Command-and-control: Alternative futures of geoengineering in an age of global weirding

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ABSTRACT

In July 2012, Russ George, the founder of Planktos Inc., organized efforts to dump 100 tons of iron sulfate off the coast of Canada to engineer a plankton bloom that would, ostensibly, absorb carbon dioxide and store it in the depths of the Pacific Ocean. As George's geoengineering experiment is one of the largest and first of its kind, many were quick to denounce his rogue action while others were delighted to see that he succeeded as a large algae bloom was reported to have emerged. Using the George event as a point of entry for exploring alternative futures of geoengineering in an age of global weirding, this project fuses the 2 x 2 scenario modeling technique with the “Mauna School” four-futures method by situating command and control, along X(control) and Y(command) axes as two critical uncertainties and key drivers of change that will impact the design, development, and diffusion of climate mitigation engineering initiatives, which some see as holding the only solution to avert global catastrophe and others condemn as a postnormal remedy.

In this century, the greatest environmental progress will come about not through endless lawsuits or command-and-control regulations but through technology and innovation. —George W. Bush (2003) [15]

1. Introduction

In July 2012, Russ George, the founder of Planktos Inc., organized an effort to dump 100 tons of iron sulfate off the coast of Canada to engineer a plankton bloom that would absorb carbon dioxide (hereafter CO\textsubscript{2}) and store it in the depths of the Pacific Ocean. While “the operators claim the iron generated a plankton bloom of about 10,000 square kilometers” [64], a 2011 report from the Intergovernmental Panel on Climate Change (hereafter IPCC) notes the low CO\textsubscript{2} storage potential and global side-effects of ocean fertilization, which is further problematized by the rising trend of ocean acidification—an impediment to algae growth [43,72]. As George's “rogue” endeavor was one of, if not, the first of its kind, many remain concerned about the overall dearth of action toward reducing global CO\textsubscript{2} emissions [54]. As the Mauna Loa Observatory recently reported, atmospheric CO\textsubscript{2} recently reached 400 parts-per-million for the first time in “more than 2.5 million years,” and the last time it was this high “the globe's temperature averaged about 3 degrees C warmer, and sea level lapped coasts 5 meters or more higher” [10]. In light of such reports, the Planktos incident has done much to re-enliven discussions...
concerning the legal, ethical, and political implications of geoengineering, which, in spite of the unanswered questions and sizable risks, some see as the only possible solution to the challenges ahead [38,50,65,66,85].

At present, there are two major types of geoengineering initiatives: CO₂ sequestration, which involves capturing, storing, and/or removing greenhouse gases, such as ocean fertilization, and solar radiation management (hereafter SRM), which centers on limiting the amount of sunlight that penetrates the atmosphere [30,41,51,71,88]. According to the IPCC’s Fourth Assessment Report (hereafter AR4), geoengineering “options tend to be speculative and many of their environmental side-effects have yet to be assessed; detailed cost estimates have not been published; and they are without a clear institutional framework for implementation” [8, p. 621]. Complicating things further, and as noted by former President Bush, there is a perceived and actual shift away from command-and-control regulation on environmental issues, which pioneered a regime of “detailed regulations followed up by an ongoing inspection program” [81]. While this strategy defined the rise of the Environmental Protection Agency (EPA) in the U.S., the limitations of this approach, particularly for large-scale climate engineering projects, are readily apparent, especially given the postnormal challenges of global warming. Explicating the postnormal contours of our historical moment, Sardar argues, “Ours is a transitional age, a time without the confidence that we can return to any past we have known and with no confidence in any path to a desirable, attainable or sustainable future” [74, p. 435]. Given the immense ethico-political issues raised by geoengineering, charting alternative futures can offer critical insights for exploring possible, probable, plausible, and preferable aspects of climate engineering initiatives, especially since, “if we cannot learn the lessons of history we need another source for the imagination to conceive of more sustainable and attainable futures” [74, p. 444].

Drawing on the “value of mash-ups” [22, p. 58], this paper fuses the 2 × 2 scenario modeling technique with the “Mānoa School” four–futures method [26] by situating command and control along X (control) and Y (command) axes as two critical uncertainties for modeling alternative futures of geoengineering. The pairing of the Mānoa School modeling method with the 2 × 2 approach provides additional complexity and context for the scenarios, which take a global perspective and focus on the events surrounding geoengineering initiatives as much as their potential design, development, and diffusion. Whereas the pole of each axis on a 2 × 2 matrix commonly denotes degree (high versus low), control (X-axis) and command (Y-axis) are not framed herein according to intensity but rather according to kind with each pole denoting unique views of both perceived and actual complexity of global warming and potential remediation strategies and tactics [68]. In order to contextualize and operationalize the alternative futures presented herein, command and control are critically explored and reterritorialized from a postnormal purview in subsequent sections. As the basis for the Y-axis, command is couched within the ongoing debate concerning the origin and meaning of the Anthropocene, which suggests that humans are now among the “great forces of Nature” [80, p. 843]. Control, on the other hand, is situated within the discourse on environmental security, which mediates the “drastic ground swell of interest in environmental change as a potentially key variable in understanding security and conflict,” specifically the weaponization of Mother Nature’s fragility and fury [31, p. 2]. As the foundation for reconceptualizing command and control, the concept of global warming is explicited to address ongoing and expected shifts in perspective, policy, and practice.

2. From global warming to global weirding

Given some of the concerns raised in AR4 and expectations that the Fifth Assessment Report (hereafter AR5), which will be officially released in 2014, will give greater weight and attention [46] to geoengineering, global warming is actually a sort of global weirding—a neologism coined by Hunter Lovins, co-founder of the Rocky Mountain Institute, and popularized by Thomas Friedman [35,36]. In light of George’s experiment and the increasing possibility that the world may need to take significant steps to abate a constellation of ecological crises, an exploration of alternative futures of geoengineering in an age of global weirding provides an opportunity to consider the impacts and ramifications of potential remedies while imagining what might lie ahead should any or all of the proposed solutions be enacted, which many find worrisome since “the cure could be worse than the disease” [79, p. 620]. Contending with the postnormal precarity of geoengineering lies at the heart of life in an age of global warming, and while this contention may seem trite to those with a penchant for forecasting alternative futures, life in a postnormal world is profoundly weird (and getting weirder) for many.¹ While the future(s) impacts and implications of climate engineering remain speculative, the two sides of the geoengineering debate are already apparent.

Articulating the two sides succinctly, George, who unsuccessfully attempted an ocean fertilization project five years earlier, argued that his efforts were “‘organic gardening, not rocket science’” [69]. While the outspoken entrepreneur’s candor was certainly intended to raise eyebrows, if not funds from investors, the purported success of his 2012 experiment mixes more than metaphors as ocean fertilization enhances natural processes of CO₂ sequestration (i.e. organic gardening) and yet presumes a level of systemic command-and-control that remains, at present, elusive (i.e. rocket science). Complicating the matter further, the U.N.’s 2010 convention on biological diversity applies only to the rather amorphous category of geoengineering initiatives that can and/or might effect biodiversity, which puts the Planktos incident into a bit of a legal gray area [92]. Considering the lack of a regulatory framework, the dearth of international law, and the absence of a

¹ This weirding has much to do with the existential challenges to traditional worldviews brought to the fore by global warming. In a study examining this exact dynamic, Barker and Bearce found that “belief in Christian end-times theology significantly predicts resistance to government action aimed at curbing global warming,” which clearly remains an issue in the U.S. and elsewhere [7, p. 272].
comprehensive treaty covering geoengineering governance and research [16, 41, 47, 83], future(s) experiments are certainly possible, if not probable, and some forecasted, sans spectacle, the emergence of the world’s “first geo-vigilante” [74].

Speaking to the conditions of possibility for the Planktos incident, Brand observes, “As soon as climatic conditions become frightening and urgent, geoengineering schemes will suddenly jump from ‘plausible but dangerous’ to ‘dangerous but we have no choice.’ The cost is low enough that a single nation or even a wealthy individual could set in motion a geoengineering project that would affect everyone on Earth” [13]. Echoing Brand’s contention, Cascio reflects, “[…] it is a near-certainty that someone (nation or wealthy non-state actor) will attempt to engage in geoengineering to head off utter disaster, allowing sufficient time for slower preventative solutions to take hold” [17, p. 21]. Similarly, Deudney and Grove contend, “[…] actors could unilaterally select geoengineering projects for their distributonal advantages, thus turning climate change into a realm of zero-sum competition” [30]. While the scale and scope of the Planktos incident was much smaller than Brand, Cascio, and Deudney and Grove forecasted, the event clearly has global implications for the future(s), even though the intended outcome was intensely more minute and present-centric. As Specter reports, the goal of the project, and Planktos in general, was to generate “lucrative carbon credits to trade on international markets” [78].

Given the complexities of global warming and recalcitrant uncertainties surrounding geoengineering events like the Planktos incident, global weirding is a fitting moniker for the emerging meshwork2 of (1) increasing technological advancement, dependence, and ubiquity, (2) impending ecological catastrophe(s), and (3) the transnational drive and reach of postnormal actants, such as Planktos, enlivened by the confluence of both actual and perceived conditions concerning the present and future(s) of the planet’s life systems, which are increasingly affected by the postnormal triumvirate of “complexity, chaos and contradictions” [74, p. 436]. Simply put, global weirding calls into question both the actual and perceived geo-normativity3 of the global climate system. One might expect that as things get weirder that there will likely be further entrenchment on both sides of the debate (organic gardening vs. rocket science), but a critical tipping point, such as the rampant and sudden melting of permafrost [11], could shift perspectives, forge uneasy alliances, and enliven hasty initiatives.4 As such, global weirding refers explicitly to the relational ecologies underlying complex events like the Planktos incident, which raises contradictions within international governance and regulatory regimes and points toward the chaos enlivened by non-statist, corporate, and unilateral, which is also to say complex, actants engaging in postnormal command-and-control.

3. Command: anthropocene vs. technopocene

We have modified our environment so radically that we must now modify ourselves in order to exist in this new environment. […] Progress imposes not only new possibilities for the future but new restrictions. —Norbert Wiener (1950) [91, p. 46].

In response to the nearly absolute scientific consensus [62] that human activity is the primary driver of global warming and, by extension, climate change, a 2008 petition was put forth by the Stratigraphy Commission of the Geological Society of London to have the Anthropocene listed as the most recent epoch of the geologic time scale [63, 95]. Although the term remains unofficial, Crutzen and Stoermer’s [20] neologism is omnipresent among scholars, scientists, and futurists.5 Consequently, the Anthropocene has assumed “a focal point in the culture wars over the recognition and interpretation of environmental process,” specifically the decidedly human role impact upon the global climate system [6, p. 61]. While the Anthropocene Working Group from the International Union of Geological Sciences is still working to decide the fate of the Holocene, which will be announced and likely voted on at the International Geological Congress in 2016, Crutzen and Stoermer’s ubiquitous neologism has become “widely accepted in the global change research community,” although the Anthropocene’s rising omnipresence within popular culture, especially media outlets, masks the ongoing controversy over its still “informal” status, which has sparked a debate about pinpointing an acceptable origin and gestures toward the immense ethico-political, if not existential, implications of establishing a new geologic era [80, p. 843].

For most, the Anthropocene has roots within the Industrial Revolution, specifically the advent of the steam engine (1784), which is when “polar ice showed the beginning of growing global concentrations of carbon dioxide and methane” [21]. Ruddiman, however, posits, “the Anthropocene actually began thousands of years ago as a result of the discovery of agriculture and subsequent technological innovations in the practice of farming,” which links major societal disruptions, such as plagues in Europe during the Middle Ages, and “anomalous gas trends” found in ice-core records [73, p. 261]. Contending that the “golden spikes for the Anthropocene” ought to be found in the ground, Certini and Scalenghe argue that

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2 Framing the meshwork as an assemblage producing both consistency and change, De Landa notes, “Unlike simple autocatalysis, a closed loop displays not only self-stimulation but also self-maintenance; that is, it links a series of mutually stimulating pairs into a structure that reproduces as a whole” [28, p. 67].

3 Calling into question the implicit and explicit privilege heterosexual frameworks have on rendering the social, Warner argues, “heteronormativity has a totalizing tendency that can only be overcome by actively imagining a necessarily and desirably queer world” [87]. Geonormativity, then, refers to the power that both actual and perceptual norms regarding the global climate system have had in limiting responses to global warming.

4 Noting the fragile state of affairs in the Arctic, Mckee observes, “As permafrost and glaciers thaw due to the centuries-long accumulation of greenhouse gases, new deposits of long-frozen energy-resources (especially coal and natural gas) become more easily available for corporate exploitation, thus creating a massively unsustainable feedback-loop between profit-driven resource-extraction and the biospheric life-support systems of the planet” [55, p. 91].

5 Slaughter’s recent “Welcome to the anthropocene” article certainly speaks to this point [77].

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the most prudent start date is when “much of the terrestrial surface of the planet was altered appreciably by organized civilizations” [18, p. 1273]. In many ways, this debate centers on scale, or the relative degree to which human activity” upon the global climate system has been impactful, and the debate concerning the interpretation of ice-core data speaks to the politicization of the Anthropocene as an intended and presumed driver of change.

What is at stake in this debate underlies one of the central questions of geoengineering: if humans have been altering the environment appreciably since the advent of agriculture, then why would we not actively and purposefully continue to do so to avert crisis, especially if human activity is likely “driving the sixth major extinction event in Earth history” [80, p. 843]. Ultimately, this query centers on command—the perceived and actual capacity for geoengineering actants to assume responsibility for the global climate system. Clearly, one of the biggest assumptions of this line of thinking centers on the contention that humans have always-already been geoengineering, albeit poorly, as record atmospheric CO₂ concentrations and forecasts for the future(s) suggest [3]. Understanding command as capacity is key as it frames both perceived and actual matters of fact—objects that are taken for reality—and matters of concern—potentialities that are given presence. From this perspective, the IPCC's forecasts have more weight as matters of concern than matters of fact, and the former are more useful for understanding how the latter’s relational ecologies emerge. However, approaches to command vary widely from organic gardening (unilateral strategies and tactics that support and enhance actual and perceived natural processes) to rocket science (strategies and tactics that account for the workings of complex systems and posit responsive, if not daring, solutions). In either case, it is clear that the debate over the origin of the Anthropocene has implications for the institutionalization of possible geoengineering remedies as the issue turns from a question of when to start geoengineering? to how might we do a better job?

If part of the intent of the Anthropocene is to enliven a sense of responsibility toward the human impact on the global climate system, then Berthon and Donnellan’s Technopocene, which was coined to engender “a new level of mindfulness on the part of humans for themselves and their technological offspring,” provides some conceptual clarity for the Anthropocene debate [9, p. 5]. By affirming the primacy of command inherent to human activities, which has never limited itself to natural processes, the Technopocene provides a more acute diagnosis, and perhaps prognosis, for the postnormal symptoms of global weirding. As this relates to the “rocket science” pole on the spectrum of command for charting alternative futures of geoengineering, the Technopocene beckons an Earth Systems Engineering and Management (hereafter ESEM) perspective, which expresses at its core “a basic, if disconcerting, truth: the Earth, as it now exists, is a product of human design” [3, p. 16]. Aligning with Anderson’s charge that humanity must learn “to govern evolution” [5] and Dator’s call to assume “responsibility for our rise” [25], an ESEM capacity draws on “a number of principles from fields such as industrial ecology, adaptive management, and systems engineering that can be relied on to enable rapid progress in developing such an approach” [3, p. 186].

While many might find this approach preferable given the uncertainties of global weirding, ESEM is not without detractors. As Hamilton contends, “there is something deeply perverse in the demand that we construct an immense industrial infrastructure in order to deal with the carbon emissions from another immense industrial infrastructure, when we could just stop burning fossil fuels” [41, p. 50]. Echoing Hamilton’s critique and specifically noting concerns over the scope of geoengineering’s implicit command, Shiva observes, “The problem of geoengineering or genetic engineering is a bunch of experts sitting with a bunch of corporations saying, ‘We’ll decide on behalf of the people’” [75]. In spite of such concerns, The Royal Society’s highly influential 2009 report backs geoengineering “as part of a wider package of options for addressing climate change” as even if the world capped and/or stopped all CO₂ emissions at present levels, global warming would continue for years to come [72]. Hamilton’s wariness of ESEM’s “utopian techno-enthusiasm” and Shiva’s critique of the corporate–industrial complexes promoting intervention offers an incisive critique, although they both might underestimate the severity of the IPCC’s forecasts (matters of concern) and the political realities of the present (matters of fact) [41, p. 111]. As Parson and Keith argue, “If research is blocked, then in some stark future situation where geoengineering is needed, only unrefined, untested, and excessively risky approaches will be available” [65, p. 1279]. As outspoken proponents of geoengineering research, Parson and Keith’s invocation of a worst-case scenario speaks directly to concerns surrounding the Planktos incident and George’s postnormal perspectivism, which has earned him the nickname, “Greenfinger” [37].

Downplaying the critiques raised by Hamilton and Shiva and cementing the Greenfinger ethos of those in support of research, Goodell notes, “Geoengineering may well turn out to be yet another tool of dominance, a newfangled way for

6 If global impact is, at least for some, a necessary criteria for establishing the origins of the Anthropocene, then there is perhaps another metric for establishing a new geologic era. As Zalasiewicz et al. observe, “From a practical viewpoint, a globally identifiable level is provided by the global spread of radioactive isotopes created by the atomic bomb tests of the 1960s; however, this post-dates the major inflection in global human activity” [94].
7 The IPCC’s AR4 forecasts an increase in both the frequency and magnitude of extreme weather events that can and likely will severely impact the projected “1.8 to 5.2 billion” people living in low-lying coastal regions “by the 2080s” [61, p. 317].
8 As Latour observes, “Appealing to realism is never enough, since it means throwing together in one package multiple matters of concern as well as unified matters of fact. So, when people doubt the existence of ‘nature’ and ‘outside reality’, you never know if they are contesting the premature unification of matters of concern under the hegemony of matters of fact, or whether they deny the multiplicity of entities revealed by the sciences. The first is indispensable, the second is plain silly” [48, p. 254].
9 Greenfinger is a play on Goldfinger, the infamous villain from the 1964 James Bond film of the same name. While George deploys this moniker tongue-in-cheek, a report filed in The Guardian suggests that he misled members of the Haida Nation, who supported the project thinking it would “environmentally benefit the ocean, which is crucial to their livelihood and culture” [54].
human beings to screw things up even faster. But it does not have to by that way. As David Keith said to me as we were riding up a ski lift one day, "We're in the gardening business now, damn it!" [38, p. 220]. If command is tantamount to capacity, particularly the perceptual and actual willingness and means to enact change, then the Technopocene versus Anthropocene distinction is useful for reifying the poles of the Y-axis, and ESEM certainly belongs at the rocket science pole while Greenfinger belongs at the organic gardening end.

4. Control: mother nature vs. ecosophical ethics

If the seventeenth and early eighteenth centuries are the age of clocks, and the later eighteenth centuries and nineteenth centuries constitute the age of steam engines, the present time is the age of communication and control. — Norbert Wiener (1948) [90, p. 39].

When mass protests erupted across the Middle East and North Africa in the early months of 2011, many were surprised at the intensity and scale of the events, especially in Egypt where draconian emergency laws had been forcefully upheld since 1967. While many were quick (and still choose) to call the Egyptian uprising the world’s first “Facebook Revolution” due to the prominent role social media played in disseminating information and organizing participants there and elsewhere, global weirding also played a critical role in creating the conditions of possibility for the postnormal events commonly known as “the Arab Spring” [82]. If anything is to be learned from the ongoing struggles in Egypt and elsewhere, it is that regional weather events can (and should now be expected to) have global consequences. As a joint report by the Center for American Progress, The Stimson Center, and The Center for Climate and Security explains, “a once-in-a-century winter drought in China reduced global wheat supply and contributed to global wheat shortages and skyrocketing bread prices in Egypt, the world’s largest wheat importer. Government legitimacy and civil society in Egypt were upset by protests that focused on poverty, bread, and political discontent” [89, p. 7]. While the authors are careful not to argue that climate change directly caused the revolts, the correlative link between the two is certainly noteworthy and speaks to the postnormal ways with which global weirding demands an attentiveness to the relational ecologies that comprise complex systems. Indeed, food was an integral part of the insurrections in Tunisia, which are often traced back to the self-immolation of Mohammed Bouazizi, a street vendor whose “unlicensed vegetable cart” was confiscated by the country’s tyrannical police force [1].

While the events underlying and surrounding the actions of a single food-cart owner should not be undervalued, the dynamics underlying the events of the Arab Spring are decidedly complex, and questions surrounding what might happen if “food prices spiral and longstanding agricultural practices are disrupted by climate change” are moving from possible to probable [86].

Although Deudney [29,31] argues that human relations with nature have always been at the center of politics, the recent emergence of environmental security and conflict as an area of political inquiry speaks to the future(s) uncertainties of the global climate system, which makes both the fragility and fury of Mother Nature national security issues [51,56,70]. Offering a polemic perspective on this tension within the environmental/national security discourse, Deudney argues, “Environmental degradation is not a threat to national security. Rather, environmentalism is a threat to ‘national security’ mindsets and institutions” [29, p. 475]. In realigning the discourse on environmental security and conflict, Deudney’s counter-intuitive contention portends the rising proactivity and responsiveness of military and intelligence actants toward environmental phenomena [2,33,42,56,93]. As Dalby observes, “in military terms, failure to plan for worst-case scenarios for climate change is an abrogation of institutional responsibility by the militaries of many states. Failure to control greenhouse gases will likely have security consequences as grave as the world wars in the twentieth century” [23, p. 149]. While Deudney argues that fears over the proliferation of strife related to global warming are overstated, Dyer argues that “the first and most important impact of climate change on human civilisation will be an acute and permanent crisis of food supply,” which will lead to regional unrest, instability, and conflict—perhaps not unlike the events of the Arab Spring [33, p. xi]. Dalby and Dyer’s attentiveness to the fury and fragility of Mother Nature offers a point of entry for linking global weirding’s matters of concern to the presumed matters of fact within the emergent environmental/national security discourse [24,33,58].

What is at stake in this linkage underlies one of the central questions of geoengineering: if statist, military, and intelligence forces are some of the most likely and capable actants, then what measures can and might ensure that remedies are not used in support of specific, which is to say state-centric, ends other than averting global-scale crises, since some argue that, “like abortion, geoengineering should be ‘safe, legal, and rare’” [13]. Ultimately, this query centers on control—the capacity for geoengineering actants to respond prudently to feedback from the planet’s life systems, including human ecologies. While it might seem obvious that these communicative processes can and ought to be open and transparent, this is by no means the standard purview among statist, military, and intelligence actants. As Cascio quips, “At best, geoengineering would be a trigger for loud debates on the floor of the United Nations and between television pundits; at worst, it would be a catalyst for war” [17, p. 24]. While neither Cascio’s best or worst case scenario have yet to come to pass, a

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10 As The Non-technical Briefing Notes for a Workshop at the Council on Foreign Relations observes, “A nation that has not done much to prepare, either in reducing its contributions to global emissions or in building adaptive capacity, might conclude that the consequences of climate change had become sufficiently severe that it was going to unilaterally engage in geoengineering — imposing large negative externalities on the rest of the world in order to reduce its own impacts [70, p., 9].
variety of statist and military actants have already sought out means to shape, if not control, the fury and fragility of *Mother Nature* for their “distributional advantage” [30].

Speaking at the 1997 *Conference on Terrorism, Weapons of Mass Destruction, and U.S. Strategy*, then U.S. Secretary of Defense William Cohen famously noted, “Others are engaging even in an eco-type of terrorism whereby they can alter the climate, set off earthquakes, volcanoes remotely through the use of electromagnetic waves” [19]. Although the United Nation’s 1978 “Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques” or Environmental Modification Convention (ENMOD) ostensibly makes such initiatives illegal [40], only 76 countries are signatories to the treaty and conspiracy theories abound in light of the U.S.’s use of this tactic during the Vietnam War, which was the impetus for the treaty [84]. If the discourse of national/environmental security offers any insight, it is that the willingness of statist, military, and intelligence actants to be forthcoming, even at the expense of their particular interest, will come to define *control* in an age of global weirding. While ENMOD was specifically enacted to prevent the weaponization of *Mother Nature*, ecological militarization remains a possibility, and if large-scale climate engineering projects were adopted, securitization would be necessary to abate sabotage and/or terrorism, which is to say that power often begets resistance.

Returning to Deudney’s point that environmentalism poses a threat to national security, the possibility also exists that geoengineering efforts, if multilaterally prescribed and globally supported, could engender a “planetary ethic” that never materialized around efforts to reduce CO₂ emissions [3, p. 170]. There have been many attempts, notably Lovelock and Margulis’ “Gaia” hypothesis, to forge a planetary ethic, but few, if any, take note of the postnormal prospects of global weirding, which calls into question the maternal fidelity of *Mother Nature* [53]. Noting the impacts and implications of the child becoming the parent, Guattari envisages an *ecosophical ethics*, since:

In the future much more than the simple defence of nature will be required; we will have to launch an initiative if we are to repair the Amazonian ‘lung’, for example, or bring vegetation back to the Sahara. The creation of new living species—animal and vegetable—looms inevitably on the horizon, and the adoption of an *ecosophical ethics* adapted to this terrifying and fascinating situation is equally as urgent as the invention of a politics focused on the destiny of humanity [39, p. 66–7].

Guattari’s gesture toward affect (terrifying versus fascinating), attentiveness to scale (repairing the Amazonian ‘lung’ versus dealing with new living species), and emphasis on praxis (bringing vegetation back to the Sahara) provides a useful rejoinder to *Mother Nature/Gaia*, which posits the “notion of the biosphere as an active adaptive control system able to maintain the Earth in homeostasis” [53, p. 3]. As it is precisely the equilibrium of *Gaia* that global warming weirds, critical perspectives on *Mother Nature* grant purchase on control’s postnormal matters of concern. Problematizing the earth’s presumed geonormativity, Miller contends, “The earth is not a super-organism. It is not an organism at all. It is best understood as an extremely complex machine that is capable of going autodestructively berserk, at least from the limited perspective of human needs” [57, p. 89]. As earthquakes, volcanoes, and the occasional meteor suggest, ours is a world of radical vicissitudes, which is also to say contingent, emergent, and dynamic matters of concern; control, then, speaks to the degree to which uncertainties are forecasted, heeded, and ultimately combated. At the rocket science pole of *control* (*X*-axis), then, one finds an *ecosophical ethics*—an attentive and adaptive enterprise aimed at openly and transparently managing the planet as machine. On the other end, one finds *Mother Nature*, whose organismic being, even if only perceived, is respected for its fragility and fury.

5. Scenarios

In 2011, the IPCC sponsored an *Expert Meeting on Geoengineering* in Lima, Peru [43]. The meeting report, whose findings will be incorporated into AR5, addresses challenges inherent to forecasting alternative futures and speaks to the difficulties in isolating a prudent, plausible, and/or probable time horizon for the diffuse effects of global weirding. As Boucher et al. observe, “As the deployment of some geoengineering technologies could have profound long-term implications for global society, assessment of the proposed methods will need to consider timescales extending at least up to, and likely well beyond, 2100” [12, p. 4]. In light of the IPCC’s assessment, the alternative scenarios herein do not have specific timeframes but generally conform to Mânoa School’s “20–50 year time horizon,” which given the postnormal dynamics inherent to global weirding could very well be sooner rather than later [26, p. 2]. As with geoengineering, two of, if not, the most...

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11 As Simons reports, “During the Vietnam war, the Americans launched Project Popeye, a secret mission to seed the tops of monsoon clouds and trigger phenomenal downpours that would wash away the Ho Chi Minh Trail used for ferrying supplies” [76].

12 On October 2, 2001, U.S. Congressional Representative Dennis Kucinich (D – OH) put forward H.R.2977, which asked for a ban on “space-based weapons” and “exotic weapons systems,” including “chemtrails,” “extraterrestrial weapons,” and, most importantly for the purposes of this project, “environmental, climate, and tectonic weapons.” As the measure did not pass, it was substantially re-written and introduced during the second session as H.R. 3616. As all direct mention of chemtrails were not part of the second bill, conspiracy theories continue to proliferate. The complete text of both bills are available online. H.R.2977: [http://thomas.loc.gov/cgi-bin/query/z?c107:H.R.2977:]: H.R.3616: [http://thomas.loc.gov/cgi-bin/query/D?h107:1.:temp/ --c107JE0Vd/]

13 As Fleming observes, “The United Nations Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (ENMOD), which entered into force in 1978, […] may have to be revisited soon to avoid or at least try to mitigate possible military or hostile use of climate control or geoengineering” [34, p. 166].

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apparent, yet recalcitrant, concerns surrounding climate change are: how bad? and how soon? While the National Oceanic and Atmospheric Administration (NOAA) estimates that the IPCC’s Arctic sea ice projections may be off by as much as 30 years, worst-case forecasts, which are becoming more common, remain just that—projections based on the best available data for a complex system undergoing dynamic change [60]. As this relates to the scenarios, each of the four futures offered herein presumes that future(s) climate changes are adversely impacting the planet’s interconnected life systems and doing so to such a degree that geoengineering is under serious consideration and/or already enacted in some way, although responses still vary according to the rocket science versus organic gardening distinction. This postulate moves the emphasis of each scenario to the ways in which actants might enable and enact geoengineering given the interstices of the command (Y) and control (X) axes.

Another critical question that needed answering before composing the scenarios was: what kinds of geoengineering are possible, probable, and plausible? While these two categories garner much of the attention and debate among scholars and scientists, highly localized weather modification practices, primarily those dealing with the water cycle, also merit serious consideration, especially as they have become increasingly common around the world. Although geoengineering is defined as efforts “to attempt large scale human control of either biogeochemical cycles or the climate itself,” local and regional weather modification practices are framed herein as geoengineering and, as such, figured heavily into the development of the scenarios, which were deeply influenced by the Mānoa School four-futures method [88, p. 45].

Developed by Jim Dator, Director of the Hawaii Research Center for Futures Studies, who “along with many other early futurists were trying to make sense of the many often conflicting images of the future that [they] encountered,” the Mānoa School four-futures method provides a mechanism for contextualizing and ultimately categorizing various “images of the future,” [26, p. 5]. Emphasizing the importance of alternatives in breaking the tyranny of the present, which is also to say expectations that growth models constitute the future, Dator contends that “each generic form has a myriad of specific variations reflective of their common basis,” which is to say that the generic forms are useful for thinking critically about the possible and potential, perhaps more so than the plausible and probable, outcomes of dynamic change [26, p. 7]. Granting equality among each of the four generic forms is paramount, which is to say that each ought to be viewed as likely as the others. With the above in mind and using the command (Y-axis) and control (X-axis) axes to constitute a 2 × 2 matrix, the Mānoa School’s Seven Driving Forces Matrix (see Table 1) was used to match each quadrant with one of the Mānoa School’s four generic forms (Transform, Growth, Discipline, Collapse) based on resonances between the governance, technology, and environment driving forces and the respective poles (rocket science versus organic gardening) of each quadrant [27]. For example, the Transform future was clearly best situated within the rocket science (command) and rocket science (control) quadrant as it denotes direct governance, transformative technology, and an artificial environment (see Table 2).

Providing additional complexity for each scenario and combating the “flatland” critique of the 2 × 2 method, the Mānoa School generic forms “differ from each other fundamentally in cosmology, epistemology, and often deontology,” although the driving forces are consistent to show the divergent possibilities within core matters of concern [26, p. 7]. In crafting the scenarios for this project, more attention and emphasis was given to the interstices between the three most impactful driving forces (governance, technology, and environment) and how they fit with each quadrant along the command and control (2 × 2) matrix (see Table 3). As a means to fill in the content of the Mānoa School forms, trends and emerging issues were drawn directly from IPCC reports and the research informing the command and control axes [8,43–46,61,92]. Furthermore, these scenarios were specifically composed for incasting, which is to say that they were “written very generally” such that the reader can “add details to the scenarios, using their creative imaginations and the rule of logical consistency with the described characteristics of each scenario” to explore interconnections between the possible, probable,

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14 According to the report from the Expert Team on Weather Modification Research for 2012/2013 from the World Meteorological Association, as of June 2013, there are currently “42 countries with active weather modification projects” [14].
15 Noting the many and varied critics of the 2 × 2 method, Curry and Schultz explain, “The best known, Richard Slaughter (2004), follows Ken Wilber in describing the approach as creating what he calls ‘flatland’; a set of future worlds in which ‘current ideologies … were insufficiently problematized and seen as natural’” [22, p. 42].
16 Developed by Jim Dator to empower foresight workshop participants to inhabit and enliven subject positions within alternative life-worlds, incasting “is designed to increase the flexibility with which people plan for the future, and to increase their creativity in making use of both opportunities and challenges emerging from change” [22, p. 49].

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plausible, and, most importantly, the preferable.\textsuperscript{17} While each scenario presents a particular subject position, the scenarios are inherently and intentionally limited and were crafted to raise questions rather than provide answers, which is precisely the purpose they serve in Ma\textsuperscript{-}noa School workshops.\textsuperscript{18}

5.1. Transform scenario

In response to forecasts of dramatic sea-level rise, large-scale climate mitigation remedies have become widely viewed as necessary and welcome given the potential impact on coastal communities, especially within the Asia-Pacific region. As the engineering and governance heir to the IPCC, the Global Knowledge Collective (hereafter GKC) grew out of an Asia-Pacific Economic Cooperation (APEC) forum and has been charged with the design, development, and diffusion of global warming mitigation strategies and tactics. With overwhelming public support and an unlimited reservoir of funding, the GKC's first initiative is a massive, open-source gaming platform to crowdsource the best solutions. As a means of connecting the global research community with the public at-large, which spends most of its time learning, working, and playing within a variety of artificial media environs, the GKC developed an expansive gaming/educational research interface centered on analyzing real-time climate data, identifying weak points in proposed remedies, and modeling alternative futures to map the social and political impacts. As the GKC's game drew to a close, the Yangon node's Solar Radiation Management Proposal (hereafter SRMP) emerged as the clear winner, and the top design, which is expected to restore Arctic sea-ice during Summer months for the first time in a generation using stratospheric sulphate aerosols, will be deployed in the coming weeks. From design to diffusion, SRMP will take only three months but must be maintained and managed indefinitely to prevent a spike in global average temperature should atmospheric carbon levels rise. As control of the planet's collective "thermostat" has been put directly in the hands of the GKC, which has no regulatory oversight other than its open-source constitution, concerns have been raised about the possible risks of SRMP. While some teams expressed concern that the voting system had been hacked,

\begin{table}[h]
\centering
\caption{2 × 2 Matrix with “Ma\textsuperscript{-}noa School” generic form and primary driving forces.}
\begin{tabular}{|l|l|l|l|}
\hline
\textbf{Transform} & \textbf{Disciplined} & \textbf{Collapse} & \textbf{Growth} \\
\hline
\textbf{Direct governance} & \textbf{strict governance} & \textbf{local governance} & \textbf{corporate governance} \\
\textbf{Transformative technology} & \textbf{restricted technology} & \textbf{stable technology} & \textbf{accelerating technology} \\
\textbf{Artificial environment} & \textbf{sustainable environment} & \textbf{overshot environment} & \textbf{artificial environment} \\
\textbf{ESEM (rocket science)} & \textbf{Ecosophical ethics (rocket science)} & \textbf{Ecosophical ethics (organic gardening)} & \textbf{Ecosophical ethics (organic gardening)} \\
\textbf{Ecosophical ethics (rocket science)} & \textbf{Ecosophical ethics (organic gardening)} & \textbf{Mother Nature (organic gardening)} & \textbf{Mother Nature (organic gardening)} \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Comparative scenario chart.}
\begin{tabular}{|l|l|l|l|}
\hline
\textbf{Transform} & \textbf{Growth} & \textbf{Disciplined} & \textbf{Collapse} \\
\hline
Direct governance & Corporate governance & Strict governance & Local governance \\
Transformative technology & Accelerating technology & Restricted technology & Stable technology \\
Artificial environment & Conquered environment & Sustainable environment & Overshot environment \\
ESEM (rocket science) & Greenfinger (organic gardening) & ESEM (rocket science) & Greenfinger (organic gardening) \\
Ecosophical ethics (rocket science) & Ecosophical ethics (organic gardening) & Mother Nature (organic gardening) & Mother Nature (organic gardening) \\
\hline
\end{tabular}
\end{table}

\textsuperscript{17} As one of the hallmarks of the Ma\textsuperscript{-}noa School method, the articulation of a preferred future, which, as Dator explains, is "the point of the exercise overall" [26, p. 12].

\textsuperscript{18} Noting the particular flow of the Ma\textsuperscript{-}noa School method, Dator argues, "the four futures exercise […] is intended to be part of an overall process that begins with examining the past and present of an organization or community, and is followed by a preferred futures visioning exercise which is itself followed by activities that use the alternative futures, and especially the preferred future, as the basis of a strategic planning process" [26, p. 14].
the winning design has the backing and blessing of the GKC’s AI (artificial intelligence) administrator. With the rise of the GKC and the adoption of SRMP, an Earth Systems Engineering and Management (ESEM) approach has finally emerged. As many, if not most, welcome the prospect of the planet fully in human hands, an ecosophical ethic has organically developed, and many see a shift in values as integral in orchestrating and maintaining support for large-scale climate engineering initiatives.

5.2. Growth scenario

A dramatic increase in both the frequency and intensity of extreme weather events, such as droughts and super storms, led to the emergence of the Central Climate Market (CCM), which is governed and regulated by a cabal of multinational corporations, such as the ROTAD Corp. As public funding for research is nonexistent, the CCM has become the sole source of research and development, and real-time climate data is made available at market rates for clients seeking to combat the diffuse effects of global warming. As the design and diffusion of geoengineering remedies are priced according to risk matrices overseen directly by the CCM, it has become, for better or worse, the global governance and regulatory body on all matters pertaining to the climate system. Although some remain critical of the CCM’s monopoly, when atmospheric carbon levels surpassed 500-parts-per-million, the world’s few remaining nation-states quickly realized that efficiency and sequestration measures were grossly inadequate, and the CCM held an auction to sell off majority shares in the few remaining publicly managed governments. While some remain weary of the aegis of corporate governance, many see the CCM’s market-based solutions as the only way to overcome decades of regulatory gridlock and governance inaction. Although the CCM has effectively taken over management of the global climate system, tensions over competing interpretations and subsequent action on CCM’s data have fueled guerrilla-style conflicts with resistance groups seeking to topple the CCM’s hegemony. While part of CCM’s contracting grants it the ability to enforce regulatory and governance oversight with extreme prejudice, these armed incursions have stretched the capacity of CCM’s private security detachments, which collectively constitute the world’s largest para-military force. A highly publicized cyberattack, which was orchestrated by one of the resistance groups, stalled the release of climate data, and rumors have spread about the CCM’s internal stability. In response to the rumors, ROTAD was quick to dispel concerns over the CCM’s possible dissolution, and as the largest stakeholder in the CCM, some expect that ROTAD might take control. Complicating things further, there have been unconfirmed reports of piracy within Arctic shipping routes, and leaked reports show that two of CCM’s Pacific cloud-seeding vessels, which play an integral part in CCM’s solar radiation management initiative, have gone offline.

5.3. Disciplined scenario

Historic flooding, which some argue was the result of widespread weather modification efforts around the world, coupled with seasonally abnormal temperatures across much of the Northern Hemisphere have been blamed for the emergence of a contagion, H4Z1, that quickly swept across six continents infecting billions and killing hundreds of millions. Following the worst of the H4Z1 outbreak, authoritarian social measures, bordering on martial law, were kept in place to maintain some semblance of order, or the tenets of the old geopolitical order, which some argue was derelict in not heeding highly-publicized reports warning of the potential for such an outbreak. With much, if not most, international travel and shipping halted due to concerns over a recurrence, an emergency meeting of the U.N. Security Council was called to discuss measures for moving forward and preventing future(s) crises. A recurrent theme among officials speaking at the talks was “our collective betrayal of Mother Nature,” and while some see the myriad challenges ahead as an opportunity for humanity to take the reigns of the biosphere, both the policy suggestions and action plans that came out of the emergency gathering clearly leaned in the opposite direction, especially with regard to large-scale climate engineering initiatives, although carbon sequestration forestalled emissions in the past. While some argued that prudent geoengineering could have prevented the H4Z1 outbreak, most find this notion worrisome given the potential risks and socio-ethical implications. Although advanced climate modeling efforts, which utilize an Earth Systems Engineering and Management (ESEM), provide extremely accurate climate data, there is no widespread public support and subsequent political will to govern Mother Nature, so to speak. While some worry that the confluence of austerity economics, autocratic politics, and strictly enforced treaties governing research on geoengineering, including formerly widespread practices such as cloud seeding, may leave the world vulnerable to future(s) crises, especially sea-level rise, the lack of public support and political will for large-scale climate mitigation efforts has effectively killed the potentiality for a robust research agenda, which has drawn sharp criticism from those worrying about uncertainties for the future(s). Conspiracy theorists have pounced on reports linking geoengineering and H4Z1, which adversely impacted urban communities in East and Southeast Asia, and some have gone so far as to argue that it was intentionally engineered.

5.4. Collapse scenario

The failure to prevent the rapid melting of permafrost has dramatically increased atmospheric carbon levels, and although a unilateral effort to manage solar radiation was hastily enacted by a private firm, who received support from the remnants of a regional governance alliance, the project was ultimately unsuccessful and enacted too late to stop the oceans from rising. As sea-level rise overtook many low-lying coastal areas across the Asia-Pacific region, the Caribbean, and Europe,
an unprecedented refugee crisis has completely incapacitated and overloaded the international order. While plans to stabilize nuclear reactors were widely adopted following the Fukushima Daiichi incident, not all sites, including a few along the coastal U.S., were unable to accommodate increased coastal surges compounded by global warming, which raised ocean temperatures and has led to more frequent and severe storms. As both international and national governance frameworks have been unable to cope with the scale and scope of these systemic crises, which has led to food and energy shortages, the flow of information to the public about the instability of the global climate system has been ceased to prevent further discontent. While much of the world struggles to navigate cataclysmic changes, some communities focused on resiliency and planned ahead for worst-case scenarios. A handful of inland urban centers have been able to maintain silvers of life as it was before the waters rose. With little certainty concerning long-term climate stability, these post-apocalyptic city-states put Mother Nature first and eschew what they deem to be unnatural means of living, which is to say that they reject any technology they consider to be unnatural. While some parts of the world have looked into the past to find sustainable trajectories for the future(s), other forms of local governance have emerged. In parts of Europe, South America, and sub-Saharan Africa, military have taken power, and as the refugee crisis has broken down national borders and boundaries, the rush to stabilize resource access, especially to energy and clean water, has led to armed conflict and further ecological degradation. In the wake of systemic collapse, seven deep-ocean oil rigs, including three in the South China Sea, are leaking either to abandonment and/or misuse by those seeking a stable source of energy.

6. Conclusion

In simple language, to have power means not to have to give in, and to force the environment or the other person to do so. Power in this narrow sense is the priority of output over intake, the ability to talk instead of listen. In a sense, it is the ability to afford not to learn. —Karl Deutsch (1963) [32, p. 111].

Deutsch’s astute, yet self-professed narrow, framing of power speaks to the dynamics of command and control within complex relational ecologies from the global climate system to the geopolitics of the international order and, perhaps most importantly, the interstices between the two. Consequently, Deudney and Grove find “theory and policy” corollaries between geoengineering and the nuclear buildup of the mid-20th century, and the possibility of sudden and severe climate change, not to mention the variety of potential responses to it, portend potentially Herculean matters of concern, which has led some in favor of geoengineering to wield the armament analogy [30]. In response to the ongoing deadlock concerning geoengineering research, Parson and Keith reflect, “Geoengineering is not arms control, at least for now. But if states fail to build cooperation and transparency now when stakes are low, it could become as difficult and fraught as arms control, or more so, in some future of severe climate change” [65, p. 1279]. Although Parson and Keith go on to note the troubling shadow cast by the Planktos incident upon those wanting to carry out transparent research, their appeal to the armament analogy speaks directly to the convergence of postnormal forces endemic to global weirding, which George’s “organic gardening” experiment embodies [69]. Furthermore, Parson and Keith’s allusion to a worst-case scenario illuminates the postnormal conditions of possibility for the design, development, and deployment of geoengineering initiatives, but their appeal to arms control also gestures toward the immense ethico-political ramifications of past experiments, particularly those with grave consequences. As Brigadier General Carter W. Clarke recounts, “we didn’t need to do it, and we knew we didn’t need to do it, and they knew that we didn’t need to do it, we used them as an experiment for two atomic bombs” [4, p. 359]. Given General Clarke’s reckoning of America’s nuclear experiment, the armament analogy is at once too simple and, yet, not complex enough, which is to say that geoengineering ought to be viewed alongside critical international issues such as arms control and, as it were, something that is uniquely postnormal.

If there is one lesson to be drawn from the Planktos incident, it is that geoengineering is beholden to the complexities of our postnormal age, which is also to say the weird(ing) power relations enlivened by times of radical uncertainty. Given the immense risks of geoengineering, which some still see as the best, or rather the best of the remaining, option(s) for mitigating severe climate change, others argue that humanity should also look within, which is to say bioengineering humans for life upon a mid- and post-climate change world as such measures are “potentially less risky than geoengineering and […] could make behavioral and market solutions more likely to succeed” [52, p. 218]. While many might find the notion of enhancing empathy or bioengineering an intolerance to carbon-intensive products, such as meat, highly objectionable, others [41,75] clearly view geoengineering with the same disdain and pessimism, which speaks to the postnormal triumvirate of “complexity, chaos and contradictions” inherent to global weirding [74, p. 436].

Whatever courses of action, if any, are employed to confront and ultimately combat global warming, the Planktos incident demonstrates that global weirding will do much to hasten the process by which decisions are (or are not) made, which is also to say that time is of essence and, perhaps most importantly, short-term thinking is grossly inadequate. As the Working Group One Contribution to the IPCC’s AR5 warns, “all proposed geoengineering methods also carry risks and side effects. […] There are also many (political, ethical, and practical) issues involving geoengineering that are beyond the scope of this report.” [46]. Given the IPCC’s understandable reluctance to forecast the range of ethico-political uncertainties that many seem to think lie ahead, modeling alternative futures, particularly for incasting, offers a critical lens from which to begin to think about the challenges and opportunities of the future(s), even, and perhaps especially, if only to imagine radical possibilities and their preferability. As Carlarne observes, “the relative absence of applicable pre-existing governance institutions [with regard to geoengineering] allows policymakers great flexibility to test the boundaries of existing systems.
of law and to develop a novel governance regime” [16, p. 668]. Deutsch’s take on power, then, offers a cogent parable for geoengineering, and if power is the ability to afford not to learn, then exploring alternative futures for geoengineering in an age of global weirding offers, at the very least, lessons in postnormal governance.

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