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Geoengineering, Ocean Fertilization, and the Problem of Permissible Pollution

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Abstract

Many geoengineering projects have been proposed to address climate change, including both solar radiation management and carbon removal techniques. Some of these methods would introduce additional compounds into the atmosphere or the ocean. This poses a difficult conundrum: Is it permissible to remediate one pollutant by introducing a second pollutant into a system that has already been damaged, threatened, or altered? We frame this conundrum as the "Problem of Permissible Pollution." In this paper, we explore this problem by taking up ocean fertilization and advancing an argument that rests on three moral claims. We first observe that pollution is, in many respects, a context-dependent matter. This observation leads us to argue for a "justifiability criterion." Second, we suggest that remediating actions must take into account the antecedent conditions that have given rise to their consideration. We call this second observation the "antecedent conditions criterion." Finally, we observe that ocean fertilization, and other related geoengineering technologies, propose not strictly to clean up carbon emissions, but actually to move the universe to some future, unknown state. Given the introduced criteria, we impose

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a "future-state constraint". We conclude that ocean fertilization is not an acceptable solution for mitigating climate change. In attempting to shift the universe to a future state (a) geoengineering sidelines consideration of the antecedent conditions that have given rise to it –conditions, we note, that in many cases involve unjustified carbon emissions –and (b) it must appeal to an impossibly large set of affected parties.

Keywords
geoengineering, climate change, remediation, ethics, policy, carbon sequestration, ocean fertilization

Introduction

The Intergovernmental Panel on Climate Change's fourth assessment (hereafter IPCC AR4) establishes an unequivocal consensus within the scientific community that carbon dioxide in the atmosphere continues to rise as a result of fossil fuel combustion and the clearing of forests (IPCC 2007b). The report forecasts changes in the earth's climate, with significant impacts on species and agriculture (IPCC 2007a). It summarizes the results of models that indicate larger climate impacts as carbon dioxide continues to increase. To maintain the atmosphere at carbon dioxide concentrations within 100 parts per million (ppm) of current levels—concentrations that will still have serious effects—it is estimated that emissions of carbon dioxide will ultimately have to be reduced anywhere from 80 percent to 100 percent (Matthews and Caldeira 2008). For a sense of scale, consider that the national goals under the Kyoto Protocol are closer to 5 percent or 8 percent and many nations are not on track as of 2008 to reach even these, more modest, goals (Kerr 2007).

Scientists and policy analysts have argued that a variety of options are necessary to accomplish the necessary reductions and that no single strategy is likely able to accomplish what is needed (Pacala and Socolow 2004). The strategies put forward have included switching to less carbon-intensive fuels and non–carbon-based energy sources; conserving energy; sequestering carbon dioxide in plant and soil biomass, geologic reservoirs, and the ocean; extracting carbon dioxide from ambient air through chemical means; and geoengineering the atmosphere or earth system to mitigate the radiative effects directly. These options can be grouped into two main categories: those that address energy production and consumption (switching fuel types, energy sources, conservation, and use of energy) and those that

address carbon dioxide or climate impacts directly (sequestration, air capture, and geoengineering). All of the options have serious advocates and most of the options are being tested, being deployed, or both.

In this article, we address proposals that seek to reduce atmospheric carbon concentrations by fertilizing the ocean with iron to encourage a phytoplankton bloom. As geoengineering proposals have gained a foothold in the public discussion, debate on this proposal has become more prominent. Although initially ocean fertilization may appear to be an extreme solution, one of the central arguments in favor of ocean fertilization is that it is not extreme, that it merely accelerates a natural process. Proponents claim that much of the excess carbon dioxide added to the atmosphere will eventually end up in the ocean of its own accord, as the ocean and atmosphere reach a new equilibrium state (Caldeira and Wickett 2005; Mueller et al. 2004). Since the ocean is an enormous common resource covering over 70 percent of the earth's surface—surface that is independent of any single nation's jurisdiction, except for 200 miles of offshore coastlines (Exclusive Economic Zones; EEZs)—it would be a prime place to resolve this global problem without trespassing on political boundaries. Moreover, proponents argue that we need to maintain the potential that ocean fertilization offers. Climate change is an enormous challenge, requiring "every available tool in our tool box." By fertilizing the oceans now, we would be in some sense "buying time" to bring other solutions on line in the next few decades that may more permanently address rising carbon dioxide concentrations.

Over a decade of research into ocean fertilization has demonstrated that there is significant uncertainty about the feasibility of this proposal (Buessler et al. 2008). Multiple field experiments have confirmed that adding iron to regions of the ocean high in other nutrients (but low in iron) have produced a burst of phytoplankton growth in the local experimental region and have drawn carbon into the ocean, at least over the course of observations in the experimental time frame, although the longer term fate of this carbon remains uncertain (Boyd et al. 2007; Strong et al. 2009a). Some have spoken out against large-scale ocean fertilization as an acceptable strategy for mitigating climate change, citing concerns about potential negative impacts to oceanic food webs, and the inability to control impacts in a fluid medium (Chisholm, Falkowski, and Cullen 2001; Chisholm and Morel 1991; Schiermeier 2003; Strong et al. 2009b). Nonetheless, small entrepreneurs and other entities have pursued the right to fertilize the ocean, suggesting that such efforts would not only have positive benefits for climate but would augment natural nutrient processes and also provide additional food in the way of fish stocks for impoverished coastal regions (Preuss 2001; Strong et al. 2009a).

In policy circles, ocean fertilization has gained attention at the highest levels of international negotiation. Reflecting the commonly held value that we should not use, the ocean as a dumping ground for our waste, the internationally respected London Convention and London Protocol treaties regulate dumping of many substances by vessels in international and local waters. While acknowledging that jurisdiction of actions falls under individual nation states, the London Convention issued a statement that large-scale ocean fertilization operations are currently "not justified" and endorsed a statement of concern by scientific advisory groups to the Convention about their efficacy and potential harm to the environment (IMO 2007a, 2007b). Similarly, the Convention on Biological Diversity has urged parties to the Convention to not pursue large-scale ocean fertilization activities until scientific uncertainties have been resolved and risks assessed (Djoghlaf 2009). In sum, these institutions have stated that large-scale ocean fertilization should not be conducted, and/or that it should not be acceptable as a means of generating offset credits for mitigating climate change. Nevertheless, such pronouncements do not preclude the potential for ocean fertilization to be revisited should scientific uncertainties be resolved.

The public as a whole remains largely unaware of ocean fertilization as an idea, although in 2009, intense opposition from a group of environmental nongovernmental organizations nearly caused the cancellation of a German–Indian iron fertilization experiment, LOHAFEX (Schiermeier 2009a, 2009b). In the end, the experiment was permitted to take place, over the objections of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2009). Deep ocean injection, a different type of carbon sequestration, has been vigorously opposed where it has been proposed, for example, in Hawaii and Norway in 2002 (Scott 2005). To date, no regulatory policy has recognized ocean fertilization as a mechanism for gaining carbon credits.

Jamieson's Four Criteria

In 1996, Dale Jamieson forged a path in the climate change arena by addressing the moral dimensions of intentional geoengineering projects like ocean fertilization (Jamieson 1996). Jamieson is mostly pessimistic about the prospect of geoengineering projects—and by this he considers not only ocean fertilization but also a range of other projects, including reforestation, space reflectors, and so on—though he acknowledges that there are some circumstances in which intentional geoengineering would be permissible.

He cautions that for this to be so, the following conditions must be met: "(1) the project is technically feasible; (2) its consequences can be predicted reliably; (3) it would produce states that are socioeconomically preferable to the alternatives; (4) implementing the project would not seriously and systematically violate any important, well-founded ethical principles or considerations" (Jamieson 1996, 326).

In the case of ocean fertilization, we certainly have reason to doubt that criteria 1-3 are being met. In what follows, we first review these three criteria, but ultimately find our strongest argument for rejection of ocean fertilization in Jamieson's fourth criterion. The first criterion, that the project is technically feasible, would require in this case that carbon could be reliably sequestered deep in the ocean and kept away from the atmosphere. This is perhaps the most common objection to ocean fertilization—that it is an unproven technology. For ocean fertilization to result in carbon storage over a long period, the carbon that is newly stored in phytoplankton must be exported to the deep ocean. In the thirteen or so experiments that have been conducted to date in the ocean, none have conclusively shown significant carbon export nor have they been able to track parcels for long periods (AWI 2009; Boyd et al. 2007). In part due to the nature of experimentation in the open sea—experiments can only be deployed for so long, a month or two at the most—it is difficult to demonstrate the long-term fate of stimulated phytoplankton growth. However, this is not the only issue. The ocean is a highly structured, dynamic, and fluid medium. Water moves about in fairly discrete parcels, with unique density signatures. Particles resulting from the addition of iron to the surface of the ocean at a particular georeferenced location will not likely fall to the sea floor directly below. And so, it has been difficult to verify the extent of particulate (and therefore carbon) export to the deep sea.

There are, of course, possible improvements in techniques, and other means of organizing experiments such that they are better able to discern and quantify the amount of carbon export. Scientists, corporations, and policy institutions (such as the London Convention) alike have continued to call for more research to better characterize some of the unknowns (Buessler et al. 2008). It is possible to envision a future scenario where ocean fertilization might indeed prove viable and where uncertainties could be reduced or better quantified. We cannot, therefore, rule out ocean fertilization on this basis alone.

We turn then to Jamieson's second and third criteria: the need for reliable predictions of consequences and an outcome of a preferred socioeconomic state. A second major argument against pursuing ocean fertilization as a strategy is that in altering natural conditions in the surface ocean, we will

produce unknown and potentially deleterious effects on marine life and the ocean food web (Chisholm, Falkowski, and Cullen 2001). There are fundamental concerns about the ecology of the ocean for its own sake but also concerns about how these changes might affect species that humans depend on for food. While some have argued that these changes will be beneficial for humans (producing more consumable protein, i.e., fish stocks), others have strenuously argued that we cannot know that these changes will be positive, and in fact, that it is likely that they may be negative (Preuss 2001). A separate but related argument is that we are not able to control the results of activities that we might pursue in the ocean, since the ocean is a fluid medium that cannot be contained and that moves on timescales of up to thousands of years. Both of these arguments resemble variants of the precautionary principle—that one should be cautious about entering into activities where an outcome is highly uncertain, harmful, and/or uncontrollable (Foster, Vecchia, and Repacholi 2000). However, one could easily also argue that the impact of climate change on food webs, ecosystems, and humans is equally uncertain, harmful, and/or uncontrollable; that its effects will be much wider ranging than that which might occur with ocean fertilization. Thus, the argument goes, mitigating climate impacts should outweigh any negative impacts of ocean fertilization.

Just as innovations in research methods may allow scientists to meet the standards of Jamieson's first criterion, it is possible to imagine a situation where the second and third criteria might be met as well. One can foresee a situation in which uncertainties over outcomes are resolved and a fertilization protocol is devised that would be, if not controllable, at least capable of being monitored. While this is not the situation at the moment, it is not out of the realm of possibility and certainly some scientists calling for more research can imagine a future where such a method would be viable (Kintisch 2007). We therefore cannot reject ocean fertilization based on Jamieson's second and third constraints either.

It is therefore against Jamieson's fourth caveat that we shall ply our argument, leading us to a position that is considerably more restrictive of geoengineering,[1] and thus considerably more pessimistic, than Jamieson's. We seek to demonstrate that remediation-oriented geoengineering projects do violate important and well-founded ethical principles and that this condition alone takes precedence over the other three. We believe that even if the project can be shown to be demonstrable and predictable to a reasonable degree of scientific certainty, and even if it would produce states that are socioeconomically preferable, these criteria may be jointly necessary, though they alone are not jointly sufficient, to permit such a geoengineering project. The

permissibility of remediation-oriented geoengineering cases can be determined not by appeal to preferable alternatives but only by the extent to which (1) they are evaluated in the context of actions that have given rise to their consideration, (2) they are (or could be) assented to by all affected parties, and (3) they aspire to return the world to its pre-polluted state.

We argue below that remediation-oriented ocean fertilization is impermissible by virtue of its scope and scale, because of the extent to which it is (1) caught up in the antecedent and continuing actions of distributed actors and (2) virtually impossible to arrive at a mutually respectful outcome. In addition, we observe that (3) conducting ocean fertilization moves the world to an unknown "third state," which, we argue, distinguishes ocean fertilization from other "true" remediation technologies.

The Problem of Permissible Pollution

Essentially, we ask in this article whether it is ethically permissible to alter the marine environment through ocean fertilization to remediate the atmosphere of carbon pollution. If so, we wonder how it could be permissible to introduce remediating agents in some cases of pollution, such as oil spills, but not in the case of carbon dioxide pollution added to the atmosphere. If not, we wonder what accounts for the difference. We call this the *Problem of Permissible Pollution*.

We acknowledge that there are many circumstances in which it *is* permissible to alter one's environment, such as conducting remediation projects after oil spills or after large-scale mining activities. We claim, however, that many engineering projects are permissible not because they bring about better or more desirable states of the world but rather because the state of the world that is brought about can be assented to by other possible affected parties, because the reasons (for the sake of which the acts are done) are justifiable.

Here are some engineering projects that we think most people, ceteris paribus, generally find permissible: (1) constructing a hospital, (2) pruning a median strip, (3) planting flowers and trees on the side of the road, and (4) cultivating a crop. In addition, consider some engineering projects that might be understood as more problematic but nevertheless permissible: (1) mining operations, (2) logging operations, (3) hydroelectric dam construction, (4) bottom trawling for fish, (5) dredging silt to prevent beach erosion, and so on. The extent to which these latter projects are permissible is open for dispute, though we believe that the dispute turns on a general assumption: these projects are established as permissible, impermissible, or indeed

controversial by the extent to which they affect sovereign actors and agents, by the extent to which they are respectful of others.[2]

A key feature of these typical engineering projects is that they are discrete and localizable to single locations, as well as to identifiable actors. For example, remediation for an oil spill occurs after a discrete oil spill has occurred and presumably ended, in a specific region of the ocean and coastline. The discrete nature of the event allows for evaluation of the harm, the wrong, the responsibility, and the appropriate remediating action. The initial act of pollution, namely the oil spill itself, has ceased. Remediation is called for and negotiated through the actions of specific actors—in most cases, the responsible and affected parties—who can be readily identified because of the localizable project. These types of remediation projects are acceptable because the initial wrong, that of the polluting act, while not erased, has at least been considered, adjudicated, and acknowledged.

Ocean fertilization is therefore different from these examples in three important respects. Carbon emissions are an ongoing source of pollution, rather than a discrete, completed act. Second, the actors who are responsible for the initial act of pollution and those that would be affected by the remediation technology are essentially acting globally, although in a distributed and uncoordinated fashion. Third, because the ocean and atmosphere are fluid media, the implementation of ocean fertilization will essentially have global impact by both intention (to remediate the atmosphere) and non-intention (ocean impacts will not be confined to any one discrete location).

Overview of Moral Argument

Our argument turns on three basic moral claims. Any of these claims in isolation may not be sufficient to disallow ocean fertilization, but taken together, they compel the conclusion that ocean fertilization is not permissible. The first claim is that the antecedent condition, that is, the identification of carbon dioxide as a polluting substance to the atmosphere, cannot be disentangled from the decision to counteract its presence in the atmosphere by fertilizing the ocean with iron. In other words, we would not be contemplating the idea of ocean fertilization were it not for the problem of carbon dioxide being released into the air by human activities. For this article, we stipulate that what is wrong with individual-level pollution is that it is disrespectful of others. Given that the release of carbon dioxide has been identified as a wrong action, simply conducting an ex post facto remediating action to repair damages does not alone authorize or permit the action (Hale

and Grundy 2009). The second claim rests on notions of justification and obtaining assent from affected parties for the remediating action (Habermas 1991). To evaluate whether it is possible to reach a mutually respectful outcome, we must be able to identify a position that "any reasonable person would (or could) accept as permissible" (Habermas 1991, 66).[3] If assent cannot be obtained, the risk of wrong to parties affected is reasonable and possible. Given that the ocean is a global reservoir, connected to a global atmosphere, actions to fertilize the iron would potentially need justification from the world's population, a practical and political unfeasibility. Thus, the justificatory burden cannot be met. Third, we suggest that the fact that ocean fertilization moves the world to a new, unknown state, rather than returning the world to its original condition before the initial polluting act makes it different than other cases of more limited remediation, which seek to return the world to its original state. These three claims underpin our argument that ocean fertilization is a morally impermissible solution to counter climate change.

In the next section, we will explore in detail a series of hypothetical situations that emphasize the importance of the continuing nature of the pollution, the issue of responsibility, and its role in determining respectful action with regard to remediation.

Why Ocean Fertilization is Impermissible: Pollution, Responsibility, and Respect

Generally speaking, many of us are inclined to think that we should do what we can to mitigate the effects of pollution; and that, depending on our degree of involvement in creating that pollution, we may even be obligated to do something about that pollution.[4] The commonplace intuition, in other words, is that we should take great care to ensure that our natural environment is safe, but that we have a responsibility to return our environment to its safe state, by cleanup or remediation, say, if we are the party responsible for having made it unsafe. It is also true that, generally speaking, moral and legal responsibility for harms arising from pollution is attributed to actors, regardless of their knowledge or their intent.

Unfortunately, ocean fertilization is not a straightforward remediation technology—aimed at returning the world to its original state—so, we cannot rely on commonplace intuitions about what is permissible. It is a remediation technology that uses grand-scale geoengineering to alter the world from one undesirable state to an unknown, but possibly more desirable, state. Our first complication, therefore, is that ocean fertilization involves

questions not about returning the world to its original state, but about moving the world to yet a different state. Clearly, the objections here are troubling. Interventions in the past that introduced species or supposedly beneficial constituents to the environment have sometimes backfired, and necessitated multiple, not always curative measures geared to remedy the mistakes of prior miscalculations.

We point this out both to underscore the uncertainty and risk involved in such projects and also to observe that the nature of a "pollutant" is fluid and context dependent (Coase 1960; Sagoff 2004). In some cases, the addition of solvents, bacteria, phytoplankton, or fertilizer is strictly a matter of returning the world to its original state, in which case it might not be considered a pollutant; and in other cases, the additive may act as a pollutant itself, altering the world to a new state. Whether any given substance should or should not be considered a pollutant depends, to a large extent, on what affected parties understand (want, hope, desire, need, expect, have reason to believe) the outcome to be. In what follows, we will simplify our examples to arrangements between two parties, though "affected parties" need not be limited to human beings and need not even be limited to non-human animals.

Perhaps, the problem could therefore be understood in a slightly tidier way. Imagine two successive decisions with two additives and three states of the world. Assume for these cases that there is a solitary decision maker—in this case, you—and a single parcel of property. Disregard, for simplicity, questions of distributed responsibility, accumulative harms, or collective property rights.

1. Additive Ξ naturally leaches from the ground onto your property, shifting the world from state A to state B. By introducing additive Θ, you can offset the effects of additive Ξ, which will change the world from state B to state C.

One natural way of thinking about this problem is to suggest that the permissibility of making this change will depend largely on the difference between states B and C, accompanied by the risk of arriving at state C. We can suppose, for instance, that a high concentration of copper sulfate (or $CuSO_4$, which is a potent, naturally occurring herbicide and fungicide) leaches into a pond near your property. You might assume that the central decision here is whether to neutralize the effects of this copper sulfate intrusion by adding lime to the pond, thereby making the pond more hospitable for plant growth. It is well known that the addition of the lime will alter the

balance of the pond such that some species of plant and fish will thrive that had not done so before and others will not thrive.[5] Eventually, a new equilibrium will arise with somewhat different biota than had earlier been in place. What you would be doing, in this case, is introducing an additive that functions just as a pollutant functions. From appearances, the answer to this conundrum will come with a straightforward assessment of whether state C is better than state B.

But now consider this case:

2. Some outside party, Smith, transports additive Ξ on a small raft over your lake and subsequently dumps the additive. This causes great harm to your lake. By introducing additive Θ, you can offset the effects of additive Ξ, which will change the world from state B to state C.

The introduction of Smith complicates matters. It is not clear, for instance, that determining the right course of action is *strictly* a matter of evaluating outcome and risk. Depending on the nature of Smith's involvement—whether accidental, negligent, intentional, or malicious, for instance—this involvement will play an important role in the determination of the appropriate course of action. Is the solution *for you* to alter the pond a second time, say, by adding lime and changing its chemical composition? That is not clear. On one hand, it seems like it might well be the right course of action. It is your pond, after all. State C appears to be far preferable to state B. It would be better for all involved, including wildlife in the pond, if the effects of the copper sulfate were neutralized. On the other hand, it might appear that the right solution is not to shift the world from B to C, but to seek some reconciliation with Smith, since he is the party responsible for destroying your pond. Maybe you seek restitution, or admission of wrongdoing, or even just an apology—but the point is that there is something more going on here.

One might assume that this case introduces no new problem: the pond is still poisoned, which remains a problem *for you* that you must address. It matters not how the pond came to be in that state. The question of Smith's responsibility can be kept separate from the question of what you should do. That central question, of course, is still whether shifting to state C is the right course of action. And so, we might naturally assume that this can be determined by the extent to which adding fertilizer is a safe and desirable option. The other question, however, regards who should be responsible for engineering that shift. These seem to be related but separable considerations, though a somewhat deeper look reveals just how intercalated these two questions are.

We maintain that the question of whether remediation is warranted is a question regarding *Smith* and his actions, not strictly regarding you and your actions, even though it is you who has been wronged. The question of which course of action to pursue, however, is a question for *you*, not for Smith, though it is Smith who has done the wronging. To seek an answer to the question of whether *you* should alter the world from B to C is to treat the prior question of Smith's pollution as though it does not matter. This would be analogous to conducting ocean fertilization remediation technology without consideration of the initial situation that warranted the remediation, namely, the fact that carbon dioxide is being released into the air by distributed, global actors. Philosophy's rich history with trolley problems and intuition pumps underlines, among other things, the importance of responsibility from all parties in the determination of permissibility of further action (Foot 1978; Kamm 1989; Quinn 1989; Thomson 1986a, 1986b). It also underscores the extent to which the moral relevance of principled and reason-driven actions does not hinge on the intentions or the motivations of the actor, so much as on the particular circumstances that characterize the unique dimensions of the problem (including its genesis). To understand the full extent of this, it may help to be more explicit.

We think that cases in which remediation is permitted are distinguished by the discreteness and completeness of the original initiating act, and not by virtue of any epistemic commitments or the motivational orientation of the offending party. So, even though it appears on cursory examination that accidental or negligent cases of pollution are cases in which follow-up remediation is permitted by virtue of their similarity to naturally occurring states of the world, this is not so. What makes these cases distinct is the involvement of the offending party in bringing about the undesirable state of the world B and the extent to which that state of the world is acceptable to the parties that have been affected.

Our view, therefore, turns on the permissibility of actions regarding state C and the observation that they cannot be adequately ascertained in ignorance of actions that have coalesced to bring about state B. We think there is good reason to characterize the two actions as one, at least when seeking ethical guidance.

Suppose now that Smith's sullying of your property is the result not of a single careless decision to transport copper sulfate over your pond but the accumulation of an ongoing progression of careless decisions, each of which is the result of Smith's lack of concern for others. What is the proper course of action here?

It seems to us that the proper course of action is to seek immediate cessation and redress from Smith for having shifted from the world from A to B. It would be wrong, or at least premature, to even entertain the possibility of fertilizing the pond to bring about state C, particularly if there could be no guarantees from Smith that he would halt transport across your pond. In other words, the salient question is not, in fact, whether C is preferable to B, but whether and how we got B in the first place, as well as *why Smith continues with his foolhardy transportation scheme*. The reason for this, presumably, is both that the transition from state A to state B is continuous, not instantaneous; and that Smith is the one who is responsible for having brought about an undesirable state of the world in the first place. To ask when and whether it is permissible to shift from state B to state C is not only premature, but it buries somewhat more critical questions about *how* the world shifted from A to B and who bears responsibility. This is importantly distinct from a case in which, say, there were some continuing, but natural, additive responsible for altering the world from A to B.

None of this is to say that, under *some* circumstances, one would not want also to pursue the course of action that shifts the pond from state B to state C; but only that when the responsibility of an offending agent enters the picture, this responsibility can often militate away from a clear answer about the permissibility of taking further action. This is particularly true if the shift from B to C is inseparable from the shift from A to B.

To grasp the role of an actor's responsibility in the determination of the permissibility of further action, imagine a reverse scenario:

3. *You* accidentally dump additive Ξ on Brown's property. By introducing additive Θ, you can offset the effects of additive Ξ, which will change the world from state B to state C.

In this case, you are the party responsible for dumping the herbicide in Brown's pond. This would appear to change dramatically the permissibility of the action of shifting the world to state C. You cannot sneak onto Brown's property and add fertilizer to his pond. You would be wrong to do so, and you would be wrong to do so specifically because you would be wronging Brown. You would be wrong to do this without first approaching Brown and asking him what sort of future he imagines for his pond. Nor can you sneak onto Brown's property and return, through some advanced remediation technology, Brown's pond back to state A.

Expansion of the principle here demonstrates just how complicated this can get. If the pond belongs to Brown and Green, then both Brown and

Green must meet to discuss the proposed shift from B to C. So too, if the pond belongs to Brown, Green, and White or to Brown, Green, White, and Black. As the community of affected parties grows in number, the number of possible objections and unconsidered views grows in number as well. What of Brown's profit? What of Green's research? What of White's political commitments? And so on down the line. Plainly, some of these considerations can be soundly discarded, but only again after butting up against the legitimate claims of others. Perhaps, Brown's profit is taken at the harm of Black, in which case, Brown's harm to Black invalidates Brown's claim to profit.

Far from a simple restriction demanding that the consent of all parties be obtained before proceeding further, what this demonstrates is that affected parties, by virtue of having been wronged, are now in a position to determine whether the cleanup project should go forward at all. *They are not*, however, *in a position to go forward* with this decision, unless they consider the actions that have led up to state B in the first place, which will involve inquiry into the nature of the precipitating events: was State B natural, accidental, negligent, preventable, intentional, and so on? The affected parties *may*, of course, administer fertilizer to return the property back to its original state; but only on the condition that they are not complicit in the continued sullying of the lake such that addition of the fertilizer becomes a mere interim step in the bringing about of C. If they are, then their movement from state B to state C can only be evaluated properly as a movement from state A directly to state C.

We have assumed, then, that it is not permissible to shift the world from A to B. Other considerations notwithstanding, we have assumed that in most cases, where primary jurisdiction remains in control of the actor, it is permissible and sometimes required, to return the world back to state A. There are complicating factors here, including the extent to which other parties will be affected and could assent to such a move, but so far as remediation is concerned, it appears permissible to move in an A-ward direction. Our question has been whether it is permissible to shift the world from state B to state C, given that B materializes as a result of some prior but continuing action. The cumulative effect of these examples is that in the case of ocean fertilization, it is not permissible to shift the world from A to B without taking into consideration the concerns of those affected; inasmuch as this is so, it is inconsistent for those affected to consider shifting from B to C if some or all of them still maintain control over the shift from A to B.

Just as it is morally impermissible to dump copper sulfate into Brown's pond, it is equally morally impermissible to dump *lime* into his pond *even if*

it is you who has created a mess with copper sulfate. On that, most will agree. Because the objective of ocean fertilization is the reversal of anthropogenic climate change, it cannot be understood independently of the root causes of anthropogenic climate change, and its justification cannot be understood without assessing the perspectives and claims of all affected parties.

Our view turns on the extent to which a community of affected parties does or could assent to reasons offered for engaging in such a drastic action. It is plain, for instance, that some parties will be beneficiaries of global climate change, in perhaps a variety of unimaginable ways, not all of which involve straightforward benefits. Some of which, in other words, may involve the fulfillment of agent-relative commitments. Equivalently, some parties may lose a great deal in a global shift brought about by geoengineering, some of which may involve the frustration of agent-relative commitments.

The point being, more than most engineering projects, ocean fertilization is a project that will literally affect *everyone*: every human, every non-human animal, and every plant. It cannot be understood independently of this. Insofar, as it is a project that will affect everyone, Jamieson's first three criteria take a back seat to his fourth criterion. Moreover, our concern here is not the same as his. We are not concerned with how the decision will be made, nor who would have political jurisdiction, but how a decision of this nature could possibly be justified. This fourth criterion, we believe, must be fleshed out in terms that are sensitive to the interests and expansive moral considerations of all affected parties. Anything else is impermissible.

Concerns and Criticisms

One might object that if ocean fertilization is impermissible, then so too are other projects of chemical or biological remediation. We do not believe this to be the case, and we think the framework that we have spelled out offers a reason why. First, many cases of remediation occur in areas over which there is clear moral and political jurisdiction. On private property, remediation technologies are of little concern, precisely because the affected parties are limited to small groups of property holders. Whatever one makes of the institution of private property, it does serve the purpose of neatly restricting the circle of affected parties and legitimate claim raisers. As noted, however, our terminology of "affected parties" is not limited to human beings or property owners, and should apply also to animal and plant life; as well as, arguably, future generations and the whole system. Obviously, we argue neither for wide property rights nor for wide moral considerability here.

Instead, we think that the argument stands even if we limit the sphere of consideration to currently existing persons.

As the scope of a project grows, and the magnitude of affected parties increases, so too does the likelihood that the project is unjustifiable. Since justifiability is, on this view, a radically procedural notion, the moral permissibility of an act hangs on whether it can be assented to by affected parties. Unfortunately, as the scope of the project grows, so too does the likelihood that the project will be costly, complicated, uncertain, risky, and controversial. Generally, technical complications go hand in hand with the expansion of moral scope. This has the effect of masking these much more serious moral considerations about the extent to which the rights and concerns of affected parties play a role in the determination of the permissibility or the impermissibility of an act.

Second, what we have aimed to show is that no act of remediation can be understood independently of the acts that necessitate remediation in the first place. If the remediation is oriented around an ongoing anthropogenic cause, and that cause continues to be generative of the problem that is necessitating the remediation, then it requires extra justificatory work to demonstrate its permissibility. This is so not because it amounts to "treating the symptoms" of the problem instead of the root cause, though this may be a concern as well. This is so not because it initiates a so-called moral hazard in which individuals do not need to bear the risks associated with their actions.[6] But rather, it is so because the act of remediation is tied tightly to the same principle that enabled action in the first instance, and insofar as this act is impermissible, so too are subsequent acts that piggyback upon it.

This claim that the moral permissibility of ocean fertilization cannot be adequately assessed independently of the actions that have necessitated it, we note, may seem prima facie implausible, as it seems to make dubious metaphysical suppositions. However, we should stress again that this is not a metaphysical position. Rather, the general idea is that the *permissibility* of an action is best established by appeal to and analysis of its most suitable description. Our position on the most suitable description of the *action* (as one encompassing not just the singular act itself, but also the reasons that an agent has for undertaking the act) is supported by many branches of ethical theory, but most notably, variants of Kantianism and Aristotelianism.[7] In the case of ocean fertilization, this bears on the determination of the permissibility of the act. It would be easy to describe the act of ocean fertilization simply, as the intentional addition of iron particles into the ocean, perhaps with the primary objective of generating phytoplankton growth.

However, it is our contention—which we do not find unreasonable—that this is an inadequate description of the action. Instead, ocean fertilization is a *response* to concerns over anthropogenic climate change stemming from distributed and uncoordinated carbon emissions into the atmosphere. Since this is the central motivating concern for ocean fertilization, we contend that the act is best evaluated with this in mind. In the same way that a murder committed in response to a threat on one's life cannot be understood adequately independently of this threat *to* one's life, so too can ocean fertilization not be adequately understood independently of distributed carbon emissions.

Finally, we consider how broadly our conclusions might apply to geoengineering in general. That is, if our account that the antecedent actions that have given rise to consideration of ocean fertilization is correct, then this would appear to apply to all forms of geoengineering. First, we make the observation that not all responses to climate change are responses of the same sort. We only analyze here the case of ocean fertilization but emphasize that all three claims made in the article are necessary to find that ocean fertilization as a form of geoengineering is impermissible. If a geoengineering solution only meets two of the three tests, as we might say for air capture, for example,[8] it would not be considered impermissible.

Conclusion

If we could devise some democratic and rights-respectful way of regulating human activities to prevent catastrophic outcomes, then this should take priority over other options. Our reason for saying so is that human activities, even when the outcome of a decentralized and largely anarchic system of control, are within our coordinative power, we should do what we can to restrain ourselves from creating these problems in the first place. If we seek to understand remediation technologies independently of the circumstances that have given rise to their possible implementation, we use a troubling presupposition: that the ultimate moral evaluation of our actions is not dependent on the reasons that inform our actions, but unilaterally determined by the extent to which we are able to weasel out of their consequences.

We can see that while there are many reasons to reject ocean fertilization as a strategy, ultimately the strongest position comes from evaluating the idea from the perspective that it violates well-founded ethical principles or considerations (Jamieson's fourth condition). In particular, ocean

fertilization threatens moral trespass, which fundamentally underlies our rejection of any act of pollution (Sagoff 2004). Beyond the straightforward harms view of pollution, we see pollution as identifying a *wrong*. Because ocean fertilization is conducted as a means of sidestepping the original and ongoing act of pollution (carbon emissions), it essentially becomes one step in the original act.

Moreover, ocean fertilization is best understood as unjustified because it cannot easily pass strict tests of justification. Beyond simple practical objections to the feasibility of orchestrating and obtaining assent from affected parties, we can easily imagine a situation where it fails justificatory scrutiny; where it is rejected by affected parties on grounds that can withstand repeated appeals to the interests and needs of many. Finally, ocean fertilization would move the world to a new state with unknown, fluid, and potentially global repercussions. We therefore find that ocean fertilization is an ethically impermissible solution to climate change.

Notes

1. For the sake of this article, we put aside the question of other geoengineering projects like the installation of enormous space reflectors or injection of stratospheric aerosols. We think these are sufficiently different in nature to warrant separate treatment, though we intend to raise concerns about the moral permissibility of these sorts of projects in future papers.
2. For the sake of this argument, we leave aside questions of nature's moral status and moral considerability, as well as questions of nature's intrinsic, inherent, instrumental, derivative, relational, objective, or relative value. The argument should stand on almost any account of nature's value, worth, or status. The community of competent, adult human beings is sufficiently expansive and diverse to accommodate a range of agent-relative reasons that provide counterpressure to the legitimacy of geoengineering projects.
3. Our argument here is perhaps best understood as broadly Habermasian, aimed to understand justified actions in terms of whether they would or could survive wide deliberative scrutiny. As such, this pragmatic position on justification invariably presents a sticking point, most often when such statements are read as offering not justificatory criteria, but as a procedural decision-making methodology. In earlier work, Habermas and other discourse ethicists have addressed concerns overuse of the "would or could" language. They have defended their position by insisting that the principle of discourse is to function as a regulative ideal governing real-life discourse, in lieu of a call to actual political consensus. For an intelligent discussion of this debate, refer to Benhabib and Dallmayr (1990).

4. To avoid begging the question against either pollution or ocean fertilization, we loosen the terminology and defer to both initial polluting agent and subsequent remediating agents as "additives." We then turn our attention to the responsibilities associated with introducing these additives and bringing about new states of the world. We reason that any additive, when introduced to remediate the effects of some other additive, can only be viewed as a continuation of the initial act. The act of introducing the follow-up additive, the remediating additive, then can only be justified according to the extent that the affected parties would (or could), assent to such remediation. If the affected parties are engaged in the business of introducing the initial additive without this assent—as is the case with the distributed responsibilities and accumulative harms—the follow-up act of remediation can also not be justified, *unless the damage has already been done*.
5. This is, in fact, a persistent question in limnology, commonly phrased as the conundrum: "Should we lime the lakes?" This particular case was inspired by the remediation of acid mine drainage at the Summitville Mine in Summitville, Colorado. See Plumlee and Edelmann (1995).
6. One coauthor has argued elsewhere that there is nothing inherently moral about the moral hazard. The only reasonable interpretation of the "moral hazard" is that it specifies a circumstance in which an independently established moral wrong is induced as insured parties change their exposure to risk. See Hale (2009).
7. Christine Korsgaard has a nice discussion of this in her book on self-constitution. She distinguishes between an act and the "description of an action," which describes not just the act, but also the reason for the act. Korsgaard observes that both Kant and Aristotle, as well as, presumably, those in their philosophical lineage, "think that the objects of choice are actions, acts done for the sake of ends. Both of them think that actions in this sense are the bearers of moral value, and that moral value, that is, dutifulness or nobility, is a property internal to actions—a formal property embodied in the principles that describe them." See Korsgaard (2009).
8. While air capture can be seen as problematic for criteria 1 and 2, that is, that of being inextricably linked to the original polluting act, and failing to obtain assent from all affected parties, it does not move the ocean, a fluid, global medium, to a third, unknown state. Geoengineering solutions that are more localized and seek to return the world to its original state may meet the test of being permissible types of engineering projects as discussed earlier. For more on this argument, please see Hale (2011).

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