Ethics, Policy & Environment
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/cepe21

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Version of record first published: 25 Jul 2012

To cite this article: Christopher J. Preston (2012): Beyond the End of Nature: SRM and Two Tales of Artificity for the Anthropocene, Ethics, Policy & Environment, 15:2, 188-201

To link to this article: http://dx.doi.org/10.1080/21550085.2012.685571

Ethics, Policy and Environment
Vol. 15, No. 2, June 2012, 188–201

Routledge
Taylor & Francis Group

SPECIAL SECTION ON THE ETHICS OF GEOENGINEERING

Beyond the End of Nature: SRM and Two Tales of Artificity for the Anthropocene

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In 1989, Bill McKibben wrote a now famous book declaring that anthropogenic climate change marked the 'end of nature.' Like threatened species, McKibben claimed, ideas can go extinct. The idea of nature untouched by human influence is one such idea, McKibben suggested, an idea now being extinguished by climate change. Until the advent of recent global warming, nature stood for 'the separate and wild province, the world apart from man to which he adapted and under whose rules he was born and died' (McKibben, 1989, p. 48). In today's warming world, 'each cubic yard of air, each square foot of soil, is stamped indelibly with our crude imprint, our X' (McKibben, 1989, p. 96). With anthropogenic climate change 'the *meaning* of the wind, the sun, the rain – nature – has already changed' (McKibben, 1989, p. 48). As a result, humans face an unprecedented and disorienting loss.

Published just as citizens and their leaders were starting to awaken to the reality of global warming, McKibben's thesis has faced a number of challenges from academics. These include the complaint that he puts too much emphasis on the idea of pristine nature (Cronon, 1995), that his approach is unnecessarily dualistic (Vogel, 2002), and that it is excessively concerned with nature's independence (Borgmann, 1995). Whatever philosophical shortcomings the original thesis contained, the success of the book makes it clear that McKibben had touched a nerve on something the public deemed important. He pin-pointed how climate change ratchets up the extent of human influence on natural processes. Climate impacts represent a more comprehensive disruption of nature than previous human influence such as the destruction of rainforests or the building of vacation homes on coastal lands. Anthropogenic warming creates a more fundamental type of change, altering what McKibben characterized as 'the most basic forces around us' (1989, p. 47). Since everything on earth operates under the influence of these forces, anthropogenic warming has the potential to shape the totality of nature in a fashion quite unprecedented in human history.

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2155-0085 Print/2155-0093 Online/12/020188–14 © 2012 Taylor & Francis
http://dx.doi.org/10.1080/21550085.2012.685571

The idea that humans can profoundly influence the climate has not proven to be an easy one to absorb. Simon Donner has pointed out how it runs counter to 'thousands of years of religious philosophy and existing traditional belief systems worldwide' (Donner, 2007, p. 232). The sky had previously been considered the 'domain of the Gods,' a realm assumed entirely beyond our control. Part of the purpose for which humans have manipulated the earth is to protect ourselves against whatever the Gods might cast down from above in the form of flood, drought, fire, or hurricane. Climate change starkly indicates that the domain of the Gods has now become merely another part of the human domain. Recognition that we can influence the weather represents, Donner claims, 'a major paradigm shift, arguably on the order of the Copernican Revolution' (Donner, 2007, p. 233).

However momentous a loss (McKibben) or paradigm shift (Donner) anthropogenic climate change represents, from an ethical point of view it is important to note that it was never anybody's intention to warm the planet through the burning of carbon intensive fuels. The desire to heat one's home, to travel by automobile, or to produce useful metals through high temperature smelting involved only the intention to make human lives better. Even though the alert about greenhouse gas concentrations and climate change had been discussed speculatively by Arhennius as far back as 1896, the complexity of the climate system led – until recently – to a great deal of uncertainty about whether human behavior could really influence the climate. Climate skeptics unscrupulously exploited this uncertainty. With the causal link always uncertain, nobody needed to accept responsibility for something that may or may not have been happening. Even now that the causal connections are more apparent, it is still sometimes claimed our moral culpability for climate change is minimal. The doctrine of double-effect can be used to suggest that we bear little responsibility for unintended consequences of actions pursued for well-intended purposes. Can we really blame ourselves for something so unexpected that was so far from our minds?

Even if this argument works to ameliorate some of the culpability for anthropogenic warming, the era in which responsibility for the climate can be evaded may be about to come to a dramatic end. With climate engineering now widely discussed as a possible response to global warming, humans for the first time are faced with the prospect of entering the domain of the Gods with full intentionality.[1] McKibben's worry comes back, this time in a more punishing form. Deliberately entering the domain of the Gods comes with a heightened moral burden. It is important for those considering the management of solar radiation to clarify exactly what type of moral burden this will be. This paper identifies two conflicting narratives that can be used to examine this burden, narratives that appear particularly important as we contemplate engineering the climate in the geological period that many are already calling 'the anthropocene.'

Solar Radiation Management and the Natural

Solar radiation management (SRM) – a suite of technologies also called sunlight reflection methods – is one of several technical strategies now being considered as a way to forestall some of the worst effects of climate warming. SRM seeks to stave off of rising temperatures by reducing the amount of sunlight reaching terrestrial and

marine surfaces (P.J. Crutzen, 2006; Launder & Thompson, 2010). As most of the planet now accepts, increases in greenhouse gas concentrations reduce the amount of energy able to leave the earth and radiate back out into space. The introduction of a difference between the amount of solar energy entering the system and the amount leaving it (measured in W/m^2) creates what is known as radiative forcing. During this forcing, components of the system either have to warm or cool to ensure that an energy balance is restored. The troposphere and the surface of the planet are currently warming to compensate for the reduction in outgoing energy caused by anthropogenic greenhouse gases. SRM techniques seek to counter this forcing by reflecting some portion of incoming solar radiation back outwards before it can be absorbed by the earth or its atmosphere.

SRM schemes range from the relatively low tech idea of painting large areas of the urban surfaces white, to the high tech suggestion of deploying billions of mirrors in orbit. The two most commonly discussed SRM ideas are cloud brightening and the deployment of stratospheric aerosols. The former involves modifying the albedo of ocean clouds to prevent solar energy from passing through them and being absorbed by the world's oceans (Latham *et al*., 2008). Marine clouds can be brightened by increasing the number of condensation nuclei around which cloud droplets form. One proposal is to spray a fine mist of sea water into the natural turbulent eddies above the ocean and let the mist mix into the existing cloud layer. To significantly influence earth's solar budget, cloud brightening advocates have estimated it would require about 1500 spray producing vessels operating continuously across the ocean commons (Salter, Sortino, & Latham, 2008). One of the advantages of cloud brightening, say these supporters, is that it could be quickly stopped. The cooling effects of these brighter clouds would cease within a day or two if the spray nozzles needed to be turned off due to unexpected effects.[2]

The other most commonly discussed SRM scheme is to increase the number of stratospheric aerosols by deploying sulphur gases to the upper atmosphere using airplanes, cannons, or long hoses (Robock, Marquardt, Kravitz, & Stenchikov, 2009). These stratospheric aerosols would reflect back sunlight even before it reached the lower atmosphere. Though most geoengineering schemes have not, for obvious reasons, been tested on a global scale, advocates of stratospheric aerosols claim that volcanoes provide good evidence of the planetary response. When Mount Pinatubo erupted in the Philippines in 1991, 20 million tons of sulphur dioxide and many additional tons of pyroclastic debris were projected into the upper atmosphere. Most of the debris settled out rapidly but the sulphur dioxide (which soon formed sulphuric acid droplets) caused a stratospheric haze which shielded a portion of the sun's rays for about two years. Temperatures in the northern hemisphere temporarily fell by 0.5–0.6 degrees Celsius. Earlier eruptions such as El Chicon (1982), Krakatau (1883), and Tambora (1815) showed similar, if less finely documented, effects.

Cloud albedo modification and the deployment of stratospheric aerosols both represent fully intentional human manipulation of the climate at a global scale.[3] If the *inadvertent* warming described in McKibben's famous book marked the end of the era of unaltered nature, then it is clear that the *deliberate* modification of the climate would mark the beginning of some fresh era of human influence. The advent of the age of SRM introduces important questions concerning the nature of artificity, the scope of human efforts at global restoration, and the morality of intentionally

manipulating earth's most fundamental natural processes. SRM would engineer significant components of the planetary system according to human design. Whether you view this as a benign form of global restoration or a hubristic form of interference with natural processes, it clearly changes our relationship to the earth in a fundamental way. One way to characterize this issue is to say that SRM turns the earth into something different, a giant artifact, Earth 2 or 'Eaarth,' as Bill McKibben has called it (McKibben, 2010). Put less provocatively, SRM, at the very least, involves 'the artificing of nature,' intentionally tweaking some of earth's basic processes in order to restore more desirable conditions. Since environmental ethicists concern themselves with both the nature/artifact distinction and with issues of environmental restoration, SRM presents them with a number of clear and significant challenges.

An Ancient Account of Artificity

To see why SRM might be viewed as a case of artificing, it is helpful to start with one of the earliest versions of the nature/artifact distinction. In *The Physics*, Aristotle characterized a natural object as one which 'has within itself a principle of movement and of stationariness (in respect of place, or of growth and decrease, or by way of alteration)' (192b8-11) (Aristotle, 1941). Any change the object undergoes is determined from wholly within that object's nature. An artifact, by contrast, lacks 'the source of its own production . . . that principle is in something else external to the thing' (192b28) (Aristotle, 1941). Changes affecting that thing are not internally generated but come from the outside. The external source Aristotle has in mind here is the intentional action of a human. Artifacts therefore display the influence of human intention in a way that natural objects do not.

Keekok Lee, a critic of certain types of contemporary technology, leaned heavily on Aristotle's account when she captured the nature/artifact distinction in this way:

> [T]he natural . . . refers to whatever exists which is not the result of deliberate human intervention, design, and creation in terms of its material efficient, formal, and final causes . . . [B]y contrast, 'the artifactual' embodies a human intentional structure. (Lee, 1999, p. 82)

On Lee's terms, a climate deliberately engineered through SRM to admit less short-wave radiation would clearly embody human intentional structure. This would make the intentionally engineered climate into an 'artificed climate' in a way that an unintentionally altered climate could never be. David Keith has also acknowledged a significant difference between intended and unintended human impacts, claiming that '[a]rtificial systems involve human agency in a fundamental way' (Keith, 2000, p. 27). Intent, in other words, *matters* and SRM, as opposed to today's anthropogenic warming, would clearly involve intent. If anthropogenic warming ended the era of untouched nature, then SRM, in some powerful sense, begins the era of global artificing.

This claim about artificity may on its own provide the starting point for a moral case against SRM from environmental ethics. Though I will not argue for the position here, at some very basic level, environmentalists have always shown a

preference for those things belonging to the metaphysical category of the natural over those things belonging to the category of the artificial. Keith, one of today's most important geoengineering researchers and someone with a great love of the natural world, warns how accepting deliberate climate modification means '. . . consciously admitting that we live on a managed planet' (Quoted in Goodell, 2010, p. 45). One interpretation of this remark is to suggest Keith is worried about how climate engineering turns the planet into something with a different, and problematic, metaphysical status. An objection to SRM from the perspective of environmental ethics, then, might be made purely on the grounds that managing the climate takes the earth and consciously artifices it into something of a different metaphysical kind, in the process thereby diminishing its value. An environmentalist with a strong preference for the natural over the artificial might posit a presumptive argument against geoengineering on these grounds alone (Preston, 2011).

Though this line of argument is tempting for its simplicity, it is beset by problems. The sharp distinction between nature and artifact made by Lee, while appearing conceptually straightforward, is far from perfect as an environmental tool. It is particularly problematic if an environmentalist wants to stipulate without further argument that natural things are generally 'good' and artifacts are generally 'bad.' One reason for this is that the distinction between these kinds of objects does not line up with the kinds of interests environmentalists possess. Some artifacts (such as solar panels and hybrid cars) are designed specifically for the purpose of serving environmental goals, while others (such as jet-skis and Hummers) have non-environmental goals in mind. Both count as artifacts on Lee's terms even though environmental thinkers want to situate themselves differently towards each. A sharply dualistic nature/artifact distinction is also problematic because it seems desirable to acknowledge different *degrees* of naturalness in objects. Presumably there is a difference in naturalness between a garden carefully planted out with native grasses and shrubs and coal-fired power plant or between a clay pot and a tupperware box. All of these artifacts contain human intention even though environmentalists will want to make important discriminations between them. Complexities about naturalness apply not just to objects but also to actions. Some human actions, such as eating, appear to be unproblematically natural while others, such as booking an airline ticket on an iPad, appear less so. To make the situation even more vexing by coming at it from a different angle, nothing humans do on this planet can ever contravene the laws of nature (as John Stuart Mill pointed out as early as 1874). Even the building of artifacts (including Hummers and golf courses) appears, by some accounts, to be a natural activity.

The puzzles that arise from assuming 'nature = good' and 'artifact = bad' are partly a consequence of trying to over-determine the metaphysical terrain. Aristotle's original distinction creates too strong a dualism between the human and the natural to be a reliable guide for today's environmental ethicists. Even if the distinction between those objects that embody human intention and those that do not turns out to be functionally crisp, the category of objects environmentalists seek to embrace and reject does not line up with the nature/artifact distinction. At a more methodological level, the attempt to carve up the metaphysical territory and then simply lay environmental norms on top has its own problems. The claim that whatever falls in the metaphysical category of the natural is good – and whatever is

artificial, bad – has to meet both the challenge of Hume's is-ought puzzle and to account for the history of the pernicious uses of this approach by natural law theorists and others. Clearly Aristotle's nature/artifact distinction creates a suite of complications for those tempted to deploy it without caution as a great metaphysical and moral divide. The complications would only be heightened when the object being artificed is the earth itself, the original home of the natural! For these and other reasons, it is best to set aside the idea that SRM is problematic for no other reason than it involves artificing the earth.

Just as McKibben's thesis about the end of nature retained considerable power despite its philosophical shortcomings, there is clearly still power to the claim that intentional modification of the climate creates a planet with its naturalness somehow compromised. An earth with a deliberately altered climate *does seem* to be a different earth in some important sense. Since it is not helpful to assert that an engineered climate is bad simply because it contains human intention, it is worth searching for more illuminating ways to think about the moral implications of artificing the Earth. For this, it is helpful to switch gears and look at debates in the environmental restoration literature.

Finding Nature in Restored Artifacts

In a provocative article titled 'The nature of artifacts,' Stephen Vogel (2003) usefully exposes some of the neglected dimensions of artificity. Vogel brings these dimensions to light through consideration of how typical projects in ecological restoration seek to re-create nature. The primary target of Vogel's article is anti-restorationists such as Eric Katz who find ecological restorations problematic due to the anthropocentric interests such projects display. In a famous article titled 'The big lie,' Katz dismissed restoration on the grounds that 'the re-created natural environment that is the end result of a restoration project is nothing more than an artifact created for human use' (Katz, 1992, p. 235). Even the most meticulously restored ecosystems, Katz lamented, '. . . will never be natural – they will be anthropocentrically designed human artifacts' (1992, p. 235). It is the anthropocentric interests fueling restoration that bother Katz. The artificed object, Katz thinks, is always designed to serve a human interest. To be truly natural, said Katz – using a characterization McKibben would surely also embrace – a thing needs to be 'independent of the activities of humans' (Katz, 1992, p. 236).

The problem with Katz's analysis, claims Vogel, is that it involves a mistaken idea of the nature of artifacts. Vogel takes issue with Katz's claim that the purpose of an artifact is entirely determined by human needs and interests. On the contrary, artifacts inevitably retain something that exceeds the best efforts at human design. One of the most clear-cut places to witness this excess is down on the farm. Living artifacts such as genetically modified organisms or domesticated sheep clearly have purposes of their own alongside those for which they were created. As well as providing grain, meat, and wool for human needs, these intentionally designed organisms strive to protect themselves against the vicissitudes of their environments and to reproduce according to their own biological drives.

What is demonstrably true of the special case of these living artifacts is also true more generally, according to Vogel, of all non-living artifacts. Turning the idea one

has for any artifact into reality literally means to '*real*-ize' an intention. When an artifact is realized it becomes materially embodied – or made real – in a way that ensures its behavior will in some measure always exceed the intention of its creators. In the process of this realization, the designer unwittingly ensures that her creation automatically exceeds whatever purposes or ideas she had in mind.

> The truth, of course, is that *every* artifact we build produces unanticipated effects, which means that *every artifact has more to it than its creators intended*: and so, what an artifact is always exceeds its relation to human intention. (Vogel, 2003, p. 156, emphasis in original)

Vogel asks us first to think of a garden. One may have the intention to grow carrots and beans, but numerous unanticipated weeds are sure to sprout and the carrot seed may not get the warmth it requires to germinate in time. There is an ineliminable wildness to an artifact like a garden. Vogel next insists that similar wildness is also present in more precisely engineered artifacts. Think of the Tacoma Narrows Bridge bringing itself down after getting buffeted by the wind or a car tire bursting without warning on a super-heated highway. This unpredictable wildness is a consequence of the material reality out of which every artifact, from a blacksmith's anvil to a space shuttle, is constructed. The wildness means that there always remains what Vogel calls a 'gap' between the intentions of those constructing the artifact and its actual behavior over time. This is the unavoidable character of every engineering project, not least in the fact that there is a temporal gap between completing the engineering plan and realizing the plan in an object. The cement has to set, the battery has to charge, the parts have to be meticulously assembled by skilled technicians. Once completed, the engineer has nothing left to do but to hope that the materials will behave as expected. Over time all engineering products experience natural aging. Vogel refers to this space between the engineer's intentions and the actual result as the artifact's 'nature,' intending with the use of this term to scramble the coherence of the nature/artifact distinction (Vogel, 2003, p. 163).

Two Tales of Artificity

Vogel's discussion of the 'gap' and the wildness still present in artifacts provides some helpful insight for thinking about the moral implications of SRM. It shows how the introduction of human intention in an attempt to restore the climate need not lead merely to the creation of a giant artifact. Nature and wildness remain. Interestingly, however, Vogel's defense of restoration does create a double-edged sword for SRM. To bring this double-edged sword into view, it is necessary to consider how the gap described by Vogel provides both reasons to embrace and reasons to be concerned about bringing human intentionality into the climatic system.

The positive edge of the sword becomes visible if you consider how much nature would be left after a project of atmospheric restoration (Jackson & Salzman, 2010). Recall how Vogel responded to Katz's worry. 'Every artifact,' Vogel insisted, 'has more to it than its producers intended' (Vogel, 2003, p. 156). Contra Katz's view, nature is never completely eliminated, even when an object or a process is

consciously artificed. After all the engineering is complete, nature remains present. From the restorationist's point of view, this is part of the point. In many cases of restoration, the artificing takes place with the *express intention* that unanticipated and beautiful results will emerge, such as when a handful of wildflower seed is randomly scattered onto a patch of restored ground and when a beaver slips unexpectedly into a restored wetland.

In this first tale of artificity, climate engineering could be viewed simply as the largest restoration project of them all. According to some scenarios the goal would be to restore global temperatures to an historical level (say, the level before the industrial revolution). According to others it would be to restrict temperature rise so that it does not exceed a particular threshold (say, 2 degrees centigrade). In both cases, the idea would be to allow ecological processes to operate in something like the fashion in which they operated historically. The fact that the gap between the role of the engineers and the behavior of the system they are artificing is utterly ineradicable would be entirely desirable from an environmental perspective. In fact, this would be part of the point of the project.

Contra Katz's worries, this artificing of the earth could hardly be dismissed as merely anthropocentric. Artificing the whole planet through SRM would be done with the intention of allowing nature to resume its previous diversity and complexity-producing processes. As Holmes Rolston, III, has suggested '... that isn't exactly ending nature. It is allowing for nature to continue.'[4] What Vogel's analysis of artifacts makes clear is that, thanks to the gap, plenty of wildness will remain. This wildness will be present in the species that find life easier under this managed climate, in the rocks and watersheds that continue to erode under slightly less extreme climatic forces, and in the evolutionary processes that will still occur in a fashion more similar to historical patterns than would otherwise have been possible.

If all went well, numerous environmental as well as human harms would be avoided. Arctic ice would be maintained, polar bears would be saved, bull trout would be preserved within their mountain streams, the rains would not be reduced in Africa, plant species would have no need to shift their ranges northwards and upwards, crops would be less likely to fail and diseases would be less likely to expand their range. Humanity would breathe a huge, collective sigh of relief as a whole host of human and natural values would be salvaged. Environmentalists could rejoice at this last-gasp preservation of those things they care about most. Whatever artificity exists in this situation, it would constantly be exceeded by the wildness that gets preserved, or, as Vogel called it – particularly appropriately in this case – by the artifact's 'nature.'

In order to appreciate the enduring presence of nature in such a restoration, it would no doubt be necessary to let go of what Vogel calls 'the fetish' displayed by McKibben and others of equating nature with the pristine or the untouched. Challenges to this fetish are already widespread throughout the wilderness literature (Callicott, 1991; Cole & Yung, 2010; Cronon, 1995; Guha, 1989). This letting-go of the pristine fetish should be particularly easy to do with the planet as a whole. Due to the size and complexity of the system, the natural spontaneity remaining after the restoration will be particularly evident when artificing the whole planet. Only the net solar radiation reaching the earth's surface would be intentionally altered. The wildness retained within the system – in its wildlife, its hydrological processes,

and its overlapping ecosystems – would be orders of magnitude greater than in any previous artificing. This first tale of artificity will be reassuring to the environmentalist worried by the prospect of intentionally manipulating 'the most basic forces' around us (as McKibben called them). Even with those forces manipulated, plenty of wildness will remain as nature continues to assert its 'nature' underneath the umbrella of a managed climate.

This residual wildness that Vogel so powerfully brought to our attention unfortunately also supplies the less appealing edge of the double-edged sword. The fact that the realization of any artifact necessarily exceeds the intention of its designer is exactly what many of those who worry about SRM fear the most. Efforts to restrict global temperature rises to a certain level with SRM are likely to have a number of effects that cannot be predicted ahead of time, some potentially catastrophic. One of the general points Vogel made about the wildness retained in every artifact drives home this uncertainty:

> To build an object – *any object* – is to build something that always exceeds one's intentions, that always possesses something of the unpredictable and unknown about it. As soon as it is built (and indeed even before) it starts to crumble as forces operate upon it – of air and gravity, of heat and light, of decay and oxidation and time – whose total effects can never been grasped at once; which means that from the very beginning the object has already escaped the builders' control, and so is something other than what they had in mind when they started to build. (Vogel, 2003, p. 163)

This is the second – and much more worrying – tale of artificity embedded in SRM. 'Escaping the builder's control' sounds ominous when read in the light of plans for global SRM. Can we be confident about the effects of any effort to intentionally manipulate something as fundamental to the planet's operation as its solar radiation budget? Current scientific uncertainty about the impact of SRM on precipitation patterns and plant productivity testifies to the legitimacy of the worry (Bala *et al.*, 2011; Mercado *et al.*, 2009; Moreno-Cruz, Ricke, & Keith, 2011; Robock, Oman, & Stenchikov, 2008). The same variation that plagues climate science in general reappears in perhaps more virulent form with SRM, where the unpredictable effects of SRM are layered on top of the unpredictable effects of anthropogenic warming.

In the face of this uncertainty, there is clearly an urgent need to do more modeling of climate impacts under different scenarios. Increasing the amount of research dollars available is important at this time, as much to find out what would not work as to find out what might.[5] With cloud brightening, it is likely that some small scale field tests might occur without too much risk. With stratospheric aerosols, since it may be impossible to limit the tests to a specific region, the risk associated with field tests may be significantly higher. Even with increased modeling and some limited field-testing, it is likely that many unknowns will remain. Phil Rasch, one of the world's experts on solar radiation management, bluntly conceded in his testimony to the US Congress, 'I think it is important to recognize that geoengineering is a gamble' (Rasch, 2010).[6]

This worry about the uncertain effects of SRM is a particularly clear example of Vogel's broader point about the nature of artificity. As Vogel admitted about every restoration, '... [T]o produce a wild artifact might mean to put natural forces into action and then to let them go, in ways that are fundamentally unpredictable and outside of our control' (Vogel, 2003, p. 161). When building even a very complex artifact like an airplane, much can be done to reduce the potential for unpredictable outcomes (even though such outcomes can still occur with disastrous results). Compared to an airplane, the climate system involves complexity of a different order – a type of 'hyper-complexity' – making the elimination of uncertainty much harder, if not impossible. Many of those who oppose SRM, as well as many of those who think SRM might one day be necessary, are worried about this uncertainty. This is why there will always be two tales of artificity in climate engineering. The very feature that is heralded as one of the greatest blessings of restoration – the retention of natural wildness and unpredictability – is also the specter that most haunts SRM.

Human Responsibility in the Anthropocene

The presence of these two tales of artificity provides a different way to interpret David Keith's remarks to Jeff Goodell about arctic ice. When Keith said we should pause before trying to cool the arctic because it involves resigning ourselves to living on a managed planet, he may not have been expressing a negative attitude towards the metaphysical category of artifacts after all. He may have been thinking instead about the additional responsibilities that voluntarily assuming such a management role would place upon us. SRM thrusts us into the role of designer and caretaker of both people and ecosystems. We must manage the climate to be both maximally restorative and minimally risky. We must do this at a global scale in the face of considerable – and perhaps ineliminable – uncertainty in the science. This is clearly a daunting challenge.

If this warning about enhanced responsibility was what Keith had in mind, it aligns with a similar caution about geoengineering expressed by environmental writer Jason Mark. Mark claims that taking responsibility for the climate would create a particular type of 'existential anxiety' (Mark, 2009). Untouched nature may have appeared to some through history as red in tooth and claw but it has also been the reassuring background context against which all human activity has occurred. John Stuart Mill once characterized it as 'the cradle of our thoughts and aspirations' (Mill, 1963–1977, p. 756). It has served as a canvas against which humans have searched for, and found, meaning in their lives. The fact that this context has always involved forces operating beyond our control has been a source of both worry and wonder. Nature might be unpredictable but, at the same time, it has always also provided both comfort and inspiration. Wild nature has been the place people have gone to escape the pressing responsibilities of the human world. Taking control of this background context of our lives would be psychologically challenging due to the immense burden it would impose on us. There would be no place on earth – or under the sky – where anxiety-producing questions such as 'Are we succeeding?' could be avoided.

One might respond that this assumption of responsibility is part of the hand we have dealt ourselves through the last two centuries of climate change (Allenby, 2000;

Thompson, 2009).[7] We have irrevocably changed the earth through our actions. Anthropogenic effects such as the large-scale physical transformation of surface ecosystems, increases in atmospheric carbon dioxide, mass species extinctions, the dissolving of carbonate shells by more acidic ocean waters, and large scale sedimentation in rivers are becoming more dramatic each year. These are all planetary scale impacts that will be recognizable to future geologists and paleontologists. Paul Crutzen, not coincidentally the same Nobel Prize winning atmospheric chemist responsible for bringing SRM into public awareness in 2006, has suggested that we give this new geological period its own label, the 'anthropocene' (Crutzen 2002). The discussion initiated by Crutzen about whether to officially recognize the anthropocene as a new geological epoch has recently been gathering steam (Jones, 2011).[8]

The defining marks of the anthropocene are the set of physical changes to the natural world currently in process. As contemplation of the possibility of SRM makes clear, however, another defining feature of the anthropocene would be the change in our moral responsibilities. Giving this epoch its own label could bring sharper focus both to our past impacts and to our future obligations. Contemplating those obligations is not for the squeamish. Taking responsibility for a restored wetland or a threatened species is considerably different from taking responsibility for the ecology of the whole earth. As Andrew Revkin has put it in the New York Times, '[T]aking full ownership of the Anthropocene won't be easy. The necessary feeling is a queasy mix of excitement and unease' (Revkin, 2011). At every moment it would be our responsibility to ensure the climate was hospitable. Rather than viewing nature in the traditional fashion as a deep source of solace and meaning, we might start to view the climate as a constant (and self-created) threat, leading to the existential anxiety Mark claims would plague us. Few changes in humanity's role on earth would impose such a heavy moral burden.

The ultimate moral issue SRM presents, then, is one of responsibility and whether we ought to take it. On the one hand, this means assuming responsibility for restoring and preserving the human and natural values we cherish. On the other, it means assuming responsibility for the risks SRM generates. We happily assume both of these in local and regional restoration projects because any unintended effects are thought to be manageable. The risks are usually limited in their scope.[9] In the case of restoring earth's climate, it is not so obvious that the risks can be managed. Taking responsibility for our impact on the climate certainly means preparing compensation funds for those people who will be most harmed, trying to maximize the resilience of ecological systems, perhaps even considering assisted migrations of threatened species (Cole & Yung, 2010; Minteer & Collins, 2010). But it may mean rejecting the risks associated with actively managing the climate of the future. Initiating a project of artificing the climate would mean taking a kind of *total responsibility* unprecedented in human history. At this point, for both psychological and prudential reasons, it is not obvious this total responsibility is something humans ought to assume.

Vogel's discussion of restoration can again be helpful here. One of the conclusions he drew was that human attempts to restore nature must be initiated with certain character traits being prominently displayed. In addition to self-awareness enabling us to admit what we have done, Vogel points out how artificing also demands

humility about what we think we can achieve. Together these virtues of self-knowledge and humility may teach us of '... our responsibility for the world we inhabit on the one hand ... [while] also remind[ing] us not to over-estimate our ability to remake it in any way we want ...' (Vogel, 2003, p. 168). Vogel further suggests that, as transformers of the world, it is important for us to acknowledge how we are 'mortal and fallible too' (Vogel, 2003, p. 168). Our mortality and fallibility are certainly traits we will want to keep in mind if we ever choose to intentionally enter the domain of the gods.

Acknowledgements

Research time for this paper was supported by US National Science Foundation grant number SES 0958095.

Notes

[1] As Fleming (2010) documents, there is a long history of humans attempting to modify the weather to satisfy (mostly) regional demands. Fleming points out that this has had a checkered history with little evidence of genuine success. The current interest in solar radiation management on a global scale is a considerably more ambitious endeavor.

[2] Due to their enormous heat capacity, the oceans would not themselves 're-warm' on the cessation of cloud brightening for a few decades.

[3] There is some debate about how localized one could make the effects of these strategies and whether their effects could remain, say, confined to the poles or whether they would inevitably become global (Keith, 2010; Robock *et al*., 2008).

[4] Rolston's full comment was: 'Some of these schemes sound like putting up a protective layer high in the sky, so that down below the usual natural processes can go on more or less as before. That isn't exactly ending nature; it is arranging for it to continue – albeit with a solar shield that is an artifact' (Holmes Rolston III, personal communication, June 13, 2011).

[5] This is a point repeatedly made by scientists involved in climate engineering research such as David Keith, Ken Caldeira, Phil Rasch and others.

[6] As so much is currently uncertain, Rasch still maintains we should do the research now so that we are as prepared as possible for the moment when taking that gamble starts to look like the lesser of two evils.

[7] Thompson suggests this hand is one that should indeed cause us anxiety. Yet he hints it should also cause us hope in that we may finally take responsibility for the effects of our actions.

[8] The Geological Society of London convened a meeting in May 2011 to discuss the plausibility of making the designation official.

[9] A few attempts at restoring regional ecological processes through biological means, however, have generated notoriously unmanageable side-effects (for example, the introduction of Myxomatosis to rabbits in Australia to control populations).

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