogy by an American writer; see Kim Stanley Robinson, *Forty Signs of Rain, Fifty Degrees Below*, and *Sixty Days and Counting* (New York: Spectra Publishers, 2005 – 2007). Sculptor Dario Robleto also "spoke" to the issue, particularly species loss; his material productions have been lost, but a response to his work is recorded in Naomi Oreskes, "Seeing Climate Change," in *Dario Robleto: Survival Does Not Lie in the Heavens*, ed. Gilbert Vicario (Des Moines, Iowa: Des Moines Art Center, 2011). Some environmentalists also anticipated what was to come, notably the Australians Clive Hamilton and Paul Gilding. Perhaps because Australia's population was highly educated and living on a continent at the edge of habitability, it was particularly sensitive to the changes under way. See Clive Hamilton, *Requiem for a Species: Why We Resist the Truth about Climate Change* (Sydney: Allen and Unwin, 2010), http://www.clivehamilton.net.au/cms/; and Paul Gilding, *The Great Disruption: Why the Climate Crisis Will Bring On the End of Shopping and the Birth of a New World* (New York: Bloomsbury Press, 2010).

13 For an electronic archive of predictions and data as of 2012, see http://www.columbia.edu/~mhs119/Temperature/T_moreFigs/. An interesting unpublished paper found in the translocated archives of the University of California, San Diego, addresses the issue of under-prediction; see Keynyn Brysse et al., "Climate Change Prediction: Erring on the Side of Least Drama?" paper submitted to *Global Environmental Change*, 2012. Whether this paper was ever published – or read – is unknown.

14 David F. Noble, *A World Without Women: The Christian Clerical Culture of Western Science* (New York: Knopf, 1992); Lorraine Daston and Peter L. Galison, *Objectivity* (Cambridge, Mass.: Zone Books, 2007); Rebecca Herzig, *Suffering for Science: Reason and Sacrifice in Modern America* (New Brunswick, N.J.: Rutgers University Press, 2005); and Naomi Oreskes, "Objectivity or Heroism? On the Invisibility of Women in Science," *OSIRIS* 11 (1996): 87 – 113.

15 Naomi Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Climate Change* (New York: Bloomsbury, 2010), chap. 5, esp. 157 n.91 – 92. See also Aaron M. McCright and Riley E. Dunlap, "Challenging Global Warming as a Social Problem: An Analysis of the Conservative Movement's Counterclaims," *Social Problems* 47 (2000): 499 – 522; Aaron M. McCright and Riley E. Dunlap, "Cool Dudes: The Denial of Climate Change among Conservative White Males in the United States," *Global Environmental Change* 21 (2011): 1163 – 1172.

16 Justin Gillis, "In Poll, Many Link Weather Extremes to Climate Change," *The New York Times*, April 17, 2012, http://www.nytimes.com/2012/04/18/science/earth/americans-link-global-warming-to-extreme-weather-poll-says.html.

17 Tom A. Boden, Gregg Marland, and Robert J. Andres, "Global, Regional, and National Fossil-Fuel CO_2 Emissions," Carbon Dioxide Information Analysis Center (Oak Ridge, Tenn.: Oak Ridge National Laboratory, 2011), http://cdiac.ornl.gov/trends/emis/overview_2008.html.

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[18] Sarah Collins and Tom Kenworthy, "Energy Industry Fights Chemical Disclosure," Center for American Progress, April 6, 2010, http://www.americanprogress.org/issues/2010/04/fracking.html; Jad Mouawad, "Estimate Places Natural Gas Reserves 35% Higher," *The New York Times*, June 17, 2009, http://www.nytimes.com/2009/06/18/business/energy-environment/18gas.html?_r=1.

[19] http://www.eia.gov/naturalgas.

[20] Emil D. Attanasi and Richard F. Meyer, "Natural Bitumen and Extra-Heavy Oil," in *Survey of Energy Resources*, 22nd ed. (London: World Energy Council, 2010), 123–140.

[21] David W. Schindler and John P. Smol, "After Rio, Canada Lost Its Way," *Ottawa Citizen*, June 20, 2012, http://www.ottawacitizen.com/opinion/op-ed/Opinion/6814332/story.html.

[22] http://security.blogs.cnn.com/2012/06/08/militarys-plan-for-a-green-future-has-congress-seeing-red/.

[23] "Georgia Power Opposes Senate Solar Power Bill," *The Augusta Chronicle*, February 18, 2012, http://chronicle.augusta.com/news/metro/2012-02-18/georgia-power-opposes-senate-solar-power-bill.

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[25] On twentieth- and twenty-first-century subsidies to fossil fuel production, see http://www.oecd.org/document/57/0,3746,en_2649_37465_45233017_1_1_1_37465,00.html; and John Vidal, "World Bank: Ditch Fossil Fuel Subsidies to Address Climate Change," *The Guardian*, September 21, 2011, http://www.guardian.co.uk/environment/2011/sep/21/world-bank-fossil-fuel-subsidies.

[26] "Canada, Out of Kyoto, Must Still Cut Emissions: U.N.," Reuters, December 13, 2011, http://www.reuters.com/article/2011/12/13/us-climate-canada-idUSTRE7BC2BW20111213; Adam Vaughan, "What Does Canada's Withdrawal from Kyoto Protocol Mean?" *The Guardian*, December 13, 2011, http://www.guardian.co.uk/environment/2011/dec/13/canada-withdrawal-kyoto-protocol; James Astill and Paul Brown, "Carbon Dioxide Levels Will Double by 2050, Experts Forecast," *The Guardian*, April 5, 2001, http://www.guardian.co.uk/environment/2001/apr/06/usnews.globalwarming.

[27] Acknowledgments to http://www.epsrc.ac.uk/newsevents/news/2012/Pages/spiceprojectupdate.aspx.

[28] IAICEP was sometimes called the Crutzen Project after the scientist who first proposed the idea in 2006. See Paul Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?" *Climatic Change* 77 (2006): 211–219, http://www.springerlink.com/content/t1vn75m458373h63/fulltext.pdf. See also Daniel Bodansky, "May We Engineer the Climate?" *Climatic Change* 33 (1996): 309–321. For a similar project that engendered heated public opposition in the early twentieth century, see http://www.handsoffmotherearth.org/hose-experiment/spice-opposition-letter/.

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[31] http://www.sciencedaily.com/releases/2012/03/120312003232.htm; http://www.pnas.org/content/105/38/14245.short.

[32] Philip Ziegler, *The Black Death* (London: The Folio Society, 1997).

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33 Remarkably, this possibility was imagined by the science fiction writer Kim Stanley Robinson.

34 Amory Lovins, *Reinventing Fire: Bold Business Solutions for the New Energy Era* (White River Junction, Vt.: Chelsea Green Publishing, 2011).

35 Oreskes and Conway, *Merchants of Doubt*.

36 For an example of this characteristic, see Justin Gillis, "Rising Sea Levels Seen as Threat to Coastal U.S.," *The New York Times*, March 13, 2012, http://www.nytimes.com/2012/03/14/science/earth/study-rising-sea-levels-a-risk-to-coastal-states.html. Note how Gillis frames the evidence, first stating that "the handful of climate researchers who question the scientific consensus about global warming do not deny that the ocean is rising. But they often assert that the rise is a result of natural climate variability." He then quotes Myron Ebell, who was not a climate researcher, but an economist and paid employee of the Competitive Enterprise Institute, a think tank that was heavily funded by the carbon-combustion complex and committed to market fundamentalism. See http://cei.org/.

37 Richard Somerville, *The Forgiving Air: Understanding Environmental Change* (Washington, D.C.: American Meteorological Society, 2008); Stephen H. Schneider, *Science as a Contact Sport: Inside the Battle to Save the Earth's Climate* (Washington, D.C.: National Geographic Press, 2009); Gavin Schmidt and Joshua Wolfe, *Climate Change: Picturing the Science* (New York: W.W. Norton and Company, 2009); James Hansen, *Storms of My Grandchildren* (New York: Bloomsbury Press, 2010); Burton Richter, *Beyond Smoke and Mirrors: Climate Change and Energy in the 21st Century* (Cambridge: Cambridge University Press, 2010); Mann, *The Hockey Stick and the Climate Wars*. For an analysis of scientists' difficulties in dealing efficaciously with public communication media, see Maxwell T. Boykoff, *Who Speaks for the Climate? Making Sense of Media Reporting on Climate Change* (Cambridge: Cambridge University Press, 2011).

38 For want of space, I have omitted a discussion of slavery. Suffice it to say that this was both a contradiction to the liberal ideal of personal freedom and a violation of free markets.

39 Richard White, *Railroaded: The Transcontinentals and the Making of Modern America* (New York: W.W. Norton, 2011).

40 Scholars noted that even nineteenth-century markets were not free. See Ha-Joon Chang, *Bad Samaritans: The Myth of Free Trade and the Secret History of Capitalism* (New York: Bloomsbury, 2008); and Ha-Joon Chang, *23 Things They Don't Tell You about Capitalism* (New York: Bloomsbury, 2012).

41 Dennis Tao Yang, "China's Agricultural Crisis and Famine of 1959–1961: A Survey and Comparison to Soviet Famines," *Comparative Economic Studies* 50 (2008): 1–29.

42 Here, the terms *capitalist* and *communist* appear in quotes to acknowledge that neither system was either purely communist or purely capitalist.

43 George H.W. Bush, "Remarks on Presenting the Presidential Medal of Freedom Awards," November 18, 1991.

44 Another irony of this period is that Friedrich von Hayek had great respect and admiration for the scientific enterprise, seeing it as a companion to "free" enterprise capitalism. By fostering commerce, von Hayek suggested, science and industry were closely linked to the rise of capitalism and the growth of political freedom; this view was shared by mid-twentieth-century advocates for an expanded role of government in promoting scientific investigations (see Naomi Oreskes, "Science, Technology, and Free Enterprise," *Centaurus* 52 [2011]: 297–310; and John Krige, *American Hegemony and the Postwar Reconstruction of Science in Europe* [Cambridge, Mass.: MIT Press, 2006]). However, when environmental science showed that government action was needed to protect citizens and the natural environment from unintended harms, the carbon-combustion complex began to treat science as an enemy to be fought by whatever means necessary. The very science that had led to U.S. victory in World War II and dominance in the Cold War became the target of skepticism, scrutiny, and attack. Science, of course, was also the subject of attack in Communist nations, although for different reasons. See, for example, David Joravsky, *The Lysenko Affair* (Chicago: University of

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Chicago Press, 1986); and Nils Roll-Hansen, *The Lysenko Effect* (Amherst, N.Y.: Humanity Books, 2004).

45 The *precautionary principle* was a formal instantiation of what was often thought of as common sense, reflected in the nineteenth-century European and American adages, "A stitch in time saves nine" and "An ounce of prevention is worth a pound of cure." Yet this traditional wisdom was swept away in neoliberal hostility toward planning and an overconfident belief in the power of markets to respond to social problems as they arose. One of the ironies of the Penumbral Period is that the discipline of economics – rooted in the ancient Greek concept of household management (*oikos*, or "house," and *nomos*, or "laws" or "rules") – failed to speak to the imperative of a managed transition to a new energy system. See *Late Lessons From Early Warnings: The Precautionary Principle, 1896 – 2000* (Copenhagen: European Environment Agency, 2002), http://www.eea.europa.eu/publications/environmental_issue_report_2001_22.

46 On twentieth- and twenty-first-century subsidies for fossil fuel production, see http://www.oecd.org/document/57/0,3746,en_2649_37465_45233017_1_1_1_37465,00.html; and Vidal, "World Bank: Ditch Fossil Fuel Subsidies to Address Climate Change."

47 Friedrich August von Hayek, *The Road to Serfdom, Text and Documents: The Definitive Edition*, ed. Bruce Caldwell (Chicago: University of Chicago Press, 2007), 87.

48 Yet another paradox: Classical liberalism was centered on the idea of individual liberty, and in the eighteenth century most individuals had precious little liberty – economic or otherwise. But by the mid-twentieth century this situation had changed dramatically: slavery was formally outlawed in the nineteenth century, and monarchies and other forms of empire were increasingly replaced by various forms of "liberal" democracy. In the West, individual freedoms – both formal and informal – probably peaked around the time von Hayek was writing, or shortly thereafter. By the end of the twentieth century, Western citizens still held the formal rights of voting, various forms of free thought and expression, and freedom of employment and travel. But actionable freedom was decreasing, first as economic power was increasingly concentrated in a tiny elite, who came to be known as the "1 percent," and then in a political elite propelled to power as the climate crisis forced dramatic interventions to relocate citizens displaced by sea level rise and climatic de-inhabitation, to contain contagion, and to prevent mass famine. So the development that the neoliberals most feared – centralized government and loss of personal choice – was rendered essential by the policies that they had helped put in place.

49 For estimates of populations at or near sea level at the turn of the twenty-first century, see Don Hinrichsen, "The Coastal Population Explosion," in *The Next 25 Years: Global Issues*, prepared for the National Oceanic and Atmospheric Administration Coastal Trends Workshop, 1999, http://oceanservice.noaa.gov/websites/retiredsites/natdia_pdf/3hinrichsen.pdf; and http://oceanservice.noaa.gov/websites/retiredsites/supp_natl_dialogueretired.html.

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