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# Green Moral Hazards

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**ABSTRACT**
Moral hazards are ubiquitous. Green ones typically involve technological fixes: Environmentalists often see 'technofixes' as morally fraught because they absolve actors from taking more difficult steps toward systemic solutions. Carbon removal and especially solar geoengineering are only the latest example of such technologies. We here explore green moral hazards throughout American history. We argue that dismissing (solar) geoengineering on moral hazard grounds is often unproductive. Instead, especially those vehemently opposed to the technology should use it as an opportunity to expand the attention paid to the underlying environmental problem in the first place, actively invoking its opposite: 'inverse moral hazards'.

**KEYWORDS**
Risk compensation; environmentalism; climate; carbon removal; geoengineering

Moral hazards are pervasive and seemingly self-evident. Cushioning the effects of risky behavior through policy interventions or new technologies leads to more such behavior. That goes for health insurance as much as for seat belts and condoms (Cassell et al., 2006; Finkelstein, 2014; Leonhardt, 2008). Mandating any of these, *ceteris paribus*, increases risky behavior. That leads some who consider the underlying behavior immoral to declare the overall policy or technology as similarly so (Thomson, 2010, pp. 58–83). Moral hazards' omnipresence, however, also makes arguments around them malleable and adaptable. Like the neoliberal economist who assumes that the character of individuals (or of society writ large) tend toward immorality and bad choices and, therefore, any form of welfare is wasteful, environmentalist often assume that the character of individuals (or society) tend toward immorality and bad choices and, therefore, any type of a technological fix – 'technofix', in short – or anything that resembles one, is similarly useless. Moral hazard's malleability and tendency to encapsulate incredible complexities makes it unhelpful as a guide for policy. Environmental policy is a prominent example (Baker, 1996; Leaver, 2015; Lockley & Coffman, 2016).

We here analyze the history of moral-hazard logic applied to green technofixes. From the birth of modern environmentalism during the Cold War, moral hazards have been applied to a panoply of technologies. Some have even claimed that modern environmentalism arose precisely to counter the morally fraught 'high-modern' techno-scientific schemes prevalent in mid-twentieth century America (Scott, 1998). In the late 1960s, environmental icon Rachel

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Carson asserted, 'The "control of nature", is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man.' (Carson, 1962, p. 297) Her critical logic extends to some of the latest possible techno-scientific environmental interventions, most prominently perhaps climate engineering technologies such as carbon removal and solar geoengineering.[1] Carbon removal is just that: removing excess carbon from the atmosphere in an attempt to lower the impacts of climate change (National Research Council, 2015a). Planting trees is one example. Direct air capture, via large industrial facilities, is another. While carbon removal addresses the problem of excess atmospheric carbon, it is still one step removed from cutting greenhouse gas emissions in the first place. Solar geoengineering, meanwhile, merely masks the problem of excess carbon. It refers to large-scale interventions attempting to cool Earth by reflecting a small portion of sunlight back into space (National Research Council, 2015b, 2021). Solar geoengineering, thus, clearly represents an emergent technology that cushions the effects of risky behavior.

While it is tempting to describe any links between (solar) geoengineering and cutting carbon emissions in the first place as 'moral hazard', it may also be a misnomer for many related concepts that fall under the guise of direct risk compensation or "risk-response feedback" (Reynolds, 2015, 2019; Jebari, 2021). It is often not a higher authority – one's government – that shields individuals (or society) from the consequences of some actions, as the provision of mandatory health insurance or seat-belt laws might do. Instead, the same individual makes both the decision to employ a particular technofix – e.g. condoms – and also decides to engage in certain risky behavior. It is, thus, not a principal-agent problem in the classic insurance context. In both cases, agency rests with the same decision-maker, making risk compensation the more apt term, along with a host of possible others, such as the neutral 'crowding out' of one action due to another.[2]

Public policy complicates the picture. One societal decision, for example, is whether to (help) provide the technofix in the first place, or whether to advertise, or suppress, its existence. Whether for birth control or (solar) geoengineering, this leads once again to a scenario closer to moral hazard – with a principal creating possible moral hazards for one or many agents. Furthermore, as much of the initial framing of (solar) geoengineering came in the form of an insurance policy against climate catastrophe, moral hazard became a way to conceptualized some of the risks inherent in such a massive and troubling potential undertaking (D.W. Keith, 2000; Hale, 2012; Lin, 2013). This framing also hews closely to the textbook definition of moral hazard, with a policy or technology intervention cushioning the effects of risk behavior and, thus, leading to more such behavior.

Definitions aside, moral-hazard-style arguments are ubiquitous in environmental thinking expressed by the panoply of organizations and individuals that constitute what is popularly referred to as the 'environmental movement.' The history of American environmental politics indicates that the technofix critique has a prehistory that set the stage for the present broadly skeptical response to (solar) geoengineering. We first analyze this prehistory (section I), focused at the sentiment and reasoning that drive environmentalists' moral-hazard arguments, looking specifically at the history of technofixes (I.A) and the case of nuclear technologies (I.B), before discussing the technophilic, 'pragmatist', and 'ecomodernist' countermovement, and tying together the different strands (II). We return to (solar) geoengineering in the second-to-last section (III). Section IV concludes.

## 1. Environmentalism's Deep Moral-hazard Roots

Two undercurrents manifest themselves through green moral-hazard logic. The first is a complete rejection of the concept of a technofix, seeing it instead as an intolerable distraction from the real work required to make social change in the service of solving environmental problems. Encapsulated within the first, is the second, which is a rejection of anything that falls short of a green revolution and thereby sustains elements of the status quo. That critique of the status quo might involve anything from the capitalist system, blind faith in unchecked economic growth, systemic racism, the patriarchy, and other endemic inequalities. Both broadly fall under the banner of moral hazards and are not new or, in fact, unreasonable reactions to what can be understood as band aids for urgent socio-economic, cultural, and political conditions that affect the environment.

For those regarding unspoiled nature as sacred and technology as a tool of destruction, moral-hazard reasoning goes to the core of what it means to be an environmentalist. It also renders that reasoning rather complex, as environmental problems and the technologies used to solve them are woven into the fabric of society. As Harvey (1996) argues, 'All debate about eco-scarcity, natural limits, overpopulation, and sustainability is a debate about the preservation of a particular social order rather than a debate about the preservation of nature *per se*.' (pp. 148–9) Defining environmental problems and developing technologies then are inherently political acts (Winner, 1980). More often than not, the hegemonic political agenda, in turn, is inherently conservative – the maintenance of the status quo.

The logic of the technofix then is often questioned on the grounds that it represents the very same values that have inflicted environmental woes upon us. Academic fields like Environmental History, the History of Technology, and Science and Technology Studies are awash with such examples of technofixes gone awry (e.g. Hughes, 2005; Jasanoff, 2016; Josephson, 2002). The consequences for humans and environments can be catastrophic, putting the most vulnerable at risk while the wealthy reap the rewards of reckless exploitation through headstrong technocracy. Technofixes present a 'terrible temptation' for individuals as well as society as a whole (Douthwaite, 1983). Especially a technology as all-consuming as (solar) geoengineering could fundamentally change who we are and what range of choices we deem admissible or conceivable for the future (Baskin, 2019).

### *1.1. Technofixes' Historic Roots*

The concept of the technofix was not new to the post-WWII period, but it was during this time that the term was coined and clearly articulated by the nuclear physicist and director of Oak Ridge National Laboratory Alvin M. Weinberg. In a 1966 speech, Weinberg asked, 'Can Technology Replace Social Engineering?' He began with the premise that 'Social problems are much more complex than are technological problems' (Weinberg, 1991).

While Weinberg made what he recognized to be the 'terribly presumptuous' claim that the creation of the hydrogen bomb was effectively 'a quick Technological Fix to the problem of war,' he quickly turned his attention to technofixes in the service of the 'conservation of our resources.' He entered the realm of green moral hazards by describing a 'social engineer' castigating a 'technologist' who believed they were acting rationally for being 'shortsighted' and 'downright immoral.' Using water as an example, Weinberg stated that instead of asking people to behave more 'reasonably' and conserve water, 'nuclear desalination' could solve the problem of water shortages, much as he thought that 'extremely cheap energy from very large nuclear reactors' will be the basis of many of tomorrow's technological fixes. Weinberg's conclusion, however, perhaps insufficiently, put his optimism and faith in perspective: Technofixes are troublesomely tempting because, 'The Technological Fix accepts man's intrinsic shortcomings and circumvents them or capitalizes on them for socially useful ends.' While they are 'eminently practical, and in the short term, relatively effective,' technofixes are also dangerous in that they, 'tend to be incomplete and metastable, to replace one social problem with another.' The best a technofix can do is to 'buy time – that precious commodity that converts violent social revolution into acceptable social evolution' (Weinberg, 1991). Reflecting upon his life as a 'technological fixer,' Weinberg (1993) doubled down: 'yes, technological fixes often have deleterious and unforeseen consequences, but social fixes also have unforeseen and deleterious consequences' that 'can be particularly devastating' because they 'aim at correcting the root causes rather than treating symptoms.'

The broader American tendency toward technofixes to social problems and its embrace of technocracy can be traced at least as far back as the Progressive Era. In fact, some of the intellectual roots of the late nineteenth and early twentieth century embrace of technocratic rule come from the mind of Bacon (1624), by some considered to be the great-grandfather of plans for 'planetary engineering' such as geoengineering and terraforming (Fleming, 2010; Fogg, 1995). Inheritors of the Baconian tradition, Americans embraced elements of technocracy during the Progressive Era. Rather than favoring grass roots decision-making and eschewing the promise of technology and scientific management, this earlier movement favored utilitarianism and technocracy over the will of the people (Hays, 1999, pp. 3, 271; Noble, 1999). The field of ecology, which would later lend its scientific authority to modern environmentalism, also emerged from this technocratic time in American history (Kingsland, 2005), leading to a bifurcation in the nascent field (Worster, 1994).

One of the first places where experts applied their knowledge to a pervasive environmental problem was in the cities. Progressive Era cities were a terrible mess where it was difficult to disentangle human and environmental problems. Cities were bathed in filth from unrestrained industrialization and wreaked from the squalor emanating from their organic inhabitants. While the ill effects of this were evident to most urbanites, many regarded it as a byproduct of progress and simply accepted this as a part of living in an industrialized urban environment (Tarr, 1996). Technocrats held incredible power in the Progressive Era and the white male sanitary engineer arose out of the squalor of the cities to save urbanites from their waste (Melosi, 1981).

Others saw through the technofaith of their day. Women, laborers, and minorities, who were relegated to the fringes of society where many of the benefits of industrialization were absent and the consequences more acute, worked to establish grassroots organizations to cope with environmental injustices. Gottlieb (2005) and Montrie (2018) emphasize how the true origins of environmentalism are intertwined with social justice and broader political links, preceding Carson (1962) and the movement of the mid-twentieth century by decades.

Urban pollution, the techno-devastation of WWI, and the rise of the Technocracy Movement in the 1920s laid the ground work for the clash between technologists and environmentalists that was to come, but techno-enthusiasm hit a fever pitch in the decades following WWII (Aiken, 1977; Pursell, 2007, pp. 228–51; Segal, 2017). Next to Weinberg, another figure stands tall in this history: Director of the Office of Scientific Research and Development Vannevar Bush. In his 1945 government report, 'Science, The Endless Frontier,' Bush proclaimed, 'Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.' (Bush, 1945; Zachary, 2018)

A month after the publication of Bush's report, the United States deployed two atomic bombs, and even the most faithful technofixers faced a crisis of conscience. Weinberg was desperate to make the 'bomb-tainted technology' associated with this 'horrible weapon,' into a panacea for all humankind (Weinberg, 1993, pp. 381, 389). Furthermore, the industrialized totalitarian regimes that emerged as forces of evil during WWII confirmed the suspicion of some that technocracy was synonymous with tyranny and the subjugation of a nation. Nevertheless, an ambitious offshoot of the efforts to build the atomic bomb, *Project Plowshare*, which Edward Teller called 'geographical engineering' and 'nuclear engineering' and Glenn Seaborg called 'planetary engineering,' invigorated the hearts and minds of a cadre of American technofixers. Seaborg and Corliss (1971) went so far as to argue that humans lived on 'a slightly flawed planet.' They ardently believed that unlocking the hidden power of the atom had granted humanity the ultimate tool to restore Eden and 'remedy nature's oversights.' Atomic bombs could be used for excavation, strip mining, creating reservoirs, harbors, canals, roadway cuts, and even disaster avoidance and recovery (Circeo, 1969; Teller, 1968). Perhaps with this Archimedean lever humans could even 'change the climate.' All this arguably also amounted to the first time 'geoengineering' was proposed, albeit in an entirely different context (Fleming, 2010; Fogg, 1995).

Beneath this impulse was a moral imperative. As with many of these mega-schemes, there is often a nod to the humanitarian goals of such an ambitious agenda. The 'problems of humanity,' including pollution, are the forefront of what Seaborg and Corliss (1971) claimed were the ultimate goal of the peaceful use of the atom (pp. 20–1, 174–88). All this established the groundwork for the clash between environmentalism and nuclear technology, followed by a resurgent techno-optimism, to which we will return in section II.

### *1.2. Environmentalism and Nuclear Technology*

Nuclear bombs are terrifying. As David Nye has noted, 'At the deepest level, the existence of atomic weapons has undermined the possibility of the sublime relationship to both natural and technological objects.' The mere 'contemplation of the bomb transforms admiration for inventors, engineers, and scientists into fear and mistrust' (Nye, 1996, p. 255). The bomb was a 'technology so terrifying' that it 'could no longer claim to be an engine of moral enlightenment' (Nye, 1996, p. 254). It is within this context that modern environmentalism was born. It was fallout radiation from atomic testing and bombing that at once helped revolutionize the field of ecology and provided a focal point for the modern environmental movement (Jessee, 2013). Carson's (1962) opening chapters called upon public anxieties about fallout and Strontium-90 to make the dangers of DDT more legible for her audience. Through figures such as Carson and the cellular biologist Barry Commoner, Americans were facing off with fallout as the fearsome and invisible foe of the atomic age. Unfortunately, Commoner observed, 'we tend to use modern large-scale technology before we fully understand its consequences' (Commoner, 1966, p. 64).

During the 'Great Acceleration' that followed WWII, a period considered a watershed by Commoner for the dramatic increase in polluting technologies, we also have the birth of the 'environment' (Commoner, 1971, p. 121). It was in this period that the interdisciplinary fields of Earth systems science and environmental science began to coalesce and find institutional support. The looming threat of nuclear war (and nuclear winter), the ascendancy of the American and Soviet space programs, satellite observation, new methods in ecology, and the rise of quantitative computer-based environmental analysis allowed scientists to comprehend the extent to which humanity was impacting the entire globe including the ocean and atmosphere (Edwards, 2010; Hamblin, 2013). It is only then that 'the environment' became a global issue of concern. An outgrowth of this all-encompassing knowledge was that for some it reaffirmed the power of humanity and recontextualized thoughts about the purposeful manipulation of the planet through technology, what would later morph into the outright attempts at (solar) geoengineering (Morton, 2015).

The rise of this Promethean frame coincided with the anxieties that accompanied this knowledge and gave rise to the modern environmental movement.[3] NASA provided Americans with iconic photographs that spurred environmental consciousness and a nostalgic return to the classic 'technological sublime' that obscured the ever-present specter of atomic holocaust (Cosgrove, 1994). With the term 'environment' granted its new meaning, a set of socio-political problems could find common cause under a movement defined by an integrated set of concerns supported by an interdisciplinary approach to scientific understanding (Warde et al., 2018).

Consequently, one way to think about the core of the debate over moral hazards and environmental policy is through how Americans have come to reconcile their relationship with modernity and its handmaiden – the high-energy technologies that increasingly proved themselves to be lethal to humans and the natural world. In 1949, Aldo Leopold posthumously extolled his audience to consider 'Thinking Like a Mountain' because '[o]nly the mountain has lived long enough to listen objectively to the howl of a wolf.' He imagined that if we were to learn to think as deeply as a mountain we would not 'have dustbowls, and rivers washing the future into the sea.' (Leopold, 1966, pp. 137, 140) With such power to change the world, the question arose – what would be the moral path? For some, conservation represented a path toward sustainability and the 'greatest good' led by utilitarian technocrats. Others, more inclined toward preservation, the path was out of town and away from the monstrous natures of industrialization and urbanization. It would be a road toward the creation of national parks and the preservation of wilderness (Hays, 1999, pp. 141–6, 189–98).

Moral-hazard rhetoric can often be dismissed as Luddism or an overly enthusiastic application of the precautionary principle (Jones, 2013). Some of the slippery slope logic is likely informed by a feeling (and truth) that public financial resources and political will are finite resources. If one were to introduce a technofix into the mix, the temptation to reprioritize away from the environment would just be too strong. (Solar) Geoengineering is often understood as a moral hazard precisely because it is presented as a technofix (Borgmann, 2012; Morton, 2015, pp. 153–4, 157).

The history of environmentalists calling upon moral-hazard arguments began during the post-WWII period when projects on the scale of geoengineering were being conceived. The anxieties around the time of the first Earth Day in April 1970 in particular can be seen as a product and problem of the 'Great Acceleration' when the momentum of massive 'brute force' technologies were resisted by some Americans as out-of-tune with nature and countered by 'soft' or 'appropriate' technologies of small scale (Josephson, 2002). Yet beneath this veneer of an apparent consensus among environmentalists were the beginnings of a countermovement that extends to this day.

## 2. Environmentalism, Techno-optimism, and the End of Nature

Stewart Brand played a significant role in the 1960s and 1970s environmental and broader counterculture movements. His *Whole Earth Catalog* was a repository of alternative or 'appropriate' technologies and represented a pronounced Promethean philosophy. 'We *are* as gods,' Brand (1968) declared, 'and might as well get good at it.' What Brand offered was an 'environmental pragmatism' that diverged from the 'organized environmental movement' that 'succeeded in part by fostering a technophobic declensionist narrative' (Kirk, 2007, p. 6). Brand's *Catalog* demonstrated that technology could be ecological and empower individuals to live as they desire. He was perhaps the first exponent of what today is sometimes called 'ecopragmatist' or 'ecomodernist' – a techno-optimistic environmentalist. Brand's brand of environmentalism seemed both pragmatic and logical. In the face of an emerging 'risk society' – in a 'world of emergencies' – what choice would humanity have but to embrace technofixes to survive the future? (Beck, 1992; Calhoun, 2004)

Clearly, not everyone agreed. For one, E. F. Schumacher (1973) helped arouse public support for a moderated technological optimism. He, too, was optimistic about the future, but he found beauty in what one might describe as a more modest form of techno-optimism, encapsulated in the title: *Small is Beautiful*. Amory Lovins (1976), meanwhile, proposed a 'soft path' energy strategy for America's future, setting up a direct clash with the pro-nuclear stance of techno-optimists. This broad debate divides environmentalists to this day, with both Brand and Lovins continuing to be active participants. It is no surprise then that Brand (2009) has become an outspoken proponent for solar geoengineering research, well ahead of most others. One of us (Wagner) once shared a stage with Stewart Brand and David Keith, at an MIT Media Lab "Forbidden Research" conference (June 21st, 2016). Wagner's topic: moral hazard.

Brand's techno-optimism, though, was still only a minority view among the broader environmental movement, and perhaps remains one to this day. Despite the vocal pronouncements of the techno-faithful, the techno-anxiety of the atomic age was a common thread of much of the broader U.S. postwar environmental movement. At this time, biologists and ecologists such as Carson and Commoner, who were skeptical of technofixes, came to play a large role in framing environmental discourse. During the Cold War, when science was regularly regarded as the ultimate authority, environmentalists looked to ecologists and environmental scientists to bolster their claims. With their help, mounting concerns over large-scale technological systems, energy, natural resources, economic growth, and pollution gained sociopolitical currency.

The celebration of the first Earth Day in 1970 was representative of this new 'age of ecology' that was emerging from popular interest in environmental science and breakthrough concepts such as the Gaia Hypothesis (Bocking, 1997; Bramwell, 1989; Worster, 1994). A large segment of this environmentally conscious constituency were Americans concerned about 'quality of life.' They wanted basics such as clean air and water, but also opportunities to commune with nature in the suburbs and convenient access to 'wild' places. Thus, a striking feature of the postwar period is how environmentalism was blended with consumerism and by the 1970s became an integral part of American culture (Hays, 1989; McCarthy, 2010). This coupling fragmented the modern environmental movement, compromised it moral stance, and tamed its radical nature. Wilderness represents one of these problems since it is an area that allows one to forget about nature *here* while preserving nature over *there* (Cronon, 1995a, pp. 81, 85–87). It is, one might say, the moral hazard of wilderness protection.

The diversity of the environmental movement is what gives the environmental moral hazard so much power. Many source aspects of their moral claim by regarding pure 'nature' as sacred and distinct from humans and their technologies (Daston & Vidal, 2010). Others are mostly concerned with the built environment, often putting environmental justice issues front and center (Montrie, 2018). Still others question whether a socially constructed concept such as 'nature' has any unambiguous moral authority at all (Cronon, 1995b). Contested moral terrain exists between those who would together join forces to levy claims of an environmental moral hazard posed by a proposed technofix. But they are united in their concern about messing with the environment because it often means messing with vulnerable humans and their values. Manipulating nature carries the historical baggage of social inequality, unintended consequences, and techno-optimistic capitalism (Spence, 1999; Spiro, 2009). Furthermore, technofixes do two problematic things that make these constituencies uneasy – they always alter 'pure nature' and run the risk of circumventing more fundamental social change.

Moral claims around wilderness and nature make environmentalist author Bill McKibben's (1989) declaration of *The End of Nature* all the more significant. Its focus: anthropogenic climate change. McKibben was chronicling the death of 'the separate and wild province, the world apart from man to which he adapted, under whose rules he was born and died' (McKibben, 1989, p. 48). Unpredictable consequences are inevitably to follow as a result of our blundering mastery over nature. Even environmentalist authors like Holthaus (2020), who otherwise paints a hopeful, 'radical vision' replete with a 'new social compact' (p. 107), envision a future with rapid deployment of new technologies. All this is significantly complicated by yet another set of powerful tools in the form of carbon removal and especially solar geoengineering.

## 3. (Solar) Geoengineering and Moral Hazard

Both carbon removal and, even more so, solar geoengineering enter highly contested moral territory, mirroring Zygmunt Bauman's (1993) lament about a world where 'there are problems in human and social life with no good solutions' (p. 245). For one, solar geoengineering is no 'solution'. While carbon removal directly addresses the root cause of the problem – excess atmospheric carbon dioxide – solar geoengineering only does so indirectly (Keith et al., 2017). Using solar geoengineering to 'buy time', meanwhile, only works in the broader context of climate policy (Buck et al., 2020). Lastly, one cannot discuss the possibility of either form of geoengineering without conjuring up concerns about messing with nature, and the ethically objectionable compromise of substituting a technofix for the seemingly more difficult work of moral and broader institutional reform (Gardiner, 2006; Hulme, 2014; Kolbert, 2021; Preston, 2011).

While those researching solar geoengineering, us included, often invoke natural analogs, primarily major volcanic eruptions, in discussing it, the artificiality of a potential solar geoengineering intervention is clear (Wagner & Weitzman, 2015). The 1992 eruption of Mt. Pinatubo might indeed be a good illustration of the temporary global cooling effects of aerosols in the lower stratosphere, but it is but a poor stand-in for a sustained, directed geoengineering program. A volcano can hardly be accused of committing errors of commission, comparing them to errors of omissions inherent in unmitigated climate change. Scientists, and others involved in a solar geoengineering program, can and surely will.

Another issue that raises moral flags is what one might call the 'fallacy of deference'. One widely cited example comes from an early Royal Society report, concluding that, 'The greatest challenges to the successful deployment of geoengineering may be the social, ethical, legal and political issues associated with governance, rather than scientific and technical issues.' (UK Royal Society, 2009, p. xi) The statement represents some underlying logic and truths, even though it is not epistemic. It could instead be seen as an attempt to apoliticize the underlying science and even hide its social and contingent nature. For one, it assumes that the climate system is more knowable and predictable than human societies. Moreover, the statement implies that governance can be separated from the oft-uncertain science. Neither is necessarily true. Uncertainties abound, and natural and social science are intimately intertwined. That alone says little about the morality of solar geoengineering, but it clearly says that technical and natural scientific questions cannot be separate from the fundamental ethical quandaries (Gardiner, 2011).

The use of natural analogs and appeals to the humanitarian nature of solar geoengineering shifts geoengineering from a contingent and temporary solution toward a full-fledged technofix (Flegal & Gupta, 2018; Svoboda et al., 2018). If nature is good, or even God, then suggesting the manipulation of the environment on such a grand scale easily yields moral antipathy. Similar rhetoric surrounded the nuclear and solar energy debates of the 1970s. Weinberg, the nuclear advocate and technofixer, lamented the 'trans-scientific,' 'low-level controversy' because 'our public [radiation] exposure standards are small compared to what God already has imposed on us' (Weinberg, 1993, p. 413). Some radiation is indeed natural, but there, as with solar geoengineering, agency matters. It is a different thing altogether when it is introduced into the environment through deliberate engineering decisions and human technologies. These problems go hand in hand with the persistence of a Promethean frame of mind. One of the moral hazards of the technofix is the attendant faith that scientists and engineers will develop more technologies and processes to deal with the unintended consequences and costs of said technofix.

The so-called 'eco-pragmatists' or 'ecomodernists' seem to be fine with this. Shellenberger and Nordhaus (2011), while condemning what they consider the superficial morality of western elite environmentalists and their apocalyptic critiques of artifice, liken technofixes to sources of salvation and, seemingly uncritically, argue how, 'Each new act of salvation will result in new unintended consequences, positive and negative, which will in turn require new acts of salvation.' No surprise, many environmentalists reacted negatively to ecomodernism (Hamilton, 2014; Kloor, 2012). Meanwhile, the link from ecomodernism to (solar) geoengineering is rather direct – with David Keith, author of *A Case for Climate Engineering* (D. Keith, 2013) and one of geoengineering's most prominent researchers, a coauthor of the *Ecomodernist Manifesto* (An Ecomodernist Manifesto [WWW Document], 2015), and articles like 'Time to Embrace Geoengineering' on ecomodernist Breakthrough Institute's website (McInnes, 2013). Moreover, Nordhaus (2018), argued that the most relevant moral hazard surrounding climate change is not geoengineering, but it is rather in attending to an optimistic faith in achieving the two-degree threshold through decarbonization. Regardless of one's specific position, it is clear that moral hazard, in the classic sense of (solar) geoengineering crowding out mitigation, is ever-present. The question is 'merely' whether that inherent property *should* imply more or less emphasis on (solar) geoengineering as part of a broad, rational climate policy portfolio. (One of us has argued emphatically elsewhere that it should not (Wagner & Merk, 2019, 2018).)

In the end, any future role for both carbon removal and solar geoengineering involve both optimistic and pessimistic visions of the future. That holds for projections of future global greenhouse-gas emissions reductions pathways as much as for society's ability to govern this new – and rightfully oft-perceived-to-be scary – set of technologies. Paul Crutzen's (2006) taboo-breaking essay framed solar geoengineering as posing a fundamental moral tradeoff: on the one hand is a world with air pollution that harms and kills yet helps cool the planet; on the other is a world with less local air pollution yet deliberately introduced stratospheric aerosols to help cool the planet. That essay did indeed break a long-standing, self-imposed taboo on solar geoengineering research, sparking a resurgence of scholarly attention to this controversial topic (Caldeira & Bala, 2017). A crucial question underlying much of this research is the fundamental environmental morality underlying it. Yet, moral claims often bleed beyond the bounds of any single topic. Green morality is no exception.

Here, as elsewhere, is a strong sense whereby invoking moral hazard has to do with the breakdown of community, the loss of trust in institutions, and anxieties about expert rule, scientific expertise, and technocracy more broadly (Oreskes, 2019; Putnam, 2000). Trust is a vital component to the equation set up in moral-hazard logic. If an easy option to solve what is at its heart a social issue is available, it will be pursued even if it might be counterproductive in the long run. This goes hand-in-hand with arguments around solar geoengineering reversing fundamental properties of climate change and policy: instead of needing to provide incentives to deploy costly emissions abatement technologies, solar geoengineering may be so cheap as to entail the opposite effect – too much deployment too soon (Barrett, 2008; Schelling, 1996; Victor et al., 2009; Wagner & Weitzman, 2015, 2012). Geoengineering governance then implies suppressing these fundamental forces – globally. That goes well beyond common definitions of 'community'. It entails the world community, where trust operates on an entirely different level than at the local bowling alley. Deeply vested interests, state powers, and the complexities of international relations – combined with a potential technology that affects everyone everywhere – turn (solar) geoengineering in a unique, global governance challenge (Victor, 2008).

Participation is key to gaining trust, but technological choices and technology policies are not typically egalitarian, democratic, or pluralist (Frumhoff & Stephens, 2018). In the end, 'There is certainly a sense in which we all – perpetrators, victims, beneficiaries, bystanders – collaborate in this social construction [of technologies]. But it is equally certain that we do not all have an equal say in that activity.' (Pursell, 2007, p. x) All this, encapsulated in historian of technology Carroll Pursell's worry about 'monolithic systems that constrict rather than liberate' (p. 316), feeds into the inherently hazardous nature of (solar) geoengineering. Likewise, if (solar) geoengineering were to be embraced as part of a broader agenda of climate restoration, the challenging interactions between the (solar) geoengineering 'technofix' and broader socio-economic transformations would take on entirely different dimensions well beyond the interaction with greenhouse-gas emissions reductions alone (Buck, 2019).

## 4. Conclusion

It is tempting to retreat to a risk and uncertainty framework at the core of solar geoengineering discussions and climate and environmental policy more broadly. Carson (1962) taught us to be terrified of DDT. She also taught Americans to think ecologically, launching segments of the modern environmental movement. Meanwhile, DDT had done a lot of good, and its existence provides comfort and safer living conditions for many, especially in the context of climate change and the expanding geographic range of mosquito and tick-borne diseases (Attaran et al., 2000). A similar logic applies to solar geoengineering. While it might normally be an unthinkable prospect, given the deadly abnormalities that are sure to come with climate change, the unthinkable might even become morally justifiable (Morrow, 2014b; Morrow & Svoboda, 2016). That might go both for the calculating expected-utility framework, and for a purely moral point of view deeply rooted in the history of environmental thought.

Risk comparisons come with their own unique set of challenges. Unquantified and unquantifiable risks are only one. Commoner (1976) responded to the claims of risk comparison espoused by nuclear energy proponents by stating that, 'In human, moral terms, it seems to me there is no valid comparison between the risks of personally tragic individual events like auto accidents and the risks of operating a device which has the acknowledged, designed capability – however improbable – of killing tens of thousands of people at once.' (p. 97) Modern-day comparisons of the significantly larger death tolls of coal compared to nuclear power have helped change some minds, but nuclear energy is still a contentious issue among many environmentalists. (Solar) geoengineering's moral hazards are deeply rooted in this long and deeply-seated history of environmentalism and environmental thought more broadly.

The 'morality' at the heart of a gut-reaction against solar geoengineering – because it defies the natural order and (deliberately) ends nature as many know and value it – may still be rather weak, or at least not deeply held. That was true even for environmentalism during its 'heyday' in the 1970s: 'The raw numbers of people interested in the topic were good for environmentalism, but their interest was not always very deep' (Rothman, 1998, p. 125) and 'people routinely professed environmentalism but equally as routinely failed to practice it' (p. 210). This might foreshadow the effective response to any potential deployment of solar geoengineering. Descriptions as an unbearable sin against the natural world may fade into nonexistence, especially when 'quality of life' issues by unmitigated climate change begin to dominate.

All that provides scant guidance. Indeed, it might be seen as a capitulation to moral hazards and unwillingness or inability to face them head-on. The more practical answer may lie in process rather than outcome.

Philosopher Helen Longino emphasizes objectivity as one of the hallmarks of good science. There, of course, she is hardly alone. But she goes further, locating objectivity squarely as a result of social processes rather than a categorization of individual scientific inquiry. 'A method of inquiry,' then, 'is objective to the degree that it permits *transformative* criticism' (Longino, 1990, p. 76). The resultant scientific knowledge is yielded through objective methods by degree, but nonetheless it is not Truth (capital 'T') but instead displays the consensus of a community of scientists that offset individual subjective values. Public participation in knowledge creation, thus, is key, as scientific communities do not operate in isolation. That goes particularly for environmental research squarely aimed at benefiting the public at large, with (solar) geoengineering research as a prominent example.

One important question is where to stop: at what point does scientific knowledge become politically actionable? At what point, for example, should politicians jump in to pass rules and regulations for DDT or carbon dioxide on the one hand, or actively pursue carbon removal technologies or encourage solar geoengineering (research) on the other? There, public participation in research, and participation of researchers in public debate clearly goes both ways. Weingart (2008, p. 143) expresses the dilemma at hand: 'Strengthening accountability and public participation in expert judgments ultimately compromises the reliability and legitimating power of the expert's specialized knowledge, and likewise, putting experts in the position of determining political agendas and decisions conflicts with democratic representation and legitimation of power.' The role of the expert is controversial because environmental policy relies on authoritative voices to make decisions, but citizens of democratic societies are typically wary of technocratic policies that entirely exclude their input. However, outright hostility (on either side of the divide) is not the answer, it may be that that demystifying science rather than denouncing it is part of the solution. Perhaps the 'teach-ins' that were so central to the first Earth Day can serve as a source of inspiration for conversations concerning geoengineering (Rome, 2013).

With (solar) geoengineering – and both publics' and policy makers' lack of knowledge and understanding – the answer may be much simpler still: rapid, deliberate education of both various publics and those involved in the policy process about what it even is, what its potential benefits and risks are, and why it is that scientists are looking at this set of potential technologies. Doing so creates the risk of moral hazard in the form of deterring other forms of climate mitigation, chiefly cutting greenhouse-gas emissions. Given the utter inadequacy of climate policy, it may just do the exact opposite: encourage more climate action across the board (Maki et al., 2019). That may be true for three reasons: solar geoengineering may be viewed as unworkable; it may (still) be viewed as crazy and immoral; or it may be viewed as a clarion call for climate action in general (Merk et al., 2016). The three reasons are neither mutually exclusive nor collectively exhaustive. They may, however, be ways out of a deeply seated dilemma posted by this and other green moral hazards.

## Notes

1. The two are sometimes collectively referred to as 'geoengineering.' Carbon removal is also sometimes called 'carbon dioxide removal' or CDR. Solar geoengineering, meanwhile comes under various names, from 'albedo modification' to 'solar radiation management' or 'solar radiation modification' (both abbreviated as SRM) to 'atmospheric climate intervention.' Much of our argument applies to both carbon removal and solar geoengineering, while it often applies even more so to the latter. We, thus, often refer to the two technologies as '(solar) geoengineering' in our discussion.
2. In the context of (solar) geoengineering, more specificity might lead to terms like 'mitigation deterrence' (McLaren, 2016) or 'mitigation obstruction' (Morrow, 2014a).
3. When framed as a movement, modern environmentalism can be painted with broad strokes and encapsulate many interest groups. This has led to the creation of a number of origin stories (e.g. Grove, 1996; Rome, 2001).

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