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Climate Change: Scientific Evidence and the Industry of Denial

Jack Smith

Climate Change: What Everyone Needs to Know by Joseph Romm. Oxford University Press, 2016, 328 pp., \$16.95 (paper).

Climate Cover-Up: The Crusade to Deny Global Warming by James Hoggan with Richard Littlemore. Greystone Books, 2009, 240 pp., \$15 (paper).

The Madhouse Effect: How Climate Change Denial Is Threatening Our Planet, Destroying Our Politics, and Driving Us Crazy by Michael E. Mann and Tom Toles. Columbia University Press, 2016, 208 pp., \$24.95 (hardcover).

Environmental issues entered the public discourse in a conspicuous way back in the 1970s with the media blitz on the dioxin contamination at Love Canal in 1978 and the Three Mile Island nuclear accident in 1979. More than nuclear, it was toxics that soon became the central environmental issue, with hundreds of hazardous waste sites dotting the country. Think of the Times Beach, Missouri, disaster in 1983. Not that nuclear power hasn't been a significant concern—consider the notoriously contaminated Hanford Site and the thirty-year battle to site a nuclear waste facility at Yucca Mountain, Nevada. How do you safely store nuclear waste for one million years?

Yet today it's not toxic waste or nuclear waste that gets the biggest billing—it's global warming. After all, if the grim predictions of climate change experts prove to be true, the Earth may not be fit for human habitation in the next century and beyond. Will climate change bring about the sixth extinction?

A sobering question, but meanwhile the human species, globally speaking, relies heavily on fossil fuels for power plants, for residential and commercial buildings, and for transportation, releasing carbon stored for millions of years. Since the Industrial Revolution, the levels of carbon dioxide in the atmosphere have risen from 280 parts per million (ppm) to about 400 ppm today. Increased carbon concentration has led to unprecedented warming. According to the Intergovernmental Panel on Climate Change, since 1880, the Earth has warmed slightly over 1.5 degrees Fahrenheit. If the planet continues its so-called business-as-usual use of carbon, the carbon concentration could reach much higher, perhaps as much as 1,000 ppm by the end of the century, causing extremely dangerous warming.

What are the environmental effects of global warming? Serious melting, for one. The Greenland and Antarctic ice sheets are melting, which contributes to sea-level rise. If seas rise too much, coastal inhabitants will have to move to the interior, and what geopolitical issues will arise from such mass migration on a planetary scale? Not only are coastal cities vulnerable but islands are also increasingly threatened. One of the most critical effects of global warming is melting permafrost, which could potentially release huge amounts of carbon dioxide as well as methane—a much worse greenhouse gas than carbon dioxide. From these releases, the planet will be further warmed, illustrative of what is called an amplifying feedback, or a global warming vicious cycle.

Extreme weather events are a second result. By now Katrina is a household word on a par with Love Canal, and Hurricane Sandy, which hit the New Jersey coast in late October 2012, is already something of an iconic weather event. The category 5 tornado that hit Joplin, Missouri, in May 2011 killed 157, garnering much national attention. Climate change-wise, if it's not violent storms, it's heat waves and serious droughts.

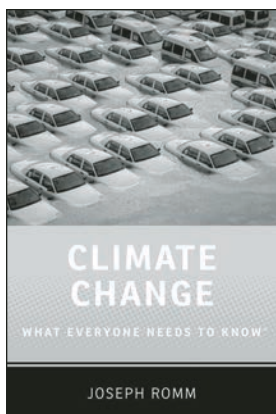
Is it too late? Has a tipping point arrived? The consensus of scientific opinion is that significant changes must be made immediately, globally, to reverse the warming trend. Reducing emissions alone will only stabilize the carbon concentration. As a useful analogy goes, the Earth is a bathtub filled to a particular level. The faucet is on. Turning off the spigot won't drain the bathtub. That takes a working drain, a carbon sink, and carbon sinks, like the permafrost, are becoming *sources* of carbon dioxide, not storage places for it. The business-as-usual path is mined with great risks as 2050 and especially 2100 approach.

Is climate science reliable? There is absolutely no question on the part of the legitimate scientific community that global warming is human-caused. Here one must distinguish between legitimate scientists and climate science deniers, who have found it profitable to join forces with the fossil-fuel industry. The books I'm reviewing contribute significantly to the scientific literature of climate change. Considered as a whole, they lay out convincing evidence in support of theories of human-caused climate change, and they provide substantial evidence that the deniers are spin-masters on the order of those who shamelessly defended the cigarette industry. To anyone at all familiar with the research, it's clear that the deniers bring no scientific evidence to rebut the findings of legitimate climate scientists.

Among the books reviewed here, the most thorough treatment of the global warming problem is *Climate Change* by Joseph Romm, who holds a PhD in physics from MIT and was acting secretary of energy in 1997. This study, which is accessible to a general audience, first lays out the climate science basics, then covers, in considerable detail, extreme weather events, projected impacts of global warming, strategies to avoid these impacts, politics and policies, the role of clean energy, and the effects of climate change on the individual. It's an exhaustive primer on the global warming issue, heavily documented with reports and studies by the leading organizations in the field and top-ranked science journals.

Romm gives us an unflinching report on the current as well as projected impacts of global warming. Because of global warming, heat waves are "more intense and more frequent" and will "last longer and cover a larger region." Droughts, or dust bowls, will be a lot worse than the ones in the 1930s. According to a 2015 study led by NASA, "carbon emissions

could dramatically increase risk of U.S. megadroughts" like those in the past that wiped out entire civilizations, including the Anasazi in the late thirteenth century, according to some researchers. "Such Dust-Bowlification would



Climate Change: What Everyone Needs to Know

Joseph Romm. Oxford University Press, 2016,
328 pp., \$16.95 (paper)

be one of the most consequential impacts of climate change for the world,” states Romm. These droughts, along with heat waves, floods, and drained aquifers will take their toll on food production. “Feeding 9 billion or more people mid-century and beyond in the face of a rapidly worsening climate is likely to prove the greatest challenge the human race has ever faced,” Romm says.

Global warming means droughts, but, counterintuitively, it also means more water vapor, which means heavier rains. Global warming hasn’t meant more hurricanes, says Romm, but of the hurricanes that have occurred, there are more Category 4 and 5 types. “Climate change is making a variety of the most dangerous extreme weather events more extreme. It is also making them more likely and thus more frequent.”

One must also consider the effects of the rapidly melting ice. According to Romm, “the faster the Arctic heats up, the faster the Greenland ice sheet melts, and the faster sea-level rise impacts coastal communities.” How high might seas rise? By 2100, based on the thinking of today’s expert researchers on this issue, seas could plausibly rise well above six feet, says Romm. In May 2014, the West Antarctic Ice Sheet appeared “close to if not past the point of irreversible collapse.” By century’s end, we could see a foot added each decade. But sea-level rise, along with its effects, isn’t a threat only in the distant future. Momentous effects will be experienced before that. In fact, “it seems very likely,” states Romm, “that hundreds of millions of people will need to relocate this century just from sea-level rise and threat of storm surge alone.” By midcentury, the new normal for the East Coast could be storm surges that rival Superstorm Sandy.

The second issue related to melting—the melting of permafrost, or tundra—hasn’t, as Romm points out, been figured into the data on projected impacts by the prestigious Intergovernmental Panel on Climate Change (IPCC). The permafrost, globally speaking, contains a vast amount of stored carbon, about 1.5 trillion tons of it, which Romm states is almost double the amount of carbon now in the atmosphere. When permafrost melts, carbon dioxide will be released but also some methane, “a much stronger heat-trapping gas.” How much stronger is thought-provoking—and alarming: “Methane is 34 times more potent at trapping heat as carbon dioxide over a 100-year time horizon, but it is 86 times as potent over 20 years.” Here, then, we have the problem of amplification on a massive scale. “The tundra is being transformed from a long-term carbon locker to a short-term carbon unlocker,” says Romm.

Besides global warming and its dangerous environmental effects, increased carbon concentration can cause serious dangers to human health, among these urban smog, low-level ozone, and rampant infectious diseases. One impact, says Romm, has not received sufficient research: diminished human cognition. Yet he notes that some recent studies look at possible indoor carbon pollution by century's end. For instance, a Harvard study conducted in 2015 revealed that "on average, a typical participant's cognitive scores dropped 21% with a 400 ppm increase in CO₂, with 6 of 9 decision-making performance domains impacted at the 930 ppm level, and 8 of 9 negatively impacted at 1400 ppm."

As we've seen, atmospheric carbon concentration spiraling out of control leads to dangerous climate change and threats to human health. Rapid climate change also poses serious security risks. Drawing from a 2014 U.S. Department of Defense study, Romm refers to impacts that can potentially "intensify the challenges of global instability, hunger, poverty, and conflict." According to this study, the risks will probably include pandemic disease.

Are the foregoing climate changes that portend such devastation reversible? "The scientific literature," says Romm, "has made it increasingly clear that key impacts are irreversible on a time scale of centuries and possibly millennia. This means that climate change creates risks that are unparalleled in human history." It also means that we must not delay action to remedy the problem. To avoid the worst impacts of global warming, he makes it clear that we must make "very deep reductions in greenhouse gas (GHG) emissions." Referring to the bathtub analogy, Romm holds that in order to stabilize carbon dioxide levels (the water in the tub), human-caused CO₂ emissions (the water from the faucet) must be reduced more than 80 percent. At that point, "the carbon sinks can essentially absorb them all." The bathtub drain will work. But to avoid the worst impacts projected for 2100, the emissions must "approach zero." It will take this level of reduction to limit global warming to 2°C (3.6°F), the "threshold for dangerous climate change" identified by scientists and governments—beyond that, it's "extremely dangerous," according to the Royal Society. Even with atmospheric carbon concentration stabilized, temperatures would continue to rise for a few decades until the Earth's climate system reaches a particular equilibrium. Yet this, unfortunately, is not all: "In addition, certain key impacts, such as the disintegration of the great ice sheets, will also not stop for decades." And

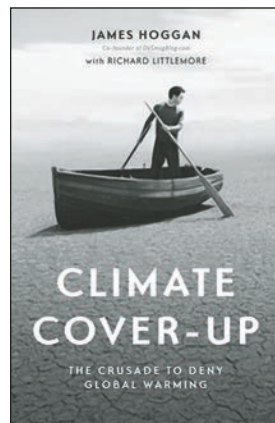
then if we factor in delay and inaction, we could be looking at a tipping point with ice-sheet collapse and rising seas for centuries, even if temperatures remain the same. But what if the Earth continues to warm a few degrees more beyond the limit of 2°C? Romm states grimly, “If we go beyond 4°C, we move into an unrecognizable world where we will need a different word entirely than ‘adaptation.’”

Romm’s *Climate Change* is a valuable contribution to the literature on global warming and, though filled with technical detail, overall a very readable book. It is structured as a series of questions related to the major issues; Romm’s detailed responses are based on hard science. But hard scientific evidence on climate change is, and has been for some time, a subject of scorn for the climate deniers, as two books I’ve chosen to review, *Climate Cover-Up* and *The Madhouse Effect*, forcefully demonstrate.

Who are these deniers? Two types, says James Hoggan, author of *Climate Cover-Up*: the first are those who, for the most part, have no scientific background but, driven by ideology, represent themselves as experts; the second are those with scientific credentials, but not in the area of climate change. Deniers of both stamps have signed on with the fossil-fuel companies, which have made it worth their while to deny what the scientific community is recording in the best peer-reviewed science journals in the country and what the National Academy of Sciences, the National Science Foundation, the IPCC, and other highly reputable organizations are saying.

Climate Cover-Up provides a broad, well-documented background to, and history of, climate change denial. James Hoggan, president of the PR firm Hoggan and Associates, holds that PR must be distinguished from “spin,” or manipulation, which is the tool of the climate change denial industry. Hoggan points out that “when Exxon gives money

Climate Cover-Up: The Crusade to
Deny Global Warming
James Hoggan with Richard Littlemore.
Greystone Books, 2009, 240 pp., \$15 (paper)



to think tanks in support of programs that sow confusion about global warming, this isn't public relations." Its purpose is not to favorably represent Exxon as a reputable company but instead to further Exxon's corporate interests at the public's expense. In this way climate science spin-doctors violate the professional code of ethics of the Public Relations Society of America.

Hoggan traces the deceptive methods of the deniers back to the cigarette industry and the obfuscation and outright lies used to protect a very profitable market. Can we call this a "conspiracy"? Yes, according to Hoggan, even though "there's something histrionic about that charge." Yet his book, he stresses, represents "conspiracies aplenty, documented and undeniable."

One convincing example deals with the Information Council on the Environment (ICE), which, as Hoggan says, "mobilized a group of scientists who in many instances were not climate change experts, but who would nevertheless make themselves available for newspaper and broadcast interviews and sign opinion page articles that could be distributed to local papers." Secondly, the Western Fuels Association, which helped launch ICE, also helped launch the Greening Earth Society, which produced *The Greening of Planet Earth*, a short video that totally misrepresented the carbon emissions problem, arguing "that Earth's plants are starving for carbon dioxide and that an increase in atmospheric carbon dioxide will result in a more fertile world." This film was made available countrywide to public and university libraries at no cost. "Imagine," says Hoggan, "the potential confusion to be suffered by a first-year student who has been reading legitimate science about global warming and checks this video out of his university library." By now, says Hoggan, one could see a pattern developing: "Corporations and industry associations were using their considerable financial resources to influence the public conversation. . . . They were hiring scientists who were prepared to say in public things that they could not get printed in the peer-reviewed scientific press."

Fossil-fuel PR groups major in Orwellian newspeak, says Hoggan, depending on a euphemism such as Frank Luntz's "energy exploration" for "oil drilling in the Arctic National Wildlife Refuge." Luntz's denier expression "sound science" makes use of "a well-tested adjective," states Hoggan—the word "sound" in opposition to peer-reviewed science. "Orwell," Hoggan says, "might have shuddered at the usage."

The evidence of peer-reviewed science is exactly what the deniers want to deny since it's not in line with corporate interests.

Front groups for the fossil-fuel industry like to represent themselves as “grassroots” organizations, states Hoggan, but they're not “spontaneous” or independently launched, the way we think of citizens' groups. Instead, they are “to be planted, tended, nurtured, and financed by the fossil-fuel companies that would benefit as the actual weight of science gave way to a manufactured ‘conventional wisdom.’” If people doubt the reality of climate change, it's certainly understandable, says Hoggan. Through its many so-called grassroots organizations, the fossil-fuel industry has made a concerted effort to “sow doubt and confusion” in the public's mind. Hoggan's exposé of these fake grassroots groups in the pocket of the fossil-fuel industry should surely resonate with anyone who has been part of a grassroots group, mobilized from the bottom up, not from the top down.

One useful venue in which deniers can spread misinformation is the mainstream media. Here, Hoggan states, “you can say what you like, knowing that the editor has no relevant expertise.” You don't have to be an expert in the field or even in a related field. You don't have to do any legitimate research or have your views evaluated by the established practice of scientific peer review. You can simply join those who “are seen to be disagreeing” with the global warming research, and in that way, the fossil-fuel industry benefits, as “the public continues to assume that the science is uncertain.”

There's another direction that climate change denial can take. In part because people are becoming aware of climate change themselves, deniers might not question the reality of global warming but concentrate on delaying action. According to Hoggan, they take this tack: “Why try to stop the warming at this stage? Instead, we should put our efforts into adaptation.” And besides, warming might even be a good thing. But at any rate, according to these “nondenier deniers,” we need to prioritize our spending, allocating it to worse social ills, “like poverty, HIV, or malaria.” But here the denialist creates a false dilemma, says Hoggan: “you suggest that your audience must accept your prioritization, because if they can't (or won't) pay for items on the top of the list, it would be irresponsible to start thinking about paying for items that are a lower priority.”

There's still another tactic that climate deniers use: the strategic lawsuit against public participation, or SLAPP, a suit meant to silence dis-

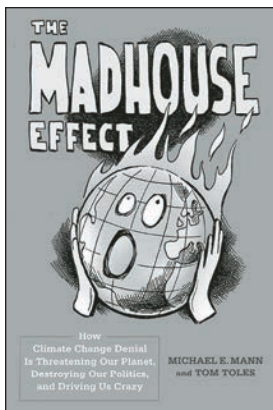
sent. If you're a legitimate scientist and take on the deniers, perhaps accusing them of misrepresentation or unethical manipulation of some kind—this charge especially—you might well find yourself the defendant in a huge lawsuit, says Hoggan. If you win, you may still have spent a huge pot of money defending yourself, perhaps against a dream team of lawyers. "It can cost tens of thousands of dollars to defend yourself in a libel trial," notes Hoggan, "and even if you win, you never recover all of your investment or any of your time."

Overall, this book is a convincing account of the persistent war against climate change science mounted by fossil-fuel interests and their front organizations. The reader is left realizing that "conspiracy" is, in truth, the right word to use for an industry that manipulates readers through an orchestrated misinformation campaign.

The Madhouse Effect brings the denial industry up to date. Michael E. Mann is Distinguished Professor of Atmospheric Science and director of the Earth Systems Science Center at Penn State University. Tom Toles is a Pulitzer Prize-winning cartoonist at the *Washington Post*. Together they provide a useful introduction on the difference between denialism and skepticism, a solid chapter covering the basics of climate science, plenty of evidence to reveal the wrongheaded denialism at work, and an enlightening section on geoengineering. Their book is not only highly accessible but also, because of the quirky cartoons, spirited.

Denialism, state the authors, must be distinguished from skepticism, which is in the true spirit of science. Denialists cannot legitimately be called skeptics, as they often have been. Denialism is "the wholesale rejection of validated, widely accepted scientific principles on the basis of opinion, ideology, financial interest, self-interest, or all these things

together." Skepticism, on the other hand, relates to peer-reviewed scientific work. It pertains to objective, critical evaluation of submissions.



The Madhouse Effect: How Climate Change Denial Is Threatening Our Planet, Destroying Our Politics, and Driving Us Crazy
Michael E. Mann and Tom Toles. Columbia University Press, 2016, 208 pp., \$24.95 (hardcover)

Like *Climate Cover-Up*, *The Madhouse Effect* situates denialism in the context of the tobacco denials. “The ‘tobacco strategy’”—an expression the authors draw from Naomi Oreskes and Eric M. Conway’s *Merchants of Doubt*—“has repeatedly been deployed in efforts to discredit scientific evidence of harm to the environment.” But why would scientists with impressive credentials, such as Frederick Seitz and S. Fred Singer, go along with this denialism? Two reasons account for this, say the authors: “ideology and money.” In terms of ideology, climate change deniers are steeped in free-market fundamentalism; in terms of money, these “scientists-for-hire” can receive substantial funds, in the hundreds of thousands of dollars, from fossil-fuel-funded front groups. The goal of these organizations, say the authors—quoting from Robert Proctor’s review of *Merchants of Doubt*—is abundantly clear: to “mislead large sections of the American public into thinking that the evidence for human-caused warming [is] uncertain, unsound, politically tainted and unfit to serve as the basis for any kind of political action.”

The authors limit the climate change basics to a short chapter, but it’s nonetheless a comprehensive overview, covering the key subjects, including the historical background for the science of global warming and the major effects of this warming: droughts, rising oceans, and extreme weather events. As for tipping points, they emphasize that public understanding is absolutely essential: “Can we stop our forward lurch before it is too late? Perhaps, but only if we experience a *different* tipping point, a tipping point in the public consciousness; only if we collectively grasp the profligate nature of our continued reliance on fossil fuels and the urgency of transitioning rapidly toward a clean-energy economy.”

For Mann and Toles, dealing with climate change is ultimately an ethical issue: “If we are *stewards* of the Earth—as many believe to be our mandate—then it is our responsibility to preserve our planet, not mortgage it for the short-term gain of narrow vested interests.” This pronouncement may seem to put too much responsibility on the individual, but perhaps not, when the situation is so “dire,” as the authors put it.

Given the seriousness of the matter, they then turn to the politicians and “talking heads” in bed with the fossil-fuel industry, who advance a six-point agenda of denial and delay: global warming is not happening; it is happening, but it’s “natural”; it’s a problem that “is self-correcting”; climate change is actually “good for us”; “it’s too late or too expensive to act”; and, finally, there are inexpensive technological solutions to the

climate change problem. These are not, in the least, convincing global warming viewpoints for Mann and Toles.

Like the authors of *Climate Cover-Up*, Mann and Toles hold the mainstream media accountable for misrepresenting the split between legitimate scientists and those in the denial camp. The split is not equally balanced—it's ninety-seven to three. "Not all viewpoints are equal when it comes to matters of science." There are objective truths, they note, whether or not people want to accept them. They judge Fox News as having "constructed an alternative universe where the laws of physics no longer apply, where the greenhouse effect is a myth, and where climate change is a hoax, the product of a massive conspiracy among scientists, who somehow have gotten the polar bears, glaciers, sea levels, superstorms, and megadroughts to play along." This alternate universe applies, they say, to the "entire Rupert Murdoch media empire, News Corp., which includes the *Wall Street Journal* and dozens of newspapers around the world." Climate denial, then, is a persistent, pervasive misinformation campaign aimed at legitimate climate science, which is, as Albert Gore put it, "inconvenient" to the fossil-fuel industry and its front groups.

There is the hard science of climate change, countered by the junk science of a massive industry of denial—the term "science," in this case, being a misnomer, according to Hoggan. Yet once we know the scientific truth, what are the best solutions? Globally, how can we work toward a maximum 2°C warmed world, admittedly dangerous but not "extremely dangerous," assuming this is, in fact, so? To help us understand, Joseph Romm looks at the numerous energy possibilities across the spectrum, from power plants to transportation.

For one thing, what can be done about carbon-polluting coal-fired plants? Romm considers, in some detail, the method of carbon capture and storage for gasified carbon. Several downsides make this not a good option: it's highly expensive; the process consumes too much energy; in storage, the pressure from large volumes of compressed gas could cause leaks or earthquakes; and leaks could be lethal. Noncarbon energy sources are needed. Nuclear power plants, while a noncarbon option, are nonetheless costly to build, use enormous amounts of water, and present a serious waste storage problem, not to mention the threat of meltdowns, such as in Japan in 2011. Hydropower is the leading source, worldwide, of renewable electricity, says Romm, with hydropower currently supplying

“more than 16% of the world’s electricity, which is more than nuclear power.” Solar, with two options—photovoltaic and concentrated solar thermal power—combined could provide as much as 27 percent of the world’s electricity needs by 2050. Wind power, says Romm, “has been the fastest-growing form of new renewable power in terms of added electricity generation per year.”

According to Romm, transportation may present the greatest challenge when it comes to emissions reductions. The most common strategies for cutting down carbon emissions here include energy efficiency, alternative-fuel vehicles, substitution (e.g. biking instead of driving), and gasoline taxes. Alternative-fuel vehicles, or AFVs, run on electricity, natural gas, hydrogen, and corn ethanol. There have been several “major barriers” to their success, among them the high up-front cost, limited range, and limited fuel stations. Romm also points out that the prime alternative fuel is presently corn-based ethanol, which does little to reduce greenhouse gases. Among other problems, ethanol requires too much arable land, and with drastic projected climate impacts, this is land that may be needed to feed as many as 3 billion more people who could be added to the world’s population in decades to come.

Instead of an AFV, Romm suggests the hybrid partial-zero emissions vehicle. As he sees it, the 2004 Prius is “arguably the world’s first truly practical and affordable (i.e. mass market) green car,” a car he has driven for ten years. And his more general recommendation: consider other hybrids, or even new diesel cars.

But beyond renewable energy and energy efficiency, are there other solutions to the climate change problem? What about certain touted technological solutions—referred to as “geoengineering”? Can we depend on them to solve the problem of global warming? Two of the books reviewed here, *The Madhouse Effect* and *Climate Change*, especially the former, provide particularly enlightening discussions of various geoengineering possibilities.

First, who would be likely to depend on geoengineering? “In some ways,” say the authors of *The Madhouse Effect*, “for the free-market fundamentalist, geoengineering is a logical way out because it reflects an extension of faith that the free market and technological innovation can solve any problem we create, without the need for regulation.” Such technological solutions may ultimately be necessary, say the authors, if despite our attempts to reduce emissions, we face extreme climate

changes, but it's more likely that contemplating geoengineering is really a crutch for those who oppose restrictions on carbon emissions.

One proposed geoengineering method is installing trillions of mirrors in space, as high as 620,000 miles above the Earth. This could cost as much as \$350 trillion, say Mann and Toles, much more than the cost of reducing carbon emissions. But cost isn't the only concern. To fully implement this method would take "a decade-long forcing," says Romm, which could lead to serious risks, including floods and droughts. He cautions that food production for as many as two billion people could be affected.

An alternative is injections of sulfate into the stratosphere, a method that could cool the planet much like volcanic eruptions. This method has the advantage of being relatively inexpensive, but there are serious downsides, including the worsening of acid rain. To add to this, if carbon continues to build up from using fossil fuels, the injection of sulfates would need to continue. And then what happens if there is a disruption of some kind, ask the authors—such as "a war, a plague, an asteroid collision"? What do we do when the reflective cover disappears? We would suddenly face decades of increased warming—giving new meaning, say the authors, to that old phrase *abrupt climate change*. This solution, then, doesn't deal with global warming itself, and besides, in reducing sunlight, it reduces an important renewable energy option: solar.

Another proposed geoengineering method to deal with the carbon-polluted atmosphere is called "direct air capture." This method mimics what trees do, but, as Mann and Toles point out, when trees "die and decompose, they give some of their carbon back to the atmosphere." The Giant Sucking Machine, as they call it, would be a perfect synthetic tree. But it would take 10 million such trees spread over the globe. Overall, this solution is much too expensive: It's "*far easier and much less expensive to prevent the CO₂ from getting into the atmosphere in the first place, whether by capturing and sequestering the carbon emitted from coal and natural gas power plants or, better yet, by getting our energy from renewable sources instead of from fossil fuels.*" Even so, as the authors note, if we still need "a stop-gap scheme to avert catastrophic climate change, carbon-sucking artificial trees may be the safest and most efficacious of all the available geoengineering schemes out there."

Romm does not recommend direct air capture either. Drawing on the U.S. National Academy of Sciences 2015 report on carbon dioxide

removal strategies, he states that they are “relatively safe, but currently unaffordable and hard to scale up to the level needed to remove and dispose of billions of tons of carbon dioxide.” Still another method is seeding the ocean—or what’s called “iron fertilization.” Mann and Toles explain, “If more iron were available, there would be more algae or ‘phytoplankton,’ which take up CO₂ when they photosynthesize.” Not a lot of iron would be needed, just “modest amounts of iron dust,” which the authors say “could potentially generate a *bloom* of phytoplankton activity, taking more CO₂ out of the atmosphere.” This should do the job, then: “As these phytoplankton continually die, they would, in principle, sink to the ocean bottom, where the carbon they gobbled up would be buried for the long term.” And yet, as with other geoengineering strategies, the authors note a significant problem with this proposed scheme: “Controlled field experiments have shown that iron fertilization at best leads to enhanced cycling of carbon in the upper ocean, with no apparent increase in deep carbon burial. Without deep burial, the removal of carbon from the atmosphere is only temporary.” But worse, say Mann and Toles, this “iron fertilization may actually favor harmful algae blooms, which are responsible for ocean dead zones and so-called red tides.”

More generally, Mann and Toles see a fundamental problem with the potential fixes offered by geoengineering, namely, “the monumental danger of tinkering with a complex system that we don’t fully understand.” Because of uncertain results on a global scale, things could be made devastatingly worse. Instead of such technological solutions, they recommend dealing with the problem at “its root cause.” Romm takes the same position, drawing upon the U.S. National Academy of Sciences 2015 report, which holds, “There is no substitute for dramatic reductions in the emissions of CO₂ and other greenhouse gases to mitigate the negative consequences of climate change, and concurrently to reduce ocean acidification.”

These three books on the problem of global warming, read against each other, provide a clear understanding of climate change and alert the reader to the need for action versus delay. If our individual choices don’t make much of a dent as far as the projected impacts of global warming are concerned, we can see how collectively they might. While this is a global problem, we can at least vote for politicians who are believers, not deniers, when it comes to policies affecting the present generation and generations to come. This problem is certainly an ethical one, as it literally means life and death. As an ethical problem, it falls under

intergenerational equity, affecting billions not yet born. In line with this thinking, Mann and Toles quote geophysicist Marcia McNutt, editor in chief of *Science*: “I wonder where in the nine circles Dante would place all of us who are borrowing against this Earth in the name of economic growth, accumulating an environmental debt by burning fossil fuels, the consequences of which will be left for our children and grandchildren to bear?”



Jack Smith

Jack Smith has published four novels, including *Hog to Hog*, which won the 2007 George Garrett Fiction Prize and was published by Texas Review Press in 2008, and, most recently, *Miss Manners for War Criminals* (Serving House Books). His short fiction and reviews have appeared widely. His creative writing book, *Write and Revise for Publication: A 6-Month Plan for Crafting an Exceptional Novel and Other Works of Fiction*, was published in 2013 by Writer's Digest Books. His coauthored nonfiction environmental book entitled *Killing Me Softly* was published by Monthly Review Press in 2002. Smith was fiction editor of *The Green Hills Literary Lantern* for twenty-five years and has taught philosophy and ethics for twenty years at North Central Missouri College.