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# Engineering an Artful and Ethical Solution to the Problem of Global Warming

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## Abstract

*The idea of geoengineering, or the intentional modification of the Earth's atmosphere to reverse the global warming trend, has entered a working theory stage, finding expression in a variety of proposed projects, such as launching reflective materials into the Earth's atmosphere, positioning sunshades over the planet's surface, depositing iron filings into the oceans to encourage phytoplankton blooms, and planting more trees, to name only a few. However, geoengineering might not be as promising a solution to the problem of global warming as its advocates claim. Many scientists, policy makers, and ethicists still dismiss the option as infeasible and too risky given the immense scale at which most geoengineering projects must be instituted and the catastrophic consequences that could, in all likelihood, result. The thesis of this article is that geoengineering should not be so easily dismissed in policy debates concerning how to mitigate the anthropogenic emissions of global greenhouse gases. My plan is to investigate the desirability of the geoengineering option for addressing global climate change in terms of its capacity to overcome collective action issues, to accommodate ethical norms, and to provide an artful, or creative, response to the problem. In the first section, a general picture of the global warming problem and the particulars of some proposed geoengineering projects are laid out. The second section frames the issue as a collective action problem that demands an innovative approach to coordinating individual and group action. In the third section, I reveal six ethical quandaries that emerge in global climate change debates and how they complicate any attempts to ameliorate or resolve the problem. The penultimate section shows how the ideas and activism of two twentieth-century titans in philosophy and ecology—John Dewey and Aldo Leopold, respectively—might be combined to address the problem of global warming through artful inquiry and the adoption of an Earth ethic. Finally, I conclude by arguing that a fundamental shift in perspective must occur if we are to take intentional climate change seriously as a possible, even if a second-best, tool in the environmentalist's tool kit.*

**KEY WORDS:** climate change, global warming, geoengineering, environmental ethics

> A spade or a watch-spring is made out of antecedent material, but does not pre-exist as a ready-made tool; and, the more delicate and complicated the work which it has to do, the more art intervenes.
>
> —J. Dewey (1996, MW 10:354)[1]

> My hope is that others will be stimulated to think through the ethics of ICC [Intentional Climate Change of geoengineering].
>
> —D. Jamieson (1996, p. 324)

The idea of modifying the Earth's atmosphere to reverse the global warming trend has, to borrow a phrase from James Bohman (1998, p. 401), come of age. According to Jay Michaelson (1998, p. 76), "the time has come to expand our policy horizons to include geoengineering, the direct manipulation of the Earth's climatic feedback system, as a serious alternative to ineffective and contentious regulation." Indeed, the idea of geoengineering has entered a working theory stage, finding expression in a variety of proposed projects, such as launching reflective materials into the Earth's atmosphere, positioning sunshades over the planet's surface, depositing iron filings into the oceans to encourage phytoplankton blooms, and planting more trees, to name only a few.[2] However, geoengineering might not be as promising a solution to the problem of global warming as its advocates claim. Many scientists, policy makers, and ethicists still dismiss the option as infeasible and too risky given the immense scale at which most geoengineering projects must be instituted and the catastrophic consequences that could, in all likelihood, result (Parr, 2008; Robock, 2008). According to the National Academy of Sciences' Committee on Science, Engineering, and Public Policy (1992, p. 433), "Engineered countermeasures [to global climate change] need to be evaluated but should not be implemented without broad understanding of the direct effects and the potential side effects, the ethical issues, and the risks. Some [schemes] do have the merit of being within the range of current short-term experience, and others could be 'turned off' if unintended effects occur." The thesis of this article is that geoengineering should not be so easily dismissed in policy debates concerning how to mitigate or solve the global warming problem. My plan is to investigate the desirability of the geoengineering option for addressing global climate change in terms of its capacity to overcome collective action issues, to accommodate ethical norms, and to provide an artful, or creative, response to the problem. In the first section, a general picture of the global warming problem and the particulars of some proposed geoengineering projects are laid out. The second section frames the issue as a collective action problem that demands an innovative approach to coordinating individual and group action. In the third section, I reveal six ethical quandaries that emerge in global climate change debates and how they complicate any attempts to ameliorate or resolve the problem. The penultimate section shows how the ideas and activism of two twentieth-century titans in philosophy and ecology—John Dewey and Aldo Leopold, respectively—might help us to address the problem of global warming through artful inquiry and the adoption of an Earth ethic. Finally, I conclude by arguing that a fundamental shift in perspective must occur if we are to take intentional climate change seriously as a possible, even if a second-best tool in the environmentalist's tool kit.

## The Global Warming Problem

That global climate change (GCC) is a problem of immense proportion, potentially threatening the continued existence of the human species, is a fairly uncontroversial proposition today. One would be relatively hard-pressed to find a well-informed individual who was unaware of the problem and some of its dimensions. Nevertheless, skeptics do exist, and skeptical responses, such as denial and discounting in the face of uncertainty, are widespread (Michaelson, 1998, pp. 85–86). However, a consensus that global warming is a problem has grown among scientists and policy makers in the past 50 years, as vivid evidence emerges, such as: (1) fast-melting glaciers and ice sheets, (2) rising sea levels, (3) the earlier bloom of plants, (4) the destruction of animal habitats, and (5) the interruption of migratory bird patterns. Unsurprisingly, these signs have generated fear that we will soon reach a catastrophic global tipping point. According to the authors of a recent article, the predicament can be compared to the task of reducing water in a bathroom tub: "As with a bathtub that has a large faucet and a small drain, the only practical way to lower the level is by dramatically cutting the inflow. Holding global warming steady at its current rate would require a worldwide 60–80 percent cut in emissions, and it would take decades for the atmospheric concentration of carbon dioxide to stabilize" (Victor, Morgan, Apt, Steinbruner, & Ricke, 2009, p. 65). Carbon dioxide, once released into the atmosphere, stays there in excess of 100 years. With the accretion of carbon dioxide and other greenhouse gases (GHGs) from anthropogenic (or human-created) sources, the Earth becomes a virtual greenhouse. Efforts at remediation inevitably lag behind the warming trend.

Nonetheless, governments have responded with regulatory projects and international political agreements that facilitate these projects. The two touchstone treaties regulating global climate change are (1) the UN Framework Convention on Climate Change (UNFCCC), signed in 1992, and (2) the Kyoto Protocol, authorized in 1997. The UNFCCC unequivocally states that developed nations are responsible for "the largest share" of global greenhouse gas emissions, and that future action should aim to reduce emissions based on principles of "equity" and consistent with the "differentiated responsibilities and respective capacities" of parties to the treaty. Shortly thereafter, signatories to the UNFCCC drafted the Kyoto Protocol to make their general commitment to "protect the global climate system for the benefit of present and future generations" more concrete. In the protocol, parties agreed to establish targets for emission reductions, representing an overall 5 percent reduction relative to 1990 baseline emissions, but differentially affecting individual countries based on the level of development, with as much as an 8 percent cut for some countries in the developed North and as much as a 10 percent increase for others in the developing South. Due to a perceived bias against developed nations, the U.S. Senate at first opposed the treaty's ratification, declaring that "meaningful participation" required developing countries to match reductions. In 2001, George W. Bush withdrew the United States from the Kyoto Protocol, marking the first case of out-and-out defection of a developed country from a GHG mitigation regime. Still, Europe has surged ahead with its own innovative, though initially faulty, emissions-trading regime, and there are signs that the United States will attempt a cap-and-trade scheme soon (Bales & Duke, 2008, pp. 80–81; Broder, 2009; Hasselknippe, 2003). Before moving on to consider some of the obstacles to collectively agreeing upon and implementing these schemes, I would like to finish this section by considering various proposals for projects to reduce climate change through intentional manipulation of the Earth's atmosphere.

Proposed geoengineering projects vary widely across at least three dimensions: design, scope, and potential consequences. Here is a sampling of those that have been seriously considered and a brief, though by no means comprehensive, account of each:

1. Solar shields: One possible approach is to launch satellites or solar shields into orbit armed with moveable reflective plates. The result, as some computer models suggest, could be an 8 percent reduction in solar radiation reaching the Earth's surface (Robock, 2008, p. 15; Victor et al., 2009, pp. 68–69).

2. Carbon sequestration: One proposal is to capture and store carbon dioxide deep underground, miles under the surface of the Earth, so that the warming effect of this pollution is effectively removed (Robock, 2008, pp. 14–15).

3. Ocean fertilization: Sometimes called the "Geritol cure," this project would involve depositing iron filings in the ocean as a way to encourage the growth of phytoplankton, which in turn serve as a virtual carbon sink (Coale, 1996).
4. Engineered weathering: Scientists propose to substitute hydrochloric acid for carbonic acid in the oceans, which would in theory speed up the process by which carbon dioxide is absorbed and stored in these water bodies.
5. Stratospheric chemical injection: Proposed by Nobel Laureate Paul Crutzen (2006) and respected climatologist Tom Wigley (2006), this response requires that sulfate aerosols be sent into the second major layer of the Earth's atmosphere, the stratosphere, in order to reflect sunlight and cool the Earth's surface.
6. Launch reflective discs or particles into orbit: Sometimes referred to as the "sunscreen proposal," this project involves placing dust particles or even compact discs into the Earth's orbit in order to reflect solar radiation and cool the Earth's surface. The "Pinatubo Effect" alludes to the eruption of Mount Pinatubo in 1991, which had the same effect (Michaelson, 1998, p. 76; Robock, 2008, p. 14).
7. Planting forests: Since deforestation removes a major carbon sink, reforesting the planet's surface with trees would have the effect of removing carbon dioxide from the Earth's atmosphere (Fearnside, 1999).
8. Painting rooftops white: Though the most widely frowned upon, painting the rooftops of building white would reflect some of the sunlight back into the atmosphere and result in a small, though still valuable, reduction in atmospheric temperatures ("Cool Roofs and Title 24," 2009).

Despite the hopeful tone of these geoengineering proposals, skepticism about whether they are scientifically sound, ethically defensible, and politically feasible persists. One of the most serious objections is that they might have devastating and irreversible, albeit unintended, consequences on the Earth's atmosphere, producing global cooling or even accelerated global warming. According to Alan Robock, the difficulty of global climate change might be, for the most part, political, i.e., a daunting matter of coordinating state action through mitigation treaties and carbon trading schemes. "If global warming is a political problem more than it is a technical problem," he writes, "it follows that we don't need geoengineering to solve it" (Robock, 2008, p. 18). Robock also offers 20 reasons that geoengineering projects might, in the end, do more harm than good. The most persuasive reasons are (1) that these projects can generate a series of unexpected cascading effects; and (2) that the moral legitimacy of any agency, government, or corporation that alone undertakes such projects is always in doubt.[3] More recently, the authors of an article in *Foreign Affairs* lament: "These strategies [for intentionally manipulating the atmosphere] could cool the planet, but they would not stop the buildup of carbon dioxide or lessen all its harmful impacts. For this reason, geoengineering has been widely shunned by those committed to reducing emissions" (Victor et al., 2009, p. 66). Likewise, in an interview conducted by *New Scientist*, researcher Ken Caldeira states: "Personally, as a citizen not a scientist, I don't like geo-engineering because of the high environmental risks. It's toying with poorly understood complex systems." However, a moment later, he admits that geoengineering might, in at least some situations, be the lesser of two evils: "Is it better to let the Greenland ice sheet collapse . . . or to spray some sulphur particles in the atmosphere?" ("Quick Climate Fixes," 2009, p. 64). So, should policy makers and scientists fund and test models to intentionally manipulate the Earth's atmosphere as a second-best option, relative to mitigation schemes? Can they do so in a way that minimizes the risks of unintended consequences and maximizes the potential for coordinated action? It is this last dimension of the problem, i.e., the question of how to coordinate group action, that I consider next.

## Collective Action

While the status quo generates a negative externality for all members of the human species, the burden of that externality is borne disproportionately by the inhabitants of poorer countries. According to the Intergovernmental Panel on Climate Change (2002, p. 12), these countries suffer the effects of global warming to a greater extent, expressed as "inequities in health status and access to adequate food, clean water, and other resources." Meanwhile, the richest country, which is responsible for 22 percent of global GHG emissions (viz. the Unites States), can afford to defect from a global scheme for regulating emissions (viz. the 1997 Kyoto Protocol) and free ride on the GHG mitigation efforts of signatory countries. Not only does this situation suggest a substantive problem of distributive justice, but it also indicates a procedural problem, namely, how might we coordinate mutually beneficial activity among actors with diverse, and sometimes conflicting, interests?[4] According to Russell Hardin (2008, p. 464), there are at least four types of coordination situations relevant to group action: (1) Prisoner's dilemma (or exchange), (2) pure conflict, (3) simple coordination, and (4) unequal coordination. These strategically distinct forms of group interaction can be formally represented, with the best payoff being 1, the second best 2, and so on, as follows:

Of the four, the most desirable form of group interaction is simple coordination (Table 1), wherein each party's interests are satisfied because their cooperation makes both better off. Less desirable is the situation—what is here called an "unequal coordination"—in which both parties want to cooperate, but every possible coordination equilibrium makes one party better off and the other worse off (Table 2). An even less desirable scenario is the classic prisoner's dilemma (Table 3), whereby the optimal move for both parties is to defect while the other seeks to cooperate, the suboptimal move is bilateral cooperation, and the worst outcome manifests when both parties defect. And the worst-case situation is pure conflict (Table 4), a scenario in which both parties wish to seize what the other has or obstruct the other's plans by dictating the proper course of action, such that the outcome is always zero-sum.[5]

**Table 1.** Simple Coordination

| | Option I | Option II |
|---|---|---|
| Option I | 1, 1 | 2, 2 |
| Option II | 2, 2 | 1, 1 |

**Table 2.** Unequal Coordination

| | Option I | Option II |
|---|---|---|
| Option I | 1, 1 | 2, 2 |
| Option II | 2, 2 | 1, 1 |

**Table 3.** Prisoner's Dilemma

| | Cooperate | Defect |
|---|---|---|
| Cooperate | 1, 2 | 4, 1 |
| Defect | 1, 4 | 3, 3 |

**Table 4.** Pure Conflict

| | Cooperate |
|---|---|
| Option I | 1, 2 |
| Option II | 2, 1 |

*Adapted from Hardin (2008, p. 464).

What I am less concerned with is how to resolve situations of pure conflict. Although the international environment is described by foreign policy realists as a Hobbesian state of nature, a "war of all against all," there has to be some presumption that actors will cooperate in addressing the global climate change problem because the fate of the human species, at least potentially, hangs in the balance. Nevertheless, even when all parties to a common project acknowledge that it is in their collective interest to cooperate, sometimes the individual costs of contributing to the effort far outweigh the prospective benefits—thereby leading to defection. In economic parlance, the marginal utility of noncooperation exceeds the marginal disutility that such noncooperation would cause to all other affected parties. When the provision of a public good or a common project (e.g., a scheme for mutual defense) is undertaken, an individual's decision to abstain from paying for the (public) good or participating in the project results in a negligible drop in utility for the contributors, a more sizeable utility loss for the whole affected group (though one that frequently goes unnoticed), and a utility windfall for the free rider. As Mancur Olson (1965, p. 15) reminds us, "those who do not purchase or pay for any of the public or collective good cannot be excluded or kept from sharing of the good, as they can where noncollective (or excludable, private) goods are concerned." Likewise, when a resource is in common use (e.g., a field for grazing herd animals), parties are more likely to selfishly exploit the scarce resource to the point of exhaustion (e.g., through overgrazing) rather than conserve or improve the resource for others, including future generations.[6] In other words, the present benefit of exploitation far outweighs the diminished future benefit of conservation.

It is easy to see the parallel between global climate change scenarios and the two types of coordination problems: (1) prisoner's dilemmas and (2) unequal coordinations. Situations where one or more (but not too many) parties defect from a GHG emissions mitigation scheme indicate a prisoner's dilemma or free-rider problem (Boran, unpublished paper; Heckatorn, 1996; Olson, 1965). Likewise, global warming scenarios can involve the overuse and exhaustion of resources in the global environmental commons (e.g., the ice-sheets of Antarctica, the atmospheric ozone layer, and the Siberian permafrost)—what Garrett Hardin (1968) more generally called "the tragedy of the commons" (Gardiner, 2001; Ostrom, 1990). Such a scenario could also have the effect of hastening the advance toward a global tipping point, and, eventually, an environmental disaster. Furthermore, putting them in combination and conceiving them temporally, i.e., as an intergenerational issue, magnifies the difficulties. Combining these two coordination problems, a stronger, richer party (nation) can defect from a GHG emissions mitigation scheme, and, as a consequence of its unregulated emissions, exhaust an environmental resource in the global commons. In the process, the weaker, poorer parties (nations) must bear the brunt of the negative externality. This combined coordination problem almost perfectly captures the phenomenon of U.S. defection from the 1997 Kyoto Protocol (Victor, 2001, 2004). Martin Adamian (2008, p. 81) pinpoints the injustice of the U.S. decision to defect: "[G]iven the historic global emissions of countries like the United States, it is . . . unreasonable to expect less developed states to assume the same responsibilities and obligations for addressing a problem that they have little responsibility for causing." Furthermore, the intergenerational injustice resulting from successive defections is itself a form of the prisoner's dilemma. Since costs from cheap energy saved in one generation are deferred for payment in a later generation and so on, the problem becomes (generationally) iterated; and since the parties do not coexist, it becomes significantly more difficult to employ the normal repertoire of incentives to guard against defection (e.g., institutional coercion, selective benefits, and moral suasion) (Gardiner, 2003, 2008, p. 33).

So, the question becomes: How can we convert collective action problems and tragedies of the commons, which roughly resemble prisoner's dilemmas and unequal coordinations, into simple and successful coordinations for responding to the problem of global warming? In order to accomplish this conversion, the affected parties must do one of three things: (1) react to the effects of global warming through accommodating human activities (e.g., by relocating low-lying communities encroached upon by rising sea levels); (2) internalize the negative externality in the responsible parties' transaction costs (e.g., through a tax or sanction), such that a strong incentive emerges to reduce or eliminate GHG emissions; and (3) reverse the climatic changes that express the externality. The first corresponds to adaptation responses, the second to mitigation projects (based both in markets, such as cap-and-trade, and government regulation, such as treaties with reduction goals), and the third implicates geoengineered schemes. At first blush, it would seem imprudent to passively retreat, acquiesce, and adapt to the deleterious effects of anthropogenic GHG emissions, especially when strategies of active reduction or reversal could be feasibly pursued.[7] Also, any scheme that cannot guarantee full compliance, whether market-based or government-regulatory, would appear suboptimal. As the typical objection goes, without an effective system of global governance, enforcement of such schemes will be unreliable and defection frequent; so, in a world dominated by nation–states, the difficulty, if not impossibility, of developing effective global governance mechanisms, invites defection and stymies cooperation (Gardiner, 2008, p. 29; Vanderheiden, 2008a). Moreover, the so-called "Gordian knot" of carbon trading schemes is not how to design a trading system, but how to arrive at an initial agreement over the proper allocation of property rights in a previously common resource (Raymond, 2006, 2008, pp. 5–13). Since geoengineering projects can be undertaken unilaterally, the coordination problem recedes. As Michaelson (1998, p. 76) notes, "geoengineering minimizes the impact of the . . . tragedy of the commons by not requiring international behavior modification." Therefore, it appears that geoengineering wins the three-way contest.

However, this conclusion could be premature. A so-called "contraction and convergence" scenario, in which developed countries cut their emissions, and developing countries' slowly converge upon the reduced emissions of their more industrialized global partners, could also yield a coordinated outcome (Althanasiou & Bauer, 2002; Bales & Duke, 2008, p. 86; Vanderheiden, 2008c, p. 57). In addition, unilaterally manipulating the planet's climate, engineering shifts that would presumably "combat or counteract the effects of changes in atmospheric chemistry" can face significant challenges from parties who fear that their interests will be harmed (National Academy of Sciences' Committee on Science, Engineering and Public Policy, 1992, p. 433). Moreover, geoengineering schemes confront several ethical objections, a consideration of which the inquiry now turns.

## Ethical Quandaries

According to Stephen Gardiner (2008, p. 25), "we cannot get very far in discussing why global climate change is a problem without invoking ethical considerations." A central question in environmental ethics, generally, is: To what degree should humans afford moral consideration to nonhuman animals, flora, fauna, biota, species, the biosphere, and ecological systems as a whole, including the oceans and atmosphere? Although this is not the exclusive purview of environmental ethicists (indeed, ecologists, nature poets, and policy scholars also care), the issue of whether to extend moral concern beyond the human species does tend, for better or worse, to dominate scholarly debates in environmental ethics. In what follows, I set forth six quandaries that arise in debates over whether geoengineering is ethically warranted, framed as oppositions between concepts and their material counterparts. Several of these bear upon the issue of extending moral concern to the nonhuman environment:

### *Man versus Nature*

Humans must conquer those natural forces that threaten their survival. Mere adaptation to global warming's effects, such as rising sea level and megastorms, is therefore a sign that nature is the victor in this ongoing man–nature struggle. Geoengineering projects express the human desire to overcome nature through the use of technology and the conversion of natural environments into built environments (Bunzl, 2008). According to some, conquering nature is a moral imperative.

### *Control versus Restraint*

An ethic of control dictates that humans manage the natural environment and treat its flora, fauna, soils, and atmosphere as resources for human use. Humans who adopt an ethic of restraint, on the other hand, resist the temptation to exploit the natural environment, instead acting as a steward and a member of the biotic community (Leopold, 1966). Geoengineering is typically thought to align with an ethic of control, not an ethic of restraint.

### *Present Generations versus Future Generations*

Either one favors the interests of one's own (present) generation or one also extends moral concern to the interests of future generations, including the preservation of the natural environment, which directly bears on those generations' quality of life. One difficulty in making this choice is that the present generation, in favoring some projects that are believed to favor the interest of future generations, including geoengineering, will likely change the composition and interests of future generations in ways that might not align with initially projected interests (Gardiner, 2003; Parfit, 1982; Rawls, 1972). Yet according to the precautionary principle and the Rio Declaration, where there are threats of irreversible harm to the environment and by implication the quality of life for future generations, "lack of full scientific certainty" ought not to bar taking "cost-effective measures to prevent environmental degradation" and harm to future generations (cited in Kiss, 1995, p. 27).

### *Global North versus Global South*

Economic disparities between the rich nations of the Global North and the poor nations of the Global South has given rise to coordination difficulties, as demonstrated by the previous discussion of collective action problems. Poorer nations argue that they are entitled to release GHGs at the level of richer nations before they are asked to reduce emissions to a lower level, for they have a right to development. Richer nations claim that regulation of GHG emissions should be distributed equally. With geoengineering, the problem is not nearly so pronounced, since richer nations can undertake projects without the consent of poorer nations; likewise, poorer nations may exercise their right to develop their industry and economy, which often involves increasing levels of anthropogenic GHG emissions (Singer, 2002; Vanderheiden, 2008a, 2008b).

### *Ecocentrism versus Anthropocentrism*

In addressing the ethical ramifications of any environmental issue, a prominent issue emerges about whether all proposed solutions should favor human interests and values, a purely anthropocentric view, or promote other values that do not directly bear upon human interests, such a biodiversity, species preservation, and biotic stability, a purely ecocentric view. While global warming bears directly on human long- and short-term interests, the question looms, should a geoengineering project or adaptation strategy that leads to ecosystem destruction, but ensured human survival, be preferred over one that preserves ecosystem health but is considerably more risky for our species' continued existence?[8]

Although these ethical quandaries do not exhaust all possibilities, they are at least illustrative of those that are encountered in debates over global warming, generally, and geonegineering, specifically. Dale Jamieson (1996, 2009, p. 326) argues that four benchmarks must be met in order for a geoengineered solution—or what he calls "an intentional climate change (ICC) project"—to be morally justified: "(1) the project is technically feasible; (2) its consequences can be predicted reliably; (3) it would produce states that are socially and economically preferable to the alternatives; and (4) implementing the project would not seriously and systematically violate any important, well-founded ethical principles of considerations." So, if there is a less risky and more feasible alternative than geoengineering, such as changing humans' consumption habits or agreeing to an enforceable mitigation treaty, then that course of action should be pursued.

## A Deweyan–Leopoldian Approach

Should safer and more easily achievable methods, such as mitigation and adaptation, crowd out the geoengineering alternative? Or should they be part of an overall strategy that includes continued research on the feasibility of geoengineering projects? In the present section, I argue that treating geoengineering as one instrument in the environmentalist's tool kit, albeit a second-best tool or instrument, is the better route. Two notions will inform my argument that we ought to sustain research on intentional climate change: (1) Dewey's concept of artful inquiry and (2) Leopold's idea of an Earth ethic.

### *Artful Inquiry*

For John Dewey, probably the twentieth century's most famous American philosopher, experimental inquiry manifests in a matrix of knowing and acting events, involving the framing of a problem, operationalizing variables, proposing hypotheses, testing them, observing/measuring results, and treating the experimental outcomes as fallible and revisable in the light of future testing. Not all knowing events are inquiry-related events, though. In what Dewey refers to as "the intellectualist tradition in philosophy" and the "quest for certainty," thinkers have "always identified degrees of logical adequacy with degrees of reality," certitude and stability (MW 10:336). Whether Hume, Kant, Descartes, or Russell, philosophers in this tradition mistake the tentative and functional status of tools in inquiry for their ontological, fixed and stable, disposition in reality. Such tools include sense impressions, data, ideas, perceptions, meanings, and norms. In turn, nonexperimental techniques for "identifying degrees of logical adequacy with degrees of reality," such as correspondence, synthesis, and coherence, replace experimental methods for testing the fitness of tools and resolving problematic situations. In the case of acting events, experimentalism involves a series of operations that transform the conditions of a problematic situation and hasten its resolution. Dewey explains how analysis reconstructs a situation for this purpose: "To break up the complexity, to resolve it into a number of independent variables each as irreducible as it is possible to make it, is the only way of getting secure pointers as to what is indicated by the occurrence of the situation in question" (MW 10:342). Thus, analysis and other experimental operations are part of this matrix of knowing and acting events that, together, constitute the process of experimental inquiry (Hickman, 2001).

Dewey reveals a generic pattern to experimental inquiry that widens its application beyond the domain of experimental science. His five-step method of inquiry was intended to apply to practical problems, or "problems of men," not solely to more specialized problems encountered in the laboratory. In the first edition of *How We Think*, Dewey spells out the five stages of experimental inquiry:

> Upon examination, each instance [of intelligent inquiry] reveals more or less clearly, five logically distinct steps: (1) a felt difficulty; (2) its location and definition; (3) suggestion of possible solution; (4) development by reasoning of the bearings of the suggestion; (v) further observation and experimentation leading to its acceptance or rejection; that is, the conclusion of belief or disbelief. (MW 6:236)

Dewey's examples of experimental inquiry include figuring out how to get to an appointment on time, identifying the function of a pole on the front of a tugboat and determining why bubbles go outside and inside of a cup once washed with hot water and placed upside-down on a kitchen counter (MW 6:234–235). Conspicuously absent from these examples are many touchstone elements of experimental inquiry found in the social and hard sciences: (1) a research design, (2) a measurement instrument, (3) a data collection process, (4) a data analysis technique, and (5) a method of generalizing data to a larger population. While encompassing experimental science, inquiry is experimental in a more general sense, that is, it involves experimental operations that can be applied to both common-sense and scientific problems: (1) observation, (2) analysis, (3) manipulation, and (4) reflection upon the conditions and consequences of a problematic situation.

Though there is a generic pattern to inquiry, the five stages do not make experimental inquiry a form of simple proceduralism or cognitive reductivism. Instead, inquiry is what Dewey calls an "artful" process of reunifying a previously disrupted situation through the activity of creative problem solving. As mentioned at the outset, Dewey observed that "the more delicate and complicated the work which it has to do, the more art intervenes" (LW 10:354). Since the boundaries of a situation are vague, there will always be areas of uncertain or unexplained experience left untouched by experimental inquiry. Though cognitively intense, the process of inquiry and experimentation can impart valuable insights about the content of our felt, had, or enjoyed (or aesthetic), experiences (Eldridge, 1998). The activities of painting the roofs of buildings white or planting trees might seem to be obvious cases of artful inquiry, but so would seeding the Earth's oceans with iron filings or engineering reflective materials to launch into the planet's atmosphere. What is important to note, though, is that inquiry does not afford these insights by recourse to mere authority or the nonexperimental techniques of the quest for certainty. Instead, modifying the Earth's atmosphere for the sake of reversing the global warming trend requires painstaking research if it is to succeed, whether as a scientific or an aesthetic ideal.

Dewey also insists that we commit to safeguarding the welfare of future generations, preserving the natural environment because it is a necessary condition for our progeny and theirs to enjoy a suitable quality of life. He writes: "The best we can accomplish for posterity is to transmit unimpaired and with some increment of meaning the environment that makes it possible to maintain the habits of a decent and refined life. Our individual habits are links in forming the endless chain of humanity. Their significance depends upon the environment inherited from our forerunners, and it is enhanced as we foresee the fruits of our labors in the world in which our successors live."[9] Moreover, for Dewey, morality cannot be detached from technology. According to one prominent Dewey scholar, "since nature retracts what is valued as quickly and as unpredictably as it proffers it, it is the job of intelligence, or technology, to ascertain whether what is valued is *valuable* [or valued after having undergone inquiry]; and if it be found to be such, to work to secure it" (Hickman, 2007, p. 174). Since morality concerns how we make better decisions about what has value in the light of previous experience, including the experience of experimental inquiry, the most ethical course of action is to keep the geoengineering option "on the table," to consider it as one of many tools for solving the problem of global climate change.

## An Earth Ethic

For Aldo Leopold, one of the most well-known American ecologists and a contemporary of Dewey's, the boundary between environment and society is not strictly demarcated. Humans should act as members of the biotic community, caring for land and the creatures that inhabit it. In the book *A Sand County Almanac*, he states that a "land ethic changes the role of *Homo sapiens* from conqueror of the land community to plain member and citizen of it. It implies respect for fellow members and also respect for the community as such" (Leopold, 1966, p. 240). Moral consideration is thereby extended beyond the human species to the non-human environment, as humans become stewards, not exploiters, of its resources. Indeed, ecology for Leopold (1966, p. 239) "simply enlarges the boundary of the community to include soils, waters, plants, and animals, or collectively: the land."[10]

How does one treat ecological systems and biotic communities ethically when they do not speak human languages, act autonomously, or make moral claims? Leopold (1966, p. 262) answers this question in one of the most oft-quoted passages in *A Sand County Almanac*: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Cashing out what biological integrity, diversity, and beauty mean in a concrete example will prove helpful here. Integrity is the capacity of all the interdependent elements of the ecosystem (e.g., soil, trees, deer, and wolves) to work together. When one element (e.g., soil) is degraded by human activities, its poor state (or erosion) negatively impacts other elements that were once healthy (e.g., the root systems of trees), and, in turn, diminishes still other elements that consume it immediately and derivatively (e.g., the leaves that herbivores eat disappear, thereby lowering the population of herbivorous deer and finally reducing the numbers of predators, such as wolves that consume the deer).[11] The stability of the ecosystem depends on this interconnectedness. Without integrity and stability, biodiversity diminishes, and, with it, the beauty that we humans delight in disappears.

According to J. Baird Callicott (2009), the land ethic is pragmatically useful, but also extremely limited. It is useful insofar as the object of ethical assessment is a small, fast, short-term, and reversible problem that manifests in small- or mid-sized biotic communities, such point-source pollution, environmentally unfriendly agricultural and forestry practices, as well as degradation to ecosystems caused by recreational activities and local development (residential, commercial and industrial). However, it is severely limited with respect to addressing large, slow, long-term, and possibly irreversible problems that occur on a global scale, such as climate change, mass extinction, and the appearance of stratospheric ozone holes. While Callicott (1989, 1999, 2009) has always argued that Leopold's land ethic is ecocentric, he respects this position when discussing his Earth ethic. If we are to see Leopold as addressing these larger and drastically more consequential problems, then we must invite a weakly anthropocentric view. Why? Because these are problems, especially in the case of global warming, which directly threaten the survival of the human species.

Even though global climate change was not an acknowledged problem during his lifetime, Leopold spoke to this class of larger-scale problems in an article that was less widely read than *A Sand County Almanac*, entitled "Some Fundamentals of Conservation on the Southwest." To quote Leopold at length:

> There is not much discrepancy, except in language, between this conception of a living earth, and the conception of a dead earth, with enormously slow, intricate, and interrelated functions among its parts, as given us by physics, chemistry, and geology. The essential thing, for present purposes is that both admit the interdependent functions of the elements . . . Possibly, in our intuitive perceptions, which may truer than our science and less impeded by words than our philosophies, we realize the indivisibility of the earth—its soil, mountains, rivers, forests, climate, plants, animals, and respect it collectively, not only as a useful servant but a living being, vastly less alive than ourselves in degree, but vastly greater than ourselves in time and space—a being that was old when the morning stars sang together, and, when the last of us has been gathered unto his fathers, will still be young. (Leopold, 1923/1991, p. 88, quoted in Callicott, 2009)

Leopold's "indivisibility of the earth . . . [that should be] respect[ed] . . . collectively, not only as a useful servant but as a living being," Callicott (2009) calls the "Earth ethic," as distinct from the "land ethic." It is an idea that anticipates Lovelock and Margulis's "Gaia hypothesis" that the Earth is a living creature by half a century. Even though the Earth ethic displaces the land ethic, we have no less of a duty to be good citizens of the Earth as we do to be good citizens of the biotic community. However, given the vastness "in time and space" of the Earth's past and future existence, it is significantly more difficult for us to foresee or predict the consequences of our own activity on its health. So, what is the upshot of Leopold's Earth ethic for the global warming and geoengineering debates? While new tools, such as geoengineering, should be part of the environmentalist's tool kit, and therefore merit sustained research into their feasibility and risks, restraint should nevertheless be exercised in experimenting with these tools on a global scale.[12] To do otherwise is not only hubristic, it is also excessively risky—indeed, it puts at risk the future of our own species.

## Conclusion

After making a valiant call for a "Climate Change Manhattan Project," one relatively recent defender of geoengineering concedes that, "geoengineering runs afoul of almost every major trend in contemporary environmentalism" (Michaelson, 1998,

p. 81). Must geoengineering be the alternative almost universally hated by environmentalists? Or is it possible to radically reorient our perspective, to see geoengineering as one among many tools in an environmentalist's flexible tool kit for addressing the problem of global climate change? Dire circumstances might force humans to adopt the perspective, as Leopold recommends, of geocitizens, becoming better stewards of the Earth and its atmosphere. Alternatively, dire circumstances might also force us to creatively inquire in a Deweyan spirit into the possibility of creating new global climate control technologies. Once joined together, a mixed Deweyan–Leopoldian rationale for geoengineering gives us an opportunity to either solve the global warming problem, or at least stem its deleterious consequences for Earth-bound humans and ecosystems. Still, my argument has not been that we should pursue intentional climate change to the exclusion of less risky and more feasible alternatives. Research on geoengineering ought to continue, as should research on mitigation and adaptation. In varying degrees, all of these are artful and ethical ways to preserve the atmosphere for future generations, and, at the same time, ways for us to behave as responsible members of the greater geocommunity. In the long term, though, we should transform our perspective from one of man dominating nature, exploiting its resources for economic gain, and, generally, exerting strict control over the environment to one of human beings living in harmony with nature, treading lightly on its lands, oceans, and atmosphere, and, generally, exercising wise restraint with respect to the environment, even when we seek to manipulate the Earth's climate for the sake of our own species' survival.

## Notes

1 Citations are to *The Collected Works of John Dewey: Electronic Edition*, edited by L. A. Hickman (1996), following the conventional method, LW (Later Works) or MW (Middle Works) or EW (Early Works), volume: page number. For example, MW 10:354 refers to the Middle Works, volume 10, page 354.

2 See the next section for a more extensive list of proposed geoengineering projects. Some high-profile figures who support geoengineering as a viable approach to solving or ameliorating the problem of global warming are Edward Teller, Wallace Broeker, William Nordhaus, and Stephen Schneider (Michaelson, 1998, p. 76).

3 The complete list of Robock's (2008, pp. 15–17) 20 reasons is as follows: "1. Effects on regional climate. [. . .] 2. Continued ocean acidification. [. . .] 3. Ozone depletion. [. . .] 4. Effects on plants. [. . .] 5. More acid deposition. [. . .] 6. Effects of cirrus clouds. [. . .] 7. Whitening of the sky (but nice sunsets). [. . .] 8. Less sun for solar power. [. . .] 9. Environmental impacts of implementation. [. . .] 10. Rapid warming if deployment stops. [. . .] 11. There's no going back. [. . .] 12. Human error. [. . .] 13. Undermining emissions mitigation. [. . .] 14. Cost. [. . .] 15. Commercial control of technology. [. . .] 16. Military use of technology. [. . .] 17. Conflicts with current treaties. [. . .] 18. Control of the thermostat. [. . .] 19. Questions of moral authority. [. . . and] 20. Unintended consequences." The final two appear to be the most cogent.

4 On the distributive justice issue, see Gardiner (2004) and Raymond (2008). How (and whether) to allocate GHG emissions usually reflects one of five basic approaches: (1) equal burden (i.e., allocations of GHG emissions should be apportioned based on prior use or possession), (2) equal efficiency (i.e., apportionment based on benchmarked emissions rates), (3) equal rights (i.e. allocated on the basis of population and equal human rights), (4) equal subsistence rights (i.e., apportionment based on the distinction between luxury and subsistence emissions), and (5) distributive nihilism (i.e., skepticism that there can be any private rights in a global common resource) (Raymond, 2008, pp. 6–8).

5 Despite the recurrence of such disagreeable situations, Hardin's (2008, p. 464) outlook is sanguine. "Instead [of resorting to violence]," he notes, "we use legal institutions or have more of less spontaneous recourse to social norms or group management to resolve such issues as our pure conflict."

6 Garrett Hardin (1968, p. 1244) describes the tragedy of the commons in similar terms: "Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. [. . .] Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."

7 For instance, citing the post-Katrina reconstruction of New Orleans as a failed effort at adaptation, Peter F. Cannavò (2008, p. 195) argues that "reliance on adaptation as a solution to global warming would mean that many more places [and their cultures] will be endangered. We are better off trying to mitigate climate change and minimize the tragic dilemmas by reducing fossil fuel consumption and deforestation." Likewise Jay Michaelson (1998, p. 76) questions the prudence of an adaptation strategy: "[O]ther than simply doing nothing and adapting to climate change when it happens—a potentially catastrophic strategy—what alternatives do we have?"

8 A version of this difficulty is the problem of the "last person." It involves asking whether the last person on Earth would have moral qualms about destroying the planet at their death. See Sylvan (2002, pp. 49–50; Hickman, 2007, p. 168).

9 Dewey, "Experience, Knowledge and Value: A Rejoinder," (LW 14:19).

10 Note that this section closely follows Callicott's (2009) PowerPoint lecture at the Prescott City library, as well as his presentation to participants in the National Endowment for the Humanities Institute on "Aldo Leopold and the Roots of Environmental Ethics," both on July 8, 2009. A fuller account of the Earth ethic will be given in Callicott's forthcoming book. Callicott gave me full permission to quote from the lecture's PowerPoint slides.

11 This example illustrates what Leopold (1966, p. 252) calls "food chains" or "food pyramids" and the consequences when humans interfere with them.

12 This point is nicely illustrated by a passage from Leopold's (1966, p. 72) *A Sand County Almanac*: "But there is one vocation—philosophy—which knows that all men, by what they think about and wish for, in effect wield tools. It knows that men thus determine, by their manner of thinking and wishing, whether it is worth while to weld any."

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