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Law in the Anthropocene Epoch

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Humans and the effects of their activities now substantially influence the entire planet, including its oceans, climate, atmosphere, and lands. Human influence has become so large that earth scientists have debated whether to identify a new geologic time period: the Anthropocene. The Anthropocene will surely have substantial effects on society and economies, and law will be no exception. The Anthropocene is the product of the aggregation of billions of individual human actions, the impact of which is exponentially increasing because of growing technological advances and population. Humans will inevitably respond to the Anthropocene, if only to adapt to the significant changes in oceans, climate, biodiversity, and other critical functions upon which society depends. These responses will ineluctably lead to greater government involvement in a wide range of human activities and the constant updating of government laws and regulations to respond to new challenges. The result will put pressure on a wide range of legal doctrines in public and private law, including torts, property, constitutional, administrative, and criminal law. These changes will parallel similar revolutionary legal changes associated with industrialization and the development of a national economy in the United States in the nineteenth and twentieth centuries. Just as with those legal changes, the legal changes of the Anthropocene will put pressure on normative commitments at the heart of American law, including the classical liberal paradigm that government intrusion into individual action should be the exception, rather than the norm. Managing the impacts of these legal changes will be a key challenge for the legal system in the next century.

TABLE OF CONTENTS

INTRODUCTION	3
I. THE ANTHROPOCENE EPOCH	8
A. IMPAIRMENTS BY HUMANS OF GLOBAL SYSTEMS	9
B. INCREASING RATE OF CHANGE IN IMPAIRMENTS	13

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C.	CONSEQUENCES FOR SOCIETY FROM THE ANTHROPOCENE	14
D.	IMPORTANCE OF THE AGGREGATION OF SMALL-SCALE INDIVIDUAL ACTIVITIES	22
II.	MANAGEMENT AND LEGAL OPTIONS TO RESPOND TO THE ANTHROPOCENE	25
A.	MANAGEMENT CHOICES FOR THE ANTHROPOCENE	25
B.	POLICY OPTIONS TO IMPLEMENT MANAGEMENT CHOICES	27
1.	Direct Public Action	28
2.	Public Regulation	29
3.	Public Subsidies	29
4.	Incentives for Private Action	32
5.	Purely Voluntary Private Action	36
6.	Synergies Among Policy Options	39
7.	Doing Nothing	40
III.	IMPLICATIONS OF THE ANTHROPOCENE FOR THE LEGAL SYSTEM	40
A.	PRIVATE LAW	42
1.	Tort Law	42
2.	Property Law	46
B.	PUBLIC LAW	48
1.	Federalism and Constitutional Law	48
2.	Administrative Law and Statutory Interpretation	50
3.	Criminal Law	55
IV.	IMPLICATIONS OF THE LEGAL IMPACTS OF THE ANTHROPOCENE	60
A.	THE LEGAL TRANSFORMATIONS OF THE ANTHROPOCENE IN HISTORICAL CONTEXT	61
B.	THE COMING DISPUTES OVER THE LEGAL SHIFTS IN THE ANTHROPOCENE	65
	CONCLUSION	67

INTRODUCTION

In an intervenor brief challenging the Environmental Protection Agency's Clean Power Plan—a rule intended to restrict greenhouse gas emissions from fossil fuel power plants—Harvard Law professor Lawrence Tribe argued that the EPA's rule “threatens to run roughshod over individual liberties in its attempt to transform the American energy sector” and “presents the risk of the very kind of arbitrary and abusive governance that the Supreme Court has condemned.”¹ One might dismiss this language as the occasionally overheated rhetoric of appellate lawyers, despite its utterance by a highly respected academic. Although Professor Tribe may be wrong about the Clean Power Plan's legality, he has hit upon a fundamental problem that will continue to develop and expand over the next several decades and portends to upend American law and challenge fundamental normative political commitments of the American legal and political system.

That problem is the current and future tension between our legal and political system, and the growing human domination of the planet. Over the next one hundred years, humanity and the Earth will experience a shift to a new stage in global conditions that some earth scientists have proposed identifying as the Anthropocene Epoch.² The identification of geologic periods is not a casual event in earth science. Transitions between geological timeframes often correlate with significant changes in the functioning of the Earth, such as the beginning and end of ice age periods.

Earth scientists have proposed the identification of a new geologic time-frame because of the immense increase in human impacts on the planet. Exponential population and economic growth over the past two hundred years have fundamentally changed the relationship between humans and the biological and physical systems on the planet.³ Whereas humans were once a minor part of how those biological and physical systems functioned, they are now the dominant contributors—and for many of the systems where humans do not dominate, human impacts are rapidly increasing such that humans will likely dominate in the future.

The example of these changes that has attracted the most legal, political, and public attention is climate change: human emissions of greenhouse gases (primarily, though not exclusively, carbon dioxide) as a byproduct of the use of fossil fuels for energy production. Those changes, if they continue on their current paths, will cause alterations in the global climate system that have not occurred in millions of years.⁴

1. Final Opening Brief of Intervenors Dixon Bros., Inc. et al. in Support of Petitioners at 39, *West Virginia v. EPA*, No. 15-1363 (D.C. Cir. Apr. 21, 2016).

2. See Colin N. Waters et al., *The Anthropocene Is Functionally and Stratigraphically Distinct from the Holocene*, 351 *Sci.* 137, 137 (2016), <http://dx.doi.org/10.1126/science.aad2622> [<https://perma.cc/5DB7-F42Y>].

3. See *infra* Part I.

4. See *infra* Section I.B.

But the human-caused changes that have led to the proposed identification of the Anthropocene extend far beyond climate change.⁵ For example, human activities have caused fundamental changes in global oceans through acidification and the introduction of pollutants; humans now dominate the global nitrogen cycle (the pathway by which the essential element, nitrogen, moves between various biological and physical sources); human-produced air pollutants such as particulates and ozone now cross halfway around the world; and, in the near future, human activities may initiate a mass extinction of biodiversity comparable to that which eliminated the dinosaurs.⁶

Thus, human-caused impairments of global systems will cause tremendous impacts on society.⁷ Political, social, and economic systems will need to dramatically change to adapt to or mitigate these impacts. Doing nothing will increasingly not be an option as the global systems we depend on for air to breathe, water to drink, and food to eat shift in response to our actions.

Law will not be exempt from these changes. Pressures to adapt to the Anthropocene, or to mitigate the changes producing the Anthropocene, will in turn put substantial pressures on the legal system, which will have to change in response. Yet legal scholarship has only just come to terms with the implications of the Anthropocene for law, which is predominantly from the perspective of international law.⁸ Moreover, as this Article develops for the first time, the

5. See RICHARD J. LAZARUS, *THE MAKING OF ENVIRONMENTAL LAW* 210–11 (2004); see also *infra* Section I.A.

6. See *infra* notes 47–49 and accompanying text.

7. In this Article, I refer to the *global systems* (such as the climate, oceans, biodiversity, and nutrient cycles) that humans will *impair* through their actions. The human-caused impairment of global systems will, in turn, cause what I call *impacts* on ecosystems and society.

8. For discussion of the Anthropocene and international or comparative law, see generally VICTOR GALAZ, *GLOBAL ENVIRONMENTAL GOVERNANCE, TECHNOLOGY AND POLITICS: THE ANTHROPOCENE GAP* (2014) (describing institutional and political challenges for international law presented by the Anthropocene); Rakhyn E. Kim & Klaus Bosselmann, *International Environmental Law in the Anthropocene: Towards a Purposive System of Multilateral Environmental Agreements*, 2 *TRANSNAT'L ENVTL. L.* 285 (2013) (calling for articulation of specific goals for international environmental law to facilitate adequate response to the Anthropocene); Louis J. Kotzé, *The Anthropocene's Global Environmental Constitutional Moment*, 25 *Y.B. INT'L ENVTL. L.* 24 (2015) (arguing the Anthropocene may prompt development of a robust global environmental constitutional order); Davor Vidas et al., *International Law for the Anthropocene? Shifting Perspectives in Regulation of the Oceans, Environment and Genetic Resources*, 9 *ANTHROPOCENE* 1 (2015) (noting challenges changes in the Anthropocene will pose to an international legal order seeking to create stability); Davor Vidas, *The Anthropocene and the International Law of the Sea*, 369 *PHIL. TRANSACTIONS ROYAL SOC'Y A* 909 (2011) (identifying possible changes in the international law of the sea that might be prompted by the Anthropocene); Davor Vidas et al., *What Is the Anthropocene—and Why Is It Relevant for International Law?*, 25 *Y.B. INT'L ENVTL. L.* 3 (2015) (noting challenges changes in the Anthropocene will pose to an international legal order seeking to create stability); Markus Vordermayer, *'Gardening the Great Transformation': The Anthropocene Concept's Impact on International Environmental Law Doctrine*, 25 *Y.B. INT'L ENVTL. L.* 79 (2015) (arguing international law may be able to respond to challenges of the Anthropocene); Jorge E. Viñuales, *Law and the Anthropocene* (Cambridge Ctr. for Env't, Energy and Nat. Res. Governance, Working Paper No. 2016-5, 2016) (identifying research agenda for law and social sciences to respond to the Anthropocene). For literature exploring the interaction of the Anthropocene and environmental law, see *infra* note 18.

Anthropocene will have deep implications for a wide swath of American law—not just environmental law.

Law may adjust in a number of ways: it may facilitate adaptation through direct changes to legal systems, such as alterations of water rights in response to changes in precipitation patterns; facilitate technological innovation that will enable restoration of impairments to the global climate system, such as tools to remove carbon from the atmosphere; or facilitate mitigation through direct change to legal systems, such as the creation of taxes or regulatory systems to reduce emissions of greenhouse gases.

Academics and policymakers have long debated the utility of different legal tools in addressing environmental change—from the use of property rights to spark innovation and individual creativity to the use of government regulation to control adverse impacts of human activities.⁹ Such debates will likely continue in the Anthropocene and our response will require a mix of those legal tools.

What will be different about the Anthropocene is that no matter which strategy we adopt (direct adaptation, mitigation, or facilitation of innovation), and no matter which specific legal approach we use (property rights, taxes, or regulation), the dramatic increase in human impairments to global systems will trigger an increase in government intrusion in individual lives and decision making. Unless we choose to do nothing about the changes in the Anthropocene (an improbable outcome given current predictions), even the most libertarian of the options—increased property rights—will require massive increases in government intervention.

The changes in our legal systems in response to the Anthropocene will in turn strain the overall structure of our legal system.¹⁰ An increase in government intervention in society, whether through property-rights enforcement, taxes, or regulation, will test a range of legal doctrines intended to protect individual rights against government overreach.

For instance, many of the changes in the Anthropocene—including climate change—are the result of millions of individual actions, such as decisions by farmers to plow fields or manage livestock. Given the global nature of climate change, it seems reasonable that national or international regulation might include controlling agricultural practices or land use. But any such regulation will create strong tensions in U.S. constitutional law that identify areas, such as

9. See generally Bruce A. Ackerman & Richard B. Stewart, Comment, *Reforming Environmental Law*, 37 STAN. L. REV. 1333 (1985) (arguing for use of market-based mechanisms); Jonathan H. Adler, *Free & Green: A New Approach to Environmental Protection*, 24 HARV. J.L. & PUB. POL'Y 653 (2001) (arguing for use of private-property rights for environmental protection); Howard Latin, *Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reforms*, 37 STAN. L. REV. 1267 (1985) (arguing for use of regulatory instruments).

10. See Douglas A. Kysar, *What Climate Change Can Do About Tort Law*, 41 ENVTL. L. 1, 54 (2011); Richard J. Pierce, Jr., Remarks, *Legal Disputes Related to Climate Change Will Continue for a Century*, 42 ENVTL. L. 1257, 1273 (2012).

land use, as presumptively reserved to governance by the states.¹¹

The changes that the Anthropocene will impose on the legal system will challenge the law's careful balance between protecting individual liberties and managing the impacts that individual actions have on society.¹² Historically, American law has struck that balance by emphasizing the importance of protecting individual liberty, a choice that has been supported by an implicit presumption that the natural world acts as a "buffer" that protects other members of society from relatively small impacts caused by most individual acts.¹³ That presumption will no longer be true in a global environment dominated by human activities. The American legal system will, therefore, have to wrestle with how to protect society from the negative impacts of a wide range of individual activities while still protecting the liberal values of individual autonomy and liberty. In many ways, this will be one of the fundamental legal and political challenges facing the American legal system in the twenty-first century. This struggle will be worked out in significant part as courts, agencies, and legislatures adapt a wide range of doctrinal areas to the new reality of the Anthropocene.

The implications of ecological interconnectedness for a legal system that has prioritized individual liberty is not entirely new—indeed, many of the debates about the rise of environmental law from the 1970s to the present wrestle with these issues.¹⁴ In many ways, the Anthropocene is a logical extension of those challenges. Environmental law began by focusing on large sources of visible and immediately harmful pollution. As discussed in more detail below, over time we have recognized that almost every human activity affects the environment.¹⁵ The Anthropocene is simply the next step in the progression of both global growth in human population and resource use, and the effects of that growth on the environment.

Precisely because of the near universal scale of the human activities that impair the global environment, the Anthropocene will present fundamentally different challenges for the legal system.¹⁶ Scholars who have described the essential characteristics and history of environmental law in the United States,¹⁷ or have even tentatively explored the political effects of the Anthropocene, have focused on how environmental law will or should change in response, and how

11. See *infra* notes 252–55 and accompanying text.

12. See Jason MacLean, *Autonomy in the Anthropocene? Libertarianism, Liberalism, and the Legal Theory of Environmental Regulation*, 40 *DALHOUSIE L.J.* 279 (2017) (noting this possibility).

13. See, e.g., LAZARUS, *supra* note 5, at 38–39.

14. See, e.g., *id.* at 36–40 (noting tension between interconnectedness and limited governmental powers); JEDEDIAH PURDY, *AFTER NATURE: A POLITICS FOR THE ANTHROPOCENE* 220 (2015) (noting same in context of takings law).

15. See *infra* Section I.C.

16. For discussions of how the global scale of the challenges of the Anthropocene is different from that addressed by traditional environmental law, see GALAZ, *supra* note 8, at 11; Kotzé, *supra* note 8, at 133; Vordermayer, *supra* note 8, at 87.

17. For one of the leading treatments of that history, see generally LAZARUS, *supra* note 5.

the political system constrains or enables new forms of environmental law.¹⁸ However, because of the pervasiveness and breadth of the problems of the Anthropocene, significant changes will not be limited to environmental law.¹⁹

This Article argues that the challenges of the Anthropocene will shape legal fields as diverse as constitutional law, criminal law, tort law, property, administrative law, and international law—a point not yet articulated or developed in legal literature. And although some of these changes are continuations of trends already marked in environmental law, others will be relatively novel as a wide range of legal areas respond to the Anthropocene. These changes are already visible at the edges of the legal system and will continue to expand as the global systems themselves change. These changes will occur whether we attempt to reduce our impairment of global systems or simply adapt to the impacts of changes in global systems.

18. See, e.g., *id.* at 208–36 (articulating how the increased impacts of consumers and services on the environment, including climate change, will require reforms to environmental law); PURDY, *supra* note 14, at 228–56 (arguing that in the Anthropocene, environmental law will need to confront issues such as agriculture and food production, animal rights, and new aesthetic perspectives about nature in a world dominated by human impacts); Nicholas A. Robinson, *Fundamental Principles of Law for the Anthropocene?*, 44 ENVTL. POL'Y & L. 13, 17–24 (2014) (developing underlying normative principles for environmental law); Nicholas A. Robinson, Keynote, *Sustaining Society in the Anthropocene Epoch*, 41 DENV. J. INT'L L. & POL'Y 467, 504–05 (2013) (encouraging the development of Environmental Impact Assessment laws as a method of adapting to environmental changes). See generally MacLean, *supra* note 12 (discussing how the pressures of the climate change will require revisions in environmental law, but leaving specific suggestions for later development).

Others have discussed the implications of climate change for law more broadly and environmental law in particular. See, e.g., Robin Kundis Craig, “Stationarity is Dead”—*Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL. L. REV. 9 (2010) (arguing for greater legal flexibility, coordination, monitoring, and environmental protection to respond to climate change); Holly Doremus, *Adapting to Climate Change with Law That Bends Without Breaking*, 2 SAN DIEGO J. CLIMATE & ENERGY L. 45 (2010) (noting importance of tradeoff between flexibility and resistance to development pressures); Holly Doremus, *Climate Change and the Evolution of Property Rights*, 1 UC IRVINE L. REV. 1091 (2011) [hereinafter Doremus, *Property Rights*] (noting importance of flexibility in property rights and a public role in managing transitions); Victor B. Flatt, Essay, *Adapting Laws for a Changing World: A Systemic Approach to Climate Change Adaptation*, 64 FLA. L. REV. 269 (2012) (noting that climate change will require fundamental reworking of legal systems but not specifically identifying the mechanisms by which law will change); J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENVTL. L. 363 (2010) (calling for greater flexibility and coordination in environmental law to respond to climate change adaptation). For an examination of the implications of the Anthropocene for agricultural law at a theoretical level, see James Ming Chen, *Anthropocene Agricultural Law*, 3 TEX. A&M L. REV. 745, 770 (2016) (arguing that the Anthropocene demands that agricultural law prioritize “survival and resource conservation”). Two scholars have begun exploring the implications of the Anthropocene for property law. See J. Peter Byrne, *Property in the Anthropocene*, 7 BRIGHAM-KANNER PROP. RTS. CONF. J. (forthcoming 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2982596 [<https://perma.cc/TCL9-VWAH>]; John G. Sprankling, *Property Law for the Anthropocene Era*, 59 ARIZ. L. REV. 737 (2017).

19. See Viñuales, *supra* note 8, at 23 (recognizing that responses to the Anthropocene will extend far beyond traditional environmental law, but focusing on developing a research agenda for comparative or international law).

In Part I of this Article, I summarize the main characteristics of the Anthropocene Epoch that will be relevant for the legal system: increasing human impairment and dominance of global systems, the consequences of those changes in terms of impacts on society, the increasing importance of the aggregation of individual activities across the globe, the increasing rate at which human systems impair global systems, and the increasing rate at which new human-caused impairments of global systems occur. Thus far, these are characteristics that have been discussed in the context of environmental law in the twentieth and early twenty-first centuries, but the scope and scale of these characteristics will continue to rapidly increase. Although legal scholars have begun to discuss the nature of the Anthropocene,²⁰ this Article provides a comprehensive overview of the characteristics of the Anthropocene that will shape the future of American law.

In Part II, I identify the ways in which society might respond to human impairment of global systems and the concomitant impacts on ecosystems and society, and establish that increased government action will be a core component of those responses. Again, although each of the individual approaches has been discussed in the legal literature, this Article provides an overarching synthesis to articulate the central role that the public sphere will play in the Anthropocene.

In Part III, I describe how increased government action in response to the challenges of the Anthropocene will exert pressure on a wide range of legal doctrines in American private and public law, specifically tort law, property law, constitutional law, administrative law, statutory interpretation, and criminal law.

Finally, in Part IV, I discuss how the legal changes in the Anthropocene will echo the legal changes in American law that responded to other fundamental social and economic revolutions. In particular, the social and economic interdependence created by industrialization and the rise of a national economy provoked significant changes in American law throughout the late nineteenth and early-to-mid-twentieth centuries. These similarities further support the idea that the legal changes in the Anthropocene will be significant and have substantial political implications. Moreover, this history also shows it is likely that the Anthropocene will drive legal changes because equally significant changes have occurred in the past. In addition, I articulate how the legal changes of the Anthropocene will sharply conflict with important normative political commitments in American politics and cut across existing ideological positions.

I. THE ANTHROPOCENE EPOCH

The concept behind the Anthropocene Epoch is that human impairments of global biological, physical, and chemical systems have become so substantial as to render the current geological time period fundamentally different from its

20. *See supra* note 18.

predecessors.²¹

There are three key characteristics of the Anthropocene relevant to understanding future changes to the legal system. First, humans are now a substantial, sometimes dominant driver of a wide range of global systems such as the atmosphere, oceans, global biodiversity, and cycling of important elements. These human impairments will have substantial negative impacts on the functioning of global systems that society depends on for its survival. Moreover, their global nature means that activities in one portion of the world may have far-reaching effects beyond political borders. Second, human impairments are often the product of the aggregation of large numbers of relatively small activities (even individual actions). Third, there is a substantial increase in the speed with which new human impairments of natural systems arise and expand, in large part because of the rapid increase in global technological change.

A. IMPAIRMENTS BY HUMANS OF GLOBAL SYSTEMS

The most obvious and commonly understood example of human impairments of global climate systems is the emission of greenhouse gases.²² Emissions of greenhouse gases, including carbon dioxide, have increased from 27 gigatons (Gt) of CO₂ equivalent (CO₂eq) per year²³ to 49 Gt over the past forty years, changing atmospheric concentrations of carbon dioxide from between 270 and 280 parts per million (ppm) before the Industrial Revolution to 398.5 ppm.²⁴ If greenhouse gas emissions continue growing at current trends, overall concentrations of carbon dioxide in the atmosphere will reach between 750 and 1300 ppm by 2100.²⁵

21. See Jan Zalasiewicz et al., *Stratigraphy of the Anthropocene*, 369 PHIL. TRANSACTIONS ROYAL SOCIETY A 1036, 1041 (2011) (“Human perturbation of some global geochemical cycles is now on a sufficient scale to leave clear markers in contemporary sediments . . .”). For instance, concentrations of atmospheric gases such as CO₂, CH₄, and N₂O in air pockets in the ice sheets are “all now at concentrations higher than observed in any ice cores for the last 800 [thousand years].” E. W. Wolff, *Ice Sheets and the Anthropocene*, in A STRATIGRAPHICAL BASIS FOR THE ANTHROPOCENE 255, 258 (C. N. Waters et al. eds., 2014). Likewise, impacts of humans on sediment and rock layers will be more significant than the changes between ice age periods in the Quaternary. See Zalasiewicz et al., *supra*, at 1047.

22. See Waters et al., *supra* note 2, at aad2622-1 (relying on climate change impacts as part of the marker for the start of the Anthropocene).

23. A gigaton is one billion tons. CO₂ equivalent is a way of converting the impacts on the climate of different greenhouse gases into a single metric: the amount of climate-forcing that results from one ton of carbon dioxide.

24. Will Steffen et al., *Planetary Boundaries: Guiding Human Development on a Changing Planet*, 347 SCI. 736, 1259855-4 tbl.1 (2015), <http://dx.doi.org/10.1126/science.1259855> [<https://perma.cc/52XD-ZJL5>]; see also WORKING GROUP I, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 50, 52 & fig.TS.5, 467 (Thomas F. Stocker et al. eds., 2014). Similar increases have occurred for other greenhouse gases, such as methane and chlorofluorocarbons. See WORKING GROUP I, *supra*, at 167 & fig.2.2, 168 & fig.2.4.

25. WORKING GROUP III, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 8 (Ottmar Edenhofer et al. eds., 2014). For discussion of the global temperature implications of this increase in carbon dioxide, see *infra* notes 73–74 and accompanying text.

But as one leading scientist has noted, “climate change is only the tip of the iceberg.”²⁶ Humans are also altering “several other biogeochemical, or element cycles, such as nitrogen, phosphorus and sulphur, that are fundamental to life on the Earth.”²⁷

Human mining of phosphorus for use as an agricultural fertilizer has dramatically increased the levels of phosphorus available for marine and terrestrial ecosystems. About 8.5 to 9.5 million tons of phosphorus per year flow from freshwater systems into the ocean, compared to a preindustrial flow of less than 1 million tons.²⁸

Human activities have doubled the amount of nitrogen available for use by plants and animals on a global scale.²⁹ Like phosphorus, much of this nitrogen enters into waterways; total nitrogen inputs from temperate regions surrounding the North Atlantic Ocean are estimated to have increased to two to twenty times their preindustrial levels.³⁰

Although both phosphorus and nitrogen are crucial to organic life, too much of them have a highly negative effect on ecosystems. High levels of nitrogen and phosphorus runoff into waterways and oceans, for instance, can cause oxygen depletion through the process known as eutrophication.³¹ This, in turn, can cause widespread mortality in fish and other animals, sometimes at a scale of tens or hundreds of square miles, as occurred at the mouth of the Mississippi River in the Gulf of Mexico.³² At the extreme, high levels of phosphorus entering into the oceans at a global scale might create a large-scale ocean anoxic event in which large sections of the oceans have no dissolved oxygen and are inhospitable for most forms of life.³³

Human-caused changes in the global atmosphere through the emission of carbon dioxide also affect oceans.³⁴ Carbon dioxide emitted by human activities

26. Will Steffen et al., *The Anthropocene: Conceptual and Historical Perspectives*, 369 PHIL. TRANSACTIONS ROYAL SOC'Y A 842, 843 (2011).

27. *Id.*

28. Johan Rockström et al., *A Safe Operating Space for Humanity*, 461 NATURE 472, 473 (2009).

29. See Alan R. Townsend et al., *Human Health Effects of a Changing Global Nitrogen Cycle*, 1 FRONTIERS ECOLOGY & ENV'T 240, 240–41 (2003); Peter M. Vitousek et al., *Human Alteration of the Global Nitrogen Cycle: Sources and Consequences*, 7 ECOLOGICAL APPLICATIONS 737, 739 & fig.1 (1997).

30. See R.W. Howarth et al., *Regional Nitrogen Budgets and Riverine N & P Fluxes for the Drainages to the North Atlantic Ocean: Natural and Human Influences*, 35 BIOGEOCHEMISTRY 75, 76, 122 (1996).

31. See Scott C. Doney, *The Growing Human Footprint on Coastal and Open-Ocean Biogeochemistry*, 328 SCI. 1512, 1515 (2010).

32. *Id.* (“Fertilizer runoff and nitrogen deposition from fossil fuels are driving an expansion in the duration, intensity, and extent of coastal hypoxia, leading to marine habitat degradation and, in extreme cases, extensive fish and invertebrate mortality . . .”).

33. See Rockström, *supra* note 28, at 474; Steffen et al., *supra* note 24, at 1259855-6. Climate change may also contribute to lower levels of dissolved oxygen in the oceans, a trend that has already been detected. See generally Sunke Schmidt et al., *Decline in Global Oceanic Oxygen Content During the Past Five Decades*, 542 NATURE 335 (2017).

34. See Doney, *supra* note 31, at 1512.

into the atmosphere is taken up in part by the oceans. There, the carbon dioxide “alters ocean chemistry, leading to more acidic conditions (lower pH).”³⁵ These rates of change in ocean acidity are “30 to 100 times faster than temporal changes in the recent geological past, and the perturbations will last many centuries to millennia.”³⁶

Higher acidity interferes with the development of the invertebrates that are the basis of the food chain in the oceans, such as coral reefs and photosynthesizing phytoplankton.³⁷ The higher acidity will, in essence, dissolve the calcium carbonate that is part of the structure of these invertebrates, making it harder or even impossible for coral reefs to form or plankton to grow.³⁸

When acidity levels become high enough in the oceans, they will contribute to the death of coral reefs, which are already under stress because of the warming of global oceans due to climate change. One scientist states, “[i]t seems highly probable that [within 100 years] coral reef ecosystems will cease to occur naturally on Earth, outside of large aquaria.”³⁹ The impacts from the loss of coral reefs will be substantial, given their role as a nursery for fish reproduction and habitat for a wide range of important species. Even more dire would be significant harm to the phytoplankton in the open oceans from acidification; phytoplankton “[c]ontribut[e] roughly half of the biosphere’s net primary production.”⁴⁰

Humans have begun to have global effects on terrestrial ecosystems and the biodiversity those ecosystems support. Even “[t]aking the most conservative view, nearly one-third of the terrestrial biosphere has now been transformed into anthromes [(human modified or dominated ecosystems)] in which pre-existing ecosystem forms and processes have been shifted outside their native range and novel anthropogenic ecological processes predominate.”⁴¹ High-end estimates suggest that during the twentieth century alone, approximately half of the terrestrial biosphere was “transformed into intensively used anthromes” such as

35. *Id.* at 1513.

36. *Id.* at 1514.

37. *See id.* at 1513–14.

38. *See* Steffen et al., *supra* note 24, at 1259855-6.

39. Toby Tyrrell, *Anthropogenic Modification of the Oceans*, 369 *PHIL. TRANSACTIONS ROYAL SOC’Y A* 887, 895 (2011) (summarizing results of one model that predicts that by the time atmospheric CO₂ reaches 560 ppm, “all coral reefs will stop growing and start to dissolve”); *see also* O. Hoegh-Guldberg, *Coral Reefs in the Anthropocene: Persistence or the End of the Line?*, in *A STRATIGRAPHICAL BASIS FOR THE ANTHROPOCENE*, *supra* note 21, at 167 (“[C]urrent rates of change are several orders of magnitude higher today than they have been for tens of millions of years.”). For a slightly more optimistic assessment of the future of coral reefs, based on the presumption that significant efforts to restrict carbon dioxide emissions will occur, *see* Terry P. Hughes et al., *Coral Reefs in the Anthropocene*, 546 *NATURE* 82 (2017).

40. Michael J. Behrenfeld et al., *Climate-Driven Trends in Contemporary Ocean Productivity*, 444 *NATURE* 752, 752 (2006).

41. Erle C. Ellis, *Anthropogenic Transformation of the Terrestrial Biosphere*, 369 *PHIL. TRANSACTIONS ROYAL SOC’Y A* 1010, 1025 (2011).

intensive agricultural use or cities.⁴² Crops now cover 12% of global surface lands with “a level of 15–20 per cent [sic] being recently regarded as an unsustainable threshold.”⁴³

Another way to understand the extent of human domination of terrestrial ecosystems is to consider how much of the global productivity of ecosystems—the conversion of sunlight to usable energy by plants—is now appropriated by humans. A widely-cited estimate is that “[h]uman activities now appropriate nearly one-third to one-half of global ecosystem production.”⁴⁴

Human domination of terrestrial ecosystems is a main contributor to global loss of biodiversity, adding to causes such as human hunting, pollution, the introduction of species to new habitats,⁴⁵ and climate change.⁴⁶ Estimates of current rates of biodiversity loss vary substantially, in part because our knowledge of current levels of biodiversity is still quite limited. Some estimates peg the rate of biodiversity loss at about 100 to 1000 times background rates.⁴⁷ These numbers would indicate that species extinction rates are at levels consistent with the prior five mass extinction events in geologic history, including the disappearance of the dinosaurs.⁴⁸ Other estimates put current rates of extinction at around three to twelve times background rates.⁴⁹

However, even scientists who provide low estimates of current species extinction rates agree that “if currently elevated extinction rates continue, the sixth mass extinction (75% species loss) would [still] occur within three to five centuries.”⁵⁰ It may happen even sooner than that: it is likely that “without enhanced conservation effectiveness,” a substantial number of species would go extinct “given that currently 22% of mammals, 14% of birds, more than 30% of

42. *Id.* at 1010; see also Peter M. Vitousek et al., *Human Domination of Earth's Ecosystems*, 277 *Sci.* 494, 495 (1997) (estimating that “the fraction of land transformed or degraded by humanity (or its corollary, the fraction of the land’s biological production that is used or dominated) fall in the range of 39 to 50%”).

43. Ellis, *supra* note 41, at 1025; see also Jonathan A. Foley et al., *Global Consequences of Land Use*, 309 *Sci.* 570, 570 (2005) (estimating that croplands and pastures occupy about 40% of the land surface); Vitousek et al., *supra* note 42, at 494–95 (estimating that between 10 and 15% of Earth’s land surface is occupied by row crops and “another 6 to 8% has been converted to pastureland”).

44. Foley et al., *supra* note 43, at 570.

45. See Zalasiewicz et al., *supra* note 21, at 1046 (“[T]he current simultaneous mass cross-transfer of species between each major and minor landmass . . . is geologically unprecedented.”). In North America, “over 50,000 species are considered invasive and are regarded as causing environmental damage on the scale of 120 billion US dollars per year.” *Id.*

46. See generally Daniel A. Farber, *Separated at Birth? Addressing the Twin Crises of Biodiversity and Climate Change*, 42 *ECOLOGY L.Q.* 841 (2015).

47. See Steffen et al., *supra* note 24; see also F. Stuart Chapin III et al., *Consequences of Changing Biodiversity*, 405 *NATURE* 234, 234 (2000).

48. See Chapin et al., *supra* note 47, at 234 (stating that humans have caused “the extinction of 5–20% of the species in many groups of organisms”). See generally Gerardo Ceballos et al., *Accelerated Modern Human-Induced Species Losses: Entering the Sixth Mass Extinction*, *SCI. ADVANCES*, June 19, 2015.

49. See Colin N. Waters et al., *A Stratigraphical Basis for the Anthropocene?*, in *A STRATIGRAPHICAL BASIS FOR THE ANTHROPOCENE*, *supra* note 21, at 1, 4.

50. *Id.* at 16.

amphibians, and 29% of evaluated reptiles are threatened with extinction.”⁵¹

Finally, metal and other toxic pollutants produced by industrial activities such as lead, cadmium, copper, zinc, and mercury can travel long distances and occur above natural background levels across the planet.⁵² “[L]ong-range atmospheric transport along prevailing air-mass trajectories leads to the presence of pollutants in the remotest regions of the world. The most pervasive pollutants that undergo long-range transport in the atmosphere are potentially toxic trace metals”⁵³

For example, “[l]ead concentrations in Greenland snow in 1960 were a factor of 200 above the [preindustrial] background level.”⁵⁴ Now, there is a “range of chemicals with no natural sources that are . . . detectable in ice cores,” including persistent organic pollutants, chlorofluorocarbons, and hydrofluorocarbons, “many of which are detectable in air dated to the 1960s and later.”⁵⁵ Similar results are found from sediment and peat core samples, observing traces of metals from human activity on a global basis, including from elements such as antimony, lead, and mercury, with a “substantial (up to 100-fold) enrichment” of these metals’ levels in the atmosphere in the twentieth century.⁵⁶ Likewise, there are elevated oceanic levels of persistent organic pollutants and methyl mercury, a highly toxic organic form of the metal.⁵⁷

B. INCREASING RATE OF CHANGE IN IMPAIRMENTS

Not only are human impairments increasingly important at a global level in an absolute sense, but the rate at which those impairments are increasing is also accelerating. Since World War II, society’s impairments of global systems have undergone what some scientists have called the “Great Acceleration.” The Great Acceleration is a result of globalization, rapid population growth, and rapid technological change over the past seventy-five years.⁵⁸ For instance, after World War II, global “[p]opulation doubled in just [fifty] years, to over 6 billion by the end of the 20th century, [and] the global economy increased by more than 15-fold.”⁵⁹ In addition, there has been increasingly rapid technological change over the past seventy-five years, producing novel forms of impairments

51. Anthony D. Barnosky, *Palaeontological Evidence for Defining the Anthropocene*, in A STRATIGRAPHICAL BASIS FOR THE ANTHROPOCENE, *supra* note 21 at 149, 160.

52. See Waters et al., *supra* note 2, at aad2622-5 (noting presence of metals such as lead and complex manmade organic compounds in polar ice caps).

53. Agnieszka Gałuszka et al., *Assessing the Anthropocene with Geochemical Methods*, in A STRATIGRAPHICAL BASIS FOR THE ANTHROPOCENE, *supra* note 21, at 221, 231.

54. Waters et al., *supra* note 49 at 15; see also Wolff, *supra* note 21, at 258; Zalasiewicz et al., *supra* note 21, at 1041 (“[I]ncreases in lead deposition (dating back to Roman times) have been detected in ice cores and alluvial sediments . . .”).

55. Wolff, *supra* note 21 at 260.

56. Gałuszka et al., *supra* note 53, at 229.

57. See Doney, *supra* note 31, at 1515.

58. See Will Steffen et al., *The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?*, 36 *AMBIO* 614, 617–18 (2007).

59. *Id.* at 617.

to global systems. As a result, “every indicator of human activity underwent a sharp increase in rate around 1950,” and thus every impairment of global systems from that human activity also underwent a sharp increase.⁶⁰ One leading scientist has described the effects and markers of the Great Acceleration to include:

the global spread of artificial radionuclides from surface A-bomb explosions; doubling of the surface reactive nitrogen reservoir . . . ; the creation and wide (global) dispersal of new human-made materials . . . ; rapid expansion in the distribution of artificial deposits on land, associated with urbanization, and of reworked sediment on continental shelves and slopes, associated with deep-sea trawling; global dispersal of pollutants associated with expansion of industrial activities, including novel organic contaminants that include persistent organic pollutants (POPs) and increased concentrations of heavy metals that are relatively rare in nature; a significant ‘step’ in the rate of increase of anthropogenic biotic change . . . ; a significant signal in polar ice marked by such indicators as lead from gasoline . . . ; [and] acceleration in the burning of hydrocarbons that has produced much of the 120 ppm increase in atmospheric carbon dioxide levels since the mid-twentieth century.⁶¹

Charts communicate far better than words the (often exponential) rate of growth in human activities and concomitant effects.⁶² Figures 1 and 2 below show increases in a range of human activities and effects on global systems over the past 200 years, showing exponential growth across the board.⁶³

C. CONSEQUENCES FOR SOCIETY FROM THE ANTHROPOCENE

All of these human impairments of global resources will cause significant impacts on human economies and societies. For instance, the large increase in the cycling of nitrogen and phosphorus in global systems contributes to eutrophication that can fundamentally alter aquatic ecosystems (eliminating fresh and marine fisheries that humans depend on for food) and can produce direct health hazards by promoting the growth of toxic algal blooms.⁶⁴ Eutrophication off the coast of Australia threatens the survival of the Great Barrier Reef, both by covering the corals in algae and promoting the proliferation of species not

60. Steffen et al., *supra* note 26, at 849.

61. Jan Zalasiewicz et al., *When Did the Anthropocene Begin? A Mid-Twentieth Century Boundary Level Is Stratigraphically Optimal*, 383 QUATERNARY INT’L 196, 199–200 (2015) (citations omitted).

62. See, e.g., Will Steffen et al., *The Trajectory of the Anthropocene: The Great Acceleration*, 2 ANTHROPOCENE REV. 81 (2015); see also Will Steffen et al., *Executive Summary*, GLOBAL CHANGE AND THE EARTH SYSTEM: A PLANET UNDER PRESSURE 15–17 (Will Steffen et al. eds., 2004).

63. Images are from Steffen et al., *The Anthropocene: Conceptual and Historical Perspectives*, *supra* note 26, at 851 fig.1.

64. See Vaclav Smil, *Phosphorus in the Environment: Natural Flows and Human Interferences*, 25 ANN. REV. ENERGY & ENV’T 53, 75 (2000).

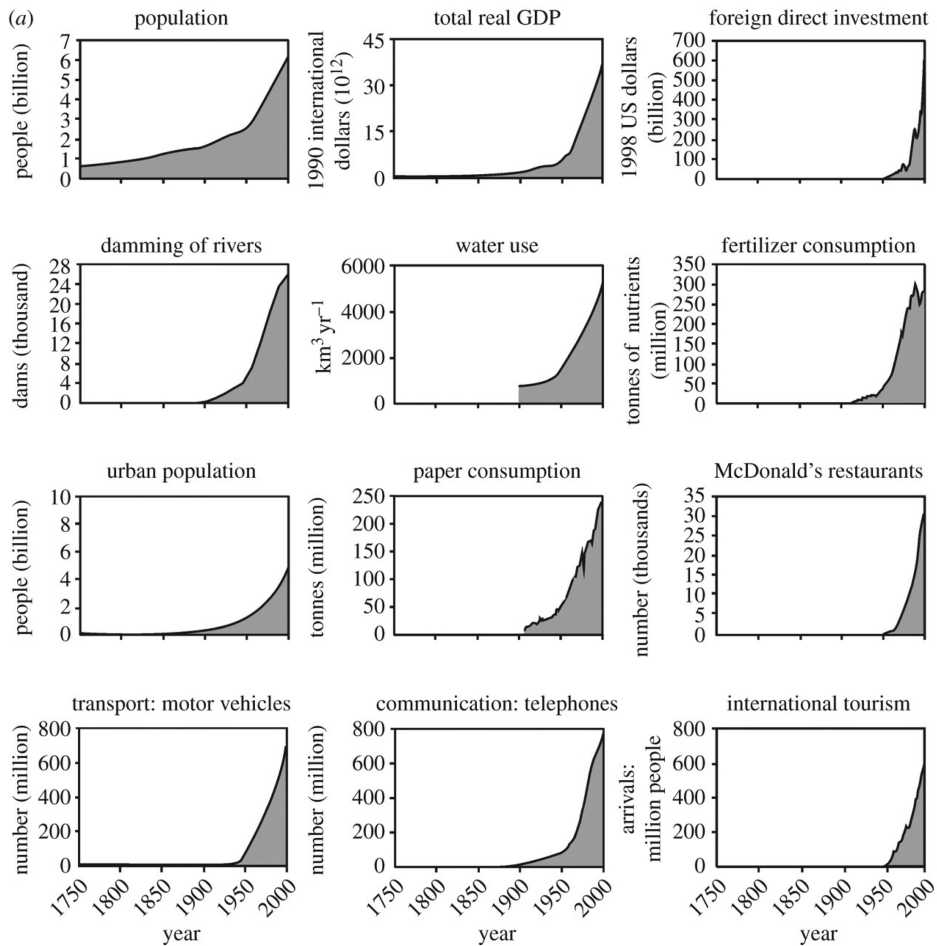


Figure 1. Increases in various human activities over the past 250 years.

previously endemic to the reef.⁶⁵ The Baltic Sea in Northern Europe has received phosphorus inputs at eight times the preindustrial rate, killing off common shellfish and fish species.⁶⁶ The increase in nitrogen cycling has other impacts as well: it contributes to worldwide air pollution,⁶⁷ ozone depletion, and climate change.⁶⁸

The global transport of toxic contaminants such as lead, polychlorinated biphenyls (PCBs), or mercury can have significant impacts on human health and

65. See Peter R.F. Bell & Ibrahim Elmetri, *Ecological Indicators of Large-Scale Eutrophication in the Great Barrier Reef Lagoon*, 24 *AMBIO* 208, 208–09 (1995).

66. See Smil, *supra* note 64, at 76.

67. See Lex Bouwman et al., *Exploring Global Changes in Nitrogen and Phosphorous Cycles in Agriculture Induced by Livestock Production Over the 1900–2050 Period*, 110 *PROC. NAT'L ACAD. SCI.* 20882, 20882 (2013); see also Townsend et al., *supra* note 29 at 241–42.

68. See Bouwman et al., *supra* note 67, at 20882.

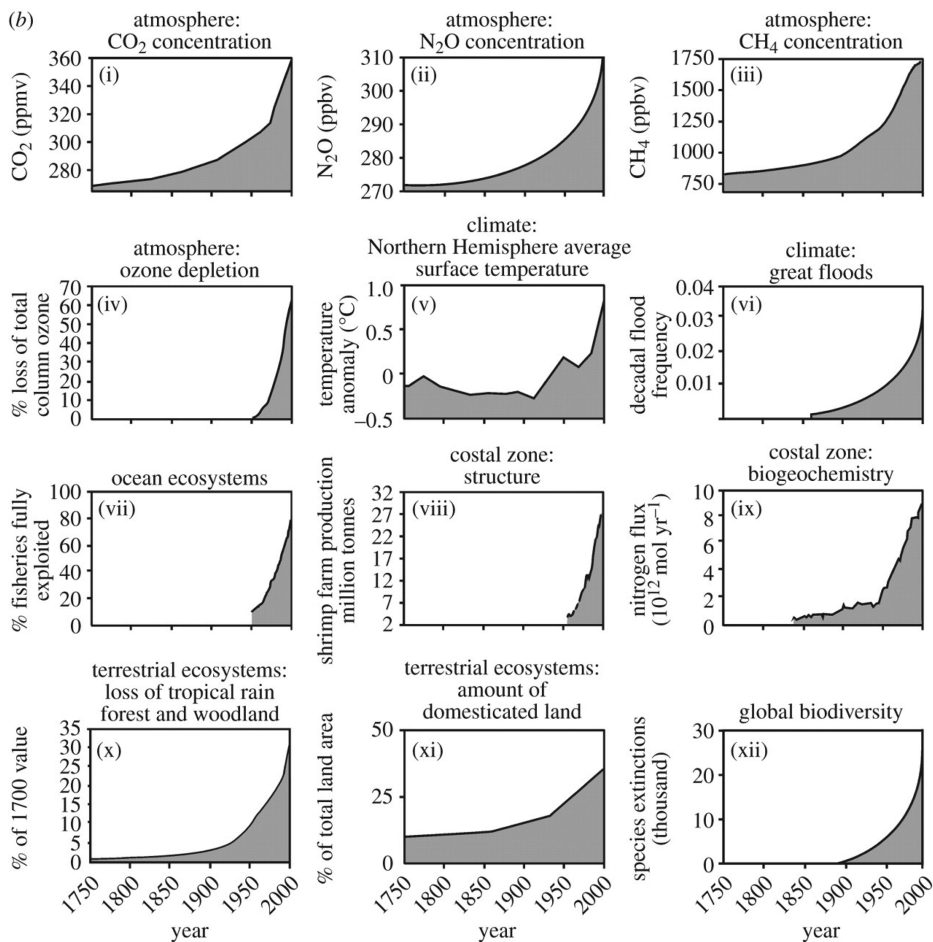


Figure 2. Increases in effects of human activities on global systems over the past 250 years.

ecosystems. For example, the U.S. government issues warnings urging pregnant women not to consume more than two or three servings of fish a week and to avoid fish with high mercury contamination because of the harm that mercury can cause to the developing nervous system of a fetus.⁶⁹

Biodiversity losses may significantly affect the functioning and sustainability of global ecosystems. For instance, biodiversity losses may reduce productivity (the ability of ecosystems to convert sunlight into energy) and rates of decompo-

69. See *Eating Fish: What Pregnant Women and Parents Should Know*, U.S. FOOD & DRUG ADMIN., <http://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm393070.htm> [https://perma.cc/W9LX-TEYY] (noting tradeoff between risk of mercury intake and the benefits of fish consumption); *What You Need to Know About Mercury in Fish and Shellfish*, U.S. FOOD & DRUG ADMIN., <http://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm351781.htm> [https://perma.cc/NC5J-5J5R].

sition of organic material (essential to the cycling of nutrients).⁷⁰ In turn, these changes can have significant effects on society through the loss of the ecosystem services that healthy ecosystems can provide, such as the cycling of nutrients essential for agricultural productivity.⁷¹ The impact of biodiversity losses on ecosystem functioning may be comparable to that from global warming or increased ultraviolet radiation resulting from the loss of the stratospheric ozone layer.⁷²

Perhaps the best studied of all the impacts of impairments on global resources in the Anthropocene is climate change. This may be because the most immediate impact of greenhouse gas emissions is an increase in overall global temperatures. Global surface temperatures have increased almost one degree Celsius from 1880 to 2012.⁷³ In 2014, the best estimates of global temperature increases by 2100 were between 3.7 degrees and 4.8 degrees Celsius, assuming current trends of increasing greenhouse gas emissions continued.⁷⁴

Those temperature increases might not sound large, but because they are increases in average temperatures, they reflect extremely large changes to global climate systems.⁷⁵ For example, increasing average temperatures also means an increase in the number of extreme heat events.⁷⁶ These events could produce significant deaths,⁷⁷ similar to the heat event in Europe in 2003 that killed 35,000 people and caused \$13 billion in damages.⁷⁸

Changes in global average temperature will likely also mean substantial changes in how precipitation is distributed across the planet. Precipitation will

70. See David U. Hooper et al., *A Global Synthesis Reveals Biodiversity Loss as a Major Driver of Ecosystem Change*, 486 NATURE 105, 105 (2012).

71. See, e.g., David Tilman, *Biodiversity and Ecosystem Functioning*, in NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS 93, 101 (Gretchen Daily ed., 1997) (describing role of nutrient cycling in ecosystem and agricultural productivity).

72. See Hooper, *supra* note 70, at 105.

73. See WORKING GROUP I, *supra* note 24, at 3.

74. WORKING GROUP III, *supra* note 25, at 8. This would reflect an increase in greenhouse gas concentrations in the atmosphere from 430 parts per million CO₂eq to between 750 and more than 1300 CO₂eq by 2100. *Id.* A wider confidence interval for the estimate in the increase in temperature includes a range from 2.5 degrees Celsius to 7.8 degrees Celsius. *Id.*

75. See WORKING GROUP I, *supra* note 24, at 77–78 Box TS.5.

76. See *id.* at 20; see also WORKING GROUP II, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY, PART A: GLOBAL AND SECTORAL ASPECTS 111 (2014) (citing a study predicting that “the number of monthly heat records will be more than 12 times more common by the 2040s”). For a recent discussion of the substantial impact climate change will have on increasing extreme climate events such as heat waves, see generally Noah S. Diffenbaugh et al., *Quantifying the Influence of Global Warming on Unprecedented Extreme Climate Events*, 114 PROC. NAT'L ACAD. SCI. 4881 (2017).

77. See WORKING GROUP II, *supra* note 76 at 13, 22–24 tbl.1, 60. Impacts will affect both urban populations in “heat islands” and rural populations that work outdoors in agriculture. See *id.* at 65 tbl.TS.4, 109, 551–55.

78. See ANDREW T. GUZMAN, OVERHEATED: THE HUMAN COST OF CLIMATE CHANGE 210 (2013). In the long-term, these extreme heat events may make outdoor conditions unfit for human habitation in significant parts of the world. See Jeremy S. Pal & Elfatih A. B. Eltahir, *Future Temperature in Southwest Asia Projected to Exceed a Threshold for Human Adaptability*, 6 NATURE CLIMATE CHANGE 197, 197–99 (2016).

likely increase near the equator and the poles and decrease in subtropical and temperate areas.⁷⁹ Because subtropical and temperate areas are currently the most productive agricultural zones, shifts in precipitation will require shifts in the location, manner, and type of agricultural production.⁸⁰ Even assuming such changes can occur without significant social disruption, the cost of altering or constructing new infrastructure to support agricultural production (for example, irrigation systems or upstream and downstream supply streams) will be enormous.⁸¹

Through the combination of increased temperatures and changes in precipitation, climate change has already caused, on average, negative impacts on global crop yields for key staple crops such as wheat and maize,⁸² and those negative impacts are expected to increase in tropical and temperate areas.⁸³ Negative impacts on the reliability and amount of global food production will increase food insecurity, particularly for the world's poorest, and threaten the stability of global food delivery systems.⁸⁴ Global forests, especially in high latitudes (such as the boreal forests across the Northern Hemisphere) will likely also experience increased rates of tree deaths, forest dieback, and fires.⁸⁵

Increased global temperatures will mean increases in global mean sea level, both because warmer water expands and because of the melting of major ice fields around the world.⁸⁶ A temperature increase of close to four degrees Celsius by 2100 would mean a sea level rise of approximately two feet across the planet.⁸⁷ These rises would cause substantial impacts to low-lying coastal zones where many of the world's largest cities are located,⁸⁸ as well as to densely inhabited delta agricultural areas such as the Mekong Delta in Southeast Asia, the Nile Delta in Egypt, and Bangladesh.⁸⁹ Hundreds of millions of

79. See WORKING GROUP I, *supra* note 24, at 21. Dry areas will likely become drier, while wet areas will become wetter. *Id.*

80. See WORKING GROUP II, *supra* note 76, at 251–52 (noting increased need for irrigation for agriculture as a result of climate change and vulnerability of rain-fed agriculture to increased variability in precipitation that may result from climate change).

81. See GUZMAN, *supra* note 78, at 13, 97–99.

82. See WORKING GROUP II, *supra* note 76, at 4–5.

83. See *id.* at 17–18, 21 tbl.1, 24 tbl.1 (noting that Central and South America and Africa will face key risks with increased heat impacts on agriculture); *id.* at 78 (“Projected increases in temperature, reductions in precipitation in some regions, and increased frequency of extreme events would result in net productivity declines in major North American crops by the end of the 21st century without adaptation, although some regions, particularly in the north, may benefit.”).

84. See *id.* at 13, 19, 60, 70–71.

85. See *id.* at 15, 276, 303–05; see also *id.* at 23 tbl.1 (noting wildfire risk in North America).

86. See WORKING GROUP I, *supra* note 24, at 46.

87. See *id.* at 21 tbl. SPM.2. More recent research has highlighted the risk of substantially higher sea level rise because of the melting of the Antarctic ice sheets. See Robert M. DeConto & David Pollard, *Contribution of Antarctica to Past and Future Sea-Level Rise*, 531 NATURE 591, 591–96 (2016).

88. See WORKING GROUP II, *supra* note 76, at 364–66.

89. See *id.* at 59. For instance, sixty million people live in the Mekong River delta and will face impacts from climate change and sea level rise. *Id.* at 505.

people already live in areas exposed to flood risks.⁹⁰ One estimate is that, without additional coastal protection, between 72 and 187 million people will be “displaced due to land loss due to submergence and erosion by 2100.”⁹¹ Impacted populations could be reduced to the few millions with upgraded coastal defenses.⁹² However, these would be quite costly.⁹³ Large amounts of significant infrastructure (such as ports, airports, roads and rails, power plants, and sewer systems) would also be adversely affected by a rise in sea level and would be costly to replace.⁹⁴ Total impacts on cities and infrastructure from sea level rise alone might cost about 9% of projected global GDP by the end of the twenty-first century.⁹⁵

Increases in global temperature will have particular impacts on mountain glaciers and seasonal snowpacks that provide essential water storage for agriculture and human use in temperate and tropical areas.⁹⁶ This form of water storage is essential to places such as California, the Andean region of South America, and much of South and East Asia where major rivers begin in the glaciers of the Himalayan mountains.⁹⁷ More than half of the world’s population lives in watersheds that originate with glaciers and snow in mountains.⁹⁸

Ocean acidification and increased ocean temperatures will combine to negatively impact coral reefs and other important ocean ecosystems that provide the basis for global fisheries.⁹⁹ The total net productivity of the open oceans will decline by up to 9% by 2100 if current emission trends continue.¹⁰⁰ The disappearance of warm-water coral reefs will have substantial economic effects,¹⁰¹ including impacts on commercially valuable shellfish.¹⁰² Loss of these

90. “The population exposed to the 1-in-100-year coastal flood is projected to increase from about 270 million in 2010 to 350 million in 2050 due to socioeconomic development only.” *Id.* at 381 (citation omitted).

91. *Id.* at 382.

92. *See id.*

93. Cost estimates range between \$25 billion and \$270 billion per year by 2100. *Id.* at 392.

94. *See id.* at 383. The value of the assets vulnerable is estimated to be \$3 trillion dollars. *Id.*

95. *Id.*

96. *See id.* at 143–45, 232, 243.

97. *See, e.g.,* Edward Wong, *Chinese Glacier’s Retreat Signals Trouble for Asian Water Supply*, N.Y. TIMES, Dec. 8, 2015, at A4.

98. *See* GUZMAN, *supra* note 78, at 116–17.

99. *See* WORKING GROUP II, *supra* note 76 at 16 fig.SPM.6; *id.* at 17 (“Due to projected climate change by the mid 21st century and beyond, global marine-species redistribution and marine-biodiversity reduction in sensitive regions will challenge the sustained provision of fisheries productivity”); *id.* at 68, 414 (noting increase of 30 to 70% of yield of some fisheries in the Arctic but a drop of 40 to 60% in tropical fisheries and the Antarctic). Although some fish populations may move towards higher latitudes, this “poses risk[s] of reduced supplies, income, and employment in tropical countries, with potential implications for food security.” *Id.* at 18.

100. *Id.* at 415.

101. “The annual economic damage of ocean-acidification-induced coral reef loss by 2100 has been estimated, in 2012, to be” between \$870 and 528 billion, though estimates have high levels of uncertainty. *Id.* at 133. These impacts may be particularly hard on coastal regions or small islands that rely on coral reefs for ecological services such as preventing coastal erosion or supporting fisheries. *See id.*

fishery resources is important because “[o]ceans provide about 17% of the animal protein consumed by the world’s human population.”¹⁰³

All of these impacts will have significant synergistic consequences for society from the combination of heat waves, harm to agriculture and fisheries, increased risks from food- and water-borne diseases, and the possible increase of tropical diseases in higher latitudes (for example, from the increase of malaria-carrying mosquitoes).¹⁰⁴ Estimates are that climate change already causes 300,000 excess deaths per year, a number that will only increase.¹⁰⁵ Overall costs to adapt to climate change are hard to estimate, but one estimate in 2010 put the cost between \$70 and \$100 billion annually by 2050.¹⁰⁶

Likewise, the disruption of the natural systems that human economies depend upon will likely “increase [the] displacement of people,” producing more refugees.¹⁰⁷ Displacement of tens or hundreds of millions of people as a result of climate change (for instance, movement of people in countries like Bangladesh in response to sea level rise) will deprive those people of access to food, clean water, security, and health services.¹⁰⁸ That deprivation, in turn, will increase the risk of disease and food insecurity, creating a vicious cycle that will further increase the human harms from climate change.¹⁰⁹

102. *See id.* at 64 tbl.TS.4; *id.* at 75 (“The global cost of production loss of mollusks could be over US\$100 billion by 2100 . . .”). Negative impacts on shellfish have already been identified on the West Coast of the United States. *See id.* at 464.

103. *Id.* at 417. “400 million depend critically on fish for their food.” *Id.* at 452.

104. *See id.* at 19; *see also id.* at 21, 24 tbl.1 (noting potential impacts on Africa and Central and South America from increased diseases due to climate change); *id.* at 722–27 (giving overview of health impacts from climate change); Maryn McKenna, *Why the Menace of Mosquitoes Will Only Get Worse*, N.Y. TIMES (Apr. 20, 2017), <https://www.nytimes.com/2017/04/20/magazine/why-the-menace-of-mosquitoes-will-only-get-worse.html> [<https://perma.cc/6HSG-CNCW>].

105. GUZMAN, *supra* note 78, at 10.

106. *See* WORKING GROUP II, *supra* note 76, at 959. However, these numbers should “be treated with caution” and likely significantly underestimate costs. *See id.* A more recent estimate was that “unmitigated warming” might “reduc[e] average global incomes roughly 23% by 2100.” Marshall Burke et al., *Global Non-Linear Effect of Temperature on Economic Production*, 527 NATURE 235, 235 (2015).

107. *See* WORKING GROUP II, *supra* note 76, at 20; *see also* Jessica Benko, *How a Warming Planet Drives Human Migration*, N.Y. TIMES (Apr. 19, 2017), <https://www.nytimes.com/2017/04/19/magazine/how-a-warming-planet-drives-human-migration.html> [<https://perma.cc/CG2F-G23F>].

108. *See* GUZMAN, *supra* note 78, 12–14; *id.* at 63 (noting that as many as twenty million Bangladeshis may be forced from their homes due to sea level rise). Indeed, the plausible range of climate refugees dwarfs the large displacements of millions of refugees from Syria that have occurred over the past few years and put significant stress on countries in the Middle East and Europe. *See id.* at 66 (noting plausible estimates of climate refugees totaling in the hundreds of millions). As of May 18, 2017, the United Nations High Commission for Refugees has registered over five million refugees from Syria. *See Syrian Regional Refugee Response*, UNHCR (last updated July 6, 2017), <http://data.unhcr.org/syrianrefugees/regional.php> [<https://perma.cc/9T5J-SP76>].

109. *See* GUZMAN, *supra* note 78, at 68 (noting difficult, unsanitary, and violent nature of conditions in many refugee camps); *id.* at 180–82, 194–96 (noting how the large movements and concentrations of people with climate change will likely facilitate the spread of disease).

Climate change will also increase the risk of political and nonpolitical violence.¹¹⁰ Large-scale migration may itself produce conflict.¹¹¹ There will also likely be increased conflict as society fights for access to shrinking or moving resources.¹¹² For instance, water is already scarce in areas such as the Middle East and parts of South Asia, and there are already transboundary disputes over water between countries that have regularly fought wars in the past 100 years. Because climate change will cause substantial reductions in major rivers such as the Jordan and the Indus, conflict over shrinking water supply seems quite plausible.¹¹³ Some countries, such as small island states in the Pacific and Indian Oceans, may completely disappear with rising sea levels.¹¹⁴ When combined, these stresses may cause the political, social, and economic systems on which our modern world depends to buckle, and in some places, collapse, further adding to the human harms.¹¹⁵

Many of the harms discussed so far are global in nature, such as climate change and ocean acidification. But even other harms—such as smog or particulate air pollution—that might normally be seen as local or regional problems in fact are increasingly the result of long-distance impacts on a global scale. As an example, consider air pollution in Los Angeles and the Central Valley of California—both regions of the United States with some of the worst air pollution problems.¹¹⁶ Both locations suffer from severe air pollution from particulate matter and from ground-level ozone.¹¹⁷ In both locations, air pollution is significantly worsened because of long-distance transport of contami-

110. *See id.* at 1 (“[T]he stresses generated by climate change will increase tensions in many parts of the world and are likely to trigger violent conflict.”).

111. *See id.* at 59 (“There are few historical precedents for the peaceful resettlement of refugee communities in stable, healthy, and economically viable environments.”); NAOMI ORESKES & ERIK M. CONWAY, *MERCHANTS OF DOUBT: HOW A HANDFUL OF SCIENTISTS OBSCURED THE TRUTH ON ISSUES FROM TOBACCO SMOKE TO GLOBAL WARMING* 181 (2010) (noting that “historical mass migrations had been accompanied by massive suffering, and typically people moved under duress and threat of violence”); Jody Freeman & Andrew Guzman, *Climate Change and U.S. Interests*, 109 COLUM. L. REV. 1531, 1583 (2009).

112. *See* WORKING GROUP II, *supra* note 76, at 20, 65 tbl.TS.4, 771–73.

113. GUZMAN, *supra* note 78, at 140–61. In the case of India and Pakistan, which share the Indus River, the relevant parties also have nuclear weapons. *Id.* at 153.

114. *See* WORKING GROUP II, *supra* note 76, at 20.

115. GUZMAN, *supra* note 78, at 11 (“We face a real risk of the collapse of human institutions that we take for granted . . .”). For a depiction of one scenario of a collapse, see generally NAOMI ORESKES & ERIK M. CONWAY, *THE COLLAPSE OF WESTERN CIVILIZATION: A VIEW FROM THE FUTURE* (2014).

116. The Los Angeles Basin and the southern San Joaquin Valley in California are out of compliance with air quality standards for five pollutants listed under the Clean Air Act, a number that is matched or exceeded by only three other counties in the United States. *See Counties Designated “Nonattainment” for Clean Air Act’s National Ambient Air Quality Standards (NAAQS)*, EPA (Feb. 13, 2017), <https://www3.epa.gov/airquality/greenbook/mapnpoll.html> [<https://perma.cc/GWL3-P3UD>].

117. *See Current Nonattainment Counties for All Criteria Pollutants*, EPA (Feb. 13, 2017), <https://www3.epa.gov/airquality/greenbook/ancl.html> [<https://perma.cc/G7S8-ZYFR>] (showing counties in Los Angeles Basin and southern San Joaquin Valley are out of compliance with Clean Air Act standards for ozone and particulate matter).

nants from China—whether from industrial sources or from dust storms.¹¹⁸ Emissions from China can at times rival domestic emissions in terms of importance.¹¹⁹

D. IMPORTANCE OF THE AGGREGATION OF SMALL-SCALE INDIVIDUAL ACTIVITIES

The paradigmatic vision of environmental pollution is a large stationary source (such as an oil refinery or factory) that releases large quantities of pollutants into the air, water, or soil from a discrete output (such as a pipe or a smokestack) often called a “point source.” That is the widely-understood public perception of pollution sources and, indeed, is the understanding of pollution sources that drives much of American environmental law.¹²⁰

There is much truth to that understanding of the sources of pollution. Before the 1970s, much of the pollution in developed countries originated from large, stationary, industrial sources.¹²¹ Management and reduction of pollution could occur with regulations that focused on these sources and we have seen significant reductions in emissions from these sources over the past forty years in the United States.¹²²

Nonetheless, close regulation of these large sources has its limits. Increasingly, strict regulation of large point sources leaves significant pollution emissions from non-point sources unregulated—causing, in many cases, significant pollution effects.¹²³ For instance, water quality in the United States has, in general, improved significantly since the early 1970s.¹²⁴ But many waterways remain impaired. And a reason those waterways remain polluted is the input of pollution from non-point sources, such as runoff from driveways, farms, lawns,

118. See Jintai Lin et al., *China's International Trade and Air Pollution in the United States*, 111 PROC. NAT'L ACAD. SCI. 1736, 1736 (2014); Tony Barboza, *Just How Much is Asia's Ozone to Blame for Bad Air in the U.S.?*, L.A. TIMES (Jan. 31, 2015, 2:00 PM), <http://www.latimes.com/science/la-me-pacific-smog-20150201-story.html> [<https://perma.cc/J9RG-TGVE>]; Edward Wong, *China Exports Pollution to U.S., Study Finds*, N.Y. TIMES, Jan. 20, 2014, at A6; see also Meiyun Lin et al., *US Surface Ozone Trends and Extremes from 1980 to 2014: Quantifying the Roles of Rising Asian Emissions, Domestic Controls, Wildfires, and Climate*, 17 ATMOSPHERIC CHEMISTRY & PHYSICS 2943, 2944 (2017).

119. See Hongbin Yu et al., *Aerosols from Overseas Rival Domestic Emissions Over North America*, 337 SCI. 566, 566 (2012); see also Lin et al., *supra* note 118, at 2943 (finding that increases in pollution from China have offset decreases in pollution in western United States, producing increases in ozone pollution).

120. See John C. Dernbach, *Harnessing Individual Behavior to Address Climate Change: Options for Congress*, 26 VA. ENVTL. L.J. 107, 111 (2008) (“Environmental laws typically focus on large sources of pollution.”); Michael P. Vandenbergh, *From Smokestack to SUV: The Individual as Regulated Entity in the New Era of Environmental Law*, 57 VAND. L. REV. 515, 517 (2004).

121. See, e.g., William L. Andreen, *Water Quality Today—Has the Clean Water Act Been a Success?*, 55 ALA. L. REV. 537, 553–54 (2004) (noting role of industrial and municipal sewage discharges in contributing to water pollution before the 1970s in the United States).

122. See Vandenbergh, *supra* note 120, at 517 n.2 (listing scholarship noting the benefits produced by regulation of large industrial sources).

123. See Hope M. Babcock, *Assuming Personal Responsibility for Improving the Environment: Moving Toward a New Environmental Norm*, 33 HARV. ENVTL. L. REV. 117, 117 (2009).

124. See Andreen, *supra* note 121, at 564–73.

and houses.¹²⁵ Thus, in the United States, more than 80% of the input of phosphorus into waterways comes from non-point sources¹²⁶—individual sources are accordingly an important component of human contributions to changes in global nutrient cycling.

As for activities that are not heavily regulated, such as greenhouse gas emissions, many of the most important impairments of global resources are also the result, at least in part, of activities by individuals.¹²⁷ Greenhouse gases do not just result from the emission of fossil fuel production and combustion in the industrial economy.¹²⁸ About one-quarter of global emissions come from agriculture, forestry, and other land-use activities that are not the products of factories with smokestacks amenable to emission control devices.¹²⁹ Stabilizing greenhouse gas emissions at about 450 ppm CO₂eq to keep temperature increases below about two degrees Celsius would likely require substantial reductions in these emissions.¹³⁰ Many of the scenarios that allow for achieving a long-term concentration of 450 ppm involve “overshooting” that emissions level from short-term emissions of carbon dioxide and absorbing those excess emissions through substantial increases in forest cover on a global basis by 2100, with the forests absorbing the carbon dioxide from the atmosphere.¹³¹

Emissions from agriculture, forestry, and other land use are primarily the result of deforestation and agricultural emissions from soil, nutrient management, and livestock.¹³² For instance, emissions from rice cultivation and livestock manure are a big contributor to greenhouse gas emissions.¹³³ Such activities are the result of the decisions by millions of individuals; they are not the product of an industrial process dependent on the consumption of fossil fuels. And the most cost-effective way to reduce these emissions involves tools such as planting more trees while not cutting existing trees down, more efficiently managing crops and grazing lands, restoring organic materials to soils,

125. See *id.* at 564; Daniel A. Farber, *Controlling Pollution by Individuals and Other Dispersed Sources*, 35 ENVTL. L. REP. 10745, 10745–46 (2005); Dave Owen, *Urbanization, Water Quality, and the Regulated Landscape*, 82 U. COLO. L. REV. 431, 441–42 (2011) (noting how increases in impervious surfaces such as driveways cause decreases in water quality within a watershed).

126. S. R. Carpenter et al., *Nonpoint Pollution of Surface Waters with Phosphorous and Nitrogen*, 8 ECOLOGICAL APPLICATIONS 559, 561 tbl.3 (1998); see also COMM. ON LONG-RANGE SOIL AND WATER CONSERVATION, NAT’L RESEARCH COUNCIL, *SOIL AND WATER QUALITY: AN AGENDA FOR AGRICULTURE* 284 (1993).

127. See Babcock, *supra* note 123, at 120–21 (“Individuals directly generate approximately one-third of U.S. greenhouse gas emissions, and one-third of the energy consumed in this country is used by households.”); Kevin M. Stack & Michael P. Vandenberg, *The One Percent Problem*, 111 COLUM. L. REV. 1385, 1389 (2011) (stating that the “risk of catastrophic climate change may be impossible to reduce unless billions of . . . individuals change their behavior”).

128. GUZMAN, *supra* note 78, at 40 (“Virtually every human activity contributes to the problem [of climate change].”).

129. See WORKING GROUP III, *supra* note 25, at 8, 24.

130. See *id.* at 10, 11 fig.SPM.4.

131. See *id.* at 11 fig.SPM.4, 433–34, 447, 462.

132. *Id.* at 24.

133. See *id.* at 86, 820 fig.11.2.

and even changing consumer diets.¹³⁴ Mitigation efforts in this area are often cost-effective relative to other reductions and also have other societal benefits, including facilitating adaptation to climate change.¹³⁵ This is not just true of greenhouse gas emissions—for instance, many of the emissions of nitrogen into the atmosphere are from agricultural activities, such as using manure.¹³⁶

As Michael Vandenberg so aptly put it:

We are polluters. Each of us. We pollute when we drive our cars, fertilize and mow our yards, pour household chemicals on the ground or down the drain, and engage in myriad other common activities. Although each activity contributes minute amounts of pollutants, when aggregated across millions of individuals, the total amounts are stunning.¹³⁷

Similarly, many of the threats to biodiversity on a global scale result from individual activities. For example, the conversion of natural habitats to agricultural land is a main driver of habitat loss and species extinctions. Much of this conversion is by small-scale farmers around the world; industrial activities produce even more conversion, but this is, in part, a response to demands by consumers for low-cost food products.¹³⁸

The effects of small-scale or individual activities are particularly challenging to manage and control. Regulation of dispersed sources requires costly information about the who, where, when, and how of the regulated activities and may require enforcement efforts that are intrusive and even undesirable.¹³⁹ For instance, the regulation of non-point sources contributing to water pollution can be tricky because non-point sources are the result of runoff from rainfall across the landscape.¹⁴⁰ Accordingly, regulation of non-point sources may require widespread government regulation of land use.¹⁴¹

The effects of individual behavior can be reduced through what is called “upstream regulation.”¹⁴² Here, the regulatory structure focuses on imposing requirements on the production and sale of consumer goods such that their use

134. *Id.* at 24, 68 tbl.TS.3, 86–87, 816, 829–35, 838–41.

135. *See id.* at 24–25, 817, 849 fig.11.13.

136. *See* David Fowler et al., *The Global Nitrogen Cycle in the Twenty-First Century*, PHIL. TRANSACTIONS ROYAL SOC’Y B, no. 1621, 2013, at 1 (2013).

137. Vandenberg, *supra* note 120, at 518.

138. *See* ANTHONY D. BARNOSKY, *DODGING EXTINCTION: POWER, FOOD, MONEY, AND THE FUTURE OF LIFE ON EARTH* 79–103 (2014).

139. *See* David E. Adelman, *Environmental Federalism When Numbers Matter More Than Size*, 32 UCLA J. ENVTL. L. & POL’Y 238, 248–49 (2014); Katrina Fischer Kuh, *When Government Intrudes: Regulating Individual Behaviors That Harm the Environment*, 61 DUKE L.J. 1111, 1152–74 (2012); Vandenberg, *supra* note 120, at 598–600.

140. *See* Daniel R. Mandelker, *Controlling Nonpoint Source Water Pollution: Can It Be Done?*, 65 CHI.-KENT L. REV. 479, 482 (1989).

141. *See id.* at 482–93; Owen, *supra* note 125, at 476–79.

142. *See* Michael P. Vandenberg et al., *Individual Carbon Emissions: The Low-Hanging Fruit*, 55 UCLA L. REV. 1701, 1703–04 (2008).

is less harmful.¹⁴³ The most significant example is stringent air quality regulations imposed on automobile manufacturers. It is far easier to administer, monitor, and enforce regulations against a handful of major automobile manufacturers than against millions of drivers.¹⁴⁴ Similarly, greenhouse gas emissions triggered by individual use of certain forms of energy that are often centrally produced—such as electricity—might be reduced through regulatory requirements imposed on the energy producer—such as a power plant—or through a carbon tax imposed on the extraction of fossil fuels.

These solutions, however, have their limits.¹⁴⁵ Increasing the cost of energy use through a carbon tax, for example, may not have a significant impact on downstream energy use because of a range of physical, institutional, and cultural constraints.¹⁴⁶ Thus, in the building sector a carbon tax may be less effective than energy-efficiency standards.¹⁴⁷ Moreover, individuals' increased use of automobiles has offset the massive reductions in emission levels of individual automobiles.¹⁴⁸

II. MANAGEMENT AND LEGAL OPTIONS TO RESPOND TO THE ANTHROPOCENE

A. MANAGEMENT CHOICES FOR THE ANTHROPOCENE

There are five primary management choices to respond to the changes in the Anthropocene: mitigation, adaptation, restoration, substitution, and doing nothing. These choices differ in how they address impairments to global systems.¹⁴⁹ Impairments to global systems matter for society because they produce negative impacts.¹⁵⁰

143. See Kuh, *supra* note 139, at 1126–31 (describing the concept and terming it “indirect” regulation).

144. See Vandenberg, *supra* note 120, at 554 (noting that “technology-based requirements imposed on . . . auto manufacturers are the centerpiece of the [Clean Air Act] ozone control requirements”).

145. See WORKING GROUP III, *supra* note 25, at 642 (noting limits of market-based instruments in shaping greenhouse gas emissions in the transit sector); Vandenberg, *supra* note 120 at 598 (stating that upstream regulation by mandating standards for the manufacture of consumer products such as automobiles “will continue to face diminishing returns . . . as the most significant products are regulated and as increasing population and activity levels continue to overwhelm product-based restrictions”).

146. WORKING GROUP III, *supra* note 25, at 1173 (noting that although a carbon tax might be “most cost effective,” the “presence of other market failures . . . means that one instrument is insufficient for dealing comprehensively with issues related to the climate problem”). Some forms of individual or household energy use—for example, for heating—are less amenable to change through regulation of large industrial sources, and instead are more likely to be affected by individual decisions with respect to setting thermostats, weatherizing houses, etc. See JASON J. CZARNEZKI, *EVERYDAY ENVIRONMENTALISM: LAW, NATURE & INDIVIDUAL BEHAVIOR* 35–36 (2011); Michael P. Vandenberg & Anne C. Steinemann, *The Carbon-Neutral Individual*, 82 N.Y.U. L. REV. 1673, 1699–1701 (2007).

147. See WORKING GROUP III, *supra* note 25, at 1157, 1158 tbl.15.2.

148. See Vandenberg, *supra* note 120, at 554–58, 558 fig.1.

149. Examples of impairments to global systems include greenhouse gas emissions that change the composition of the Earth’s atmosphere, and thus the global climate.

150. Examples of negative impacts include climate change causing sea level rise, extreme heat and weather events, and loss of snow and glacier water storage systems.

Mitigation involves efforts to reduce the human impairments of global resources.¹⁵¹ Examples of mitigation include reducing the emissions of greenhouse gases that cause climate change through the decarbonization of electricity production, reducing the destruction of habitats that harms biodiversity, and reducing the inputs of nitrogen and phosphorus into waterways and oceans.

Adaptation involves societal efforts to reduce or eliminate the negative impacts caused by human impairments of global resources without reducing the activities or impairments that cause those impacts.¹⁵² For example, in the context of climate change, adaptation involves efforts to reduce the negative effects of climate change on society without reducing the emissions of greenhouse gases that cause climate change. Examples of adaptation in the climate change context include constructing higher seawalls to protect coastal cities from increases in sea level and changing agricultural practices to respond to increased droughts and flooding.¹⁵³ In the context of biodiversity, adaptation might include introducing new species to control previously introduced invasive species or the use of human-triggered prescribed burns to replace natural fire cycles that are an important component of functioning ecosystems. In the context of ocean acidification, adaptation might include adding minerals such as calcium to the waters surrounding coral reefs to buffer those reefs against the harm from acidification.

Restoration involves efforts by society to undo the human impairments of global resources and return the global resource to its prior state. For instance, in the context of climate change, restoration might involve extracting greenhouse gases emitted from the atmosphere. This might be through technological fixes (such as creating machines that remove greenhouse gases from the atmosphere) or through management of natural ecosystems (such as facilitating forest growth to absorb carbon dioxide).¹⁵⁴ For biodiversity, restoration might include the reintroduction of species to places where they are currently absent, such as the return of wolves to Yellowstone National Park in the 1990s.¹⁵⁵

Substitution involves efforts by society to replace the benefits provided by global resources with other tools (whether manmade or natural). In the climate change context, substitution for the human impairments of the global climate

151. See WORKING GROUP III, *supra* note 25, at 37 (“‘Mitigation’, in the context of climate change, is a human intervention to reduce the sources or enhance the sinks of greenhouse gases . . .”). The IPCC definition also includes what I call “restoration,” which would involve “enhanc[ing] the sinks of greenhouse gases.” See *id.*

152. See WORKING GROUP II, *supra* note 76 at 5 (“[Adaptation is t]he process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.”).

153. There will be activities that will facilitate both adaptation and mitigation. See WORKING GROUP III, *supra* note 25, at 1186–87 (noting linkages in agriculture and forestry for climate change).

154. In the context of climate change, this is often referred to as carbon dioxide removal or negative emissions technologies. See *id.* at 485.

155. See generally MARTIN A. NIE, BEYOND WOLVES: THE POLITICS OF WOLF RECOVERY AND MANAGEMENT (2003) (describing wolf reintroduction to Yellowstone).

system might include the dispersion of aerosol particles in the upper atmosphere to reflect sunlight, offsetting the increased insulation of the atmosphere.¹⁵⁶

In contrast with restoration, substitution would leave the global system in its impaired state and attempt to address the negative effects of the impairment. For example, injecting aerosols into the upper atmosphere might offset the increased insulation of the atmosphere from greenhouse gases by reducing the amount of sunlight reaching the Earth's surface, but it would do nothing about the increased levels of greenhouse gases. A restoration approach would attempt to reduce the increased levels of greenhouse gases, which is the underlying impairment.

Both substitution and adaptation seek to reduce the negative impacts on society from the impairment of global systems. The difference is that substitution seeks to reduce those negative impacts at a global level by changing how global systems work overall to reduce the negative effect—for example, by changing the reflectivity of the upper atmosphere. Adaptation seeks to reduce those negative impacts on a smaller geographic scale, either by changing human activities and infrastructure (for example, building infrastructure to hold back a rise in sea level or altering human agricultural patterns), or by managing, protecting, or restoring natural places or processes that help mitigate the negative effects of impaired global systems (for example, restoring or protecting beach dunes to absorb the impact of sea level rise).

The implications of doing nothing are fairly obvious: it is society's option to simply accept the negative effects of the global system's impairment. As an extreme example, we might imagine the citizens of a large coastal city threatened by sea level rise simply watching the sea level rise and doing nothing at all. Of course, there is probably no pure version of doing nothing. Even if the citizens of our hypothetical city are willing to watch the waves rise onto their front steps, they would eventually be forced to leave their city and that, in and of itself, would be a form of adaptation.¹⁵⁷

B. POLICY OPTIONS TO IMPLEMENT MANAGEMENT CHOICES

All of our management choices might be pursued through one or more of five policy options:¹⁵⁸ (1) public entities might directly undertake responsive action,

156. In the context of climate change, both substitution and restoration fall within the concept of geoengineering, at least to the extent that they rely on technological fixes to respond to climate change by either changing the composition of the atmosphere to reduce greenhouse gases (restoration) or offsetting the impacts on the global climate from increased greenhouse gas concentrations (substitution). See WORKING GROUP III, *supra* note 25, at 484.

157. Adaptation that is delayed after extended periods of doing nothing may often be more costly and disruptive than proactive adaptation. If the citizens of our hypothetical city had built a sea wall or moved their infrastructure away from low-lying areas earlier on, their response would likely be less costly and less chaotic than if they waited until the last minute.

158. See WORKING GROUP III, *supra* note 25, at 94, 97 tbl.TS.9 (providing overview of these options); *id.* at 239–42; see also Neil Gunningham & Mike D. Young, *Toward Optimal Environmental Policy: The Case of Biodiversity Conservation*, 24 *ECOLOGY L.Q.* 243, 245 (1997); James Salzman,

which is known as direct public action;¹⁵⁹ (2) public agencies might attempt to shape private behavior through tools such as regulation, permits, taxation, or other measures that use penalties or constraints to incentivize private actors to change what they are doing;¹⁶⁰ (3) public agencies might subsidize private parties to undertake actions that advance mitigation, adaptation, restoration, or substitution goals;¹⁶¹ (4) private parties might act in response to economic incentives;¹⁶² or (5) private parties might act on their own, without any basis in economic incentives.¹⁶³

All of these methods of implementation will have roles to play. However, many of the most effective methods will involve significant public involvement and, indeed, significant public coercion. I will only talk briefly about the first two options, direct public action and public regulation, because the public nature of these actions is relatively straightforward.

1. Direct Public Action

Direct public action will be an important component of the response to harms to global systems. To the extent that government entities are central components of energy production, decisions by those entities about whether to extract or burn fossil fuels for energy production will have substantial effects on the mitigation of climate change. Likewise, public land managers will have an

Teaching Policy Instrument Choice in Environmental Law: The Five P's, 23 DUKE ENVTL. L. & POL'Y F. 363, 364 (2013).

159. Another variant of direct government action would be government agencies using their procurement powers to support technological innovation or reductions in emissions through, for example, the purchase of solar panels for government buildings or the requirement of energy-efficient construction for government buildings. See WORKING GROUP III, *supra* note 25, at 1156.

160. I include both “command-and-control” and “market-based mechanisms” within this category because both tools ultimately depend on restrictions on private activities to operate. See *id.* at 1155–56 (identifying these two categories as “economic instruments” and “regulatory approaches”). This is most obvious for command-and-control regulation in which private parties must comply with limits on their activities or face civil or criminal penalties. But for two reasons, it is also true for both taxes or tradable emission permits. First, in both cases, the private entities cannot undertake activities without gaining permission from the state, either through the acquisition of a permit or through the payment of a tax. Second, in both cases, failure to comply with the permit or tax obligation will result in the imposition of civil or criminal penalties.

161. The key distinction between subsidies and tools such as regulation or taxation is the lack of direct government coercion—the private actors have the choice to accept the subsidies.

162. For instance, a homeowner might move away from a low-lying area because of concerns about economic loss from future storm surges and the lack of private insurance—a form of adaptation. An industrial company might reduce greenhouse gas emissions because of a concern that it could be held liable in tort for the harms from those emissions or because doing so will increase positive perceptions of the company among the public, leading to increased sales—a form of mitigation. That same company might plant trees to absorb greenhouse gas emissions to reduce its tort liability risk—a form of restoration. Some of these economic incentives will be mediated by private law systems such as contract, property, or tort law.

163. For instance, individuals might buy carbon offsets to reduce the emissions that are produced by their daily lives (for example, flying on airplanes or driving cars) because they believe emissions reduction is important. Companies might reduce carbon emissions from their operations because they have a strong sense of corporate social responsibility.

important role to play in eliminating human harms to biodiversity by protecting habitats against development projects. Adaptation efforts will involve public entities through their investments in public infrastructure such as roads, flood protection, and sewer and water systems, whether those investments are a response to climate change threats, such as sea level rise, or to the loss of ecosystem services due to the decline in biodiversity.¹⁶⁴ To the extent that restoration might involve management of public natural resources such as forests or wetlands to increase carbon uptake from the atmosphere or to increase biodiversity, the public agencies managing those resources will be central to restoration. Finally, any substitution effort for global systems will likely occur through public entities given the scale and cost of the action entailed. For instance, injection of sulfur aerosols into the upper atmosphere to increase the reflection of sunlight would cost at least tens of billions of dollars a year,¹⁶⁵ and it is hard to imagine any government allowing such private interference with the global climate.

2. Public Regulation

Public regulation of private activities is also a fundamental component of many current and proposed efforts to respond to harms to global systems such as climate change. For instance, environmental regulation is a key part of many of the efforts to mitigate or reduce harms to global climate, biodiversity, and water and air pollution.¹⁶⁶ Adaptation may also involve significant government regulation, such as building codes to improve infrastructural resilience to extreme weather events.

3. Public Subsidies

Government subsidies to encourage voluntary private action have an important role to play in responding to the challenges of the Anthropocene, but they nonetheless create significant public involvement in and regulation of private activity: they necessarily require the government to pick the recipients of the subsidies and they require public monitoring and enforcement to ensure recipients are in compliance with the program rules. They also require analyzing whether such subsidies will produce a meaningful change in the subsidy recipients' behavior.

164. One example of an investment in infrastructure to respond to the loss of ecosystem services is a town that constructs a levee to protect against increased flooding that results from the loss of wetlands upstream.

165. See P. J. Crutzen, *Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?*, 77 *CLIMATIC CHANGE* 211, 213 (2006).

166. There is a wide range of forms of so-termed "light-handed regulation" in which state supervision of regulated industry is indirect, less intrusive, or more flexible. Nonetheless, state power ultimately backstops the regulatory structure. See Neil Gunningham & Cameron Holley, *Next-Generation Environmental Regulation: Law, Regulation, and Governance*, 12 *ANN. REV. L. & SOC. SCI.* 273, 278–80, 285–86 (2016).

In the context of mitigating climate change, payments by governments to private entities to install solar generation equipment have led to a significant increase in the production of renewable energy in countries such as Germany and China, and in U.S. states such as California.¹⁶⁷ Subsidies might also be useful in the context of adaptation—for instance, payments could incentivize landowners to voluntarily move property out of flood-risk areas. Finally, restoration could be implemented through payments to landowners to improve agricultural or forestry techniques to maximize carbon retention. Similar programs have been used to encourage U.S. farmers to rest agricultural lands that have important conservation value, providing both mitigation benefits against additional harm to habitats and biodiversity, and restoration of habitats to improve biodiversity.¹⁶⁸ Subsidy payments might also encourage farmers to reduce fertilizer use and to create buffer zones between farms and waterways to reduce phosphorus and nitrogen runoff into those waterways.¹⁶⁹

Despite their voluntary nature, subsidies will still involve significant state involvement in private activities. First, subsidies inherently involve the government awarding benefits to certain entities and denying them to others. If payments are made without regard to whether the subsidies advance the goals of the subsidy program, they are simply free, ineffectual handouts of money. Indeed, Republicans criticized the Department of Energy's loan guarantee program to facilitate commercial development of solar technologies because it involved the government picking "winners and losers," with the possibility of government corruption and industry rent-seeking.¹⁷⁰ These concerns motivate economists' broader distrust of subsidies.

However, there is a more fundamental way in which subsidies will involve government power. As noted above, for subsidies to be effective, they must actually produce the action that the payments are intended to induce. Thus, there will need to be audits or checks on whether subsidy recipients comply with the terms of the program. In some cases, this might be a trivial requirement. Payments for production of solar electricity, for example, only require verifying the equipment is actually producing electricity—a task that an electricity meter can perform.

But there are many areas where these compliance efforts will be much more difficult. Consider the use of offsets in greenhouse-gas-emissions trading sys-

167. See, e.g., Björn A. Sandén, *The Economic and Institutional Rationale of PV Subsidies*, 78 SOLAR ENERGY 137 (2005).

168. See J.B. Ruhl, *Farms, Their Environmental Harms, and Environmental Law*, 27 ECOLOGY L.Q. 263, 324 (2000).

169. For example, these tools have been used in efforts to reduce nutrient inputs from agriculture into the Chesapeake Bay. See Timothy D. Searchinger, *Cleaning Up the Chesapeake Bay: How to Make an Incentive Approach Work for Agriculture*, 16 SE. ENVTL. L.J. 171, 185–203 (2007); see also Cynthia J. Aukerman, *Agricultural Diffuse Pollution Controls: Lessons for Scotland from the Chesapeake Bay Watershed*, 20 J. LAND USE & ENVTL. L. 191, 240–57 (2004).

170. See, e.g., STAFF OF H.R. COMM. ON ENERGY & COMMERCE, 112TH CONG., *THE SOLYNDRA FAILURE* 147 (2012) (majority staff report).

tems. Offsets are essentially subsidies: they allow entities that are regulated under the emissions trading system to pay other entities that are not regulated to take steps to reduce greenhouse gas emissions.¹⁷¹ In return, the regulated entity gets an “offset” that reduces its obligations to lower emissions. Offsets are often used for activities that are hard to regulate directly but that might still have significant greenhouse gas emission consequences (for example, the management of forests to improve their ability to absorb carbon from the atmosphere).¹⁷² But these offset programs require compliance checks and have been the subject of fraud.¹⁷³

The more important a subsidy program is for responding to the harms to a global system, the more essential compliance efforts will be. The environmental stakes will be higher, but so will the economic stakes. If the subsidy program is a core component of a massive effort by society to respond to global challenges, then the payments will necessarily be large, increasing the incentives for fraud. Accordingly, government supervision and enforcement will be stricter and start to resemble regulation as the subsidy program becomes more important.

Finally, subsidies do not necessarily include a “baseline” for measuring the appropriate level of harm caused by human activity. Instead, they simply pay people not to do something harmful or to change their behavior in ways that might reduce harm. But again, the more the subsidy program increases in size, the greater the incentive for individuals to attempt to qualify under the subsidy program. This can create perverse incentives for individuals to increase their harmful activities (or threaten to increase their harmful activities) to obtain government subsidies. This is not a hypothetical concern; in fact, this type of behavior was a huge problem with the Kyoto Protocol’s Clean Development Mechanism (CDM), in which developing world companies would construct facilities that emit greenhouse gases simply so they could receive payments to control those emissions.¹⁷⁴

171. See Heather C. Lovell, *Governing the Carbon Offset Market*, 1 WILEY INTERDISC. REV.: CLIMATE CHANGE 353, 353 (2010).

172. See *Compliance Offset Program*, CAL. ENVTL. PROT. AGENCY AIR RES. BD., <http://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm> [<https://perma.cc/5EJT-F3K6>] (last updated Mar. 23, 2016) (allowing offsets for greenhouse gas emission permit requirements for forest management and methane capture from agriculture and other sources).

173. See Richard G. Newell et al., *Carbon Markets 15 Years After Kyoto: Lessons Learned, New Challenges*, 27 J. ECON. PERSP. 123, 138–39 (2013); Michael W. Wara & David G. Victor, *A Realistic Policy on International Carbon Offsets* 5 (Stanford Univ. Program on Energy & Sustainable Dev., Working Paper No. 74, 2008); *Combating Complexities of Carbon Fraud*, FORBES (June 16, 2010, 10:51 AM), <http://www.forbes.com/2010/06/16/cap-and-trade-fraud-entrepreneurs-technology-wharton.html> [<https://perma.cc/3WPE-5F7H>]; McKenzie Funk, *The Hack That Warmed the World*, FOREIGN POL’Y (Jan. 30, 2015), <http://foreignpolicy.com/2015/01/30/climate-change-hack-carbon-credit-black-dragon> [<https://perma.cc/9AX6-3HSU>]; Ryan Jacobs, *The Forest Mafia: How Scammers Steal Millions Through Carbon Markets*, ATLANTIC (Oct. 11, 2013), <http://www.theatlantic.com/international/archive/2013/10/the-forest-mafia-how-scammers-steal-millions-through-carbon-markets/280419> [<https://perma.cc/5R7F-E75V>].

174. See Michael Wara, *Measuring the Clean Development Mechanism’s Performance and Potential*, 55 UCLA L. REV. 1759, 1781–89 (2008).

Efforts to address this problem are notoriously difficult to develop. The most commonly proposed solution is the concept of “additionality,” under which subsidies are only paid-for activities that would not occur but for the payment of the subsidy.¹⁷⁵ So, payments to maintain forests that absorb carbon from the atmosphere will be issued only if the recipient can demonstrate that the forests would otherwise not be protected. The problem with additionality is that because it turns on hypothetical decision making and the motives of individual actors, it can be difficult to demonstrate whether it is truly present.¹⁷⁶ Again, the higher the stakes of a subsidy program, the more likely that challenges demonstrating additionality will be present. Even if these challenges can be overcome, additionality would still require significant government supervision and intrusion to enforce.

Why are these baseline problems not present in government coercion of private actors? In the context of government regulation or taxation, the government can prevent entry into an activity or prevent activity levels from being increased in response to the policy, which is not possible with a purely voluntary subsidy program.¹⁷⁷

4. Incentives for Private Action

Private actors responding to economic incentives are another possible option to respond to the challenges of the Anthropocene. Yet, even here, public involvement will be necessary if this option is to be successful: current economic incentives are inadequate to produce sufficient private action, increasing those incentives through private property rights would require a massive expansion of state power, and even private implementation of management choices such as adaptation will require significant public coordination to succeed.

The problem is that, based on simple economic incentives, we would expect underprovision of effective responses to the harms to global systems. The global systems at issue in the Anthropocene are common systems—many, such as the climate or oceans, are not even owned by any government, let alone by private entities. Actions by private actors that damage these systems do not result in economic impacts on those private actors. Because of this externality, the private actors do not have an incentive to mitigate impairments of the global

175. See Peter Erickson et al., *Net Climate Change Mitigation of the Clean Development Mechanism*, 72 ENERGY POL’Y 146, 147 (2014).

176. See WORKING GROUP III, *supra* note 25, at 1251 (noting that additionality is “difficult to establish in practice due to the counterfactual nature of the *baseline*”); Erickson et al., *supra* note 175, at 147; Wara & Victor, *supra* note 173, at 15.

177. Of course, one could prohibit subsidies related to new or expanded activities, something that was tried in the context of the CDM. See Wara, *supra* note 174, at 1781–89. However, this leaves subsidy designers caught between two opposing challenges. On the one hand, strict enforcement of this kind of rule would prevent the subsidy from addressing significant harms from new or increased activities that were going to occur anyway. A purely voluntary subsidy program can do nothing about these new harms. On the other hand, subsidy recipients have an incentive to frame their activities as already existing so they can qualify for the subsidy.

systems.¹⁷⁸

Thus, it is perhaps no surprise that studies of government-sponsored voluntary programs for firms to reduce greenhouse gas emissions have been “critical,” finding that “little reduction was achieved” and that any impacts were “short lived.”¹⁷⁹ Voluntary programs that are integrated within a larger mandatory regulatory program, where the voluntary program allows for partial fulfillment of mandatory regulatory standards, are more effective.¹⁸⁰ However, here the backstop of government regulation may be particularly important and the results are still mixed.¹⁸¹

Similar challenges face what is often called private or voluntary environmental governance: the use of private contracting, standard-setting, and auditing systems to accomplish environmental goals without government enforcement or involvement.¹⁸² The effectiveness of voluntary environmental governance depends on private actors overcoming collective action problems to establish the governance structure, on producing firms having an incentive to join the governance system (presumably based in part on the gains from increasing the firm’s appeal to consumers), and on consumers being motivated to have an impact on important environmental challenges.¹⁸³ Voluntary environmental governance, therefore, cannot be a complete or even primary solution to the effects of human impairments of global systems.¹⁸⁴

178. See WORKING GROUP III, *supra* note 25, at 38 (“Because the [greenhouse gas] emissions of any agent (individual, company, country) affect every other agent, an effective outcome will not be achieved if individual agents advance their interests independently of others.”); Gunningham & Young, *supra* note 158 at 258–59 (noting voluntary action depends on self-interest).

There is evidence that some mitigation options may produce private benefits that offset the cost of implementation (for instance, by saving on energy costs). See WORKING GROUP III, *supra* note 25, at 79, 247–48. Even here, however, independent private action faces various barriers, including transaction costs and psychological barriers that may require legal or policy intervention. See *id.* at 80.

179. *Id.* at 1171–72.

180. See *id.* at 1172.

181. See *id.*

182. See Sarah E. Light & Michael P. Vandenbergh, *Private Environmental Governance*, in DECISION MAKING IN ENVIRONMENTAL LAW 253, 261 (LeRoy C. Paddock et al. eds., 2016) (defining the concept of “private environmental governance”). Important examples include certification systems like the Marine Stewardship Council and the Sustainable Forestry Initiative. See *id.* at 256 tbl.II.19.1.

183. See Tracey M. Roberts, *The Rise of Rule Four Institutions: Voluntary Standards, Certification and Labeling Systems*, 40 *ECOLOGY L.Q.* 107, 120–22, 126 (2013). Overcoming these collective action failures to set up voluntary governance systems may be somewhat easier for large multinational corporations that contribute large amounts of carbon emissions. See Michael P. Vandenbergh & Jonathan A. Gilligan, *Beyond Gridlock*, 40 *COLUM. J. ENVTL. L.* 217, 254, 260–78 (2015); see generally Sarah E. Light, *The New Insider Trading: Environmental Markets Within the Firm*, 34 *STAN. ENVTL. L.J.* 3 (2015).

184. See Roberts, *supra* note 183, at 121–22, 143–44; Vandenbergh & Gilligan, *supra* note 183, at 303 (“The private climate governance strategy . . . is not a substitute for a national and international carbon price . . .”); see also Gunningham & Holley, *supra* note 166, at 275 (noting that “a range of findings suggest that state law approaches are the single most important driver of improved environmental performance, particularly of large industries”).

Still, there may be important roles for voluntary environmental governance as a complement that can offset some of the limitations of government action. See Roberts, *supra* note 183, at 129–43. For

One possible solution to the lack of incentives for private actors is to adapt private law systems to protect the global systems affected by private action. We could facilitate tort lawsuits in nuisance against those who harm the global climate;¹⁸⁵ we could give property rights, enforceable through trespass, against harm to biodiversity or the oceans,¹⁸⁶ and so on. Scholars in the free-market environmentalist community have called for these efforts, arguing that government regulation can be avoided in many cases through effective expansion of private rights to the environment.¹⁸⁷

Whatever the merits of free-market environmentalist arguments in the context of local environmental resources such as the right to clean water in a small tributary stream, there are significant, if not intractable, logistical problems to expanding these rights to global systems such as the climate, biodiversity, and oceans. How would we give any individual a property right in a portion of the stable climate or a property right in a troposphere that has ozone protecting against solar radiation?

But let us assume that these problems might be overcome. We would still be left with a massive, unprecedented expansion of property and tort rights into a wide range of global systems that have previously been unowned, owned communally, or owned publicly. For these rights to be effective, and to create effective economic incentives for actions to mitigate harms to global systems, those rights will require state enforcement.¹⁸⁸ Courts will need to adjudicate property or tort lawsuits, and state officials will need to force defendants to pay plaintiffs or comply with injunctions. If our goal is to truly address the many challenges the Anthropocene presents to the global systems that society depends upon, then we would need a massive increase of state authority. No portion of the globe would be free from the possibility of trespass or nuisance on someone's private property rights because few if any actions, even everyday actions, would be free from the possibility of trespass or nuisance.

instance, Vandenberg and Gilligan have made a strong case that voluntary measures, coordinated by NGOs and large multinationals, could result in the reduction of about 1 Gt of CO₂ emissions per year, an important contribution to buy time until governments are able to implement effective policies. See Vandenberg & Gilligan, *supra* note 183, at 303. Nonetheless, although important in the short term, even this amount is only a fraction of the overall reductions in greenhouse gas emissions that are required over the next several decades.

185. See Eric Biber, *Climate Change and Backlash*, 17 N.Y.U. ENVTL. L.J. 1295, 1308 n.44 (2009) (listing scholarly articles advocating this approach).

186. See Eric Biber, Case Note, *A House with a View*, 109 YALE L.J. 849, 853 (2000) (discussing *Lee County v. Kiesel*, 705 So. 2d 1013 (Fla. Dist. Ct. App. 1998)).

187. See Jonathan H. Adler, *Conservative Principles for Environmental Reform*, 23 DUKE ENVTL. L. & POL'Y F. 253, 271–76 (2013) (arguing for greater use of property rights and nuisance to address environmental problems); Jonathan H. Adler, *Water Rights, Markets, and Changing Ecological Conditions*, 42 ENVTL. L. 93, 97 (2012) (arguing for greater use of property rights to address climate change adaptation).

188. See MacLean, *supra* note 12, at 21–23 (noting the necessary role of the state in creating property rights and markets).

This is the problem with what is sometimes called the “cornucopian” response to environmental problems: that with enough human ingenuity, people can innovate their way out of serious environmental challenges.¹⁸⁹ There may be some truth to this perspective when it comes to the use of resources extracted from the environment, such as oil, gas, and minerals. As those resources become scarcer, there are economic incentives to improve the efficiency of their use or develop substitutes as prices increase. But these kinds of incentives do not exist in the context of the impairments by human actions to global systems such as the atmosphere, climate, and oceans. When humans extract resources from the environment, they often obtain a property right in those resources and, accordingly, they can benefit from the increased value of those resources. No such property rights exist for the global climate. Any benefits that develop from reducing harms that humans cause to the global climate will be divided essentially equally among the planet’s several billion human inhabitants.¹⁹⁰

What about other responses to harms to global systems, such as adaptation or restoration? Would they too require massive expansions of private law property and tort rights to facilitate private action for adaptation or restoration? With respect to restoration, the answer is almost certainly yes. Again, the problem is that the global system that we seek to restore is a commonly owned or unowned system, so there are no economic incentives for private actors to take restoration steps.

Economic incentives might motivate a range of adaptation techniques. For instance, landowners who move their houses because of the threat of damage from rising sea levels are responding to economic incentives, based in part on their existing property rights to the land on which their houses are located. But there is reason to believe there are limits to the extent to which private activities based on economic incentives can respond to problems, such as climate change, without significant public intervention.

First, individual rational adaptation efforts might be collectively irrational. For instance, individual landowners might decide to armor their portion of the shoreline to provide short-term resistance to sea level rise. Not only might these efforts prove futile in the long run, but they will also have negative impacts on other neighbors and public resources. Armoring might divert the force of waves and storms onto other property owners, accelerating erosion on their properties. Armoring might also result in the erosion or loss of important public beaches and wetlands that provide essential recreation sites, wildlife habitats, and ecosystem services.¹⁹¹ Public regulation can reduce these risks by restricting how and when private adaptation efforts affect other property owners or public resources,

189. See generally ORESKES & CONWAY, *supra* note 111.

190. See Jonathan M. Barnett, *The Illusion of the Commons*, 25 BERKELEY TECH. L.J. 1751, 1773 (2010) (arguing that significant, capital-intensive innovation typically requires property rights); see also Jonathan H. Adler, *Is the Common Law a Free-Market Solution to Pollution?*, 24 CRITICAL REV. 61, 72–74 (2012) (noting challenges in using property rights to address pollution).

191. See Doremus, *Property Rights*, *supra* note 18, at 1105–08.

but that, of course, would result in increased public intervention in private decision making.

Second, adaptation efforts might require substantial public coordination to be successful. This is most obvious for infrastructure such as roads and energy or water systems. We already have public planning processes for this kind of infrastructure for good reasons that will only be more relevant in a world where societies are adapting to significant changes in global systems. But even for other human activities, particularly urban or suburban development, there are important coordination problems that are typically solved through public regulation such as zoning.¹⁹² For example, individual homeowners' decisions to stay or move from an isolated barrier-island community vulnerable to sea level rise will pose important public questions about the extent to which emergency services can respond to residents during extreme storm events, the cost-effectiveness of providing public services to those communities (particularly if residents start leaving the community), and the impacts on the community from individual decisions to leave.¹⁹³ For example, in New Orleans after Hurricane Katrina, choices about the extent to rebuild portions of the city necessarily involved contentious and difficult public decisions about infrastructure, services, and risk.¹⁹⁴

5. Purely Voluntary Private Action

Finally, there is purely voluntary private action without any economic incentive. However, if private action incentivized by economic pressures will be inadequate to respond to changes in global systems, it seems even more implausible that purely voluntary action will be enough. Moreover, the social norms or communal management that are central drivers of voluntary private action are difficult to scale at a global level and often significantly shaped by government intervention.

As with private action drive-by economic incentives, government interventions can reduce the underprovision of private responses by facilitating the use of voluntary private decision making. For instance, the government can mandate the production and distribution of information about the environmental impacts of products or processes, allowing producers and consumers to make

192. For an overview of the voluminous scholarly literature on the merits and demerits of zoning, see JESSE DUKEMINIER ET AL., PROPERTY 986–87 (8th ed. 2014).

193. This is no longer a hypothetical example. Public action has already begun to evacuate a vulnerable, primarily indigenous community on the Louisiana coast because of sea level rise. The coordination problems here are not only about physical infrastructure, but also about how to maintain and improve the social infrastructure of communities that move, an infrastructure that is essential for individual wellbeing. See Coral Davenport & Campbell Robertson, *Resettling the First American 'Climate Refugees.'* N.Y. TIMES (May 3, 2016), <https://www.nytimes.com/2016/05/03/us/resettling-the-first-american-climate-refugees.html> [<https://perma.cc/6KGQ-6F3X>].

194. See, e.g., KARL F. SEIDMAN, COMING HOME TO NEW ORLEANS: NEIGHBORHOOD REBUILDING AFTER KATRINA 254 (2013) (walking through the extensive planning of post-Katrina rebuilding of New Orleans).

decisions that minimize environmental impacts.¹⁹⁵ Examples include organic food labeling programs, sustainable forestry certification programs, and energy efficiency reporting requirements for automobiles and appliances. Again, however, these informational tools only work to the extent that private individuals believe it is in their interest to make the environmentally preferred choice or are willing to altruistically make such a choice.¹⁹⁶ In the context of climate change, these measures have been “mostly supplementary to other policy instruments such as obligatory standards.”¹⁹⁷

What about the possibility that changes in social norms might alter private actions without relying on the government? In the future, might it be possible that burning fossil fuels would be so socially unacceptable that people would not do it, even if there were no government prohibition against it?

We have seen dramatic changes in social norms over time—for example, smoking and driving without a seatbelt have become less socially accepted¹⁹⁸ and gay marriage more accepted.¹⁹⁹ In the environmental context, littering has become socially unacceptable in the United States.²⁰⁰

There are, however, several problems with relying simply on changes to social norms to respond to changes in global systems. First, prior examples of substantial changes in social norms pale in comparison to the changes in behavior required to respond to the changes in global systems in the Anthropocene, both in terms of the scale of the changes and the rapidity of their occurrence. Consider the reduction of greenhouse gas emissions to respond to climate change. Massive changes in social norms would be necessary to achieve the reductions needed to mitigate harms to the global climate system, requiring residents in developed and developing countries to forego many of the benefits of modern industrial society such as electricity, automobiles, airplanes, and the embedded carbon in many consumer goods. Of course, it is possible to implement substitutes for carbon emissions for some of these activities. For instance, solar panels can provide electricity for a house during the daytime. But these substitutes often require individuals to make large expenditures or commit to long-term contracts.

195. See WORKING GROUP III, *supra* note 25, at 1170.

196. See *id.* (“Since information programmes typically provide information and leave it to firms or consumers to take appropriate action, those actions will usually only be taken spontaneously, or if they are perceived to have negative private costs economically.”).

197. *Id.*

198. See NAT’L HIGHWAY TRAFFIC SAFETY ADMIN., U.S. DEP’T OF TRANSP., SEAT BELT USE IN 2013—USE RATES IN THE STATES AND TERRITORIES 1 (2014) (reporting national seat belt usage rate of 87%); *Trends in Current Cigarette Smoking Among High School Students and Adults, United States, 1965–2014*, CTRS. FOR DISEASE CONTROL & PREVENTION, http://www.cdc.gov/tobacco/data_statistics/tables/trends/cig_smoking [<https://perma.cc/Y65U-UGXR>] (last updated Mar. 30, 2016).

199. See *Changing Attitudes on Gay Marriage*, PEW RES. CTR. (May 12, 2016), <http://www.pewforum.org/2016/05/12/changing-attitudes-on-gay-marriage> [<https://perma.cc/R5JR-VW2D>] (summarizing same-sex marriage public opinion polling trends since 2001).

200. See KEEP AMERICA BEAUTIFUL, LITTERING BEHAVIOR IN AMERICA 38 (2009) (showing declining littering rate from 1968 to 2008).

Second, many individuals do not have control over the decisions necessary to effectively mitigate, adapt, or restore. Individuals do not have control over the electric grid and, even individuals who choose to go off the grid, will still purchase goods produced with greenhouse gas emissions. In a modern industrial society, individuals' actions rely on broader systems that are currently dependent on greenhouse gas emissions. Changing those systems will require coordinated public action.

Finally, many changes in social norms correlate with changes in laws. Smoking became less acceptable due to an increase in fines and enforcement,²⁰¹ driving without a seatbelt is now illegal,²⁰² and changes in perceptions about same-sex marriage paralleled judicial recognition of a legal right to same-sex marriage.²⁰³ To what degree the changes in social norms were a product of legal changes, or preceded those legal changes, is a difficult question to answer, but there is substantial legal and psychological literature stating that legal changes facilitate changes in social norms.²⁰⁴ In other words, the shaping of social norms significantly interacts with legal change and state regulation of private behavior. Even in this context, the state plays an important role in responding to global harms.

Another possible manner in which private action, unmediated by the state or law, might produce collective action to address environmental problems is through communal resource management. Elinor Ostrom has demonstrated that communities in many cases can develop systems to successfully manage the extraction of resources from the environment, even where the resources are communally owned, without state enactment or enforcement of management rules.²⁰⁵

There are, however, important reasons to question the extent to which this kind of community-based management can address human impairments of global resources. First, Ostrom's work has focused on small-scale resources such as fishing by a particular community or management of particular irrigation projects.²⁰⁶ These forms of community-based management are more likely to work when the community can exclude outsiders or violators from the resource; the community rules can match specific local conditions of effective

201. See generally David T. Levy et al., *The Effects of Tobacco Control Policies on Smoking Rates: A Tobacco Control Scorecard*, 10 J. PUB. HEALTH MGMT. PRAC. 338 (2004) (discussing the effects of various tobacco control policies on smoking rates).

202. See Alma Cohen & Liran Einav, *The Effects of Mandatory Seat Belt Laws on Driving Behavior and Traffic Fatalities*, 85 REV. ECON. & STAT. 828, 828–29 (2003) (finding seat belt laws substantially increased in latter half of twentieth century and contributed to increased seat belt usage).

203. Compare *Changing Attitudes on Gay Marriage*, *supra* note 199, with *Obergefell v. Hodges*, 135 S. Ct. 2584 (2015) (recognizing a constitutional right to same-sex marriage).

204. See Eric Biber & J.B. Ruhl, *The Permit Power Revisited: The Theory and Practice of Regulatory Permits in the Administrative State*, 64 DUKE L.J. 133, 223 nn.321–34 (2014) (providing an overview of the literature).

205. See generally ELINOR OSTROM, *GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION* (1990).

206. See *id.* at 26, 182–84.

resource management; there is greater homogeneity of interests within the community; members of the community are repeat players with regular ongoing interactions with the resource and each other; effective management, enforcement, and monitoring produce direct benefits for community members; and the community is relatively small in number.²⁰⁷ All of these factors are more likely to be present in a relatively small communal resource management problem in a specific community where the extraction of the resource provides direct benefits to the community. By contrast, the global resource management problems at the heart of the Anthropocene often involve global-scale challenges produced by the discharge of the products of human activities into global commons. Thus, the individuals involved are numerous and heterogeneous, exclusion of outsiders or violators from the resource is difficult or impossible,²⁰⁸ individuals rarely have repeat interactions with others involved in the resource management problem,²⁰⁹ and there are few if any benefits from effective management or monitoring by individuals.²¹⁰

Even if communities were to develop helpful norms to address a particular global resource management problem, the challenges we face in the Anthropocene are a moving target. As Part I demonstrates, climate change is only one of a series of management challenges that we will face going forward. Moreover, the pace at which these management challenges arise and become serious threats to human and natural systems is accelerating. Thus, it will be difficult for norms, at the societal or community level, to evolve at the necessary rate to keep up with the rise and expansion of future challenges.

6. Synergies Among Policy Options

To this point, each policy option has been analyzed independently, but many of these options will be implemented in concert. For instance, as noted above, social norms that drive voluntary private action might be shaped or built by

207. *See id.* at 89–90, 94–96, 146, 188, 202–06, 211; *see also, e.g.*, JAMES ACHESON, *THE LOBSTER GANGS OF MAINE* (1988).

208. Indeed, when it comes to the global climate, there are no outsiders.

209. Again, at the extreme in the context of climate change, there are few, if any, interactions between individuals on different continents who are each contributing to the emission of greenhouse gases.

210. Although individuals in a fishing community might directly benefit from monitoring compliance with community fishing rules or norms (because they will receive additional fish if those rules or norms are followed), the benefits of any one individual enforcing norms with respect to the use of global resources are much, much smaller. Ostrom notes that for large-scale, common-pool resource management problems, community-based norms are less likely to be successful. *See OSTROM, supra* note 205, at 183–84.

Community-based norms may still be part of an overall system of addressing global resource management problems, such as by building community-based systems within an overall governmental management system. *See Elinor Ostrom, Polycentric Systems for Coping with Collective Action and Global Environmental Change*, 20 *GLOBAL ENVTL. CHANGE* 550, 550 (2010). But as even Ostrom concedes, state action at the national or international level is ultimately an essential component of addressing global resource management problems like climate change. *Id.* at 555 (stating “[t]here is no question that an international treaty is a major step that needs to be taken” to address climate change).

public regulations that change preferences. Subsidy programs that facilitate affirmative efforts by private actors might be paired with taxes to deter harmful private actions. For example, a carbon tax imposed on the combustion of fossil fuels could work in conjunction with a subsidy program for investments in renewable energy. Regulatory systems might serve as a backstop for a subsidy system—payments to landowners to restore native habitats for endangered species can be combined with regulations that prohibit the landowners from destroying the remaining habitat. Yet, given the centrality of public involvement in the policy options that will likely succeed, combining policy options will simply mean that public involvement in any successful response to the Anthropocene is all the more likely.

7. Doing Nothing

In summary, if society decides to respond to the negative effects caused by human impairments of global systems like the climate, its response will involve significant increases in governmental authority over private actions. But that still leaves the final option for responding to the Anthropocene: doing nothing. Is it possible that the dominant response of society will be doing absolutely nothing?

Although possible, this seems an unlikely outcome.²¹¹ First, it is important to acknowledge the many current efforts by governments and private parties around the world to respond to problems such as climate change.²¹² Even if those responses are seriously inadequate, they nonetheless indicate the significant political and social pressures to respond that will only increase with time. Second, doing absolutely nothing is not a feasible long-term option. As the summary above makes clear, human impairments of global systems will have a significant negative impact on society and, if nothing else, it will be forced to adapt.

III. IMPLICATIONS OF THE ANTHROPOCENE FOR THE LEGAL SYSTEM

The Anthropocene will tend to produce greater governmental intrusions into private activities. Some tools such as carbon taxes might be less intrusive but, as noted above, taxes imposed only on the extraction of fossil fuels from the ground will still leave many human causes of climate change unaddressed. Taxes may also fail to effectively incentivize individual actions, such as purchasing energy-efficient appliances or retrofitting homes to improve efficiency.

211. Of course, inadequate action is a likely response. But over time, even inadequate action will impose significant pressures on the legal system.

212. See WORKING GROUP III, *supra* note 25, at 1150 (discussing “substantial increase” in government action on climate change mitigation between 2007 and 2012 and noting that in 2012, “39% of countries, accounting for 73% of population and 67% of greenhouse gas emissions, were covered by climate law or strategies”).

Thus, these taxes will need to be complemented by a range of more intrusive regulatory tools.

Moreover, even carbon taxes nevertheless involve a level of government regulation that, at least for some, is highly alarming. For instance, the Supreme Court recently considered whether and how under the Clean Air Act the EPA could regulate greenhouse gas emissions from relatively small industrial sources—even at the level of dry cleaners, gas stations, and small apartment building furnaces.²¹³ In an effort to defend regulation of these kinds of entities under the Clean Air Act, various parties argued that a range of regulatory tools might reduce or eliminate the burdens of regulation on small sources.²¹⁴ But the Court, per Justice Scalia, was not convinced and expressed its concerns about recognizing in the agency “[t]he power to require permits for the construction and modification of tens of thousands, and the operation of millions, of small sources nationwide,” which it called an “extravagant statutory power over the national economy.”²¹⁵ As for “‘streamlining’ techniques . . . such as ‘general’ or ‘electronic’ permitting” that would reduce administrability problems, they would not “address the more fundamental problem of [the] EPA’s claiming regulatory authority over millions of small entities.”²¹⁶ It seems unlikely that these concerns would be addressed even with a carbon tax program that minimized red tape—such a program would still entail substantial regulatory coverage over much of the economy.

The Anthropocene will also bring surprises as new harms emerge and the impacts of existing harms are better understood. Surprises will often require changes in legal systems, such as changes in regulations or private law systems like property. Again, the greater the consequences of human impairments of global systems, the more surprises we will likely see and the greater the legal system will need to develop.

The general patterns of legal implications of the Anthropocene are therefore greater government intrusion in individual activities and the constant updating of laws and regulations. How will these play out in the context of specific legal fields or doctrinal questions? In this Part, I analyze a range of possibilities across private and public domestic law in the United States.²¹⁷ I emphasize, however, that these examples are nonexhaustive given that more examples will surely surprise us in the decades to come.

These changes in private and public law will likely occur through a range of mechanisms—for instance, common law judicial reinterpretation and development of precedent might drive many of the changes in private and public law, but changes might also be the result of legislative revisions to relevant statutes

213. *See* *Util. Air Regulatory Grp. v. EPA*, 134 S. Ct. 2427, 2436 (2014) (plurality opinion).

214. *See id.* at 2444–45, 2444 n.7.

215. *Id.* at 2444.

216. *Id.* at 2444 n.7.

217. For the sake of brevity, I focus on American law in my analysis. However, the implications will surely be significant for international law and legal systems across the globe.

(for example, giving administrative agencies broad authority to regulate or expanding criminal law prohibitions to cover a wider range of individual activity). None of these forms of legal change are novel. What will likely be novel in the Anthropocene is the rate at which these legal changes will be developed—an increased rate of change which, as we shall see, will itself put pressure on existing legal doctrines.

A. PRIVATE LAW

1. Tort Law

In the context of mitigation in private law, we will see a narrowing of the scope of individual activities or behaviors that are seen as too trivial to be covered by the legal system. As the aggregation of individual behaviors becomes more important for impairments of global resources, such as climate, it will be harder to argue that certain activities are too small or unimportant to warrant the attention of the legal system. In the end, the Anthropocene will require the legal system to reevaluate its preexisting commitment that small-scale individual actions are legally insignificant. As discussed in Part IV, there is a long history of the legal system changing its perspective on what types of harms are important enough to warrant legal intervention—just as in those previous examples, the demands of the Anthropocene and the need for some form of legal response are likely to force a reevaluation of the legal irrelevance of small scale individual actions.

Tort law provides multiple examples of the tension between the need to address the individual actions at the heart of the Anthropocene and existing legal doctrine, including proximate cause and allocating liability among multiple tortfeasors.

Proximate cause is a doctrine that prevents liability from being imposed for activities whose causal connections are too remote from a plaintiff's claimed injury.²¹⁸ Most commonly, it is framed as a “foreseeability” test: whether the defendant could have reasonably foreseen the resulting harm at the time the defendant acted.²¹⁹ It can be understood, at least in part, as articulating when a defendant's actions are not important enough to warrant the cost and expense of further litigation. If the causal chain is long and complicated, one might

218. See W. PAGE KEETON ET AL., PROSSER AND KEETON ON THE LAW OF TORTS 280–81 (5th ed. 1984). The most recent Restatement for tort law moves the questions that were previously considered under proximate cause to the scope of the defendant's duty to the plaintiff. See RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL AND EMOTIONAL HARM ch. 6 (AM. LAW INST. 2005). The issues I address here would remain equally relevant. I rely on the concept of proximate cause for my discussion in part because that is the dominant approach taken by commentators and courts considering these questions in the context of climate change.

219. See RESTATEMENT (THIRD) OF TORTS § 29 cmt. j. Courts often apply this standard by restricting liability to the type of harm that the defendant could have reasonably foreseen and to the class of people the defendant could have reasonably foreseen harming. *Id.*; see also *Overseas Tankship (U.K.) Ltd. v. Morts Dock & Eng'g Co.* [1961] AC 388 (PC).

conclude that the defendant's actions did not really matter. Another way of understanding proximate cause is that in a world of complexity and uncertainty, there are certain impacts on our lives from others that we simply have to accept because unpacking whether those other actions really harmed us is too complicated or difficult.²²⁰ A third way of understanding proximate cause is that if we were to impose liability on actions that harm others, no matter how remote the causal connection, we might all be paralyzed by the fear that anything that we do, no matter how trivial, might result in excessive liability because of unforeseen impacts on others.²²¹

But in the Anthropocene, there are causal connections between some of the most trivial everyday activities and the harms that occur across the planet. It is hard to see how most individuals would have foreseen the wide range of harms that would result from everyday actions in the Anthropocene or the wide range of people around the world harmed by those actions.²²² A range of scholars, agencies, and judges have already noted the challenges of establishing proximate cause between emissions from even the largest emitters (for example, oil and gas companies) and the global harms of climate change because climate change is ultimately the product of emissions from the activities of billions of people over decades and even centuries.²²³ Or, in the context of human impairment of global nutrient cycles, every farmer in the Mississippi River basin is a contributor to the dead zone at the mouth of the Mississippi River, but proving proximate cause for each of those farmers would be a difficult matter.

Proximate cause also raises an issue for plaintiffs asserting standing to sue in federal court, for which tracing causation between the defendant's actions and plaintiff's injuries is an essential component. For instance, in dismissing a nuisance lawsuit by an Alaskan native village against major oil companies, one of the judges in a concurring opinion expressed skepticism that the village could establish a causal connection between the emissions from the oil company's

220. See H.L.A. HART & TONY HONORÉ, CAUSATION IN THE LAW 305 (2d ed. 1985); KEETON ET AL., *supra* note 218, at 263.

221. See *Staelens v. Dobert*, 318 F.3d 77, 79 (1st Cir. 2003) (stating that without proximate cause, "liability would extend endlessly, one harm leading inevitably to others").

222. Of course, with broader popular understanding of the risks of climate change, maybe the wide range of harms and harmed individuals caused by greenhouse gas emissions is now foreseeable. However, that would still not address the underlying policy concerns behind proximate cause doctrine—for example, the risk of liability for the distant effects of a wide range of everyday activities. In addition, under proximate cause doctrine, there may be superseding, subsequent causes that exist in the causal chain between the defendant's original action and the plaintiff's harm. For instance, natural storms that are unforeseeable by the defendant can break the proximate cause chain. RESTATEMENT (THIRD) OF TORTS § 29. Again, given the wide geographic and temporal scope of harms in the Anthropocene, it is hard to see how any defendant could foresee the wide range of natural events that would interact with (for example) greenhouse gas emissions to cause harm to plaintiffs.

223. For scholarly assessments, see, for example, Kysar, *supra* note 10, at 10–20. For an example of a regulatory agency decision that depended on the lack of a causal relationship between greenhouse gas emissions and harm to the environment, see the refusal by the U.S. Fish and Wildlife Service to protect the polar bear from greenhouse gas emissions. See *generally In re Polar Bear Endangered Species Act Listing and § 4(d) Rule Litigation*, 794 F. Supp. 2d 65 (D.D.C. 2011).

activities and products and the harm to the village from coastal erosion caused by climate change:

By [the village of] Kivalina's own factual allegations, global warming has been occurring for hundreds of years and is the result of a vast multitude of emitters worldwide whose emissions mix quickly, stay in the atmosphere for centuries, and, as a result, are undifferentiated in the global atmosphere. Further, Kivalina's allegations of their injury and traceability to [the oil companies'] activities is not bounded in time. Kivalina does not identify when their injury occurred nor tie it to [the companies'] activities within this vast time frame. Kivalina nevertheless seeks to hold these particular [companies], out of all the greenhouse gas emitters who ever have emitted greenhouse gases over hundreds of years, liable for their injuries.²²⁴

We might decide that imposing liability on everyday activities is improper under tort law. At one level, it does seem unfair that someone who drove their car to work that morning should be on the hook for the harms to a poor farmer in Bangladesh, or that a farmer in North Dakota is responsible for the economic losses suffered by a shrimper in Louisiana who is affected by nutrient pollution in the Gulf of Mexico.²²⁵ But if we hold that nothing related to these impairments of global resources meets the test of proximate cause—and there are plausible arguments that under current doctrine not even the largest polluter in the United States would meet that test²²⁶—then we have essentially given up on tort law as a response to the challenges of the Anthropocene. That means we are giving up on private law as a solution to some of the most important challenges in the next century.²²⁷

Similar challenges relate to how tort law should address the accumulation of many small harms, each of which individually would not be sufficient to cause the plaintiff's harm, but collectively do cause harm. If there are multiple tortfeasors whose actions individually caused harm to the plaintiff, courts will

224. *Native Vill. of Kivalina, v. ExxonMobil Corp.*, 696 F.3d 849, 868–69 (9th Cir. 2012) (Pro, J., concurring). These issues of causation for standing purposes will also be problematic in the context of public law litigation seeking judicial review of administrative agency action or inaction. *See, e.g.*, *Wash. Envtl. Council v. Bellon*, 732 F.3d 1131, 1142 (9th Cir. 2013) (denying standing for environmental group challenging state regulation of greenhouse gas emissions in part for lack of causation). For arguments that justiciability doctrines such as standing should not bar litigation, see Benjamin Ewing & Douglas A. Kysar, *Prods and Please: Limited Government in an Era of Unlimited Harm*, 121 *YALE L.J.* 350, 391–95 (2011). For a broader discussion of the problems that ecological interdependence in the Anthropocene create for standing, see Jedediah Purdy, *Coming into the Anthropocene*, 129 *HARV. L. REV.* 1619, 1627 (2016) (reviewing JONATHAN Z. CANNON, *ENVIRONMENT IN THE BALANCE: THE GREEN MOVEMENT AND THE SUPREME COURT* (2015)).

225. *See* Kysar, *supra* note 10, at 54–55 (noting fairness concerns such as the “imperfect abilities [of individuals] to predict and prevent harmful consequences of [their] action[s]”).

226. *See id.* at 18 (stating that given the near universal nature of greenhouse gas emissions by all members of an industrial society, “there is a problematic arbitrariness” in selecting a defendant for a tort lawsuit).

227. *See id.* at 4.

find liability.²²⁸ However, human impairments of global resources usually involve the accumulation of millions of individual decisions that combined cause serious consequences for human and natural systems. Everyone's greenhouse gas emissions merge in the atmosphere to contribute to climate change. Because everyone is liable, perhaps no one is.²²⁹

The Third Restatement identifies at least limited situations where liability might be imposed on defendants, even where their actions were not sufficient to cause harm.²³⁰ But it is an open question whether courts would apply this doctrine to the fact patterns common in the Anthropocene, where it is only the joint action of millions of actors that is sufficient to cause harm.²³¹ The case law in the standing context discussed above, though analogous, raises doubts about whether this would occur. And courts have regularly rejected liability for what they consider *de minimis* contributions to causal harms under a proximate cause theory.²³²

At heart, the tort system is best designed to address specific actions by identifiable individuals that directly cause substantial harm to other identifiable individuals.²³³ Such a requirement is arguably necessary "in order for individuals to enjoy the freedoms of liberal society."²³⁴ In a less crowded, less human-dominated world, this conception of the scope of tort law seems less problematic. Physical harms to the environment did not aggregate on a global scale in the nineteenth century at the same level as they do in the twenty-first century.²³⁵ Population densities were often low enough such that natural systems could buffer the impacts of one person's actions on another.

But these are not the conditions of the Anthropocene. We can no longer assume that nature will buffer the impacts of humans on one another. And those impacts will only increase with population growth, economic growth, and technological change. Importantly, those who would advocate for a primarily private law response to the challenges of the Anthropocene must reconcile the likelihood that such a response will involve substantial expansion of liability

228. See RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL AND EMOTIONAL HARM § 27 (AM. LAW INST. 2005) (stating that multiple sufficient causes can lead to liability).

229. See Kysar, *supra* note 10, at 35–36 (noting this problem); see also RESTATEMENT (THIRD) § 36 (de minimis exemption for causal contributions to plaintiff's harm).

230. See RESTATEMENT (THIRD) OF TORTS § 27 cmt. f, illus. 3; see also *id.* cmt. g (noting similar findings in toxic torts context). But see *Aldridge v. Goodyear Tire & Rubber Co.*, 34 F. Supp. 2d 1010, 1020 (D. Md. 1999) (requiring that a defendant's actions be sufficient to cause harm in order to find liability), *vacated on other grounds*, 223 F.3d 263 (4th Cir. 2000).

231. See RESTATEMENT (THIRD) OF TORTS § 27 cmt. i (noting the difficulties of this sort of fact pattern and uncertainty as to judicial results).

232. See *id.* § 36 (de minimis exemption for causal contributions to plaintiff's harm).

233. See Kysar, *supra* note 10, at 3–4 ("Built as it is on a paradigm of harm in which A wrongfully, directly, and exclusively injures B, tort law seems fundamentally ill-equipped to address the causes and impacts of climate change: diffuse and disparate in origin, lagged and latticed in effect . . ."); see also *id.* at 62 ("Classical tort is most comfortable with liability when A is shown to have directly and exclusively caused a discrete harm to B.").

234. *Id.* at 14.

235. See *supra* Figures 1 & 2.

under tort law doctrines, such as nuisance and trespass, with related fundamental changes to doctrines, such as proximate cause and divisibility of harm. The ultimate result might be a tort law that becomes more similar to administrative law—existing models include the use of quasi-administrative systems to respond to mass torts such as the harms caused by asbestos to millions of workers and consumers.²³⁶

2. Property Law

Property is another private law field that the Anthropocene will most visibly affect, both from mitigation and adaptation efforts. The Anthropocene will create pressures for property systems to update in response to the increasingly rapid changes in human impairments to global systems and the impacts of those impairments on human and natural systems. However, that increased rate of response in property systems will in turn put pressure on doctrinal rules such as takings claims for compensation by the government to property owners for changes in property rules.²³⁷

First, consider the impacts that mitigation might have on property. As discussed above, the Anthropocene will drive greater government regulation of the uses of private property.²³⁸ Moreover, with the increased rate of change of human impairments of global systems and the addition of new impairments of global systems over time, the level and nature of regulation will change in an accelerating manner.

Activities that property owners could pursue without legal constraints will now be subject to regulation, changing property rights. At least some property owners will respond with takings claims. As Holly Doremus notes, takings law can be understood as an effort to protect property owners during transitions in property or regulatory regimes from outsized losses caused by changes in the rules.²³⁹ In the Anthropocene, those transitions will come faster and be more drastic.²⁴⁰ The result will be a fundamental challenge to one of the core rationales of strong protection for property rights: protecting property owners' reliance on their property entitlements to encourage investment in the property (both economic and otherwise).²⁴¹

236. See generally Linda S. Mullenix, *Resolving Aggregate Mass Tort Litigation: The New Private Law Dispute Resolution Paradigm*, 33 VAL. U. L. REV. 413 (1999).

237. For an in-depth examination of a range of additional property law issues that will develop in the Anthropocene, see generally Byrne, *supra* note 18; Sprankling, *supra* note 18.

238. See *supra* Section II.B.4. See generally Sprankling, *supra* note 18.

239. See Doremus, *Property Rights*, *supra* note 18, at 1093–94; Holly Doremus, *Takings and Transitions*, 19 J. LAND USE & ENVTL. L. 1, 3 (2003). See generally Sprankling, *supra* note 18.

240. See LAZARUS, *supra* note 5, at 40 (noting need for restrictions of private property rights to address environmental harms and need for rapid responses to changes in environmental harms that will unsettle property rights).

241. See Sprankling, *supra* note 18, at 26–28 (arguing that Takings Clause jurisprudence will need to change in the Anthropocene).

One example of this problem is the regulation of private property under the Endangered Species Act. More and more species have been listed for protection under the Act over the past fifteen years, as the impacts of habitat destruction, invasive species, and climate change accumulate and threaten more species.²⁴² The accelerating addition of new listed species concomitantly produces more regulations on the property owners whose lands are habitat for the listed species.

Adaptation will pose similar challenges to property systems.²⁴³ As the consequences of human impairments of global resources affect society, many of the adaptation responses might require restricting individual use of property rights, or even reallocating those property rights.

For instance, consider water rights, which are predominantly allocated according to a prior appropriation system in Western states and are treated as a limited form of a property right. As precipitation and snowfall patterns change as a result of climate change, the distribution of water will change as well. How should the legal system take those changes into account? One option is simply to allow owners to transact among themselves to respond to changes in water availability and need. But water is not like stock certificates (which can be transferred electronically) or even computers (which can be shipped by trucks on roads). Specialized, expensive infrastructure is used in much of the West to store and transfer water, which may significantly limit the utility of trading to redistribute resources. More fundamentally, many would argue that there is a fundamental public role in allocating water rights, at least for water for human consumption.²⁴⁴ That public role is one of the justifications for the massive public investments in water infrastructure in the West. We may be uncomfortable leaving redistribution of water rights to the free market if such a market even exists.²⁴⁵ It therefore seems likely that water rights reallocations in the context of climate change will involve public decision making.²⁴⁶

At heart, a key challenge that the Anthropocene poses is that the effectiveness of property systems as a resource management tool depends on the accuracy of an assumption that most of the impacts of an individual property owner's decisions are felt by that property owner—in other words, spillovers of an

242. Currently, more than 1,600 species are listed for protection in the United States. *See Listed Species Summary (Boxscore)*, U.S. FISH & WILDLIFE SERV., <http://ecos.fws.gov/ecp0/reports/box-score-report> [<https://perma.cc/BGG5-GYV9>]. In 2008, 1,300 were listed. *See Biber, supra* note 185, at 1335.

243. For important earlier scholarly work on this question in the context of climate change, see Doremus, *Property Rights, supra* note 18, at 732; A. Dan Tarlock, *Takings, Water Rights, and Climate Change*, 36 Vt. L. REV. 731, 732 (2012).

244. *See, e.g.,* Eric T. Freyfogle, *Water Rights and the Common Wealth*, 26 ENVTL. L. 27, 30–36 (1996).

245. *See* Doremus, *Property Rights, supra* note 18, at 1091 (“Markets, however, will not adequately protect the collective, as opposed to the private, interests climate change will put at risk.”).

246. *See* Sprankling, *supra* note 18, at 18–20 (noting importance of concept of equitable sharing in property law in the Anthropocene and reallocation of property rights).

owner's decisions across property lines are minimal.²⁴⁷ But as with tort law, in the Anthropocene there will be significant spillovers from the aggregation of individual actions historically thought of as having only local impacts. The scale of the impacts of many more property owner decisions will be much larger, making property less ideal as a resource management system.²⁴⁸ Property may also move more towards a system where the rights of property holders are less absolute, more qualified, and more open to revision over time.²⁴⁹ For example, one model here is water law in California, which has recognized the important public role in the allocation of water rights and the need to reallocate or readjudicate water rights where necessary to respond to important public interests.²⁵⁰

B. PUBLIC LAW

Public law systems will also face significant stresses in the Anthropocene because of the acceleration of change and the increase of global spillovers from individual actions.

1. Federalism and Constitutional Law

The increasing importance of local, individual actions for global systems in the Anthropocene will create tensions in constitutional law, such as for principles of federalism and the scope of the federal treaty-making power.

The Supreme Court has expended much effort recently to police borders between topics that it considers appropriate for federal involvement and topics that are best left to state or local primacy.²⁵¹ The Court has stated that an important component of an analysis of federal exercise of Commerce Clause power is whether allowing federal power would interfere with core functions of state or local governments, such as criminal or family law.²⁵² An important example is the Court's stated belief that land-use regulation is a primarily state

247. In his classic article, Robert Ellickson made the point that private property rights are best designed to address small-scale events whose impacts are limited in their geographic scale. See Robert C. Ellickson, *Property in Land*, 102 YALE L.J. 1315, 1324 fig.1, 1325 fig.2 (1993); see also Joseph L. Sax, *Property Rights and the Economy of Nature: Understanding Lucas v. South Carolina Coastal Council*, 45 STAN. L. REV. 1433, 1445–46 (1993) (noting importance of spillovers for determining utility of property rights). The issue of environmental spillovers creating tensions with private property rights has been discussed regularly in the context of environmental law. See, e.g., Purdy, *supra* note 224, at 1628.

248. See Sprankling, *supra* note 18, at 18.

249. See *id.* at 1 (“[W]e must shift from a property law system premised on stability to a more dynamic system that accommodates large-scale change.”).

250. See *Nat'l Audubon Soc'y v. Super. Ct. of Alpine Cty.*, 658 P.2d 709, 732–33 (Cal. 1983) (remanding dispute over water rights to tributaries to Mono Lake for reevaluation by state water agency based on public interest in protecting the Lake and associated fisheries).

251. See, e.g., *United States v. Morrison*, 529 U.S. 598, 617–18 (2000) (striking down federal civil remedy for violence against women because there is a distinction between “what is truly national and what is truly local”); *United States v. Lopez*, 514 U.S. 549, 567–68 (1995) (striking down federal criminal prohibition on possession of guns near schools on same grounds).

252. See, e.g., *Morrison*, 529 U.S. at 617–18; *Lopez*, 514 U.S. at 567–68.

or local activity. Indeed, the Court has relied on this principle to narrowly interpret the geographic scope of federal regulatory power under the Clean Water Act to avoid the constitutional concerns that broad jurisdiction might pose for state land-use law.²⁵³ But it is precisely the impacts of individual development decisions on wetlands and upstream waterways that have important implications for downstream water quality and for facilitating the transport of nutrients like phosphorus and nitrogen that produce dead zones in oceans.²⁵⁴ Land-use development decisions also matter for the destruction of habitats essential for interstate migratory species.²⁵⁵

Likewise, land-use activities such as agriculture, forestry, and residential and commercial land development, are an important component of greenhouse gas emissions—about one quarter.²⁵⁶ They are also an important component of many responses to excess greenhouse gas concentrations in the second-half of the twenty-first century that involve facilitating reforestation of private lands.²⁵⁷ These might be considered quintessentially state or local activities, yet they have global implications. As another example, land-use decisions in China have contributed to desertification that has, in turn, produced dust pollution that has impacts in North America.²⁵⁸

More broadly, the Anthropocene will erode fundamental distinctions between what is global and local.²⁵⁹ It is not for nothing that a common refrain of environmental activists is “think global, act local.”²⁶⁰ It seems plausible that under the Commerce Clause, the federal government could justify strict regulation of local land-use decisions on the basis of the impacts of those decisions on climate change. Of course, if this is possible, it is hard to say whether there remains any substantial distinction between what is local and federal.

253. The jurisdictional question is over the definition of “waters of the United States,” to which the Clean Water Act applies. Members of the Court have expressed concerns that a broad definition of “waters of the United States” to include, for example, wetlands isolated from rivers or streams, might lead to federal encroachment into local and state powers to regulate land use. *See Rapanos v. United States*, 547 U.S. 715, 737–38 (2006) (plurality opinion) (expressing concern that an “expansive interpretation” of the geographic scope of waters of the United States would “result in a significant impingement of the States’ traditional and primary power over land and water use” and stating that “[r]egulation of land use . . . is a quintessential state and local power” (quoting *Solid Waste Agency of N. Cook Cty. v. U.S. Army Corps of Eng’rs*, 531 U.S. 159, 174 (2001))). Based on those concerns, the Court has excluded certain kinds of wetlands, such as isolated wetlands, from the regulatory scope of the Clean Water Act. *See Solid Waste Agency*, 531 U.S. at 174.

254. For a summary of the relevant academic literature on how upstream development activities can affect downstream water quality, see Clean Water Rule: Definition of “Waters of the United States,” 80 Fed. Reg. 37054 (June 29, 2015).

255. *See Solid Waste Agency*, 531 U.S. at 194 (Stevens, J., dissenting) (describing the importance of wetlands for migratory bird species).

256. *See* WORKING GROUP III, *supra* note 25, at 8.

257. *See supra* notes 129–31 and accompanying text.

258. *See* Yu et al., *supra* note 119, at 566.

259. *See* LAZARUS, *supra* note 5, at 35 (stating that “the vast spatial and temporal boundaries of many environmental problems do not readily lend themselves to local control”).

260. *See, e.g.*, Oliver P. Hauser et al., *Think Global, Act Local: Preserving the Global Commons*, 6 SCI. REP., Nov. 2016, at 1, <https://www.nature.com/articles/srep36079> [<https://perma.cc/MPM6-R8M5>].

The same analysis would equally apply to federal authority under the Treaty Clause. Again, the Court has articulated concerns about the expansion of federal power under the Treaty Clause to include everyday behavior properly covered by state or local powers, such as criminal law. It was those concerns that led the Court in *Bond v. United States* to narrowly construe legislation implementing the Chemical Weapons Ban Treaty.²⁶¹ But again, if there is any point of consensus in the climate policy literature, it is that some sort of international agreement at some point will be required to address climate change.²⁶² And again in an industrial society, it is hard to find activities that do not contribute in some way to climate change. So in the context of climate change, where is the line between activities properly within the scope of the federal treaty power because they relate to international relations and activities properly within the scope of state or local law?²⁶³

One plausible response in constitutional law to these pressures is a move away from the formalism that has characterized some of the recent Supreme Court federalism jurisprudence, and towards more functionalist or case-by-case decision making about the scope of federal versus state versus local power. In other words, the Court might start blurring the borders of federal and state power. Although the result might in practice be greater federal power, it may also expand state power in some circumstances.²⁶⁴

2. Administrative Law and Statutory Interpretation

The acceleration of change in the Anthropocene will place pressures on legal doctrines in both administrative law and statutory interpretation: increasing the discretion available to administrative agencies, increasing the tension between administrative agency actions and statutory language, and increasing the number of difficult statutory interpretation problems that courts will need to address.

In the context of administrative law, the accelerating rise and scale of new human impairments of global resources will likely trigger a concomitant increase in novel regulatory interventions. That presents at least two challenges for administrative law. First, the result will be increasing power and authority in regulatory agencies vis-à-vis regulated entities. The Supreme Court has ex-

261. 134 S. Ct. 2077, 2083 (2014) (narrowly construing criminal statute implementing a treaty banning chemical weapons to exclude “an amateur attempt by a jilted wife to injure her husband’s lover” because “our constitutional structure leaves local criminal activity primarily to the States, [and] we have generally declined to read federal law as intruding on that responsibility”).

262. See Ostrom, *supra* note 205, at 555.

263. This question poses a serious challenge to the members of the Court in *Bond* who would have directly held that the Treaty Clause of the Constitution only authorizes congressional legislation that involves “intercourse with other nations” and not “purely domestic affairs.” *Bond*, 134 S. Ct. at 2103 (Thomas, J., concurring in the judgment). Otherwise, the Court feared the Treaty Power would convert into “a ‘police power’ over all aspects of American life.” *Id.* (quoting *United States v. Lopez*, 514 U.S. 549, 584 (1995) (Thomas, J., concurring)).

264. For instance, to the extent that states can make strong arguments that activities traditionally within their jurisdiction are relevant for climate change policy—such as land-use decisions—that might lead courts to narrowly interpret federal preemption of state activity in areas such as climate change.

pressed concern about the expanded regulatory powers asserted by federal agencies over the past several years.²⁶⁵ Some of those concerns might be pegged to a conservative Supreme Court concerned about the actions of a Democratic president. But the concerns about arbitrary administrative powers are not unique to this context and indeed are fundamental concerns in the field.²⁶⁶ Judicial review of administrative agency decisions, requirements for public notice and comment on proposed regulations, and due process for administrative adjudicatory decisions can all be explained in part based on concerns about unchecked administrative agency power. As the stakes and scope of regulatory power increase, those concerns will also increase, creating pressure for additional procedural requirements for agency action, such as various proposals in Congress to impose additional analytic steps for agency rulemaking.²⁶⁷ Of course, those restrictions will necessarily be in tension with the pressures on administrative agencies to enact rules to respond to the new challenges in the Anthropocene.

There is a second problem that also goes to the heart of administrative law. Unless Congress significantly increases the pace at which it enacts legislation, it seems likely that agencies will be operating under existing statutory authorizations to develop these regulations.²⁶⁸ Many federal regulatory statutes, especially in the environmental arena, provide a fairly capacious scope for administrative agency action. For instance, the definition of “air pollutant” in the Clean Air Act is broadly written—broad enough that the Supreme Court had little problem concluding that greenhouse gases could fall within it, even though greenhouse gas emissions were likely far from the minds of the legislators who drafted the term in the early 1970s.²⁶⁹ In the context of greenhouse gas regulation, the EPA has (with prompting from the Supreme Court) taken that broad authority to construct a regulatory program for greenhouse gas emissions, despite no specific mention of the problem of greenhouse gas emissions in the statute.²⁷⁰

But again, if administrative agencies promulgate increasingly ambitious regulatory systems pursuant to relatively general statutory provisions, this would

265. *See, e.g.*, *Util. Air Regulatory Grp. v. EPA*, 134 S. Ct. 2427, 2444 & n.7 (2014) (plurality opinion); *Rapanos v. United States*, 547 U.S. 715, 721 (2006) (plurality opinion) (characterizing a regulatory agency as an “enlightened despot”).

266. *See* JERRY L. MASHAW ET AL., *ADMINISTRATIVE LAW: THE AMERICAN PUBLIC LAW SYSTEM* 33 (6th ed. 2009).

267. *See, e.g.*, *Regulations From the Executive in Need of Scrutiny Act of 2015*, H.R. 427, 114th Cong. (2015).

268. This has already become an issue in the context of the regulation of greenhouse gases under the Clean Air Act. For a discussion of that example, and the more general problem of a disconnect between current societal challenges and old statutes, see Jody Freeman & David B. Spence, *Old Statutes, New Problems*, 163 U. PA. L. REV. 1, 8–42 (2014); *see also* LAZARUS, *supra* note 5, at 32–33 (noting the difficulty of enacting updated environmental legislation in the U.S. political system and the importance of such updates given the dynamism of human and natural systems).

269. *See* *Massachusetts v. EPA*, 549 U.S. 497, 533 (2007).

270. *See* Freeman & Spence, *supra* note 268, at 20–42.

raise concerns about the accountability of administrative agencies to Congress. In theory at least, agencies are simply enacting statutes pursuant to congressional authorization.²⁷¹ But an agency that takes broad language from Congress to impose regulations that have sweeping economic and social implications challenges that conception. Various legal scholars and judges have called for a revival of the nondelegation doctrine to reduce these accountability concerns.²⁷² Although nondelegation-doctrine challenges were unsuccessful in the 1930s and were specifically rejected in the environmental context in 2001 by the Supreme Court,²⁷³ they may become more appealing as regulatory impacts expand in scope.²⁷⁴

Indeed, one can understand some of the Court's analysis in the *Utility Air Regulatory Group* case as a response to these concerns.²⁷⁵ The Court rejected the EPA's interpretation of the Clean Air Act as applying to all greenhouse gas emissions in part based on a concern that Congress had not clearly authorized the substantial regulatory authority that the EPA was claiming:

[The] EPA's interpretation is also unreasonable because it would bring about an enormous and transformative expansion in [the] EPA's regulatory authority without clear congressional authorization. When an agency claims to discover in a long-extant statute an unheralded power to regulate 'a significant portion of the American economy,' we typically greet its announcement with a measure of skepticism. We expect Congress to speak clearly if it wishes to

271. MASHAW ET AL., *supra* note 266, at 72 ("The agent—the administrative agency—has only those powers provided by its principal—the legislature.")

272. *See* *Indus. Union Dep't, AFL-CIO v. Am. Petroleum Inst.*, 448 U.S. 607, 672 (1980) (Rehnquist, J., concurring in the judgment); THEODORE J. LOWI, *THE END OF LIBERALISM: IDEOLOGY, POLICY, AND THE CRISIS OF PUBLIC AUTHORITY* 155 (1969); *see generally* JOHN HART ELY, *DEMOCRACY AND DISTRUST: A THEORY OF JUDICIAL REVIEW* (1980) (arguing for a return to the governmental structure cabined by procedural due process as laid out in the Constitution).

273. *See* *Whitman v. Am. Trucking Ass'ns*, 531 U.S. 457, 486 (2001) (rejecting challenge to the Clean Air Act); *A. L. A. Schechter Poultry Corp. v. United States*, 295 U.S. 495, 551 (1935) (invalidating New Deal regulations as an unconstitutional use of Congress's power according to the nondelegation doctrine).

274. *See* Lisa Heinzerling, *The Power Canons*, 58 WM. & MARY L. REV. 1933, 1934 (2017) (noting concerns expressed by individual Supreme Court justices that recent expressions of regulatory authority by federal administrative agencies are not adequately constrained by statutory language, and arguing that these concerns have expressed themselves in Supreme Court opinions striking down various agency regulations). Some recent individual opinions by Supreme Court justices appear to express nondelegation doctrine concerns. *See, e.g.,* *Dep't of Transp. v. Ass'n of Am. R.R.s*, 135 S. Ct. 1225, 1237 (2015) (Alito, J., concurring) ("The principle that Congress cannot delegate away its vested powers exists to protect liberty."); *id.* at 1240 (Thomas, J., concurring in the judgment) ("The Constitution does not vest the Federal Government with an undifferentiated 'governmental power.'"); *City of Arlington v. FCC*, 133 S. Ct. 1863, 1879 (2013) (Roberts, C.J., dissenting) (stating that the "danger posed by the growing power of the administrative state cannot be dismissed" and that part of the concern is the lack of legislative control or guidance over agency powers).

275. *See* Heinzerling, *supra* note 274, at 1933 (arguing that *Utility Air Regulatory Group* created a new interpretive canon that "[w]hen an agency charged with administering a long-existing statute asserts regulatory authority it has not previously used, in a matter having large economic and political significance, its interpretation will be met with skepticism").

assign to an agency decisions of vast ‘economic and political significance.’ The power to require permits for the construction and modification of tens of thousands, and the operation of millions, of small sources nationwide falls comfortably within the class of authorizations that we have been reluctant to read into ambiguous statutory text.²⁷⁶

The fundamental problem in the context of administrative law is that, in theory, agencies are exercising limited regulatory powers, constrained by congressional directives and authorizations, subject to substantial procedural limitations that protect regulated parties from arbitrary action.²⁷⁷ But increasing the scope for regulatory authority challenges the first two assumptions and puts great pressure on procedural limitations to do the work of protecting against arbitrary executive or agency action.

Courts doing their own work interpreting statutes will face similar difficulties. The Anthropocene will produce new problems that legislators will not have had an opportunity to address. There will be mismatches between statutes and problems that require resolution, but the legislature may not be able to update statutes in a timely manner to provide that resolution. The result may be extremely creative interpretations of statutes by both agencies and courts.

Again, the *Utility Air Regulatory Group* case is an instructive example. The EPA had concluded that carbon dioxide was an air pollutant that required regulation under the Clean Air Act.²⁷⁸ However, that conclusion triggered provisions of the Clean Air Act that would have required regulatory and permitting requirements that would have been extremely burdensome on both state and federal regulatory agencies and a wide range of regulated parties, including millions of small entities.²⁷⁹ This was because the threshold for regulation under many provisions of the Clean Air Act is the emission of between 100 and 250 tons of pollutants per year, a threshold that makes sense for previously regulated pollutants that Congress had in mind when it drafted the statute in the early 1970s.²⁸⁰ These pollutants are the byproduct of combustion or other industrial operations and are produced in relatively small quantities. However, carbon dioxide is the direct product of the combustion of fossil fuels, a central component of the modern industrial economy, and it is produced in extremely large quantities.²⁸¹ Accordingly, the EPA drafted a regulation (the

276. *Util. Air Regulatory Grp. v. EPA*, 134 S. Ct. 2427, 2444 (2014) (plurality opinion) (internal citations omitted).

277. *See City of Arlington*, 133 S. Ct. at 1877 (Roberts, C.J., dissenting) (noting importance for congressional guidance and judicial review to constrain agency discretion).

278. *See Util. Air Regulatory Grp.*, 134 S. Ct. at 2436–37 (plurality opinion).

279. *See id.* at 2436 & n.2.

280. *See id.* at 2443.

281. *See id.* at 2436 (noting carbon dioxide is emitted at levels “orders of magnitude greater” than other pollutants regulated under the Act); *see also* Regulating Greenhouse Gas Emissions Under the Clean Air Act, 73 Fed. Reg. 44,354, 44,500, 44,506 (July 30, 2008) (to be codified at 40 C.F.R. ch. 1) (noting differences in production levels of different pollutants).

“tailoring rule”) that would (at least initially) have limited the scope of Clean Air Act regulation for carbon dioxide to sources emitting between 50,000 and 100,000 tons per year, phased in over time.²⁸²

In considering a challenge to this the EPA regulation, the Court noted the extreme extent to which the EPA was effectively rewriting the statute as it substituted one numeric cutoff for another that was plainly in the text of the statute.²⁸³ The EPA argued that applying the statutory text directly would lead to absurd results.²⁸⁴ Ultimately, however, the Court concluded that the EPA’s interpretation was simply too drastic of a revision.²⁸⁵ In so doing, the Court expressed concerns that radical statutory interpretation by implementing agencies would undermine Congress’s lawmaking powers and duties—in some ways, echoing the nondelegation doctrine concerns discussed above.²⁸⁶

But the Court shied from imposing Clean Air Act regulation on millions of sources in America and instead performed its own creative interpretation of the statute and read the term “air pollutant” to have a different meaning in one section of the Act than it had in other portions of the Act.²⁸⁷ Based on that reading, the Court concluded that only a limited number of greenhouse gas emissions could be regulated.²⁸⁸ The Court frankly admitted it was performing creative statutory interpretation to address the dilemmas posed by the mismatch between the statute and climate change.²⁸⁹ Cases like this may start to recur more and more in the future, requiring agencies and courts to effectively rewrite statutes that a legislature is unable to correct.

In the context of administrative law and statutory interpretation, we may see an increasing movement of power to both agencies and courts as they seek to keep law updated with the increasingly rapid changes of the Anthropocene. In some ways, this development may produce increasing power for agencies and the Executive Branch vis-à-vis the legislature, but we may also see courts becoming more careful in their review of agency decision making because of concerns that agencies are less tethered to statutory limits. And courts them-

282. *See Util. Air Regulatory Grp.*, 134 S. Ct. at 2437–38 (plurality opinion).

283. *See id.* at 2444–45.

284. *See id.* at 2442–43.

285. *See id.* at 2445 (“An agency has no power to ‘tailor’ legislation to bureaucratic policy goals by rewriting unambiguous statutory terms.”).

286. *See id.* at 2446 (“Were we to recognize the authority claimed by EPA in the Tailoring Rule, we would deal a severe blow to the Constitution’s separation of powers.”); *see also* Heinzerling, *supra* note 274, at 1933–34 (arguing that the *Utility Air Regulatory Group* opinion was based on hostility to revised understandings of regulatory statutes promulgated by administrative agencies).

287. *See id.* at 2439–42.

288. *See id.* at 2442. The Court limited the scope of greenhouse gas regulation to “anyway” sources, which would be regulated under the Clean Air Act anyway because of emissions of other air pollutants. *See id.* at 2447–49.

289. The Court noted that “[o]ne ordinarily assumes ‘that identical words used in different parts of the same act are intended to have the same meaning,’” but stated that the Court “must do [its] best” and that there was no “insuperable textual barrier” to interpreting the term “air pollutant” to mean different things in different portions of the statute. *See id.* at 2441–42 (quoting *Env’tl. Def. v. Duke Energy Corp.*, 549 U.S. 561, 574 (2007)).

selves may find themselves increasingly taking on legislative tasks as they review statutes in the context of new problems.

3. Criminal Law

The final area of public law that I will examine is criminal law, where the increased need to regulate individual activity will create tensions with doctrines that seek to limit the scope of broad criminal prohibitions (such as mental state requirements) and give notice to defendants of prohibitions (such as proximate cause and the rule of lenity).

If criminal law is used to manage or control the widespread, everyday behaviors that are drivers of the changes in the Anthropocene, legislatures might resort to broad criminal law prohibitions or restrictions on individual conduct, such as a ban on the use of the internal combustion engine.²⁹⁰ Broad criminal law prohibitions on a wide range of conduct are already present to some extent in current environmental criminal law.²⁹¹ For instance, provisions of both the Clean Water Act and Clean Air Act criminalize violations of routine recordkeeping requirements and negligent discharges from sources governed by the Acts.²⁹²

An important source of broad conduct prohibitions in current criminal law is the rise of criminal enforcement for regulatory systems intended to manage public health and safety risks in an industrial society. Instead of simply trying to criminalize activities that definitively have caused or will cause harm, criminal law was used to prevent the risk of harm.²⁹³ Courts and legal scholars justified these changes by noting that industrialization created interconnectedness and interdependency. For example, contamination in one food or drug manufacturing facility might produce illness in thousands of people.²⁹⁴

290. Such a broad ban is not in force today. But there are a wide range of broad criminal prohibitions in both state and federal law. For an overview, see William J. Stuntz, *The Pathological Politics of Criminal Law*, 100 MICH. L. REV. 505, 513–17 (2001). For examples, see CAL. PENAL CODE § 374.4 (West 2007) (misdemeanor penalties for willful or negligent littering); *id.* § 374.7 (for disposal of waste into waterways); *id.* § 374.8 (for improper disposal of hazardous wastes).

291. See David M. Uhlmann, *Prosecutorial Discretion and Environmental Crime*, 38 HARV. ENVTL. L. REV. 159, 167–71 (2014).

292. See *id.* (noting possibility of criminal prosecution for unpermitted discharges and for failure to keep accurate records).

293. See *Morissette v. United States*, 342 U.S. 246, 255–56 (1952) (“Many violations of such regulations result in no direct or immediate injury to person or property but merely create the danger or probability of it which the law seeks to minimize.”); Richard G. Singer, *Strict Liability*, in 4 ENCYCLOPEDIA OF CRIME & JUSTICE 1541 (Joshua Dressler et al. eds., 2d ed. 2002) (noting that strict liability statutes were intended to encourage defendants to “merely regulate their behavior by making them more cautious”).

294. See *United States v. Dotterweich*, 320 U.S. 277, 280 (1943) (upholding criminal conviction for violation of drug labeling and adulteration regulations because of the “circumstances of modern industrialism” which put “the lives and health of people . . . largely beyond self-protection”); see also Mark Kelman, *Strict Liability: An Unorthodox View*, in 4 ENCYCLOPEDIA OF CRIME & JUSTICE 1512, 1514 (Sanford H. Kadish et al. eds., 1st ed. 1983). For the most explicit summary of the connection, see the Supreme Court’s statement in *Morissette*:

The use of broad criminal prohibitions has obvious political problems: no one is proposing banning the internal combustion engine, for now. But even prohibitions that are politically feasible will place significant pressures on the criminal law.

Some of the doctrinal issues that will develop are already visible in the courts' reactions to existing criminal law prohibitions that might apply to a wide range of everyday conduct. The Supreme Court has often interpreted these laws narrowly by imposing mental state requirements.²⁹⁵ In taking this approach, the Court has expressed concerns that these broad prohibitions might criminalize everyday activities that potential defendants would not consider to be covered by the criminal law.²⁹⁶ By requiring a mental state in which the defendant knew that his activity would cause harm or intended that the activity would cause harm, the Court protects defendants against criminal liability for an activity that they (or a reasonable person) might have assumed to be innocent and lawful.²⁹⁷ For example, the Supreme Court has expressed concern that strict liability for food stamp misuse might "criminalize a broad range of apparently innocent conduct."²⁹⁸

Courts distinguish *malum in se* offenses, which are "naturally evil as adjudged by the sense of a civilized community," from *malum prohibitum* of-

The industrial revolution multiplied the number of workmen exposed to injury from increasingly powerful and complex mechanisms, driven by freshly discovered sources of energy, requiring higher precautions by employers. Traffic of velocities, volumes and varieties unheard of came to subject the wayfarer to intolerable casualty risks if owners and drivers were not to observe new cares and uniformities of conduct. Congestion of cities and crowding of quarters called for health and welfare regulations undreamed of in simpler times. Wide distribution of goods became an instrument of wide distribution of harm when those who dispersed food, drink, drugs, and even securities, did not comply with reasonable standards of quality, integrity, disclosure and care. Such dangers have engendered increasingly numerous and detailed regulations which heighten the duties of those in control of particular industries, trades, properties or activities that affect public health, safety or welfare.

342 U.S. at 253–54.

295. See, e.g., *Posters 'N' Things, Ltd. v. United States*, 511 U.S. 513, 516, 524 (1994) (imposing mental state requirement for prohibition on "sale and transportation [of] . . . drug paraphernalia"); *Liparota v. United States*, 471 U.S. 419, 425–26 (1985) (imposing mental state requirement for criminal penalties for food stamp misuse).

296. See, e.g., *Staples v. United States*, 511 U.S. 600, 610 (1994) (imposing mental state requirement for statute criminalizing possession of unregistered machine gun because of "long tradition of widespread lawful gun ownership by private individuals in this country"); *Liparota*, 471 U.S. at 426–27 (imposing mental state requirement for misuse of food stamps because "to interpret the statute otherwise would be to criminalize a broad range of apparently innocent conduct"); *United States v. Int'l Minerals & Chem. Corp.*, 402 U.S. 558, 564–65 (1971) (noting that although "[p]encils, dental floss, paper clips may . . . be regulated . . . they may be the type of products which might raise substantial due process questions if Congress did not require" *mens rea* for criminal violations).

297. As such, these cases can be understood as advancing the fundamental criminal law goal that defendants have fair notice that their activities were prohibited by criminal laws before penalties can be imposed. See *Boyce Motor Lines, Inc. v. United States*, 342 U.S. 337, 340 (1952).

298. *Liparota*, 471 U.S. at 426; see also *Staples*, 511 U.S. at 611 (expressing concern that regulations might affect activities or items that are "so commonplace and generally available that we would not consider them to alert individuals to the likelihood of strict regulation").

fenses, which are “wrong only because made so by statute.”²⁹⁹ Where the Court has upheld conduct prohibitions that do not require significant mental state elements, it has often justified them as part of *mala prohibita* public welfare statutes, where criminal penalties are appropriate despite no moral opprobrium or deviancy to the defendant’s activity.³⁰⁰ The Court has explained that liability in this context is supportable in part because of the need to prevent risks of severe harm in an industrial society,³⁰¹ and because the defendant was acting in a highly regulated area where the activities were dangerous, such as the transportation of hazardous wastes.³⁰²

But it is an open question whether the *malum prohibitum* concept can really support expansion of criminal law in the Anthropocene. Is everything now highly regulated and potentially dangerous? How severe are the risks posed by the accumulation of millions of individual actions? The *malum prohibitum* category has often been applied to large regulated entities with sophisticated compliance capacity³⁰³—the same is true of much modern environmental law that has strict liability elements. But it is an open question whether the same approach can be applied to the millions of individuals whose actions contribute to the harms in the Anthropocene.

Another question is how to update the criminal law so that it can effectively manage new and emergent harms in the Anthropocene. One option is to criminalize results, rather than conduct. For instance, the Migratory Bird Treaty Act (MBTA) prohibits almost all harms to migratory birds³⁰⁴ and may subject

299. *State v. Horton*, 51 S.E. 945, 946 (N.C. 1905); see also ROLLIN M. PERKINS & RONALD N. BOYCE, *CRIMINAL LAW* 16 (3d ed. 1982) (discussing differences between *malum in se* and *malum prohibitum* offenses).

300. See RONALD N. BOYCE ET AL., *CRIMINAL LAW AND PROCEDURE* 653 (10th ed. 2007); SANFORD H. KADISH ET AL., *CRIMINAL LAW AND ITS PROCESSES* 252 n.c (8th ed. 2007) (“In the area of regulatory crimes . . . the moral quality of the act is often neutral . . .” (quoting Henry M. Hart, *The Aims of Criminal Law*, 23 L. & CONTEMP. PROB. 401, 431 n.70 (1958))).

301. See *United States v. Dotterweich*, 320 U.S. 277, 280–81 (1943) (noting that strict liability criminal law can “serve as effective means of regulation” because “[i]n the interest of the larger good it puts the burden of acting at hazard upon a person otherwise innocent but standing in responsible relation to a public danger”); Kelman, *supra* note 294, at 1514.

302. See *United States v. Int’l Minerals & Chem. Corp.*, 402 U.S. 558, 564–65 (1971) (rejecting *mens rea* and notice concerns for a statute that criminalized violations of regulations covering hazardous waste transportation because “dangerous or deleterious devices or products or obnoxious waste materials are involved, the probability of regulation is so great that anyone who is aware that he is in possession of them or dealing with them must be presumed to be aware of the regulation”); see also *Posters ‘N’ Things, Ltd. v. United States*, 511 U.S. 513, 524 (1994); *Staples v. United States*, 511 U.S. 600, 607 (1994); John C. Coffee, Jr., *Does “Unlawful” Mean “Criminal”? Reflections on the Disappearing Tort/Crime Distinction in American Law*, 71 B.U. L. REV. 193, 213 (1991) (arguing that “ordinary human experience” should be crucial in determining what actions are dangerous enough to prompt criminal liability).

303. Coffee, *supra* note 302, at 237–38 (noting ability of “specialized community” of highly regulated, highly sophisticated corporate actors to incorporate the complex requirements of the modern regulatory state); see also Uhlmann, *supra* note 291, at 174 (noting complaints that environmental criminal law “targets law-abiding small business people”).

304. See 16 U.S.C. § 703 (2012) (making it unlawful to “pursue, hunt, take, capture, [or] kill” migratory birds).

the actor to criminal penalties.³⁰⁵ The advantage of this results approach is that it focuses on the harms we want to prevent without requiring the law to specify all the ways that harm might occur. As new technologies produce new harms, they are automatically covered by the statute.

But such an approach raises serious concerns for the criminal law. Defendants may be prosecuted for actions that caused harm (such as the killing of migratory birds) even if they had no prior knowledge that their actions might cause that harm. Indeed, these results statutes can effectively produce strict liability when they penalize seemingly innocuous behaviors that have not been identified as deviant or abnormal.

One way to address these notice problems is to interpret the statute to require a mental state requirement, such as an intent to cause the harm. Some courts have adopted this approach in the context of the MBTA.³⁰⁶ Another approach, even if a court has upheld the use of effectively strict liability, is to limit the scope of liability based on a notice requirement. In *United States v. Apollo Energies, Inc.*, the Tenth Circuit refused to apply criminal penalties to a defendant charged with violating the MBTA for operating oil and gas extraction equipment that attracted and killed nesting migratory birds.³⁰⁷ The court held that only defendants who had received prior notice from the regulatory agency about the equipment's risk to birds could be criminally prosecuted.³⁰⁸ The court argued that otherwise the defendant would not have been able to reasonably foresee harm to birds from the mere operation of oil and gas equipment, and thus could not have proximately caused harm to the birds.³⁰⁹

Proximate cause is a related challenge for criminal statutes that impose liability based on results. Similar to the MBTA, the Endangered Species Act (ESA) prohibits acts that take individual members of endangered species.³¹⁰ In *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*, the Supreme Court upheld an agency regulation that extended the prohibition on takings to actions by private landowners that modify the habitat of endangered species.³¹¹ The dissent, which would have struck down the regulation, expressed concern that the regulation lacked a proximate cause requirement. Without proximate cause, the dissent warned that a broad restriction on habitat modification might lead to criminal liability for “a farmer who tills his field and causes erosion that makes silt run into a nearby river which depletes oxygen and thereby ‘impairs [the] breeding’ of protected fish.”³¹²

305. *See id.* § 707.

306. *See, e.g.*, *United States v. Wulff*, 758 F.2d 1121, 1125 (6th Cir. 1985).

307. 611 F.3d 679, 691 (10th Cir. 2010).

308. *See id.*

309. *See id.* at 689–91.

310. *See* 16 U.S.C. § 1538 (2012).

311. 515 U.S. 687, 708 (1995).

312. *Id.* at 719 (Scalia, J., dissenting) (alteration in original).

The majority stated that concerns about broad liability under the ESA attaching to individuals doing everyday activities were unfounded because, for criminal liability to attach, the relevant activity must have proximately caused the harm to the endangered species.³¹³ Proximate cause in *Sweet Home* limited the scope of criminal law to prevent punishment of everyday activities,³¹⁴ but those everyday activities are exactly what contribute to human impairments of global resources such as the climate or biodiversity.³¹⁵

Finally, broad criminal prohibitions on conduct can avoid the need to update the law as a large amount of potentially harmful activity is swept in, even if that activity has not yet been understood or foreseen as harmful. Again, these kinds of statutes raise notice concerns that might lead courts to impose mental state requirements to protect defendants against liability for activities they thought were otherwise lawful. Courts might also be skeptical about broad statutory language being interpreted to apply to new activity that the legislature may not have intended to be covered. To achieve both goals, courts might draw upon the rule of lenity, which in part is intended to ensure that criminal penalties closely track what the legislature intended to cover through narrowing constructions of criminal statutes.³¹⁶ The doctrine has been framed as a “nondelegation doctrine” that requires clear articulation by legislatures as to what the scope of criminal law is, and it prevents the delegation of the power to define criminal law to prosecutors or courts.³¹⁷ Courts have relied upon the rule of lenity to impose mental state requirements for criminal law provisions.³¹⁸ As with the nondelega-

313. *See id.* at 696–97 n.9.

314. Proximate cause in criminal law is used to ensure there is a just relationship between the harms the defendant caused and the defendant’s actions. *See, e.g.,* *People v. Schaefer*, 703 N.W.2d 774, 785 (Mich. 2005) (“[Proximate causation] is a legal construct designed to prevent criminal liability from attaching when the result of the defendant’s conduct is viewed as too remote or unnatural.”); MODEL PENAL CODE § 2.03 (AM. LAW INST. 2016); HART & HONORE, *supra* note 220, at 395. Given the higher stakes a defendant faces under criminal law as compared to tort law, proximate cause is usually more strictly applied in the criminal law context. *See* *United States v. Schmidt*, 626 F.2d 616, 618 n.3 (8th Cir. 1980); WAYNE R. LAFAVE, 1 SUBSTANTIVE CRIMINAL LAW § 6.4(c), at 472 (2d ed. 2003).

315. For instance, unlike Justice Scalia, most biologists would not be surprised that a farmer had caused harm to fish in a watershed through causing erosion that damages water quality. For discussion of how *Sweet Home* shows the challenges of common law causation issues in the Anthropocene, see Purdy, *supra* note 224, at 1630–31.

316. *See* Lisa K. Sachs, Note, *Strict Construction of the Rule of Lenity in the Interpretation of Environmental Crimes*, 5 N.Y.U. ENVTL. L.J. 600, 600–01 (1996); *see also* *United States v. Santos*, 553 U.S. 507, 514 (2008) (“The rule of lenity requires ambiguous criminal laws to be interpreted in favor of the defendants subjected to them.”). Sometimes the Court has required that the statute contain “grievous ambiguity” for the rule of lenity to apply. *See* *Staples v. United States*, 511 U.S. 600, 619 n.17 (1994) (citing cases).

317. *See* Dan M. Kahan, *Lenity and Federal Common Law Crimes*, 1994 SUP. CT. REV. 345, 347 (1994) (stating that “the rule of lenity . . . is best understood as a ‘nondelegation doctrine’”); *see also* *United States v. Wiltberger*, 18 U.S. (5 Wheat.) 76, 95 (1820) (stating that the rule of lenity is based on the “plain principle that the power of punishment is vested in the legislative, not in the judicial department”); Zachary Price, *The Rule of Lenity as a Rule of Structure*, 72 FORDHAM L. REV. 885, 909 (2004).

318. *See* *Liparota v. United States*, 471 U.S. 419, 427 (1985).

tion doctrine in the administrative law context discussed above, if the rule of lenity is strictly applied, then it may be very difficult for criminal penalties to be applied to the wide range of new circumstances in which humans are impacting global resources.

Although the Anthropocene will require the legal system to address the accumulation of many individual activities, the implications of new technologies, and the identification of new harms, addressing these issues through criminal law will create tensions in a field that has traditionally focused on penalizing deviant behavior³¹⁹ and has relied on the deviance of prohibited activity to help provide notice to actors about what can be criminally sanctioned.³²⁰ The tension will be resolved in one of two ways: a weakening of the criminal law doctrines that restrict its application to deviant activities clearly and previously prohibited, or the supplanting of criminal law by administrative and civil remedies.

Ultimately, the tensions between criminal law and the Anthropocene may best be resolved by avoiding a central role for criminal law, at least in the context of regulating individual behavior (as opposed to, for instance, regulating the behavior of large economic entities such as corporations). The risks to individual liberty and damage to the criminal legal system may be just too high.

IV. IMPLICATIONS OF THE LEGAL IMPACTS OF THE ANTHROPOCENE

One reason to have confidence that the Anthropocene will produce significant legal changes is that these legal changes are not completely novel. The American legal system has responded to substantial economic and social changes in the past. Many of those economic and social changes have analogies to the changes that we will see in the Anthropocene: increasing interconnectedness in the growth of a national, industrial economy, increasing rapidity of technological innovation, and increasing changes provoked by industrialization that have

319. See Kelman, *supra* note 294, at 1514 (noting criticisms of strict criminal liability on the ground that “punishing someone who has not intentionally, recklessly, or negligently caused the sorts of harms that are proscribed is unjust”); Coffee, *supra* note 302, at 198 (noting “close linkage between the criminal law and behavior deemed morally culpable by the general community”); Saira Mohamed, *Deviance, Aspiration, and the Stories We Tell: Reconciling Mass Atrocity and the Criminal Law*, 124 YALE L.J. 1628, 1631 (2015) (“We typically think of the criminal law as punishing those who deviate from what society deems expected, normal, or good.”); Francis Bowes Sayre, *Public Welfare Offenses*, 33 COLUM. L. REV. 55, 56 (1933) (stating that the public would reject criminal law if it “inflict[ed] substantial punishment upon one who is morally entirely innocent”).

320. See Kelman, *supra* note 294, at 1514–15 (noting concerns that strict liability might result in punishment of defendants who were only “unlucky” and would not have “been aware that he was inflicting socially proscribed results”); see also Coffee, *supra* note 302, at 211–13 (criticizing application of environmental criminal law to actions such as burying paint without a permit because even though these actions might be hazardous, under “common sense” based on “ordinary human experience,” they should not be subject to criminal prosecution). *But see* Mohamed, *supra* note 319, at 1636 (arguing that it can be appropriate and effective for the criminal law to punish common or everyday acts as part of an effort to push members of society to achieve “aspirational goals,” though the argument is limited to the context of mass atrocities where the actions lead to severe harms).

impacts on individuals beyond their control. This led to the developments that we are witnessing with the dawn of the Anthropocene: increased involvement of higher-scale levels of government (particularly federal power), increased use of delegation to administrative agencies, greater regulatory authority by government agencies over economic activity, and greater displacement of or changes to tort doctrine.

And just as these changes in the past produced political upheaval as legal changes collided with entrenched political norms, the legal changes of the Anthropocene will also challenge important norms in our political system. Managing those tensions will be a huge task for the legal system in this century.

A. THE LEGAL TRANSFORMATIONS OF THE ANTHROPOCENE IN HISTORICAL CONTEXT

In nineteenth-century America, economic growth and technological change accelerated over time, building a national economy based on industrialization and urbanization. These economic changes were both supported by and prompted changes in the legal structure that recognized the importance of larger-scale economic relationships and the need to respond to the fundamental challenges of industrialization. For instance, the growth of the national economy in the late nineteenth century made it difficult for states to regulate railroads, control corporate trusts, and protect competition as corporations became national in scale and states began to compete for corporate charters.³²¹ This pressure encouraged the enactment of federal regulatory efforts such as the Sherman Antitrust Act and the Interstate Commerce Commission.³²² Likewise, pressure for the development of a uniform commercial law that would facilitate the burgeoning expansion of a national market led to the legal changes that allowed for the negotiability of commercial paper,³²³ the loosening of state corporate law to allow for the general incorporation of companies,³²⁴ and the federal courts' expansion of the Dormant Commerce Clause to restrict state protectionist legislation.³²⁵

Industrialization created other pressures for legal change in the late nineteenth and early twentieth centuries. The development of wage labor for large

321. See, e.g., Charles W. McCurdy, *The Knight Sugar Decision of 1895 and the Modernization of American Corporation Law, 1869–1903*, 53 BUS. HIST. REV. 304, 305–08 (1979).

322. See, e.g., KERMIT L. HALL & PETER KARSTEN, *THE MAGIC MIRROR: LAW IN AMERICAN HISTORY* 222–26 (2d ed. 2009); 2 MELVIN I. UROFSKY & PAUL FINKELMAN, *A MARCH OF LIBERTY: A CONSTITUTIONAL HISTORY OF THE UNITED STATES: FROM 1877 TO THE PRESENT* 526–35 (2d ed. 2002); McCurdy, *supra* note 321, at 323–28.

323. See, e.g., 1 MELVIN I. UROFSKY & PAUL FINKELMAN, *A MARCH OF LIBERTY: A CONSTITUTIONAL HISTORY OF THE UNITED STATES: FROM THE FOUNDING TO 1890* 264–66 (2d ed. 2002); 2 G. EDWARD WHITE, *LAW IN AMERICAN HISTORY: FROM RECONSTRUCTION THROUGH THE 1920S* 180–81, 194–202 (2016).

324. See, e.g., MORTON J. HORWITZ, *THE TRANSFORMATION OF AMERICAN LAW 1870–1960: THE CRISIS OF LEGAL ORTHODOXY* 85–91 (1992); UROFSKY & FINKELMAN, *supra* note 323, at 262–63.

325. See HALL & KARSTEN, *supra* note 322, at 258–59; see, e.g., Charles W. McCurdy, *American Law and the Marketing Structure of the Large Corporation, 1875–1890*, 38 J. ECON. HIST. 631 (1978) (arguing that the rise of national corporations with centralized marketing and distribution networks created pressure on federal courts to restrict state protectionist legislation).

industrial organizations altered the economic relations that many American citizens were a part of, creating vulnerability to processes and risks that were often beyond their control.³²⁶ For example, industrial accidents in railroads and factories increased along with rapid industrialization in the late nineteenth century.³²⁷ Initially, many cases were dismissed on the grounds that employers were not responsible for the harms caused by other employees or the injured worker.³²⁸ The result, however, was a substantial number of injured and destitute employees.³²⁹ Moreover, the integrated and complex nature of industrial operations made proving fault and causation quite difficult.³³⁰ Reformers argued that corporations and employers were in a better position to reduce harm in part because they could use investments in technology and their control over work rules to prevent employees from getting into dangerous situations.³³¹ However, firms that acted on their own to reduce accident rates were at a competitive disadvantage compared to firms that took no action.³³² To address the problems faced by the tort system in responding to industrial accidents and the competitive disincentives for corporations to act on their own, states moved to workers compensation systems in which payments would typically be made to injured workers regardless of fault.³³³ The result was the creation of one of the first large, modern administrative bureaucracies at the state level in the United States.³³⁴ The rise of workers compensation and associated safety regulatory systems is an example of how responses to the interconnectedness and vulnerability of individuals in an industrializing society led to “greater penetration by law and legal institutions into day-to-day life.”³³⁵

Legal responses to the nationalization of the economy and the economic and physical vulnerability of individuals in an industrial, interconnected society were amplified during the New Deal. The Great Depression created powerful arguments for both the national scope of economic activity and the challenges of individuals or states being able to address the problems created by a national, industrial economy.³³⁶ The response was a fundamental reshaping of federal power. The Supreme Court recognized the interconnectedness of economic activities in a modern industrial society and rejected the distinctions between

326. See JONATHAN LEVY, *FREAKS OF FORTUNE: THE EMERGING WORLD OF CAPITALISM AND RISK IN AMERICA* 4 (2012).

327. See BARBARA YOUNG WELKE, *RECASTING AMERICAN LIBERTY: GENDER, RACE, LAW, AND THE RAILROAD REVOLUTION 1865–1920* 81 (2001); JOHN FABIAN WITT, *THE ACCIDENTAL REPUBLIC: CRIPPLED WORKINGMEN, DESTITUTE WIDOWS, AND THE REMAKING OF AMERICAN LAW* 2–3, 25–28, 37–38 (2004).

328. See HORWITZ, *supra* note 324, at 56–59; WHITE, *supra* note 323, at 232; WITT, *supra* note 327, at 47–63.

329. See WITT, *supra* note 327, at 64–65.

330. See WHITE, *supra* note 323, at 247–48; WITT, *supra* note 327, at 38, 66.

331. See WITT, *supra* note 327, at 119–22.

332. See *id.* at 124.

333. See WHITE, *supra* note 323, at 256; WITT, *supra* note 327, at 126, 144–46.

334. See WITT, *supra* note 327, at 10–11, 188.

335. HALL & KARSTEN, *supra* note 322, at 216.

336. See *id.* at 290, 295–96.

intrastate and interstate economic activity as a basis for limiting federal regulatory scope.³³⁷ The federal government created large bureaucracies with substantial discretion to address novel and complex problems as they arose.³³⁸ Regulatory power expanded to even constrain a farmer growing wheat for subsistence purposes.³³⁹

Starting in the late nineteenth century, integrated manufacturing companies dominated the production and sale of many consumer products.³⁴⁰ Long supply chains, from parts manufacturers to wholesalers to retailers to consumers, made proving products liability claims difficult for consumers in many common situations.³⁴¹ Courts responded by creating strict liability for products liability on behalf of consumers, even if there was no direct relationship with the product manufacturer, avoiding difficult problems of fault and causation.³⁴² Again, changes in the legal system paralleled the implications of interconnectedness in a modern, industrial economy, addressing limitations in tort law's ability to manage harms.

Legal transformations in response to environmental pressures are also not new in American history. For much of the nineteenth century, the federal government sought to dispose of public lands in the West to facilitate economic development. But in the late nineteenth century, the American public and government became more aware of the limits of natural systems to support human economic development. Drastic reductions in forest cover across North America prompted fears of a "timber famine" because of profligate harvesting by private landowners. The extinction of the passenger pigeon and the near-extinction of the bison, both of which were once so numerous they could not be

337. See *id.* at 304; UROFSKY & FINKELMAN, *supra* note 322, at 704–11. For instance, in upholding federal regulation of labor relations, the Court rhetorically asked, "[w]hen industries organize themselves on a national scale, making their relation to interstate commerce the dominant factor in their activities, how can it be maintained that their industrial labor relations constitute a forbidden field into which Congress may not enter?" *NLRB v. Jones & Laughlin Steel Corp.*, 301 U.S. 1, 41 (1937).

338. See HORWITZ, *supra* note 324, at 222–25. A pre-New Deal example is the creation of the Federal Trade Commission, which was given broad discretion to respond to novel forms of efforts by companies to create and protect monopolies. See UROFSKY & FINKELMAN, *supra* note 322, at 590.

339. See *Wickard v. Filburn*, 317 U.S. 111, 118–19 (1942).

340. See Kyle Graham, *Strict Products Liability at 50: Four Histories*, 98 MARQ. L. REV. 555, 565–66 (2014).

341. See G. EDWARD WHITE, *TORT LAW IN AMERICA: AN INTELLECTUAL HISTORY* 171 (Expanded ed. 2003); Graham, *supra* note 340, at 566–67, 568–69.

342. See Graham, *supra* note 340, at 567, 601 ("[S]trict products liability averted the thorny problems that could arise with proving a particular defendant's fault when there existed multiple parties in the supply chain and a product that could have been compromised anywhere between the points of manufacture and sale."). A leading commentator called this change "the most rapid and altogether spectacular overturn of an established rule in the entire history of the law of torts." William L. Prosser, *The Fall of the Citadel (Strict Liability to the Consumer)*, 50 MINN. L. REV. 791, 793–94 (1966) (footnote omitted); see also George L. Priest, *The Invention of Enterprise Liability: A Critical History of the Intellectual Foundations of Modern Tort Law*, 14 J. LEGAL STUD. 461, 461 (1985) ("The dimensions of this revolution in the law are comparable only with those of Realism and *Brown v. Board of Education*."). Some courts did explicitly note the changes in manufacturing and supply chains in reaching these results, as did some legal scholars. See Graham, *supra* note 340, at 567 nn.73 & 74.

counted, showed the dangers of overexploitation of wildlife resources.³⁴³ The response was the rise of the conservation movement, which pushed for active government intervention to protect natural resources for long-term, sustainable human use.³⁴⁴ Federally owned forest lands that had once been open for sale or disposal were changed to forest reserves, with the intent to be owned in perpetuity by the state and managed for long-term public benefit. The federal government began enacting legislation to restrict the unrestricted hunting and killing of wildlife, particularly migratory birds.³⁴⁵ States enacted fish and wildlife laws to restrict hunting, in particular eliminating the commercial sale of wildlife.³⁴⁶

These changes were themselves substantial, given the baseline of unrestrained economic development for much of the nineteenth century. But they also had ripple effects on wider legal doctrine. The move to retention of federal lands required the creation of a federal bureaucracy to manage and control access to those lands.³⁴⁷ That in turn prompted a series of Supreme Court cases that helped lay the foundation for the modern administrative state, validating the delegation of powers from legislatures to agencies, including the possibility of criminal penalties.³⁴⁸ It also prompted changes in doctrine that recognized sweeping federal authority to retain and manage public lands.³⁴⁹ Federal efforts to protect migratory birds prompted a watershed Supreme Court case upholding broad federal authority under the Treaty Clause.³⁵⁰

If anything, the changes in the Anthropocene may be more long term and fundamental than the changes we have seen in the past. The move from a local to a national economy created dislocation and prompted a range of regulatory and legal responses, including shifting the locus of governance from informal, local levels to more formal, national levels. But in the Anthropocene, far more activities that were formerly seen as local will have national and global implications. Conversely, just as individuals became more vulnerable and more impacted by national and global economic forces over the nineteenth and twentieth centuries, those vulnerabilities and impacts will only increase in the twenty-first century due to factors such as climate change.

343. See Eric Biber & Josh Eagle, *When Does Legal Flexibility Work in Environmental Law?*, 42 *ECOLOGY L.Q.* 787, 818 (2015).

344. See *id.* at 818–19.

345. See Migratory Bird Treaty Act, 16 U.S.C. § 712 (2012); Biber & Eagle, *supra* note 343, at 819–22.

346. See Biber & Eagle, *supra* note 343, at 819–22.

347. See CHRISTINE A. KLEIN ET AL., *NATURAL RESOURCES LAW: A PLACE-BASED BOOK OF PROBLEMS AND CASES* 73–75 (3d ed. 2013).

348. See *United States v. Grimaud*, 220 U.S. 506, 514, 523 (1911) (upholding conviction of grazer for violating Forest Service regulations).

349. See *Light v. United States*, 220 U.S. 523, 535–37 (1911).

350. See *Missouri v. Holland*, 252 U.S. 416, 435 (1920).

B. THE COMING DISPUTES OVER THE LEGAL SHIFTS IN THE ANTHROPOCENE

The history of legal transformations makes clear that the legal transformations prompted by the Anthropocene will also lead to sharp, sometimes bitter, legal and political contests. Changes toward a national regulatory state—most dramatically during the New Deal—were met with objections due to late-nineteenth-century conceptions of state power being necessarily limited to protecting personal autonomy and economic growth.³⁵¹ That same tension will replicate itself in the legal shifts prompted by the Anthropocene. A primary legal shift in the Anthropocene is the expansion of state power to regulate individual activity—whether it is through tort law, property law, administrative law, or criminal law—to manage the dramatic effects that individual activity will have on global systems. But that threatens a shrinking of the space that is outside regulation by government, which may be of deep concern to a traditional liberal notion of governance.

It is important to keep in mind that even if the government does not actively regulate private activity in response to the Anthropocene, that does not mean the state should be construed as absent. State inaction in the face of harm imposed on billions of people, caused by billions of other people, can be understood as validating, endorsing, or at least condoning those harms. As realists first noted, the distinction between act and omission is just as blurry for the state as it is for other legal actors.³⁵² And so, the expansion of the scope of government regulation that is the most likely result of the Anthropocene should not be compared to a utopian world in which there is minimal state imposition. The comparison should instead be to a dystopia where state enforcement of preexisting property and other legal rights facilitates the infliction of massive harm on many of the most vulnerable people in the world.

Nonetheless, the conflict between traditional understandings of the liberal state and the demands of the Anthropocene is a real one. As discussed below, government regulation does have its costs, even if it is replacing government inaction with its own set of costs. The most obvious political reaction to this conflict might be a continuation of conservative resistance to the expansion of the regulatory state. Yet the discomfort will be bipartisan. The pressures that the Anthropocene will place on criminal law to expand the scope of potential liability, for example, are in deep tension with progressive efforts to decriminalize a wide range of activities and combat mass incarceration.³⁵³

351. See, e.g., Samuel R. Olken, *The Decline of Legal Classicism and the Evolution of New Deal Constitutionalism*, 89 NOTRE DAME L. REV. 2051 (2014).

352. See Joseph William Singer, *Legal Realism Now*, 76 CALIF. L. REV. 465, 477–95 (1988).

353. See, e.g., Carl Hulse, *Why the Senate Couldn't Pass a Crime Bill Both Parties Backed*, N.Y. TIMES, Sept. 16, 2016, at A8 (noting these cross-cutting pressures in bipartisan criminal justice reform efforts); Gideon Yaffe, *A Republican Crime Proposal that Democrats Should Back*, N.Y. TIMES, Feb. 12, 2016, at A27 (arguing liberals should support decriminalization efforts by Republican Congress, even if it means scaling back on strict liability penalties for violating environmental law, because of the

There are important concerns about the dramatic expansion of state power that will likely result in the Anthropocene. For instance, broad criminal prohibitions carry the risks of arbitrary enforcement by empowered prosecuting officials,³⁵⁴ of corruption (as individuals seek to buy security from enforcement officials), of political persecution or personal vendettas pursued by empowered enforcement officials, of disproportionate enforcement of the rules against poor and marginalized communities—as in the war on drugs³⁵⁵—and of potentially undermining the expressive and educational functions of criminal law.³⁵⁶ Sweeping regulation by the government has the potential to stifle individual initiative and entrepreneurial activity as actors avoid political and legal risks or are deterred by paperwork and compliance burdens. Placing more and more decisions about individual behavior under some form of regulatory guidance or control may be asking too much of our political system, which is criticized for its dysfunction. Increasing the scope for administrative agency discretion creates the possibility of sweeping authority for the president and executive branch, authority that will not necessarily be exercised benignly. Increasing the scope of power of the federal government with regard to states expands the scope of power for one set of political actors while undermining the benefits of a federalist system, which functions by diffusing power, reducing the risk of arbitrary and excessive government action.

Resolving these tensions will be a crucial question for the legal system in the coming decades. Trying to completely articulate specific solutions for how to resolve these tensions is beyond the scope of this Article. However, there are some ideas that are worth exploring. For instance, permit programs can be designed to be less burdensome and intrusive on regulated parties, like general permits used in a number of existing environmental law programs.³⁵⁷ Tax programs may also reduce government intrusion and compliance obligations, which is one reason some conservatives have embraced carbon taxes to address climate change.³⁵⁸ However, as noted above, carbon taxes cannot completely address climate change issues on their own, and even carbon taxes involve a level of government intrusion that some may not be able to embrace.

benefits of reducing mass incarceration impacts on the poor and minorities). As noted *infra*, one could distinguish between decriminalization efforts focused on corporations versus those focused on individuals.

354. See Stuntz, *supra* note 290, at 519 (describing how broad criminal prohibitions empower prosecutors).

355. See *id.* at 573–75 (describing how broad criminal prohibitions on vice activities were historically predominantly enforced against marginalized communities).

356. See *id.* at 520–22.

357. See Biber & Ruhl, *supra* note 204, at 212–28 (describing general permit programs).

358. See Adler, *supra* note 187, at 277–78; Bob Inglis, *Putting Free Enterprise to Work: A Conservative Vision of Our Environmental Future*, 23 DUKE ENVTL. L. & POL'Y F. 247 (2013) (calling for revenue-neutral carbon tax); Daniel A. Farber, *The Conservative as Environmentalist: From Goldwater and the Early Reagan to the 21st Century* 2 (U.C. Berkeley Pub. Law Research Paper No. 2919633, 2017) (noting limited conservative support for carbon taxes).

Regardless of the specific policy tools that are developed, there is one key principle that will make resolution of these tensions easier. The earlier that we—as a legal system and as a society—move to recognize the underlying changes, the easier our task will be to resolve these tensions. Early and proactive action to respond to the Anthropocene will give us more leeway to adjust to the new future and develop innovative solutions to mitigate the legal and political risks of these legal changes.³⁵⁹ A simple hypothetical question makes the stakes clear: Do we think that the risk of political and legal disruption will be lower or higher if we wait until millions of climate refugees are fleeing sea level rise, if droughts and changes to precipitation and water storage systems are causing dramatic impacts on agricultural systems, and if our economic and physical infrastructure is under severe stress?

Recent political events make this point even clearer. The wave of refugees from Syria, Iraq, Afghanistan, and other Middle Eastern states has caused significant political turmoil in Europe, contributing to the rise of populist, nationalist politicians in Europe and the United States.³⁶⁰ There is some evidence that climate change impacts, like drought, contributed to the political instability that produced the ongoing civil war in Syria.³⁶¹ More direct is the evidence that increasing economic migration to Europe from the Sahel region of Africa is being driven by desertification in the Sahel, driven in part by climate change.³⁶² As climate change and other impacts of the Anthropocene increase over the coming decades, there will be concomitant increases in human migration, contributing to increasing political and economic instability. That political and economic instability is far more likely to threaten the liberal political order than any changes in the legal system to reduce and ameliorate the impacts of the Anthropocene.

CONCLUSION

If history is any predictor, then just like the substantial legal upheaval that was initiated by industrialization or the development of a national economy, the Anthropocene will bring deep and structural changes to American law in a wide range of areas, beyond those covered in this Article. Those legal changes will create inevitable pressures on many of the fundamental normative principles in

359. See Doremus, *Property Rights*, *supra* note 18, at 1094 (arguing that transitions to new legal rules will be more successful and fair if they are “planned and gradual rather than a sudden lurch in response to a crisis”).

360. See, e.g., *Europe Migrant Crisis: EU Faces ‘Populist Uprising,’* BBC (May 16, 2016), <http://www.bbc.com/news/world-europe-36304721> [<https://perma.cc/D9J5-B93P>]; Simon Shuster, *European Politics Are Swinging to the Right*, TIME (Sept. 22, 2016), <http://time.com/4504010/europe-politics-swing-right> [<https://perma.cc/QA6R-GF7T>].

361. See Colin P. Kelley et al., *Climate Change in the Fertile Crescent and Implications of the Recent Syrian Drought*, 112 PROC. NAT’L ACAD. SCI. 3241, 3241 (2015).

362. See Somini Sengupta, *Heat, Hunger and War Force Africans onto a ‘Road on Fire,’* N.Y. TIMES (Dec. 15, 2016), <https://www.nytimes.com/interactive/2016/12/15/world/africa/agadez-climate-change.html> [<https://perma.cc/96MP-TQVF>].

American law, including the concepts of a limited government and federalism. In many ways, one of the central challenges for the law in the upcoming century will be how to manage the pressures created by the Anthropocene while remaining committed to the central values of the American political system.

The focus of this Article has been on the legal doctrinal changes that the Anthropocene will produce. But it is important to keep in mind that our response to the Anthropocene as a society will ultimately be a political one.³⁶³ We will make political choices about whether we will prioritize reducing the impairment that our actions cause on global systems, or reacting and adapting to the social and ecological impacts that those actions cause. We will make political choices about who will gain and who will lose (or perhaps more accurately, who will lose most and who will lose less) from the transition to the Anthropocene. We will make political choices about how proactive to be in responding to the Anthropocene, or whether we will play catch-up, putting even greater pressures on our legal, social, political, and economic systems. Whatever political choice we make, the legal landscape will never be the same.

363. See Purdy, *supra* note 224, at 1645–48.