PRISON OR PRECAUTION: UNILATERAL, STATE-MANDATED GEOENGINEERING UNDER PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW

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INTRODUCTION

Global temperatures are rising, polar ice is melting, and the oceans are acidifying.[1] In short, climate change is well under way.[2]

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1 U. Cubasch et al., *Introduction, in* CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS (T.F. Stoker et al. eds., 2013) [hereinafter IPCC 2013 REPORT],

According to the latest IPCC report, which was released in its entirety in November of 2014, this change is largely anthropogenic.[3] If humans maintain current rates of greenhouse gas ("GHG") emissions and take no remedial action, we will easily pass the so-called "tipping point"[4] beyond which the Earth's climate systems spiral out of control and the damage cannot easily be undone.[5] Indeed, we may have already passed the tipping point.[6] In order to meaningfully slow or permanently stop climate change, all the major industrialized nations in the world must cut back considerably on GHG emissions.[7] This would necessarily involve significant investment—for example, in new forms of energy and updates to infrastructure—and a concerted global effort to implement alternative energy consumption practices.

Yet the global economy and the economies of developed states in particular are intimately linked to current levels and forms

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http://www.climatechange2013.org/images/report/WG1AR5_Chapter01_FINAL.pdf.

2 *Id.*

3 *Id.*

4 Lisa V. Alexander et al., *Summary for Policy Makers, in* CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 16, (T.F. Stoker et al. eds., 2013) [hereinafter IPCC 2013 SUMMARY FOR POLICY MAKERS], http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf ("Equilibrium climate sensitivity is *likely* in the range 1.5°C to 4.5°C (*high confidence*)."); *id.* at 26 ("Based on Earth System Models, there is high confidence that the feedback between climate and the carbon cycle is positive in the 21st century.").

5 *See* WILLIAM NORDHAUS, THE CLIMATE CASINO: RISK, UNCERTAINTY, AND ECONOMICS FOR A WARMING WORLD 50–66 (2013) (defining and describing the "tipping points in the climate casino").

6 *See* Jonathan Foley et al., *Boundaries for a Healthy Planet*, SCI. AM., (Apr. 2010), http://www.scientificamerican.com/article/boundaries-for-a-healthy-planet/ ("Our group's analysis shows that three processes already exceed their boundaries: biodiversity loss, nitrogen pollution and climate change."); Chris Mooney, *The Melting of Antarctica Was Already Really Bad. It Just Got Worse.*, WASH. POST, (Mar. 16, 2015), http://www.washingtonpost.com/news/energy-environment/wp/2015/03/16/the-melting-of-antarctica-was-already-really-bad-it-just-got-worse/ (summarizing two studies which together indicate current rates of polar ice melt could lead to twenty feet of sea level rise).

7 *See, e.g.*, NORDHAUS, *supra* note 5, at 176–81 (projecting the dramatic difference in cost effectiveness between one hundred percent and fifty percent global participation, and concluding that "unless virtually all countries participate very soon, and do so in an efficient manner, achieving the Copenhagen target of limiting the increase in global temperature to 2°C is not possible with current or readily available technologies").

of energy consumption.[8] Additionally, some states have taken the position that the developed world should bear the brunt of the burden because, although states like China and India account for a large percentage of current emissions, states like the United States and European nations are responsible for more emissions historically.[9] Thus, until the historic agreement reached in Paris at the end of 2015, international negotiations to reduce emissions floundered for over a decade.[10]

Geoengineering, also known as climate engineering, could hold the key to preventing irreparable environmental harm. Geoengineering is the manipulation of the climate to slow or stop climate change or its symptoms without direct mitigation (i.e., without decreasing GHG emissions).[11] Yet the concept is highly

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8 THE NEW CLIMATE ECONOMY, ENERGY, BETTER GROWTH, BETTER CLIMATE: THE NEW CLIMATE ECONOMY REPORT, CH. 4 (2014), http://2014.newclimateeconomy.report/energy/; INSTITUTE FOR ENERGY RESEARCH, *Global Consumption of Fossil Fuels Continues to Increase* (June 18, 2015), http://instituteforenergyresearch.org/analysis/global-consumption-of-fossil-fuels-continues-to-increase/ (noting the 2008 financial crisis caused a dip in the world's ever-increasing energy consumption).

9 *See, e.g.*, Jennifer Duggan, *How China's Action on Air Pollution Is Slowing Its Carbon Emissions*, GUARDIAN (Nov. 21, 2013, 11:50 AM), http://www.theguardian.com/environment/chinas-choice/2013/nov/21/china-air-pollution-carbon-emissions.

10 Coral Davenport, *Nations Approve Landmark Climate Accord in Paris,* N.Y. TIMES (Dec. 12, 2015), http://www.nytimes.com/2015/12/13/world/europe/climate-change-accord-paris.html?_r=0; Tim Eigo, *Running Hot & Cold Q&A with Dan Bodansky: Expert Says Climate Change Policy Develops—Slowly*, ARIZ. ATT'Y, (Oct. 2010), at 22, 25–26 ("I've been following climate negotiations since 1991, when the framework convention was being negotiated. So I'll be talking about how the history of climate change has evolved. It started as a scientific issue in the 1970s, became a political issue in the 1980s, the first step was negotiation of the U.N. Framework Convention on Climate Change in 1991–92. That led to the negotiation of the Kyoto Protocol. And since then we've not been making a whole lot of progress for the last 13 years.").
Only time will reveal the Paris Agreements' efficacy, which is now hotly debated. *See* Tom Bawden, *COP21: Paris Deal Far Too Weak to Prevent Devastating Climate Change, Academics Warn*, INDEPENDENT (Jan. 8, 2016), http://www.independent.co.uk/environment/climate-change/cop21-paris-deal-far-too-weak-to-prevent-devastating-climate-change-academics-warn-a6803096.html ("The deal may have been trumpeted by world leaders but is far too weak to help prevent devastating harm to the Earth . . . .").

11 *See What Is Geoengineering?*, OXFORD GEOENGINEERING PROGRAMME, http://www.geoengineering.ox.ac.uk/what-is-geoengineering/what-is-geoengineering/ (last visited Aug. 24, 2014); Erik Conway, *Just 5 Questions: Hacking the Planet*, NAT'L AERONAUTICS AND SPACE ADMIN. (Apr. 14, 2014), http://climate.nasa.gov/news/1066/.

controversial. Some, though not many, have looked to geoengineering as a potential silver bullet to the climate change problem.[12] If there is a chance we could avoid the negative effects of climate change without fundamentally altering the global economy, the logic goes, we must pursue it. Others consider geoengineering extremely dangerous, both environmentally and politically. Many scientists have viewed the concept as such a threat to mitigation strategies that they have argued it should not even be discussed, let alone investigated or considered as an option.[13]

More likely, the truth lies somewhere between these two extremes. Given the serious, long-term global warming humans have already set in motion,[14] geoengineering is simply one strategy that ought to be researched and possibly employed in order to keep the climate from spiraling out of control.[15] However, we must consider which methods of geoengineering—as there are a

12 *See* David Suzuki, *Geoengineering: Silver Bullet or Cover Up for Climate Change?*, HUFFINGTON POST CAN. (Aug. 21, 2013, 9:40 AM), http://www.huffingtonpost.ca/david-suzuki/geoengineering-climate-change_b_3787099.html (arguing that a common misconception about geoengineering is that it could be a cure-all for climate change).

13 *See* Matthew Watson, *Why We'd Be Mad to Rule Out Climate Engineering*, GUARDIAN (Oct. 8, 2013, 10:07 AM), http://www.theguardian.com/environment/2013/oct/08/climate-engineering-geoengineering-climate-change (describing the ongoing, intense debate among experts over the inclusion of geoengineering in the latest IPCC report); Karen N. Scott, *International Law in the Anthropocene: Responding to the Geoengineering Challenge*, 34 MICH. J. INT'L L. 309, 354 (2013). ("[T]hese technologies arguably present a moral hazard; simply knowing that they are available may cause states and individuals to abandon the costly but necessary emissions reductions required to reduce atmospheric concentrations of greenhouse gases.").

14 *See, e.g.*, Eric Rignot, *Global Warming: It's a Point of No Return in West Antarctica. What Happens Next?*, OBSERVER (May 17, 2014, 3:30 PM), http://www.theguardian.com/commentisfree/2014/may/17/climate-change-antarctica-glaciers-melting-global-warming-nasa (reporting that a large part of Antarctica will definitely collapse due to climate change).

15 *See* Brad Plumer, *Should We Use Geoengineering to Cool the Earth? An Interview with David Keith*, WASHINGTON POST (Oct. 30, 2013), http://www.washingtonpost.com/blogs/wonkblog/wp/2013/10/30/david-keith-explains-why-geoengineering-isnt-as-crazy-as-it-sounds/ ("[G]eoengineering may be the best way to limit some of the damage from the carbon-dioxide we've already put in the atmosphere. At the very least, [Keith] says, scientists need to start researching the idea more thoroughly.").

multitude—would be best. Numerous metrics are relevant to such an inquiry, including safety, cost, political viability, and implementation-readiness. This Note considers only one narrow, but critical, aspect of the inquiry: whether any forms of unilateral, state-mandated geoengineering would be legal according to principles of international environmental law.

Part I of this Note briefly investigates alternative methods of geoengineering and their environmental and economic consequences. Part II considers which international environmental principles would be implicated by the implementation of geoengineering and what those principles might mean for the legality of geoengineering in general. In an effort to weigh alternatives to the gridlocked international negotiation process, this Note assumes that any geoengineering would be undertaken unilaterally by the U.S. government. The Conclusion then makes recommendations for U.S. policy, both domestic and international, given the analyses and conclusions of the previous sections.

I. METHODS OF GEOENGINEERING AND THEIR CONSEQUENCES

As stated above, there are many different methods of geoengineering. These methods can be divided into two main categories: solar radiation management ("SRM") and carbon capture and storage ("CCS").[16]

A. *Solar Radiation Management: Fast, Cheap, and Dangerous*

SRM works by reflecting some of the energy from the Sun back into space before it can impact the Earth's atmosphere and raise global temperatures.[17] This process could be implemented in space, in the atmosphere, or on the Earth's surface.[18] Atmospheric SRM might involve, for example, increasing the reflectivity and whiteness of clouds by pumping seawater into the atmosphere.[19]

16 *See, e.g.*, OXFORD GEOENGINEERING PROGRAMME, *supra* note 11.

17 *Id.*

18 A good illustration of this is available on the BBC News website, "Three Proposals to Reduce Temperature." *Tackling Climate Change with Technology*, BBC NEWS, http://news.bbc.co.uk/2/hi/technology/8338853.stm (last visited Aug. 24, 2014).

19 *See* Chris Berdik, *From the Labs: Six Geoengineering Ideas*, BOS. GLOBE (Oct. 20, 2013), http://www.bostonglobe.com/magazine/2013/10/19/geoengineering-schemes-from-cloud-brightening-space-mirrors/Dw9xmqdbtdV8cGv4K93cJN/story.html.

Alternatively, sulfate particles could be injected into the atmosphere[20]—a technique shown to be successful due to the global cooling following volcanic eruptions.[21] Space-centered SRM, which would not directly alter the Earth's atmosphere, might involve the placement of reflective satellites (sometimes called "space mirrors") in Earth's orbit in order to divert small amounts of radiation from the Sun before it even reaches the atmosphere.[22]

As evidenced by the foregoing examples, atmospheric or space-centered SRM methods would necessarily take place in the global commons.[23] By contrast, most earth-bound SRM methods—such as painting urban surfaces like rooftops and streets white to increase their reflectivity[24]—could be implemented exclusively within a nation's sovereign borders. This sort of scheme would be more difficult to implement, however, because it would typically involve the participation of many private property owners or institutionalization through local legislation,[25] and the resultant cooling would generally be less significant than could be achieved through other SRM methods.[26]

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20 *Id.*

21 *See* Karen Harpp, *How Do Volcanoes Affect World Climate?*, SCI. AM. (Oct. 4, 2005), http://www.scientificamerican.com/article/how-do-volcanoes-affect-w/ ("Despite its smaller ash cloud, El Chichón emitted more than 40 times the volume of sulfur-rich gases produced by Mt. St. Helens, which revealed that the formation of atmospheric sulfur aerosols has a more substantial effect on global temperatures than simply the volume of ash produced during an eruption. Sulfate aerosols appear to take several years to settle out of the atmosphere, which is one of the reasons their effects are so widespread and long lasting.").

22 *See* Berdik, *supra* note 19.

23 *See* Division of Environmental Law and Conventions, *IEG of the Global Commons*, UNEP, http://www.unep.org/delc/GlobalCommons/tabid/54404/Default.aspx (last visited Aug. 24, 2014).

24 *See generally* Hashem Akbari et al., *The Long-Term Effect of Increasing the Albedo of Urban Areas*, ENVTL. RES. LETTERS 1 (Apr. 12, 2012), http://iopscience.iop.org/article/10.1088/1748-9326/7/2/024004/pdf (describing the resulting cooling effect of painting urban surfaces for albedo enhancement).

25 *Id.* (proposing the customization of "local ordinances, standards, policies and programs to promote the use of white or light color urban surface materials as they are replaced," and noting that such replacement can take anywhere from ten to thirty years).

26 *Compare id.* (projecting small but significant cooling effects for every square meter of urban space replaced with a lighter-colored material, and suggesting it could take one to three decades), *with* David Rotman, *A Cheap and Easy Plan to Stop Global Warming*, MIT TECH. REV. (Feb. 8, 2013), http://www.technologyreview.com/featuredstory/511016/a-cheap-and-easy-plan-to-stop-global-warming/ ("According to Keith's calculations, if operations [to

Because scientists necessarily rely on models or small-scale experiments rather than live, full-scale experiments to predict the results of SRM, each of these methods involves significant levels of scientific uncertainty, and therefore significant risk.[27] Recent studies indicate, for example, that the injection of sulfates into the atmosphere would adversely affect monsoon seasons in Africa.[28] Similarly, the use of space mirrors could cause severe droughts in the United States and Eurasia.[29] It is difficult to anticipate what other unintended consequences SRM could have on the climate.

Another major flaw in any SRM plan is that it necessarily does not address the underlying cause of climate change: the presence of significant GHGs in the atmosphere. SRM may lower global temperatures, addressing the oft-cited problem of global warming. Yet the other ramifications of GHG emissions, such as ocean acidification, would continue unabated under any SRM regime.[30] For this reason, one scientist compared addressing climate change by utilizing SRM to "taking aspirin for cancer."[31] It would merely mask the symptoms of the disease. Furthermore, because SRM would not require mitigation in order to achieve global cooling effects, if mitigation were not simultaneously implemented, SRM would essentially become a prison sentence.

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inject sulfur into the stratosphere] were begun in 2020, it would take 25,000 metric tons of sulfuric acid to cut global warming in half after one year.").

27 *See, e.g.*, JEFF GOODELL, HOW TO COOL THE PLANET: GEOENGINEERING AND THE AUDACIOUS QUEST TO FIX EARTH'S CLIMATE 6 (2010) (pointing out that "there's no practice planet Earth").

28 *See* Damian Carrington, *Geoengineering Could Bring Severe Drought to the Tropics, Research Shows*, GUARDIAN (Jan. 8, 2014), http://www.theguardian.com/environment/2014/jan/08/geoengineering-drought-tropics-climate-change-volcano. *See generally* Angus J. Ferraro et al., *Weakened Tropical Circulation and Reduced Precipitation in Response to Geoengineering*, ENVTL. RES. LETTERS 1 (Jan. 8, 2014) (studying the effects of geoengineering on rainfall in the tropics).

29 *See Space Mirrors Will Dry Out US and Eurasia*, NEW SCIENTIST (June 13, 2012), http://www.newscientist.com/article/mg21428695.700-space-mirrors-will-dry-out-us-and-eurasia.html.

30 GLOBAL OCEAN COMMISSION, CLIMATE CHANGE, OCEAN ACIDIFICATION AND GEO-ENGINEERING (Nov. 2013), http://www.globaloceancommission.org/wp-content/uploads/GOC-paper02-climate-change.pdf ("A major drawback of all solar radiation management (SRM) technologies is that they do nothing to combat ocean acidification, other than perhaps ameliorating release of seabed methane.").

31 Graeme Wood, *Re-Engineering the Earth*, ATLANTIC (July 1, 2009), http://www.theatlantic.com/magazine/archive/2009/07/re-engineering-the-earth/307552/.

Without mitigation, once we begin pumping sulfates or seawater into the atmosphere, we risk catastrophic swings in climate conditions if we ever stop.[32] Then the purported cure could become as deadly as the disease itself.

In short, both commencing SRM geoengineering *and* ceasing it have the potential to be extremely dangerous to the climate. Still, there are significant upsides to SRM as well. Studies indicate that SRM would cause global cooling very effectively, and could be deployed soon.[33] And compared to the CCS methods discussed below, most SRM methods[34] appear incredibly inexpensive to implement.[35]

B. *Carbon Capture and Storage: Slow and Expensive, yet Effective*

While in practice CCS methods vary widely in form, in principle each method removes carbon dioxide (and potentially other GHGs) from the atmosphere. CCS could involve ambient air capture or point source capture of GHGs, reforestation or afforestation, or ocean fertilization—to name just a few approaches.[36]

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32 *See* Brad Plumer, *One Problem with Geoengineering: Once You Start, You Can't Really Stop*, WASH. POST (Jan. 2, 2014), http://www.washingtonpost.com/blogs/wonkblog/wp/2014/01/02/one-problem-with-geoengineering-once-you-start-you-cant-ever-stop/.

33 *See Tackling Climate Change with Technology*, *supra* note 18 (comparing different types of geoengineering according to effectiveness and cost).

34 Two exceptions are space mirrors and earth-bound albedo enhancement. *See supra* notes 22, 24–26 and accompanying text.

35 *See, e.g.*, William Daniel Davis, *What Does "Green" Mean?*, 43 GA. L. REV. 901, 925–26 (2009); Wood, *supra* note 31, at 72; Plumer, *supra* note 32. Of course, the relatively low cost of most SRM creates its own challenges, including the potential for rogue geoengineering by states or private parties. *See* David G. Victor, *On the Regulation of Geoengineering*, 24 OXFORD REV. ECON. POL'Y 322, 324 (2008) ("One large nation might justify and fund an effort on its own. A lone Greenfinger, self-appointed protector of the planet and working with a small fraction of the Gates bank account, could force a lot of geoengineering on his own. Bond films of the future might struggle with the dilemma of unilateral planetary engineering."). For the opposite view—that the risk of unilateral action is minimal—see Joshua Horton, *Geoengineering and the Myth of Unilateralism: Pressures and Prospects for International Cooperation*, 4 STAN. J.L. SCI. & POL'Y 56 (2011).

36 *See* SCIENCE AND TECHNOLOGY COMMITTEE, U.K. HOUSE OF COMMONS, THE REGULATION OF GEOENGINEERING: FIFTH REPORT OF SESSION 2009–10, at 12 (2010), http://www.publications.parliament.uk/pa/cm200910/cmselect/cmsctech/221/221

Effective CCS would have many benefits. Unlike SRM, most CCS could be implemented on a state's sovereign soil;[37] as discussed in Part II, this likely gives rise to fewer legal quandaries. Also unlike SRM, CCS would by definition address the underlying causes of climate change, even in the absence of mitigation efforts.

Yet the obstacles to broad implementation of CCS are significant. When it comes to the "capture" of GHGs, lack of technology and potentially insurmountable costs are the central issues. For example, the technology required for efficient, large-scale ambient air capture of GHGs does not exist.[38] Similarly, many sources of GHGs, such as automobiles and airplanes, are not currently susceptible to point-source capture technology.[39] And while point-source capture is already installed in some large, coal-fired power plants, it increases the cost of electricity generated by those power plants by three to four cents per kilowatt-hour.[40] As for afforestation and reforestation, the enormous quantity of trees required to make any impact on climate change is staggering.[41]

.pdf; OXFORD GEOENGINEERING PROGRAMME, *supra* note 11.

37 This excludes ocean fertilization, which would likely be implemented in international waters. However, ocean fertilization has been the subject of significant controversy due to rogue experimentation, *see* Grant Wilson, *Murky Waters: Ambiguous International Law for Ocean Fertilization and Other Geoengineering*, 49 TEX. INT'L L.J. 507, 509 (2014) (describing HSRC's dumping of one hundred tonnes of iron into the Pacific, likely in violation of Canadian and international law, to increase the salmon population and test ocean fertilization), and multiple studies have called its effectiveness into question, *see id.* at 516, 520–22 (pointing out that only twenty percent of the world's oceans are susceptible to ocean fertilization, and that the results of various studies of the effectiveness of ocean fertilization "are inconclusive regarding how much carbon is actually sequestered.").

38 *See* Klaus S. Lackner et al., *The Urgency of the Development of CO_2 Capture from Ambient Air*, 109 PROC. NAT'L ACAD. SCI. 13156, 13161 (2012), http://www.pnas.org/content/109/33/13156.full.pdf+html (concluding that "air capture research is still in its infancy" and acknowledging the difficulty in predicting this nascent technology's costs).

39 *See id.* at 13156.

40 NORDHAUS, *supra* note 5, at 164.

41 "The Canadian province of British Columbia has vast tracts of forest that are largely untouched. Suppose that British Columbia were to devote half of its forest land, or about 300,000 square kilometers, to carbon removal. This would involve growing trees, cutting them after they mature, and storing them in a way that prevents leakage of CO_2 into the atmosphere. British Columbia would soon have a huge mountain of trees, but devoting half the province to the project would offset less than 0.5 percent of the world's CO_2 emissions in coming years." *Id.* at 166.

The "storage" aspect of CCS is equally problematic. Most sequestered carbon today is injected into porous rock several kilometers underground.[42] Recent studies indicate that this practice may increase the likelihood of earthquakes.[43] Such earthquakes could break the seals of the storage system, possibly allowing some sequestered carbon to leak back into the atmosphere.[44] Large leaks from a storage facility could result in rapid, harmful climate change. With the possibility of massive leaks, this is perhaps another example of a cure worse than the disease itself.

Simply put, efficient CCS technology is months or years of costly research away. It will likely increase energy consumption costs once implemented. Storage of any captured GHGs involves its own environmental and economic hazards. Finally, without concurrent mitigation efforts, suddenly ceasing CCS would still implicate the same environmental risks as suddenly ceasing SRM: rapid swings in temperature leading to extreme climate events and potentially mass extinctions across the globe.[45] Yet if it can be safely implemented, CCS in conjunction with mitigation may be our best chance of avoiding a climate tipping point.

In addition to these scientific and financial considerations, a state implementing a unilateral geoengineering scheme must also evaluate the legal ramifications. The next Part addresses one portion of that inquiry: how unilateral, state-mandated geoengineering might implicate the principles of international law.

II. IMPLICATED PRINCIPLES OF INTERNATIONAL LAW

A. *Background*

The Statute of the International Court of Justice ("ICJ") lists three primary sources of international law that may be used to resolve a dispute among states: treaties, customs, and "general principles of law recognized by civilized nations."[46] A principle of

42 *See* Jeff Hecht, *Earthquake Risk for Carbon Capture and Storage Schemes*, NEW SCIENTIST (June 20, 2012, 1:24 PM), http://www.newscientist.com/article/dn21954-earthquake-risk-for-carbon-capture-and-storage-schemes.html.

43 *Id.*; NATIONAL RESEARCH COUNCIL, INDUCED SEISMICITY POTENTIAL IN ENERGY TECHNOLOGIES 1 (2013), http://www.nap.edu/catalog.php?record_id=13355.

44 *See* Hecht, *supra* note 42.

45 *See* Plumer, *supra* note 32.

46 Statute of the International Court of Justice art. 38, ¶ 1, June 26, 1945, 59

international law may be either "hard" and binding or "soft" and non-binding, depending on whether the principle has become customary.[47]

The rationale of customary law is rooted in reliance and predictability.[48] In order for a principle to attain the status of customary law, it must be consistently practiced by states, with the understanding that the practice is a legal duty.[49] However, if a particular state openly and consistently refuses to recognize an emerging (and later, established) custom, the non-participating state is exempt as a "persistent objector," even as other states are bound.[50]

Although non-binding, principles of international environmental law that do not yet have customary status still serve as guiding precepts for state action—in both the international and domestic arenas.[51] And because many principles in the field of international environmental law are relatively recent legal developments, they could still become customary law in the future.[52]

Stat. 1031.

47 PHILIPPE SANDS AND JACQUELINE PEEL, PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW 94–95, 112 (2012). Of course, if a state is a signatory to a treaty which includes a principle, then that principle is binding on the state within the context of the treaty terms regardless of whether the principle is a customary law.

48 *See Customary International Law*, INT'L JUD. MONITOR (Dec. 2006), http://www.judicialmonitor.org/archive_1206/generalprinciples.html.

49 "'[C]ustomary international law' results from a general and consistent practice of states that they follow from a sense of legal obligation." *Customary International Law*, LEGAL INFO. INST. (last visited Mar. 20, 2015), https://www.law.cornell.edu/wex/customary_international_law.

50 *See Customary International Law*, *supra* note 48.

51 *See generally, e.g.*, Carl Bruch, *Is International Environmental Law Really "Law"?: An Analysis of Application in Domestic Courts*, 23 PACE ENVTL. L. REV. 423, 462 (2006) (analyzing domestic courts' use of international environmental law, including principles, though noting that "[w]hile courts have a role in giving legal force to international environmental law, the primary responsibility for operationalizing international environmental law [domestically] rests with the legislative and executive branches.").

52 *See, e.g.*, Simon S.C. Tay, *Southeast Asian Fires: The Challenge for International Environmental Law and Sustainable Development,* 11 GEO. INT'L ENVTL. L. REV. 241, 242–43 (1999) ("[A] focus on these principles is essential to understanding and forecasting the future development of international environmental law and to judging present practices. The self-description of international environmental law as 'soft' is not an admission of inadequacy or failure, but is instead a conscious and necessary stratagem for influencing the development of new policies and 'hard' laws. International environmental law

Thus while some principles are fairly well established as customary law,[53] there is considerable disagreement among states and scholars as to the legal status of other principles.[54] This Note focuses on several notable general principles, analyzing each in turn to evaluate the impact they may have on the development of a U.S.-mandated, unilateral geoengineering program.[55]

B. *Analysis*

1. *The Principle of Sovereignty over Natural Resources*

Principle 21 of the Stockholm Declaration[56] and Principle 2 of the Rio Declaration[57] (hereinafter referred to jointly as the "principle of sovereignty over natural resources") provide at least a foundational legal justification for some unilateral geoengineering. The principle of sovereignty over natural resources is well established and widely considered customary law; the ICJ said as much in *The Threat or Use of Nuclear Weapons*, an advisory opinion from 1996.[58] As its name suggests, the principle is rooted

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might be an uncompleted project, but one undeniable achievement in this relatively new field has been the articulation of principles that serve as a blueprint for the further construction of laws.").

53 *See, e.g., infra* notes 58, 66, 82 and accompanying text (pointing out the long histories of the principle of sovereignty over natural resources, the preventive principle, and the principle of cooperation).

54 *See, e.g., infra* notes 77–78 and accompanying text (discussing the precautionary principle/precautionary approach debate).

55 Numerous articles have evaluated existing treaties to determine whether any offer a viable governance structure for geoengineering. No treaties were intended to perform that function, so the fit would seem inevitably imperfect. *See generally, e.g.*, David A. Wirth, *Engineering the Climate: Geoengineering as a Challenge to International Governance*, 40 B.C. ENVTL. AFF. L. REV. 413 (2013); Daniel Bodansky, *May We Engineer the Climate?*, 33 CLIMATE CHANGE 309 (1996). The principles selected here were drawn from multiple sources, but for a relatively inclusive list of principles relevant to international environmental law—and a thorough discussion of the background and legal status of each—see SANDS & PEEL, *supra* note 47, at 187–237.

56 United Nations Conference on the Human Environment, *Declaration of the U.N. Conference on the Human Environment*, princ. 21, U.N. Doc.A/CONF.48/14 (June 16, 1972) [hereinafter *Stockholm Declaration*].

57 United Nations Conference on Environment and Development, *Rio Declaration on Environment and Development*, princ. 2, U.N. Doc. A/CONF.151/26/Rev.1 (Vol. 1) Annex I (Aug. 12, 1992) [hereinafter *Rio Declaration*].

58 Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion, 1996 I.C.J. 226, ¶ 29 (July 8).

in sovereignty rather than environmental concerns.[59] Essentially, a state may authorize activities within its sovereign jurisdiction as it chooses, including activities that may harm the state's own environment. The state has the right to pursue these intra-territorial activities without interference from other states.[60]

Critically, however, a state's sovereignty over its natural resources is not unlimited. Both Principle 21 and Principle 2 are explicitly circumscribed by the other principles of international law.[61] Principle 21 and Principle 2 also articulate a significant responsibility as well as a right: the responsibility not to cause environmental damage beyond the acting state's sovereign borders.[62] Yet neither Principle 21 nor Principle 2 define "damage," specify how much damage would give rise to a violation, or clarify any legal standards for determining liability if a certain threshold of damage is reached. These uncertainties—typical of even well-established principles of international law—are challenges the United States would face if it seriously considered the implementation of unilateral geoengineering.

Geoengineering implemented entirely within the borders of the United States would seem fairly clear cut under the principle of sovereignty over natural resources, so long as its effects did not harm the environment of other states.[63] Indeed, at least for reforestation, afforestation, land-based albedo enhancement, and point-source and ambient air carbon capture, the principle of

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59 *See* SANDS & PEEL, *supra* note 47, at 191–92.

60 *See id.* at 192–93.

61 *Stockholm Declaration*, *supra* note 56 ("States have, *in accordance with the Charter of the United Nations and the principles of international law*, the sovereign right to exploit their own resources. . . .") (emphasis added); *Rio Declaration*, *supra* note 57 ("States have, *in accordance with the Charter of the United Nations and the principles of international law*, the sovereign right to exploit their own resources . . . .") (emphasis added).

62 *Stockholm Declaration*, supra note 56 ("States have . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."); *Rio Declaration*, *supra* note 57, ("States have . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.").

63 And such harm would seem unlikely, unless the United States (improbably) attempted something like ocean fertilization inside its own waters, which could lead to negative environmental impacts in international waters or in the waters of a neighboring state. See discussion *supra* Part I for a further evaluation of the negative consequences of various geoengineering methods.

sovereignty over natural resources should provide a legal argument that unilateral geoengineering is a state right.[64] The United States would argue that, as a sovereign nation, it is free to utilize its land and its resources in whatever way it sees fit, without international interference. If other countries are free to fill the atmosphere with GHGs, the United States is certainly free to remove those GHGs, or to limit their effects, when the activities that accomplish this occur wholly within the state's sovereign borders.

However, the principle's limitations could preclude this argument for most SRM methods because, as described above in Part I.A., such geoengineering could affect monsoon seasons, lead to droughts, or cause other environmental harms well outside U.S. borders. Still, environmental harms from SRM are not guaranteed. Furthermore, a state allegedly injured by U.S. geoengineering would likely struggle to prove causation—i.e., that the geoengineering in question actually resulted in the state's injury—which could be required for the state to recover anything against the United States.[65] Therefore, if this principle of sovereignty over natural resources were the only implicated international law, the United States might be willing to assume the risk of liability and implement an SRM program—at least if circumstances became sufficiently urgent.

But no single principle exists in a vacuum. The United States must also contend with the principles of preventive action and precaution, each of which could arguably doom a unilateral geoengineering program before it begins.

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64 The validity of this argument remains an open question, and if ever tested, would likely be in the climate change context. *See* SANDS & PEEL, *supra* note 47, at 195 (discussing the controversial "effects" doctrine, and the extent to which a state may implement unilateral environmental measures under the principle of sovereignty over natural resources).

65 Although both the principle of sovereignty over natural resources and of good neighborliness have been viewed as customary law by international tribunals, *see* SANDS & PEEL, *supra* note 47, at 192, 195–96, it remains unclear whether and how a good neighborliness violation would give rise to liability, *see id.* at 706–14 (discussing how to define "environmental damage," what threshold of harm might give rise to liability, and options for the appropriate standard of care). No international liability regime currently exists for geoengineering-related harms. For a more in-depth discussion on liability in geoengineering, see generally Joshua B. Horton, Andrew Parker, & David Keith, *Liability for Solar Geoengineering: Historical Precedents, Contemporary Innovations, and Governance Possibilities*, 22 N.Y.U ENVTL. L.J. 225 (2015).

2. *The Principles of Preventive Action and Precaution*

The principle of preventive action, which is firmly rooted in international law,[66] requires states to do what is necessary to address "serious or irreversible"[67] environmental harms, ideally *before* they occur.[68] This may initially appear to overlap with the principle of good neighborliness.[69] Yet while the latter is rooted in sovereignty concerns, the former focuses on avoiding environmental harms themselves, with a particular emphasis on due diligence and procedure.[70] Thus a state may be obligated to prevent environmental damage even within its own jurisdiction. Consequently, depending on the form of unilateral geoengineering, this could further limit the legally viable options. For example, if turning the entire state of North Dakota into an exclusively oak forest would constitute an environmental harm for purposes of the principle of preventive action, it would violate international law despite being permissible under the principle of sovereignty over natural resources.

However, the principle of preventive action applies to actions for which the potential risks are *known*.[71] Nearly all forms of geoengineering involve high levels of uncertainty, because (as noted in Part I) full-scale testing is often impossible. Massive-scale afforestation could negatively impact local ecosystems, or it could have no serious impact.[72] Spraying sulfate particles into the atmosphere, if done very precisely, might have no noticeable effect at all on the climate other than to cause cooling—or it could have apocalyptic ramifications.[73] We simply do not know what all the

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66 *See* SANDS & PEEL, *supra* note 47, at 200, 202–03.

67 This is one example of the threshold for harm articulated in international agreements. *See, e.g.*, *Stockholm Declaration*, *supra* note 56, princ. 6 ("The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems.").

68 *See* SANDS & PEEL, *supra* note 47, at 201.

69 *See infra* notes 82–86 and accompanying text.

70 *See* SANDS & PEEL, *supra* note 47, at 200.

71 *See* ROSIE COONEY, THE PRECAUTIONARY PRINCIPLE IN BIODIVERSITY CONSERVATION AND NATURAL RESOURCE MANAGEMENT: AN ISSUES PAPER FOR POLICY-MAKERS, RESEARCHERS AND PRACTITIONERS 8 (2004).

72 *See, e.g.*, *Great Green Wall: Afforestation in China*, ECONOMIST (Aug. 23, 2014), http://www.economist.com/news/international/21613334-vast-tree-planting-arid-regions-failing-halt-deserts-march-great-green-wall.

73 *Cf.* Plumer *supra* note 32 (explaining that suddenly ceasing sulfate sprays

potential risks are, or the potential severity of expected risks, for many forms of geoengineering. Therefore, the United States could argue that it has no obligation under the principle of preventive action to refrain from unilateral geoengineering—if the state has made reasonable efforts to determine and quantify the risks, satisfying due diligence, but the risks remain uncertain. Furthermore, the United States or others in the international community may in fact be obligated under the very same principle to *implement* geoengineering if anthropogenic climate change becomes a great enough threat to the environment and mitigation alone is no longer a viable option.[74]

Although uncertainty of the risks may leave the principle of preventive action largely out of the legal fray, such uncertainty could still implicate the precautionary principle. Principle 15 of the Rio Declaration provides one articulation of the precautionary principle: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[75] Essentially, a lack of scientific certainty does not excuse actions (or inactions) that could cause environmental harm.

Like all principles of international law, the specifics of the precautionary principle are a bit murky.[76] The precautionary

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could lead to catastrophic swings in climate conditions—swings which could just as easily be caused by a too-rapid initial implementation of sulfate sprays).

74 Article 2 of the UNFCCC articulates the principle of preventive action as applied to climate change:

> "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would *prevent dangerous anthropogenic interference with the climate system*. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

United Nations Framework Convention on Climate Change art. 2, May 9, 1992, 1771 U.N.T.S. 107 [hereinafter UNFCCC] (emphasis added). Note that the threshold for harm in this case is "dangerous" rather than "serious or irreversible."

75 *Rio Declaration*, *supra* note 57, princ. 15.

76 For an interesting analysis of the precautionary principle's inherent incoherence, see CASS SUNSTEIN, LAWS OF FEAR: BEYOND THE PRECAUTIONARY PRINCIPLE (2005) ("[T]he Precautionary Principle is literally incoherent, and for one reason: There are risks on all sides of social situations. It is therefore

principle is relatively new.[77] Some states, including the United States, do not even recognize it as a principle of international law, referring to it instead as the "precautionary approach."[78] Articulations of the precautionary principle commonly include qualifying language that the environmental threat must be "serious" or "irreversible," though this is not always the case.[79] The extent of scientific uncertainty necessary to avoid implicating the principle—if possible at all—is also currently unclear.

Because the United States has consistently declined to recognize the precautionary principle as binding law, it would seem unlikely that the principle would sway U.S. policymakers from implementing an otherwise valid unilateral geoengineering program. Indeed, if a U.S. geoengineering plan were properly challenged in the ICJ on the grounds that the plan violated the precautionary principle, the United States would likely deny that precaution is a principle at all, then claim a persistent objector exemption in the alternative. And if the United States were to factor the precautionary principle into its calculus (as any good lawyer would advise policymakers to do), the state would certainly prefer an interpretation with limiting language requiring "irreversible" environmental harm. While some geoengineering methods, such as SRM if improperly implemented or rapidly ceased,[80] could cause both dangerous and irreversible environmental harm, other geoengineering methods seem relatively unlikely to cause permanent environmental damage.[81] Moreover, unilateral geoengineering would presumably only be implemented to address the threat of serious or irreversible environmental damage brought about by anthropogenic climate change. Accordingly, much like the principle of preventive action,

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paralyzing; it forbids the very steps that it requires. Because risks are on all sides, the Precautionary Principle forbids action, inaction, and everything in between."). Sunstein proposes a "catastrophic harm precautionary principle" instead, to resolve this incoherence. *See generally* Cass Sunstein, *Irreversible and Catastrophic*, 91 CORNELL L. REV. 841 (2006).

77 *See* SANDS & PEEL, *supra* note 47, at 217–18.

78 *See* Gregory C. Shaffer, Mark A. Pollack, *Hard vs. Soft Law: Alternatives, Complements, and Antagonists in International Governance*, 94 MINN. L. REV. 706, 793–94 (2010) (describing the United States' persistent efforts to thwart the development of the precautionary principle in WTO cases).

79 *See* SANDS & PEEL, *supra* note 47, at 218–21.

80 *See* discussion *supra* Part I.A.

81 *See* discussion *supra* Part I.B.

the precautionary principle could underscore the *need* for geoengineering rather than preclude its implementation.

3. *The Principles of Cooperation and Common but Differentiated Responsibility*

The unilateral nature of a geoengineering plan adopted exclusively by the United States presents its own legal challenges, particularly given the principle of cooperation (also referred to as the principle of good neighborliness). The principle of cooperation is well established in international environmental law.[82] As Principle 24 of the Stockholm Declaration states: "[i]nternational matters concerning the protection and improvement of the environment should be handled in a cooperative spirit by all countries, big and small, on an equal footing."[83] Under this principle, broadly understood, states should work together in good faith on environmental issues. In individual instances, this may manifest as information sharing or joint decision-making requirements.[84] The principle of cooperation has also been interpreted to encourage states to work together to create suitably uniform regulatory regimes for resolving environmental problems.[85]

The United States could at least minimize legal challenges to its unilateral program if it first attempts to bring its preferences and ideas before an international forum—perhaps during a meeting

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82 *See* SANDS & PEEL, *supra* note 47, at 203–04 ("The obligation to co-operate is affirmed in virtually all international environmental agreements of bilateral and regional application, and global instruments. It also underscores the ICJ's reminder of the need to establish suitable common regimes.") (footnotes omitted).

83 *Stockholm Declaration*, *supra* note 56, princ. 24.

84 *See, e.g.*, United Nations Environment Programme (UNEP) Draft Principles of Conduct, In the Field of the Environment for Guidance of States in the Conservation and Harmonious Utilization of Natural Resources Shared by Two or More States, princ. 7, U.N. Doc. UNEP/1G12/12 (1978), reprinted in 17 I.L.M. 1097, 1099 (1978) ("Exchange of information, notification, consultations and other forms of co-operation regarding shared natural resources are carried out on the basis of the principle of good faith and in the spirit of good neighborliness."); Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, art. 20, Sept. 8, 1995, 34 I.L.M. 1542 (outlining international cooperation in enforcement).

85 *See* Kasikili/Sedudu Island (Bots. v. Namib.) 1999 I.C.J. 1045, ¶¶ 102–03 (Dec. 13).

under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC). If and when the United States fails to convince the international community to take reasonable steps to implement necessary geoengineering, then it may proceed with its own geoengineering program without any argument that it did not make a good faith effort to cooperate with other nations. But any international agreement or negotiation takes time—often years. Even if the U.S. government ever amassed the political will and unity internally to implement a national geoengineering program, given the current, deep partisan divide on possible climate change legislation, such will could be fragile and falter during extended international talks.[86] The chance that, by waiting to bring the rest of the international community on board, no geoengineering program would be implemented at all may be too great a risk.

As an alternative, the United States could begin the process of implementing a geoengineering program—which would no doubt take some time to set in motion—while simultaneously attempting to negotiate internationally. The principle of cooperation arguably requires no more than good faith and transparency; indeed, it would be unreasonable and infeasible for the principle to require complete unanimity in every situation. If the United States makes information on its plans publicly available, and invites international comment on its plans or sincerely attempts to come to international consensus, these actions may be sufficient to fulfill its obligations under the principle of cooperation. Furthermore, even after its geoengineering program is in place, the United States could work collaboratively with other states to uniformly regulate geoengineering internationally, as well as solicit enforcement or implementation aid from other states.

The principle of common but differentiated responsibility also obligates a state to cooperate with the international community to

86 Jocelyn Kiley, *Ideological Divide Over Global Warming as Wide as Ever*, PEW RES. CTR. (June 16, 2015), http://www.pewresearch.org/fact-tank/2015/06/16/ideological-divide-over-global-warming-as-wide-as-ever/. And the United States is not the only country to face such polarized views on climate change. Political parties have lost control over governments due in part to climate change-related disagreements. Bruce Stokes, *The U.S. Isn't the Only Nation with Big Partisan Divides on Climate Change*, PEW RES. CTR. (Nov. 6, 2015), http://www.pewresearch.org/fact-tank/2015/11/06/the-u-s-isnt-the-only-nation-with-big-partisan-divides-on-climate-change/.

address climate change[87] and other environmental issues. One iteration of the principle can be found in Principle 7 of the Rio Declaration, which reads in part: "States shall co-operate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributors to global environmental degradation, states have common but differentiated responsibilities."[88] The differentiation in responsibility is based on a particular state's contribution to the environmental problem, as well as the state's (typically economic) capacity to address the problem.[89]

In the climate change context, of course, developed nations like the United States are both the wealthiest and the largest historical contributors to increased atmospheric GHGs.[90] Therefore, under a straightforward application of the principle of common but differentiated responsibility, the United States should bear a greater obligation to address the climate change problem than many other states. If geoengineering becomes necessary to stop or slow the harmful effects of climate change, then the United States should be *more* responsible for developing at least one viable form and implementing it.[91] Perhaps the principle of common but differentiated responsibility, like the principle of cooperation, would oblige the United States to attempt some greater international involvement in its geoengineering program. Even more likely, the principle would oblige other states, such as

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87 Although not all environmental resources fall under the purview of the principle of common but differentiated responsibility, the Earth's climate appears to; climate change has been designated a "common concern of humankind" in treaties. UNFCCC, *supra* note 74, pmbl.

88 *Rio Declaration*, *supra* note 57, princ. 7; *see also Stockholm Declaration*, *supra* note 56, princ. 23.

89 SANDS &PEEL, *supra* note 47, at 233, 235.

90 *See supra* note 9 and accompanying text.

91 Although this Note focuses on state-mandated geoengineering to highlight potential legal pitfalls or incentives under principles of international law, there are clearly other possibilities. The United States could sponsor geoengineering in a variety of ways that would not require a top-down, government-implemented program. For example, the United States could offer tax incentives to companies that enter the field or provide economic development grants. Use of unique tools, such as a contest for federal funding, could also be arranged. Federal agency regulatory authorities could (and, given the potential environmental harms, likely should) assume the oversight of this development, although congressional action to set strict time limits may be needed to ensure timely development and implementation of any model that gains agency approval. Other nations may have similar means to implement geoengineering.

the members of the European Union, to affirmatively seek to participate. Yet in absence of broader international agreement on a geoengineering program, the principle should not preclude the United States from moving forward alone—so long as the geoengineering method adopted "conserve[s], protect[s] and restore[s] the health and integrity of the Earth's ecosystem" rather than further harming it.

4. *The Principle of Sustainable Development and the Polluter Pays Principle*

Two additional principles are less relevant for this inquiry into state-mandated, unilateral geoengineering, but are still interesting and fairly recent innovations in international environmental law: the principle of sustainable development and the polluter pays principle.

Sustainable development has been a robust area of scholarship in recent years,[92] no doubt because it integrates three important strands of international law—human rights law, trade law, and environmental law—into one overarching goal. Although the concepts underpinning the principle of sustainable development have long histories in international law, the term itself first appeared on the scene in the 1980s, and an articulation of the principle was not present in treaties until as late as 1992.[93] Despite its relative youth, the principle is now recognized by states and tribunals all across the globe.[94]

Broadly speaking, sustainable development is the responsibility of states to ensure that their current activities and resource use will still allow both present and future generations to meet their own needs.[95] Based on a survey of various international

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92 *See, e.g.*, KLAUS BOSSELMANN, THE PRINCIPLE OF SUSTAINABILITY: TRANSFORMING LAW AND GOVERNANCE (2013); HANS CHRISTIAN BUGGE & CHRISTINA VOIGT, SUSTAINABLE DEVELOPMENT IN INTERNATIONAL AND NATIONAL LAW: WHAT DID THE BRUNDTLAND REPORT DO TO LEGAL THINKING AND LEGAL DEVELOPMENT, AND WHERE CAN WE GO FROM HERE? (2008); John C. Dernbach, Patricia E. Salkin, Donald A. Brown, *Sustainability as a Means of Improving Environmental Justice*, 19 J. ENVTL. & SUSTAINABILITY L. 1 (2012); John R. Nolon, *Shifting Paradigms Transform Environmental and Land Use Law: The Emergence of the Law of Sustainable Development*, 24 FORDHAM ENVTL. L. REV. 242 (2012–2013); Alison Peck, *Sustainable Development and the Reconciliation of Opposites*, 57 ST. LOUIS U. L.J. 151 (2012).

93 *See* SANDS & PEEL, *supra* note 47, at 206.

94 *See id.* at 207.

95 SANDS & PEEL, *supra* note 47, at 206–07.

agreements, Philippe Sands and Jacqueline Peel describe the principle as encompassing four primary (and sometimes overlapping) elements, each of which could constitute principles in their own right.[96] These are: the principle of intergenerational equity, or the duty to preserve resources for future generations; the principle of sustainable use; the principle of intragenerational equity, or the duty of a state to consider the needs of other states; and the principle of integration, or the responsibility of states to have their environmental and economic objectives influence one another rather than handle them independently.[97]

When it comes to a unilateral geoengineering program, this principle seems to take an analytical backseat to the principles that focus more on environmental damage or the potential for it, such as the principle of preventive action and the precautionary principle. If mitigation and adaptation become insufficient approaches to address the harmful environmental effects of climate change, then it may ultimately be in the best interests of both present and future generations to implement some geoengineering plan. On the other hand, if a particular form of geoengineering would harm the environment more than help, then the principle of sustainable use would cut against its implementation. Ultimately, the United States would need to consider just how harmful implementing geoengineering would be to the environment and the Earth's natural resources, and compare that to how harmful *failing* to implement geoengineering would be.

The relevance of the polluter pays principle would depend on the geoengineering legislation enacted by the United States. The principle, which is still a fairly recent development, but which the United States has already integrated into its own domestic laws,[98] obliges states to ensure that the cost of an environmental harm is borne by the person or entity which causes it, so that the cost is not a market externality.[99]

If the United States adopted a regulatory approach to geoengineering similar to its approach to military defense

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96 *See id.*

97 *See id.*

98 *See generally* Eric Thomas Larson, *Why Environmental Liability Regimes in the United States, the European Community, and Japan Have Grown Synonymous with the Polluter Pays Principle*, 38 VAND. J. TRANSNAT'L L. 541 (2005).

99 *See id.* at 545.

contracts, then under the polluter pays principle the U.S. government would be responsible for ensuring that the private entity that organized and implemented the geoengineering program would incorporate any environmental damage into its contract price. By contrast, if the United States were to create a governmental body to implement a geoengineering program—as when the federal government created the Tennessee Valley Authority to construct and maintain dams in the Tennessee Valley basin, for example[100]—then the polluter pays principle would not necessarily be implicated at all.

CONCLUSION

The arguments for and against geoengineering, even when analyzed through the lens of these principles of international environmental law, hang in large part on the efficacy and risks of the particular geoengineering plan itself. If scientists conclusively discover that geoengineering of a certain variety will be damaging to the ecosystems of foreign countries, then unilateral implementation of such geoengineering would be prohibited under the principles of sovereignty over natural resources and preventive action.[101] If scientists develop a clearer understanding of the risks of certain geoengineering, even if environmental harm remains uncertain, the geoengineering is more likely unlawful under the precautionary principle[102]—although the United States would probably either deny the principle's existence altogether or claim an exemption as a persistent objector.[103]

Yet we *know* with some scientific certainty that climate change is a threat to the Earth's environment;[104] if geoengineering becomes the only way to end or lessen the severity of that threat, perhaps the risk-based arguments against geoengineering would lose their forcefulness. Indeed, as Principle 15 of the Rio Declaration states, "[w]here there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent

100 Tennessee Valley Authority Act of 1933, 16 U.S.C. § 831 (2014).
101 *See supra* notes 56–74 and accompanying text.
102 *See supra* note 75 and accompanying text.
103 *See supra* note 78 and accompanying text.
104 *See supra* notes 1–7 and accompanying text.

environmental degradation."[105] Threats of serious or irreversible damage due to climate change only grow as GHG emissions continue unabated. Thus, based on this non-binding articulation of the precautionary principle, lack of scientific certainty regarding geoengineering (which in some forms is quite cost effective[106]) and its risks ought not be a basis for delaying the implementation of a geoengineering plan in order to stop the harmful effects of climate change.

Of course, it is worth noting that the incentives appear somewhat backward here. First, the less we know about the dangers of geoengineering, the more lawful those programs appear to be under the principles of preventive action and precaution. Yet as a policy we would not wish scientists to stop researching geoengineering and leave its risks a total mystery in order to implement it. Second, in order for the public to break out of its current inertia of inaction and rally behind a geoengineering program (to say nothing of basic mitigation), it may need to witness even more, and even more extreme, environmental catastrophes caused by climate change. Yet as a policy it would be far better to solve the problem of climate change *before* its more tragic consequences manifest—and by the time the worst of the problem is apparent, it may already be too late. While this second problem is perhaps an unavoidable aspect of the democratic process, the first problem could potentially be addressed through reinterpretation of existing principles of international law, or even through the development of a new principle. For example, as noted, Cass Sunstein has proposed an alternative conception of the precautionary principle so that its directive is clearer in times of looming environmental disaster.[107] Alternatively, perhaps the principles of sustainable development or preventive action ought to expand to encompass an emphasis on scientific research, so we can better understand how our actions impact the environment and alter our conduct accordingly.

The principles of international law also clearly articulate a strong preference for coordinated effort, transparency, and uniform regulatory frameworks. This is unsurprising, given the roots of

105 *Rio Declaration*, *supra* note 57, princ. 15.

106 *See supra* Part I.

107 *See supra* note 76 (noting how the precautionary principle can be interpreted to both require and prohibit the same action).

international law itself; the United Nations, for example, was formed "[t]o achieve international co-operation in solving international problems of an economic, social, cultural, or humanitarian character"[108] and avoid "the scourge of war."[109] A unilateral geoengineering program by any state would be challenging, though perhaps not impossible, to justify in the face of the principles of cooperation and common but differentiated responsibility.[110] Still, while consensus is a worthy ideal, it is not often a practicality. If the United States were to make a good faith effort to accomplish its goals in an international forum, and make information about any program it intended to implement publicly available, then it could argue it had the legal right—and perhaps even the legal obligation—to move forward with its geoengineering program in the absence of international agreement.[111]

Given all the variables weighed in this Note—the upsides and downsides of various methods of geoengineering, and the arguments for and against unilateral, state-mandated implementation under the principles of international environmental law—some policy recommendations naturally emerge.

First, recognizing the ambivalent nature of the principles of preventive action and precaution, set against the clear dangers of climate change, the United States should promote or fund research into all forms of geoengineering—but with particular emphasis on point source and ambient air CCS. CCS methods have a lower risk of dramatic fluctuations in atmospheric temperatures (assuming safe storage practices) and address ocean acidification as well as global warming.[112] They are also most justifiable to implement unilaterally under principles of international environmental law, because the programs could take place exclusively on sovereign soil. Additionally, unlike the cheapest SRM methods, they would not add any foreign substances to the atmosphere, but would rather remove GHGs—making it easier for the United States to counter arguments that a CCS program had harmed resources held in common or common interest with other states. If the United States

108 U.N. Charter art. 1, ¶ 3.

109 *Id.* at pmbl.

110 *See supra* notes 82–91 and accompanying text.

111 *See id.*

112 *See supra* Part I.B.

further wished to share any technological developments with other nations, or seek international input on its research in this area, this would put the United States in an even better position under the principle of cooperation.

Second, and simultaneously, the United States should work to uniformly regulate implementation of and research into the more dangerous and less costly forms of geoengineering, such as sulfate particle or saltwater sprays, in the international community. Doing so will highlight the dangers involved to states that may be more tempted to implement such geoengineering methods on their own—perhaps island nations that are facing the complete loss of their land[113]—as well as illustrate the United States' good faith in seeking to address climate change through geoengineering in a cooperative fashion.

Indeed, a recent, two-part National Research Council committee report on geoengineering supports these two recommendations.[114] Its analysis is based on the political and scientific problems posed by various geoengineering methods.[115] Perhaps with both science and principles of international law pointing in similar directions, the international community will take heed, and begin to coordinate regulation of the most dangerous and cheapest forms of geoengineering. In the meantime, research into at least the lowest risk forms of geoengineering will harm no one, and should begin in earnest. Given the minimal progress that the world has made in mitigating GHG emissions thus far, the research may turn out to have been a necessary precaution. And if the United States or any other actor does

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113 *See, e.g.*, Axel van Trotsenburg, *Pacific Islands Facing a Rising Tide*, WORLD BANK (Sept. 3, 2013), http://www.worldbank.org/en/news/opinion/2013/09/03/pacific-islands-facing-a-rising-tide.

114 *See generally* NATIONAL RESEARCH COUNCIL, CLIMATE INTERVENTION: CARBON DIOXIDE REMOVAL AND RELIABLE SEQUESTRATION (2015) [hereinafter CARBON DIOXIDE REMOVAL REPORT]; NATIONAL RESEARCH COUNCIL, CLIMATE INTERVENTION: REFLECTING SUNLIGHT TO COOL EARTH (2015); Press Release, National Academies, Climate Intervention Is Not a Replacement for Reducing Carbon Emissions; Proposed Intervention Techniques Not Ready for Wide-Scale Deployment (Feb. 10, 2015), http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=02102015 (summarizing the two reports, including that "overall the risks [of CCS, aside from ocean iron fertilization] are relatively low and generally understood" and that "it would be 'irrational and irresponsible' to implement sustained albedo modification without also pursuing emissions mitigation, carbon dioxide removal, or both.").

115 *See, e.g.*, *id.* at tbl. S1.

eventually implement geoengineering to address the climate change disaster, one can only hope that the chosen method is thoroughly researched beforehand, that it is initiated as a last resort, and that it does not become just another prison for future generations, as the climate change problem has been for ours.