GEOENGINEERING:
A Climate Change Manhattan Project

by Jay Michaelson

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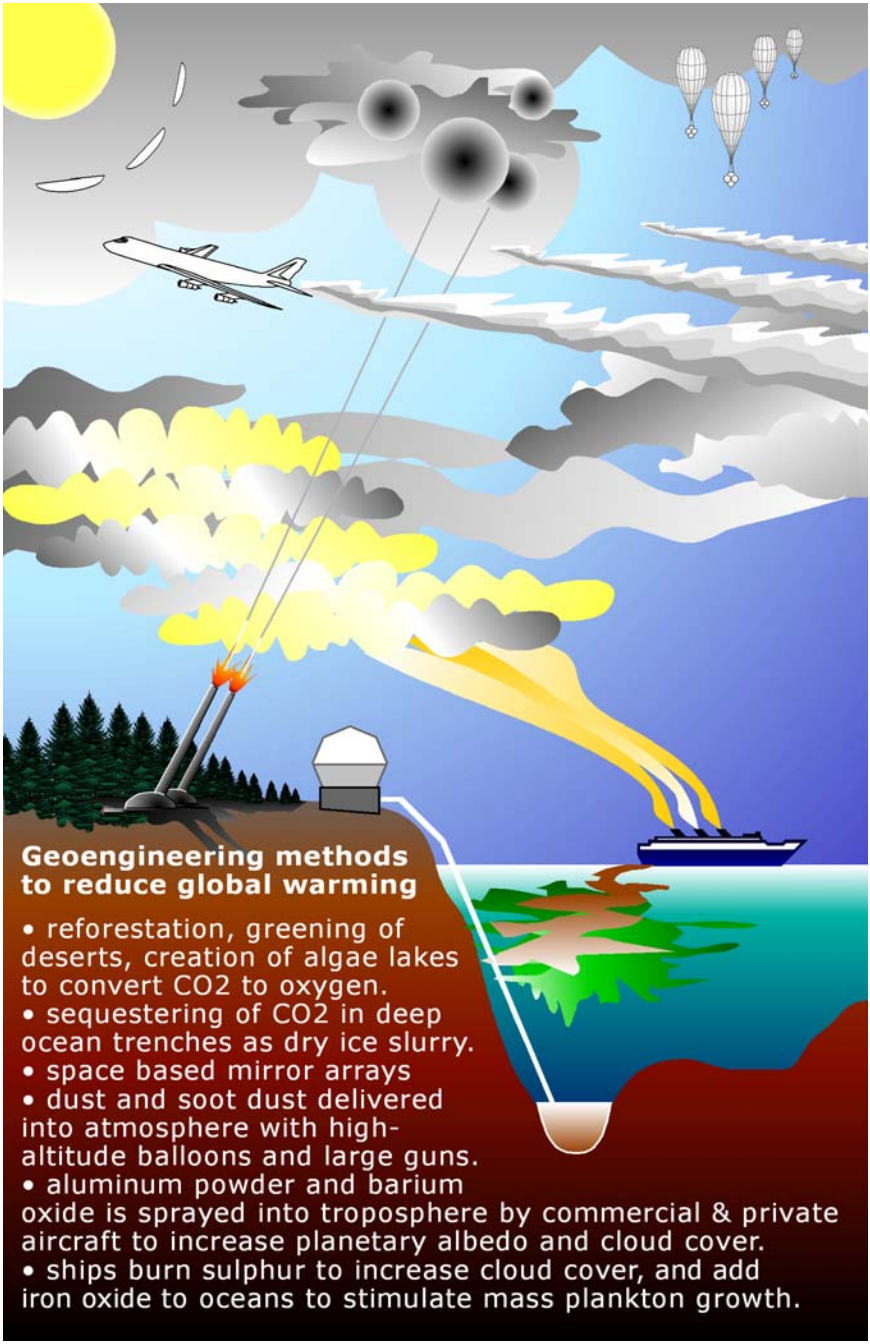

Ilustration by Bruce Conway - www.lightwatcher.com.Based on; *Policy Implications of Greenhouse Warming Mitigation, Adaptation, and the Science Base by N.A.S.*/ http://books.nap.edu/books/0309043867/html/R1.html#pagetop.

Introduction

Why are we fiddling while the Earth burns? Though the vast majority of the world's scientific and political communities now agree that some warming of the Earth's climate is occurring as anthropogenic changes take place in the atmosphere, [FN1] there is *75 equally widespread agreement that our recently renewed efforts to mitigate its consequences are woefully inadequate. [FN2] Notwithstanding the many proposals, [FN3] and limited progress toward a binding climate change treaty at the recent Third Conference of the Parties to the U.N. Framework Convention on Climate Change (COP3) in Kyoto, Japan (hereinafter "Kyoto Conference"), [FN4] creating effective climate change policy remains "the most difficult negotiation anyone *76 has tried to do." [FN5] Why?

This Article argues that the lack of success in climate change policy stems from the exclusive focus of policymakers on various forms of preventive regulation. Because climate change regulation requires an extraordinary amount of will and coordination, and because uncertainty, cost, equity, and other factors threaten the effective implementation of a Kyoto-style program, a regulation-only approach is dangerously myopic. Not even the most austere post-Kyoto regulatory regime can avert a probable temperature rise of 2 to 3 degrees Fahrenheit during the next century, and most observers estimate that more politically feasible plans will yield a rise of between 3 and 8 degrees. [FN6] Yet other than simply doing nothing and adapting to climate change when it happens--a potentially catastrophic strategy--what alternatives do we have? [FN7]

In the wake of Kyoto, the time has now come to expand our policy horizons to include geoengineering, the direct manipulation of the Earth's climatic feedback system, [FN8] as a serious alternative to ineffective and contentious regulation. Once derided as science fiction, [FN9] geoengineering has lately begun to merit serious debate in academic, [FN10] scientific, [FN11] and econometric literature, [FN12] *77 and has gained the tentative support of such diverse figures as Edward Teller, [FN13] Wallace Broecker, [FN14] William Nordhaus, [FN15] and Stephen Schneider. [FN16]

First, the science of geoengineering--though not the primary focus of this Article--is no longer the arrogant climatologist's Tower of Babel. [FN17] In particular, two proposals have yielded encouraging scientific data: the oft- maligned "Geritol cure" [FN18]--sowing iron filings in the ocean to stimulate the growth of car-

bon-consuming phytoplankton; [FN19] and the "sunscreen" proposal, which *78 calls for the controlled emission of dust particles to reflect solar radiation and incrementally cool the Earth, [FN20] simulating the counter-greenhouse "Pinatubo Effect" measured in the wake of Mount Pinatubo's eruption in 1991. [FN21]

From a policy perspective--which is the primary focus of this Article-- geoengineering, though perhaps counterintuitive, should be very attractive to both greenhouse "True Believers" and the most ardent of skeptics. To the skeptic, and the policymaker, geoengineering offers a relatively painless, relatively cheap alternative to costly and unpopular regulation. Allowing airplanes to fly dirtier (the "sunscreen proposal") may involve some implementation and secondary costs, but compared with the economic upheavals associated with even modest reductions in carbon dioxide emissions, it is a bargain, especially if implementation may be delayed while our uncertainty about climate change lessens. [FN22]

To the greenhouse True Believer, geoengineering offers both hope and despair: hope for a solution to climate change, despair at retreating from prevention as that solution. To any thoughtful environmentalist, a Big Fix is woefully counterintuitive--it treats symptoms, not causes, and allows the rapacious consumerism of the West to progress unchecked. Indeed, that is what makes it popular with skeptics. But a geoengineering policy can work. True, it does not make the polluter pay, or halt the destruction of ancient forests. And, as discussed below, there are serious ecological concerns associated with any tampering with the Earth's climatic systems. *79 But because, as argued in this Article, geoengineering avoids the pitfalls of a traditional, regulation-based climate change strategy, the True Believer should still be convinced. Climate Change "Marshall Plans," [FN23] designed to curtail greenhouse gas (GHG) emissions, tend to fail before they begin. Developing technology to affect the climate directly--a Climate Change Manhattan Project-- can work.

Part II of this Article discusses in detail why the international community lacks the will to prevent climate change. First, I argue climate change is a uniquely absent problem: the harms from climate change may not be present for decades, and there is real uncertainty as to the problem's scope and magnitude. Second, climate change is institutionally and economically difficult to address: reduction in fossil fuel use and deforestation, the linchpins of a successful climate change prevention strategy, [FN24] could radically alter the economic and social fabric of "Northern" industrialized countries and stunt the growth of "Southern" developing ones. Climate change regulation is extremely expensive [FN25]

and complex, requiring implementation, coordination, and monitoring by international institutions ill- equipped for such tasks. Third, climate change is a tragedy of the commons: [FN26] it rewards nations that cheat on agreed-upon limits, particularly more developed nations who face a "cooperator's loss" even if everyone cooperated fairly. Of course, it looks like we should all benefit from stopping climate change. But a little insight shows that the negotiation problems *80 evident at the Kyoto Conference, [FN27] and the inadequacy of Kyoto's proposed cuts relative to our present scientific data, [FN28] are the natural results of the perverse incentives inherent in climate change regulation. And Kyoto is just the beginning: those same incentives point toward serious implementation problems yet to come.

Enter the Climate Change Manhattan Project. Part III argues that in every place where regulation stumbles, geoengineering succeeds. It avoids the problem of absence by offering a potentially remedial solution that may be adjusted in accord with the effects of climate change, and with a shorter lag time than preventive regulation. With secondary and social costs properly counted, geoengineering costs less than regulation while avoiding its webs of political and institutional malaise. And geoengineering minimizes the impact of the cooperator's loss/tragedy of the commons by not requiring international behavior modification. Part III thus proposes that existing national and international bodies shift their emphases from seeking to implement a climate change regulatory regime to developing a Climate Change Manhattan Project, by means of research, funding, and eventual implementation of geoengineering proposals.

Geoengineering is often considered a highly immodest proposal, and part IV of this Article is devoted to defending the idea against several arguments typically made against it. First, the response to the claim that geoengineering "just won't work" is to argue that such a claim is premature in practice and foolish in principle. Of course, the case for any new technology is "uneasy," [FN29] and uncertainty will remain up until a geoengineering project is put into place, but such uncertainty is not sufficient reason to fail to initiate research now. Nor can we be daunted by the prospect of vast, unforeseen secondary consequences of tampering with the Earth's climate; again, it is too early to tell. Caution is wisdom--but inordinate skepticism flies in the face of a century of technological achievement.

There are deeper concerns regarding a geoengineering policy, however: that it is unnatural, that it destroys the very nature we seek to create. Yet taking these objections seriously, a Big Fix may, *81 in ultimate ecological impact, actually help more than it

hurts: with careful and controlled implementation, it can offset already existing anthropogenic interference with the Earth's systems.

Finally, however, it must be conceded that geoengineering runs afoul of almost every major trend in contemporary environmentalism. Beyond their brute ugliness, "Geritol cures" and "Earth sunscreens" treat shallow symptoms, not deep causes, and thus fail to "kill two birds with one stone" as would a serious program of combating deforestation or cutting GHG emissions. In part V of this Article, I offer some deeper reflections on this issue. Part V insists that it is time for environmentalists to reclaim the Big Fix, that holists and deep ecologists must, in a Rawlsian vein, learn to speak the pragmatic language of political discourse. If for no other reason, they must do this because geoengineering offers hope for solving climate change beyond the too-little, too-lates of Kyoto--essentially if you are one of the people who care about climate change, you should support geoengineering, because most people still do not care enough. But on a deeper level, geoengineering asks environmentalists how much they value their private philosophies, and how much they value the estuaries, islands, and trees that are threatened by climate change.

In the post-Kyoto world, we need more than promises of emissions cuts and tradeable permits. We need a Climate Change Manhattan Project.

II. Preventing Climate Change Through Regulation

A. Introduction: Will and Uncertainty

The climate change problem presents a curious pair of phenomena: universal agreement that something bad is happening, and universal inability to stop it. Since there is considerable, real controversy surrounding the extent of climate change, it is worth beginning with what we do know. We know the following:

1. the climate is warming; [FN30]

2. concentrations of GHGs in the atmosphere are increasing; [FN31]

3.(82) the latter phenomenon theoretically can cause the former; [FN32] and;

4. increases in the Earth's temperature are likely to have costly effects. [FN33]

At the same time, it is worth noting what we do not know, namely:

1a. to what extent climate has changed, and is likely to change if current trends continue; [FN34]

2a. to what extent atmospheric composition is changing as a result of human activity; [FN35]

3a. to what extent the warming of the Earth's climate is due to atmospheric change (anthropogenic or otherwise), and to *83 what extent it is a natural fluctuation; [FN36]

4a. the extent to which the effects of climate change will be adverse to human and other biological interests, [FN37] and how those adverse effects compare to harm resulting from other risks. [FN38]

There is thus considerable uncertainty regarding what should be done by concerned national or international actors: we do not know how much we are causing a problem, so we do

not know how much to cut back. Nor is it clear how the problems associated with climate change compare to other human and environmental crises in magnitude and urgency. Of course, these uncertainties are garden variety environmental policy issues; uncertainty is an intrinsic part of the policymaking process, and thus must be taken into account in developing effective policy responses. [FN39] But there is one more thing about the climate change problem which is certain:

5 (*84). we have not done much about it. [FN40]

This part suggests three main accounts of the tortured history from Rio [FN41] to Kyoto, [FN42] all of which point to the need to take a different route on the road to come: the absence of immediate consequences of climate change; the costs and complexities associated with addressing it; and the economic incentives in place that discourage cooperative action.

B. Climate Change Is an Absent Problem

Every environmental problem that has been addressed over the last thirty years has been a present one. In the pollution-conscious days of the 1960s and 1970s, American environmental legislation was passed in the face of rivers that burned and air that clogged the lungs. Species protection laws and treaties have sprung into existence in response to measurable declines among photogenic animals such as the bald eagle, African elephant, and rhinoceros. Even the "invisible" problem of ozone depletion was solved after--and only after--it became a graphically present issue on the front *85 pages of prominent newspapers. [FN43]

The adverse effects of global climate change, however, remain a matter of prognostication because the real problems associated with such climate change have yet to manifest themselves. "Doomsday scenarios," such as massive flooding and crop dislocation, remain only hypotheses based upon scientific projection. This feature of the climate change problem distinguishes it from previously encountered global environmental issues and has at least three policy effects: denial, discounting, and aggravated uncertainty.

First, and perhaps most obviously, the absence of any visible effects of global warming makes the problem deniable. Given its political appeal, it is not surprising that denial remains the primary tactic of those opposed, for whatever reason, to preventing climate change, [FN44] and the absence of the

problem's effects allows this strategy to continue. In the absence of tangible effects, deniers may attack the science--and the scientists--instead of the problem. [FN45]

Second, absent problems may be unduly discounted. It is a *86 commonplace notion of both economics and psychology that we discount future problems in favor of present benefits. [FN46] For the policymaker this simple fact presents a political dilemma: the beneficiaries of today's climate change regulation are unborn, while the bearers of the cost are constituents. However much as today's cost-bearers care about future generations, they are still likely to demand, at least implicitly, some positive rate of return on the costs they bear. In general, that demand for a return is reflected in interest rates, rates that translate into discount rates for projects that are investments for future generations. Finding an appropriate discount rate is essential for crafting efficient policy responses. But, of course, an efficient discount rate may not yield an optimal (or even satisfactory) ecological result. [FN47]

Third, absent problems exacerbate uncertainty. As stated above, there is some uncertainty regarding the extent to which climate change is an anthropogenically driven problem. [FN48] There is even greater controversy surrounding the effects of climate change: it may indeed be a doomsday scenario, or it may be a minor irritant. [FN49] Nor is it certain from a political or ethical perspective how the human and ecological benefits of a stable climate would balance against the costs of maintaining it. [FN50] Were the climate change problem present, the question would be largely one of measurement and interpretation; as it currently stands, it is one *87 of measurement, interpretation, prognostication, and hedging one's bets. [FN51]

While highlighting uncertainties and denying the problem can easily get out of hand, [FN52] the absence of any serious effects of climate change allows such tactics to proceed in the political arena--and should factor into more serious policy considerations as well. Climate change is not like whales washing up on beaches; absent visible effects, it is hard to muster political will on the basis of computer models.

C. Climate Change Is Difficult to Address

Anyone who watched the maneuvering and horse trading at the recent Kyoto Conference understands that climate change is a difficult problem to address. [FN53] Indeed, the difficulties have just begun; any regulatory regime, even one of market mechanisms or "voluntary" emissions reductions, requires continued enforcement, monitoring, and domestic approval, long after ratification is complete. Yet climate change is different not only in extent, but also in kind, from previously solved problems such as localized pollution or global ozone depletion, presenting unique issues of cost, equity, complexity, disagreement, and institutional inefficiency. The nations of the world are not settling for an insufficient level of GHG reduction out of laziness; they are responding to the intense combination of factors which makes climate change so difficult a problem to solve.

1. Cost.

The economic cost of climate change regulation. While it is easy to overestimate the role cost-benefit analysis can and should play in *88 our public policy debates, [FN54] the sheer expense of cutting back on fossil fuel use should give any thoughtful policymaker pause. [FN55] William D. Nordhaus estimates the cost of carbon taxes needed to yield the "optimal" GHG reduction from uncontrolled levels of about nine percent in the near future to fifteen percent latein the next century would begin at five dollars per ton of carbon and rise to twenty dollars per ton. [FN56] Given present carbon emissions of at least nine billion tons per year, [FN57] such carbon taxes would carry an initial marginal cost of forty-five billion dollars annually. Considering Nordhaus's estimate of $5.6 trillion in total costs of unabated climate change, taxing emissions at those rates would yield net annualized benefits under certain discounting assumptions, [FN58] but only after tomorrow's uncertain benefits are realized. The taxes are paid today.

More dramatic cuts are even more expensive. Nordhaus estimates that stabilizing GHG emissions at 1990 levels, as urged by the *89 Framework Convention on Climate Change, would require a carbon tax starting at ten dollars per ton but rising within twenty years to ninety dollars per ton, [FN59] at a marginal annual cost by 2015 of $810 billion, which--Nordhaus claims--yields an annualized global loss of $762.5 billion. [FN60] In contrast, Nordhaus estimates the net benefits of a successful geoengineering policy as $224 billion, far surpassing even his optimal regulatory regime. [FN61]

To be sure, such calculations are not completely certain. William Cline, disputing Nordhaus's time horizon, discounting procedure, and assumptions about population and income, argues that much higher rates of GHG reduction are efficient--perhaps as high as seventy-one percent reductions from 1990 baselines by 2050, although with attendant higher marginal costs. [FN62] Cline also surveys the estimated cost of reducing carbon emissions according to seven different economic models. [FN63] Using varying rates of GHG reduction and differing policy portfolios, these models yield U.S. Gross Domestic Product (GDP) losses ranging from 1.3% [FN64] to three percent (and a huge loss--eight percent of GDP--for China). [FN65]

In addition to these considerable economic effects of carbon taxes and similar cost-internalizing programs, it is worth thinking briefly about the secondary effects of technological changes that might accompany such reductions. By way of example, consider asking citizens of the United States, by far the world's largest emitter of greenhouse gases, to reduce their automobile use by a mere ten percent, or put up with a minor ten percent reduction in car performance. For some, the change would not be traumatic: many people live in urbanized areas with adequate mass transit, *90 and many people do not rely on, or value, automobiles at all. But small social changes add up. Even if people value their time only as much as they are paid for it (hardly a safe assumption), minor inconveniences, such as longer commutes, are very expensive. If translated into lost wages, a mere fifteen minutes of lost time per person per day, at an average hourly wage of $11.82 per hour [FN66] yields an annual cost of $740.86 per person, or $92.6 billion across the U.S. working population. [FN67]

It is worth repeating, however, that doing nothing--even in Nordhaus's relatively conservative model--also carries extremely high costs: Nordhaus estimates the total cost of climate change, if we do nothing about it, to be approximately $5.6 trillion. [FN68] Cline, arguing that cost estimates should be made over a 200-300 year reversal horizon, projects the cost of unabated climate change to be $335.7 billion to the United States alone. [FN69] Still, other "costs," such as potentially widespread ecological damage in the wake of disturbed growing seasons, weather patterns, and habitat suitability, escape calculation.

Regardless of how the cost-benefit curves actually play out, however, we incur these costs through indecision and a failure to act--and if recent progress towards a climate change treaty is any indication, international actors excel at agonized indecision. More importantly, the parties with a voice at climate change negotiations do not stand to bear the future economic impact of

climate change. [FN70] Nordhaus's rational GHG reduction has not been pursued, and even popular "no regrets" policies and moderate steps *91 towards mild forms of greenhouse taxes have been met with intense political resistance. [FN71] Obviously, the resistance to immediate costs both generally and by concentrated interests with vested stakes in the status quo takes the form more of a presumptive rejection than of a balanced and rational weighing of costs and benefits. [FN72]

The social costs of climate change regulation. The costs of climate change regulation extend beyond primary and secondary economic impacts, as reduction in fossil fuel use may reshape the social fabric of both developed and developing nations. [FN73] These social costs, while perhaps difficult to quantify, are not at all "soft" when incorporated into the decisionmaking calculus of the international policymaker. Moreover, since existing concentrations of wealth are largely a result of the most effective wealth-maximizing activities--themselves often tied to environmentally destructive practices--those with the most stake in the status quo, including utilities, heavy industry and the like, will likely absorb most of the costs of a regulatory regime. Regulation, in short, causes those with the most clout to be most opposed to mitigation efforts. [FN74] This perverse effect of the "polluter pays" principle helps explain why ecologically effective GHG reduction measures were not agreed to in Kyoto, notwithstanding popular support for pursuing them. [FN75]

More generally, curtailing industry and public utilities and suggesting "less is more" in societies where "bigger is better" are quite costly propositions. [FN76] Notions of "living lightly" and minimizing *92 environmental exploitation may indeed be desirable--and may possibly be necessary for other social or environmental agendas--but the social costs of such efforts are not mere societal detritus. [FN77] Consider again the American case of the automobile. In terms of social costs, it is ludicrous to state--as above--that Americans value their cars only inasmuch as they are paid for the time cars save. While it is easy to mock the "idolator of the Automobile," the political reality is that most Americans are strongly attached to automobiles and the freedom of mobility they represent. [FN78] It may be a worthy long-term goal to disabuse Americans of this notion. But in the meantime, GHG reductions are, socially speaking, nontrivial in cost. Insofar as many people see the encroachment upon their freedom to consume as a restriction on property rights, removing even a single stick from the "bundle" may be seen as an encroachment upon the whole. [FN79] A real change in consumption and transportation habits would necessitate a fundamental reworking of

the suburbs-based American geography, which depends on intensive automobile use for its structure--costs whose "hard" economic translations we can only estimate (as attempted in the thought experiment above). [FN80] As deep ecologists have argued for decades, serious environmentalism--at least in the climate change context--requires much more sacrifice than simply recycling one's newspapers. [FN81]

Of course, deep ecologists may not be completely right: some consumption-friendly steps, such as zero-emission vehicles or alternative energy sources, may go a long way toward controlling climate *93 change without requiring intrusive regulation or geoengineering marvels. [FN82] Even these policies, however, necessitate substitutions for environmentally favored goods that have not been at all popular in recent years. [FN83] Any policy which requires us to change our attitudes must consider whether the cost of doing so is prohibitive.

2. Equity.

The problem of equitably distributing the costs of global warming between "Northern" industrialized nations and "Southern" developing nations further complicates efforts to address global warming, with Southern nations objecting to their having to bear costs of solving a problem created by the North. [FN84] Equity also threatens to undermine supposedly efficient and wealth-spreading means of attaining emissions reductions, such as "joint implementation," wherein one country's emission reduction limits may be offset by another. [FN85] Indeed, the "development" language of the Rio UNCED Declaration recognized the assertion by Southern countries that, far from shouldering extra burdens, they should be *94 entitled to exploit the natural environment to at least the same level as Northern countries already have done. [FN86] Developing nations have more recently refused to accept any new GHG emissions commitments, threatening the ultimate success of the Kyoto process. [FN87]

It may be that equity concerns are more properly a subsection of the "costs" of climate change programs, insofar as they may be compensated for by "bribes" paid to developing nations. [FN88] It may also be that equity concerns will vanish of necessity, as most experts believe that developing nations will bear a disproportionate share of the harms from climate change, no matter who caused them. [FN89] At the very least, the global nature of climate change together with the non-global nature of its causes immediately makes equity a central issue to be addressed in any climate change strategy. [FN90] Climate change

regulation, however, tends to exacerbate the problem of equity: GHG emission reduction is inconceivable if the developing world grows and consumes at Northern rates. [FN91] A focus on preventive regulation is unlikely to inspire cooperation--or success--among those nations well aware that they are at the short end of the development stick.

3 (*95). Complexity.

Climate change is a complex problem: it is caused by the GHG-producing activities of every human being, animal, and (dead) plant on the planet. Unlike ozone depletion, which was attributable to chemicals manufactured by a small number of parties, all of us "manufacture" GHGs, whether by breathing, driving, using electricity, or raising cattle. [FN92] Consequently, any effective climate change strategy would have to include both a wide variety and a large number of emission reduction steps, with attendant enforcement mechanisms to ensure that the steps are actually taken. [FN93] Nor does the enforcement problem disappear if, as seems likely, international bodies only set targets and rely on national or regional entities to set up actual emission reduction programs. Extensive monitoring of the tremendous number of "polluters" will still be necessary and enforcement mechanisms will still have to be put in place to ensure that countries continue to meet emission reduction targets. [FN94] Both the prescription and the enforcement of climate normalization steps will have to be quite wide-ranging and complex.

4. Disagreement.

Divergent interests among international actors further complicate climate change regulation. [FN95] Some nations--island countries, for example--have a strong incentive to fight global warming at any cost, while others see only limited anticipated harms and clear benefits in maintaining the status quo. [FN96] Even among industrialized *96 nations, interests diverge widely, as evidenced by the gap between the European Community's initial Kyoto proposal of fifteen percent to thirty percent GHG emissions reductions and the United States' initial proposal of reductions to 1990 levels by 2008. [FN97]

The exigencies of international politics play a prominent role as well. For example, in an emissions-reductions-only world, China is an absolutely essential "problem" player: even if every other nation froze its GHG emissions, world emissions would rise forty percent if China raised per capita emissions to half of U.S. levels. [FN98] Yet, historically, China has responded in a generally hos-

tile manner toward claims of international law and comity, and more recently, developing nations--led by China, India, and Brazil--have demanded a "pass" at Kyoto, arguing that developed nations should reduce first. [FN99] Given China's extremely high marginal cost of GHG reduction, [FN100] domestic coal resources, importance as a world economic force, and unique political dynamic, "disagreeing" with China is an inevitable, but potentially insurmountable, obstacle blocking negotiation of international protocols for GHG reduction.

China is but one example, of course. The trouble with regulation is that every nation's diverging set of interests has to somehow be accommodated in one unified set of agreements--a Herculean task, as demonstrated in Kyoto. [FN101] Nations often have unique and *97 unexpected concerns; Australia, for example, generally an environmental leader, opposed strict GHG emissions limits in the Kyoto negotiations largely because of its $6.5 billion coal export industry. [FN102] Yet because climate change regulation must encompass all major producers of GHG, Kyoto-style negotiations must in some way account for every idiosyncrasy and still produce an enforceable outcome.

Most importantly for the post-Kyoto phase of climate change policy, disagreements in negotiation do not simply go away once a compromise is reached. Emissions targets are meaningless without cooperation and enforcement among nations, a process which revolves not around high-profile conventions and press releases, but around ongoing communication and monitoring. With interests as divergent as they are in the climate change arena, focusing on source reduction regulation makes meaningfully addressing the problem a very difficult task indeed.

5. Institutional inefficiency.

The inefficient nature of the global environmental institutions amplifies such difficulties. [FN103] While the inefficiency of global institutions does not by itself render a problem impossible to solve, it does exacerbate all of the foregoing difficulties associated with climate change remediation by adding considerable transaction costs to the search for solutions. [FN104] Moreover, agreement is only the beginning of the challenge: enforcement problems are amplified by the lack of coordination on the institutional level. [FN105] The institutional structure amplifies disagreements, provides "heckler's vetoes," and subsequently empowers single nations to play to domestic pressures and not yield to consensus. Furthermore, the lack of institutional coordination leads to inefficient replication of effort as various international entities, each

with slightly different *98 mandates and agendas, work separately (and sometimes at cross-purposes) on the same issue.

Scholars and politicians have offered remedies to this situation, ranging from careful calls for a global environmental organization [FN106] to less nuanced cries for "world government." [FN107] Unfortunately, the trouble with such proposals is that few countries want an efficient international environmental organization. Nations concerned about sovereignty fear incursions on their territorial and national integrity. [FN108] Transnational corporations fret over further encumbrances on maximizing profit. Many environmentalists may even dislike the idea, fearing loss of democratic participation in decisionmaking processes. The inefficient mess of international environmental policy is a mess by design.

Attempting to legislate and enforce a climate change regulatory regime maximizes the problems of institutional inefficiency because multilateral negotiations and enforcement are institution-heavy activities. As recent history has shown, they encourage fragmentation, inaction, and competing agendas among the nations and non-governmental actors of the world. [FN109] Relying on inefficient international institutions for development and enforcement of climate change regulation is a significant, but unavoidable, obstacle.

In sum, focusing on ways to prevent climate change maximizes all of the difficulties of cost, equity, complexity, disagreement, and institutional inefficiency. Even a highly determined set of policymakers faces considerable challenges--a fortiori a consortium of reluctant national representatives meeting in Kyoto or the myriad of bureaucrats who must meet in their wake to iron out and enforce the details. It is possible to minimize some of these tensions, if policymakers widen their horizons beyond traditional preventive strategies to include remedial strategies such as geoengineering. Before turning to this discussion in part III, however, it is worth addressing one final aspect of the climate change policy crisis: that climate change is a tragedy of the commons.

D (*99). Climate ChangeIs a Tragedy of the Commons

The preceding two sections have discussed why we lack the will to solve climate change as a practical problem: because global warming is an "absent" crisis, and because it presents unusual technical and institutional difficulties. Yet even if we had perfect information and no discounting of future harms, and even if the difficulties associated with addressing climate change were

somehow alleviated, global warming would remain, in principle, a variant on the now-classic "Tragedy of the Commons." [FN110]

A tragedy of the commons occurs when each user of a common resource, in using that resource, reduces the value of the resource to herself to a degree smaller than the amount of utility she receives from the use, and reduces the value of that resource to all users to a degree greater than the amount of utility she receives from the use. Although each rational user has a stake in the survival of the commons, she has a much larger stake in the immediate gains from exploiting it. Thus, absent cooperation (enforced or otherwise), every rational actor will have an incentive to deplete the commons and, realizing everyone else has the same incentive, to do so as quickly as possible. [FN111]

The case of climate change presents an imperfect tragedy of the commons, because international actors face varying degrees of expected harm and benefit from their use of the common resource. [FN112] Some (e.g., France, Germany, and most other developed nations) face an ordinary prisoner's dilemma, in which they benefit from cooperative action, but would benefit more if all other actors cooperated and they did not. [FN113] Others (e.g., China, and possibly the United States) face what has recently been termed a "cooperator's loss," where some nations would prefer no cooperation at all to universal cooperation. [FN114] Still others (e.g., island nations) *100 while still perhaps facing the prisoner's dilemma, expect far more serious captured harms from climate change. At the same time, some nations have an incentive for no action at all because most international actors face at least as much benefit (in terms of present-day financial gain and stability) from the status quo as harm from climate change.

Of course, it may be possible to influence domestic public opinion to the extent that even a nation supposedly facing a cooperator's loss--such as the United States--may perceive its own expected harms to outweigh its present benefits. But, in general, most nations face so much uncertainty regarding their own share of climate change's expected costs [FN115] that they favor continuing to emit GHGs (or eliminate carbon sinks) rather than hoping to receive an uncertain share of a deferred common good. [FN116]

Negotiating and enforcing a regulatory regime for addressing climate change is thus a matter of forcing most nations to act against their present interests. Of course, this is true for any contractual solution to a tragedy of the commons, from Hardin's original grazing example [FN117] to recent efforts to preserve fishing stocks. In contrast to such cases, where the same fishers

or cattle owners who must agree are the parties whom the agreement benefits, the actors presently doing the most harm in the climate change case are not the same as those facing the most benefit from mitigating climate change. On the contrary, many private actors--whether they be extractive industries in Brazil, American manufacturers, or any automobile driver--have a much greater stake in preventing climate change regulation than most parties have in achieving it.

Climate change regulation thus involves not just one "tragic" choice, but millions. Because regulation implies changes in behavior, *101 every individual actor participates in a tragedy of the commons in deciding whether or not to obey regulations. If diplomats were able to carry out the results of their negotiations to curb greenhouse emissions by themselves, they might be able to reach an enforceable solution. Instead, diplomats must carry compacts back to their citizenry, demanding, for instance, that three billion automobile owners change their daily habits for the common good. In the latter case, the tragedy of the commons is replayed millions of times, every day, across the globe, with tough enforcement mechanisms needed to force this irrational choice on every actor, every time, everywhere. Even market mechanisms, which seek to compensate for these perverse incentives, only disguise irrational choices--and as the recent history of failed gasoline and energy taxes in the United States suggests, voters are quite aware of the veiled costs they are being asked to bear.

Thus, even if the practical problems associated with addressing climate change were to vanish, and climate change were to become more "present" than it is now, countries facing either a "cooperator's loss" or a "prisoner's dilemma" would continue to be confronted with an incentive to do absolutely nothing, and many private parties would still oppose any action.

E. Summary: Climate Change and Its Regulation

1. Effective regulation requires more will than we presently have.

The foregoing analysis demonstrates that the problems inherent in climate change make Kyoto-style regulatory approaches to climate change especially prone to failure. This is not to say that any agreement or treaty is doomed, or that all are equally bad; to gloss over the important distinctions between what policies have worked and what have not is, at best, unhelpful. But any regulatory policy will have to reckon with the three sets of problems discussed above, namely:

1. Global warming is an absent problem, and thus deniable and discounted. In the absence of tangible evidence, it is politically tenable to do nothing, especially in light of uncertainty regarding how much, and what type, of action is required.

2. Global warming is a difficult problem to solve--it is costly, unevenly distributed, complex, debatable in scope, and ill-matched to our policymaking apparatus. A great deal of motivation is needed, therefore, to achieve any meaningful progress.

3 (*102). Global warming presents a tragedy of the commons, so that even if international actors were prepared and competent to act, they would have a structural disincentive to do so.

The paradox stated at the beginning of this Article--that climate change is potentially dangerous yet little has been done about it--is, then, less of a paradox. We have done little about it because we have rational incentives to do little about it. Again, though no problem is utterly unsolvable, this troika of stumbling blocks appears endemic to any regulatory approach to climate change.

There are at least three remaining approaches to the climate change problem: addressing the root causes of climate change, doing nothing now and adapting to climate change when and if it occurs, and trying to solve the climate change problem directly via geoengineering. [FN118]

2. Changing deep structures is very difficult.

Perhaps, if regulation is unlikely to succeed in any serious way given the current institutional, economic, and social contexts, we might try to change the deep, underlying causes of climate change--a market economy driven by growth in goods and populations, and the productive capability to meet consumer demand. [FN119] Although most of the discussion of this point will be deferred to part V, it should be clear that such changes are very costly and contentious ones. To say there is a lack of agreement on whether (and how) to remake the world's economic and social structure is surely an understatement. Of course, progress can take place *103 through evolution rather than revolution, and the role of environmental education, in both shallow and deep

modes, should not be minimized. [FN120] Indeed, it is probably the case that--given the variety of environmental and other issues facing the world--some form of "deep reorientation," however gradual, will eventually be necessary, absent radically new technologies to overcome our current concerns.

Unfortunately, in the meantime, several billion people remain committed to consumption-based lifestyles and modes of self-definition. Changing deep structures is likely to be a difficult, time consuming, and potentially divisive process that, while it would alter the fundamental assumptions of present cost-benefit curves and consequently yield some kind of "efficient" result, hardly seems like the policy recommendation for a more urgent problem such as global climate change. Again, though a more thorough treatment of this issue must be postponed to the end of this Article, it is clear for present purposes that a "deep structural" approach would be at least as difficult to achieve and as "costly" as ordinary climate change regulation.

3. Adapting to climate change is myopic and risky.

The polar opposite to the "deep structural" alternative to climate change regulation is adaptation: we could just wait and see. At some point, if predictions are correct, climate change will have disastrous effects on many people, and less costly, but still serious, effects on many others. At that time, climate change will cease to be an absent problem. In such a context, gaining consensus on preventive regulation will probably be much easier, particularly if some of the more dire predictions--rising sea level, megastorms--come to pass. While we wait for such action to take effect, it is quite possible for human beings simply to adapt to a changing world, [FN121] whether by means of dikes, changing agricultural patterns *104 or other methods. [FN122]

Two central problems plague the adaptation strategy. First, adaptation is an extremely risky bet. [FN123] No sensible ecologist or economist, upon a thorough review of the relevant facts and uncertainties associated with climate change, can legitimize a "do nothing" solution. Even after discounting the expected harms from climate change by our uncertainty regarding its extent, the least risk-averse among us would still rationally choose some preventive action, [FN124] albeit in tandem with adaptive strategies.

The second problem with adaptation is that it will inevitably force difficult choices that will likely doom many ecosystems to destruction. Hobson's choices will abound: do we spend our limited resources on saving the rainforest from drought, or on saving Rio de Janeiro, where hundreds of thousands of people live,

from flood? Assuming that human lives will take priority, the adaptation strategy dooms rainforests, estuaries, riparian zones, and any other ecotones that are unable to adapt or move. We might be able to replant America's breadbasket in Canada, but many animals--and people--cannot move to cooler climes in order to save themselves. We might be able to save Miami Beach, but the Everglades is likely sunk (perhaps literally). Adaptation really means "let nature burn."

Unsatisfied with this hyper-Darwinian anthropocentrism, the balance of this Article will discuss a third remaining alternative to regulation: addressing climate change as a problem that may be directly mitigated through technological means. To reiterate, technology is a source-reduction strategy as well as a remedial one--and useful analyses have considered the feasibility of alternative fuels and other less-coercive means of affecting the problem. [FN125] But *105 this Article intends to focus on technology as it is used in geoengineering: a non-regulatory policy of climate change mitigation.

III. The Political Economy of Geoengineering

A. Introduction: A Climate Change Manhattan Project

The projected insufficiency of Kyoto's emission reduction regime, [FN126] and the problems of absence, cost, and incentives discussed in part II, cry out for an alternative to our present state of climate change policy myopia. Geoengineering--intentional, human-directed manipulation of the Earth's climatic systems--may be such an alternative. This part proposes that, unlike a regulatory "Marshall Plan" of costly emissions reductions, technology subsidies, and other mitigation measures, a non-regulatory "Manhattan Project" geared toward developing feasible geoengineering remedies for climate change can meaningfully close the gaps in global warming and avert many of its most dire consequences.

What would a Climate Change Manhattan Project look like? In the first stage, it would consist of a shifting of existing environmental agencies' climate change priorities: away from more research into whether the globe is warming, away from further negotiations and unpopular incentive programs, and towards research into how to solve global warming if it happens.

In some ways, this phase has already begun, as geoengineering has moved from the pages of science fiction to respectable scientific and policy journals. [FN127] One of the most encouraging

proposals today focuses on the creation of vast carbon sinks by artificially stimulating phytoplankton growth with iron "fertilizer" in parts of the Earth's oceans. [FN128] Another proposal suggests creating miniature, *106 artificial "Mount Pinatubos" by allowing airplanes to release dust particles into the upper atmosphere, simulating the greenhouse- arresting eruption of Mount Pinatubo in 1991. [FN129] Such findings, though encouraging, remain on a very preliminary level. Phase One of a Climate Change Manhattan Project would be a dedicated, "serious look at geoengineering" [FN130] by coordinated efforts in the scientific community.

For the policymaker, the flexibility of this first phase is a key attraction. It need not--though it may--be an international, top-down research and development effort. It might take the form of several "Golden Carrot" programs offering rewards to the first private actor to develop a feasible geoengineering proposal. [FN131] Geoengineering innovations might even spring from interested "exo-national" actors, along the lines of media magnate Ted Turner's unilateral effort to fund U.N. programs, or, given the financial windfall I suggest awaits a successful proposal, self-interested ones. [FN132]

Obviously, the devil will be in the details in this phase of a geoengineering Manhattan Project. First and foremost, how will the secondary environmental effects of increased atmospheric dust, or vast phytoplankton blooms, be measured and contained? [FN133] In the words of one geoengineering expert, "[w]e really don't understand the climate well enough, so we don't want to start something where the cure might be worse than the disease." [FN134]

There are also important policy questions that should be addressed *107 at the first phase of a geoengineering Manhattan Project. How will geoengineering be funded? How will it be monitored? Who will be ultimately responsible, in case secondary effects do result? [FN135] Such questions are important, but they are questions we have barely begun to ask. Notwithstanding geoengineering's growing popularity in many circles, the policy discourse is still in its infancy. Dismissing the science of "ocean laxatives" or "giant space mirrors" [FN136] now is as nonsensical as denying humans could ever walk on the moon, or create a workable horseless carriage. [FN137] It is also far too early to write off geoengineering from a policy perspective, as some have done. [FN138] Not only has there not yet been a Climate Change Manhattan Project, there hasn't even been a Kitty Hawk.

Once the research into geoengineering has yielded feasible results (if any), the second phase of a geoengineering Manhattan

Project would involve the development and deployment of the most feasible geoengineering proposal(s) to emerge from the first phase. It is difficult to know now exactly what the Manhattan Project would finally look like; the shape of this second phase obviously depends entirely on the results of the first. Obviously, some international coordinating and/or monitoring will be necessary, particularly of secondary effects, though one of the advantages of a geoengineering remedial strategy over a regulatory preventive one is its relatively lower level of reliance on international enforcement. Funding will also be a critical issue at this second stage of a geoengineering Manhattan Project. In an ideal world, climate change might be geoengineered away simply by letting airplanes fly a little dirtier or by taking some similarly inexpensive step. But more probably, some coordinated effort at funding a geoengineering project will be necessary, and will doubtless be a contentious *108 process. At this point, it is premature to debate the details--again, we have not yet begun to ask the basic questions.

I recognize that geoengineering is a somewhat startling policy recommendation. It seems quite unwise to monkey with the Earth's climate, and, in any event, seems inefficient: why lime lakes to reduce the effects of acid rain when you could just cut down sulfur dioxide emissions? But there are reasons why figures as diverse as Stephen Schneider, [FN139] Edward Teller [FN140] and William Nordhaus [FN141] have endorsed the idea. Given today's political and economic climates, emissions reductions alone cannot do the job. It would be better if everyone "cared enough" to make effective GHG reduction possible. But in a world where it is very expensive to do so, those who do care should support a policy that will work with those who don't.

Of course, geoengineering is not the only solution to climate change. Kyoto- style emissions reduction packages, if implemented, remain an essential component, and carry many secondary benefits as well. Nor is a Climate Change Manhattan Project the only non-regulatory approach to climate change. Education campaigns, for example, whether coordinated centrally or developed "bottom-up" from grassroots communities, are a potential winner; [FN142] enough individuals who value the Earth may well counter those who assign greater value to other goods, and make it possible to change consumption behavior. [FN143] Population control is another indirect approach to addressing climate change (and most other environmental problems), particularly as high-growth-rate nations in the developing world become more affluent in the coming century; a world of 6 to 10 billion people consuming at American rates *109 is a highly unsustainable propo-

sition. [FN144] To be sure, these alternatives deserve considered debate and action. I simply argue that geoengineering does as well.

Geoengineering merits consideration by the post-Kyoto community because, as a policy tool, it succeeds where regulation fails. Geoengineering the global climate is not pretty, but it has a very appealing political economy--apparently, the prettiest policy is not always the best one. Geoengineering minimizes the very problems regulation maximizes: absence, difficulty, and economic incentives. Before turning to a defense of geoengineering in part IV, it is to these positive features that we now turn.

B. Geoengineering May Be a Remedial Solution

As suggested in part II, absent problems tend to be ignored until they are present, especially when the costs of addressing the problem are high. In such a case, a need arises for an approach that can feasibly be put into place when the problem in question becomes visible. In other words, a remedial solution is needed, rather than a preventive one.

Geoengineering is such a solution. It is remedial, not in the sense that it allows action to be postponed until after the tides have risen and crops have failed, but in the sense that it remedies a (potentially present) problem rather than prevents an absent one. As such, geoengineering is a matter not of prognostication and prevention--as regulation is--but of diagnosis and treatment.

Geoengineering thus minimizes many of the problems of absence that plague efforts to regulate GHG emissions. Uncertainty, while obviously still present in any action regarding a system as complex as the Earth's climate, is reduced when we act directly against the problem--a warmer climate--than indirectly. The *110 problems of discounting and deniability are reduced to the extent that geoengineering can take effect with less of a lag time than a GHG reduction regime. Of course, the extent to which geoengineering is a temporally remedial solution depends on the results of "stage one" of the Manhattan project, on which engineering proposal is feasible. But insofar as geoengineering can minimize the time between sacrifice and reward, it minimizes the discounting of that reward and the deniability of the need for the sacrifice.

Again, it is important to emphasize that geoengineering's potential to be a remedial solution should not lull us into thinking that no action should be taken now. [FN145] In the first place, there are many "no-regrets" regulatory and technological steps

that should be taken in tandem with any geoengineering strategy. Second, while the deployment phase of geoengineering may take less time to have an effect than preventive regulation, the initial research should begin without delay. Obviously, we cannot wait until the climate has changed drastically before researching ways to fix the problem; to the extent that the costs of "Phase One" must be incurred today, the absence problem remains in place. But by minimizing the uncertainties associated with predicting how much GHG reduction is needed today to have an effect in forty years, geoengineering greatly reduces the policy effects of climate change's absence. We need to develop the dental drill now, so that it may be ready when the cavity comes, but in political-economic terms, that is still much easier than trying to stop eating sweets.

C. Geoengineering Is Easier to Implement than Regulation

1. Cost: Geoengineering is cheaper than regulation.

Economic costs. Economic and scientific analyses of geoengineering have suggested that, notwithstanding the likely high price tag of developing and deploying a Big Fix, geoengineering is far less costly than other climate change policy options. [FN146] A massive seeding of the ocean's phytoplankton or a periodic program of distributing particulate matter in the atmosphere can be cheaper than simply conserving fossil fuels, not because the geoengineering solutions are inexpensive, but because the social and economic costs of *111 conservation are very high. Recall from part II that the marginal cost of carbon taxes necessary to achieve an economically efficient nine percent GHG emissions reduction (i.e., nine billion tons less per year) is estimated at forty-five billion dollars annually. [FN147] Stabilizing GHG emissions at 1990 levels, in contrast, would require a carbon tax starting at ten dollars per ton but rising within twenty years to ninety dollars per ton, [FN148] at a marginal annual cost by 2015 of $810 billion. [FN149] Conserving is expensive.

On the contrary, and contrary to intuition, geoengineering may not be expensive at all. Though it is far too early to hazard financial guesses, distributing enough particulate matter to equal Mount Pinatubo's twenty million tons of dust may be done--one proposal suggests--simply by modifying ordinary commercial airplanes to fly dirtier. [FN150] Nor is the 430,000 tons of iron seeding that is likely to be required to offset the three billion tons of carbon that humans release into the atmosphere each year [FN151] a

major expense; annual production of iron ore currently exceeds 900 million tons per annum. [FN152] Again, though it would be foolish to calculate costs before research has even begun, there is nothing about geoengineering in principle that makes it unaffordable. Indeed, though Nordhaus gives geoengineering only limited treatment in his work, he estimates the net benefits of a successful geoengineering policy, if technologically feasible, at $224 billion, far surpassing his own "optimal" regulatory regime. [FN153]

Moreover, geoengineering projects carry secondary economic benefits. A Climate Change Manhattan Project could well be a variant *112 on the phenomenon noted in "America's Green Strategy," [FN154] the short but influential argument (popularized by public figures such as Vice President Al Gore) [FN155] that forcing investments in environmentally-friendly technologies is, in the long term, an excellent economic strategy for the United States because such technologies will inevitably be required worldwide. [FN156]

Alternatively, the secondary economic benefits of geoengineering might take the form of "Golden Carrot"-type rewards to whomever develops a desired technology first. [FN157] Or a Climate Change Manhattan Project may be a more benign version of the familiar pattern of government expenditures for military technologies (even those it does not need) in order to keep politically valuable jobs in place. [FN158] Attack jets, after all, are not only military equipment: they are high-paying jobs for California voters and high-yield plums for important political players. The problem with beating swords into plowshares has been that plowshares do not pay as well.

Some geoengineering proposals, however, may actually carry economic benefits for the parties who develop the technologies, and thus may more closely resemble politically attractive military investments than politically painful restraints on economic growth. In other words, the Big Fix may act as a plowshare but pay like a sword.

Finally, geoengineering may be cheaper in political-economic terms because of the relative distribution of costs among politically relevant entities. Recall from part II.C.1 that climate change regulation *113 faced the unfortunate challenge of forcing the most powerful members of the industrialized world to incur the majority of the costs of GHG emissions reduction, because existing concentrations of wealth are largely a result of the most effective wealth- maximizing activities, which presently are tied to environmentally destructive practices. Since overall growth is dependent on infrastructure, and infrastructure is dependent on greenhouse-gas-producing activities (including energy production,

industry, and transportation), it is easy to see why those who have the most resources (and thus, usually the most political power) depend the most on the environmental status quo.

Geoengineering, in contrast to regulation, leaves powerful actors and their interests relatively intact. Insofar as it does, it is logical to conclude that a geoengineered solution will be far less offensive to them, and thus more likely to succeed. Geoengineering, even if it were to carry a higher immediate price tag, would carry lower overall political-economic costs than legislative solutions because the costs are relatively minor to the distributionally advantaged actors. In terms of political economy, playing well on Wall Street is a significant asset.

Social costs. Even if geoengineering were expensive, and even if it were not superior to climate change regulation in terms of its effects on elites, it may yet be the cheapest available strategy in terms of political economy because it carries almost no social costs whatsoever. No one need change lifestyles, take a bus instead of a car, or pay more at the gas pump to combat climate change, if geoengineering can offset the climate effects of business as usual. Consumptive patterns of life, which the majority of Westerners seem to enjoy, can continue unabated. [FN159] Nor (unfortunately) does geoengineering limit destructive practices like deforestation. [FN160] While these features may make geoengineering less attractive to some environmental advocates, it is not a trivial political point that no one will bear the significant economic and/or social *114 costs of changing those behaviors. For a policy-maker, the costs of a policy are not only the immediate financial investments or sacrifices that are necessary, they include undesirable political and social effects of implementation. Unlike reducing automobile use in the United States, for example, with its avalanche of economic effects and perceived interference with Western consumptive patterns, [FN161] seeding iron filings in the sea and layering particulate matter in the sky carry very low social costs. To be sure, there are "social costs" associated with any government program, particularly one which may carry a large taxpayer-funded price tag. [FN162] But it should be obvious that, compared with reducing fossil fuel use, geoengineering requires very little commitment from "ordinary people." [FN163] To the extent that this reduced burden of social costs translates into ease of implementation, geoengineering is more likely to succeed in the long term than climate change regulation.

2. Equity:Geoengineering is more fair than regulation.

Ironically, geoengineering may represent savings to powerful interests relative to the costs of climate change regulation and, at the same time, be more fair to those at the opposite end of the distributional spectrum. The developing world's pre-Kyoto demands for a "pass" notwithstanding, [FN164] individuals and groups in developing countries will almost certainly have to curtail or forestall some consumption under any serious regulatory program, sacrificing at least future benefits expected from consumption-heavy activity. [FN165] But assuming that the wealthiest nations pay the most for "Phase Two" of a Climate Change Manhattan Project (recalling that this "payment" may return dividends to those nations), costs borne by developing nations could conceivably be very low indeed.

*115 From an equitable perspective, the cost effectiveness of engineering resembles the option of "joint implementation" under the present FCCC. It allows those countries that value climate stability more (or, under the FCCC, simply are required to reach higher emission reductions targets) to pay the most. [FN166] Joint implementation strategies rely on Northern countries to fund carbon mitigation projects in the South, where they are more cost efficient. Likewise, a Climate Change Manhattan Project would have countries fund geoengineering projects commensurate with their ability to do so, their valuation of climate change, their responsibility for the current problem, and/or their technological expertise. In each of these categories, developed nations seem more likely to respond than less developed nations. Given the fact that developed nations are disproportionately responsible for climate change (at least relative to population), [FN167] geoengineering neatly works out as a "polluter pays" principle for climate change. [FN168]

In response to this claim, some may argue that, in fact, the developing world would not have to make many changes in a well-negotiated climate change treaty in any case, and might actually profit from a regulatory regime to the extent that heavier producers and exporters are restricted. [FN169] In an ideal world, for example, India might be able to continue growing before reaching its greenhouse gas targets, while the United States would have to impose serious limits on industry, or transportation, or other carbon-producing activities. India might then enjoy a period in which it becomes cheaper and more profitable to invest there than in the United States.

This equity-based argument in favor of regulation is riddled *116 with holes. First, if past experience is any guide, it is naive to expect such a lopsided arrangement to emerge from interna-

tional negotiation. [FN170] Countries protect their own interests, and those with the most power do so most effectively. Surely, if there were any real advantage to developing nations, the "North" would fight it strenuously. The "ideal world" is one that, given the present structure of the international bargaining arena, will never arrive. Second, even the most pro-South arrangement would have to impose limits either on southern population growth or carbon production, since it is absolutely inconceivable for a regulatory regime to succeed in a world full of Americans, with American levels of consumption. [FN171] The equitable "ideal world" is not only nonexistent as a matter of fact; it is inconsistent as a matter of policy.

Geoengineering will not take any positive steps to erase inequalities in the world. It will not spur technology transfer to the South, or lead to cooperative investment, or have any of the "positive side-effects" associated (perhaps) with legislative solutions like joint implementation. [FN172] But geoengineering does not make matters worse for the developing world, and that is far fairer than any realistic strategy of preventive regulation, carbon taxes, or technological substitutions.

3. Complexity: Geoengineering is administratively simpler than regulation.

A Climate Change Manhattan Project is likely to involve considerable research, intricate engineering, sustained monitoring of complicated Earth systems, and potentially tangled sources of money. Nevertheless, even the most complex of geoengineering projects cannot approach the complexity of imposing international *117 climate change regulations on five and a half billion human beings. Pursuing geoengineering as a policy thus avoids many of the "complexity" traps associated with regulation. [FN173]

Geoengineering effectively has one point of focus: the technological "fix" itself, in contrast to the billions of GHG emitters targeted by regulation. Geoengineering thus makes climate change less of a problem that can only be addressed by the coordinated efforts of thousands of parties, and more of a problem like CFC reduction, where it was possible to focus on a handful of producers whose interests could be co-opted. [FN174] From a political point of view, a geoengineering plan is far simpler to implement than trying to regulate more than five billion carbon dioxide emitters.

4. Disagreement:
Geoengineering is less contentious than regulation.

Geoengineering is less likely to create disagreement than a regulatory regime because fewer interests are at stake: the "Geritol cure" threatens no one's livelihood. The divergence of interests noted in part II matters very little because few of those interests need to be accommodated through tedious negotiation and strict enforcement. Indeed, as geoengineering reduces the stakes various parties have in opposing action on climate change, there may no longer be lost profits and lost jobs to justify the opposition at all.

Additionally, those nations that had rational incentives to oppose climate change regulations, given the diffuse nature of the harms expected, have fewer reasons to oppose geoengineering. China's staggering marginal costs from any serious regime of GHG abatement--even constraining GHG emissions to double present levels could cause an eight percent loss in GDP [FN175]--are no longer relevant, as they were in a regulation-only scenario. [FN176] A Climate Change Manhattan Project, thankfully, does not require China, or similarly situated countries, to act against its clear national interests to abate global warming.

Finally, even those who would benefit from some GHG abatement *118 may disagree about what type of regulatory regime is best, yet geoengineering captures the common interest parties have in avoiding global climate change and eliminates the various incentives for and against competing regulatory regimes. There would be no more discussion of clean coal versus dirty coal or afforestation versus hydrogen cars since few parties stand to lose or gain more utility than that enjoyed by the rest of the world from a geoengineering project. [FN177] Though, of course, several disagreements will remain (funding, whose technology is used, etc.), many of the obstacles in the path of reaching agreement on greenhouse gas reduction are reduced by a geoengineering project because it requires the participation of fewer parties and the curtailment of fewer interests.

5. Institutional inefficiency:
Geoengineering minimizes institutional roles.

A Climate Change Manhattan Project minimizes the institutional inefficiency inherent in international policymaking bodies by minimizing involvement of international institutions, reducing the number of decisions, and focusing costs on a small number of parties. Of course, funding and initial implementation of a Cli-

mate Change Manhattan Project may still have to be negotiated among international actors. The initial appropriations decision, if made by an international body, will be a serious institutional commitment, as will continued monitoring and coordination efforts. Yet unlike the conflicting agendas and interests that arise in the face of restrictions on production and consumption, geoengineering only requires financial payments by contributing parties. More importantly, geoengineering minimizes the need for an "international enforcement body," [FN178] for consortia to set limits, timetables, frameworks, conventions, or targets, or for laborious negotiations over emission levels. Existing international institutions are fairly well suited to most of the institutional involvement required by geoengineering, such as monitoring and funding. [FN179] Indeed, some geoengineering projects might conceivably be undertaken unilaterally, *119 although the political and international legal problems attending unilateral action that affects the climate of the entire world are considerable. [FN180]

Geoengineering not only avoids requiring international agencies to make and enforce rules; it minimizes the role of government altogether, as compared to a regulatory regime. By relying on technological innovation and development, geoengineering increases the role of private actors relative to that of government. Geoengineering, instead of requiring widespread enforcement of complex and growth-threatening rules, gives private firms around the globe a financial incentive to solve the climate change problem. [FN181] To whatever extent marshaling these sectors of the economy is more efficient than a government program of rule-enforcement, a geoengineering Manhattan Project is likely to be more efficient than a regime of climate change regulation.

Note on the status of geoengineering under international law. One vital institutional issue for geoengineering proposals is geoengineering's status under international law, which at the moment is unclear. Although no provision of international law currently mentions geoengineering specifically, [FN182] some commentators have pointed out that any unilateral or even multilateral geoengineering project might be illegal insofar as it causes transboundary effects, beneficial or not. [FN183] Daniel Bodansky also notes that ocean fertilization projects would be subject to the provisions of the 1982 U.N. Convention on the Law of the Sea [FN184] which established 200-mile exclusive economic zones (EEZs) from which any marine scientific *120 research may be excluded. Iron seeding may be subject to the Antarctic Treaty System as well. [FN185] Steps that affect the atmosphere directly, Bodansky claims, are even more problematic in light of existing laws and treaties. [FN186]

Moreover, the response that geoengineering affects the global commons no more than present-day GHG emitting activities is likely to be legally unsustainable, given that geoengineering is an intentional alteration of the Earth's climate, whereas GHG emissions are unintentional. Further complicating the picture are various soft law provisions in the Stockholm and Rio declarations, which, although supportive in principle of any effort to mitigate climate change, also encode into international legal understanding precautions about intentional disruptions of the Earth's natural processes. [FN187] Bodansky goes so far as to suggest that obtaining the various forms of consent needed for a serious geoengineering program may even be more institutionally difficult than negotiating a GHG reduction treaty, particularly as geoengineering triggers the "precautionary principle" that emerges from international law's grappling with unfamiliar technologies. [FN188]

These are serious and legitimate concerns. Obviously, the easiest way to circumvent these legal restrictions is to act collectively, but to do so awakens the institutional problems of collective action that geoengineering promised to avoid. [FN189] In the alternative, it may be worth recalling that, as Michael Riesman and others have pointed out on a number of occasions, international law is less a set of rules "on the books" than a process of communication between various actors in fora that are constantly shifting in their legitimacy and acceptability. [FN190] Certainly, any large-scale geoengineering project *121 will take place in the context of the political realities of this communication process, with the interests of states likely to be taken into account not in adjudicative proceedings but in political negotiations between parties. Given that geoengineering raises a "largely unprecedented" set of international legal issues, [FN191] the communicative process of international lawmaking will likely not be as much a matter of formal treaties as of the evolving assent of actors in the international community. While this resolution may not directly address the difficulty of collective action invoked by geoengineering proposals, it is characteristic of the dialogical process of international lawmaking, especially in the context of a novum such as geoengineering.

D. Geoengineering Avoids the Tragedy of the Commons

Geoengineering avoids the tragedy of the commons simply by avoiding any form of behavior modification. The decision to cheat or cooperate is neatly reduced to the question of paying for the geoengineering project. The difficulties associated with funding

and implementing a Climate Change Manhattan Project, however, are more like ordinary international negotiation issues than like an ineluctable tragedy of the commons.

In a geoengineering scenario, those nations facing a "cooperator's loss" [FN192] would still have no incentive to spend any amount of resources greater than the small amount of benefits they would receive. However, the disparity between the burden shouldered by a nation facing a cooperator's loss and a nation facing an ordinary prisoner's dilemma is much less, because half of the equation--the difference in stake in the status quo--is removed. Moreover, since no nation can be sure ex ante what the present value of their costs from climate change (economic and otherwise) will be, there is no way to know whether one is in a cooperator's loss or prisoner's dilemma situation. At the very least, this diminution of the stakes to each party promotes greater agreement among international actors and reduces the disincentive to cooperate.

E. Summary

To sum up the case for geoengineering's political economy, a geoengineering policy avoids, minimizes, or inverts all of the factors*122 that make climate change regulation so expensive, and thus so demanding of will. First, the primary cost of geoengineering is probably lower than that of a GHG emissions reduction program, and is certainly lower in political and social costs, both to individuals enjoying consumptive lifestyles and power elites enjoying profits from them. Second, geoengineering is more equitable than a legislative regime, given the fact that developed countries will almost certainly pay the lion's share of the cost and because a geoengineering strategy does not limit growth in the developing world. Third, geoengineering is far simpler than regulation, requiring none of regulation's friction- building "details work" or enforcement mechanisms. Fourth, its greater simplicity minimizes the potential for disagreement between parties. Fifth, geoengineering avoids many of the institutional transaction costs of climate change regulation, which, in light of the demonstrated--and probably intentional--impotence of international bodies, are potentially lethal to any effort to combat climate change. Finally, geoengineering project avoids most of the actor's dilemmas that result in a tragedy of the commons.

IV. In Defense of Geoengineering

A. "It Just Won't Work" / "It Will Do More Harm than Good"

Immodest proposals should elicit skepticism. When one faces a costly proposal involving unproven and potentially dangerous technology, particularly when it involves interfering with a system as complex as the Earth's climate, it is natural to expect Babel-like failure to follow Babel-like arrogance. Geoengineering has a checkered history, at best, from the Army Corps of Engineers' choking of the Everglades to the Soviet Union's attempts to reverse the flow of Siberian rivers to grow cotton and melt part of the Arctic ice cap. [FN193] What if the Big Fix leaves us worse off than we were before? [FN194]

The danger of altering the Earth's climatic systems, when we *123 cannot even successfully maintain a tiny "Biosphere II," [FN195] was well expressed by the National Academy of Sciences:

Geoengineering options have the potential to affect greenhouse warming on a substantial scale. However, precisely because they might do so, and because the climate system and its chemistry are poorly understood, these options must be considered extremely carefully. . . . Some of these options are relatively inexpensive to implement, but all have large unknowns concerning possible environmental side-effects. They should not be implemented without careful assessment of their direct and indirect consequences. [FN196]

The response to such concerns, however, should be caution, not dismissal. [FN197] Regarding primary efficacy, there is good evidence that some geoengineering proposals--iron seeding [FN198] or particulate scattering, [FN199] for example--show considerable promise. Though, as stated at the outset of part III, it is far too early to be certain of success, [FN200] it is also far too early to be dismissive. While *124 the case for technological optimism is "uneasy," [FN201] the case for technological pessimism--in the face of a century of technological progress that shows little sign of abating--is just plain weak. [FN202]

Regarding secondary effects, caution should inspire more research, not less. A global "sunscreen" may also cause acid rain or affect the ozone layer, [FN203] but it may not: what is needed by policymakers are answers from scientists. Of course, as any scientist knows, "answers" are more often estimates and prognostications than definite results. If this turns out to be the case at the end of Phase One of a Climate Change Manhattan Project, than

Phase Two should proceed carefully. In the case of the "sunscreen" dust proposal, we could proceed gradually, releasing less dust than Mount Pinatubo did in 1991. [FN204] In any event, we should not let panic at the scale of the problem or the danger for unintended effects replace calm investigation of the possibilities before us. [FN205] What is important to remember, again, is (1) that we can progress slowly and cautiously, and (2) that we have not yet even begun to do so.

Clearly, it would be easy--and tragic--for confidence to turn to hubris, and for would-be climate engineers to repeat old mistakes. This consequentialist objection does not undermine the principle of a geoengineering project, however, or the efficacy of geoengineering as a policy tool. Nor does the objection recognize that some geoengineering techniques have already produced favorable and reliable experimental data. [FN206] Finally, this complaint *125 does not adequately consider the uncertain and grave context in which climate change policies are made. We are already in a mess; the question is how best to clean it up.

B. "It Costs Too Much"

Although the relative economy of geoengineering is treated above in part III.C.1., two objections remain based not on geoengineering's cost relative to that of preventive regulation, but on its cost alone. It may be that the up- front investment in geoengineering makes it either (1) impractical or (2) counterproductive.

1. The high cost of geoengineering makes it impractical.

The first major cost-based objection to geoengineering is that it is simply impractical to expect the nations of the world to spend billions of dollars on ocean seeding in an era of shrinking budgets and (in the United States, at least) suspicion of cooperative international activity. The obvious rebuttal is that some geoengineering proposals may turn out to be quite affordable-- particulate matter spreading, for example. [FN207] Nevertheless, even if geoengineering techniques demand large up-front investments, the objection is answerable.

Assuming arguendo that geoengineering will be expensive up front, it still seems less different to throw money at a problem than to enforce a restrictive and costly regulatory regime. Even if the price tag is high, the geoengineering project remains affordable in terms of political economy because it minimizes costs that factor into the political calculus, such as social costs and effi-

ciency costs borne by distributionally advantaged (politically powerful) parties as discussed in part III.C.1. So long as the cost of a geoengineering project is not so astronomical as to prevent consideration of the political economies, it is likely to be more "affordable" in political- economic terms than any other option currently on the table.

Two more general responses to the contention that geoengineering's potentially high cost makes it impractical are warranted. First, any serious debate on climate change must recognize that a geoengineering project is not a decorative boondoggle; it is a necessary measure taken to prevent serious degradation to the *126 earth's environment that would have huge attendant costs for many human interests. If serious debate were to emerge, geoengineering's "sticker shock" might wane in the context of rational reflection of the costs of climate change itself. [FN208] Second, and in a similar vein, the fairness of a "polluter pays" approach as embodied in geoengineering [FN209] may itself help ameliorate the reluctance of the polluters to pay. Thus, the charge that the cost of a geoengineering project renders it impractical is rebuttable by reconsidering the political economy of geoengineering as compared with regulatory solutions and recalling that notions of propriety and fairness also have political value, however attenuated.

2. The high cost of geoengineering makes it inefficient at best, counterproductive at worst.

Even if we can afford geoengineering, the cost-objector may retort, perhaps there is a better investment. Instead of throwing billions of dollars at a dubious plan to cool the Earth, perhaps we would be better off allowing developing countries to progress technologically (and thus adapt better to a changed climate) and coaxing private enterprise to develop zero-emission vehicles, nanotechnological carbon-eaters, or some other decentralized "Small" Fix. One might even argue, as Gregg Easterbrook has, that geoengineering is a misappropriation of funds, because, while climate change is a problem, it is not as severe as more prosaic challenges such as providing safe drinking water or curbing urban pollution in the developing world. [FN210]

In response, the first objection is really just a variation on "wait and see," and as such is a high-risk proposal. Perhaps nanotechnology will save the world. [FN211] But perhaps it will not. In the meantime, climate change policymakers must develop strategies to cope with today's (and tomorrow's) problems in the best possible way. A successful strategy may include grants to

private enterprise to develop climate-friendly technologies. Just as we ought not put all our hopes in a Big Fix, however, we should not put all our hopes in the white knight of as-yet-unknown technology.

*127 The second objection--that geoengineering is inefficient or perhaps even inhumane in the face of widespread malnutrition and disease--is basically an argument against any climate change strategy, and it is simply not borne out by the facts. The Easterbrook policy of "give me a fish today, and let the ocean burn tomorrow" is particularly inept in light of the probability that the most serious effects of climate change will be felt by the developing world. [FN212] Moreover, many local problems (e.g., the lack of safe drinking water) are difficult for the "international community" to address, for reasons of high transaction costs, national sovereignty, and the myriad of difficulties associated with any long term, overseas commitment. The concept of a Climate Change Manhattan Project, on the other hand, allows and encourages the developing world to be a free rider on a project financed mostly (one would presume) by the industrialized nations of the world. Finally, since it restricts growth less in the developing world than would regulation, [FN213] a Climate Change Manhattan Project allows developing nations to more quickly progress away from the serious environmental threats of unsafe water, unhealthy air, and topsoil loss, through proven means such as sewage treatment, newer (cleaner) automobiles and factories, and modern agriculture.

C. "It Is Unnatural"

One intuitive objection to intentionally manipulating the climate is that it is unnatural. Surely, "Nature knows best." [FN214] And if it does, geoengineering is misguided, not only because of the practical risks just addressed, but because human interference with the Earth's climate is both unethical and profoundly unwise. Seen in this light, geoengineering is a question not of Nordhaus's risk proposals, but of Bill McKibben's "The End of Nature." [FN215] Almost all aspects of the natural world, the argument runs, are somewhat less "Other" than they were, something closer to a manufactured event than they once had been. [FN216] These may seem like "soft" concerns, *128 of minimal consequence to a policymaker. However, supposedly soft concerns often translate into very "hard" political preferences. More importantly, soft concerns define who we are and why we live. Ultimately, the hardest and driest economic calculations reduce to the "soft" inner preferences of putatively rational actors, who re-

veal themselves in myriad expressions of utility. If geoengineering is seen as cutting the Earth's nose off to spite its face by a majority of people, then it is not a good policy since it fails to achieve the environmental objectives in which we are interested.

Several responses to the unnaturalness objection are possible. First, the need to mitigate climate change may simply outweigh the aesthetic valuation of the natural world. The costs of coping with dead forests and shifting agricultural zones are not scare tactics, but serious concerns that may outweigh eco-aesthetic (or even religious) reservations about a man-made sky. If the consequences of global warming track the more acute predictions of greenhouse "doomsayers," this is certainly the case: few may insist on the integrity of Gaia if millions of people (and animals) will starve.

Second, one may respond fatalistically by noting that geoengineering is no more a direct alteration of the environment than the everyday effects of millions of cars and factories. Any refusal to tinker with Nature is an illusion: we have already done so, and the only remaining question is whether to continue to do so negligently, or to begin to tinker benevolently. It would be better to "let the meadow be," and not move mounds of Earth around with bulldozers, but not once the meadow has already been plowed over. [FN217]

*129 Finally, one may counter wilderness-aesthetes on their own terms by replying that while geoengineering is an ugly interference with nature, it removes even uglier ones. Global warming is no mere abstract, aesthetic injury. While problematic, geoengineering is actually right in the context of global warming insofar as "a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community." [FN218] We are not cutting off our nose to spite our face; we are performing corrective plastic surgery.

It is true that the ethical and aesthetic objections favor preventive regulation that would avoid the initial ecological insult. Yet climate change policies must be viewed in terms of their effects. What will work best? If geoengineering fulfills Leopold's above-quoted dictum best, it seems the most ethical choice. To be sure, the objections are strong: it was Henry David Thoreau who said that "[i]n wildness is the preservation of the world." [FN219] And it is also true that, at first, geoengineering seems like the ultimate betrayal of this ideal. But if models of climate change are correct, New England will experience a warming of 1.5 to 4.5 degrees Celsius, which will render Walden woods unable to sustain its native flora. What then?

D. "It Subverts Other Efforts"

While there is a chance that geoengineering will work, there is also a chance that it will not. In the meantime, one might object, a focus on geoengineering subverts other efforts to attain sensible reductions in GHG emissions. [FN220] Stephen Schneider voices this concern in his account of the 1992 National Research Council panel on climate change policy, where some worried that "even the very thought that we could offset some aspects of inadvertent climate modification by deliberate climate modification schemes could be used as an excuse by those who would be negatively affected by controls on the human appetite to continue polluting and using the atmosphere as a free sewer." [FN221] This political concern is warranted. Insofar as the Big Fix lulls us into thinking that we have done all we need to do about global warming, it is, as one *130 environmentalist put it, a classic "high risk-high gain" policy. [FN222] Either it works, or we are in a lot of trouble.

By way of response, it must be conceded that geoengineering can be a high risk option. But it does not have to be. First, geoengineering should be developed in parallel with emissions reductions. Recall that economists believe a sizable amount of GHG emissions can be reduced quite cheaply. [FN223] Surely, those inexpensive reductions should be pursued vigorously to produce a "safety cushion" while the potential of geoengineering is evaluated. [FN224] Second, wise geoengineering is timely geoengineering. As stated above, we ought not wait until remediation is necessary before exploring the option: we must build the drill before the cavity develops. If Phase One of the Climate Change Manhattan Project begins now, a reasoned set of answers to many geoengineering questions may emerge well in advance of the "point of no return" for climate change regulation.

Geoengineering undoubtedly strengthens the hand of the procrastinator, but prompt and wise policy planning cuts against the complacent position. We must begin now. Advocates correctly fear putting their eggs into an untested basket, but we need not drop the emissions-reductions basket to grab hold of the geoengineering one. Proponents of geoengineering must take responsibility for ensuring that the policy does not degenerate into simple procrastination.

V. Who's Afraid of Giant Laser Space Frisbees? [FN225]

My suspicion is that any dyed-in-the-wool environmentalist who has read this far is, at best, troubled. I suspect that I have

not convinced her that geoengineering is the right policy for climate *131 change mitigation, and I have perhaps only planted some seeds of malaise regarding the prospects for post-Kyoto success. Such a result would not be surprising: geoengineering runs counter to deeply-held, fundamental ideas about what sorts of policy solutions are "right" for environmental problems. Geoengineering treats a symptom, not a cause. It is non-holistic in nature, focusing on only one problem, while intentionally ignoring others. Essentially, a Climate Change Manhattan Project seeks to cure lung cancer with the latest technology, when really the smoker should just quit smoking. [FN226]

Geoengineering more than just "feels wrong." [FN227] The tunnel-vision of geoengineering robs the environmental community of the ability to solve other critical problems at the same time as climate change: deforestation and overconsumption, for example. Surely, it is better to just get used to the idea of "living lightly" [FN228] than to scatter dust in the sky or seed oceans with iron, especially when living lightly is good for all of us anyway.

With these fundamental values challenged, it is not surprising that many in the environmental community object to geoengineering as a policy tool. [FN229] Debates on the Big Fix are, to some extent, debates on what is the "right" thing for environmental policy, and they speak directly to the proper intersection between environmental philosophy and environmental action. Do we treat symptoms or causes? Believe in technology, or mistrust it?

To paraphrase a famous film subtitle, it is time for environmentalists to learn to stop worrying and love the Big Fix. In the following discussion, I identify three environmental constituencies that are likely to be offended by geoengineering: "deep" environmentalists, holists, and "political" environmentalists. Each of these tendencies within contemporary environmental thinking has merit, but--I argue--each can also blind its adherents to real solutions outside their paradigm.

A (*132). "Deep" Environmentalists [FN230]

I have analogized geoengineering to trying to treat lung cancer instead of trying to quit smoking. A deep environmentalist, one who cares about root causes and philosophical underpinnings rather than just the effects thereof, would want to find and eliminate the factors behind the desire to smoke. But is it trivial in forming policy to take into account that the world really likes to smoke? I think not: politics and policymaking are largely a world

of competing preferences, not an academic forum where the ideal theoretical answer is the right answer. Of course, it is sad that the world's smoker would rather suffer serious illness than kick the habit. Thus, it is right for leaders to preach sensibility from their bully pulpits. We should teach "living lightly," simple frugality, and critical thinking to our children. We should try to soften the blow of consumerism and advocate sustainable development in place of rapacious deforestation and biodiversity loss. But while we do all of that, what do we do about climate change?

While the preacher is at the bully pulpit, the deacons should be working to solve the problem. Were the planet a teenager trying her first cigarette, it surely would be smarter to address 'root causes' to prevent her from smoking at all. But in the case of climate change, the smoker has been at it for many years, and the addiction is firmly in place. In such a situation, focusing on the "real problem" simply may not work. Strong interests anchor the status quo, and they are not easily condemned "black hats," but a wide range of actors with motives that are not necessarily selfish or shortsighted.

Moreover, an environmentalist's distaste for the materialistic ideals that undergird the root causes of climate change does not make attempting to thwart those ideals either practical or morally *133 justified. Conspicuous consumption is deeply entrenched in American self-conceptions, and in conceptions of Americans by people in the developing world who want to be like them. [FN231]

I suggest it is both unwise and counter-democratic to tell billions of consumers that "We Know Better," and set about changing deep structures without regard to the life-defining goals of the consumers themselves. Such action is unwise because it pins the biosphere's integrity on the hope of overcoming something deeply ingrained in Western culture. And it is counter-democratic because, until the members of that culture change its constitutive forces, overcoming them in the name of a paternalistic deep environmentalism thwarts their clearly expressed preferences. [FN232]

On the practical side, this debate echoes in many quarters of the environmental movement. Should we try to force reduced levels of consumption, or settle for "green fees?" Should we attempt to revalue "living lightly" or try to develop "no-regrets" environmentally-friendly technologies? Should an environmentalist tell McDonald's to "shut its doors" or work to package its unsustainable product in more sustainable containers? [FN233] Ultimately, it may be that the only way to a sustainable future is for McDonald's to shut its doors, but this will not happen today, or next year. Likewise, other engines of industry will continue to run

for a long time. In the meantime, ought we not do what we can to address the climate change problem itself?

On the political-philosophical side, the question becomes a Rawlsian one: how to maintain "private" philosophical beliefs and yet also engage in "public" political discourse. [FN234] I suggest that, in this vein, geoengineering may be a type of "principled self-contradiction" *134 for a deep environmentalist. Even setting aside the practical arguments just advanced-- that it is unwise to bet the planet on changing people's deeply held practices--a deep environmentalist ought in principle to advocate policies that are based not on private philosophical ideas, potentially incommensurate with public discourse, but on the limited shared values of a Rawlsian liberalism. [FN235] Repairing the climate does not reflect deep environmental ideology as does preventive regulation--hence the Rawlsian "contradiction"--but it may be more in accord with values a deep environmentalist shares, in a liberal state, with a non-environmentalist. As such, it is the Rawlsian choice.

Both practically and philosophically, geoengineering is one example of environmentalism speaking the language of non-environmentalists. It allows for greens and consumers to disagree radically on fundamental issues of self- actualization--but still save the planet.

B. Holists

Apart from the philosophical objections of "deep environmentalism," holism may offers another principled challenge to geoengineering. In recent years, sound environmental science and a philosophical conception of ecological interconnectedness have encouraged us to think of the Earth's ecosystems as interconnected. The Earth is--if not one organism [FN236]--a highly complex amalgam of billions of interdependent agents. [FN237] It makes sense, given this understanding, that environmental problems should be dealt with holistically and comprehensively. The problem of climate change should be solved in a way that takes account of, and incorporates, the interconnectedness of the Earth's systems--not in a way that treats the climate as some distinct, treatable illness. *135 Surely, a holist would reason, it makes sense to have a unified approach to what is, in fact, an intricately complex, but ultimately unified, web of interrelationships.

It may make sense ecologically, but not necessarily politically. For a policymaker, "changing everything" requires a big base of support, and differently situated people tend to have different,

divergent interests. Addressing one problem at a time, while not as neat, ecologically sound, or efficient as a single integrated solution, does narrow the realm of affected behavior considerably, thus increasing the possibility for agreement. If one hundred people together are destroying the room they live in, for instance, it will be difficult to have them all change their behavior in a "holistic manner," because each will object to one or more aspects of the change. But if we can get them each to help clean the floor, perhaps all but a small minority will agree. Then we can think about the air quality, and get all but the cigarette smoker on board. Each incremental decision--though in the aggregate less efficient than a "holistic" approach--is easier to arrive at when there is less room for disagreement. Moreover, each decision may take a different form--we may want a broom for the floor, but a legal norm for the air--and diversity in a policy portfolio provides strength.

To take a more familiar example, it would surely be optimal to empower oppressed indigenous people at the same time as we save a tropical rainforest by granting local populations more control over forest resources. But if a simple purchase of land will save more rainforest, and a separate human-rights campaign can help the indigenous people, and if each has a better chance for success than the integrated empowerment solution, then perhaps it is wiser to divide and conquer. Better to divide opponents whose interests differ and reach incremental consensus than fight them all at once and lose. A policy of land rights for indigenous people may offend agricultural interests, governing power elites, present title holders, and a host of other constituencies. A land purchase, on the other hand, offends fewer people, may please some (power elites for instance), and is more likely to succeed. Meanwhile, a separate human rights campaign is unlikely to interest agricultural users or (some) transnational corporations, and it also is more likely to succeed. Killing one bird at a time may be the "right" way to go, because it minimizes opposition and makes coalition-building easier.

Clearly, this is an oversimplified example, but the point should *136 be clear: holism is not always effective. Treating the Earth system's problem of climate change, while separately addressing deforestation, fossil fuel consumption, habitat loss, population growth, and so on, may well be the overall best strategy. Different coalitions may be assembled to reach a consensus on each individual issue where no one coalition could be assembled to tackle it all together. [FN238]

Finally, holism is flawed because it tries to take the "big picture" into account without necessarily knowing how to frame the picture. Holism multiplies uncertainty. It requires large-scale guessing regarding both present conditions, causes for present conditions, and likely future conditions, with each guess clouded in uncertainties and information costs. Acting holistically makes sense if we know exactly where we are, why we are here, and where we are headed, but in an uncertainty-riddled context such as global climate change, [FN239] wholesale, holistic alterations radically amplify the risks of making mistakes. Of course, holism remains important; only a fool would not look at causes, contexts, and consequences for points of leverage in battling climate change. In some cases, however, holistic policy prescriptions actually lessen the opportunity for consensus-building and may magnify the uncertainties and information costs associated with environmental policy.

C. Political Environmentalists

There is still one final group afraid of Giant Laser Space Frisbees: "political" environmentalists who use one problem to get at another. Though perhaps somewhat disingenuous, environmental sleight-of-hand has become a modus operandi for large segments of the environmental community, and for good reason: it has often been successful. Spotted owls are the subject of litigation, but saving old-growth forests is the real goal. The Clean Air Act is invoked in a lawsuit over pollution from a proposed highway, but limiting *137 unwanted road-building is the actual aim. Hamstrung as they are by limited regulations to work with, environmentalists have become very innovative in pursuit of their goals. An "anti-car" policy is likely to fail, but a "clean air" policy might . . . just . . . work. Thus, subterfuge becomes an effective tool.

Climate change is an excellent subterfuge; it allows environmentalists to "get at" fossil fuel use, deforestation, perhaps even overconsumption itself-- in the name of saving civilization as we know it. Geoengineering, in contrast, gets at nothing other than climate change. On the contrary, not only does sowing plots of ocean with iron filings not save the rainforest, it costs environmentalists precious leverage in their efforts to do so because some of the pressure to address the underlying causes is relieved. [FN240] One of the very strengths of geoengineering--that it requires relatively little sacrifice--is thus one of its great drawbacks to political environmentalists. Anyone who wants to use climate change as a way to "get at" some undesirable but politically popular

activity will be sorely disappointed by a geoengineering project.

Political sleight-of-hand can engender a certain ambivalence. It is somewhat dishonest, and can be counterproductive, as in the case of a hopeless but photogenic species such as the California condor being saved instead of more needy but less attractive candidates. Sleight-of-hand can also be a tremendous gamble; trying to kill two birds with one stone is often riskier than trying to kill just one. In the case of climate change, using the biosphere's climatic integrity as a leverage point is quite a risk: if scientists are right, we may be in deep trouble if GHG emissions and deforestation (the "real targets") are not reduced. When the nominal goal is itself important, sleight-of-hand is a high-stakes game.

At the same time, such practices ought not to be condemned too quickly. Sleight-of-hand in service of the environment is often the only way to operate--and it is how many people accomplish good things. Should Thurgood Marshall and the NAACP have been more "honest" and tried simply to have federal desegregation laws passed? Was Brown wrongly decided because there was a more "honest" way to solve the problem than self-esteem charts and the Fourteenth Amendment? Using the Clean Air Act to stop snowmobiling, or the Endangered Species Act to stop logging, seems no *138 more "dishonest" than using the Constitution to judicially force desegregation.

Surely, then, sleight-of-hand is not always a bad thing. [FN241] The question is whether climate change is more like the spotted owl or the forest itself; is climate change useful primarily because of its leverageability, or is it a problem that ought to be addressed on its own terms? Particularly in climate change's relation to deforestation, the question is not an easy one. One might be tempted to concede to the political environmentalists that geoengineering should be aggressively pursued as a fall-back, but is too easily a cop-out--that allows unabated deforestation, fossil fuel use, and unhealthy climate complacency--to really trust. Yet climate change is real enough, and threatening enough, to address on its own terms, in the most efficient way possible. Environmentalists have lost credibility by using climate change as, to use Justice Scalia's words from another context, "some ghoul in a late-night horror movie that repeatedly sits up in its grave and shuffles abroad." [FN242] We ought not trivialize the threats of climate change by addressing them only when convenient for other purposes.

D. Summary

What the deep environmentalist, holist, and political environmentalist all have in common is an agenda wider than climate

change, and the Big Fix lets them down every time. Yet these factions cast a long shadow on the intellectual ambiance of contemporary environmentalism. [FN243] The desire to "take everything into account" is admirable. It is grounded in good science, respectable philosophy, and seasoned political savvy. Yet the practical, philosophical, and political motivations behind doing so often act at *139 cross-purposes with the need to protect the Earth's climate from potentially devastating change.

What a Climate Change Manhattan Project asks on a philosophical level is whether the sorts of strategies and norms that have guided thoughtful environmentalism are always applicable, all the time. Many times in writing this Article, I have been struck by the ways in which my own proposal flies in the face of what I believe to be the right thing to do environmentally. But the right thing exists in the mind. Climate change is in the atmosphere.

VI. Conclusions

Throughout this investigation, I have tried to suggest that the 160 nations whose representatives gathered last December in Kyoto are not so stupid or selfish as to not understand the threats of climate change, and that the insufficiency of the Kyoto process's results are instead the result of deeply- rooted problems with the regulatory approach to climate change policy. Global warming is an absent, exceedingly difficult problem, and modifying our behavior to the extent necessary to solve it is complex, expensive, and, for some, counterproductive.

We need an alternative to the policy myopia that sees emission reductions as the sole path to climate change abatement. While the proposal for a Climate Change Manhattan Project made in this Article may not be as aesthetically elegant as a climate change Marshall Plan of prevention strategies, it can be far more effective. Direct manipulation of the climate, whether by iron seeding, particulate scattering, or another mechanism, has the advantage of avoiding or minimizing the problems of absence, difficulty, and economic structure which plague efforts to implement climate change regulation. Of course, no one policy prescription is a "silver bullet." Efforts to reduce carbon emissions and deforestation must continue in the wake of the Kyoto Conference, both to prevent global warming and to minimize resource depletion, habitat loss, and so on. But given the existing structural dynamics of international environmental policy, a Climate Change Manhattan Project to research, develop, and deploy a workable geoengineering program is the policy option that is best politically, least invasive socially, and most efficient economically--at

least in the meantime.

A geoengineering project may be expensive, unreliable, dangerous, ugly, and unwise--although I attempted to answer each of these objections in part IV. But so are many cures for a desperate *140 situation. It is also true, as I discussed in part V, that geoengineering is a narrowly tailored cure for symptoms of a problem whose true causes go much deeper. And it is true that some leverage for addressing these causes is lost when the looming threat of climate change is removed by geoengineering. But is the health of the biosphere really a commodity environmentalists can afford to leverage?

In the end, the debate about geoengineering is largely a debate about what sorts of environmental policies to pursue in an imperfect world. It seems almost preposterous to buck the trends of holistic systems management and suggest running like the Sorcerer's Apprentice from symptom to symptom. It may also seem as though driving less or cutting fewer trees is simpler than scattering dust particles in the stratosphere. It is certainly more elegant. But when the Damocles' sword of massive biotic disruption is hanging over our heads, we should choose what works. And the bottom line is that, though the regulatory strategies envisioned in Kyoto must continue to play out their roles, we need more than a global Marshall Plan of incentives and reductions to avert potentially disastrous climatic change. We need a Manhattan Project.

Sources

(publishers note:Pages numbers noted in Sources may be inaccurate due to the reformatting.)

FNa1. Joseph Levy & Company, Tel Aviv. J.D., Yale Law School, 1997; B.A., Columbia University, 1993. An earlier version of this Article was awarded the 1997 Ambroze Gherini Prize in international law and policy by Yale Law School. Much of the Article was written during a postgraduate summer research fellowship with the Olin Foundation for Law, Economics and Public Policy at Yale Law School. I am grateful to the Olin Foundation for its support during the course of the research for this project, as well as to Dan Esty, Frank Loy, Susan Rose-Ackerman, Alan Schwartz, and Carol Rose for reviewing earlier drafts of this Article.

FN1. Though uncertainties associated with the present state of our knowledge are real, and discussed in some detail, infra part II.A, recent events in Kyoto suggest that the consensus on climate change has at last reached critical mass. That some climate change is occurring is almost universally believed. See William R. Cline, The Economics of Global Warming 13-35 (1992) (discussing in detail the scientific data available and charting increases of mean temperature over last hundred years); Committee on Science, Engineering and Public Policy, Policy Implications of Greenhouse Warming 18 (1991) (estimating 3.4 to 9.4 degrees Fahrenheit range of warming); William D. Nordhaus, Managing the Global Commons 3-6 (1994); Office of Policy, Planning and Evaluation, U.S. Envtl. Protection Agency, Policy Options for Stabilizing Global Climate 10 (1989) (1.5 to 5.5 degrees Celsius prediction); Panel on Policy Implications of Greenhouse Warming, Nat'l Academy of Sciences, Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base (1992) [hereinafter NAS]; Wilfred Beckerman, Global Warming and Economic Action, in The International Politics of the Environment 253, 258 (Andrew Hurrell & Benedict Kingsbury eds., 1992) (noting "general consensus" among scientists that rise in world temperature in 21st century will be between 1.5 and 4 degrees Celsius); David W. Keith & M. Granger Morgan, Subjective Judgments by Climate Experts, 20 Envtl. Sci. & Tech. 468 (1995) (displaying chart of prominent atmospheric scientists' predictions on global climate change); Adam Aronson, Note, From Cooperator's Loss to Cooperative Gain: Negotiating Greenhouse Gas Abatement, 102 Yale L.J. 2143, 2145 (1993) (surveying estimates of climate change in scientific community). For layperson's surveys of sci-

entific consensus on climate change, and political battles surrounding it, see John Firor, The Changing Atmosphere 57 (1990) (surveying estimates varying from 2.7 to 9.9 degrees Fahrenheit warming over next century); Al Gore, Earth in the Balance 5 (1992) (displaying graph of increased carbon dioxide concentrations in the atmosphere from 1958 to the present); Bill McKibben, The End of Nature 18-31 (1989); Christopher D. Stone, The Gnat is Older than Man: Global Environment and Human Agenda 13-25 (1993).

FN2. See William K. Stevens, Experts Doubt Rise of Greenhouse Gas Will be Curtailed, N.Y. Times, Nov. 3, 1997, at A1 (stating that "it is widely agreed [among climatologists], based on proposals on the table, that any action emerging from Kyoto would be insufficient to prevent an eventual doubling of greenhouse gases").

FN3. See, e.g., Joshua M. Epstein & Raj Gupta, Controlling the Greenhouse Effect: Five Global Regimes Compared (1990); Christopher Flavin, Slowing Global Warming: A Worldwide Strategy (1989); World Resources Inst., Greenhouse Warming: Negotiating a Global Regime (1991); Elizabeth Barratt-Brown et al., A Forum for Action on Global Warming: The UN Framework Convention on Climate Change, 4. Colo. J. Int'l Envtl. L. & Pol'y 103 (1993); John J. Fialka & Jackie Calmes, Clinton Proposes Global-Warming Plan, Wall St. J., Oct. 23, 1997, at A2 (discussing President Clinton's proposed three-tiered emissions reduction plan).

FN4. See John F. Fialka, Global-Warming Treaty is Approved, Wall St. J., Dec. 11, 1997, at A2. It thus remains to be seen to what extent a compromise can be implemented--rather than merely negotiated--between the United States, Europe, the developing world, and the other constituencies whose interests diverged so sharply at Kyoto. What is important here is that even the most austere of greenhouse gas (GHG) reduction plans cannot avert climatic change, and, as everyone at the conference agreed, Kyoto is but the first step on the road toward seriously addressing the problem. See Stevens, supra note 2; Kevin Sullivan & Mary Jordan, The Challenge: Incorporating Many Nations' Needs Into One Treaty, Wash. Post, Nov. 15, 1997, at A1. Both Kyoto's tumultuous negotiations and the limited nature of its possible success point to the need for wider policy horizons.

FN5. Michael A. Lev, Forecast for Global Warming Pact Is Cloudy, Maybe Stormy, Chi. Trib., Nov. 10, 1997, at 6 (quoting

U.S. envoy Timothy Wirth).

FN6. Stevens, supra note 2. Atmospheric carbon dioxide levels are presently at approximately 360 parts per million (ppm). Present negotiations aim at stabilizing carbon dioxide concentrations between 450 ppm and 550 ppm--although even the latter target has been deemed impossible "from a political point of view," by the head of the Kyoto conference's subgroup on targets and emissions timetables, Dr. Luiz Gylvan Meira Filho. Id. The "450 target" would likely keep temperatures from rising more than 2 to 3 degrees Fahrenheit over the next century, but is extremely unlikely to be attainable, given current rates of growth in emissions. The "550 target" would likely yield a temperature rise of between 3 and 8 degrees Fahrenheit, depending on which climatological model is to be believed. Id.; see also NAS, supra note 1.

FN7. See William D. Nordhaus, A Perspective on Costs and Benefits, EPA J., Mar.-Apr. 1990, at 44; Joel B. Smith, Standardized Estimates of Climate Change Damages for the United States, 32 Climatic Change 313, 313 (1996) (summarizing work of Nordhaus, Cline, Fankhauser, and Titus, and suggesting range of $42.3 billion to $52.8 billion cost of damages to the United States alone).

FN8. See Thomas Schelling, The Economic Diplomacy of Geoengineering, 33 Climatic Change 303, 304 (1996) (defining geoengineering as "altering the chemistry of the atmosphere" through intentional and to some degree unnatural means). For a useful discussion of the history of geoengineering in academic literature from the 1960s to the present, see Stephen Schneider, Geoengineering: Could--or Should--We Do It?, 33 Climatic Change 291, 291-95 (1996).

FN9. See Will Nixon, The Big Fix, NRDC Amicus J., Winter 1995, at 16; see also Sharon Begley, On the Wings of Icarus, Newsweek, May 20, 1991, at 64.

FN10. See Dale Jamieson, Ethics and Intentional Climate Change, 33 Climatic Change 323 (1996); David W. Keith & Hadi Dowlatabadi, A Serious Look at Geoengineering, 73 Eos 289 (1992); James Edward Peterson, Can Algae Save Civilization? A Look at Technology, Law and Policy Regarding Iron Fertilization of the Ocean to Counteract the Greenhouse Effect, 6 Colo. J. Int'l Envtl. L. & Pol'y 61 (1995); Schelling, supra note 8.

FN11. See NAS, supra note 1, at 433-64, 460 (discussing geoengineering proposals and commenting on the cost of some of the proposals, stating that "[p]erhaps one of the surprises of this analysis is the relatively low costs at which some of the geoengineering options might be implemented"); see also Robert E. Dickinson, Climate Engineering: A Review of Aerosol Approaches to Changing the Global Energy Balance, 33 Climatic Change 279 (1996); Schneider, supra note 8; Edward Teller, The Planet Needs a Sunscreen, Wall St. J., Oct. 17, 1997, at A22.

FN12. See William D. Nordhaus, An Optimal Transition Path for Controlling Greenhouse Gases, 258 Science 1315 (1992) (providing economic calculations of costs and benefits of geoengineering) [hereinafter Nordhaus, Optimal Path]; Changing the World, The Economist, Feb. 26, 1994, at 85 (providing summary of costs and benefits of various geoengineering proposals); William D. Nordhaus, Count Before You Leap, The Economist, July 7, 1990, at 21 [hereinafter Nordhaus, Count Before You Leap].

FN13. See Teller, supra note 11. Edward Teller may be better known to readers as "the father of the H-bomb," product of a Manhattan Project of an earlier time.

FN14. See Patrick Huyghe, Geoengineering Our Way Out of Trouble (visited Jan. 3, 1998) <http://www.columbia.edu/cu/21stC/issue-2.1/huyghe.htm> (quoting environmental scientist Wallace Broecker's tentative support for "insurance against a bad climate trip" in the form of geoengineering).

FN15. See Nordhaus, Optimal Path, supra note 12, at 1319 (stating that "the advantage of geoengineering over other policies is enormous"); see also Schelling, supra note 8, at 303 (stating that geoengineering could "immensely simplify greenhouse policy, transforming it from an exceedingly complicated regulatory regime to a problem in international cost sharing").

FN16. See Schneider, supra note 8.

FN17. For useful scientific analyses of a climate change geoengineering policy, see Keith & Dowlatabadi, supra note 10; William J. Broad, Scientists Dream Up Bold Remedies for Ailing Atmosphere, N.Y. Times, Aug. 16, 1988, at C1.

FN18. See Huyghe, supra note 14.

FN19. See Kenneth H. Coale et al., A Massive Phytoplankton Bloom Induced by an Ecosystem-Scale Iron Fertilization Experiment in the Equatorial Pacific Ocean, 383 Nature 495 (1996); Bruce W. Frost, Phytoplankton Bloom on Iron Rations, 383 Nature 475 (1996); Peterson, supra note 10, at 68; see also Michael J. Behrenfeld et al., Confirmation of Iron Limitation of Phytoplankton Photosynthesis in the Equatorial Pacific Ocean, 383 Nature 508 (1996); D.J. Cooper et al., Large Decrease in Ocean-surface CO sub2 Fugacity in Response to In Situ Iron Fertilization, 383 Nature 511 (1996). On the potential policy applications of these findings, see Richard Monastersky, Iron Versus the Greenhouse: Oceanographers Cautiously Explore a Global Warming Therapy, 148 Sci. News 220 (1995); William J. Broad, Debating Use of Iron as Curb of Climate, N.Y. Times, Nov. 12, 1996, at C1.

FN20. See Dickinson, supra note 11 (presenting charts and models of estimated reflectivity and aerosol optical depth); J.F.B. Mitchell et al., Climate Response to Increasing Levels of Greenhouse Gases and Sulphate Aerosols, 376 Nature 501 (1995) (stating that "[a]fter greenhouse gases, sulphate aerosols probably exert the next largest anthropogenic radiative forcing of the atmosphere"); Graeme L. Stephens, Dirty Clouds and Global Cooling, 370 Nature 420 (1994) (noting role of aerosols in microphysical characteristics of clouds in context of proposals to seed clouds in order to promote cooling); Changing the World, supra note 12; Nordhaus, Count Before You Leap, supra note 12, at 20; Teller, supra note 11 (arguing that "the planet needs a sunscreen").

FN21. See Dickinson, supra note 11, at 284; see also Gore, supra note 1, at 57- 60 (surveying effects of volcanic eruptions on climate from distant past to Pinatubo eruption); Bob Johnstone, The Pinatubo Effect, Far E. Econ. Rev., Sept. 26, 1991, at 86. One additional side effect of aerosols and dust particulates in the atmosphere may be an increase in cloud brightness, which could increase reflectivity even more. Dickinson, supra note 11 at 285. At the same time, there is some concern that the benefits of aerosol "cooling" would not be uniform and could allow "some regions heated to excess and others to deficit." Schneider, supra note 8, at 297-98.

FN22. See infra notes 54-65 and accompanying text.

FN23. See Gore, supra note 1, at 295-360.

FN24. Susan Subak et al., National Greenhouse Gas Accounts:

Current Anthropogenic Sources and Sinks, 25 Climatic Change 15 (1993). Fossil fuel burning is estimated to release approximately five billion tons of carbon per year. Beckerman, supra note 1, at 256; B.J. Mason, The Greenhouse Effect, 30 Contemp. Physics 417 (1989); see also John Douglas, The Cost of Greenhouse Insurance, EPRI J., Dec. 1992, at 28 (analyzing role of fossil fuels as commercial power sources in light of climate change effects). Deforestation, though second to fossil fuel use as a cause of anthropogenic climate change, is a "double hit" for the global climate, both removing valuable carbon sinks and causing the release--according to recent estimates--of 2.8 million metric tons of carbon dioxide per year. Kenton R. Miller et al., Deforestation and Species Loss: Responding to the Crisis, in Preserving the Global Environment 78, 98 (Jessica Tuchman Mathews ed., 1991).

FN25. See infra notes 54-65 and accompanying text.

FN26. See Aronson, supra note 1 (describing climate change as a prisoner's dilemma or "cooperator's loss," depending on orientation of nations); see also Adam Chase, Barriers to International Agreements for the Adaptation and Mitigation of Global Climate Change: A Law and Economics Approach, 1 Touro Envtl. L.J. 17 (1994); see generally H. Scott Gordon, The Economic Theory of a Common Property Resource: The Fishery, 62 J. Pol. Econ. 124 (1954); Garrett Hardin, The Tragedy of the Commons, 162 Science 1243 (1968).

FN27. See William K. Stevens, No Accord, and Little Optimism, at Bonn Talks on Global Warming, N.Y. Times, Nov. 1, 1997, at A7; see also Emissions Plan Assailed, Chi. Trib., Oct. 24, 1997, at 8 (discussing friction between U.S. and European delegates to Kyoto Conference).

FN28. See Stevens, supra note 2.

FN29. Clayton P. Gillette & James E. Krier, The Un-easy Case for Technological Optimism, 84 Mich. L. Rev. 405 (1985).

FN30. See NAS, supra note 1, at 153; see also Cline, supra note 1, at 29 (charting temperature increase); Firor, supra note 1; Intergovernmental Panel on Climate Change, IPCC First Assessment Report 199 (1990) [hereinafter IPCC].

FN31. Carbon dioxide concentrations are now at approximately 360 ppm, up from the pre-industrial level estimated at 280 ppm.

See Cline, supra note 1, at 26 (stating that "[t]here is unambiguous evidence on the buildup of carbon dioxide in the atmosphere" based on reliable ice core samples); IPCC, supranote 30, at xvi; Nordhaus, Count Before You Leap, supra note 12, at 19; Stevens, supra note 2.

FN32. See Stephen Schneider, The Greenhouse Effect: Science and Policy, 243 Science 771, 771 (1989) ("The greenhouse effect, despite all the controversy that surrounds the term, is actually one of the most well-established theories in atmospheric science .... What is controversial ... is exactly how much Earth's surface temperature will rise given a certain increase in [GHGs]."). Though Schneider omits several important uncertainties discussed here, it is worth emphasizing his point that the physics of carbon dioxide and other gases absorbing and subsequently transmitting heat is not a matter of theoretical fancy but is a scientifically measured property. To what extent this property is responsible for climate change may remain somewhat unclear, but the greenhouse effect itself is not mumbo-jumbo; it is science.

FN33. See Nordhaus, supra note 1, at 82-83 (estimating $5.6 trillion total primary and secondary costs); Samuel Fankhauser, The Social Costs of Greenhouse Gas Emissions: An Expected Value Approach, 15 Energy J. 157, 181 (1994) (using stochastic modeling to calculate order-of-magnitude costs for climate change at $20 per ton of carbon emitted during 1991-2000, $23 per ton during 2000-2010, $25 per ton during 2010-2020, and $28 per ton during 2020- 2030); Smith, supra note 7. One frequently publicized concern regarding climate change is its effect on agriculture, though the actual consequences in this area are particularly unclear. See Susan Helms et al., The Impact of Climate Change on Agriculture, 33 Climatic Change 1 (1996) (noting recent studies suggesting maintenance of current levels of agricultural production); see also discussion infra note 37 (focusing on valuation of wilderness and other ecological goods as incorporated into economic analyses).

FN34. See Daniel L. Albritton, What We Know; What We Don't Know, EPA J., Mar.- Apr. 1990, at 4-6; see also IPCC, supra note 30, at 7-10; Lester Lave & Hadi Dowlatabadi, Climate Change: The Effects of Personal Beliefs and Scientific Uncertainty, 27 Envtl. Sci. & Tech. 1962 (1993); Richard S. Lindzen, A Skeptic Speaks Out, EPA J., Mar.-Apr. 1990, at 46 (noting complexities not taken into account in climate models).

FN35. Though humans emit between 5.5 and 7.7 billion tons of CO sub2 per year into the atmosphere, skeptics frequently point out that this may be a drop in the bucket relative to the total atmospheric picture. See Bert Bolin, How Much CO sub2 Will Remain in the Atmosphere? The Carbon Cycle and Projections for the Future, in The Greenhouse Effect: Climatic Change and Ecosystems 93 (Bert Bolin et al. eds., 1986). Because we do not know how much given amounts of GHGs affect the climate, estimates of how much GHG output needs to be reduced vary considerably. Aronson, supra note 1, at 2146 (noting prescribed reductions in GHG emissions ranging from 11% to 25% from baseline over next twenty years).

FN36. See Albritton, supra note 34; see also Stone, supra note 1, at 20-25. That increases in temperature may be resultant from non-anthropogenic activity (e.g., sunspots) has also been theorized by some. See Frederick Seitz et al., Scientific Perspectives on the Greenhouse Problem (1989); William J. Broad, Another Possible Climate Culprit: The Sun, N.Y. Times, Sept. 23, 1997, at C1 (reporting on data that sunspots may be responsible for climate change).

FN37. Although naive claims that the world would be "better off" a few degrees warmer betray an ignorance of basic ecology, some cogent arguments have also been made that because climate change effects may most be felt at the poles, or at nighttime, or during winter, the economic effects in fact be beneficial. See Wilfred Beckerman, Global Warming: A Skeptical Economic Assessment, in Economic Policy Toward the Environment 52, 55-59 (Dieter Helm ed., 1991); Beckerman, supra note 1. Both of Beckerman's useful economic analyses of climate change are marred by a simplification of the science involved and a failure to fully explore the value of ecosystemic and environmental protection, as quantifiable in revealed preference valuations. Beckerman also neglects the secondary effects of climate change on habitat; he considers the primary effects of a potential rise in sea level, for example, but ignores the secondary effect on very economically productive estuarine ecosystems. Id. at 264-67. It is also worth bearing in mind that "uncertainty" cuts both ways: Cline summarizes several possible catastrophic outcomes of climate change which could conceivably come to pass, including much higher rise in sea levels and alteration of the "deep ocean conveyor" with attendant secondary consequences for weather patterns and ocean currents. Cline, supra note 1, at 34-35.

FN38. See James K. Hammitt, Outcome and Value Uncertainties in Global-Change Policy, 30 Climatic Change 125, 125-26 (1995) (arguing that value uncertainties are in some cases more important than outcome uncertainties in determining policy responses).

FN39. See Lave & Dowlatabadi, supra note 34 (discussing role of personal and group uncertainty in policy formation); Simon Shackley & Brian Wynne, Representing Uncertainty in Global Climate Change Science and Policy: Boundary- Ordering Devices and Authority, 21 Sci., Tech. & Hum. Values 275 (1996) (analyzing role of uncertainty in policymakers' understanding of scientific authority); W. Kip Viscusi & Richard Zeckhauser, Environmental Policy Choice Under Uncertainty, J. Envtl. Econ. & Mgmt. 97-98 (1976); Fred Pearce, All Gas and Guesswork, New Scientist, July 30, 1994, at 14 (noting difficulties in negotiations at Climate Change Convention due to lingering scientific uncertainties); see also Nordhaus, supra note 1, at 187 (estimating rates of savings that can be obtained through gaining additional information).

FN40. Such a statement may seem odd in the wake of Kyoto's sound and fury, but given that no mainstream climatologist believes that an emissions reduction accord can prevent a doubling of atmospheric carbon dioxide levels from pre- industrial levels, with attendant 3 to 8 degrees Fahrenheit rises in temperature, it is not an overstatement. See Stevens, supra note 2; Lev, supra note 5.

FN41. The Framework Convention on Climate Change (FCCC), signed in 1992 at Rio's UN Convention on Environment and Development, "urges" nations to stabilize GHG emissions at 1990 levels. See Jessica T. Mathews, Greenhouse Warming: Negotiating a Global Regime 1 (1991); Daniel Bodansky, The United Nations Framework Convention on Climate Change: A Commentary, 18 Yale J. Int'l L. 451 (1993); Hilary F. French, Forging a New Global Partnership, in State of the World 1995, at 170, 173 (Linda Starke ed., 1995).

FN42. The recent Kyoto Conference, which sought to solidify Rio's exhortations in binding emissions targets, followed years of grandstanding and retreating on the part of various political leaders. See John H. Cushman, Jr., U.S. Seeks Binding Pact to Combat Global Warming, N.Y. Times, July 17, 1996, at A6 (reporting

on U.S. proposal of binding targets at Geneva talks on implementing Framework Convention on Climate Change); cf. John H. Cushman, Jr., U.S. Taking Cautious Approach in Talks on Global Warming, N.Y. Times, Dec. 8, 1996, at A1, A14 (reporting on U.S. proposal to delay emissions targets until 2010); Rio Emissions Treaty Targets Under Question, Oil & Gas J., July 29, 1996, at 40 [hereinafter Rio Emissions] (pointing out continued rise in GHG emissions and discussing effect on insurance industry); Nicholas Schoon, Rio Summit's Green Pledges To Be Broken, The Independent (London), Oct. 11, 1996, at 8 (reporting on senior official with International Energy Agency's comments that forecasts from Rio signatories showed annual CO sub2 emissions expected to rise by 8 to 14 percent between 1990 and 2000, despite pledge to freeze at 1990 levels); see generally Gunther Handl, Controlling Implementation of and Compliance with International Environmental Commitments: The Rocky Road from Rio, 5 Colo. J. Int'l Envtl. L. & Pol'y 305 (1994).

FN43. See Donald K. Anton, The Internationalization of Domestic Law: The Shrinking Domaine Reserve, 87 Proc. Am. Soc'y Int'l L. 553, 559 (1993) (remarks of Professor Jutta Brunnee on connection between information and action, stating that "even the ozone protocol was reacting to an existing problem, and it will continue to react to the amount of information available about the problem").

FN44. See e.g., Gregg Easterbrook, A Moment on the Earth 10-20 (1993); Jonathan H. Adler, Global Warming Controversy: Cool Climate, Competitive Enterprise Inst. Update, July 1996, at 1. Easterbrook's denial is interesting. His entire case for resting easy about Western environmental problems is premised on a policy of global "worst-first," a case that would collapse if climate change were a truly serious threat; were climate change demonstrated, Easterbrook's own argument would force him to call for large changes in Western behavior with regard to the natural environment. This is true, it seems, for many greenhouse deniers, for whom it is difficult to see what other tactical options even exist in the light of their various political-philosophical commitments. Given that some internationally coordinated action is required to address climate change, it is no surprise that persons with political commitments against large-scale action find no room in their political models for the possibility of a problem like global warming. With no policy tools ideologically available, the only possible option is to deny the problem: how could a libertarian solve global warming?

FN45. Indeed, as consensus on climate change builds, see supra note 1, many in the anti-environmental community have now taken to attacking the objectivity of the scientific community itself. See, e.g., Bette Hileman, Global Warming Is Target of Disinformation Campaign, Chemical & Engineering News, Aug. 19, 1996, at 33 (discussing disinformation campaign mounted by Virginia climatologist and paid greenhouse denier Patrick Michaels and the Global Climate Coalition against the UN Intergovernmental Panel on Climate Change); Frederick Seitz, A Major Deception on "Global Warming," Wall St. J., June 12, 1996, at A16 (attacking IPCC report as deleting key phrases regarding uncertainty after peer-review process); James M. Sheehan, Global Warming Controversy: Hot Politics, Competitive Enterprise Inst. Update, July 1996, at 1 (alleging politicization in the Intergovernmental Panel on Climate Change so thorough "that its integrity and objectivity cannot be taken for granted").

FN46. For an application of the discount rate to climate change, see William D. Nordhaus, To Slow or Not to Slow: The Economics of the Greenhouse Effect, 101 Econ J. 920, 933-34 (1991) (using four percent discount rate on expected costs and benefits associated with climate change); Peterson, supra note 10, at 103- 04. Of course, preferring present goods is not an innovation of economists--a bird in hand has long been worth two in the bush.

FN47. See Nordhaus, supra note 2, at 82-87 (noting that the "efficient" four percent discount rate does not yield a GHG reduction strategy that avoids all adverse effects).

FN48. See supra notes 24-26.

FN49. See Beckerman, supra note 1, at 269-76; Hammitt, supra note 38; Viscusi & Zeckhauser, supra note 39, at 105-08; Aronson, supra note 1; supra notes 23-24 and accompanying text.

FN50. In this way, climate change regulations echo the familiar cost-benefit conundra that have become grist for the American political mill. Even if we were to agree that some action is necessary, and even if we had perfect information regarding how effective greenhouse gas reduction measures would be, we would still not necessarily find consensus on an algorithm comparing benefits and harms. If domestic experience is any guide, unquantifiable terms such as "safety" and "health" will probably be bandied about in debate with some numerical limits emerging from negotiation rather than from risk analysis. See Jay

Michaelson, Note, Rethinking Regulatory Reform: Toxics, Politics, and Ethics, 105 Yale L.J. 1891 (1996) (discussing role of rhetoric and risk analysis in valuation methods for comparing lives saved by toxics regulation to financial costs borne by toxics producers).

FN51. See Victor R. Baker, Uncertainty in Science and Decisionmaking, 9 Ariz. J. Int'l & Comp. L. 253 (1992); Viscusi & Zeckhauser, supra note 39, at 105-10 (discussing in detail the policy dynamics of "hedging bets"); Daniel Bodansky, Scientific Uncertainty and the Precautionary Principle, Env't, Sept. 1991, at 33. A colleague called my attention to the interesting parallel between the climate change dilemma--whether to hedge one's bets to avoid a disastrous outcome--and Pascal's classic decision to believe in God because, if it turned out that God did in fact exist, to not believe (and act appropriately) would bring disaster. See Blaise Pascal, Pensees (1828).

FN52. See, e.g., Adler, supra note 44, at 1 (likening predicting climate to "predicting the weather," suggesting that because 1996 "has been a cool year," global warming is not happening, and stating that "the model projections are hooey").

FN53. See Lev, supra note 5 (quoting U.S. Undersecretary of State for Global Affairs Timothy Wirth as characterizing climate change negotiations as "the most difficult negotiation anyone has ever tried to do on a brand new topic").

FN54. See generally Beckerman, supra note 1 (omitting secondary and environmental costs from analysis of policy options); Nordhaus, Count Before You Leap, supranote 12, at 19 (contrasting the need for economic growth with the desire for environmental protection, and stating that "climate warming will probably be a boon to Alaska"--though it would of course be disastrous for Alaskan ecosystems and biota, if not the economy). As always, the questions to ask in evaluating economic analyses are how social and other goods have been quantified, and whether the provisional economic values attached to them acceptably reflect the dynamics of public choice. Only to the extent that economic models incorporate public valuations for supposedly "non-economic" goods (e.g., wilderness preservation), which include valuations both of use- value and intrinsic-value (the latter at least as measured by revealed preference or surrender value), are they at all instructive in a real-world public choice debate. See Michaelson, supra note 50, at 1911-22 (discussing use of cost-benefit analysis in environmental regulation).

FN55. Nordhaus and others make the point that there are plenty of "no-regrets" climate change policies that do not involve fossil fuel cutbacks, such as reducing deforestation and strengthening enforcement of CFC agreements. See Nordhaus, Count Before You Leap, supra note 12, at 21. Nordhaus admits, however, that "no regrets" policies cannot do the job alone, and that some additional "greenhouse insurance" is likely to be essential.

FN56. Nordhaus, supra note 1, at 93-96.

FN57. Id. at 71, 80.

FN58. Id. at 83. Nordhaus had earlier calculated the annualized global impact of the optimal policy to be $16.39 billion/year. William D. Nordhaus, Optimal Greenhouse-Gas Reductions and Tax Policy in the "DICE" Model, 83 Am. Econ. Rev. 313, 315 (1993) (hereinafter, Nordhaus, DICE). Using a four percent discount rate on future benefits received from preventing global warming, Nordhaus argues that the nine percent reduction level is the point at which the discounted future benefits of minimizing climate change outweigh the costs of preventing it. He admits, however, that the nine percent level is not sufficient to prevent all adverse effects. Of course, Nordhaus's and similar analyses beg the question: to what extent have the externalities associated with climate change, particularly those related to indirect economic goods, been taken into account? Of course, even this nine percent reduction level is more stringent than the program implemented at Kyoto. See Fialka, supra note 4.

FN59. Nordhaus, supra note 1, at 95.

FN60. Id. This and the other annualized costs are averages, of course; in earlier years, the marginal cost would be lower and might outweigh the annualized discounted future benefits, but as the tax rate increases over later years, the net loss would grow. See Cline, supra note 1, at 165-70 (discussing Nordhaus's models).

FN61. Nordhaus, supra note 1, at 82; See infra part III.C.1.

FN62. Cline, supra note 1, at 306-09.

FN63. See id. at 186-87 (chart summarizing analyses). The models differed widely even on what amount of carbon tax would

be required to reach the optimal reduction in GHG emissions, with 2025 estimates ranging (in 1990 dollars) from $33/ton (Nordhaus) to $215/ton (OECD) to $375/ton (Manne-Richels).

FN64. Id. at 183 (discussing U.S. Dep't of Energy, National Energy Strategy: Powerful Ideas for America (1991); DOE estimate based on a $500/ton carbon tax to yield a 20% GHG reduction).

FN65. Id. at 153-57 (discussing Alan S. Manne & Richard G. Richels, CO sub2 Emissions Limits: An Economic Cost Analysis for the USA, 11 Energy J. (1990)).

FN66. Louis Uchitelle, Hourly Wage Jumps for 2d Straight Month, N.Y. Times, July 6, 1996, at 31 (reporting statistics of U.S. labor department).

FN67. Assuming 125 million (approximately 50% of the United States population) employed with a five day work week and two weeks of vacation per year.

FN68. Nordhaus, supra note 1, at 83. Nordhaus had earlier estimated the total cost of climate change at $4.1 trillion. Nordhaus, Optimal Path, supra note 12, at 1317. Though this number seems astronomical, it is spread over an indefinite period, and represents only 0.56% of the discounted value of total consumption. Id. at 1318. Moreover, the United States would likely suffer a total cost of only $61.6 billion, assuming a 2.5 degrees Celsius warming. Cline is very critical of Nordhaus's time horizon and predicts much larger losses. See infra note 69.

FN69. Cline, supra note 1, at 130-33. Cline also notes that his long-term analysis "has the sobering implication that much of the damage usually considered is already unavoidable," id. at 133, and claims that 20% GHG reduction targets are far too modest in light of the long-term economic costs of climate change. Id. at 311.

FN70. On the problem of "intergenerational equity," see Edith Brown Weiss, In Fairness to Future Generations: International Law, Common Patrimony, and Intergenerational Equity (1989); see also James C. Wood, Intergenerational Equity and Climate Change, 8 Geo. Int'l Envtl. L. Rev. 293 (1996).

FN71. See French, supra note 41, at 174.

FN72. It is ironic, in this light, that Nordhaus himself suggests that irrationality takes the form primarily of "panicky eco-action." Nordhaus, Count Before You Leap, supra note 12, at 19. To repeat, if he has correctly identified the optimal level of GHG reduction--and, to be sure, most environmental activists feel his "optimal" level is utterly insufficient in light of the ecological and human values at stake--there must by definition be a degree of irrationality among those who oppose even his nine percent level of GHG reduction, which includes most of the world's representatives at Kyoto. See Sullivan & Jordan, supra note 4.

FN73. I am well aware that these arguments are somewhat suspicious, insofar as they are anti-environmentalists' boilerplate topics. See, e.g., Beckerman, supra note 1; Adler, supra note 44, at 4 (concluding that because a 60% reduction in CO sub2 is necessary for meaningful climate change abatement, economic "stagnation" is the only alternative to doing nothing).

FN74. For discussions of concentrated political interests in climate change and environmental law, see Bruce A. Ackerman & William T. Hassler, Clean Coal/Dirty Air (1981).

FN75. This problem is replicated on an international level, with the United States having both the most power and the most to lose in a climate change reduction regime.

FN76. See Americans and Their Automobiles, Am. Demographics, June 1992, at S16 (attributing half of U.S. petroleum consumption to transportation fuels and noting relation between consumption and direct and indirect government subsidies); Deborah Bleviss, Transportation: The Auto, EPA J., Mar.-Apr. 1990, at 26 (stating that 25% of American CO sub2 emissions come from automobiles).

FN77. This point is discussed in more detail infra part V.

FN78. See Americans and Their Automobiles, supra note 76.

FN79. This political reality is of course the exact opposite of Cardozo's classic formulation of the "bundle" of property rights, which was essentially an explanation of how particular incursions on or protections of use of property could be justified, even if without precedent. See Benjamin N. Cardozo, The Paradoxes of Legal Science 129 (1928) ("The bundle of power and privileges to

which we give the name of ownership is not constant through the ages. The faggots must be put together and rebound from time to time ...."); see also Stephen R. Munzer, A Theory of Property 22-36 (1990); J.E. Penner, The "Bundle of Rights" Picture of Property, 43 UCLA L. Rev. 711 (1996).

FN80. See supra part II.C.1.

FN81. See infra note 119 and accompanying text. Of course, much of environmental law is based on the ancient Roman law principle of "Sic utere tuo ut allienum non ledas," roughly, the third century equivalent of "live and let live." Yet at the same time, regulation illustrates the tension between the two exhortations--the requirements of living may be cramped by the injunction against harming others.

FN82. Such strategies constitute the core of President Clinton's global warming plan. The plan includes five billion dollars in tax incentives and research and development projects to spur domestic innovation, and eventual international trading in carbon dioxide emissions permits to extend incentives to innovate worldwide. See Fialka & Calmes, supra note 3; Brian McGrory, Clinton Plan Takes a Middle Path, Boston Globe, Oct. 23, 1997, at A1.

FN83. See infra note 125 and accompanying text.

FN84. See Tariq Osman Hyder, Climate Negotiations: The North/South Perspective, in Confronting Climate Change 323-26 (Irving Mintzer ed., 1992). Developing countries present a host of equity-based objections to climate change reduction programs, including: 1) that the principle of "international action" itself is but a shill for continued Northern imperialism; 2) that, given present day environmental and other problems developing countries, the harms of climate change ought to be more severely discounted; and 3) that developing countries cannot and should not have to bear the burdens of GHG reductions to rectify a situation they did not create. See Robert J. Saunders, Is It Economically Viable for Developing Countries to Cut Down Carbon Dioxide Emissions?, 9 Ariz. J. Int'l & Comp. L. 205 (1992).

FN85. Usually, a Northern country's emission limits, which would be very expensive to achieve, might be offset by carbon reduction efforts in a Southern country, where the costs of such activity are lower. See Tim Jackson, Joint Implementation and Cost-Effectiveness Under the Framework Convention on Climate Change, Energy Pol'y, Feb. 1995, at 117. But see Pearce, supra

note 39 (observing that joint implementation is hampered by information costs). One of joint implementation's equitable side benefits is said to be technology transfer (although the technology associated with simple carbon sink creation-- i.e., planting trees--is often minimal), but Southern countries would be correct to point out that such transfer often does not occur, even when promised. See Martin Khor, North Stalls Eco-Friendly Technology Transfers, Global Info. Network, Aug. 19, 1996.

FN86. See Rio Conference on Environment and Development, 22 Envtl. Pol'y & L. 204 (1992). It should be noted that Northern countries, led by the United States, bitterly fought the inclusion of a "right to development," which, opponents said, could be construed as a Constitutional-level right that could trump any environmental rules or responsibilities. One wonders if the development "right" is taken seriously, whether some compensation ought to be offered for the opportunity costs of developing nations under a climate change regulatory regime.

FN87. See Fialka, supra note 4; China's Role in Kyoto Crucial, Dow Jones News Service, Nov. 5, 1997, available in Westlaw, DJNS Database.

FN88. Some have become quite cynical regarding the motives of Southern negotiators on the equity issue. See, e.g., Angela Gennino & Sara Colm, The Killing Forests, San Francisco Wkly., June 24, 1992 (quoting anonymous official as stating that "Southern elites say 'equity' but what they mean is 'money"').

FN89. See Nordhaus, Count Before You Leap, supra note 12, at 20; Aronson, supra note 1.

FN90. Of a total $4.1 trillion in climate change damages, Nordhaus estimates only $55 billion will be felt by the United States, Nordhaus, supra note 46, at 920-37, though it has been well observed that the United States, with only 4.8% of the world's population, is responsible for 25% of the world's GHG emissions. See Michael Grubb, The Greenhouse Effect: Negotiating Targets 15 (1991); Aronson, supra note 1, at 2164. Interestingly, this share is predicted to decline to 12% a century from now, perhaps complicating the familiar equitable picture. See Cline, supra note 1, at 337.

FN91. Beckerman, for example, calculates that if everyone but China absolutely froze GHG emission rates, and China raised

per capita emissions to the U.S. level, total world emissions would rise a staggering 40%. Beckerman, supra note 1, at 274; see infra text accompanying notes 96-100.

FN92. Schelling, supra note 8, at 306. Of course, some greenhouse gases are worse than others--methane, for instance, is twenty times as potent as carbon dioxide in terms of its effect on climate change. See Cory M. Gonyo, Landfill Gas/Methane Gas: A Liability and an Asset, 1 Greater N. Cent. Nat. Resources J. 243, 247 (1996).

FN93. See Schelling, supra note 8. Regarding the enforcement issue specifically, see Mary Ellen O'Connell, Enforcement and the Success of International Environmental Law, 3 Ind. J. Global Legal Stud. 47 (1995); see also Handl, supra note 42; Andrew Watson Samaan, Note, Enforcement of International Environmental Treaties: An Analysis, 5 Fordham Envtl. L.J. 261 (1993) (surveying mechanisms currently existing to enforce international environmental treaties).

FN94. See O'Connell, supra note 93; Samaan, supra note 93. The elimination of the enforcement problem in technological approaches to international environmental policy is discussed infra part III.C.4.

FN95. See John S. Perry, International Organizations and Climate Change, in World Climate Change: The Role of International Law and Institutions 33, 45 (V. Nanda ed., 1983) (noting "profoundly divisive" nature of climate change); China's Role in Kyoto Crucial, supra note 87; Sullivan & Jordan, supra note 4.

FN96. See Aronson, supra note 1, at 2150-59. For a discussion of Aronson's distinction between the prisoner's dilemma and the "cooperator's loss" faced by some potential parties to a climate change treaty, see infra part II.D.

FN97. U.S. Position Unchanged Ahead of Kyoto Conference, Dow Jones Int'l News Service, Nov. 9, 1997, available in Westlaw, DJNS Database.

FN98. See Cline, supra note 1, at 340-42; Beckerman, supra note 1, at 274; China's Role in Kyoto Crucial, supra note 87.

FN99. Sullivan & Jordan, supra note 4, at 7. The United States, in particular, has fiercely opposed exempting developing nations

from Kyoto's round of cuts. William K. Stevens, No Accord, and Little Optimism, at Bonn Talks on Global Warming, N.Y. Times, Nov. 1, 1997, at A7 (reporting U.S. insistence on "meaningful participation" of developing countries).

FN100. Cline estimates an eight percent GDP loss by 2040, and 11% GDP loss by 2100, if they were to constrain carbon emissions to twice their present levels. Cline, supra note 1, at 340.

FN101. British Deputy Prime Minister John Prescott put it succinctly less than a month before the Kyoto Convention began: "It's a horrendous task to get agreement with such wide disparities." Nicholas Schoon, Prescott Flies to Tokyo to Save the World and Encounters Only Hot Air, The Independent (London), Nov. 10, 1997, at 7. "War stories" are not limited to Kyoto, of course. See, e.g., David A. Wirth, Negotiating Climate Change: The Inside Story of the Rio Convention (1995); James D. Desmond, The Earth Summit and Limits on Carbon Dioxide Emissions: Reading Between the Lines, 8 J. Nat. Resources & Envtl. L. 357 (1992). Often, international disagreements result in a multitude of contradictory declarations. Compare Stockholm Declaration of the United Nations Conference on the Human Environment, Principle 21, U.N. Doc. A/Conf.48/14/Rev. 1 at 2 (1973), 11 I.L.M. 1416 (1972) (expressing nations' responsibility to the global environment) with Rio Declaration, Principle 2, U.N.Doc.A/CONF.151/26 (vol. I) (expressing nations' right to environmental--and developmental--policies so long as they do not cause harm to others).

FN102. Sullivan & Jordan, supra note 4, at 1.

FN103. See French, supra note 41, at 179-88 (discussing successes and failures of international environmental institutions, and making proposals for improvements).

FN104. SeeChase, supranote 26, at 30.

FN105. See O'Connell, supra note 93; Samaan, supra note 93.

FN106. See Daniel C. Esty, The Case for a Global Environmental Organization, in Managing the World Economy: Fifty Years After Bretton Woods (Peter B. Kenen ed., 1994).

FN107. See William Ophuls, Ecology and the Politics of Scar-

city 219-20 (1977) (arguing that the rationale for world government has become "overwhelming").

FN108. See Andrew Hurrell & Benedict Kingsbury, The International Politics of the Environment: An Introduction, in The International Politics of the Environment 1, 7-11 (Andrew Hurrell & Benedict Kingsbury eds., 1992).

FN109. See Lev, supra note 5; Schoon, supra note 101.

FN110. Hardin, supra note 26, at 1243; Gordon, supra note 26, at 128-35. For discussions of the tragedy of the commons in the climate change context, see Beckerman, supra note 1, at 253-54; Aronson, supra note 1.

FN111. See Hardin, supra note 26.

FN112. See Cline, supra note 1, at 325-28; Aronson, supra note 1, at 2149-51.

FN113. If "C" denotes cooperate and "D" defect, the prisoner's dilemma preference ordering is DC > CC > DD > CD (the first letter indicates the action of the player, the second, the action of other players). Potential "free riders" such as these include most industrialized nations; international treaties generally try to prevent free riders through formal or informal enforcement mechanisms.

FN114. Aronson, supra note 1, at 2151. The preference ordering for a cooperator's loss is DC > DD > CC > CD. Aronson argues that the United States, because of its high stake in the status quo, faces a cooperator's loss, as do developing nations. Id. at 2153-60.

FN115. Of course, each individual's uncertainties do not "add up" to total uncertainty; if there is a massive change in climate, surely some tremendous effects will be felt somewhere. Past climatic changes, some historians suggest, have brought about nothing less than the downfall of political empires and civilizations. See H.H. Lamb, Climate, History, and the Modern World (1982); T.M.L. Wigley et al., Climate and History: Studies in Past Climates and Their Impact on Man (1981).

FN116. Cline, supra note 1, at 328-30 (noting that despite the predictions of game theory, some individual industrial countries

have been willing to move forward with emissions reductions, owing to the imperfection of the prisoners' dilemma in the context of climate change and various political forces).

FN117. Hardin, supra note 26. Interestingly, Hardin's classic example of a grazing commons has historically been regulated in England since at least the middle ages, perhaps as tacit recognition of the incentive structure he describes. Conversation with Professor Robert Ellickson, Yale Law School (Spring 1995).

FN118. Some technological approaches to climate change--encouraging eco- friendly replacements for fossil fuels, for example--share many of the advantages of geoengineering and ought not be lumped in with "command and control" regulations. Yet technology-forcing is likely to take place only in some kind of regulatory context--some internationally coordinated program of emissions reductions--and it shares with traditional forms of regulation the emphasis on changing behavior (to some extent) in order to prevent climate change. This bears a closer resemblance to carbon taxes and reduction targets than to iron seeding and particulate spreading.

FN119. See, e.g., Barry Commoner, Making Peace with the Planet (1990); Bill Devall & George Sessions, Deep Ecology: Living as if Nature Mattered (1985); Gore, supra note 1, at 238-60 (arguing for an "environmentalism of the spirit" involving changes in attitudes about the relationship between humanity and the natural world); The Deep Ecology Movement: An Introductory Anthology (Alan Drengson & Yuichi Inoue eds., 1995) [hereinafter Deep Ecology Movement]; Dale Jamieson, Ethics, Public Policy, and Global Warming, 17 Sci., Tech. & Hum. Values, 139, 146-51 (1992) (arguing that climate change poses deep moral and ethical challenge requiring value reorientation and education).

FN120. See Carol M. Browner, Why Environmental Education?, EPA J., Spring 1995, at 6 (stating government interest in environmental education); see also C.A. Bowers, Educating for an Ecologically Sustainable Culture (1995).

FN121. Discussions of adaptation as a climate change strategy do appear occasionally in the policy literature, although generally from only one side of the ideological table. See Nordhaus, Count Before You Leap, supra note 12 (noting that some adaptation will be inevitable); Michael Redemer, Industry's Position: One View, EPA J., Mar.-Apr. 1990, at 48 (advocating adaptation as

primary climate change strategy); Joel B. Smith, Adaptation: Another Approach, EPA J., Mar.-Apr. 1990, at 29.

FN122. See Nordhaus, supra note 7, at 44.

FN123. Nordhaus himself admits that "if we are truly to stabilize climate, we must begin to act today; adaptations to climate change can take place gradually over the decades to come." Id. Nordhaus's advocacy of some adaptive measures comes in the context of a three-pronged proposal for more research, development of climate-neutral technologies, and "no regrets" policies such as curbing deforestation and slowing the growth in fossil fuel use.

FN124. See id.

FN125. See Douglas, supra note 24; Hydrogen as an Alternative Automotive Fuel, Automotive Engineering, Oct. 1994, at 25. Despite Nordhaus's and others' claim that these are "no-regrets" policies, funding for alternative fuels has been cut drastically in recent years of belt-tightening (and ideological shifts) in the federal government. See Coalition Charts Cost of GOP Energy R&D Budget Cuts, Energy Daily, June 14, 1996 [hereinafter Coalition Charts Cost] (noting $285 million cut in research appropriations for renewable energy sources in FY 1997 budget); Joseph F. Schuler, Jr., Research and Renewables: Funding at the National Energy Labs, Pub. Util. Fortnightly, Aug. 1, 1996 (noting $113 million cut in National Energy Laboratories' FY 1996 budget). The Clinton administration has thus far requested increases in alternative fuel research, Coalition Charts Cost, supra (noting "Clinton administration proposed increasing funding for DOE's energy efficiency R&D programs to $566 million in fiscal 1997, up from $418 million in fiscal 1996"), and promoted alternative energy programs, Allen R. Myerson, Administration to Press Alternative Fuel Plan, N.Y. Times, Feb. 22, 1995, at C2 (reporting on plan to require state governments and energy companies to buy vehicles that run on natural gas or other alternative fuels), but with little success.

FN126. See Stevens, supra note 2; Teller, supra note 11.

FN127. See NAS, supra note 1, at 58-59; Keith and Dowlatabadi, supra note 10; Nordhaus, Optimal Path, supra note 12, at 1319; Schneider, supra note 8; Changing the World, supra note 12; Teller, supra note 11; Huyghe, supra note 14.

FN128. This is the so-called "Geritol cure." Peterson, supra note 10, at 68. The first serious research on the "Geritol cure" stemmed from John Martin's proposals in the late 1980's. Huyghe, supra note 14. Since then, a considerable body of data has been amassed. See Behrenfeld et al., supra note 19; Coale et al., supra note 19; Frost, supra note 19; Monastersky, supra note 19; Broad, supra note 19.

FN129. This is the so-called "sunscreen" proposal. See Dickinson, supra note 11; Teller, supra note 11; Huyghe, supra note 14 (quoting Wallace Broecker's endorsement of sunscreen proposal as one of the "cheapest and least dangerous" geoengineering policies as "insurance against a bad climate trip").

FN130. See Keith & Dowlatabadi, supra note 10.

FN131. See Alan S. Miller, Energy Policy from Nixon to Clinton: From Grant Provider to Market Facilitator, 25 Envtl. L. 715 (1995); Richard Williamson, The Clinton Administration's New Energy Policies, 2 Tulsa J. Comp. & Int'l L. 115, 117 (1994).

FN132. See infra part III.C.1.

FN133. See NAS, supra note 1, at 59; Huyghe, supra note 14 (noting the failure to properly engineer atmosphere in the Biosphere II experiment, a fortiori in the Earth's actual systems); Begley, supra note 9; Schneider, supra note 8, at 292. These concerns are discussed in more detail infra part IV.C.

FN134. See Huyghe, supra note 14 (quoting Robert Watts).

FN135. Stephen Schneider believes this institutional requirement may itself cripple geoengineering. Schneider, supra note 8, at 299. I discuss the institutional issues associated with geoengineering infra part III.C.5.

FN136. Nixon, supra note 9.

FN137. See Victor Navasky, Tomorrow Never Knows, N.Y. Times Mag., Sept. 29, 1996, at 216 (humorously surveying false scientific and other predictions of the last 200 years). Other howlers from Navasky's essay: "[s]pace travel is utter bilge," uttered by the British Astronomer Royal in 1956; and "[d]ata processing is a fad and won't last out the year," by a business editor at Prentice

Hall. Id.

FN138. See, e.g., Huyghe, supra note 14 (quoting director of the Office of U.S. Global Change Research Program Michael MacCracken as stating that "[t]he fundamental trouble with most geoengineering proposals is that the ones with the fewest side effect are those with the greatest up-front costs").

FN139. Schneider, long an outspoken advocate of limits on growth to prevent climatic catastrophe, has advocated "more systematic study of the potential for geoengineering." Schneider, supra note 8, at 29; see also Schelling, supra note 8; Huyghe, supra note 14.

FN140. Teller, supra note 11.

FN141. Economist Nordhaus states that, should a feasible geoengineering technology be developed, the economic "advantage of geoengineering over other policies is enormous." Nordhaus, Optimal Path, supra note 12, at 1319.

FN142. See Browner, supra note 120 (discussing the importance of environmental education and the EPA's Environmental Education Program); see also Bowers, supranote 120.

FN143. The amount of time and expenditure needed for such "reeducation" is a matter of debate, of course, and it does seem somewhat intellectually arrogant to expect that if everyone were simply better educated, they would all have a certain ecological opinion. I would say, though, that penetrating the "black box" of revealed preferences is probably the only way to effect the massive sorts of value-reorientations needed for "effective" serious conservation and environmental programs.

FN144. Absent some limits, developing world consumption renders futile any climate change agreement. Either the developing world will (and should) attain 'Western' consumption rates--in which case population really is the problem--or the developing world is expected to stay in some sort of nebulous and inequitable second-tier level of consumption. Most models of GHG emissions assume some progress toward the former. See Cline, supra note 1, at 360; Grubb, supra note 90, at 17 (noting that "[i]f China and India emitted carbon at the same per capita rate as the U.S., world emissions would be nearly trebled"); Beckerman, supra note 1, at 274 (noting that if no one else but China raised

GHG emissions at all, but China raised per capita emissions to half the U.S. level, total world emissions would rise a staggering 40%); Rio Emissions, supra note 42 (noting energy council predictions that 50% of GHG emissions in 2020 will come from developing countries). But see Saunders, supra note 84 (questioning economic viability of reduction in developing country CO sub2 emissions).

FN145. See infra part IV.D.

FN146. See NAS, supra note 1, at 460; Nordhaus, supra note 1, at 82-83; Nordhaus, Optimal Path, supra note 12. But see Huyghe, supra note 14 (quoting U.S. Global Climate Change research official as claiming geoengineering costs are prohibitive.

FN147. See Nordhaus, supra note 1, at 87; see also supra part II.C.1. Given a $4.1 trillion total cost of unabated climate change, Nordhaus calculates that this policy yields a net annualized benefit of $11 billion. Nordhaus, supranote 1, at 82.

FN148. Nordhaus, supra note 1, at 95.

FN149. Id. As discussed supra, Nordhaus claims this policy's costs do not outweigh the benefits, and indeed have a net annualized global cost of $762.5 billion.

FN150. See Changing the World, supra note 12, at 85-86. Geochemist Wallace Broecker has a different view: he believes the "sunscreen" proposal would cost in the area of $50 billion. See Huyghe, supra note 14.

FN151. See Peterson, supra note 10, at 74 (citing John H. Martin, Glacial- Interglacial CO sub2 Change: The Iron Hypothesis, 5 Paleoceanography 1, 10 (1990)). This relatively large "bang for the buck" results from the fact that only one iron atom is needed to stimulate enough plankton to consume approximately 10,000 carbon atoms. See Changing the World, supra note 12, at 85.

FN152. See Peterson, supra note 10, at 75 (citing U.S. Bureau of Mines, Mineral Commodity Summaries 1990, at 87 (1990)). Of course, disseminating the iron throughout the high seas is the largest practical and financial issue.

FN153. See Nordhaus, supra note 1, at 82.

FN154. See Michael E. Porter, America's Green Strategy, Sci. Am., Apr. 1991, at 168. Certainly, there is much debate on whether competitiveness is hampered or helped by restrictive regulations, see, e.g., Richard Stewart, Environmental Regulation and International Competitiveness, 102 Yale L.J. 2039 (1994); Edith Brown Weiss, Environmentally Sustainable Competitiveness: A Comment, 102 Yale L.J. 2123 (1993), but, since geoengineering is not a set of restrictive regulations, the supposedly stifling set of "costs" with which Stewart is concerned do not arise.

FN155. Gore, supra note 1, at 335-37.

FN156. American skepticism aside, this has already been Germany's Green Strategy. Companies in Germany, which has some of the world's strictest environmental laws, now control 20% of the three billion dollar global market for environmentally friendly technologies. Sullivan & Jordan, supra note 4, at 7; see also Anton, supra note 43, at 564 (quoting remarks of Joel Paul on Germany's success in international plastics markets because of successful domestic plastic recycling program).

FN157. Miller, supranote 131; Williamson, supranote 131.

FN158. Indeed, in the 1996 budget, $11 billion more was allocated to defense spending than President Clinton even requested. Pat Towell, Defense Hawks Win a Round in Pentagon Budget Fight, Cong. Q. Wkly. Rep., June 8, 1996, at 1606.

FN159. See Schneider, supra note 8, at 300 (comparing society's reliance on GHG-producing technology to an addict's dependence on heroin, and suggesting that geoengineering is like administering methadone instead of curing the addiction).

FN160. Schelling notes that afforestation is basically a geoengineering strategy, although not what most people "have in mind" when they think of geoengineering. Schelling, supra note 8, at 305. Of course, curtailing deforestation and encouraging reforestation are "no-regrets" environmental policies and should be pursued in any case. See Robert J. Moulton & Kenneth Andrasko, Reforestation, EPA J., Mar.-Apr. 1990, at 14 (discussing U.S. tree-planting initiatives); Nordhaus, supra note 7, at 45.

FN161. See supra part II.C.1.

FN162. Some "social costs" are associated with the bare primary expense of a geoengineering project, particularly in cases where the cost is not offset by reductions in other expenditures. It is also true that asking Americans (and others) to part with their tax dollars is not an effortless endeavor. But it is one to which governments are both accustomed and well suited, and a type of "sacrifice" with which most nations' citizens are familiar, in contrast to the sorts of lifestyle alteration that would follow from a sizable reduction in consumption or destructive production.

FN163. Indeed, it may be for this reason that many people "of a right-wing and technocratic frame of mind" have tentatively embraced geoengineering. Changing the World, supra note 12, at 86. My project here, and particularly in part V, is to convince the rest of us that it is worth examining as well.

FN164. See Stevens, supra note 99.

FN165. See supra part II.C.2.

FN166. See Jackson, supra note 85; Pearce, supra note 39.

FN167. See supra note 90. I acknowledge that geoengineering allows for "free riders," particularly on the part of lesser developed countries (LDCs), but some degree of free ridership is what equity concerns tend to be all about. See Aronson, supra note 1.

FN168. Geoengineering is only a "polluter pays" policy on the national level, however. More locally, it may be quite the opposite: the heaviest polluters (power plants, vehicle users, etc.) may bear no correlation whatsoever to those who must pay the most for a geoengineering project. As such, geoengineering is somewhat unfair relative to an optimal regulatory regime, but since this unfairness is not across North-South boundaries, it is distinct from the equity issues discussed here.

FN169. It may also be the case that, if a tradeable permits system is set up for carbon emissions similar to the sulfur dioxide system in the United States, developing countries would stand to gain an effective subsidy. Given that it is likely to be cheaper to attain reductions there than in industrialized nations, most LDCs would probably sell their credits at a price greater than the actual cost of reducing emissions. See Aronson, supra note 1, at 2160-74.

FN170. See Stevens, supra note 99 (reporting U.S. insistence that developing countries share burdens in emissions reduction plans).

FN171. See supra note 90 and accompanying text. It is interesting to note as an aside that those who seek to defuse the "population bomb"--i.e., those who argue that consumption, not population, is the real enemy of eco- sustainability--seem to miss this point; surely any non-Western-centric person would want people in the developing world to enjoy whatever goods and services they want, including those enjoyed by Westerners. But unless a radically different consumption pattern emerges in the developing world, such equality will spell disaster. The "population bomb" returns whenever we try to end inequality of wealth. Worse, Nathan Keyfitz has noted that population growth is occurring at such a steep rate in some countries that it seriously hinders the sorts of development that tends to slow population growth. Nathan Keyfitz, Population Growth Can Prevent the Development That Would Slow Population Growth, in Preserving the Global Environment, supra note 24, at 39.

FN172. See supra note 85 and accompanying text.

FN173. See Schelling, supra note 8, at 306; supra part II.C.3.

FN174. See Katya Jestin, International Efforts to Abate the Depletion of the Ozone Layer, 7 Geo. Int'l Envtl. L. Rev. 829 (1995).

FN175. See Cline, supra note 1.

FN176. See Beckerman, supra note 1, at 274 (noting that if no nations other than China raised GHG emissions at all, but China raised per capita emissions to half of the U.S. level, total world emissions would rise a staggering 40%).

FN177. Such international disagreements regarding means to a GHG-reduction ends are reminiscent of the domestic debates that were the subject of Bruce A. Ackerman and William T. Hassler's book, Clean Coal/Dirty Air, where pollution abatement mechanisms were chosen more on the basis of political exigencies than maximal environmental efficiency. See supra note 74.

FN178. See supra note 93 and accompanying text.

FN179. But see Schneider, supra note 8, at 299 (arguing that some geoengineering proposals, such as periodic scattering of particulate matter, require centuries-long monitoring and deployment institutions).

FN180. See infra notes 182-91 and accompanying text.

FN181. See Porter, supra note 154, at 168 (arguing that innovation in the area of pollution control often results in lowered costs and improved quality and competitiveness); Sullivan & Jordan, supra note 4, at 7 (noting that German companies, responding to tough domestic laws, now enjoy a 20% share of the three billion dollar global market for environmentally friendly technologies).

FN182. Stephen Schneider has argued for just such a treaty, given the potential of localized climate modification as "an overt or clandestine weapon." Schneider, supra note 8, at 294 (discussing W.W. Kellogg & Stephen Schneider, Climate Stabilization: For Better or For Worse?, 186 Science 1163 (1974)).

FN183. Daniel Bodansky, May We Engineer the Climate?, 33 Climatic Change 309, 309, 316 (1996) (discussing how the uncertain nature of climate engineering raises unresolved legal and political issues); see also Schneider, supra note 8, at 299 (discussing potential for political conflict resultant from geoengineering, whether or not adverse effects were actually caused by climate manipulation).

FN184. U.N. Doc. A/Conf.62/122, 21 I.L.M. 1261 (1982).

FN185. Peterson, supra note 10, at 84-90 (providing comprehensive treatments of the status of iron filing projects under the Antarctic Treaty, Canberra Convention, and Madrid Protocol); Bodansky, supra note 183, at 314-15.

FN186. See Bodansky, supra note 183, at 315.

FN187. See Peterson, supra note 10, at 79-84.

FN188. Bodansky, supra note 183, at 319; see also Schneider, supra note 32, at 777 (noting that "the prospect for international tensions resulting from any deliberate environmental modifications is staggering, and our legal instruments to deal with these tensions are immature").

FN189. Peterson suggests that obtaining an International Court of Justice (ICJ) advisory opinion on the legality of a particular geoengineering proposal might defuse potential international tensions in advance. Peterson, supra note 10, at 96-97. Of course, the ICJ frequently moves at a snail's pace itself, often more concerned with following public opinion in the international arena than with shaping it.

FN190. W. Michael Riesman, International Lawmaking: A Process of Communication, 87 Proc. Am. Soc'y Int'l L. 101 (1993).

FN191. Bodansky, supra note 183, at 309.

FN192. Aronson, supra note 1, at 2150-60.

FN193. See Schneider, supranote 8, at 291-92 (discussing plans by the Soviet Union to melt part of the Arctic ice cap and divert Soviet rivers). The practical and philosophical objections directly connected with an "un-natural" approach to climate change are discussed below in part IV.C.

FN194. See Begley, supra note 9; Nixon, supra note 9, at 17-18. Stephen Schneider notes that the negative effects of a geoengineering project gone awry may be as much political as ecological; negative environmental effects could inspire conflicts if parties blame geoengineering for the problem. Schneider, supra note 8.

FN195. See Huyghe, supra note 14 (quoting Josh Tosteson, curriculum coordinator at Biosphere 2: "Do we have the capacity intellectually to understand complex systems at the level of the globe well enough to make intelligently thought- through conscious perturbations that result in only the consequences that we want, and nothing else? My intuitive answer to that question is: No, we don't.").

FN196. NAS, supra note 1, at 59-60.

FN197. See Broad, supra note 19 (discussing dismissal of proposal of growing phytoplankton carbon sinks with iron filings before research was ever conducted). Broad quotes Russell Seitz, an associate of the Olin Center for Strategic Studies at Harvard University thus: "It's much too early to have a policy debate, [yet] despite this, the issue seems to [have] been born politi-

cized. Witness the rush to criticize the hypothesis in the early 1990s before the experiment was even done. Given the extent of our ignorance, and the stakes, I'm astonished to see polemics getting the better of science." Id. Of course, it must be noted that in this particular case, a limited experiment was conducted, with controversial results: zooplankton quickly blossomed and consumed the phytoplankton with no net positive effect on carbon dioxide levels, Nixon, supra note 9, at 19 (citing study by Richard Barber of Duke University's Environment Marine Laboratory), though subsequent experiments have yielded better results. See Broad, supra note 19 (quoting scientists as estimating 2,500 tons of CO sub2 removed from ocean during experiment); see generally Behrenfeld et al., supra note 19.

FN198. See Dickinson, supra note 11; Johnstone, supra note 21; see also supra note 20.

FN199. See, e.g., Peterson, supra note 10, at 68-79; Teller, supra note 11; see also supranote 20.

FN200. If one wanted to be more precise, it is certainly possible to factor this uncertainty into an overall risk-benefit calculation for a Climate Change Manhattan Project. If we assume, for instance, that there is a 25% chance all our research and development will not yield a productive solution (that estimate is likely quite high), one would simply multiply the benefits of a Big Fix (however much money saved and other "utility" gained by averting climate change) by a factor of .75, to account for the uncertainty. Of course, in comparing costs, one would also have to factor in the uncertainty of any legislative program--that, for example, all our carbon emissions reductions are simply not enough to avert high costs--and given that the earth's climate is such a complicated system, it seems intuitively that this uncertainty would surely rival the "skepticism factor" of the most stubborn technological pessimist. Risk and uncertainty are unavoidable no matter what regime is selected. See generally John D. Graham & Jonathan B. Wiener, Risk vs. Risk: Tradeoffs in Protecting Health and the Environment 193-225 (1995); Daniel C. Esty, What's the Risk in Risk?, 13 Yale J. on Reg. 603 (1996).

FN201. See Gillette & Krier, supra note 29.

FN202. Of course, there have been plenty of failures of "Big Science" from dirigibles to the Supersonic Transport; no project offers a guarantee of success. But the existence of some past

failures amid many past successes is insufficient reason not to try. At the very least, "climatic engineering proposals deserve further analysis and should not be dismissed out of hand." Nordhaus, supra note 7, at 44.

FN203. See Huyghe, supra note 14 (reporting concerns of geochemist Wallace Broecker).

FN204. See Gore, supra note 1, at 57-60; Dickinson, supra note 11, at 284.

FN205. Some reasons geoengineering creates such unease may be those identified by Paul Slovic in his useful study of risk-averseness. Paul Slovic, Perception of Risk, 236 Science 280, 283 (1987). Slovic identified two factors that cause disproportionate risk aversion: dread and unknowability. Geoengineering--the technology of which is unfamiliar and the scope of which is somewhat awe (or dread) inspiring--possesses both.

FN206. See supra notes 19-20.

FN207. But see Huyghe, supra note 14, (citing cost estimate for "sunscreen" proposal by Wallace Broecker of $50 billion).

FN208. See Cline, supra note 1, at 130-33 (estimating 200-year cost to U.S. alone as $335.76 billion in 1990 dollars); Nordhaus, supra note 1, at 83 (estimating $5.6 trillion total cost of unabated climate change).

FN209. See supra part III.C.2.

FN210. See Easterbrook, supra note 44; Stone, supra note 1, at 27.

FN211. See K. Eric Drexler, Engines of Creation (1986); Ed Regis, Nano: The Emerging Science of Nanotechnology, Remaking the World Molecule by Molecule (1995).

FN212. Nordhaus, supra note 1, at 49-50; Nordhaus, Count Before you Leap, supra note 12.

FN213. Recall that given developing countries' rates of population growth and drive to industrialize, any climate change regime which allows both unchecked population and unchecked industrialization in the developing world is doomed. See supra note

144.

FN214. This is Barry Commoner's "Third Law of Ecology." See Barry Commoner, The Closing Circle 41 (1971).

FN215. McKibben, supra note 1, at 47.

FN216. That humanity is a part of nature is a well-accepted tenet of environmental science (if not some Western philosophy) but should not be construed as an elision of all things humanly created (factories, paintings, etc.) with those things not humanly created (fields, canyons). This simple criterion helps avoid the slippery slope of moving from the fact that humans are part of the natural world to the curious result that nothing is more "natural" than anything else.

FN217. This particular response can justify all sorts of mischief, since it is always possible to find some human interference to supposedly justify more. The presence of an old farmhouse in the woods, for example, hardly justifies building a new shopping mall, despite the "previous interference." Surely, even as we understand that nothing in the natural world is ever "100% pure," it is possible to draw distinctions in terms of scale of human interference: a farmhouse and a shopping mall are both human interference, but the latter is of a wholly different scale from the former, as suggested in the previous footnote. In the case of climate change, the "positive" interference with natural systems caused by geoengineering ought to be no greater than the "negative" interference of anthropogenic climate change, if side-effects may be minimized. Thus the appropriate metaphor is not a bulldozer tearing up a meadow, but rather one covering up a pit dug in it. The landfill is unnatural, but only compensates for a previous condition.

FN218. Aldo Leopold, A Sand County Almanac 262 (1949).

FN219. Henry David Thoreau, Walden (1828).

FN220. See Begley, supra note 9; Changing the World, supra note 12.

FN221. Schneider, supra note 8, at 295.

FN222. Conversation with Frank Loy, Chairman of League of Conservation Voters (Dec. 1996).

FN223. See Nordhaus, supra note 46 (arguing that initial 11% reduction in GHG emissions would be relatively inexpensive).

FN224. This presents a resource allocation problem imbued with considerable uncertainty. An important justification for a Climate Change Manhattan Project is that the costs of emissions reduction are too high. Yet a hedge against the failure of geoengineering will require resources that might otherwise lead to its success. The line drawn ought to buy enough emissions reduction to protect against catastrophe while leaving resources for geoengineering that will give it a significant chance of success.

FN225. I take my subtitle from a segment of the much-missed comic strip Bloom County, which featured Opus the Penguin, about to present a "Star Wars"-style missile-defense plan at a congressional appropriations hearing, confronting a bespectacled scientist researching "Giant Laser Space Frisbees."

FN226. Cf. Schneider, supra note 8, at 299-300. Schneider's choice of metaphor is that of a heroin addict.

FN227. See Schneider, supra note 8, at 299-301 (offering an eloquent "personal perspective" on his intuitive objections to geoengineering, despite acknowledgment that the study of geoengineering is probably needed).

FN228. See generally Bill McKibben, Hope, Human and Wild 225 (1995).

FN229. See Begley, supra note 9 (quoting Jessica Tuchman Mathews of World Resources Institute, stating that "[t]echnological fixes can turn around and bite you"); Nixon, supra note 9 (discussing NRDC position against geoengineering).

FN230. The category of "deep environmentalist" is meant to include those who believe that environmental problems should be solved by addressing the problems' root causes, such as overconsumption and growth-obsession, rather than by focusing on tangible symptoms. I am using this neologism in place of "deep ecology" because the latter term, while initially a useful counterpoise to "shallow environmentalism," has come to represent a developed philosophical school with which many non-anthropocentric and holistic environmentalists disagree. See generally

Devall & Sessions, supranote 119, at 63-77; Deep Ecology Movement, supra note 119; Arne Naess, The Shallow and the Deep, Long- Range Ecology Movements: A Summary, 16 Inquiry 95, 95-100 (1973) (coining the term). Interestingly, Naess himself ceased using the term "deep ecology" in favor of "New Philosophy of Nature" because he too felt the term had become divisive and perhaps invidious. Robert Aitken Roshi, Gandhi, Dogen, and Deep Ecology, in Deep Ecology: Living as if Nature Mattered, supra note 119, at 235.

FN231. Obviously, a history of Western consumption from Thorstein Veblen's The Theory of the Leisure Class (1899) to the present is well beyond the scope of this Article. Suffice to say that the norms underlying Western patterns of GHG production are largely outside the scope of effective environmental policy as well.

FN232. Of course, parallel with the Veblenian issues in the previous footnote is the raging debate as to the autonomy of the modern subject in a world of prefabricated, commercial signs. I do not intend to suggest by my remarks here that each consumer is in control of her environment, or that consumerist environments are not manipulated by interests other than democratic social forces. Obviously, the situation is more complex. I do suggest that, absent some other means of understanding individual preference, it is presumptuous to assume that everyone would prefer to be greener than they are--and counter- democratic to act on such an assumption.

FN233. Fred Krupp, Executive Director, Environmental Defense Fund, Remarks at the Ecorealism Conference, Yale Law School (Spring 1995) (referring to criticism of his organization's activities from within the environmental community).

FN234. See John Rawls, Political Liberalism 213-54 (1993).

FN235. Such a position also justifies the environmental "sleight of hand" discussed below in part V.C, in which various ultimate goals (e.g., saving an ancient forest) are pursued, apparently disingenuously, through subversive means (e.g., litigating over spotted owls).

FN236. See James Lovelock, The Ages of Gaia: A Biography of Our Living Earth (1988); Scientists on Gaia (Stephen H. Schneider & Penelope J. Boston eds., 1991). Interestingly enough, a variant on the Gaia hypothesis has been used to cast some skepticism on

global warming: Lindzen, supra note 34, notes that the Earth's self-correcting mechanisms are likely to offset any cataclysmic effects of climate change.

FN237. Cf. Commoner, supra note 214, at 33 (Commoner's "First Law of Ecology: Everything Is Connected to Everything Else"). Commoner's basic principle is now widely accepted in "earth systems" approaches to ecology and environmental regulation. See, e.g., T.E. Graedel & Paul J. Crutzen, Atmospheric Change: An Earth System Perspective (1993).

FN238. See David A. Wirth, Public Participation in International Processes: Environmental Case Studies at the National and International Levels, 7 Colo. J. Int'l Envtl. L. & Pol'y 1 (1996). Despite the wishes of some holists to make international environmental policy the site of increased general public participation in governance, it should be noted that the two are often incompatible: after all, the more voices present in an arena, the less likely "consensus" can emerge. Perhaps along the same lines as the division of contentious issues above, it may be that the interest in participatory decisionmaking should itself be occasionally separated from the interest in environmental protection. Such a discussion remains outside the scope of this investigation.

FN239. See supra part II.B.

FN240. See supra part IV.D.

FN241. Barry Commoner has argued that using limited statutes in such a way defeats the purposes of a deeper environmentalism and subverts the goals of environmentalists. Barry Commoner, Failure of the Environmental Effort, Current History, Apr. 1992, at 176. Commoner charges that sleight-of-hand encourages piecemeal gains over wider, more systemic changes which he claims would ultimately be more productive.

FN242. Lamb's Chapel v. Center Moriches Union Free School District, 508 U.S. 384, 398 (1993) (Scalia, J., dissenting). On allegations of a credibility problem in the environmental movement, see Easterbrook, supra note 44.

FN243. Of course, this claim must be quickly attenuated: "contemporary environmentalism" is quickly becoming the province as much of Newt Gingrich and the public relations industry's Green Machine as of John Muir and Aldo Leopold. See Newt Gingrich, To

Renew America 193-200 (1995) (describing himself as an environmentalist); John C. Stauber & Sheldon Rampton, Toxic Sludge is Good for You: Lies, Damn Lies, and the Public Relations Industry 122- 42 (1996) (describing industry attempts at "greenwashing").