Given the high levels of greenhouse gases already in the atmosphere and the likelihood of growing emissions in the future, even aggressive limits on greenhouse gas emissions might ultimately fail to prevent dangerous climate disruptions. To prepare for this risk, some scientists have started to explore techniques that directly influence or control global and regional climatic systems to offset climate change effects. As climate engineering research expands, U.S. environmental law could become an important forum for efforts to control nascent climate engineering technologies. Federal and state agencies should start now to map out regulatory strategies and guidance for potential requests to authorize climate engineering experiments or to control objectionable projects.

Climate engineering will also offer an unprecedented test of the scope of federal judicial power and the institutional competence of U.S. courts to review environmental projects designed to have a literally global impact. Prior climate change tort actions have tested the ability of courts to ascribe responsibility or assign liabilities to individual parties for damages caused by widely dispersed global activities. Climate engineering presents the mirror image of climate change public nuisance actions: rather than affixing responsibility for a share of a global phenomenon, lawsuits against climate engineering projects can pursue a clearly identifiable small number of parties who expressly and intentionally attempt to create global climate effects. Federal courts in particular may need to review key doctrines (including standing, political question, redressability and proximate causation) to account for a potential role as the domestic court system of first resort for legal challenges to global environmental remediation projects.

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I. INTRODUCTION

The long-running struggle over climate change policy may ultimately fall under the shadow of a much larger concern: what if our best current strategies and legal measures to control greenhouse gas emissions and adapt to climate change, in the end, are simply not enough?

The question is becoming increasingly important. While U.S. regulatory and policy efforts have picked up new momentum, federal legislative efforts in the United States have ebbed after Congress’ failure to pass a comprehensive climate change bill. International efforts to limit GHG emissions have not yet

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1 The history of prior climate change legislative and regulatory initiatives is complex and fast-moving, and it lies beyond the scope of this article. Recent key events, however, include President Obama’s decision to focus his first Oval Office speech on the need to move away from fossil fuels and to reduce greenhouse gas (GHG) emissions through fostering renewable energy technologies. Remarks by the President to the Nation on the BP Oil Spill, June 15, 2010, http://www.whitehouse.gov/the-press-office/remarks-
achieved significant reductions in GHG emissions (or even appreciably dented the rate of increase in emissions)\(^2\) Anthropogenic GHG emissions remain at historically high levels,\(^3\) and the growing use of fossil fuels by developing economies virtually guarantees large increases in future emissions.\(^4\) Given the current lack of economically viable alternatives, petroleum will likely remain the primary source of energy for transportation for decades and will drive further

\(^2\) The sixteenth Conference of the Parties to the U.N. Framework Convention for Climate Change in Cancun, Mexico announced on December 11, 2010 a set of agreements that outlined voluntary commitments to provide financing for green energy development and to reduce GHG emissions. The Cancun agreements do not address any plans or strategy to continue the binding emission limits of the Kyoto Accords, which are set to expire in 2012. *Cancun Climate Outcome 'Consistent with U.S. Objectives*, ENVIRONMENTAL NEWS SERVICE (Dec. 14, 2010) http://www.ens-newswire.com/ens/dec2010/2010-12-14-02.html. Similarly, the parties at the fifteenth Conference of the Parties in 2009 in Copenhagen failed to reach any binding agreement that would significantly limit future GHG emissions. A small subgroup (including the United States, China and India) instead agreed to examine steps to limit the rate of future growth of GHG emissions, and the remaining body of delegates desultorily “took notice” of the new Copenhagen Accords. UNFCC, *Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009. Addendum, Part Two: Action taken by the Conference of the Parties at its fifteenth session* at p. 4 (March 30, 2010). See also J. Broder, *Climate Goal is Supported by China and India*, THE NEW YORK TIMES at p. A9 (March 10, 2010). More importantly, some initial assessments of the Cancun Agreement have concluded that it did not include sufficient emission reduction pledges to keep global temperature increases below a target of 2.0 degrees C or less. C. Chen *et al*, *CANCUN CLIMATE TALKS – KEEPING OPTIONS OPEN TO CLOSE THE GAP*, Climate Action Tracking briefing paper at p. 2 (Dec. 11, 2010).


significant GHG emissions.\(^5\) And even if these accelerating GHG sources could be slowed, the atmosphere has already received sufficient anthropogenic GHGs to assure that climate change effects will grow during the next century or even accelerate as self-reinforcing warming processes take root.\(^6\) The risk of self-reinforcing feedback processes has also heightened concerns over abrupt and disruptive climate change.\(^7\)

Against this pessimistic backdrop, some scientists have begun to seriously study direct actions to modify the Earth’s climate in ways that would offset anthropogenic global warming. These strategies include releasing sulfur dioxide aerosols into the upper stratosphere to reflect solar radiation back into space, enhancing the reflectivity of clouds in the polar oceans, constructing and distributing millions of mechanical units to filter ambient air and remove carbon dioxide (CO\(_2\)), reflective satellites to control solar radiation reaching the earth’s surface, and seeding oceans with iron to enhance phytoplankton growth and draw large quantities of CO\(_2\) out of the atmosphere. These ideas, collectively labeled “climate engineering” or “geoengineering,”\(^8\) are polarizing and controversial, but their rapid emergence as "Plan B" for climate change strategies will ultimately put federal and state environmental laws squarely in the middle of contentious

\(^{5}\) Oil demand for transportation is the largest growth segment of total oil demand, and by 2030 oil demand in developing countries will exceed that in countries in the Organization of Economically Developed Countries. J. Weaver, *The Traditional Petroleum-Based Economy: An “Eventful” Future*, 36 CUMBERLAND L. REV. 505, 528 (2006) (discussing energy use projections by major energy corporations and U.S. agencies).

\(^{6}\) For example, some scientists have argued that arboreal soils and permafrost may release large amounts of CO\(_2\) as they thaw in a warming climate. Such soils contain significantly more carbon than the amount of CO\(_2\) already in the atmosphere. As a result, those increased CO\(_2\) emissions may in turn magnify climate change effects and enhance ambient temperature increases, which would then accelerate continuing CO\(_2\) emissions from the soils. See, e.g., E. Davidson and I. Janssens, *Temperature Sensitivity of Soil Carbon Decomposition and Feedbacks to Climate Change*, NATURE at p.165 (March 9, 2006), doi:10.1038/nature04514.

\(^{7}\) Some climatologists have concluded that geologic records show that Earth’s climate can change significantly and abruptly over a time span as short as ten years. Under this model, Earth’s climatic system can shift quickly and unpredictably from one stable state into another without gradual or cumulative changes. For example, if increased levels of fresh water in the North Atlantic lead to a disruption or cessation of the Gulf Stream component of the ocean currents that convey warmer waters toward northern Europe and Africa, those regions could see dramatic drops in temperatures and changes in precipitation over a short time span. R. Gagosian, President of Woods Hole Oceanic Institution, *Abrupt Climate Change: Should We Be Worried?*, presentation to Davos Summit on Feb. 10, 2003 (updated July 6, 2010), located at http://www.whoi.edu/page.do?cid=9986&pid=12455&tid=282; W. Broecker, *Thermohaline Circulation, the Achilles’ Heel of Our Climate System: Will Man-Made CO\(_2\) Upset the Current Balance?*, 278 SCIENCE 1582, 1584 (Nov. 28, 1997). The U.S. National Academy Sciences noted in 2002 that available evidence suggests that abrupt climate changes are not only possible but likely in the future, potentially with large impacts on ecosystems and societies.” U.S. National Academy of Sciences, National Research Council on Abrupt Climate Change, *ABRUPT CLIMATE CHANGE: INEVITABLE SURPRISES* at p. 18 (National Academy Press 2002).

\(^{8}\) In keeping with the developing trend, this article uses the term “climate engineering” instead of “geoengineering.” The term “geoengineering” can also apply to large-scale earth moving operations, and some groups have begun to use “climate engineering” as a clearer term. Chairman Bart Gordon, H. Comm. on Science and Technology, 111TH Cong., *Engineering the Climate: Research and Strategies for International Coordination* at p. 13 (Comm. Print 2010); J. Shepherd, *GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY* at p. 30 (The U.K. Royal Society)
fundamental disputes over the future direction of U.S. and global climate change policy.

If climate engineering someday becomes a component of U.S. and global climate change policy, U.S. environmental laws will almost certainly be used to attack demonstrations of climate engineering technologies conducted by U.S. corporations and citizens, or which occur in territories or airspace under U.S. jurisdiction. Advocates have frequently turned to U.S. environmental laws to slow or stop the implementation of arguably risky or unexamined technologies. For example, opponents used U.S. environmental laws to challenge the deployment of genetically modified organisms into the environment, the distribution of nanomaterials into the workplace and commerce, and the siting of certain renewable energy technologies. In each of these cases, and many more like them, environmental laws were used to slow adoption of new technologies. Ironically, if climate engineering proves an essential component of federal climate change policy to control or minimize climatic disruptions, environmental law may play an instrumental role in limiting options available to address one of the most daunting environmental challenges of our time.

If existing U.S. environmental laws become the initial battleground for disputes over climate engineering research and test projects, those fights may yield surprises for litigants on both sides. On one hand, U.S. environmental laws could extend an unexpectedly long and broad reach over novel climate engineering technologies. The federal courts have allowed administrative agencies, including the U.S. Environmental Protection Agency (EPA), a considerable degree of flexibility and freedom to interpret current statutes to cover emerging environmental threats and concerns. Beyond this statutory malleability, the federal judiciary may provide a more hospitable forum for climate engineering litigation than it has offered to climate change tort claims under federal common law. Climate engineering litigation can sidestep some of the jurisprudential traps that have waylaid other climate change courtroom initiatives by presenting a reversed image of earlier climate change public nuisance lawsuits.

As a result, climate engineering litigation may provide an unexpected opportunity for U.S. courts to clarify threshold issues on the judicial branch’s ability to hear lawsuits over global climate change. While federal climate change nuisance lawsuits have garnered the most immediate attention, legal battles over climate engineering projects may ultimately offer a faster, clearer, and more compelling avenue for the U.S. courts to define their role in the developing law of climate change control and liability.

This article examines how U.S. environmental laws might apply to climate engineering research and how the U.S. courts would review disputes over those projects. Part I surveys the development and background of climate change policy

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and explains how climate engineering fits into that structure. Part II outlines specific technologies and techniques used in climate engineering. The attributes of climate engineering itself will define the likely parties involved in future legal actions as well as the likely initial strategies and approaches to these legal issues. Part III of the article examines how such challenges might avoid, or fall prey to, roadblocks that have impeded efforts to bring environmental lawsuits targeting governmental or private entities for their contributions to global climate change effects. Part IV points out how this new type of environmental litigation may provide an opportunity for U.S. courts to address climate change issues in a context better suited to their institutional role and limits, and offers suggestions on how the federal government might best respond to these challenges as a result.

II. CURRENT CLIMATE CHANGE LEGAL STRATEGIES: CONTROLLING EMISSIONS AND MITIGATING DAMAGES

Existing international and U.S. regulatory strategies to mitigate climate change (with some important exceptions) focus largely on either mitigation or adaptation. These approaches generally seek to limit future climate disruption by either reducing current or future emissions of GHGs through regulatory controls, incentives and sequestration activities, or by helping societies or ecosystems to adapt to an environment with higher temperatures. From the U.N. Framework Convention on Climate Change through the Kyoto Protocol to the Cancun Agreement, almost every international agreement has incorporated these two approaches. While the UNFCC and its implementing instruments also offer other compliance options that would arguably reduce ambient GHG levels through afforestation or agricultural activities, these alternatives generally concentrate on generating credits or allowances that can

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10 Mitigation strategies focus on reducing or modifying activities that lead to anthropogenic GHG emissions primarily by reducing current and future emissions. United Nations, Annex II. Glossary of Terms, IPCC FOURTH ASSESSMENT REPORT at p. 76 (Alfons P.M. Baede, ed., 2007).

11 Adaptation strategies focus on modifying human societies and ecosystems to exist under higher temperature climates without attempting to minimize those temperature changes. For a survey of potential mitigation strategies that large urban centers may use to deal with higher temperatures, see M. Kahn, CLIMATOPOLIS: HOW OUR CITIES WILL THRIVE IN THE HOTTER FUTURE (Basic Books, N.Y. 2010).

12 UNFCC, Annex II. Glossary of Terms, IPCC FOURTH ASSESSMENT REPORT at pp. 76 and 94 (Alfons P.M. Baede, ed., 2007).


14 UNFCC, KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (1998).

offset GHG emissions from other activities. Individual efforts by other nations primarily adopt mitigation and adaptation techniques as well.

U.S. legislative initiatives and state programs have likewise focused primarily on mitigation and adaptation. For example, both the Regional Greenhouse Gas Initiative (RGGI) and California's A.B.32 statutory program establish cap-and-trade programs that seek to limit future emissions of carbon dioxide and other greenhouse gases and thereby reduce the growing amount of greenhouse gases in the atmosphere. While this generalization admittedly excludes some projects that actively remove greenhouse gases from the atmosphere (for example, carbon sequestration through afforestation), the majority of climate change mitigation strategies focus on either reducing the flow of gases into the atmosphere or planning to adapt to an altered global climate.

But a growing group of researchers note efforts to curb current and future GHG emissions may not be sufficient to keep the amount of GHGs in the atmosphere below a critical threshold. They base their concerns on the physical properties of some GHGs and the sheer volume of GHGs already in the atmosphere. One estimate of the longevity of atmospheric CO₂ perturbations concluded that the atmosphere would still retain 40 percent of its peak CO₂ concentration enhancement over preindustrial values as a quasi-equilibrium state even after 1,000 years. The decay rate of the remaining CO₂ would fall to even slower rates for years after the 1,000-year mark. While pre-industrial concentrations of carbon dioxide in the atmosphere were approximately 280 ppm, the existing atmospheric loads of CO₂ would approach 352 ppm even if all industrial activities halted immediately. This CO₂ burden will not cycle out of

16 The mechanisms under the Kyoto Protocol are emissions trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI). Article 17 of the Kyoto Protocol governs emissions trading. Article 12 defines CDM, which allows an Annex B party under the Protocol to implement an emission-reducing program in a developing country and thereby earn certified emission reduction credits equal to one ton of carbon dioxide. Joint Implementation falls under Article 6 and allows an Annex B party to earn emission reduction units from emission-reducing or emission removal projects in other Annex B countries. For more information, see The Mechanisms under the Kyoto Protocol: Emissions Trading, the Clean Development Mechanism, and Joint Implementation at http://unfccc.int/kyoto_protocol/mechanisms/items/1673.php.

17 Brazil, for example, has used a mixture of energy efficiency, renewable electricity, cogeneration, and bio-fuels to reduce the country's annual emissions by 10 percent. Pew Center on Global Climate Change, Climate Change Mitigation in Developing Countries: Brazil, China, India, Mexico, South Africa, and Turkey (2002). The study also notes that deforestation in Brazil is a major contributor to climate change, and the government has done very little to abate that problem.


20 Id.
the atmosphere for several hundred years.\footnote{S. Solomon et al., Irreversible climate change due to carbon dioxide emissions, 106 PNAS 1704, 1705 (Feb. 10, 2009) at www.pnas.org/cgi/doi/10.1073/pnas.0812721106 . While emissions of other GHGs such as methane or nitrous oxides can affect climate change over a time period of decades or centuries, they do not persist in the atmosphere on the same timescales as CO\textsubscript{2}. Id. See also Forster, P. et al, Changes in atmospheric constituents and in radiative forcing, in CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, eds Solomon, S. et al (Cambridge University, Cambridge, UK, and New York), pp. 747-845 (2007).} In effect, significant climate changes due to elevated ambient GHG levels may have already happened – we are simply waiting for the full ramifications of changes that prior activities have already begun. The risk of self-reinforcing processes that release GHGs and the prospect of abrupt climate change have only heightened these concerns.

Given these daunting challenges, some engineers and scientists began to call for strategies to directly alter climate change processes. The idea of this type of climate engineering is not new. The advent of advanced weather radar systems after World War II put the practice of planet-wide climate modification within reach. In a well-publicized and controversial early climate engineering effort, General Electric attempted to modify the strength and path of an Atlantic hurricane. Known as “Project Cirrus,” the effort apparently succeeded in changing the path of the storm and drove it out to sea before it would have made landfall on the east coast of Florida. Unfortunately, the new path led the storm toward the Georgia coast where it inflicted serious damage.\footnote{General Electric Research Laboratory, History of Project Cirrus: Compiled by Barrington S. Havens, Report RL-758 (July 1962). A high-resolution PDF copy of the original GE report is available at http://www.archive.org/details/historyofproject00have.} GE abandoned its hurricane program, but discussions of climate engineering continued to circulate through the climate and science community since the 1960s, and several different framework concepts have already been published for review.\footnote{For an illuminating review of the colorful prior attempts to modify the weather, see J. Fleming, FIXING THE SKY: THE CHECKERED HISTORY OF WEATHER AND CLIMATE CONTROL (Columbia University Press, N.Y. 2010). For a survey of existing weather modification law, see the work of the late Professor Ray Jay Davis who was the recognized expert in weather modification law. For a list of federal and state laws governing weather modification as well as a bibliography of other works, see R. Davis, Real Property Issues in Weather Control, in 8-71 THOMPSON ON REAL PROPERTY § 71.06.}

Climate engineering and other adaptation strategies have historically drawn opposition out of concerns that they would simply distract popular attention and political will away from needed GHG emission control strategies.\footnote{See, e.g., J. Goodell, HOW TO COOL THE PLANET: CLIMATE ENGINEERING AND THE AUDACIOUS QUEST TO FIX THE EARTH’S CLIMATE (Houghton Mifflin Harcourt, Boston/New York 2010) at p. 13 (“[a]lthough the dream of manipulating the weather is almost as old as civilization itself, the idea of studying ways of deploying technology to manage the earth’s climate was seen by some scientists as politically incorrect, dangerous, or just downright silly”).} That resistance shifted significantly in 2006. After long reluctance to seriously scrutinize climate engineering strategies, several climate scientists stepped forward to urge new efforts to actively study these alternatives as a fallback strategy to control climate change if current greenhouse gas emission control
strategies failed. In particular, Paul Crutzen – a Nobel Prize laureate for atmospheric science studies – published a keynote paper that assessed the possibility of releasing aerosol particles into the upper atmosphere to reduce the amount of sunlight reaching the earth's surface. Crutzen’s paper concluded that this strategy could yield substantial temperature reductions on a global scale, but it also pointed out large areas of uncertainty and highlighted undesirable effects that this strategy might cause. For example, he noted that these techniques would not reduce damages due to increased rain acidification or answer the unchecked acidification of ocean waters.

After the Harvard symposium, the discussion of climate engineering proposals has steadily grown in scientific journals and spilled over into more mainstream sources and policy considerations. Most reports call for research and studies, but not for immediate action. The British Royal Society released a comprehensive study of climate engineering options that highlighted major likely technologies and concluded “further research and development of climate engineering options should be undertaken to investigate whether low risk methods can be made available if it becomes necessary to reduce the rate of warming this century.” That sentiment is also seen in proposed legislative and policy changes such as the IPCC’s plans to convene meetings in June 2011 to consider the scientific basis for climate engineering as well as its costs and impacts. Additionally, Congress has called multiple committee hearings and announced a policy of encouraging research on the topic. Most recently, the House Committee on Science and Technology held hearings to assess the implications of what committee members called “large-scale climate intervention.”

The burst of interest in climate engineering has already sparked efforts to limit research and demonstration projects. Most of the early attention has focused on ocean fertilization experiments because over 20 experiments have already


occurred on the high seas. One particular proposal by Planktos, Inc., a commercial venture group seeking to generate tradable carbon credits, created controversy because it would have released 100 tons of iron ore dust into the Pacific Ocean near the Galapagos Islands in August 2007. The experiment aimed to investigate marine phytoplankton blooms as a potential tool to sequester CO$_2$ in deep waters. After strong environmentalist opposition (including a permanent patrol vessel by Greenpeace to intercept and halt any attempt by Planktos to release the iron), Planktos abandoned the project in February 2008.

In response to the controversy, EPA notified Planktos that the iron seeding might require a permit under the Marine Protection, Research and Sanctuaries Act. The United States also submitted a statement of concern to the parties to the London Convention. A committee of the International Marine Organization then adopted a resolution that included a “scientific statement of concern” and called for a halt to ocean fertilization projects unless they constituted legitimate scientific research. The Convention subsequently adopted another resolution containing an assessment framework for scientific research into ocean fertilization. These resolutions, in effect, declared that the Convention parties prohibited ocean fertilization projects conducted for commercial or non-scientific purposes, and even scientific research could proceed only on a case-by-case basis.

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32 EPA notified Planktos that MPRSA might apply to the experiment if it took place in waters under U.S. jurisdiction or if Planktos undertook the project from a U.S. flagged vessel. Planktos responded that it would not use a U.S. flagged vessel for the experiment. See discussion infra at n. 61 of potential MPRSA requirements for climate engineering projects.


The Convention intends to promulgate regulations governing ocean fertilization research by 2012.\textsuperscript{36}

Other governmental entities have taken action as well. In 2009, the German federal government ordered a team of researchers from the Alfred Wegener Institute Polar and Marine Research to halt a test of iron seeding in the Southern Ocean in response to complaints that the iron releases constituted prohibited marine pollution.\textsuperscript{37} Although the German government quickly withdrew its order, legal opposition to climate engineering projects has escalated. Most notably, the latest Conference of Parties to the Convention on Biological Diversity adopted a resolution that called for a limited moratorium on climate engineering activities “until there is an adequate scientific basis on which to justify such activities.”\textsuperscript{38} Other advocacy groups have actively advocated a moratorium on further climate engineering research at both international conferences\textsuperscript{39} and in independent policy statements.\textsuperscript{40}

Despite calls for a moratorium on climate engineering research, the comparatively low research costs have enticed private investors to take initial steps into the field. For example, Bill Gates has funded more than $4.5 million worth of research into reducing the amount of GHGs in the atmosphere through adaptation measures and climate engineering. In 2010, Gates was part of a group providing funds to a Silicon Valley inventor’s plan to enhance the whiteness of clouds in order to reflect solar radiation.\textsuperscript{41} Additionally, private companies such as


\textsuperscript{37} Who Ate All the Algae? Using Phytoplankton to Capture CO\textsubscript{2} Hits a Snag, THE ECONOMIST (March 26, 2009) at http://www.economist.com/node/13361464 (last checked on Nov. 20, 2010).

\textsuperscript{38} Conference of the Parties to the Convention on Biological Diversity, Biodiversity and Climate Change: Draft decision submitted by the Chair of Working Group I (Oct. 29, 2010). The original draft text included language that might have supported a blanket ban on climate engineering research projects, but the final text limited the prohibition to climate engineering projects that might impact biodiversity and which lacked transparent and effective governance mechanisms. The final language also included important exceptions for small scale scientific research and includes a working definition of “geoengineering.” Biodiversity and Climate Change, Draft Decision Submitted by Chair of Working Group I, UNEP/CBD/COP/10/L.36 at 8(w), 9(o), 9(p) (Oct. 29, 2010).

\textsuperscript{39} Hands Off Mother Earth! Civil Society Groups Announce New Global Campaign Against Geoengineering Tests, (April 21, 2010) (over 60 civil society groups announced a joint campaign to oppose climate engineering tests), last verified on Nov. 20, 2010.

\textsuperscript{40} See, e.g., Etc Group, GEOPIRACY: THE CASE AGAINST GEOENGINEERING at pp. 39-40 (Oct. 2010), available at http://www.etcgroup.org/en/node/5217 (last verified on Nov. 20, 2010) (calling for ban on climate engineering research until governance framework in place). Numerous other groups have called for the establishment of a governance structure before significant additional climate engineering research takes place. See, e.g., the World Academy of Art & Science has published an initial study arguing for the creation of international conventions to control and regulate geoengineering projects on an international scale.

as Climos have formed to attract capital and to conduct research outside the realm of public subsidies or public policy statements. If climate engineering projects ultimately yield tradable credits for reductions in GHG emissions, private investors will have even stronger incentives to become more actively involved in climate engineering research and projects.


III: THE NEXT STEP: POSSIBLE CLIMATE ENGINEERING STRATEGIES

Several possible engineering strategies have surfaced to address global climate change effects. Surprisingly, initial evaluations of some of these strategies show that they might significantly reduce climate change effects caused by current GHG levels in the atmosphere. Each of these techniques, however, poses unique risks and areas of concern where more research and information will be needed.

Controversy has already emerged over the definitions of “climate intervention” or “geoengineering.” These disagreements arise largely from the fact that the definition of these terms could exclude some technologies from any future regulatory framework or treaty governing climate engineering. For example, some definitions would exclude techniques such as biochar management, carbon capture and sequestration, and albedo enhancement through white roofs and more reflective vegetation. Most definitions, however, include three common elements:

- the intentional intervention or manipulation
- of environmental systems, including systems related to climate
- to reduce or offset the effects of anthropogenic global warming.

The technologies described below contain each of these concepts. This article will focus on technologies that, by consensus, squarely fall within the definition of climate engineering, but many of the legal issues raised below will also apply to techniques that might lie outside some definitions of the term.

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42 Scant information is available regarding these companies, but for more information on Climos’s funding and business model, see [http://www.climos.com/faq.php#9](http://www.climos.com/faq.php#9).

43 As noted above, some entrepreneurs have already undertaken ocean iron seeding projects in hope of generating tradable carbon emission credits for profit. Other entrepreneurs will undoubtedly view climate engineering as a set of valuable marketable technical skills that they can provide governments or individuals who wish to respond to or forestall climate events. Notably, at least one proposed amendment to the American Clean Energy and Security Act of 2009 specifically excluded ocean fertilization projects from the definition of CO2 “sequestration” that would receive funding and tax credits. This amendment is available at [http://www.rules.house.gov/111/SpecialRules/hr2998/waxman1_hr2998_111.pdf](http://www.rules.house.gov/111/SpecialRules/hr2998/waxman1_hr2998_111.pdf).

44 Some definitions of “climate engineering” or “geoengineering” would exclude capture of GHGs in biochar, enhancement of planetary albedo through widespread planting of highly reflective plants, or dispersal of genetically modified organisms engineered to withdraw large amounts of GHGs. R. Lal, *Sequestering Atmospheric Carbon Dioxide*, 28 CRIT. REV. PLANT SCI. 3, at pp. 90 (2009); D. Keith,
Most proposed climate engineering strategies seek either to remediate existing high stores of CO₂ in the ambient atmosphere, or to intervene directly in climatic processes that generate global warming. For example, one category of climate engineering would modify the amount of solar radiation that reaches the Earth’s surface (solar radiation management, or SRM). By contrast, other technologies spur uptake of GHG by marine, geological or arboreal biological sources or by mechanical devices to remove or directly reduce existing stocks of GHG in the atmosphere (carbon dioxide removal, or CDR). While SRM technologies tend to attract the most concern and legal attention (for reasons discussed below), even CDR technologies can pose nettlesome policy and legal issues. For example, the use of CDR may significantly affect delicate ecosystems where the technology is deployed.\footnote{For example, large scale iron seeding to enhance algal blooms may deplete levels of oxygen in the water column or promote the production of algal toxins. Large scale CO₂ capture devices may also generate large volumes of calcium carbonate waste streams and possibly create waste disposal issues. H. Herzog, \textit{Assessing the Feasibility of Capturing CO₂ from the Air} (2003); D. Alvarez, \textit{Behavior of Different Calcium-Based Sorbents in a Calcination/Carbonation Cycle for CO₂ Capture}, 21 \textit{ENERGY FUELS} 1534, 1540 (2007); C. Tricka, \textit{Iron enrichment stimulates toxic diatom production in high-nitrate, low-chlorophyll areas}, 107 \textit{PNAS} 5887, at p. 5889 (2010); A. Miller, et al., \textit{Global Change and Oceanic Primary Productivity: Effects of Ocean-Atmosphere-Biological Feedbacks in 73 Global Climate Change and Response of Carbon Cycle in the Equatorial Pacific and Indian Oceans and Adjacent Landmasses} 473 (2007).}

With this division in mind, some of the most imminently feasible climate engineering approaches would include the following methods:

\textit{Reducing Solar Influx}. Much of the initial scientific scrutiny and concern has centered on techniques that directly reduce the amount of sunlight reaching the earth’s surface. Several different techniques can achieve this goal. In particular, Crutzen’s proposal would use the dispersal of sulfate aerosol particles in the upper troposphere to scatter and reflect sunlight back into space. According to his calculations, this approach can yield significant reductions in surface global temperatures on a wide scale for a comparatively small cost of $25 to $50 billion annually.\footnote{\textit{Id.} at 213 (to counteract global warming effects, the project would need to inject one to two teragrams of sulfur particles into the stratosphere each year; such an effort would cost $25 to $50 billion annually). Estimates of the cost of unabated climate change damages are notoriously difficult and controversial. \textit{See}, e.g., N. Stern, \textit{Stern Review on the Economics of Climate Change} (Cambridge University Press, Cambridge, UK 2006). By comparison, however, one study estimates that the State of Alaska alone will face costs of up to $10 billion over the next few decades to address damage to its infrastructure caused by rising global temperatures. P. Larsen and S. Goldsmith, \textit{Estimating Future Costs for Alaska Public Infrastructure At Risk from Climate Change}, Institute of Social and Economic Research (University of Alaska Anchorage June 2007), available at \url{www.iser.uaa.alaska.edu/publications/JuneICICLE.pdf}.} Other proposals would involve the use of space based reflective particles
or mirrors placed in low or geostationary orbit to directly scatter sunlight before it reaches the Earth’s atmosphere.

*Enhance Production of High-Albedo Cloud and Surface Cover.* Because certain types of clouds also reflect a significant percentage of sunlight back into space, several proposals have focused on using seeding techniques to generate wide swaths of cloud cover over ocean areas. These techniques rely on recent scientific data showing that boat and jet contrails can be surprisingly effective at generating persistent high-level cloud formation. Under these proposals, autonomous sailing craft equipped with solar-powered engines would pump seawater to create a fine mist that they would disperse above sea level. In theory, these mists would have the ability to seed subsequent cloud formations.47

*Increase Formation of Sea Ice.* To halt or reverse the rapid shrinkage of polar ice caps and sea-based ice shelves, several scientists have proposed the use of sea-based snow projection for ice manufacturing that would seed additional production of ice at polar latitudes. This approach, which would also rely on tidal or solar power to generate the ice, would theoretically need sufficient sea ice to create an enhanced albedo that would reflect sunlight back into space and reduce surface temperatures. As a result, the new ice would arguably enhance a cascade effect leading to greater natural sea ice production.48

*Direct CO₂ Sequestration Through Ocean Seeding.* One frequently discussed method of climate engineering is the addition of trace elements such as iron to certain portions of the ocean to enhance blooms of algae.49 Because certain portions of the ocean ecosystem are limited by the scarce amounts of iron, even a comparatively small addition of distributed iron particles can lead to a burst of phytoplankton growth that can directly absorb CO₂ from the atmosphere directly above the ocean's surface. In theory, the phytoplankton would then die and precipitate downward with

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48 *Lift Off: Research into the possibility of engineering a better climate is progressing at an impressive rate—and meeting strong opposition,* The Economist, November 4, 2010 at http://www.economist.com/node/17414216.

49 As noted above, the Alfred Wegener Institute in Germany planned to conduct an iron seeding experiment in 2009. See *supra* at n.36. The research ship was loaded with 20 tons of iron and ready to sail when the German government ordered them to stop and conduct further research before attempting the experiment. Q. Schiermeier, *Ocean fertilization experiment suspended,* NatureNews, January 14, 2009, http://www.nature.com/news/2009/090114/full/news.2009.26.html.
CO₂ locked in their body mass. At the ocean floor, the phytoplankton would then be sequestered on a long-term basis.⁵⁰ According to some studies, this process has already begun on a natural basis due to releases of particulate iron from receding glaciers that have enhanced polar phytoplankton blooms. Recent proposals have noted that iron fertilization of the ocean can also have substantial regional effects on wind patterns and the albedo of clouds affected by the release of sulfates from the enhanced phytoplankton growth.⁵¹

**Marine Heat Transfer.** Many of the most problematic climate change effects arise from higher ocean surface temperatures. For example, some climate models show that a broader difference between ocean surface temperatures and ambient air temperatures may lead to the formation of stronger and potentially more destructive hurricanes.⁵² Ocean temperatures at deeper levels, however, remain much less affected by higher ambient air temperatures or surface solar radiation. As a result, some researchers have suggested that ocean heat pumps could moderate these climate effects by exchanging cooler deep marine waters with warmer surface waters. These ocean heat pumps would consist of a large number of floating columns that would rely on the energy of wave motions to transport cooler water to the surface. Some models show that a significant number of these floating heat exchangers could arguably reduce ocean surface temperatures over a broad area and potentially mitigate processes that might exacerbate the risk of more severe hurricanes.⁵³

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⁵⁰ One common criticism of ocean fertilization experiments (and, indeed, of climate engineering approaches in general) is that they do not address other serious consequences of elevated ambient CO₂ levels. For example, heightened CO₂ levels have contributed to growing acidification of ocean waters. Some researchers have suggested that some technologies could directly reduce ocean acidification on at least a regional level. K. House, et al., *Electrochemical acceleration of chemical weathering as an energetically feasible approach to mitigating anthropogenic climate change*, 41 ENVT. SCI. & TECH. 8464 (2007), doi 10.1021/es0701816. While these additional large-scale projects also likely qualify as climate engineering, this article will focus instead on projects directly aimed at either SRM or CDM.


⁵² K. Trenberth, *Warmer Oceans, Stronger Hurricanes*, SCIENTIFIC AMER. at 44, (July 2007). Prof. Kerry Emanuel from MIT was one of the first to publish research connecting these areas, and in 2008 Prof. Emanuel released new findings further supporting his 2005 research. For an interview with Prof. Emanuel on this topic, see *Exploring the Links Between Hurricanes and Ocean Warming*, YALE ENVIRONMENT 360, Sept. 15, 2010, [http://e360.yale.edu/feature/exploring_the_links_between_hurricanes_and_ocean_warming/2318/](http://e360.yale.edu/feature/exploring_the_links_between_hurricanes_and_ocean_warming/2318/).

⁵³ Royal Society Study, *supra* n.28 at 19.
Direct Air Capture. Another proposed strategy would tackle ambient CO₂ levels in a direct fashion by using a large number of mechanical devices to “scrub” the CO₂ out of the air. This approach, if adopted on a large scale, would use liquid or dry sorbents to capture CO₂ (typically in a carbonate), chemically release the CO₂ in a subsequent step, and then reuse the restored sorbent to collect more CO₂. The captured CO₂ could either be sold for commercial use or geologically sequestered. Under these scenarios, the global deployment of 10 million CO₂ capture units could theoretically reduce ambient CO₂ levels by five parts per million per year, and the projected costs could drop to $30 per ton of CO₂ captured.⁵⁴ If it proves cost-effective, this technology could reduce ambient CO₂ levels with fewer side effects than other potential climate engineering techniques.

As climate engineering studies continue to refine potential methods and techniques, some of the strategies above may undergo significant revisions. For example, one suggested modification would use precisely engineered nanoparticles in place of sulfate aerosols to scatter sunlight from the upper atmosphere back into space. The proposal notes that these particles could remain in the upper stratosphere for a much longer time than sulfate aerosols, and the nanoparticles can be engineered to cause them to aggregate in polar regions.⁵⁵ This type of regional climate engineering may offer an important step in protecting the environments facing the highest risks (such as the polar ice caps and the Great Barrier Reef), but regional SRM climate engineering efforts may pose especially high risks of weather disruption and governance challenges.⁵⁶

While the field obviously remains in its infancy, several striking characteristics of these various climate engineering techniques may affect future assessments of their legal status. First, all of these techniques offer the prospect of immediate and short-term moderation of climate change effects. This benefit, however, comes with a high degree of uncertainty about other potential costs and damages. For example, proposals to reduce solar influx through troposphere

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⁵⁴ K. Lackner, Washing Carbon Out of the Air, SCIENTIFIC AMERICAN at p. 65 (June 2010); D. Keith et al, Climate Strategy with CO₂ Capture From the Air, 74 CLIMATIC CHANGE 17-45 (Jan. 2006)


⁵⁷ Staff of House of Representatives Committee on Science and Technology, 111th Cong. Report on Geoengineering: Assessing the Implications of a Large Scale Climate Intervention Hearing (Comm. Print 2009) (testimony by Dr. Shepherd of the Royal Society that “[i]t would . . . be generally undesirable to attempt to localize SRM methods, because any localized radiative forcing would need to be proportionally larger to achieve the same global effect, and this is likely to induce modifications to normal spatial patterns of weather systems including winds, clouds, precipitation and ocean currents and upwelling patterns” ).
distribution of aerosols have raised concerns that aerosol distribution might alter regional precipitation patterns, could delay recovery of the ozone layer and thereby increase skin cancer rates, will not address - or in fact may enhance - ocean acidification, might increase risk of damage to aircraft engines, and may cause particulates to precipitate onto surface environments in ways that affect human or ecological systems.58

The second notable common effect of these climate engineering approaches is that they can be performed unilaterally. As opposed to global emission control conventions that require participation from all of the significant players to yield any material effects, a single nation or even large corporation may have the resources to undertake one or many of these climate engineering projects. The cost of an aerosol distribution project could easily fall within the scope of a single nation's resources.59

Third, every one of these climate engineering techniques will likely spark strong and impassioned opposition from potentially affected individuals and interest groups. Because of the large unknowns associated with each of these techniques and the risk of unintentional damages that they pose, several environmental advocacy groups have already soundly denounced any approach that would use climate engineering.60 Other groups and governments have opposed the use of climate engineering projects, or even investigations into their soundness, because they might detract from efforts to reduce ongoing emissions into the atmosphere. This opposition will likely only grow if concerns that large greenhouse gas levels already in the atmosphere may lead to cataclysmic climate change because even comparatively small amounts of change to the atmosphere's composition may have large, unpredictable or chaotic effects on surface climate. In other words, while abrupt climate change might give climate engineering projects a sense of urgency, it also creates a risk of unexpected catastrophic effects.

58 See, e.g., V. Borvkin et al., Geoengineering climate by stratospheric sulfur injections: Earth system vulnerability to technological failure, CLIMATIC CHANGE at 255 (June 19, 2008) (DOI 10.1007/s10584-008-9490-1, available at Springerlink.com) (concluding that “stratospheric sulfur injections might be a feasible emergency solution for cooling the planet,” but the injections would have to continue “for millennia unless future generations find a secure way to remove CO₂ from the atmosphere.” The authors also point out that “[a] critical consequence of climate climate engineering is a possibility of extremely rapid warming in case the emissions are abruptly interrupted” leading to warming in polar regions that could exceed 10 degrees Celsius within a few decades).

59 This prospect of unilateral climate engineering efforts by a major national power has already surfaced. In November 2005, the head of the Russian Global Climate and Energy Institute (and former vice-chair of the IPCC) urged Russian President Vladimir Putin that Russia should immediately release 600,000 tons of sulfur aerosol particles into the atmosphere. C. Brahic, Hacking the Planet: The Only Climate Solution Left?, 2697 NEW SCIENTIST 8, 10 (April 9, 2009), available at http://www.newscientist.com/article/mg20126973.600-hacking-the-planet-the-only-climate-solution-left.html

IV. LEGAL PRINCIPLES FOR CLIMATE ENGINEERING DISPUTES

Most of the nascent legal challenges to climate engineering projects have focused on using existing international legal regimes to oppose or control test programs or demonstration efforts. This initial orientation appropriately reflects the global consequences of climate change issues and the planned fora for climate engineering experiments, such as in polar environments or on the high seas. The UNFCCC Conference of the Parties in Cancun, Mexico saw efforts to persuade delegates to begin initial discussions over the regulation of climate engineering approaches and define the coalitions on either side of the suits, but the modest climate agreement from the conference did not expressly discuss this issue.\(^{61}\)

A. Potential Challenges Under U.S. Environmental Laws to Climate Engineering Projects

Less discussed, however, are approaches that would use domestic national laws to control unilateral climate engineering projects.\(^{62}\) In particular, U.S. courts will likely host some of the initial legal actions to fight climate engineering efforts that might cause environmental damage or large-scale unanticipated effects. The emergence of U.S. courts would merely reflect existing trends. Research projects on climate engineering have already received a high level of attention in the United States, and U.S. citizens and corporations have provided significant early funding for climate engineering theoretical research. Some early climate engineering projects will likely be directed by U.S. citizens or within U.S. territory, and domestic U.S. environmental statutes would offer attractive opportunities to challenge those first efforts. Federal and state courts may also offer personal jurisdiction over U.S. citizens who undertake or participate in other climate engineering projects. Last, U.S. courts and environmental laws may offer opportunities for injunctive relief or damages that other national court systems might not grant as readily.\(^{63}\)

\(^{61}\) For example, a large collection of environmental groups have banded together into a campaign named “Hands Off Mother Earth” (HOME). The HOME coalition will advocate for an international prohibition or regulation of efforts to test or implement climate engineering technologies. The coalition’s goals and background are further described at http://www.handsoffmotherearth.org/about/ (last verified on Nov. 29, 2010).

\(^{62}\) This general statement, notably, does not reflect either EPA’s assertion of MPRSA jurisdiction over ocean fertilization experiments by ships flying the U.S. flag or the German federal government’s unilateral action under German law to temporarily restrict ocean fertilization experiments in the Southern Ocean in 2009. See discussion supra at n.35.

\(^{63}\) In addition to federal environmental laws, state laws have a rich body of regulatory requirements for weather modification activities. These laws typically addressed efforts to make or control amounts of rainfall in a local region. See supra at n.23. While weather modification laws might provide a useful historical backdrop, these state and local laws ultimately will not likely play a significant role in legal challenges to climate engineering projects on a global or regional scale.
For example, if a corporation with significant operations in the United States (or which had incorporated itself within a U.S. state) decides to undertake a climate engineering project within the United States, environmental groups could draw on many potential options under multiple federal environmental statutes to contest the project. We can only sketch some of those challenges here. Most importantly, the specific facts surrounding each climate engineering project – including its location, type of technology, scale and projected effects – will play a critical role in invoking the jurisdiction and application of particular federal or state environmental statutes. Current nascent climate engineering proposals simply lack enough detail (as yet) to allow a fully focused assessment of the environmental statutory and regulatory duties that they might trigger.

While these proposals remain partially undefined, we can still forecast general principles and strategies for the application of federal U.S. environmental statutes to climate engineering efforts. A few key questions will guide the application of federal environmental statutes to climate engineering projects:

**Whom does the statute regulate?** Most environmental statutes expressly define the “person” who falls within the statute’s requirements. The definition of “person” in the Clean Air Act, for example, expressly includes individuals, corporations, states and federal governmental agencies. This broad scope of “person” means that virtually anyone sponsoring a climate engineering project – including state agencies or federal entities – will fall within the ambit of “persons” who must comply with Clean Air Act requirements.

**Where does the statute apply?** While this analysis focuses on climate engineering projects occurring within U.S. territory, many initial projects may occur outside U.S. territory or on the high seas. If so, climate engineering litigation could pose difficult questions of extraterritorial application of federal environmental laws. The federal courts have generally have disfavored a broad application of those laws outside U.S. borders without express Congressional authorization. Actions outside the United States that have direct

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effects within U.S. borders, however, have provided a basis for application of U.S. environmental laws to foreign actors.66

Will the court have jurisdiction over the defendants? Even if the federal courts upheld the extraterritorial application of U.S. environmental statutes, claimants would still need to satisfy minimum contacts required for the constitutional exercise of personam jurisdiction over persons or corporations acting entirely outside the United States.67 The simple fact that the individual may be an individual U.S. citizen or be incorporated in a U.S. state, by itself, may not suffice without further statutory authorization or additional contacts to the U.S. forum.

Who is opposing the project? The identity of the persons challenging the climate engineering project can play a large role in determining which causes of action and remedies might be available. In particular, the U.S. government, a state entity or a local governmental unit would have access to a broader array of potential actions and remedies than private parties in citizen suits. For example, the federal government can bring actions or issue administrative orders to respond to emergencies or to imminent threats to human health or the environment. Governmental entities, as trustees for natural resources, might also have the ability to seek compensation for any damages to natural resource damages caused by climate engineering projects.68

With these questions in mind, the federal environmental statutes that might first apply to climate engineering projects would probably include the following laws:

1. The Clean Air Act.

The federal Clean Air Act69 provides the most likely statutory basis to challenge initial climate engineering projects. Most notably, EPA has already

66 See, e.g., Pakootas v. Teck Cominco Metals, Ltd., 452 F.3d 1066 (9th Cir. 2006) (CERCLA liability does not reach beyond the U.S. borders into Canada, but finding a Canadian factory created a “facility” within the United States because its discharges flowed directly into a U.S. waterbody).


68 For example, see the discussion infra at n.91-92 on the United States’ broad emergency authorities under the Comprehensive Environmental Response, Compensation and Liability Act to respond to releases of “pollutants” that pose an imminent and substantial threat to human health and the environment.

69 42 U.S.C. § 7401 et seq. (2010). The CAA sets out complex interlocking requirements for facilities that emit sufficient amounts of specified air pollutants. In particular, the CAA requires owners and operators to obtain permits if their facilities (i) emit sufficient amounts of criteria air pollutants to qualify as major sources that need either Prevention of Significant Deterioration permits for areas that meet ambient air quality standards, or non-attainment New Source Review permits for facilities in non-attainment areas; (ii)
determined that the Clean Air Act applies to greenhouse gas emissions and provides an appropriate statutory vehicle to address climate change. EPA has relied on existing Clean Air Act authorities to undertake an ambitious regulatory initiative to require GHG emission controls. This effort has included a finding under the Clean Air Act that GHG emissions endanger public health and welfare as well as a determination that major stationary sources must obtain PSD or NSR permits for GHG emissions. Given EPA’s willingness to regulate activities to reduce emissions of GHG effects, it may take an expansive view of the Clean Air Act’s applicability to other activities that might alter climate processes or directly release aerosols or other compounds into the atmosphere to mitigate climate change effects.

The Clean Air Act therefore offers obvious avenues for claimants who oppose certain types of climate engineering projects. For example, an environmental advocate might assert that the dispersion of a sulfate aerosol in the upper stratosphere constituted a release of an air pollutant that violates Clean Air Act prohibitions or requires a permit or authorization. If so, they could bring a citizen suit to compel the EPA Administrator to undertake her non-discretionary duty to stop or control those emissions from the project.

Such a citizen suit action, however, would throw a sharp light on potentially difficult jurisdictional questions evoked by applying the Clean Air Act to climate engineering projects. One threshold issue would be whether stratospheric aerosols, when released intentionally to achieve a specific purpose,

install maximum available control technology on sources in a facility that emit hazardous air pollutants; (iii) control emissions or leaks of certain substances that deplete stratospheric ozone; or (iv) obtain tradable emission credits or limit emissions of sulfur dioxide (SO2) that can contribute to the formation of acid rain. The operators must include all of these controls in a comprehensive federal facility operating permit under Title V of the CAA, and they must submit a certified statement that verifies that the facility has either complied with its permit requirements or has listed all of its deviations from the permit. This cursory overview of the CAA obviously and intentionally overlooks the vast and rich body of complex statutory and regulatory requirements set out by the Act. For further background on the Clean Air Act, see R. Martineau and D. Novello (ed.), CLEAN AIR ACT HANDBOOK (2d ed. 2004).

By contrast, the U.S. government has not supported the use of other federal environmental statutes in other contexts to regulate activities that might affect climate change. See discussion infra at __ (Interior Department’s refusal to use Endangered Species Act authorities to designate critical habitat for threatened species as a basis to regulate activities that might contribute generally to climate change).


A significant portion of sulfate particulates released into the upper stratosphere might also fall down to the troposphere where it might directly contribute to ground-level air pollution concerns.

The federal government would have different tools to fight a proposed climate engineering project, including enforcement actions for failure to comply with federal environmental statutes as well as administrative orders to abate imminent endangerments to human health or the environment. See discussion supra at p. 29.
constitute a “pollutant” that would trigger Clean Air Act jurisdiction. Second, the Clean Air Act has historically not applied to activities which promote healthier ambient atmospheric conditions through any means other than emission controls. For example, prior efforts to reduce ambient particulate matter concentrations or directly reduce ambient ozone levels have not triggered Clean Air Act regulatory requirements. The Clean Air Act also obviously lacks an express regulatory framework for emission limitations on climate engineering projects that might not conveniently fall into the existing rules for industrial source categories, priority pollutants under Title I for ambient air quality standards, air toxics regulated under Title III or even stratospheric ozone protection under Title VI.

Some of these difficult questions will ultimately turn on the specific design of the proposed climate engineering technology. For example, proposals to reduce solar radiation influx through releasing sulfate aerosols in the upper stratosphere may open several legal challenges under the Clean Air Act. This particular technology could pose regulatory obligations under:

(i) Title I for non-attainment of national ambient air quality standards. Sulfur dioxide is a criteria pollutant with a NAAQS level as well as extensive permitting requirements for areas not in attainment with that standard. In addition, sulfate aerosols could constitute a

74 The Clean Air Act only applies to releases of “pollutants” that meet statutory and regulatory criteria. 42 U.S.C. § 7602(g). For example, the intentional discharge of chemicals into the air to fight forest fires has not triggered a need for Clean Air Act permits. U.S. Forest Service, Decision Notice and Finding of No Significant Impact: Aerial Application of Fire Retardant (Feb. 18, 2008). Historical attempts to modify weather through cloud seeding or other rain-making technology have fallen under separate state regulatory regimes rather than the Clean Air Act. See discussion infra at n. 24, p. 10.

75 While they have received comparably little attention, some proposed technologies would directly remove or absorb criteria pollutants from the ambient atmosphere. For example, state environmental agencies have explored the use of certain catalytic coatings for mobile sources, concrete structures, high-volume air conditioning systems, and road surfaces which would directly absorb ozone and its precursors. Such materials have been successfully introduced in Japan, Italy, and Great Britain as a method of controlling emissions, and since 2005 have been used as part of the SIP strategy for the Dallas-Ft. Worth area. See http://www.tceq.state.tx.us/assets/public/implementation/air/sip/miscdocs/area_8-31-05.pdf, cited in D. Chen, et al., Photocatalytic Coating on Road Pavement/Structures for NOx Abatement.

Theoretically, EPA and delegated states could also authorize techniques that directly remove air pollutants from the ambient atmosphere as an appropriate technology to satisfy BACT requirements for Title I permitting purposes. We have not located any BACT approvals, however, that have authorized this approach.

76 While EPA has not used the Clean Air Act to regulate technologies that directly reduce ambient levels of criteria pollutants, states have sought EPA’s approval of these techniques so that they could claim credit for pollutant reductions for SIP modeling purposes. See supra n. 63 to TCEQ proposed emission reduction increment for requiring catalytic coating for HVAC to directly reduce ozone and its precursors.

77 It is unclear whether the generation and dispersal of sulfate aerosols would require the direct emission of sulfur dioxides which would fall within the sulfur dioxide NAAQS. In addition, sulfate aerosols may also come within air quality planning and permitting requirements under Title I if their emission would contribute to the formation or decomposition of compounds into sulfur dioxide in ambient environmental conditions.
precursor for the formation of particulate matter (PM) that falls within either PM NAAQS standard. Some proposals for sulfate dispersion in the upper atmosphere would rely on large stationary generators that would then convey their sulfate emissions into the stratosphere through immensely long flexible tubes supported by high-altitude balloons. These sources arguably might trigger Clean Air Act permitting requirements if the generators emit enough sulfur dioxide or PM to constitute a major source.

Title I also imposes restrictions on emissions from major sources that might impair visibility in mandatory Class I areas. It is unclear whether sulfate aerosol or other scattering media would potentially affect visibility or regional haze formation. If so, visibility New Source Review requirements might apply to climate engineering projects that qualify as stationary major sources.

(ii) Title II – Releases of large amounts of sulfates from aircraft flying in the upper atmosphere may invoke complex regulatory provisions that govern emissions from mobile sources and aircraft. The Clean Air Act’s mobile source program may have limited application, however, because it largely targets emissions from the operation of engines rather than intentional releases conveyed by the mobile sources themselves.

Title II may have a more direct application to other climate engineering proposals that rely on solar radiation scattering by stratospheric aerosol particulates. Recent models have shown that aircraft contrails in the upper atmosphere can have a significant effect on climate systems. As a result, some scientists have suggested that aircraft fuels could be formulated to enhance this scattering effect by promoting the creation of high-altitude contrails or by encouraging formation of particulates. An aircraft

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78 EPA has promulgated two NAAQS for particulate matter. In 1987, EPA changed the indicator for particles from TSPs to PM₁₀ including particles with a mean aerodynamic diameter less than or equal to 10 micrometers not to be exceeded once per year. *Revisions to the National Ambient Air Quality Standard for Particulate Matter*, 52 Fed. Reg. 24,634 (July 1, 1987). EPA later issued a second NAAQS that set a lower ambient concentration threshold for PM₂.₅ because EPA had concluded that ultrafine PM contributed to increased incidents of pulmonary disease and other human health effects. *National Ambient Air Quality Standards for Particulate Matter*, 62 Fed. Reg. 38,652 (July 18, 1997).


80 If these stationary source facilities were located in non-attainment areas, it would raise the interesting question of whether they fall under non-attainment emission limitations even though their ultimate discharge actually occurs far above or outside the non-attainment area itself.

operator who sought to use these fuels may have to assure that the fuel meets mobile source fuel standards set out by EPA under Title II.

(iii) Title IV – Sulfur dioxide is also a regulated precursor for the formation of acid rain. While this program regulates sources in specific industrial categories (e.g., power plants), large-scale releases of sulfur aerosols which may affect the acidity of regional precipitation might lead to regulatory scrutiny.\(^82\)

(iv) Title VI – the Clean Air Act empowers EPA to regulate emissions of stratospheric ozone depleting substances (ODS) to assure that the United States meets its obligations under the Montreal Convention. Under Title VI, EPA can add certain compounds to the list of ODS if it concludes that they contribute to ozone depletion. Some scientists have raised concerns that the release of sulfur aerosols into the upper stratosphere may cause significant ozone depletion.\(^83\) If so, EPA may have regulatory authority to add these types of activities and substances to the list of ODS and implement controls on their distribution and use. To date, EPA has not included stratospheric sulfate aerosols to the list of ODS under Title VI.

Importantly, the potential application of these Clean Air Act requirements to climate engineering projects does not necessarily deny EPA the flexibility to modify these regulatory standards in certain circumstances. For example, the Clean Air Act’s provisions and exemptions for research projects may provide EPA with some degree of flexibility to handle initial rounds of climate engineering projects or experiments.\(^84\) EPA may also have the ability to modify some regulatory obligations through consent agreements or compliance schedules that provide an alternative pathway for satisfying Clean Air Act requirements.

2. **Clean Water Act.**

Climate engineering projects that require the addition of substances to waters of the United States may require authorization under the federal Clean

\(^{82}\) As noted previously, the application of these requirements for SO2 to sulfate aerosol projects will depend on whether dispersal of sulfates requires the direct emission of SO2 into the atmosphere or will contribute to heightened SO2 ambient levels due to the decomposition of other compounds or through other atmospheric chemical processes. See discussion supra at n.72.


Water Act. This act prohibits the discharge of any pollutant from a point source into navigable waters unless that discharger has a permit or other form of authorization. For example, a project that disperses iron or other nutrients into U.S. marine waters for a fertilization demonstration project may constitute a discharge that requires a permit under either the National Pollutant Discharge Elimination System (NPDES) or a delegated state program. Notably, EPA has construed the definition of “pollutant” to include the addition of heat to water bodies. If a climate engineering project involves the addition or shifting of heat levels within U.S. waters, those transfers of heat may trigger NPDES permitting requirements.

The Clean Water Act may also directly affect climate engineering projects that require alterations to land use or geographic features. For example, some climate engineering proposals would encourage the placement of highly reflective materials onto large swaths of land to increase surface albedo. By reflecting more sunlight back into space, these projects would reduce solar influx and ultimately reduce climate change effects. Other projects would encourage large-scale CO2 sequestration through the construction of artificial wetlands or restrictions on land uses which release trapped carbon. If these efforts would involve alterations or placement of materials into wetlands within the jurisdictional reach of the Clean Water Act, the project operators may have to obtain authorization or permits from the U.S. Army Corps of Engineers.

Water quality concerns could also indirectly affect climate engineering projects. For example, direct CO2 capture will generate a large volume of CO2 in either a gaseous or liquid form. While some of that CO2 will likely be used as a product or in other industrial processes, direct capture strategies may have to address the management or disposal of large volumes of captured CO2. If direct

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86 Id. at § 1311. The prospects for significant field tests of iron fertilization in U.S. waters is likely low because waters identified as suitable for fertilization (i.e., high in chlorine but low in nutrients) are in the Southern Ocean and in the Indo-Pacific regions. Most of the experiments are also likely to occur on the high seas. Attempts to replicate these conditions in U.S. waters for such a test might trigger Clean Water Act obligations.

In addition to the Clean Water Act, the Rivers & Harbors Act of 1899 (“Refuse Act”) imposes strict liability for discharges of “refuse” into waters of the United States. While this statute has historically applied to the discharge of refuse or solid waste that poses a threat to navigability of U.S. waterways, federal courts have interpreted the Refuse Act to prohibit the unpermitted discharges of pollutants into U.S. waters. 33 U.S.C. § 407 (2010); New York v. New Jersey, 256 U.S. 296 (1921). If a climate engineering demonstration arguably requires the discharge into U.S. waters of a material that might constitute a “refuse” (e.g., the large scale deposition of iron or other nutrients into U.S. waters), that project may require authorization from the U.S. Army Corps of Engineers.

87 Id. at § 1342; 40 C.F.R. § 122.2 (defining “pollutant” to include heat).

88 See discussion supra at n.53 (climate engineering proposals to use marine heat pumps to reduce the surface temperature of ocean waters and thereby reduce the risk of the formation of extreme storms or hurricanes).
capture systems use geologic sequestration to manage that CO₂, those sequestration wells will likely trigger EPA regulatory requirements under its underground injection well program. ⁸⁹ State regulatory programs will also affect geologic sequestration aspects of any significant direct CO₂ capture systems.

Climate engineering permitting under the Clean Water Act may pose some of the same conceptual challenges raised by the Clean Air Act. For example, the intentional release of materials into U.S. waters for an express remedial purpose may not constitute a discharge of a “pollutant” because the materials are not being discarded. ⁹⁰ In addition, materials released into the ambient air for a climate engineering project may ultimately precipitate into U.S. waters, but that type of generalized deposition may not constitute a discharge from a “point source” that would trigger NPDES permitting requirements. ⁹¹


The federal Endangered Species Act ⁹² imposes stringent limits on the actions of governments and individuals that might result in the taking of an endangered or threatened species by directly harming individuals of that species or by damaging the species’ critical habitat. If a climate engineering project could potentially affect a large region, that geographic area may include habitat for endangered or threatened species. In those circumstances, a claimant may seek to halt the project through a citizen suit or a request for injunctive relief if the proposed climate engineering project arguably threatens to take any members of an endangered species or to indirectly damage critical habitat. ⁹³

Obviously, such an action could face significant standing, causation and evidentiary challenges. The U.S. Supreme Court has already held that plaintiffs cannot bring citizen suits under the Endangered Species Act to challenge funding

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⁹⁰ See n.62 supra at 26.

⁹¹ Id. The Clean Water Act sets out much less onerous requirements for discharges from non-point sources into U.S. waters. In an analogous situation, however, at least one federal court has ruled that the generalized spraying of pesticides that then precipitates into navigable waters constitutes a discharge of pollutants from a point source that triggers NPDES permitting requirements. National Cotton Council of America v. U.S. Environmental Protection Agency, 553 F.3d 927 (6th Cir. 2009) (striking down EPA regulations attempting to exempt pesticide application from NPDES permit requirements).


⁹³ This challenge could either allege that the climate engineering project itself threatens to cause a taking of a protected species in violation of Section 9, or that the project requires federal approval, funding or permitting such that it triggers federal consultation requirements under Section 7(a)(2) of the Endangered Species Act.
decisions for actions abroad that arguably threaten a listed species unless the plaintiffs show that they have suffered a concrete, specific and actual or imminent injury arising from that action. 94 Persons challenging climate engineering projects under the Endangered Species Act may face similarly challenging burdens of proof to demonstrate standing. Those burdens may be alleviated somewhat because climate engineering projects expressly seek to cause detectable changes in climate patterns. As a result, the defendant’s own statements related to the project may remove the need to prove at least some causation issues (namely, whether the defendant’s actions have resulted in altered climate effects). Plaintiffs would likely still have to show, however, that these climate effects resulted in some threat to the listed species at issue.

More importantly, the plaintiffs would also have to demonstrate that the climate engineering project’s impact rises to the level of a “taking” through alteration of critical habitat or injury to individual members of the species. If the nexus between the climate engineering project and the injuries is too indirect, it may not demonstrate that the project proximately caused the injury within the meaning of “take” under the statute. 95

Last, the U.S. Department of the Interior promulgated interpretative rules on May 14, 2008 for the proposed designation of polar bears as a threatened species. These rules sought to limit the scope of ESA listings and protections to exclude measures that addressed global climate change mitigation as a necessary step to protect critical habitat for endangered or threatened species. 96 The rule expressly declared that the United States would not use the Endangered Species Act as a tool to address climate change concerns. These same policy choices may drive the United States to use caution when adapting federal environmental statutes to oppose climate engineering projects.

94 Lujan v. Defenders of Wildlife, supra at n. 58, p. 23.


3. **National Environmental Policy Act.**

NEPA\(^\text{97}\) requires the federal government to undertake an environmental review of any major federal agency action that is likely to have a significant impact on the environment. While NEPA applies solely to governmental actions, it could play an important role if a climate engineering project required the federal government to undertake any significant permitting action or to perform any major actions related to the project.\(^\text{98}\) The Council on Environmental Quality has expressly directed federal agencies to account for climate change implications in their review of governmental actions for potential NEPA assessment.\(^\text{99}\) If a federal agency must review a proposed climate engineering project for permitting, government financial assistance or other support, it must review the project’s purported impact on climate systems when assessing whether it qualifies for a categorical exemption or will have a significant impact that would require a fuller environmental impact statement.

The federal government’s environmental review may extend beyond an assessment of individual climate engineering projects. If a federal agency decides to craft a strategy for authorizing or supervising climate engineering projects, that policy decision may lead the agency to undertake a programmatic environmental impact statement. This PEIS could require a comprehensive assessment of the cumulative and global effects of a decision to allow or control climate engineering projects. That assessment would explicitly and expressly focus on the possible climate change effects that the projects might have on their targeted climate systems.

The applicability of NEPA requirements will turn heavily on the specific factual context for the climate engineering project as well as the nature of the federal government’s action related to the project. For example, statements by proponents about a climate engineering experiment’s intended regional or global effects might constitute a prima facie demonstration that the project will have a significant impact and thereby trigger the need for a full environmental impact statement.

4. **Marine Protection, Research and Sanctuaries Act.**

In contrast to other federal environmental statutes, the Marine Protection, Research and Sanctuaries Act (MPRSA, or “Ocean Dumping Act”) has already


\(^{98}\) Notably, if the responsible federal agency had to conduct an environmental assessment or a full environmental impact statement, that action could also trigger a requirement for the agency to enter into the federal consultation process under Section 7(a)(2) of the Endangered Species Act. *See discussion supra n. 90.*

\(^{99}\) *N. Sutley, DRAFT NEPA GUIDANCE ON CONSIDERATION OF THE EFFECTS OF CLIMATE CHANGE AND GREENHOUSE GAS EMISSIONS* (Feb. 18, 2010).
been invoked to challenge climate engineering projects. The MPRSA implements the United States’ obligations under the London Convention to restrict the dumping of pollutants or refuse into the high seas, and it also sets out a comprehensive regulatory program to govern the placement of materials into the marine environment that might impair its health or ecological functions. The MPRSA, as a result, applies both to discharges into waters under U.S. jurisdiction as well as to acts on the high seas by ships under the U.S. flag.  

Because of its reach to actions on the high seas, opponents invoked the MPRSA to fight Planktos’ planned release of iron filings into the Pacific Ocean. Several environmental groups filed a petition with EPA that contended the planned experiment would constitute the dumping of pollutants that violated the MPRSA, and they asked EPA to intervene and halt the experiment. EPA responded by notifying Planktos that the MPRSA could apply to the planned release, and it asked Plaktos to confirm whether it would seek a permit or other authorization before proceeding with the project. Planktos responded that it would not trigger MPRSA obligations because it would use a vessel flying under a different national flag for the experiment. Planktos’ response, in part, led the United States to alert the parties to the London Convention and seek consideration by the parties for a regime to govern ocean fertilization experiments.

The MPRSA may offer a powerful initial platform to regulate climate engineering projects that involve actions in waters under U.S. jurisdiction or on vessels flying the U.S. flag. The MPRSA’s express legislative purpose is to “regulate the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities.” Unless authorized by a permit, MPRSA generally prohibits (1) transportation of material from the U.S. for the purpose of ocean dumping; (2) transportation of material from anywhere for the purpose of ocean dumping by U.S. agencies or U.S.-flagged vessels; and (3) dumping of material transported from outside the U.S. into the U.S. territorial sea or into the contiguous zone to the extent that it may affect the territorial sea or the territory of the United States. Given its broad scope and its express extraterritorial application to activities by U.S. vessels, the MPRSA may offer a strong and clear platform to challenge climate engineering projects that might otherwise lie outside the reach of other domestic federal environmental statutes.

100 33 U.S.C. § 1441(a)(1)-(2).

101 See discussion supra at n.31-35 (describing EPA action in response to proposed Planktos project).


103 Id. at § 1401(c).
5. Other statutes.

This initial survey of federal environmental statutes has focused on major laws that offer the clearest opportunity to challenge climate engineering research projects. Several other federal statutes, however, could offer additional avenues for legal review if the specific climate engineering proposal would fall within their coverage. For example, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) might create liability for persons responsible for releases of materials that might constitute hazardous substances in climate engineering projects.\footnote{42 U.S.C. § 9601 et seq. (2010). For example, the dispersal of large quantities of aerosols or engineered particulates into the stratosphere may constitute an arrangement for the disposal of those materials once they inevitably precipitate onto the ground. Similar arguments might be made for minerals or compounds dispersed onto the ocean surface for fertilization projects. If these materials fall within CERCLA’s broad definition of “hazardous substance,” researchers who arranged for the dispersal of those materials may face strict liability for response costs incurred to respond to those releases. This risk could be especially problematic if the releases allegedly cause natural resource damages in addition to costs incurred to respond to the release. \textit{Id.} at § 9607(a).} Because that liability would be strict as well as joint and several (if the release caused an indivisible harm), potentially responsible parties for climate damage resulting from a climate engineering project might face the daunting task of proving which portion of those damages should be attributed to their activities. More importantly, the United States might have a broader scope to compel persons performing a climate engineering project to undertake emergency action to abate an imminent and substantial threat to human health and the environment. As opposed to its provisions establishing the liability of potentially responsible parties for response costs, CERCLA authorizes the federal government to undertake any action needed to respond to a release of “pollutants” rather than a hazardous substance.\footnote{\textit{Id.} at § 9604(a)(1). CERCLA defines “pollutant” much more broadly than the term “hazardous substance.” \textit{Id.} at § 9601(33) (defining “pollutant” to “include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring” with the exception of petroleum. \textit{Id.}} While this action may not result in liability for potentially responsible parties, it could nonetheless impose substantial restrictions on an ongoing climate engineering project that arguably created a threat to human health or the environment.

Other federal environmental statutes might apply to climate engineering projects. The Migratory Bird Treaty Act imposes strict liability on persons whose activities cause the taking of a migratory bird, and that liability can be criminal.
A climate engineering project that unintentionally caused the deaths of migratory birds therefore might pose a risk of significant liability.\textsuperscript{106} Ocean fertilization projects in coastal waters that might affect marine sanctuaries could be subject to regulation under the National Marine Sanctuaries Act\textsuperscript{107} or the Marine Mammal Protection Act.\textsuperscript{108} The Offshore Continental Shelf and Lands Act may also provide a basis for citizen suits to challenge climate engineering projects that involve use of submerged lands in the U.S. territorial sea or exclusive economic zone.\textsuperscript{109}

Notably, this initial overview of potential environmental challenges touches solely on federal statutory options. Claimants may find that state environmental laws offer richer opportunities to challenge climate engineering projects that might require an environmental impact statement or a state permit with more stringent emission or operating requirements.\textsuperscript{110}

B. Potential Barriers to U.S. Judicial Review of Challenges to Climate Engineering Projects

In addition federal environmental statutory programs, federal or state common law nuisance claims may provide a viable avenue for judicial review of climate engineering projects. This field of law is in a state of high flux, and the U.S. Supreme Court recently granted certiorari to review a Second Circuit decision that would allow such a claim to proceed to trial.\textsuperscript{111} The Court’s decision follows several federal court decisions that have already undertaken searching scrutiny of climate change public nuisance claims -- \textit{Native Village of Kivalina v. ExxonMobil Corp.},\textsuperscript{112} \textit{Comer v. Murphy Oil}\textsuperscript{113} and \textit{Connecticut v.}

\textsuperscript{106} 16 U.S.C. § 1703 et seq. (2010). For example, a demonstration project to adjust the acidity of marine waters may involve the addition of chemical buffering agents to affect the pH level of waters over a broad area. If these chemicals injured or killed migratory birds feeding in the area, the project’s operator might arguably face civil and criminal liability under the MBTA.

\textsuperscript{107} 16 U.S.C. § 1431 et seq. (2010). The NMSA authorizes the Secretary of Commerce to designate and protect areas of the marine environment with special national significance, and it authorizes civil fines up to $130,000 per violation per day and damages against persons who injure marine sanctuary resources. \textit{Id. at §§ 1436, 1437(d)(1) and 1443(a)(1).}


\textsuperscript{110} For example, the California Environmental Quality Act has provided the basis for numerous citizen suits to challenge state actions where the government failed to properly account for climate change effects in state environmental impact statements. Cal. Pub. Res. Code § 21000.

\textsuperscript{111} \textit{American Electric Power Company et al. v. Connecticut et al.}, petition for a writ of certiorari granted, No. 10-174, (Dec. 6, 2010), Decision available at \url{www.supremecourt.gov/qp/10-00174qp.pdf}.

\textsuperscript{112} \textit{Native Village of Kivalina v. ExxonMobil Corp.}, 663 F.Supp 2d 863 (N.D. Calif. 2009)

\textsuperscript{113} \textit{Comer v. Murphy Oil USA}, 585 F.3d 855 (5th Cir. 2009).
American Electric Power Co.\textsuperscript{114} -- and on the role that federal courts can (or should) play in global climate change tort disputes. These decisions have centered on political question doctrine, standing, ability to prove causation, and displacement or preemption. The courts have rendered mixed decisions on climate change public nuisance claims, and the U.S. Supreme Court’s decision in \textit{AEP} may shed some much-needed light on this field of law.

The application of public nuisance tort principles to climate engineering projects, however, need not await the Court’s ruling in \textit{AEP}. In contrast to public nuisance damage lawsuits for climate alterations arising from past and global GHG emissions, climate engineering challenges may provide a clearer avenue to bring climate change tort actions into the federal courts. While still raising important claims over climate change responsibilities and liability, these actions will neatly sidestep – or even reverse – the typical challenges raised against climate change nuisance suits under federal common law.

Before examining the application of federal tort liability theories to climate engineering projects, it is important to note that the primary opposition to climate engineering projects will likely rely on federal environmental statutes rather than federal common law tort claims. While statutory claims can still face standing and justiciability problems, those concerns are greatly lessened when Congress has established a statutory framework for judicial review. By doing so, Congress can exercise its power to define a property interest or procedural right which can become a legally protectable interest. An invasion of that statutory right thereby can support standing and justiciability. For example, the U.S. Supreme Court in \textit{Massachusetts v. EPA} held that when Congress gives a procedural right to protect a plaintiff’s concrete interests, the plaintiff “can assert that right without meeting the normal standing requirements of redressability and immediacy; [...] the litigant has standing if there is some possibility that the requested relief will prompt the injury-causing party to reconsider the decision that allegedly harmed the litigant.”\textsuperscript{115} Claimants attacking a climate engineering project could meet standing and justiciability requirements by showing a federal environmental statute provides them with a similar substantive or procedural right. As noted previously, U.S. environmental statutes could provide an array of possible options to contest climate engineering research or demonstration projects.\textsuperscript{116}

Numerous other articles have surveyed the key challenges and procedural status of the three key climate change public nuisance lawsuits currently before

\begin{itemize}
\item \textsuperscript{114} \textit{Connecticut v. American Elec. Power Co., Inc.}, 582 F.3d 309 (2d Cir. 2009).
\item \textsuperscript{115} \textit{Massachusetts v. E.P.A.}, 549 U.S. 497, 517-18 (2007).
\item \textsuperscript{116} \textit{See Section III.A. supra.}
\end{itemize}
the federal appellate courts,\textsuperscript{117} and this article will only recount the key aspects of those cases as they might illuminate public nuisance lawsuits to halt climate engineering efforts. It will also focus on the trial court decisions to some extent because their rationale offers the most insight on how federal trial courts will initially respond to climate engineering lawsuits. In each of the problematic areas for climate change public nuisance actions, a legal action seeking damages or injunctive relief against a climate engineering project would face significantly lesser difficulties in presenting a viable claim.

**Political Question.** The most threatening jurisprudential shoal for public nuisance climate change suits has been the political question doctrine. The political question doctrine, while much debated over its doctrinal justifications and exact formulation, holds generally that federal courts cannot entertain cases which present controversies or issues which either the U.S. Constitution has committed to the other two political branches or the judicial branch lacks the institutional capacity to resolve or enforce.\textsuperscript{118} In particular, the political question doctrine can allow a federal court to dismiss requests for relief that would require the court to implement a long-term and complex remedial scheme in an area where the court lacks special expertise. The political question doctrine also applies to cases that turn on multifaceted non-legal factors which, ultimately, rest on political judgments on allocation of benefits or responsibilities.

Climate change public nuisance suits are highly susceptible to political question challenges, and the three key cases have each spurred numerous motions to dismiss on political question grounds. Because each of the three suits raise different claims and seek varying types of relief, the trial courts have offered different rationales in their opinions granting each motion to dismiss. For


\textsuperscript{118}Baker v. Carr, 369 U.S. 186, 189 (1962). In this seminal opinion, the U.S. Supreme Court described the specific factors that identify a political question. The well-known Baker factors include (i) a constitutional commitment of the issue to another political branch, (ii) a lack of judicially discoverable or manageable standards for the court to resolve the issue, (iii) the impossibility of deciding the issue without making an initial policy determination outside of judicial discretion, (iv) the impossibility of undertaking the issue without expressing a lack of respect to another branch, (v) an unusual need for unquestioning adherence to a prior political decision, and (vi) the potential for embarrassment from multiple pronouncements on one question at issue. *Id.*

For an analysis of the political question doctrine as it specifically relates to climate change cases, see J. May, *Climate Change, Constitutional Consignment, and the Political Question Doctrine*, 85 DENV. U. L. REV. 919 (2008); S. LaTourette, *Climate Change: A Political Question?*, 40 RUTGERS L.J. 219 (2008). The foreign policy aspect of the political question doctrine is likely to see fresh scrutiny by the courts as an increasing number of lawsuits swirl around the activities of American companies in theaters of war. See *The Political Question Doctrine: Executive Deference, and Foreign Relations*, 122 HARV. L. REV. 1193 (2009).
example, in *Connecticut v. AEP* the state plaintiffs requested an injunction that would limit greenhouse gas emissions from coal-fired power plants in multiple northeastern states under a plan that would compel the plants to gradually reduce their emissions over decades of operation. Not unexpectedly, the trial judge concluded that the plaintiff’s request would force the trial court to make decisions that effectively allocated liabilities and influenced regional power generation on an open-ended basis. Judge Preska described this type of injunctive relief as squarely within the sphere of issues that the political question doctrine barred from federal court review:

> . . . a non-justiciable political question exists when a court confronts ‘the impossibility of deciding without an initial policy determination of a kind clearly for non-judicial discretion.’ As the Supreme Court has recognized, to resolve typical air pollution cases, courts must strike a balance ‘between interests seeking strict schemes to reduce pollution rapidly to eliminate its social costs and interests advancing the economic concern that strict schemes [will] retard industrial development with attendant social costs.’ In this case, balancing those interests, together with the other interests involved, is impossible without an ‘initial policy determination’ first having been made by the elected branches to which our system commits such policy decisions, *viz.*, Congress and the President.\(^{119}\)

The Second Circuit reversed the trial court’s dismissal order because the appellate panel concluded that the requested relief only affected a small number of power plants and did not pose intractable allocation judgments. The federal courts, according to the Second Circuit, had long handled complex questions like these as part of their inherent award of equitable relief to multiple parties.\(^{120}\)

*Comer* and *Kivalina* also yielded initial trial court rulings that dismissed the complaints because they posed political questions, but the courts diverged on their rationales. The *Comer* trial court stated that the plaintiffs’ claim asked the

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\(^{120}\) Id. at 326. As this article went to press, the U.S. Supreme Court granted certiorari to review the Second Circuit’s decision in *Connecticut v. AEP*. The Court did not specify the exact issues on which it sought argument, but the certiorari petition requested review on multiple grounds that included standing, political question and displacement by subsequent regulatory activities. The Court’s decision could clarify or establish new standards on these issues that would have direct relevance for future challenges to climate engineering projects.

Notably, the Solicitor General of the United States filed a brief that asked the U.S. Supreme Court to overturn the Second Circuit decision on prudential political question grounds. *Brief for the Tennessee Valley Authority in Support of Petitioners at 11, American Elec. Power Co. Inc. v. Connecticut*, 582 F.3d 309 (No. 10-174) (August 2, 2010). The Court rejected the Solicitor General’s request that the Court grant certiorari, vacate the Second Circuit’s opinion, and remand the case back to the Second Circuit for further consideration.
court to “balance economic, environmental, foreign policy and national security interests and make an initial policy determination of a kind which is simply non-judicial. . . These policy decisions are best left to the executive and legislative branches of the government, who are not only in the best position to make those decisions but are constitutionally empowered to do so.”\textsuperscript{121} While the Fifth Circuit panel decision disagreed and concluded that the complaint raised no political question, the full Fifth Circuit subsequently vacated that opinion without issuing a substantive analysis of its own to replace it.

By contrast, the \textit{Kivalina} trial court concluded that the limited relief sought by the plaintiffs nonetheless posed a political question because (i) the plaintiffs’ claims rested on allegations of emissions and damages on a global scale that lacked any judicially discoverable or manageable standards, and (ii) the issues raised by the plaintiffs’ claims would require the trial court to make a fundamentally legislative policy judgment.\textsuperscript{122} The district court gave no credit to the defendants’ argument that the global warming issue may involve foreign policy and related economic issues and therefore failed the first step in the \textit{Baker} test. The court wrote that “the fact that this case ‘.touches foreign relations’ does not ipso facto place it beyond the reach of the judiciary,” and it noted that \textit{Baker} itself cautions against sweeping generalities regarding foreign policy being textually delegated to the executive.\textsuperscript{123}

A lawsuit seeking to halt a climate engineering project probably would not face the vulnerabilities to a political question attack described in the three public nuisance trial court opinions. Rather than seek a judicial determination on liabilities arising from global activities over decades arguably caused by thousands (if not millions) of other parties in both the United States and throughout the world, a judicial challenge to a climate engineering project could involve a plaintiffs who challenge a discrete set of proposed actions by a limited and readily identifiable group of defendants that the court could easily address through injunctions or other equitable relief. Depending on the scope of the project, this relief would likely not require any continuing oversight by the court of complex technical activities with sweeping economic consequences, and the court’s actions would not impinge on any overt textual commitment of the issue to either other governmental branch.\textsuperscript{124}

\textsuperscript{121} \textit{Comer v. Murphy Oil Co.}, \textit{supra} n. 88, 585 F.3d 855 n.2; transcript of ruling from bench, Aug. 30, 2007, at p. 40 (available at author’s files).

\textsuperscript{122} \textit{Village of Kivalina}, \textit{supra} at n. 87, at 873.

\textsuperscript{123} \textit{Id.}

\textsuperscript{124} Some aspects of climate engineering lawsuits may arguably ask the court to take actions that fall into the sphere of foreign affairs powers because they involve activities outside the United States. Unless those projects involved foreign governments or their instrumentalities, though, it is unlikely that these types of disputes will fall within the core activities which the U.S. Constitution textually commits to the legislative and executive branches.
Standing. Standing has also posed a significant hurdle for federal public nuisance lawsuits seeking damages or injunctive relief for climate change effects. While standing pitfalls in climate change public nuisance litigation have already spurred a large amount of scholastic analysis and commentary, the basic principles of Article III standing illuminate why plaintiffs might face significant challenges in bringing claims for damages allegedly caused by generalized climate change attributable to specific defendants. As the U.S. Supreme Court has repeatedly noted, a plaintiff must meet three factors to demonstrate standing: an injury-in-fact (i.e., a specific and concrete invasion of a protectable interest held by the plaintiff), causation (i.e., a fairly traceable connection between the injury-in-fact and the defendant’s conduct), and redressability (i.e., it is likely and not speculative that the plaintiff’s injury will be remedied by the relief sought by the plaintiff).

Given that GHG emissions worldwide contribute to general global warming and that any effective relief arguably requires reductions in GHG emissions from a vast array of sources located throughout the world, these irreducible constitutional standing requirements obviously may pose a challenge for most climate change public nuisance claimants. The *Kivalina* trial court did not allow the case to go forward because of the political question doctrine discussed above and because the plaintiffs could not show that any particular act by the defendants could be fairly traced the plaintiffs’ injuries. In particular, the judge noted that “[e]ven accepting the allegations of the Complaint as true and construing them in the light most favorable to Plaintiffs, it is not plausible to state which emissions—emitted by whom and at what time in the last several centuries and in what place in the world—‘caused’ Plaintiffs’ alleged global warming..."

If the United States itself chose to undertake a climate engineering project on any significant scale, however, the court could face many of the same issues raised in federal common law public nuisance tort actions against large GHG emitters. For example, if the U.S. government pursued a large-scale program to forestall an alleged climate emergency, the court hearing a challenge to that program could find itself wrestling with complex technical monitoring issues and foreign policy concerns.

125 Because the trial court dismissed the plaintiffs’ claims in *Connecticut v. AEP* solely on political question grounds, it expressly declined to rule on whether the plaintiffs had standing to bring their claims. *Connecticut v. AEP, supra* at n. 89, 406 F.Supp.2d 272 n.6. The vacated *Comer* appellate panel opinion concluded that the plaintiffs had standing because they needed only to show that the defendants’ actions had contributed to (rather than solely or materially caused) global warming harms. *Comer v. Murphy Oil Co., supra* at n. 88, 2007 WL 6942285 (2007). The *Comer* plaintiffs have filed a petition for certiorari to the U.S. Supreme Court for review the Fifth Circuit’s decision to vacate the panel opinion (even though the Fifth Circuit subsequently lacked sufficient judges to conduct an en banc review). 607 F.3d 1049 (5th Cir. 2010).


injuries.”128 Allowing the suit to go forward, the court held, would make the dozen defendants responsible for the emissions released by “virtually everyone on Earth.”129 The Connecticut v. AEP trial court added in a footnote that, “because the issue of Plaintiffs’ standing is so intertwined with the merits and because the federal courts lack jurisdiction over this patently political question, I do not address the question of Plaintiffs’ standing.”130 The Second Circuit disagreed, finding it had a duty to determine sua sponte whether or not the plaintiffs had Article III standing before delving into the merits of the case.131

By contrast, plaintiffs seeking to challenge a proposed climate engineering project would have a much easier burden of proof for standing. First, a climate engineering demonstration project will presumably involve an effort expressly designed to generate a measurable regional (or ultimately global) effect distinguishable from general climate change impacts. The plaintiffs in turn could attribute those effects and potential risks to the defendants’ specific actions in the tests. As a result, plaintiffs could use the defendant’s explanations to justify the basis for the experiment or project to build a prima facie case for both injury-in-fact and causation. Proof of redressability also might not pose a major hurdle because the court presumably could address the alleged risks or injuries by enjoining the climate engineering project or awarding damages to compensate the specific injuries alleged by the plaintiffs.132

Causation: Aside from the difficulties they have faced in showing that the defendants’ actions could be “fairly traced” to alleged harms, climate change

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128 Village of Kivalina at 873. The Comer trial court reached a similar conclusion on standing by noting that “[t]hese are not injuries which are fairly attributable to these individual defendants. . . . I do not think that under our system of jurisprudence that [harm from CO2 emissions] is attributable to a larger group that are not before the Court, not only within this nation but outside of our jurisdictional boundaries as well.” Trial transcript for Comer v. Murphy Oil Co., supra note 88, at p. 36 (Aug. 30, 2007) (on file with author).

129 Village of Kivalina at 874.

130 Connecticut v. AEP, 406 F.Supp.2d 265, 271 n. 6 (S.D.N.Y. 2005). The Second Circuit’s panel opinion overruled this aspect of the trial court’s opinion and found that the plaintiff’s had standing to bring their claims because they need only show that the defendants’ “contributed to” the undifferentiated harms of global warming and that the court could grant some measure of relief (even if that relief could not result in measurable decreases in overall global warming effects). As noted above, the defendants have filed a petition for certiorari with the U.S. Supreme Court to review the panel opinion. At time of submission of this manuscript, the U.S. Solicitor General had filed a brief urging that the U.S. Supreme Court grant the petition for certiorari and overturn the Second Circuit’s opinion because the federal courts should not hear global warming federal common law nuisance cases due to prudential standing grounds. See discussion supra at 104.

131 Connecticut v. AEP, supra at n.117, 582 F.3d at 333.

132 While climate engineering opponents might face serious difficulties in quantifying the amount of harm or damages they might suffer from a research test or demonstration project, the federal courts have long issued injunctions to halt activities that might increase the risk of harm if that harm satisfied general or statutory tests for issuance of injunctions. Winter v. Natural Resources Defense Council, 129 S.Ct. 365 (2008) (setting out standards for issuance of injunctions to halt alleged violations of NEPA requirements by the Navy’s sonar tests).
public nuisance plaintiffs will face even higher causation hurdles if their claims proceed to trial. The same features that make standing difficult to establish – the thorough mixing of CO₂ emissions on a global basis in relatively short time period, the long residence time of CO₂ in the atmosphere, the complex processes by which CO₂ and other GHG emissions can lead to multiple changes to climate (and, in turn, to weather or marine conditions) – will pose daunting challenges for public nuisance plaintiffs who wish to establish specific causation (as well as causation-in-fact) between the defendants’ emissions and the alleged damages from climate change. By contrast, demonstration efforts and test projects for climate engineering research will have the express goal of altering climate globally or in a discrete region in measurable ways. The overt aims, design and public statements for climate engineering projects may help reduce the evidentiary burdens to show that the projects caused, or might cause in the future, harms to individuals or the environment.¹³³

Preemption and Displacement. While the trial courts in the Kivalina, Comer and Connecticut v. AEP cases each dismissed the claims on political question or standing grounds, they also heard vigorous arguments that any federal common law public nuisance claims had been displaced by subsequent federal governmental actions that had fully occupied the field. In particular, the defendants alleged that the Executive Branch’s efforts to participate in multilateral negotiations that would create a binding treaty to limit GHG emissions on a global basis demonstrated the Executive’s exercise of its constitutional authority to negotiate treaties, and that any attempt by the federal courts to impose GHG emission limits through public nuisance verdicts would undermine the United States’ negotiation position. The defendants also argued that the failure of Congress to pass any GHG emission limits reflected a policy decision not to impose GHG emission limits which displaced any federal common law causes of action that might lead to conflicting results. As EPA has promulgated an increasingly large array of regulatory limits and permitting obligations for GHG emissions, the growing federal regulatory presence has led to increasing arguments that federal common law in this arena is simply displaced.¹³⁴

To the extent that federal environmental statutes might apply to climate engineering projects, federal common law tort plaintiffs may need to plead their cases carefully to sidestep displacement arguments. If they fail to persuade the court that federal environmental statutes can support challenges to climate engineering projects, the plaintiffs could argue in the alternative that the failure of

¹³³ Claimants would still have to link alleged climatic changes to actionable harms such as economic loss or aesthetic injuries before they could demonstrate individual or organizational standing.

¹³⁴ See discussion supra at 22 of the U.S. Solicitor General’s brief on the Connecticut v. AEP certiorari petition. The Solicitor General, on behalf of the Tennessee Valley Authority, expressly argues that EPA’s decision to issue an endangerment finding for GHGs and to begin permitting for GHG emissions from mobile sources and major stationary sources has displaced any federal common law that might govern those emissions.
environmental statutes and regulations to expressly address climate engineering concerns leaves undisturbed the federal courts’ common law authority to hear tort claims. Given the lack of any express U.S. treaty, legislation or regulation to address climate engineering, defendants may not be able to prove that current federal statutes and regulations have displaced the federal courts’ authority to hear common law challenges to climate engineering projects that may affect specific plaintiffs.\(^{135}\)

Last, federal common law may also provide a scaffold in U.S. courts for climate engineering legal attacks that rely on U.S. environmental treaties and other international obligations. As confirmed by long-standing U.S. Supreme Court precedent, federal common law incorporates customary international laws as the law of the United States for purposes of the Supremacy Clause.\(^{136}\) In addition, treaties can become directly enforceable (if implemented by the Senate or if self-executed) as supreme federal law in U.S. courts. If climate engineering challenges assert that prior international conventions or treaties or international customary law prohibit those experiments, U.S. federal and state courts may provide a potentially friendly forum to assert those claims.\(^{137}\)

V. CONCLUSION

The challenge of climate engineering governance ultimately should require an international framework because climate engineering projects will inherently affect multiple nations and will cross jurisdictional lines in a way that will make it difficult for any regional or national regulatory scheme to effectively control risks posed by these projects.\(^{138}\) Even viewed solely as a national

\(^{135}\) To the extent the plaintiffs bring nuisance claims under state law under either the federal court’s supplemental or diversity jurisdiction, or they simply bring their claims in state courts, these same analytical concerns will probably dominate an analysis of whether federal activities have preempted either conflicting state court actions or the entire field in general under the Supremacy Clause. U.S. CONST. Art IV § 2.


\(^{137}\) The United States has already entered into one international convention that might limit climate engineering experiments if they have military motives or implications. Under the Environmental Modification Treaty, the parties agree “not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.” CONVENTION ON THE PROHIBITION OF MILITARY OR ANY OTHER HOSTILE USE OF ENVIRONMENTAL MODIFICATION TECHNIQUES, Art. I §1 (entered into force in 1978). If an individual sought to conduct a climate engineering demonstration or research project in a fashion that might constitute such a military or “hostile use,” the United States may have a treaty obligation to take all constitutional steps to stop the project. Id. at art. IV (“[e]ach State Party to this Convention undertakes to take any measures it considers necessary in accordance with its constitutional processes to prohibit and prevent any activity in violation of the provisions of the Convention anywhere under its jurisdiction or control”). The Convention does not provide for any private actions by citizens of member States to directly enforce its provisions.

\(^{138}\) One concern not addressed here is whether principles of international and domestic law for transnational claims may raise additional opportunities for application of U.S. environmental laws and tort standards to climate engineering projects. For example, a foreign court may reach a judgment under its domestic law that would either seek to restrain or impose damages against operators of a climate engineering project. Attempts to enforce that judgment in the United States may raise complex issues of comity,
regulatory initiative, the novel risks and aspects of climate engineering point out the need for an explicit federal legislative response that would give clear direction to both agencies and researchers on critical issues such as permitting, liability and oversight.

In the absence of international action or federal legislative direction, however, U.S. environmental statutes and laws may provide a workable initial forum to lay the groundwork for risk management and governance of climate engineering projects that take place in the United States or which involve U.S. citizens or vessels. Researchers seeking to test or deploy climate engineering technologies will first have to determine whether federal and state environmental regulatory programs could apply to their projects. While Congress clearly did not foresee these technologies when it passed the key federal environmental statutes, certain aspects of climate engineering projects may fall under current federal environmental regulatory authority. In particular, climate engineering projects that seek to reduce solar radiation influx through large scale releases of sulfate aerosols from stationary sources may find themselves potentially subject to Clean Air Act regulation. To the extent federal environmental laws may oblige climate engineering researchers to seek authorizations or permits, the federal agencies in charge of those programs might need to begin drafting regulatory strategies and guidance that discuss the procedures and standards for their decisions to approve or reject these projects. Alternatively, federal agencies may also wish to explore their powers to halt objectionable climate engineering projects that pose unacceptable risks or spark strong public concern.

To the extent these federal and state environmental programs may not apply to specific climate engineering projects, challengers may instead turn to common law public nuisance causes of action to seek injunctions or damages. While U.S. federal common law on climate change public nuisance is in a deep state of flux and will soon receive U.S. Supreme Court review, climate engineering tort challenges may sidestep the controversy. In contrast with federal common law public nuisance climate change actions for effects from current and historical GHG emissions, climate engineering tort suits will present a better match with the U.S. courts’ institutional constraints and constitutional competencies (although they will still test the U.S. courts’ facility with highly complex and technical scientific issues). Absent earlier regulatory or legislative action to establish a framework for governing climate engineering efforts within U.S. jurisdiction, the federal and state courts should prepare for the bracing task of resolving domestic disputes over projects that are literally intended to reshape the global climate.

enforcement of foreign judgments that conflict with U.S. public policy, and due process constraints. The prospect of multiple and overlapping domestic court judgments arising from a single climate engineering project raises the risk of a patchwork array of national laws that will yield conflicting direction and liability standards. It also may empower nations with the harshest liability standards to seek to constrain or entirely halt climate engineering projects sponsored in other nations because of concerns that climate engineering liability.
Aside from these immediate legal questions, advocates on both sides of the climate engineering debate will face deep and difficult questions of environmental policy and judicial review. Environmental petitioners, for example, might find themselves wrestling over whether to oppose projects that would counteract disruptive climactic change effects and reduce ongoing environmental damage. Alternatively, defendants may find themselves arguing that federal environmental laws do not apply to their actions because they have not altered the environment as much as they have attempted to preserve or restore it. They will likely contend that federal agencies and the courts should use a more generous or accommodating standard when reviewing climate engineering projects that serve, ultimately, a restorative goal.

This issue evokes an even more challenging issue: can environmental statutes require the use of climate engineering techniques in certain circumstances? If the Endangered Species Act arguably mandates the use of habitat alteration or adaptation measures to save imperiled species, that same legal rationale could extend to regional or global climate engineering technologies that would allow threatened or endangered species to avert certain extinction. Ironically, the strong language of the UNFCC adopts a precautionary principle that could support a duty to take action even in the face of scientific uncertainty. Article 3 of the Convention establishes that “precautionary measures” against climate change should happen even without “full scientific certainty” regarding a strict cause and effect relationship. The language of this section reflects the signatories’ desire for policies to mitigate GHG emissions even without a unanimous chorus of support from the international community. Advocates for climate engineering can argue that under the convention’s mandate, even if the scientific community has not reached a consensus regarding its methods, climate engineering does offer a necessary “precautionary measure.”

The federal judicial branch has been rightly categorized as the least dangerous branch because of the unique limits and fragility of judicial review and the judicial power to resolve cases and controversies. Some climate engineering disputes may squarely meet the definition of case or controversy under federal constitutional law, yet still raise questions over projects that literally and intentionally could have global consequences. If so, the federal courts may find that even the most circumspect exercise of their judicial power to review climate engineering disputes could place the least dangerous branch squarely at the center of global efforts to address climate change. Climate engineering legal actions, as a result, could become an important crucible to test new legal theories for global environmental projects that invoke domestic or international mechanisms for liability and governance.
