THE RULE OF ECOLOGICAL LAW: A TRANSFORMATIVE LEGAL AND INSTITUTIONAL FRAMEWORK FOR THE HUMAN-EARTH RELATIONSHIP

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ABSTRACT

The failure of current legal mechanisms and institutions to counter the growing global ecological crisis reflects an absence of the rule of ecological law from the global to the local level. Just as ecological economics has yet to crowd out environmental components of neo-classical economics, a parallel notion of ecological law has not yet displaced contemporary environmental law.

The rule of ecological law, building on existing concepts like sustainability law, is founded on the notion that economic and socio-political spheres must be subservient to global ecological limits beyond which lie catastrophic ecological, social and economic collapse. Planetary boundaries of safe operating space for humanity, along with complementary measures and principles, provide the scientific and ethical basis of the rule of ecological law.

The limitations of contemporary environmental law are illustrated with mostly ineffective attempts to address systemic environmental problems like eutrophication, acid rain, climate change and depletion of the ozone layer, followed by a critique of the broader legal and institutional architecture now in place to address global environmental challenges. The current approach to trade and the environment highlights the failure of the global governance infrastructure to respect global ecological boundaries on the human enterprise.

In response to the ineffectiveness of current mechanisms and structures, ten essential features principles of the rule of ecological law are identified, along with elements of an institutional framework for housing them. Although the transition from a growth-insistent economy that seems headed toward ecological collapse to an economy based on the rule of ecological law is elusive, the European Union is identified as a useful structural model.

RÉSUMÉ

Le fait que les mécanismes juridiques et institutionnels actuels ne répondent pas de manière efficace à la crise écologique mondiale met en évidence l'absence d'un régime de primauté de droit écologique du niveau local au niveau global. Tout comme l'économie écologique n'a pas encore réussi à remplacer les éléments environnementaux de l'économie néo-classique, une conception similaire du droit écologique n'a pas encore supplanté le droit contemporain de l'environnement.

La primauté du droit écologique se fonde sur le concept actuel du droit du développement durable et sur l'idée que les sphères de l'économie et de la socio-politique devraient être subordonnées aux limites mondiales écologiques dont le dépassement assure un effondrement catastrophique écologique, économique et sociale. Des limites planétaires des champs d'activités humaines, complétées par d'autres principes et indices, sont à la base de la primauté du droit écologique.

Les faiblesses du droit contemporain de l'environnement se révèlent dans les mesures tout à fait inefficaces qui ont été adoptées pour régler les problèmes environnementaux comme l'eutrophication, les pluies acides, les changements climatiques et l'appauvrissement de la couche d'ozone. Un énoncé de ces mesures est suivi d'une critique de l'architecture plus large du droit et des institutions qui sont en place actuellement pour faire face aux défis environnementaux mondiaux. L'approche actuelle pour intégrer le commerce international et la protection de l'environnement met en évidence l'échec de l'infrastructure de gouvernance mondiale en ce qui concerne le respect des limites écologiques pour les activités humaines.

En réponse à l'inefficacité des mécanismes et des structures actuelles, dix caractéristiques de la primauté du droit écologique sont identifiés, ainsi que des éléments d'une structure institutionnelle pour les encadrer. Bien que la transition d'une économie dominée par l'obsession de la croissance économique à une économie fondée sur la primauté du droit écologique soit difficile à réaliser, l'Union européenne peut être un modèle structurel utile.

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ACRONYMS

ACES	American Clean Energy and Security (Bill)
APEC	Asia-Pacific Economic Cooperation
BRAC	Base Realignment and Closure (Commission)
CEC	Commission for Environmental Cooperation (North America)
CFC	Chlorofluorocarbon
DICE	Dynamic Integrated model of Climate and the Economy
DR-CAFTA	Dominican Republic-Central America-United States Free Trade Agreement
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency (United States)
FTA	Free trade agreement
G20	Group of Twenty nations
GDP	Gross domestic product
GEO	Global Environmental Organization
GHG	Greenhouse gas
HANPP	Human appropriation of net primary production
HCFC	Hydrochlorofluorocarbon
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
LEED	Leadership in Energy and Environmental Design
LRTAP	Long-range Transboundary Air Pollution
MEFA	Material and energy flow accounting
NAAEC	North American Agreement on Environmental Cooperation
NAAQS	National Ambient Air Quality Standard (United States)
NAFTA	North American Free Trade Agreement
NEPA	National Environmental Policy Act (United States)
NGO	Nongovernmental organization
NHTSA	National Highway Traffic Safety Administration (United States)
PPM	Parts per million
SEM	Submissions on Enforcement Matters
TEEB	The Economy of Ecosystems and Biodiversity
TEU	Treaty on European Union
TFEU	Treaty on the Functioning of the European Union
TIFA	Trade and investment framework agreement
TMDL	Total Maximum Daily Load
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WEO	World Environmental Organization
WQS	Water Quality Standard
WTO	World Trade Organization

Introduction: Current Legal Regimes and Institutions Support a Dangerous Set of Global Ecological Trends

"It is the nature of all biological species to multiply and expand heedlessly until the environment bites back."[1] — Edward O. Wilson

In Greek mythology, Apollo blessed Cassandra with the ability to know the future in exchange for her love for him, and when she then rejected his love, he cursed her by making it so nobody would ever believe her. Hard facts – or, "inconvenient truths"[2] - about the growing global ecological crisis often face Cassandra's dilemma.[3] The overriding reality of the contemporary era is that, according to many emerging measures, human society is using up the Earth's capacity to support life faster than it can regenerate.[4] Current trends on how humans provide for themselves and discard their waste portend catastrophe. Yet, information that tells this story is routinely ignored, resisted or drowned out in public and political discourse, such that normative regimes that would lead the human community along pathways that would adequately confront the catastrophic trends either fail to emerge or are rejected.[5] Consequently, the global community's *de facto* governance structure,[6] from the global to the local level, lacks the

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[1] Edward O. Wilson, *The Future of Life* (New York: Alfred A. Knopf, 2002) at 76.
[2] See Albert Gore Jr., *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It* (New York: Rodale, 2006); Dan Miller, "A REALLY Inconvenient Truth" *The Berkeley Cybersalon* (August 18, 2009), online: fora.tv <http://fora.tv/2009/08/18/A_REALLY_Inconvenient_Truth_Dan_Miller>.
[3] See Alan Atkisson, *Believing Cassandra: An Optimist Looks at a Pessimist's World* (White River Junction, VT: Chelsea Green, 1999).
[4] See Johan Rockström *et al.*, "Planetary boundaries: exploring the safe operating space for humanity" (2009) 14:2 Ecology and Society art. 32, online: <http://www.ecologyandsociety.org/vol14/iss2/art32/>; James Gustave Speth, *The Bridge at the Edge of the World* (New Haven, CT: Yale University Press, 2008) at Introduction; Chris Hails *et al*., eds., *The Living Planet Report* (Gland, Switzerland: WWF International, 2008) [*LPR Report 2008*].
[5] As one set of commentators stated by way of example, "[w]henever biodiversity preservation poses a threat to human livelihood, comfort, or convenience, the politically expedient choice is usually to liquidate the natural capital." Paul R. Ehrlich and Robert M. Pringle, "Where Does Biodiversity Go from Here? A Grim Business-as-usual Forecast and a Hopeful Portfolio of Partial Solutions" (2008) 105 Proceedings of the Nat'l Ac. of Sci. 11579, 11580.
[6] See Peter G. Brown and Geoffrey Garver, *Right Relationship: Building a Whole Earth Economy* (San Francisco: Berrett Koehler: 2009) [Brown and Garver, *Right Relationship*] at 19.

legal and institutional mechanisms that would allow hard ecological truths to carry determinative weight in policy and law making.

This situation, writ large, reflects an absence of the rule of ecological law. Just as ecological economics has yet to crowd out conventional neo-classical economics and its environmental subcomponent, environmental economics, a parallel notion of ecological law has not made significant inroads against contemporary notions of environmental law. Yet, the scientific case for these shifts is becoming increasingly irrefutable. Scientists are increasingly buttressing their consensus[7] that uncompromising ecological boundaries constrain the human economy. Beyond these limits, the climate changes, the global ecosystem reacts to human additions of nutrients, or biodiversity is lost to such an extreme that the ecological context for the human enterprise irreversibly and catastrophically moves into a new systemic state.[8] These systemic boundaries, buffered with means to allow the flourishing of life and not merely its survival, can be seen as the base of a structure of ecological law that must be obeyed and enforced to fend off catastrophe and to enhance the capacity for life to flourish. In this thesis, I argue that the looming prospect of transgressing critical ecological points of no return requires the global community to fashion a systems-based legal and institutional structure that is built on this foundation of ecological law under an expanded notion of the rule of law.

[7] See generally Naomi Oreskes and Erik M. Conway, *Merchants of Doubt* (New York: Bloomsbury Press, 2010) (convincingly refuting the notion that scientists have not reached consensus that humans are causing climate change, a notion they attribute to "merchants of doubt" who are motivated by a fear that regulations to address climate change will restrict market freedoms).

[8] See generally Rockström *et al*., *supra* note 4 (describing "planetary boundaries" for nutrients, climate change, biodiversity and other features of Earth systems).

A. Highlighting the Ecological, Social and Economic Catastrophe of Continuing Current Economic Trends Reveals Openings for Legal and Institutional Reform

The twenty-first century will be a time when growing numbers of people on Earth[9] will struggle with significant new ecological challenges to keep the engines of the human economy running. On one hand are increasing constraints on the human pursuit of material and energy resources. Paul Ehrlich and Robert Pringle recently spelled out the essence of this part of the challenge in stark terms:

> Supplying the consumption of the next 2.6 billion people will almost certainly have a greater environmental impact than supplying the last 2.6 billion added since 1975. Our species has already plucked the lowest-hanging resources and converted the richest lands. To maintain the pace, metals will have to be won from ever-poorer ores, and oil, natural gas, and water will need to be obtained from ever-deeper wells and transported farther—all requiring accelerating energy use. So-called ''marginal lands,'' often the last holdouts of biodiversity, are the final frontier, awaiting conversion into more human biomass.[10]

The pace to which Ehrlich and Pringle refer, it bears underscoring, is exponential and therefore accelerating. On the other hand are the accelerating challenges related to climate change, biodiversity loss and other global-scale ecological impacts of human activity.

Imagine the year 2100 on planet Earth if Ehrlich and Pringle's description of resource exploitation is realized and current dominant economic and ecological trends and patterns continue unabated. The average surface temperature of the planet is on average 5 degrees Celsius higher than it was in 1990, and weather events like cyclones, hurricanes, tornadoes, droughts and floods occur more frequently and with much greater severity than in 2000,[11] and in places where in 2000 it was widely accepted they would

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[9] Approximately 6.9 billion in 2010, with a mid-range forecast of 9.1 billion by 2050 (compared with low- and high-range forecasts of 8 and 10.5 billion). UN, ECOSOC, Population Division, *World Population Prospects: The 2008 Revision* (2010) online: <http://esa.un.org/unpd/wpp2008/all-wpp-indicators_components.htm>; Ehrlich and Pringle, *supra* note 5 at 11580.

[10] Ehrlich and Pringle, *ibid.* at 11580.

[11] Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report* (2007) [IPCC 2007 *Synthesis Report*] at 45-49. This picture is built in part from the consequences that the IPCC associates with their A1F1 and A2 emissions scenarios, which have been described as

not occur.[12] The Amazon forest has converted almost entirely to savannah.[13] Nearly all tropical coral-based ecosystems in the Caribbean, the Red Sea, the tropical Indian Ocean, Southeast Asia, the Great Barrier Reef and the islands of the South Pacific are either lifeless skeletons or in late stages of disintegration.[14] Half of the species present on Earth in 2000, from the polar bear at high altitudes to countless species of tropical amphibians at lower ones, are extinct, but the hardiest invasive species—and probably jellyfish—are thriving.[15] The island nations of Tuvalu, Kiribati, the Marshall Islands and the Maldives are deserted and in the process of being swallowed by the ocean.[16] The same holds for low-lying cities, such as London, Bangkok, Cairo, Shanghai and Venice.[17] Violence and lawlessness reign.[18] The roads, railways and urban infrastructure of the year 2000 are in shambles. As modeled in the updated analysis in *Limits to Growth: The 30-Year Update,*[19] global population, industrial output and food production have crashed from their peaks in the first half of the century, with per capita consumption and prospects for the hapless survivors drastically reduced (Figure 1). Average human life expectancy is around forty years, and even though the human population has crashed to four billion people, poverty and hunger are widespread and increasing.[20]

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the scenarios that most closely represent a forward projection of past and current forms of development.

[12] *See* Mark Lynas, *Six Degrees: Our Future on a Hotter Planet* (London: Fourth Estate, 2007), at 48-50 (discussing the first ever known hurricane in the South Atlantic, Hurricane Catrina, off the coast of Brazil in March 2004).

[13] See Timothy N. Lenton *et al.*, "Tipping elements in the Earth's climate system" (2008) 105 Proceeedings of the Nat. Ac. of Sci. 1786 at 1790.

[14] See Lynas, *supra* note 12 at 40-45, 61, 100, 225; J.E.N. Veron, "Veron: The end is in sight for the world's corals" (2010) *Climate Progress,* online: <http://climateprogress.org/2010/12/07/j-e-n-veron-coral-reefs-bleaching/>.

[15] See Wilson, *supra* note 1 at 77; Anthony J. Richardson *et al*., "The jellyfish joyride: causes, consequences and management responses to a more gelatinous future" (2009) 24:6 Trends in Ecology and Evolution 312 at 314-16.

[16] Lynas*, supra* note 12 at 52-53.

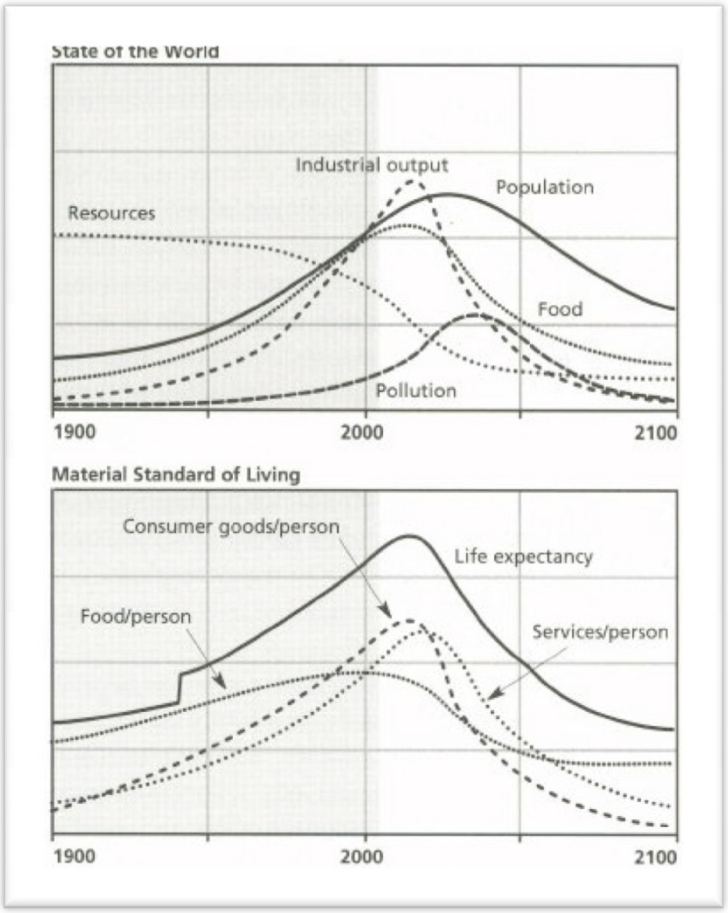
[17] Johann Hari, "There Won't Be a Bailout for the Earth" The Independent (26 November 2010) online: Independent Print Limited <http://www.independent.co.uk/opinion/commentators/johann-hari/johann-hari-there-wont-be-a-bailout-for-the-earth-2143876.html>.

[18] See Lynas, *supra* note 12 at 226-30.

[19] Donella Meadows, Jorgen Randers and Dennis Meadows, *Limits to Growth: The 30-Year Update* (White River Junction, VT: Chelsea Green Publishing Company, 2004).

[20] See *ibid*. at 168-69.

Figure 1. A Business-as-past View of the 21st Century[21]



It would be naïve to suggest that the global community appears ready, or even headed toward being ready, to accept politically a common story line regarding the catastrophic scenario that the global scientific community increasingly agrees is likely without difficult and unprecedented policy changes at the global to the local level.[22] The

[21] *Ibid*. Bastien Girod and Thomas Flüeler propose the term "business-as-past" as preferable to "business-as-usual," which they criticize as neglecting the uncertainty of future development. Bastien Girod and Thomas Flüeler, "Future IPCC Scenarios - Lessons Learned and Challenges to Scenario Building in Climate Change Policy", online: (2009) International Energy Workshop <http://www.iccgov.org/iew2009/speakersdocs/Girod-Flueeler_IPCCScenariosLessons.pdf>., at 12. For example, none of the IPCC scenarios have projected GHG emissions in the 2000s that are as high as emissions actually have been, which is a truer representation of business-as-past. *Ibid*; see also UNEP, *Climate Change Science Compendium* (2009) at 8.

[22] See Suzanne Goldenberg, "Obama Environment Agenda Under Threat from Incoming Republicans" *The Guardian* (31 October 2010) online: <http://www.guardian.co.uk/world/2010/oct/31/republican-onslaught-obama-environment-agenda> (noting that just 16% of Republicans in the United States believe that humans cause

Intergovernmental Panel on Climate Change [IPCC] has issued four assessments, each more certain than the previous that the global climate is changing, that the changes are due primarily to the human enterprise and that the extrapolation of current trends without significant policy interventions is catastrophic.[23] A distinguished group of scientists from the Stockholm Resilience Centre and elsewhere estimate that of nine biophysical planetary boundaries that they identify for "safe operating space for humanity,"[24] three have already been crossed. The World Wide Fund for Nature's *Living Planet Report 2010* indicates that the global human ecological footprint in 2007 was fifty percent greater than the available biocapacity of the planet, and the trend was in the direction of a steady increase in footprint.[25] The *Stern Review on the Economics of Climate Change* in 2006 called for an immediate global commitment to "sustained long-term action" to address climate change at an annual cost of one percent of global gross domestic product [GDP] to avoid the far greater future costs of inaction.[26] *Limits to Growth: The 30-Year Update* indicates that current patterns of consumption and production in the human economy are eroding the economy's ecological base, with increasing risk of a catastrophic "overshoot and collapse" scenario involving crashes in food production, the global economy and human population.[27] The Millenium Ecosystem Assessment, published in 2005, concluded that the unprecedented pace and extent of human alteration of ecosystems have "resulted in a substantial and largely irreversible loss in the diversity of life on Earth"[28] and predicted worsening impacts on biodiversity if current trends continue.[29]

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climate change); J.B. Ruhl, "Climate Change Adaptation and the Structural Transformation of Environmental Law" (2010) 40 Envtl. L. 363 at 369.

[23] See generally IPCC 2007 *Synthesis Report, supra* note 11.

[24] Rockström *et al*., *supra* note 4 .

[25] Duncan Pollard et al., eds., *Living Planet Report 2010* (Gland, Switzerland: World Wide Fund for Nature, 2010) [*LPR 2010*] at 8.

[26] Nicholas Stern, *The Economics of Climate Change: The Stern Review* (Cambridge, UK: Cambridge University Press, 2007) at vii. But see William Nordhaus, *A Question of Balance: Weighing the Options on Global Warming Policies* (New Haven, CT: Yale University Press, 2008) at 165-191 (critiquing the *Stern Review*).

[27] Meadows *et al., supra* note 19 at 136-78.

[28] Millenium Ecosystem Assessment, *Ecosystems and Human Well-being: Synthesis* (Washington, DC: Island Press, 2005) at 1.

[29] *Ibid*. at 1-20. See also Wilson, *supra* note 1 at 77 (estimating that half of the existing plant and animals species on the planet will go extinct by 2100 under current trends).

None of these prominent descriptions of looming catastrophic consequences of maintaining current institutional and political arrangements for managing the global economy have yet had any significant impact on global governance. The dangerous trends continue unabated. Indeed, the United National Environment Programme [UNEP] reported in 2009 that the actual trend in global greenhouse gas emissions surpasses the hypothetical scenario of the IPCC from the late 1990s that projected the highest level of greenhouse gas emissions.[30] Moreover, some impacts of climate change have become unavoidable: no matter what actions we take, we are almost certainly already "committed" to sea level rise on the order of at least one meter, significant loss of glaciers that will affect numerous communities in tropical and temperate zones, ocean acidification that will destroy massive amounts of coral and significantly disrupt marine ecosystems and regional climate shifts that will bring drought and other difficult conditions to new regions.[31] Aspirational declarations both to mitigate and adapt to climate change and other ecological threats abound, but concrete action that would impose the rule of ecological law from the global to the local level has been virtually absent.

Many possible explanations exist of this Cassandra's dilemma. Climate change skeptics, deniers and "merchants of doubt" have outsized prominence in the media and the political realm, such that public opinion in parts of the world where radical shifts in policy are essential, like North America, does not sufficiently support rigorous regulation of greenhouse gas emissions.[32] Even where the scientific evidence of ecological crisis is accepted, the belief that technological solutions—geo-engineering, for example—will emerge remains strong.[33]

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[30] UNEP, *Climate Change Science Compendium, supra* note 21 at 8. See also Miller, *supra* note 2.
[31] UNEP, *Climate Change Science Compendium, ibid.* at 8, 11.
[32] See Andrew C. Revkin, "Energy for the Economy" *The New York Times* (22 January 2011), online: <http://www.nytimes.com/2011/01/23/opinion/23revkin.html>; Oreskes and Conway, *supra* note 7 at 16-17, 202-203, 214-215, 240-243, 269-270.
[33] See Nathan Pelletier, "Of laws and limits: An ecological economic perspective on redressing the failure of contemporary global environmental governance" (2010) 20 Global Environmental Change 220 at 221.

More fundamentally, the grand project of the global community, as reflected in the plans of the Group of Twenty [G20][34] nations, is centered on perpetuating global economic growth while maintaining the consumption habits of the developed world and helping the developing world attain them.[35] The main proposals to achieve these goals are to stabilize financial markets and the international monetary system, to "boost and sustain" global demand, to expand liberalized trade and avoid protectionism and to "promote broadly shared growth beyond crisis."[36] Yet, these plans allude only vaguely to climate change and other global ecological challenges. No mention whatever of aggregate ecological limits that unavoidably constrain the economy or of the need to prioritize a radical reduction in the material and energy throughput of the economy in order to conserve its ecological base can be found in the G20's outlook. Parallel global efforts to address climate change, biodiversity loss and the like are weak cousins of the economically driven consensus on economic growth and resource intensive development and appear far from leading to concrete and effective policy regimes. Thus, although the conversation on de-materialization of the economy seems to have begun in discrete parts of the world, notably Europe,[37] it has not taken hold in the global discourse that is driving actual policy.

Instead, the world remains in the grip of the myths of neo-classical economics, with growth in GDP seen as the panacea both to poverty in the developing world and to climate change and other ecological threats worldwide.[38] From this perspective, fears that controlling climate change or reducing material and energy use and waste generation in

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[34] G-20, online: <http://www.g20.org/index.aspx>.
[35] See Peter G. Brown and Geoffrey Garver, "Economics without ecocide" *The Montreal Gazette* (12 November 2009), online: <http://www.montrealgazette.com/story_print.html?id=2212656&sponsor=> [Brown and Garver, "Economics without ecocide"].
[36] G20 Seoul Summit, Leaders' Declaration (2010) online: <http://www.g20.org/Documents2010/11/seoulsummit_declaration.pdf>. See also Brown and Garver, "Economics without ecocide," *ibid.* Crisis here means economic crisis only.
[37] See Degrowth Conference Barcelona 2010. Online: <http://www.degrowth.eu/v1/>.
[38] See Brown and Garver, *Right Relationship, supra* note 6 at 8; Herman Daly, *Beyond Growth* (Boston: Beacon Press, 1996) at 37; Robert Nadeau, *The Environmental End Game: Mainstream Economics, Ecological Disaster, and Human Survival* (New Brunswick, NJ: Rutgers University Press, 2006) at 146-64; William E. Rees, "Globalization and Sustainability: Conflict or Convergence?" (2002) 22:4 Bull. of Sci., Tech. & Soc. 249 *passim;* Pelletier, *supra* note 33 at 221.

the economy will hinder growth far outweigh fears that the ecological impacts of the economy will ultimately undermine growth and lead to overshoot and collapse. Indeed, this weighing never even takes place, because neo-classical economics blindly assumes that sustained growth will lead to substitutes for resources and waste sinks, if ever they run out, and that humankind need only follow price signals to know when it is time for those substitutes to come on line.[39] As a result, powerful social constructs like the American Dream, which depend on a level of consumption, self-orientation and sense of unrestricted choice that is not easily reconcilable with a collective imperative to decrease the ecological impact of the human enterprise rapidly and drastically, continue to reign in the public imagination as what is desirable—and realistic.

But, because ceding to utopian storylines that run counter to the mounting evidence of the ecological catastrophe of continuing past patterns and trends means ceding ultimately to hopelessness about the human prospect on Earth, the effort to construct new storylines that avoid catastrophe and promote life's flourishing must continue.[40] Indeed, believing that current patterns and trends in the economy will not have catastrophic consequences is far more utopian than the ecological Cassandras' calls for transformation.[41] How, then, to shift the relative weight in discourse of these opposing notions of utopia—one based on the weight of science and the other on the self-contained magic of neo-classical economics? For Slavoj Zizek it is not sufficient simply to claim that there is time to act to prevent catastrophe at some point in an uncertain future.[42] Instead, he sees a way to inspire the radical transformation needed to take on impending ecological catastrophes in

> confront[ing] the forthcoming crisis: we should first perceive it as our fate, as unavoidable, and then, projecting ourselves into it, adopting its standpoint, we should retroactively insert into its past (the past of the future) counterfactual possibilities ("If we had done this and that, the catastrophe we are in now would not have occurred!") upon which we then act today.[43]

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[39] See William Nordhaus, *supra* note 26 at 16-17, 20, 197; Pelletier, *supra* note 33 at 223.
[40] See e.g. Thomas Berry, *The Great Work: Our Way Into the Future* (New York: Three Rivers Press, 1999) at 21-32.
[41] See Pelletier, *supra* note 33 at 226; Brown and Garver, *Right Relationship, supra* note 6 at 19.
[42] Slavoj Zizek, *In Defense of Lost Causes* (London: Verso, 2008) at 459-60.
[43] *Ibid.* at 459.

The idea is to overcome resistance that many reform proposals confront in the face of cultural trends and entrenched patterns and beliefs by magnifying and then reflecting back to the present the even more repelling consequences of following those patterns and beliefs through to their catastrophic conclusion.

Looking back to the year 2011 from the ravaged human and ecological condition that an increasing number of projections of business-as-past foretell for the year 2100, what went wrong? What could have prevented catastrophe and paved a more gentle path to an Earth unavoidably altered by climate change and other impacts of human society, but still able to provide good lives for people and their earthly cohabitants? More specifically, what about global governance, and the legal and policy structures and institutions that support it, could have changed to put humanity on this more hopeful course? In short, how could the rule of ecological law have come about?

B. Thesis Outline

Without necessarily answering that frustrating last question, this thesis proposes criteria and a framework for the rule of ecological law from the global to the local level. Part I provides a broad definition of the rule of ecological law. It then introduces the concept of planetary boundaries and explains how they, along with complementary ecological indicators and ethical principles, can serve as a foundation for the rule of ecological law. Part II examines how the rule of ecological law is different from contemporary notions of environmental law and responds to its limitations. The limitations of contemporary environmental law are illustrated with an analysis and critique of specific attempts to establish systemic limit-based regulatory regimes to address environmental problems like acid rain and climate change. Part III extends this critique of specific mechanisms to the broader legal and institutional architecture now in place to address global environmental challenges. The United States' outdated approach to trade and the environment is presented as a seminal example of the failure of the global governance infrastructure to recognize and respond to global ecological boundaries for the human enterprise. Part IV proposes how the concept of ecological boundaries can merge with the notion of the rule of ecological law and presents ten essential features principles for the rule of ecological law. It then presents some essential elements of an

institutional framework for the rule of ecological law, starting with the premise that such a framework must encompass and constrain the global legal and policy infrastructure for trade, finance and economic development. The thesis concludes with the observation that the path towards a transition from a growth-insistent economy that seems headed toward ecological collapse to an economy based on the rule of ecological law is elusive. The dense fog of social discourse that shields it from our collective view has been collecting for a long time. At best we can hope that the fog will clear and the turnstile at the foot of that path will appear.

Part I. The Rule of Ecological Law and Its Scientific Foundations

A central argument of this thesis is that the rule of ecological law is needed to address limitations of contemporary environmental law. But what is the rule of ecological law? The term "ecological law" has rarely been used, let alone well defined. This Part first provides a broad definition of the rule of ecological law, with guidance from past uses of the terms "ecological law" and "sustainability law". Then it introduces the concept of planetary boundaries and explains how they, as complemented by other ecological indicators and ethical principles, can provide a foundation for the rule of ecological law.

A. A General Definition of the Rule of Ecological Law

The rule of ecological law combines the notion of ecological law with the notion of the rule of law. The meaning of the rule of ecological law therefore depends on the meaning of these two elements and how they complement each other.

The rare uses of the term "ecological law" to date do not entirely capture the meaning intended in this thesis. William Howarth makes a distinction between environmental quality law, which he defines as the law controlling the quality of environmental media such as air and water, and ecological law, which he defines as the law related to the relationships between environmental media and their living

components.[44] O.S. Kolbasov, whose use of the term dates back to 1976,[45] takes the opposite tack. Noting the fragmentation in the Soviet Union of legal regimes related to the interaction of society and nature,[46] he describes ecological law as including "the entire complex of issues of nature-use and nature protection, excluding those that pertain to constitutional, administrative, state, civil, economic, labor and criminal law."[47] Thus, Kolbasov would combine legal regimes dealing with the use of land, minerals, forests and water with those dealing with the protection of wildlife and environmental media like air and water, but not if they are covered by the various other legal orders he lists.

As used in this thesis, ecological law comprises and transcends both of Howarth's concepts and it goes well beyond Kolbasov's constrained attempt to harness together fragmented legal regimes related to the human-Earth relationship. It is more akin to the ecologically imbued notion of law that Thomas Berry evoked in *The Great Work*:

> To achieve a viable human-Earth situation a new jurisprudence must envisage its primary task as that of articulating the conditions for the integral functioning of the Earth process, with special reference to a mutually enhancing human-Earth relationship. Within this context the various components of the Earth—the land, the water, the air, and the complex of life systems—would each be a commons. Together they would constitute the integral expression of the Great Commons of the planet Earth to be shared in proportion to need among all members of the Earth community.[48]

In this view of the law, a sustainable human-Earth relationship requires that "inherent rights of the natural world [be] recognized as having legal status [and t]he entire question of possession and use of the Earth, either by individuals or by establishments, needs to be considered in a more profound manner than Western society has ever done previously."[49] For Berry, "[e]cology is not a part of law; law is an extension of ecology."[50]

The best encapsulations of Berry's conception of law as an ecologically grounded guide for a mutually enhancing human-Earth relationship are in Klaus Bosselmann's

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[44] William Howarth, "The Progression Towards Ecological Quality Standards" (2006) 18 J. Envtl. L. 3 at 3-4.
[45] O.S. Kolbasov, "The Concept of Ecological Law" (1989) 4 Conn. J. of Int'l. Law 267 at note 3.
[46] *Ibid.* at 267-70.
[47] *Ibid.* at 277.
[48] Berry, *supra* note 40 at 61.
[49] *Ibid*.
[50] *Ibid.* at 84.

"principle of sustainability"[51] and David Boyd's similar notion of "sustainability law."[52] Boyd characterizes sustainability law as "an attempt to imagine a system of laws and policies that facilitate processes, products, and patterns of behaviour which are good for the planet."[53]

> Sustainability law would not be about merely *mitigating* the damage inflicted by industrial economies and western lifestyles. Sustainability law would focus on *transforming* the relationship between humans and the natural environment from one based on minimizing harm to one based on maximizing harmony. Instead of asking if we can limit the ecological damage caused by contemporary industrial society, sustainability law asks if we can do things in a completely different way that avoids creating environmental problems in the first place. Sustainability law will challenge the belief that human activities must inevitably damage the natural world.[54]

Sustainability law "would be firmly rooted in science and the laws of nature, beginning with a clear understanding of the laws of thermodynamics and explicit recognition of the biophysical limits of the planet Earth."[55] Unlike Kolbasov's notion of ecological law, sustainability law as Boyd envisions it would be embedded within and throughout the legal, social and economic infrastructure, not a specialty area of the law.[56]

Bosselmann take an approach similar to Boyd's, rejecting "weak sustainability" that merely integrates economic growth with social prosperity and environmental protection and insisting that the core of sustainability is about respecting and maintaining the Earth's ecological integrity.[57] His central thesis is that with this grounding in ecological integrity, "sustainability has the historical, conceptual and ethical quality typical for a fundamental principle of law."[58] The principle of sustainability to

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[51] Klaus Bosselmann, *The Principle of Sustainability: Transforming Law and Governance* (Burlington, VT: Ashgate Publishing Co., 2008).
[52] David R. Boyd, "Sustainability Law: (R)Evolutionary Directions for the Future of Environmental Law" (2004) 14 J. of Envtl. L. and Practice 357.
[53] *Ibid.* at 365.
[54] *Ibid.* at 364-365.
[55] *Ibid.* at 367.
[56] *Ibid.* at 364.
[57] Bosselmann, *supra* note 51 at 1-2, 53. See also Laura Westra, "Ecological Integrity: Its History, Its Future and the Development of the Global Ecological Integrity Group" in Laura Westra, Klaus Bosselmann & Richard Westra, eds., *Reconciling Human Existence with Ecological Integrity* (Sterling, VA: Earthscan, 2008) 5 at 16-18 (calling for a central focus on ecological integrity in international and supranational law).
[58] *Ibid.* at 4.

Bosselmann is as broad and fundamental as foundational principles like equality, justice and freedom,[59] establishing a paramount "duty to protect and restore the integrity of the Earth's ecological systems."[60] In his view, the Earth Charter, with its emphasis on the interdependence of all life forms, the value of all living things regardless of their value to humans, and the dignity and potential of human beings, is the most profound expression of the broad and foundational legal principle of sustainability.[61]

The rule of ecological law as used here and sustainability law and the principle of sustainability as Boyd and Bosselmann conceive them have much in common. However, the term "ecological law" makes clear that global ecological limits have primacy over the economic and social spheres that are usually associated, along with environmental concerns, with "sustainability"—often in a confusing way.[62] Both Boyd and Bosselmann recognize this essential primacy of ecological integrity.

An additional clarification of "ecological law" warrants emphasis. Although ecological law is firmly grounded in the science of how the Earth works and of complex systemic thresholds in the global ecosystem,[63] science alone cannot determine its elements. The laws of thermodynamics and the science of ecology, both central to the scientific understandings on which ecological economics and ecological law are built, cannot simply be plugged in to make the human-Earth relationship right. Both a thriving tropical forest and a lifeless toxic waste dump have their own ecology, and both obey the laws of thermodynamics. The same holds true for an Earth with or without human survival. Scientific laws and principles apply to whatever circumstances the Earth and its inhabitants and the cosmos offer up. But, ecological law is not indifferent to those circumstances, or to the human place in them. Beyond science, ecological law derives

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[59] *Ibid.* at 5, 57.
[60] *Ibid.* at 53.
[61] *Ibid.* at 57, 73-75.
[62] See e.g. Ben Boer, "Sustainability Law for the New Millenium and the Role of Environmental Legal Education" (2000) 123 Water, Air, and Soil Pollution 447 (using the term "sustainability law" without a clear definition, and with reference both to notions of sustainable development based merely on integration of economic, social and environmental concerns and the stronger notion contained in the Earth Charter); see also Pelletier, *supra* note 33 at 224.
[63] See Brown and Garver, *Right Relationship, supra* note 6 at 37-62; *Daly*, supra note 38 at 29-30. Rockström *et al*., *supra* note 4 *passim*.

from a fundamental normative choice to manage the human enterprise so as to offer up circumstances to which ecology, thermodynamics and the other sciences will apply in ways that preserve ecological integrity and keep the human-Earth relationship flourishing. The planetary boundaries and other ecological indicators help describe those circumstances, and they provide a basis for the normative decision inherent in ecological law.

What of the "rule of law"? The rule of law as used in this thesis conveys the dual notions that, on one hand, legal institutions and norms from the global to the local level should provide a coherent, reliable, fair and just framework for managing human affairs and, on the other, that the scientific laws that govern how the Earth works necessarily constrain the legal architecture for ecological law. The United Nations Security Council captures the essence of the first of these notions in its description of the rule of law as

> a principle of governance in which all persons, institutions and entities, public and private, including the State itself, are accountable to laws that are publicly promulgated, equally enforced and independently adjudicated, and which are consistent with international human rights norms and standards. It requires, as well, measures to ensure adherence to the principles of supremacy of law, equality before the law, accountability to the law, fairness in the application of the law, separation of powers, participation in decision-making, legal certainty, avoidance of arbitrariness and procedural and legal transparency.[64]

However, the rule of law as used in this thesis is open to a pluralistic notion of law, so as to include normative regimes that transcend traditional notions of law but are still successful in conforming behavior to desired objectives while also promoting peace, equality and justice.[65] As Bosselmann notes, ecological law (or the principle of sustainability) still lacks the broad, normative impact of such a widely accepted guiding legal principle, even if it has increasingly influenced the legal sphere.[66]

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[64] United Nations, Security Council, *The Rule of Law and Transitional Justice in Conflict and Post-conflict Societies: Report of the Secretary General* (2004) Document No. S/2004/616 at ¶ 6. This definition draws on A.V. Dicey's seminal conception of the rule of law in the Anglo-American legal tradition as grounded in the supremacy of law, built on the absence of arbitrary governmental power, a central role for the judiciary to oversee the administration of the law and equality of all people before the law. See Margaret Jane Radin, "Reconsidering the Rule of Law" (1989) 69 Boston U. L. Rev. 781 at note 2 and accompanying text.

[65] See Bosselmann, *supra* note 51 at 5, 75 (supporting the Earth Charter's promotion of a sustainable, peaceful and just global society).

[66] *Ibid.* at 53-54, 58, 62-67.

The second aspect of the "rule of law" is inherent in emphasizing the rule of *ecological* law, which clarifies that the norms and laws of concern are founded not only in legal principles but also in planetary boundaries and other expressions of the uncompromising ecological limits on the life support capacity of the Earth. In this vein, the authors of *Right Relationship: Building a Whole Earth Economy* [*Right Relationship*], assert that "the 'rule of law' means that global regulatory limits required to meet ecological limits and ensure fair sharing of the earth's bounty must be respected."[67]

B. Planetary Boundaries and Complementary Concepts Can Serve as a Scientific Foundation for the Rule of Ecological Law

In September 2009, an international team of researchers led by Johan Rockström of the Stockholm Resilience Centre proposed a novel biophysical framework that they suggested might serve as the basis for "novel and adaptive governance approaches at global, regional and local scales."[68] This framework is built around the concept of "planetary boundaries" of the "safe operating space" for humanity. The boundaries are systemic global ecological limits beyond which humans face an unacceptable[69] "risk of deleterious or even catastrophic environmental change at continental to global scales."[70] Rockström and his colleagues proposed nine planetary boundaries based on climate change, ocean acidification, stratospheric ozone depletion, atmospheric aerosol loading, land use, freshwater use, chemical pollution, biodiversity loss and nutrient (i.e. nitrogen and phosphorous) cycles, and they provided preliminary estimates for all of these except chemical pollution and atmospheric aerosol loading.[71] The boundaries they propose are:

- For climate change, limiting carbon dioxide in the atmosphere to 350 ppm and net radiative forcing to +1 watt per meter squared (zone of uncertainty: 350-550 ppm and +1 to +1.5 watt per meter squared);
- For ocean acidification, maintaining at least 80% of the pre-industrial level of aragonite in the surface waters of the oceans (zone of uncertainty: 70 to 80%);

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[67] Brown and Garver, *Right Relationship, supra* note 6 at 135.
[68] Rockström *et al.*, *supra* note 4 at 28.
[69] Rockström *et al.*, *supra* note 4 at 2. The authors acknowledge that the limits reflect a normative notion of acceptable risk, which is captured in their use of the term "safe" to describe the conditions the boundaries would maintain.
[70] *Ibid*.
[71] *Ibid*. at 6; see also Jean-Claude Fritz, "Genèse et prospective des préoccupations écologiques" in Marguerite Boutelet and Jean-Claude Fritz, eds. *L'ordre public écologique/Towards an Ecological Public Order* (Bruxelles: Bruylant, 2005) 3 at 13.

- For depletion of stratospheric ozone, limiting the loss to no more than 5% of pre-industrial levels (zone of uncertainty: 5 to 10%);
- For interference with nitrogen and phosphorus cycles, limiting the flow of phosphorus to the oceans to no more than 10 times greater than the flow due to phosphorus from natural weathering (zone of uncertainty: 10 to 100 times greater), and limiting the amount of nitrogen removed from the atmosphere by human means to no more than 35 megatonnes of nitrogen per year (25% of the amount naturally fixed by terrestrial ecosystems) (zone of uncertainty: 25 to 35%);
- For global freshwater use, limiting freshwater withdrawals to no more than 4,000 cubic kilometers per year (zone of uncertainty: 4,000 to 6,000 cubic km per yr);
- For land use change, limiting the percentage of the global ice-free land surface converted to cropland to 15% (zone of uncertainty: 15 to 20%);
- For biodiversity, limiting the rate of extinction of species to no more than 10 extinctions per million species per year (zone of uncertainty: 10 to 100 extinctions).[72]

The concept of planetary boundaries contains a powerful message with respect to governance. As conceived, the planetary boundaries are "non-negotiable."[73] The Rockström team emphasizes that "[t]he thresholds in key Earth System processes exist irrespective of peoples' preferences, values or compromises based on political and socioeconomic feasibility, such as expectations of technological breakthroughs and fluctuations in economic growth."[74] Thus, arguing that it is not economically or politically feasible to establish a legal and policy regime that strictly respects the planetary boundaries is tantamount to arguing that ensuring the prospect for humanity's long-term safe operation is not economically or politically feasible—in other words, that ensuring economic and political feasibility is not economically and politically feasible. Instead, the relevant inquiry involves establishing the planetary boundaries and how to adjust economic and political policy so as to respect them.

The rule of ecological law derives directly from the recognition that the long-term viability of the human enterprise depends on strict observance of planetary boundaries, keeping in mind that the ones Rockström and his fellow researchers propose are open to revision, refinement and complementary measures. However, the strictness with which these limits must be respected has some unavoidable, and welcome, flexibility. First, as Rockström and his colleagues explain, the boundaries include a notion of how "safe" the

[72] Based on Rockström *et al.*, *ibid.* at 8-9.
[73] *Ibid.* at 4.
[74] *Ibid*. at 7.

operating space for humanity should be, which requires "normative judgments of how societies deal with risk and uncertainty."[75] Working through the relevant questions of risk and uncertainty, particularly in a governance context, is complex and will affect how the rule of ecological law is formulated and implemented. Second, although the planetary boundaries imply limits on the aggregate scale of human economic activity, the "operating space" that they envelope allows "humanity . . . the flexibility to choose a myriad of pathways for human well-being and development."[76] Third, the planetary boundaries are interrelated and dynamic, which means that they change over time. Moreover, the processes underlying the boundaries have momentum and will not respond to policy interventions instantaneously, or sometimes even at all within normal policy planning horizons, such that efforts to mitigate human influences on them must be combined with efforts to adapt the human enterprise to changes in them.[77] This explains in part the Rockström group's suggestion that governance based on the boundaries must be adaptive.[78]

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[75] *Ibid.* at 5. See also Mariachiara Tallacchini, "Before and Beyond the Precautionary Principle: Epistemology of Uncertainty in Science and Law" (2005) 207 Toxicology and Applied Pharmacology S645, S646 ("[P]olicy-related science must help to define the problems which, as they have to find a social application, are linked to broad judgments that eventually demand a political choice even where they appear to be purely scientific or technical problems").

[76] Rockström *et al.*, *ibid.* at 7. See also Wendell Berry, "Faustian Economics: Hell Hath No Limits" (May 2008) Harper's Magazine 35, online: <http://www.harpers.org/archive/2008/05/page/0037> at 40-41 ("If the idea of appropriate limitation seems unacceptable to us, that may be because, like Marlowe's Faust and Milton's Satan, we confuse limits with confinement. . . . A small place, as I know from my own experience, can provide opportunities of work and learning, and a fund of beauty, solace and pleasure—in addition to its difficulties—that cannot be exhausted in a lifetime or a generation.")

[77] See Ruhl, *supra* note 22 at 365 (contending that whatever limitation on greenhouse gases the United States might adopt, "[h]umans and our fellow species are looking into a future of climate change that will last a century or more, and we've done very little in the United States to prepare ourselves for it."); Lenton, *supra* note 13 (describing the extent to which actions already taken have "committed to" the Earth to climate change).

[78] There are two general categories of adaptiveness. One is the need for continual updating of boundaries and the governance mechanisms underlying them. The other is the need to be adaptive in response to far-reaching systemic changes that may occur even if boundaries are respected. For example, climate change that will occur even below a boundary of 350 ppm of carbon dioxide in the atmosphere will require adaptation that will significantly challenge entire regulatory or conservation regimes. For example, climate change may so alter the ecology of protected areas that the purposes for which they were established may need to be changed, or new protected areas to protected the ecosystem values for which they were established may need to be created. In other words, the whole notion of "preserving" an ecosystem may be obsolete in some cases. See Ruhl, *ibid.* at 394-95 ("The transition [from managing for preservation to managing

The flexibility as to possible pathways for the human enterprise can be illustrated with the so-called IPAT formula developed by Paul Ehrlich and John Holdren in the 1970s.[79] By this formula, I = f(PAT), aggregate environmental impact (I) is a function of the size of the human population (P), per capita human affluence (or, more accurately, consumption, which tends to correlate closely with affluence[80]) (A), and technology (often expressed as the environmental impact per unit of affluence or consumption[81]) (T). Each of the planetary boundaries, or related concepts like an upper limit on the global ecological footprint,[82] can be considered as a fixed value of the I variable, which in turn constrains the P, A and T variables. Thus, if P rises, A or T must fall, but the system is flexible because the combinations of P, A and T for a fixed value of I are infinite. Moreover, all of those variables are distributed in complex but interrelated ways from the global the local level. Thus, for each combination of P, A and T, additional flexibility exists in regard to the global distribution of rights, responsibilities and opportunities that exist within the human enterprise and the broader community of life with which humans share the planet. In *Right Relationship,* an additional factor, ethics (E), was included—I = f(PATE)—to reflect explicitly the ethical choices involved in combining the other factors.[83]

Although normative ecological limits like planetary boundaries are both uncompromising and flexible, they are obviously not the exclusive source of criteria for governance at any level. Indeed, at least one critique of the planetary boundaries concept warns that overreliance on thresholds in general can support justification of behavior right

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for change], to put it bluntly, is from the nature we once knew to the nature that we expect to find around us on the other side of climate change.")

[79] Paul R. Ehrlich and John P. Holdren, "Critique of *The Closing Circle*" (May 1972) Bulletin of the Atomic Scientists 16.

[80] See Speth, *supra* note 4 (graphs preceding the introduction); Fridolin Krausmann *et al*., "Resource flows and land use in Austria 1950–2000: using the MEFA framework to monitor society–nature interaction for sustainability" (2004) 21 Land Use Pol'y 215.

[81] See e.g. Jeffrey D. Sachs, *Common Wealth: Economics for a Small Planet* (New York: The Penguin Press, 2008) at 29-30.

[82] Ecological footprint is a measure of human use of the Earth's life support capacity, expressed in terms of normalized "global hectares" of productive land. It was developed in the 1990s by William Rees and Mathis Wackernagel. See Brad Ewing *et al*., *The Ecological Footprint Atlas 2010* (Oakland, CA: Global Footprint Network, 2010)[*The Ecological Footprint Atlas 2010*] at 9; Meadows *et al*., *supra* note 19 at 3.

[83] Brown and Garver, *Right Relationship, supra* note 6 at 76-84.

up to the threshold—the edge of the cliff—when other criteria might provide reasons for staying well back.[84] One source of additional constraint might be regional or local ecosystem impacts that are more important than the contribution of a local or regional impact to an aggregate limit at the global level. More broadly, social, political or cultural concerns grounded in ethics and justice that transcend the notions of safety and survival inherent in the Rockström group's proposals may provide grounds for additional restraint.

For example, in *Right Relationship,*[85] the notion of right relationship is proposed as the central concept for global governance. Right relationship derives from Aldo Leopold's land ethic,[86] updated as follows: "A thing is right when it tends to preserve the integrity, resilience and beauty of the commonwealth of life."[87] It serves as a "guidance system for functioning in harmony with scientific reality and enduring ethical traditions."[88] Right relationship reflects the scientific reality that the Earth is essentially closed to material inputs but open to energy from the sun, characteristics that define limits on the Earth's life support capacity. But right relationship also has ethical foundations, in that it "include[s] the fair sharing of the earth's life support capacities with all of life's commonwealth."[89] Right relationship may transcend the notion of planetary boundaries because it is framed not only around the outer bounds of the global environmental stresses that pose threats to well being of humans and other forms of life, but also seeks a positive, flourishing human-Earth relationship.[90] The situation that would exist if all of the parameters on which the planetary boundaries are based were at their safe limit is not necessarily one in which the integrity, resilience and beauty of the commonwealth of life is preserved and enhanced. Thus, by adding ethical criteria that are not necessarily reflected in the scientific derivation of planetary boundaries, right relationship may provide a basis for developing forms of governance, and a deeper notion of ecological law, that go beyond the concept of safe operating space for humanity.

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[84] William H. Schlesinger, "Planetary boundaries: Thresholds risk prolonged degradation" (2009) *Nature Reports Climate Change. Nature Reports Climate Change*, online: <http://www.nature.com/climate/2009/0910/full/climate.2009.93.html> at 112.
[85] Brown and Garver, *Right Relationship, supra* note 6.
[86] Aldo Leopold, *A Sand County Almanac* (New York: Oxford University Press, 1949) at 224-25.
[87] Brown and Garver, *Right Relationship, supra* note 6 at 5.
[88] *Ibid.* at 4.
[89] *Ibid.* at 17.
[90] Cf. Berry, *supra* note 40 at 61 (calling for a mutually enhancing human-Earth relationship).

Part II. Existing Legal Mechanisms Based on Systemic Limits Are Ineffective

General aspirational statements and non-binding commitments to respect ecological limits of one kind or another are not difficult to find in international and domestic arenas.[91] For example, Principle 3 of the *Rio Declaration on Environment and Development* states that "[t]he right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations."[92] Similarly, in the *National Environmental Policy Act of 1969* [*NEPA*], the United States Congress stated the official environmental policy of the United States as follows:

> The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further *the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man*, declares that it is the continuing policy of the Federal Government . . . to use all practicable means and measures . . . in a manner calculated to foster and promote the general welfare, *to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of American*s.[93]

A growing number of countries enshrine in their Constitutions the right to a healthy or clean environment, which may imply the need to respect ecological limits.[94] The Constitution of Ecuador goes so far as to accord nature, or Pacha Mama, the right to have its existence and the maintenance and regeneration of its vital cycles, function, structure

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[91] See Boutelet and Fritz, *supra* note 71, at xi ("Les conditions nécessaires à l'affirmation d'un ordre écologique existent, révélées par la multiplication des situations de crise et par les progrès de la science. Les divers préambules des conventions internationales et des lois nationales le traduisent aussi en termes non équivoques depuis trente ans."); Fritz, *supra* note 71 at 21 (citing the Convention on the Conservation of Migratory Species, the Bern Convention on the Conservation of Wildlife and Natural Habitat of Europe, the Ramsar Convention, the Convention on International Trade in Endangered Species and New Zealand's Environment Act).

[92] UNEP, Rio Declaration on Environment and Development (1992).

[93] *National Environmental Policy Act,* 42 U.S.C. §§ 4321 *et seq*. (2006) (emphasis added).

[94] See Barry Hill, Steve Wolfson and Nicholas Targ, "Human Rights and the Environment: A Synopsis and Some Predictions" (2003) 16 Georgetown Int'l Envtl. L. Rev. 359 at 381-89 (noting that over ninety countries have constitutional provisions relating to the environment, more than 50 of which establish a state duty to protect the environment or a right to a healthy environment; and providing details of the examples of the constitutions of India, the Philippines, Colombia and Chile). Cf. Kirsten H. Engel, "State Environmental Standard-Setting: Is There a "Race" and Is It "To the Bottom"?" (1997) 48 Hastings Law Journal 271 at 289 (contending that "[i]n many ways, [the U.S.] Congress has treated minimum health and environmental protection as a fundamental human right").

and evolution respected integrally, and to be restored.[95]

In addition to these broad and quite general commitments are several specific international legal mechanisms or domestic statutory or regulatory provisions that are implicitly or explicitly founded on system-based limits to the introduction of pollutants or on economic activity.[96] At the international level, the *Montreal Protocol on Substances that Deplete the Ozone Layer* [*Montreal Protocol*][97] addresses the emission of substances that deplete stratospheric ozone, and the *United Nations Framework Convention on Climate Change*[98] and its *Kyoto Protocol*[99] contains various obligations designed to address global climate change. At the national or regional level, the *Clean Water Act*[100] and the *Clean Air Act*[101] in the United States contain provisions intended to prevent broad systemic pollutant overloads, as does the critical loads concept employed in the European Union's air pollution regulation[102] and the *Convention on Long-range Transboundary Air Pollution* [*LRTAP*].[103] Although some of these provisions have had moderate success—in particular, the *Montreal Protocol*—they hardly amount to a comprehensive and coherent approach to implementing binding and effective system-based limits.

This Part begins with a general discussion of the distinction between contemporary environmental law and the rule of ecological law, which exposes the roots of the relative ineffectiveness of most systems-based mechanisms of contemporary environmental law. It then reviews the record of performance of some examples of systems-based regulation in an effort to reveal the conditions that must be met in order to

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[95] *Constitution of the Republic of Ecuador* (2008) arts. 71 and 72.
[96] One set of analysts indicate that "[h]undreds of tradable emission permit schemes have been introduced over the past 30 years, beginning with an offset mechanism under the US Clean Air Act in 1977." Ernst von Weizsäcker *et al*. *Factor Five: Transforming the Global Economy through 80% Improvements in Resource Productivity* (London: Earthscan, 2009) [*Factor Five*] at 286.
[97] 16 September 1987, 1522 U.N.T.S. 3, (entered into force 1 January 1989).
[98] 9 May 1992, 1771 U.N.T.S. 107 (entered into force 21 March 1994).
[99] *Kyoto Protocol to the United Nations Framework Convention on Climate Change*, 11 December 1997, 2303 U.N.T.S. 148 (entered into force 16 February 2005).
[100] 33 U.S.C. §§ 1251 *et seq*. (2006).
[101] 42 U.S.C. §§ 7401 *et seq*. (2006).
[102] EU, *Directive of the European Parliament and of the Council 2001/81/EC of 23 October 2001on national emission ceilings for certain atmospheric pollutants* [2001] O.J. L 309/22. See also Rockström *et al*., *supra* note 4, Supplemental Information at 6.
[103] 13 November 1979, 1302 U.N.T.S. 217 (entered into force 16 March 1983).

have a comprehensive approach to the rule of ecological law aimed at preserving and enhancing the global ecosystem on which the human economy depends. To highlight the possibilities for ecological law to support the enhancement of the human-Earth relationship, it closes by imagining strict compliance with systems-based environmental protections.

A. The Rule of Ecological Law Responds to Overarching Flaws in Contemporary Environmental Law

Environmental economics attempts to correct environmental market failures by internalizing environmental costs into the prices of goods and services, for example by using the "polluter pays" principle.[104] However, it has been criticized as operating too much within a neo-classical economic paradigm that is incapable of respecting aggregate ecological boundaries in a systemic manner.[105] The emerging but still largely tractionless[106] field of ecological economics attempts to respond to this deficiency by positing the functioning of the global ecosystem as the overarching constraint on the human economy.[107] In law, an analogous deficiency is apparent.[108] The envelope of contemporary environmental law is turning out to be deficient as a means to enclose the

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[104] See Brown and Garver, *Right Relationship, supra* note 6 at 13.

[105] Herman Daly and Josh Farley define "environmental economics" as "[t]he branch of neoclassical economics that addresses environmental problems such as pollution, negative externalities, and valuation of nonmarket environmental services[,] focuses almost exclusively on efficient allocation, and accepts the pre-analytic vision . . . that the economic system is the whole, and not a subsystem of the containing and sustaining global ecosystem." Herman E. Daly and Joshua Farley, *Ecological Economics: Principles and Applications* (Washington: Island Press, 2004) at 432. By contrast, they define "ecological economics" as "[t]he union of economics and ecology, with the economy conceived as a subsystem of the earth ecosystem that is sustained by a metabolic flow or 'throughput' from and back to the larger system." *Ibid*. at 431. See also Rees, *supra* note 38 at 251, 259-61. Cf. Peter A Victor, *Managing Without Growth: Smaller By Design, Not Disaster* (Cheltenham UK: Edgar Elgar, 2008) at 27-32 (contrasting conventional understandings of the economy with the view of the economy as "an 'open system' with biophysical dimensions").

[106] See Lisa Heinzerling and Frank Ackerman, "Law and Economics for a Warming World" 1 Harvard Law & Policy Review 332 at 348 ("[Ecological economics] has yet to develop a comprehensive new synthesis—and it has not had any significant influence on economic theory in general.")

[107] See Daly and Farley, *supra* note 105 at 4-5, 431.

[108] See Boutelet and Fritz, *supra* note 71 at x ("[I]l paraît essentiel d'intégrer pleinement la dimension écologique à la notion d'ordre public[, ce qui] est même d'autant plus urgent que cette dimension a été ignorée et n'a pas fait l'objet de référence directe et explicite jusqu'à une période récente et qu'elle reste relativement négligée ou sous évaluée dans le droit actuel").

human economy within systemic ecological constraints.[109] Just as ecological economics emerged to address inherent limitations of environmental economics, a new notion of ecological law is needed to transcend limitations of contemporary environmental law.

Ecological law responds to two key flaws of contemporary environmental law. The first flaw is the reductionist, as opposed to holistic, tendency in environmental law to focus on environmental problems as discrete and isolated.[110] The reductionist approach in environmental law obscures consideration of the aggregate impacts of human activity on the global ecosphere and impedes the full integration of a systemic ecological approach into the entire legal infrastructure. The second is the tendency in environmental law toward monetization as a way to normalize social preferences and to regulate the relationship between environmental problems and the development pressures that create them, for example by assessing the costs and benefits of environmental regulation primarily in terms of monetized valuations.[111] The tendency to incorporate the language of money into the law is rooted ultimately in the conception of humans as apart from nature, and as rational actors free to accommodate and own elements of nature in the quest to maximize personal wealth and well being.[112]

The holistic approach has not been entirely absent from contemporary environmental law, as the opening section of *NEPA* attests.[113] As the environmental awakening in the United States emerged in the 1960s and 1970s, holistic ecological thinkers helped bring an ecological perspective into the law.[114] For example, Kenneth

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[109] Robert V. Percival, "Environmental Law in the Twenty-first Century" (2007) 25 Va. Envtl. L.J. 1 at 8.
[110] See David Boyd, *supra* note 52 at 366. See also Nadeau, *supra* note 38 at 47 (discussing neo-classical economics' roots in the notion in Newtonian physics that the fundamental units in science are discrete parts, such as atoms, and not systems).
[111] Cf. Lisa Heinzerling, "Risking It All" (2005) 57:1 Ala. L. Rev. 155 at 164-69 (discussing the related problems associated with cost-benefit analysis of environmental regulations).
[112] For a rich discussion of the history of the utilitarian tendency in economics and the environmental law it has heavily influenced, traced back to metaphysical and deist theories underlying the "natural law" of economics that informed Adam Smith's "Invisible Hand," see Nadeau, *supra* note 38 at 81-123.
[113] See page 26 above.
[114] See generally Richard Delgado, "Our Better Natures: A Revisionist View of Joseph Sax's Public Trust Theory of Environmental Protection, and Some Dark Thoughts on the Possibility of Law Reform" (1991) 44 Vanderbilt L. Rev. 1209; A. Dan Tarlock, "The Future of Environmental

Boulding offered the powerful notion of the Earth as a spaceship, which captured well the finiteness of the Earth and its life systems;[115] Aldo Leopold's land ethic was revived; and Joseph Sax's public trust theory of environmental protection had wide influence on environmental policy.[116] However, from the beginning, the "deep ecology,"[117] public trust or Leopoldian elements of environmentalism had a low probability of hardening into substance; as Dan Tarlock put it, they represent "such a radical break from the western philosophical and legal tradition that stewardship does not reflect our actual behavior."[118] The enthusiastic environmentalism of the environmental awakening gave way to the economically driven ideology of the 1980s, and the economic gloss over environmental law has only hardened since.[119]

The human experience historically, and in particular in the developed world in the past few centuries, drives many people to claim that a capitalist, growth-driven development pattern, fueled by the Earth's bounty, works just fine, with environmental challenges only at the margins.[120] Things always work out. But, "the argument that 'nothing has changed, man has always lived off nature by using and transforming it' is fallacious"[121] because the aggregate scale and the nature of human-Earth interactions have brought the human enterprise to, and perhaps past, crucial tipping points.[122] The alternative argument that technological solutions will come to the rescue, as in the past,[123]

'Rule of Law' Litigation" (2000) 17 Pace Envtl. L. Rev. 237 at 238-41.

[115] See Delgado, *ibid*. at *1219*; Brown and Garver, *Right Relationship, supra* note 6 at 16-17.

[116] See generally Delgado, *ibid*.

[117] See generally Arne Naess, "A Defence of the Deep Ecology Movement" (1984) 6 Envtl. Ethics 265.

[118] Tarlock, *supra* note 114 at 240.

[119] See generally Heinzerling, *supra* note 111. Cf. Westra, *supra* note 57 at 12 (noting that "the strong green sentiments expressed in the preambles or mission statements of [environment protection acts] are quickly lost, in the interest of economics, 'business as usual' and the status quo . . .").

[120] See, e.g., Michael Hardt and Antonio Negri, *Empire* (Cambridge, MA: Harvard University Press, 2000) at 269-271 (noting that predictions in the early twentieth century that the capitalist system had "reached the threshold of a fatal disaster" by overaccumulating at the expense of the non-capitalist environment were either mistaken or premature).

[121] Fritz, *supra* note 71 at 6.

[122] See *ibid*.; Rockström *et al.*, *supra* note 4.

[123] See Sachs, *supra* note 81 at 30.

likewise becomes more and more dangerous with the rising risk and imminence of catastrophe.[124]

The assumption that all relevant factors in the economy can be monetized and then subject to economic forces have even crept into ecological economics, along with other fundamentals of a neoclassical economic perspective. In 1997, Robert Costanza, a prominent ecological economist, led a group of researchers who estimated the total value of the world's ecosystem services and natural capital at $33 trillion, compared to a world gross national product of $18 trillion.[125] A more recent example is the estimate, reported in the *Synthesis Report of The Economy of Ecosystems and Biodiversity* [*TEEB Report*],[126] that the value of pollination by bees and other insects globally is 153 billion euros.[127] This figure is perhaps intended to express in the most ideal, universal form, the importance of bees. However, it implies that if bees disappeared as a result of human activities, for 153 billion euros we could purchase a substitute for them.

William Nordhaus does something similar with his Dynamic Integrated model of Climate and the Economy [DICE], which he uses to "weigh[] the costs of slowing climate change against the damages of more rapid climate change"[128] with all the costs and benefits expressed in dollars.[129] He concludes that with annual average global economic growth of approximately two percent between 2000 and 2100,[130] and discounting future value at four percent annually,[131] the human community should invest two trillion dollars over the next century to eliminate five trillion dollars of climate damages, leaving seventeen trillion dollars of climate damages unabated because we would be better off

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[124] See Fritz, *supra* note 71 at 16 (warning against reliance on "miracles of technological progress").
[125] Robert Costanza *et al*., "The value of the world's ecosystem services and natural capital" (1997) 387 Nature 253.
[126] Pavan Sukhdev *et al., The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB* (TEEB, 2010)[*TEEB Report*].
[127] *Ibid*. at 8.
[128] William Nordhaus, *supra* note 26 at 5.
[129] *Ibid.* at 4.
[130] The economic growth rate is estimated by using Nordhaus's estimated average growth in per capita consumption of 1.3 percent, along with his projected growth in population from about six billion to 8.5 billion over the next century. *Ibid.* at 41, 108.
[131] *Ibid.* at 10.

investing in other things that will have a higher net benefit.[132] Nordhaus assumes that the value of the vast ecosystemic impacts of climate change can be monetized and compared readily to the values of goods and services in the economy, and that we will be able to buy our way out of whatever problems are related to an average temperature on Earth 2.6 degrees Celsius higher than in pre-industrial times.[133]

Monetary valuation of ecosystems and their services to humans, or of anything really, carries with it the assumption that having assigned a dollar value, we have discerned a thing's true value. Yet, in doing so, we subject that thing to the impossible assumptions of perfect information and idealized rationality in the market and to the increasing abstractness of money and wealth, and we strip it of its ecological—and, ultimately, spiritual—essence as a process or an element that triggers and responds to reactions in a complex, evolving web of ecological relationships.

Tortured comparisons of value as in the *TEEB Report* and Nordhaus's work using the DICE model support a legal infrastructure that includes contemporary environmental law. Under the notion of ecological law that is proposed here, the value of pollination by bees would be assessed on the basis of such factors as the right of bees to their share of the Earth's ecological capacity, along with their role in the functioning of ecosystems, including in some cases their functioning so as to provide food to people and other creatures. The legal infrastructure would support a focus on understanding the role of bees in maintaining ecosystem functioning and on limiting the impacts of the human economy on bees and their role in ecosystem functioning to the minimum level that allows both bees and humans to flourish. But human flourishing in this conception does not imply unlimited consumption and affluence; rather, it is flourishing within a space for humans collectively that is bounded by ecological limits and that allows flourishing of as much other life as possible. Attaching a dollar value to pollination by bees scarcely advances this framework—and, it is insulting to bees.

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[132] *Ibid.* at 15.
[133] *Ibid.* at 14. Nordhaus's assumptions have received harsh criticism. See e.g. John D. Sterman, "All models are wrong: reflections on becoming a systems scientist" (2002) 18:4 System Dynamics Review 501 at 519.

In the United States, the trend appears to be toward more, not less, subjugation of the Earth's ecological basis to neo-classical economic frameworks. Arguments based on economic efficiency that question the appropriateness or extent of environmental regulation have increased since the suite of federal environmental laws were adopted in the 1970s. In the past twenty years, some American legal scholars have asserted that federal environmental laws may impede states from achieving optimal outcomes in terms of overall social welfare, for example by forcing uniform federal standards that prevent economic activity that a particular state might find socially preferable.[134] However, this retrograde analysis reduces notions of justice and fairness to monetized conceptions of social welfare and ignores "Congress's intent . . . to preserve conceptions of fairness or justice that would be harmed if a state were allowed to fully use advantages conferred upon it by accidents of nature to obtain a competitive edge over other states."[135] The rule of ecological law would trend against this call for making environmental values even more subservient than they already are to social and economic preferences.

In short, ecological law would cordon off the sphere of market exchanges based on abstract monetary units to a considerably greater extent than occurs under contemporary notions of environmental law. In this sense, ecological law bears some similarity to the proposal that the notion of emergy, which is "based on the principle that the energy embodied in a resource or service determines its value,"[136] should be incorporated into environmental law. Relating the value of goods and services to their relationship to the flows of energy within systemic, sun-driven life processes—whether the energy is fossil energy that the sun produced long ago or contemporary energy that photosynthesis makes available in the short term in biomass—could establish a firmer basis for using a common economic notion of value in connection with legal norms.[137] Ecological law flows from the notion of enclosing the spark of economic competition and

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[134] See e.g. Richard L. Revesz, "The Race to the Bottom and Federal Environmental Regulation: A Response to Critics" (1997) 82 Minn. L. Rev. 535 at 536.
[135] Engel, *supra* note 94 at 295.
[136] Mary Jane Angelo and Mark T. Brown, "Incorporating Emergy Synthesis Into Environmental Law" (2007) 37 Envtl. L. 963 at 963.
[137] See Brown and Garver, *Right Relationship, supra* note 6 at 57 ("In a whole earth economy, the primary income is actually sunlight. Spending that sunlight wealth is a matter of using up life and other matter and energy.")

market exchange within an engine of cooperation that runs according to the systemic dynamics of the global ecosystem.[138] More deeply, it draws from a conception of the human-Earth relationship "based on a feeling of awe for the cosmos and embracing an ethic of humankind's appropriate place in, and relationship to, the cosmos and the earth."[139]

B. Relatively Weak System-based Mechanisms: U.S. Programs for Implementing Total Maximum Daily Loads, Greenhouse Gas Emissions Limits and Trading of Emissions of Sulfur Dioxide and Europe's Critical Loads and Levels Approach

Three areas of United States environmental law and one of European environmental law demonstrate the difficulties in implementing strict system-based limits under the contemporary notion of environmental law. The first example is Total Maximum Daily Loads [TMDLs] under the United States' *Clean Water Act*, which establish the maximum amount of a pollutant that can be emitted to a water body without exceeding the federal water quality standards for the pollutant. The second is the as-yet largely undeveloped authority to regulate carbon dioxide through provisions of the United States' *Clean Air Act* so as to mitigate climate change.[140] The third is critical loads and levels for air pollutants under the *LRTAP*,[141] which is central to air pollution control in Europe. The last is the Acid Rain Program in the United States, specifically the provisions of the *Clean Air Act* that establish a cap-and-trade program for emissions of sulfur dioxide. These mechanisms are described as weak because they have not achieved the systemic objectives that underlie them. Further, the systemic limits on which they are based are not always founded entirely on ecosystemic criteria, and they generally have only indirect links to planetary boundaries and to the threat of global systemic catastrophe.

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[138] *Ibid.* at 86-87.
[139] *Ibid.* at 20.
[140] See generally *Massachusetts v. EPA,* 549 U.S. 497 (2007).
[141] See note 96, *supra.*

1. TMDLs under the United States *Clean Water Act*

The *Clean Water Act* requires States to identify waters within their boundaries in which any applicable water quality standard [WQS] required by the Act is not being met and to rank the waters "taking into account the severity of the pollution and the uses to be made of the waters."[142]

> Each State shall establish for the waters identified [as not meeting WQSs], and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation.[143]

Thus, TMDLs reflect an effort to establish systemic limits tied to ecological and other criteria reflected in WQSs.

Under the United States Environmental Protection Agency's [EPA's] regulations, TMDLs must include the pollutant load from point sources that have government-issued permits (the "wasteload allocation"[144]), along with the combined load from nonpoint sources and natural background sources (the "load allocation"[145]).[146] They must be set "at levels necessary to attain and maintain the applicable narrative and numerical WQS with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality."[147] Once established, TMDLs provide a basis for incorporating into States' "continuing planning processes"[148] a system for adjusting permits for point sources that contribute to

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[142] *Clean Water Act* § 303(d)(1)(A).

[143] *Clean Water Act* § 303(d)(1)(C). Section 304(a)(2) provides that

> the [EPA] Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall develop and publish, within one year after October 18, 1972 (and from time to time thereafter revise) information . . . for the purpose of section 1313 of this title, on and the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

[144] 40 C.F.R. § 130.2(h).

[145] 40 C.F.R. § 130.2(g).

[146] 40 C.F.R. § 130.2(i).

[147] 40 C.F.R. § 130.7(c)(1).

[148] *Clean Water Act* §§ 303(d)(4), 303(e), 33 U.S.C. §§ 1313(d)(4), 1313(e); 40 C.F.R. § 130.5.

non-attainment of water quality standards and for exploring ways to control nonpoint sources that the *Clean Water Act* regulates less rigorously.[149]

Unlike end-of-pipe regulations that are established based on technological and economic considerations,

> the TMDL program promises an 'ambient' approach to water monitoring and standards. That is, instead of focusing on releases from known sources of water pollution (i.e., monitoring discharges from discrete, identifiable pollution sources), regulation and reporting will increasingly be concerned with the *in situ* quality of waterbodies themselves.[150]

States are required to establish WQS that set limits on ambient water quality, "taking into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes, and also taking into consideration their use and value for navigation."[151] Thus, WQS under the *Clean Water Act* take into account the uses that States designate for their waters, as well as water quality criteria, which the EPA is required to publish and update, for protecting those designated uses.[152]

Water quality criteria, and hence water quality standards that rely on them, must reflect

> the latest scientific knowledge
> (A) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, including ground water;
> (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes; and
> (C) on the effects of pollutants on biological community diversity, productivity, and stability, including information on the factors affecting rates of eutrophication and rates of organic and inorganic sedimentation for varying types of receiving waters.[153]

Water quality standards therefore reflect both the economic considerations that are

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[149] See Robert W. Adler, "Freshwater: Sustaining Use by Protecting Ecosystems" (2009) 39 Envtl. L. Reporter News & Analysis 10309 at 10314; David S. Caudill and Donald E. Curley, "Strategic Idealizations of Science to Oppose Environmental Regulation: A Case Study of Five TMDL Controversies" (2008) 57 U. of Kan. L. Rev. 251 at note 10.
[150] James Boyd, "The New Face of the Clean Water Act: A Critical Review of EPA's Proposed TMDL Rule" (2000) Resources for the Future, Discussion Paper 00-12, at 2.
[151] *Clean Water Act* § 303(c)(2)(A).
[152] *Clean Water Act* § 303(c)(2)(A).
[153] *Clean Water Act* § 304(a)(1), 33 U.S.C. § 1314(a)(1).

inherent in designating different uses for different waters and the ecological considerations involved in ensuring that waters are of sufficient quality to protect designated uses.

The EPA's National Water Quality Inventory for the year 2004 indicates that forty-four percent of the assessed rivers and streams; sixty-four percent of the assessed lakes, ponds and reservoirs; and thirty percent of assessed bays and estuaries were "impaired," that is not meeting applicable WQS.[154] Nonpoint sources were a key contributor to impairment of waters in the United States, with agricultural pollution identified as a top source of impairment for rivers and streams and for lakes, ponds and reservoirs, and atmospheric deposition of mercury and other pollutants as an important source of impairment for lakes, ponds and reservoirs and for bays and estuaries.[155] "Legacy pollution" due to contamination from sediments that release pollutants discharged in the past is another important source of impairment in some waters.[156]

Because TMDLs establish the limit on aggregate loadings needed to maintain water quality at levels established, at least in part, according to ecological criteria, they are a possible proxy for a systemic ecological boundary.[157] They also have at least an indirect relationship to the still largely uncertain planetary boundaries for chemical pollution and nutrient fluxes.[158] However, the States and EPA have been slow in developing TMDLs. The federal and state governments essentially ignored the mandate to establish TMDLs for impaired waters until spurred by litigation to do so in the

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[154] U.S., Environmental Protection Agency, *National Water Quality Inventory: Report to Congress, 2004 Reporting Cycle* (Washington: EPA, 2009), at 1-2. The inventory covers "16% of the nation's 3.5 million miles of rivers and streams, … 39% of the nation's 41.7 million acres of lakes, ponds, and reservoirs [and] 29% of the nation's 87,791 square miles of bays and estuaries." *Ibid*.

[155] *Ibid.* at ES-2.

[156] James Boyd, *supra* note 150 at 5.

[157] However, the methodology for establishing TMDLs has been criticized for, among other things, being based on "inadequately validated mechanistic simulation models" and ignoring or downplaying important causes of water quality impairment, such as "altered flows, changes in physical habitat, presence of alien taxa" and a number of pollutants and pollutant interactions. James R. Karr and Chris O. Yoder, "Biological Assessment and Criteria Improve Total Maximum Daily Load Decision Making" (June 2004) Journal of Environmental Engineering 594 at 594.

[158] See Rockström *et al*., *supra* note 4 at 8-9, 12-4, 18-19 (discussing uncertainty with respect to the nutrient and chemical pollution boundaries).

1990s.[159] Although the States and EPA have established over 20,000 TMDLs since 2000, in 2004, 38,886 waters had been identified as impaired and EPA's goal as of 2009 was to attain WQS for 2,250 of those.[160] Further, once established, TMDLs are insufficient to overcome other provisions in the *Clean Water Act* that limit or complicate the ability to regulate key contributors to water quality problems, especially nonpoint sources of water pollution.

Several factors explain EPA's mediocre record in promulgating TMDLs and the poor prospects for the TMDL program to lead to significant improvements in water quality. In the first two decades of the *Clean Water Act*, environmentalists and the state and federal environmental agencies were focused on regulation and enforcement of point source discharges.[161] As long as those efforts yielded improvements in water quality—which they did—the TMDL program could be kept on the back burner (or in the cupboard) without causing significant concern.

Now that the TMDL program has slowly come to life, its functional limitations are becoming more apparent. The most critical limitation is that once TMDLs are established, States are not required to develop plans to implement them or to apply them in a binding manner to nonpoint sources.[162] In July 2000, the Clinton Administration EPA finalized a TMDL rule that required States to develop implementation plans providing details on and schedules for actions to reduce point and nonpoint pollutant loadings of impaired waters, but the Bush Administration EPA withdrew the rule in 2003 before it became effective.[163]

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[159] James Boyd, *supra* note 150 at 7; Karr and Yoder, *ibid*. at 594.
[160] Adler, *supra* note 149 at 10310, 10312. The number of completed TMDLs is up from 11,408 as of May 2005. Caudill and Curley, *supra* note 149 at note 17.
[161] James Boyd, *supra* note 150 at 1-6.
[162] U.S., Environmental Protection Agency, *What is a TMDL?*, online: <http://www.epa.gov/owow/TMDL/overviewoftmdl.html#aftertmdl> ("Although states are not required under section 303(d) to develop TMDL implementation plans, many states include implementation plans with the TMDL or develop them as a separate document. When developed, TMDL implementation plans may provide additional information on what point and nonpoint sources contribute to the impairment and how those sources are being controlled, or should be controlled in the future.")
[163] U.S., Environmental Protection Agency, *Withdrawal of Revisions to the Water Quality Planning and Management Regulation and Revisions to the National Pollutant Discharge*

The vulnerability of TMDLs to attack as not comporting with "sound science" may explain in part the political reluctance to require States to implement them. This vulnerability starts with the decision to list waters as impaired and continues through to the detailed inventory of loading sources and their impacts. David Caudill and Donald Curley explain:

> [T]he issues of the "soundness" of TMDL science, the challenge of scientific uncertainties, and the effect of political and economic interests on science have been part of the national TMDL controversy. In July 1999, during the last years of the Clinton administration, the EPA issued its draft of a comprehensive TMDL regulation to improve pollution control by focusing on nonpoint sources. The opposition was overwhelming--a perfect storm of anti-government and anti-Clinton sentiments, state concerns about resources and funding, industry complaints, House and Senate hearings receptive to critics, and even (as the proposal was watered down with concessions) criticism by environmental groups. Upon issuance of the final TMDL rules in July 2000, the EPA was "left without a single, unified constituency" as well as "a rule nobody liked." Congress delayed application of the rule by way of an appropriations rider until October 2001, and the controversy continued until the rule's effective date was delayed until March 2003; eventually it was withdrawn.[164]

Looking forward, "[f]ederal authority to mandate nonpoint source controls remains weak. Implementation of the analytic tools required by the TMDL process will be costly and difficult. And conflicts are almost certain to arise due to the geographically interrelated nature of pollution sources and legal jurisdictions."[165] As Robert Percival notes,

> [n]on-point source pollution is widely, and properly, understood as one of the top problems that regulatory policy has failed to come to grips with. So long as most land management decisions remain the fiercely guarded province of state and local authorities, solutions to non-point source pollutions problems will remain elusive.[166]

The example of mercury contamination of many United States waters illustrates

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Elimination System Program in Support of Revisions to the Water Quality Planning and Management Regulation; Final Rule (19 March 2003), 68 Fed. Reg. 13608, at 13608; U.S. Environmental Protection Agency, *Revisions to the Water Quality Planning and Management Regulation and Revisions to the National Pollutant Discharge Elimination System Program in Support of Revisions to the Water Quality Planning and Management Regulation* (13 July 2000), 65 Fed. Reg. 43586 at 43586, 43667

[164] Caudill and Curley, *supra* note 149 at 256 (notes omitted).

[165] James Boyd, *supra* note 150 at 4.

[166] Percival, *supra* note 109 at 31.

well the many difficulties in relying on the TMDL program to restore the water quality of impaired waters. As of February 2011, approximately 3,800 water bodies in the United States were listed as impaired with mercury contamination and the EPA had approved about 6,900 mercury TMDLs.[167] Much mercury impairment of water bodies in the United States is due to atmospheric deposition of mercury, a large share of which comes from the emissions of coal-fired power plants.[168] Identifying which mercury sources affect a particular impaired water body is a complicated matter, although methodologies for establishing these source-receptor relationships are now well advanced.[169] Another complication is that a notable amount of atmospheric deposition of mercury in the United States comes from foreign sources, and a notable amount of mercury emissions in the United States migrate outside of United States borders. Thirty percent of mercury deposition in the Western United States was due to Chinese sources, mostly coal-fired power plants, according to a 2004 estimate, while two-thirds of United States mercury emissions leave the country.[170] As a result of these complications, the United States has far to go before TMDLs can provide a reliable basis for protecting aquatic ecosystems from mercury and other pollutants.

2. Carbon Dioxide under the United States *Clean Air Act*

The United States Supreme Court's ruling in *Massachusetts v. EPA*[171] confirmed the authority of the federal government in the United States to regulate carbon dioxide and other greenhouse gases as pollutants under the *Clean Air Act*. A group of states, local governments and non-governmental organizations[172] brought the case to challenge the

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[167] U.S., Environmental Protection Agency, *National Summary of Impaired Waters and TMDL Information* (2011), online: <http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T#status_of_data>.
[168] U.S., Environmental Protection Agency, *Total Maximum Daily Loads (TMDLs) and Mercury* (2010) online: <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/mercury/index.cfm>.
[169] See U.S., Environmental Protection Agency, *Model-Based Analysis And Tracking Of Airborne Mercury Emissions To Assist in Watershed Planning* (2008) online: <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/mercury/upload/2008_10_28_tmdl_pdf_final300report_10072008.pdf>.
[170] Percival, *supra* note 109 at 18-19.
[171] *Massachusetts v. EPA,* 549 U.S. 497 (2007).
[172] See *Massachusetts v. EPA,* 549 U.S. at 504.

EPA's decision not to regulate greenhouses gases emitted by motor vehicles under *Clean Air Act* § 202(a)(1). That provision provides:

> The [EPA] Administrator shall by regulation prescribe (and from time to time revise) in accordance with the provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare. . . .[173]

The Supreme Court's decision turned on its rejection of EPA's argument that substances that contribute to climate change, like greenhouse gases, are not "air pollutants" as defined in the Act. According to the Act,

> [t]he term "air pollutant" means any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term "air pollutant" is used.[174]

The Court held that on its face, this definition unambiguously includes greenhouse gases emitted to the ambient air.[175] As to EPA's determination as to whether an air pollutant endangers the public health of welfare, the Act provides that "effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate . . . ."[176] The Court ruled that "EPA can avoid taking further action only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do."[177]

The decision in *Massachusetts v. EPA* is rooted indirectly in a systems-based analysis of the role of greenhouse gases in altering the global climate system. The Court's reasoning is based in large part on recognition of the potential impacts of a pollutant not directly on the health of individual humans due to its presence in ambient

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[173] *Clean Air Act* § 202(a)(1), 42 U. S. C. §7521(a)(1) (2006).
[174] *Clean Air Act* § 302(h), 42 U.S.C. § 7602(g) (2006).
[175] 549 U.S. at 528-29.
[176] *Clean Air Act* § 302(h), 42 U.S.C. § 7602(h) (2006).
[177] 549 U.S. at 533.

air, but on ecosystems on which human health and welfare depend.[178] Carbon dioxide and the other greenhouse gases that the ruling implicitly includes stand out in this regard from other pollutants that are regulated under the *Clean Air Act*. Despite this distinction, the Court rejected the argument that carbon dioxide is not covered by the *Clean Air Act* because it is of concern *only* at the global level of climate change, unlike the pollutants with more direct and local effects on human health and welfare that are typically regulated under the Act.[179]

Following the decision in *Massachusetts v. EPA*, the EPA in the Obama Administration issued a so-called endangerment finding[180] under *Clean Air Act* § 202(a) that emissions of carbon dioxide and five other greenhouse gases may reasonably be anticipated to endanger public health or welfare. The endangerment finding opened the door to broader regulation of greenhouse gases under the *Clean Air Act*. Subsequently, in April 2010, the EPA and the National Highway Traffic Safety Administration [NHTSA] jointly issued new greenhouse gas emission and fuel-economy standards for passenger cars and other light-duty motor vehicles in model years 2012 through 2016.[181] The new standards

> require these vehicles to meet an estimated combined average emissions level of 250 grams of carbon dioxide (CO2) per mile in model year 2016, equivalent to 35.5 miles per gallon (mpg) if the automotive industry were to meet this CO2 level all through fuel economy improvements.[182]

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[178] See 549 U.S. at 508-09, 521-22 (citing the UNFCCC's objective of reducing anthropogenic interference with the Earth's climate system, the findings of the IPCC on climate change impacts and affidavits in support the standing of the plaintiff States and organizations attesting to the risks from global warming of severe and irreversible changes to natural ecosystems).

[179] 549 U.S. at note 26. Many pollutants with local effects, like sulfur dioxide and mercury, also have broader systemic effects (such as acid rain and contamination of fish from mercury deposition into fish-bearing waters) that the EPA has taken into account in regulating them.

[180] U.S. Environmental Protection Agency, *Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act*, 74 Fed. Reg. 66496 (2009) (to be codified at 40 C.F.R. Chapter 1) [*GHG Endangerment Finding*].

[181] U.S., Environmental Protection Agency and National Highway Traffic Safety Administration, *Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule*, 75 Fed. Reg. 25324 (2010)(codified at 40 CFR Parts 85, 86, and 600; 49 CFR Parts 531, 533, 536, et al.) [*Light-Duty Vehicle Rule*].

[182] U.S., Environmental Protection Agency, Regulatory Announcement, "EPA and NHTSA Finalize Historic National Program to Reduce Greenhouse Gases and Improve Fuel Economy for Cars and Trucks" (April 2010), online <http://epa.gov/otaq/climate/regulations/420f10014.pdf>.

In October 2010, the EPA and NHTSA announced their intention, supplemented in December 2010, to adopt greenhouse gas emission and fuel economy standards for light-duty motor vehicles in model years 2017 to 2025 that could lead to a fleet average fuel economy of forty-seven to sixty-two miles per gallon by 2025, depending on the stringency of the new rule.[183] The endangerment finding and the preamble to the final vehicle emissions and fuel economy rule recognize climate change as a significant long-term threat to the global environment and the role of anthropogenic emissions of greenhouse gases in the problem.[184] Significantly, however, neither makes reference to a global or national limit for greenhouse gas emissions or to safe thresholds for atmospheric concentrations of greenhouse gases, changes in the net radiative forcing, or the increase in the average global temperature.

The EPA has undertaken other relatively mild regulatory measures related to climate change. In October 2009, it finalized a rule mandating as of 2010 the reporting of greenhouse gases from approximately 10,000 power plants, other industrial facilities, and certain landfills and manure management facilities, which together account for about eighty-five percent of emissions in the United States.[185] The EPA asserts that the new reporting requirement "will provide a better understanding of where GHGs are coming from and will guide development of the best possible policies and programs to reduce emissions."[186]

Taken together, EPA's regulatory actions to address climate change include restrictions that at least incrementally tend toward respect for a scientifically derived systemic boundary such as proposed by the Rockström research team. However, EPA's nascent climate change regulations are mute as to what any such boundary might or ought

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[183] See 75 Fed. Reg. 62739 (2010); 75 Fed. Reg. 76337 (2010).
[184] *GHG Endangerment Finding*, *supra* note 180; *Light-Duty Vehicle Rule*, *supra* note 181 at 25326.
[185] *Mandatory Greenhouse Gas Reporting Rule*, 40 C.F.R. Part 98 (2009), 74 Fed. Reg. 56374 *et seq.* (2009); U.S. Environmental Protection Agency, News Release, "EPA Finalizes the Nation's First Greenhouse Gas Reporting System/Monitoring to being in 2010" (22 September 2009), online: <http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/194e412153fcffea8525763900530d75!OpenDocument>.
[186] U.S., Environmental Protection Agency, News Release, *ibid*.

to be and are ultimately linked to the focus in the *Clean Air Act* on protecting human health, as opposed to ecosystems more broadly. Further, the obstacles to policy mechanisms in the United States that are linked to, and rapidly working toward, a planetary boundary for climate change are significant, and the early signs as the regulatory authority to address the problem takes shape are not encouraging. Five such obstacles stand out.

First, the United States has adopted overall greenhouses gas emissions targets for the purposes of international climate change negotiations in 2009 and 2010, but they do not match up with emissions limits that the IPCC and others have proposed as necessary to meet an eventual return to an atmospheric concentration of carbon dioxide of 350 ppm from the current 390 ppm. The non-binding objective of the United States is to reduce its domestic emissions of greenhouse gases to seventeen percent below 2005 levels by 2020, which is equivalent to a four percent decrease from 1990 levels.[187] By contrast, the IPCC's 2007 assessment indicates that limiting the global temperature rise to two degrees Celsius—a level generally consistent with the Rockström team's proposed climate change boundary[188]—will require emissions from developed world countries to decrease by ten to forty percent from 1990 levels by 2020.[189] The United States targets appear to be an attempt to negotiate, on the basis of political and socio-economic factors, with an ecological limit that the Rockström team postulates as uncompromising as to those factors—in other words, the targets appear to pose an unacceptable risk of catastrophe. If

[187] See Letter from Todd Stern, U.S. Special Envoy for Climate Change, to Yvo de Boer, Executive Secretary, UNFCCC (28 January 2010), online: <http://unfccc.int/files/meetings/application/pdf/unitedstatescphaccord_app.1.pdf>.
[188] Rockström *et al., supra* note 4 at 7-9.
[189] Sujata Gupta, *et al*. "Policies, Instruments and Co-operative Arrangements" in B. Metz *et al.*, eds., *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (New York: Cambridge University Press, 2007) at 748; See also UNFCCC, Draft decision -/CP.16, Outcome of the work of the Ad Hoc Working Group on long-term Cooperative Action under the Convention (2010) online: <http://unfccc.int/files/meetings/cop_16/application/pdf/cop16_lca.pdf> at Paragraphs 4 and 37.

the EPA's greenhouse gas regulations are based on these targets, they are near certain to be insufficient.[190]

Second, the extent of reductions in greenhouse gas emissions that could be achieved using existing mechanisms under the *Clean Air Act* is limited. Robert Nordhaus estimates that existing authorities could be used to regulate sources responsible for seventy to eighty percent of carbon dioxide emissions, or (because other greenhouse gases account for twenty percent of total greenhouse gas emissions) fifty-nine to sixty-seven percent of total greenhouse gas emissions.[191] Thus, a significant amount of greenhouse gas emissions—forty percent, according to Nordhaus[192]—would be left uncontrolled. Moreover, a full sixty percent reduction in greenhouse gas emissions could be achieved only with complete elimination of the emissions subject to regulation under the Act. Many factors make this level of reduction virtually impossible, not least the projections of a fifty-seven percent increase in vehicle miles traveled in the United States from 2004 to 2030, which would require emissions per mile to decrease by thirty-six percent just to hold the total level of emissions steady.[193]

Third, the lack of binding and ambitious greenhouse reduction legislation or regulations in the United States has impeded progress on binding international greenhouse gas emission reduction rules, which in turn reinforces the political impasse to adoption of strong legislation in the United States.[194] The non-binding *Copenhagen Accord,*[195] of which the Conference of the Parties of the *United Nations Framework Convention on Climate Change* [UNFCCC] "took note"[196] at their annual meeting in

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[190] Even then, however, a failed effort in the United States Senate in 2010 to withdraw the EPA's authority to regulate greenhouse gases by disapproving its December 2009 endangerment finding may re-emerge in future sessions of Congress, where hostility to regulation of greenhouse gases remains strong. See U.S., Joint Resolution, S.J. Res. 26, 111th Cong., 2010 (not enacted).
[191] Robert R. Nordhaus, "New Wine Into Old Bottles: The Feasibility of Greenhouse Gas Regulation Under the Clean Air Act" (2007) 15 N.Y.U. Envtl. L. J. 53 at 69.
[192] *Ibid*.
[193] *Ibid.* at 70-71.
[194] See Cass R. Sunstein, *Worst-case Scenarios* (Cambridge, Massachusetts: Harvard University Press, 2007) at 103-04.
[195] Conference of the Parties, *Copenhagen Accord,* Dec. 2/CP.15, UNFCCCOR, 2009, FCCC/CP/2009/11/Add.1 (2010) 4 [*Copenhagen Accord*].
[196] Conference of the Parties, *Outcome of the work of the Ad Hoc Working Group on*

2009, states a shared objective of holding the increase in global temperature below two degrees Celsius;[197] the Rockström group sees a high probability of attaining this objective if the planetary boundary of 350 ppm carbon dioxide in the atmosphere is respected.[198] But, the targets that the United States and other countries have proposed since that time do not line up with the two degree Celsius objective. The *Cancun Agreements* reached at the UNFCCC's Sixteenth Conference of the Parties in 2010 state hopefully, but without binding commitments, that "[s]caled-up overall mitigation efforts that allow for the achievement of desired stabilization levels are necessary, with developed country Parties showing leadership by undertaking ambitious emission reductions . . . ."[199] The agreements affirmed the two degree Celsius target and made reference to the emissions reductions that the IPCC's Fourth Assessment Report said were necessary to reach that target—an implicit incorporation of reductions beyond the decrease in emissions in developed countries of twenty-five to forty percent from 1990 levels by 2020 associated with an atmospheric concentration of carbon dioxide of 450 ppm.[200]

Fourth, Congressional efforts to move beyond the authority to regulate greenhouse gases in the *Clean Air Act* stalled after the United States House of Representatives passed the *American Clean Energy and Security Act of 2009*[201] [*ACES Bill*] and appear to be effectively blocked for the indefinite future following the mid-term elections in the United States in 2010.[202] The *ACES Bill* would have amended the *Clean Air Act* with a new Title on global warming pollution, with provisions that aimed to achieve a twenty percent reduction from 2005 levels of United States greenhouse gas emissions by 2020, a forty-two percent reduction from 2005 levels by 2030, and an eighty-three percent

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Long-term Cooperative Action under the Convention, Dec. 1/CP.15, UNFCCCOR, 2009, FCCC/CP/2009/11/Add.1 (2010) 3.

[197] *Copenhagen Accord, supra* note 195 at ¶ 1.

[198] Rockström *et al.*, *supra* note 4 at 11.

[199] UNFCCC, Draft decision -/CP.16, Outcome of the work of the Ad Hoc Working Group on long-term Cooperative Action under the Convention (2010) online: <http://unfccc.int/files/meetings/cop_16/application/pdf/cop16_lca.pdf> at ¶ 2(a).

[200] *Ibid.* at ¶¶4 and 37.

[201] U.S., Bill H.R. 2454, *American Clean Energy and Security Act of 2009,* 111th Cong., 2009 [*ACES Bill*] (not enacted).

[202] See Richard Blackwell, "Prospects for cap and trade system waning" *The Globe and Mail* (3 November 2011), online: The Globe and Mail <http://www.theglobeandmail.com/report-on-business/economy/prospects-for-cap-and-trade-system-waning/article1783998/>.

reduction from 2005 levels by 2050.[203] The massive bill would have implemented a complex cap-and-trade mechanism to attain those objectives, along with programs to increase energy efficiency and renewable energy use, promote "clean" transportation, improve the national electrical grid, support development of carbon capture and sequestration technologies, and support development of "clean energy" (including nuclear energy).[204]

Last, almost forty years after the *Clean Air Act* was adopted, National Ambient Air Quality Standards (NAAQSs) for more traditional pollutants have not been attained in many areas. Section 108 of the *Clean Air Act* provides that

> [f]or the purpose of establishing national primary and secondary ambient air quality standards, the Administrator shall within 30 days after December 31, 1970, publish, and shall from time to time thereafter revise, a list which includes each air pollutant—
> **(A)** emissions of which, in his judgment, cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare; **(B)** the presence of which in the ambient air results from numerous or diverse mobile or stationary sources . . . .[205]

The EPA is required to establish these NAAQSs solely on the basis of the impacts of pollutants on human health, without accounting for technological or economic factors.[206]

To date, EPA has established NAAQS for six pollutants: carbon monoxide, lead, nitrogen dioxide, two sizes of particulate matter (PM10 and PM2.5), ground-level ozone and sulfur dioxide.[207] The Act requires the States to identify "non-attainment areas" within their borders in which any of the NAAQSs are not attained and to develop plans for adjusting air emissions permits, revising motor vehicle programs or taking other

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[203] *ACES Bill, supra* note 180, § 311 (proposed *Clean Air Act* § 702).
[204] *ACES Bill*, generally.
[205] *Clean Air Act* § 108(a)(1), 42 USC § 7408(1)(1) (2006).
[206] *Clean Air Act* § 109(b)(1), 42 U.S.C. § 7409(b)(1) (2006); See also Engel, *supra* note 94 at 288-89; *GHG Endangerment Finding, supra* note 180 at 66515-66516.
[207] See U.S., Environmental Protection Agency, *National Ambient Air Quality Standards (NAAQS)* (2010) online: <http://www.epa.gov/air/criteria.html>. For a variety of reasons, designation of carbon dioxide as a criteria pollutant for which a NAAQS would be established is highly problematic and unlikely, and the EPA currently is not seeking such as designation. However, the rationale of the decision in *Massachusetts v. EPA,* which did not directly apply to the NAAQS provisions of the *Clean Air Act*, could arguably be used to force such a result. See Robert Nordhaus, *supra* note 191 at 59-63.

measures in order to protect areas that are in attainment and to achieve attainment of NAAQSs in non-attainment areas.[208] The persistent failure to attain NAAQSs despite these programs, particularly for ground-level ozone associated with motor vehicle emissions,[209] like the persistent failure to attain water quality standards through TMDLs, portends difficulty in achieving reductions in greenhouse gas emissions in the United States that would be needed to stay within ecologically-based system boundaries.

3. Critical Loads and Levels of Air Pollutants in Europe

The critical loads and levels approach was developed[210] under the United Nations Economic Commission for Europe's *LRTAP*.[211] As with TMDLs and NAAQSs, the general concept behind this approach is to establish the threshold levels of ambient pollutants below which harmful effects on receptor ecosystems will be prevented. Critical levels are defined as "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may

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[208] See *Clean Air Act* § 182, 42 U.S.C. § 7511a (2006).

[209] See e.g., U.S., Environmental Protection Agency, "8-Hour Ozone Nonattainment and Maintenance Areas (1997 Standard)" (2010) online: <http://www.epa.gov/airquality/greenbk/map8hrnm.html>; U.S. Environmental Protection Agency, "Counties Designated Nonattainment for PM-10" (2010) online: <http://www.epa.gov/airquality/greenbk/mappm10.html>; U.S. Environmental Protection Agency, "Counties Designated Nonattainment for SO_2" (2010) online: <http://www.epa.gov/airquality/greenbk/mapso2.html>; U.S. EPA, "PM-2.5 Nonattainment Areas (2006 Standard)" (2010) online: <http://www.epa.gov/airquality/greenbk/mappm25_2006.html>. See also *GHG Endangerment Finding, supra* note 180 at 66530; Heinzerling, *supra* note 111 at 155 (noting a report in 2004 that "[a]lmost 160 million Americans live in areas that violate the federal Environmental Protection Agency's (EPA) new standard for ozone pollution.").

[210] See Rockström *et al.*, *supra* note 4, Supplementary Information at 6; Malcolm S. Cresser, "The Critical Loads Concept: Milestone or Millstone for the New Millenium?" (2000) 249 The Science of the Total Environment 51; Umweltbundesamt, *Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads & Levels and Air Pollution Effects, Risks and Trends* (Berlin: Umweltbundesamt, 2004) at I-1; United Nations Economic Commission for Europe (UNECE), "ICP Modelling and Mapping: International Cooperative Programme on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends" (undated) online: UNECE <http://www.unece.org/env/lrtap/WorkingGroups/wge/mapping.htm>.

[211] See *supra* note 96. Fifty-one countries, including the European Union, nearly all European States, Canada and the United States, have ratified the Convention as of November 2010. UNECE, "Status of the Convention on Long-range Transboundary Air Pollution and its related Protocols" (8 November 2010) online: <http://www.unece.org/env/lrtap/status/Status%20of%20the%20Convention.pdf>.

occur according to present knowledge."[212] Critical load is defined as a "quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge."[213] Critical loads and levels are estimated using biological and other indicators of the systemic effects of pollutant exposure and loading.[214] For example, critical levels with respect to vegetation are based in large part on the effects of pollutants on "growth changes, yield losses, visible injury and reduced seed production"[215] in five main vegetation categories: "agricultural crops, horticultural crops, semi-natural vegetation, natural vegetation and forest trees."[216]

Once critical loads and levels are estimated, they serve as a basis for limiting releases of pollutants to the environment. "[C]ritical loads and levels provide a sustainable reference point against which pollution levels can be compared."[217] The critical load and level approach uses complex modeling to estimate the emissions reductions and allocations that are needed to keep levels of individual pollutants or pollutants in combination below systemic thresholds.[218] Central to the approach is the use of modeling and mapping. Maps that show where critical levels and loads are exceeded (exceedance maps) are used to allocate the loads and levels to emissions from different countries;[219] and maps of the concentrations and depositions of pollutants are used to assess the effects of pollutants in specific ecosystems.[220] Accounting for the dynamic nature of the pollutant-receptor relationships and the behavior of receptor

[212] UNECE, "ICP Modelling and Mapping: Critical Loads and Levels Approach" (undated) online: UNECE <http://www.unece.org/env/lrtap/WorkingGroups/wge/definitions.htm>; Umweltbundesamt, *supra* note 210 at III-1.
[213] UNECE, "ICP Modelling and Mapping: Critical Loads and Levels Approach" (undated) online: UNECE <http://www.unece.org/env/lrtap/WorkingGroups/wge/definitions.htm>; Umweltbundesamt, *ibid.* at V-1.
[214] See Umweltbundesamt, *ibid.* at I-1; UNECE, "ICP Modelling and Mapping: Critical Loads and Levels Approach" (undated) online: UNECE <http://www.unece.org/env/lrtap/WorkingGroups/wge/definitions.htm>.
[215] Umweltbundesamt, *ibid*. at III-1.
[216] *Ibid.* at III-1.
[217] *Ibid.* at I-1.
[218] See *Ibid.* at I-1. The Parties to the Convention cooperate on the development of maps of critical loads and levels of different pollutants, which can then be compared with maps of pollutant deposition associated with actual or modeled emissions scenarios. *Ibid*. at I-4.
[219] *Ibid.* at II-1.
[220] *Ibid.* at II-1.

systems in response to change, such as delayed biological effects of pollutant loading, the approach uses dynamic modeling to "assess time delays of recovery in regions where critical loads cease being exceeded and time delays of damage in regions where critical loads continue to be exceeded."[221] However, while dynamic modeling has been applied successfully with respect to pollutants like sulfur dioxide that cause acidification, it is more difficult, and to date has been less successful, with respect to the more complex biogeochemical processes and feedbacks involved in eutrophication.[222]

The phrase "according to present knowledge" in the definitions of critical levels and critical load reflects awareness of the uncertainties involved in the approach.[223] The manual describing the critical loads and levels methodology explains that "[t]he errors concomitant with the different methods are strongly dependent on the scale considered and the availability of data."[224] Thus, for example, the working group considering the critical load of sulfur in soils and groundwater found that

> the concept being put to them was an over-simplification in too many respects. The absolute critical load value for soil at any particular site would depend upon a number of factors other than just soil parent material. These included annual precipitation, forest tree or other vegetation type, texture, drainage, slope, soil depth, sulfate absorption capacity and base cation deposition from the atmosphere . . . .[225]

Despite the complexities and uncertainties that must be addressed, reasonable progress has been made in estimating critical loads and levels using the approach. It has been used to establish critical loads for eutrophication and acidification due to sulfur and nitrogen-based pollution and for heavy metals, specifically cadmium, lead and mercury; and to develop critical levels for ozone, nitrogen oxides, sulfur dioxide and ammonia.[226] As well, a methodology exists to examine the combined effects of multiple pollutants on ecosystems through "critical load functions."[227]

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[221] *Ibid.* at VI-1.
[222] Till Spranger *et al.*, "Modelling and Mapping Long-term Risks Due to Reactive Nitrogen Effects: An Overview of LRTAP Convention Activities" (2008) 154 Envtl. Pollution 482 at 484.
[223] See Cresser, *supra* note 210 at 52.
[224] Umweltbundesamt, *supra* note 210 at II-16.
[225] Cresser, *supra* note 210 at 52.
[226] Umweltbundesamt, *supra* note 210 at I-5; Spranger, *supra* note 222 at 483.
[227] Spranger, *ibid.* at 483.

Although critical loads and levels are established on the basis of the systemic effects of pollution, exceedances are still widespread in Europe, but decreasing.[228] As with NAAQS and TMDLs in the United States, technical and economic factors determine the extent and rate of progress.[229] The initial levels of emissions reductions required under the *LRTAP* were based solely on technical and economic considerations, without taking into account the connection between exceedances and loads.[230] In the next set of protocols, "cutting sulphur dioxide emissions to achieve deposition levels below critical loads was not feasible for all ecosystems in Europe. Even so, the negotiations [of abatement measures] were based on the assessment of environmental effects and the protection of ecosystems as well as technical and economic considerations."[231] Currently, gradual attainment of critical loads and levels is a long-term objective of the eight protocols that set out the obligations of the signatories to reduce emissions,[232] but complete elimination of exceedances is not necessarily anticipated. Thus, the European Union's *National Emission Ceilings Directive* acknowledges the current impossibility of meeting the long-term objective and adopts interim objectives and measures that are based on technical feasibility and cost effectiveness.[233] For example, full implementation of the *1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone*[234] is expected to reduce the area with excessive levels of acidification in Europe from 93 million hectares in 1990 to 15 million hectares, the area with excessive eutrophication from 165 million hectares in 1990 to 108 million hectares, and the number of days with excessive ground-level ozone in half.[235] But not to eliminate them.

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[228] *Ibid.* at 484.
[229] See Pelletier, *supra* note 33 at 221.
[230] Umweltbundesamt, *supra* note 210 at I-3.
[231] *Ibid.* at I-3.
[232] See, e.g., *Protocol to the 1979 Convention on Long-range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone* (30 November 1999) Document of the Economic and Social Council EB.AIR/1999/1 (entered into force 17 May 2005) [*1999 Gothenburg Protocol*] Article 2; EU, *Directive of the European Parliament and of the Council 2001/81/EC of 23 October 2001 on national emission ceilings for certain atmospheric pollutants* [2001] O.J. L 309/22 [*National Emission Ceilings Directive*] at 22 ("The exceedance of critical loads should . . . be gradually eliminated and guideline levels respected."), Article 1.
[233] *National Emission Ceilings Directive, ibid.* at 22, Article 5.
[234] *1999 Gothenburg Protocol, supra* note 211.

In a 2008 study by the current Chair[236] of the International Cooperative Programme on Modeling and Mapping under the *LRTAP*, widespread exceedances of the critical load for eutrophication and acidification were expected in 2010, largely becaue of animal husbandry.[237] The study concludes:

> The eutrophication of terrestrial ecosystems due to nitrogen emissions into the atmosphere in Europe will remain, and poses a risk to biodiversity and other environmental targets on a continental scale. Animal husbandry increasingly determines magnitude and spatial pattern of critical load exceedance, i.e. the risk to sustainability with respect to the long-range transport of air pollutants. This conclusion holds for eutrophication as well as acidification.[238]

Elsewhere, the *LRTAP* has been praised as "a successful international mechanism for alleviating the global problem of air pollution [that has resulted in] a significant production of data concerning air pollution, reduction of a number of pollutants, an increasing exchange of scientific information, and a stimulation of national pollution reduction efforts."[239] By contrast, others have questioned the effectiveness of the *LRTAP* because political and economic considerations have consistently taken precedence over the Convention's environmental goals.[240]

4. Cap-and-trade Program for Sulfur Dioxide under the United States *Clean Air Act*

Another only marginally effective mechanism that bases restrictions on an activity or pollution on ecosystemic effects is the cap-and-trade program under the United States *Clean Air Act* to control acid rain due to sulfur dioxide emissions.[241] In amendments to

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[235] UNECE, "Protocol to Abate Acidification, Eutrophication and Ground-level Ozone" (undated) online: UNECE <http://www.unece.org/env/lrtap/multi_h1.htm>. The national ceilings and modelling framework do not apply to the United States or Canada, which are allowed to employ alternative strategies pursuant to the Protocol and the *LRTAP*. William J. Shapiro, "Protocol to Abate Acidification, Eutrophication and Ground Level Ozone" (1999) 11 Colo. J. Int'l Envtl. L. & Pol'y 208 at 216.
[236] UNECE, "ICP Modelling and Mapping: International Cooperative Programme on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends" (undated) online: UNECE <http://www.unece.org/env/lrtap/WorkingGroups/wge/mapping.htm>.
[237] Spranger, *supra* note 222 at 484, 485. See also Shapiro, *supra* note 235 at 219.
[238] Spranger, *ibid.* at 485-86.
[239] Shapiro, *supra* note 235 at 211-12. See also Roda Mushkat, "Globalization and the International Environmental Legal Response: The Asian Context" (2003) 4 Asian-Pac. L. & Pol'y J. 49 at 74.
[240] See Pelletier, *supra* note 33 at 221.
[241] *Clean Air Act* Title IV, 42 U.S.C. §§ 7651-7651o (2006).

the *Clean Air Act* in 1990, a cap-and-trade mechanism was established for sulfur dioxide emissions from electric utilities and other air pollution sources. Under this program, a gradually diminishing cap on emissions from the entire category of sources was established, an initial set of quotas of emissions was allocated to the sources so as to respect the initial cap, and a market was created to allow sources to buy and sell the right to emit sulfur dioxide within the overall cap. The program has two phases, the initial phase covering the largest electric utilities and the second phase, which began in 2000, bringing smaller sources into the emissions market.[242]

A key driver of this new legislation was the desire to reduce acid rain in areas downwind of major sulfur dioxide sources, particularly coal-fired power plants. In enacting the new provisions, the United States Congress found that acid rain is a problem of national and international significance that "represents a threat to natural resources, ecosystems, materials, visibility, and public health."[243] The purpose of the Acid Rain Program is

> to reduce the adverse effects of acid deposition through reductions in annual emissions of sulfur dioxide of ten million tons from 1980 emission levels, and, in combination with other provisions of this Act, of nitrogen oxides emissions of approximately two million tons from 1980 emission levels, in the forty-eight contiguous States and the District of Columbia.[244]

"At the heart of this scheme is the government's choice of a permissible pollution level,"[245] but nothing in the Act links the desired reductions to a particular objective for the ecosystems to which acid rain causes harm, even if some amount of protection of those ecosystems was anticipated. Indeed, after reviewing the legislative process leading to adoption of the 1990 Clean Air Act Amendments, Lisa Heinzerling concluded that "Congress appears to have paid scarcely any attention to the pollution level set by the . . . Amendments and to have concentrated instead on satisfying powerful interest groups

[242] *Clean Air Act* § 405, 42 U.S.C. § 7651d (2006).
[243] *Clean Air Act* § 401(a), 42. U.S.C. § 7651(a) (2006).
[244] *Clean Air Act* § 401(b), 42 U.S.C. § 7651(b) (2006).
[245] Lisa Heinzerling, "Selling Pollution, Forcing Democracy" (1995) 14 Stanford Envtl. L.J. 300 at 301.

through its allocation of permits."[246] Indeed, one critic has suggested that even greater reductions in sulfur dioxide emissions would have been achieved by allowing controversial command-and-control provisions that the amendment effectively repealed to remain in effect, albeit at greater cost.[247]

The Acid Rain program in the United States is nonetheless widely viewed as a success. According to one source, "[e]missions of SO_2 have been reduced at a faster rate and at considerably lower cost than expected [and] by 2005, SO_2 emissions from the power plants included in the program had fallen 35% from 1990 levels."[248] However, some amount of the decline of sulfur dioxide and nitrogen oxides emissions has been attributed to an increase in the availability of relatively cheap low-sulfur coal in the 1990s.[249] In addition, although the reductions in sulfur dioxide and nitrogen oxides emissions have been significant, the European Community achieved a seventy percent reduction in sulfur dioxide emissions between 1980 and 2001, almost twice the percentage reduction achieved in the United States over the same time period; in 2001 the emissions of sulfur dioxide per unit of GDP were 494 kilograms per million euros in Europe and 1,150 kilograms per million euros in the United States.[250]

The Acid Rain Program has also had only partial success in terms of the reduction of impacts on downwind ecosystems. A 2005 report on the effects of acid rain on lakes in the Adirondack Mountains in New York State states:

> Despite many denials, acid rain did and does exist and was and is a significant ecological threat. It has been significantly but only partially abated, and as we write this in 2005 the Adirondacks are still threatened. More abatement is needed, and

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[246] *Ibid.* at 303. Arnold W. Reitze, Jr.'s, review of the legislative history of the 1990 Clean Air Act Amendments lends credence to this conclusion. Arnold W. Reitze, Jr., "The Legislative History of U.S. Air Pollution Control" (1999) 36 Houston L. Rev. 679 at 717-725.
[247] Curtis A. Moore, "The 1990 Clean Air Act Amendments: Silk Purse or Sow's Ear?" (1992) 2 Duke Envtl. L. & Pol'y F. 26 at 40-42 (claiming that the reductions would have amounted to 12 million tons as opposed to the 10 million tons that the Amendments were designed to achieve).
[248] Holly Doremus and W. Michael Hanemann, "Of Babies and Bathwater: Why the Clean Air Act's Cooperative Federalism Framework Is Useful for Addressing Global Warming" (2008) 50 Ariz. L. Rev. 799 at 802.
[249] *Ibid.* (citing Moore, *supra* note 247).
[250] EU, European Commission, "Comparison of the EU and US Approaches Towards Acidification, Eutrophication and Ground Level Ozone" in *Assessment of the Effectiveness of European Air Quality Policies and Measures,* Doc. B4-3040/2003/365967/MAR/C1 (2004), online: <http://ec.europa.eu/environment/archives/cafe/activities/pdf/case_study1.pdf> at 8.

even then the recovery will be slow. Acid rain . . . is cumulative and persistent.[251]

According to a 2001 study, "power plants must cut SO_2 emissions an additional 80% in order to allow sensitive waters and soils in the Northeast to recover."[252] In other words, the Acid Rain program is best seen as a success in terms of its ability to achieve a certain amount of pollution reduction with lower costs to industry than would have been the case with traditional command and control standards,[253] but not necessarily in terms of reducing pollution to a sufficient degree to allow ecosystems damaged by acid rain to return to their pre-disturbance condition.

Tradeable pollution rights mechanisms like the Acid Rain program in the United States are suitable for some environmental problems but not others. First, while they may work well for substances like sulfur dioxide and carbon dioxide, where the sources and environmental effects are relatively fungible, they are less appropriate in the case of the exchange of wetlands or other ecosystems, where no such fungibility among what is being traded exists.[254] In the case of toxic pollutants like mercury, which pose the problem of toxic hotspots that trading alone will not sufficiently address, trading is rarely if ever appropriate and must be instituted with extreme care.[255]

C. A Relatively Successful System-based Limit: *The Montreal Protocol on Substances that Deplete the Ozone Layer*

The most prominent example of moderately successful regulation that imposes limits on pollutants or activity in order to avoid unacceptable harm to ecological or biogeochemical systems is the international regime for controlling substances that deplete stratospheric ozone. Although this example may provide some basis for imagining a

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[251] Jerry Jenkins *et al. Acid Rain and the Adirondacks: A Research Summary* (Ray Brook, NY: Adirondacks Lakes Survey Corporation, 2005) at 1.
[252] Doremus and Hanemann, *supra* note 248 at 802.
[253] See U.S., Environmental Protection Agency, *Acid Rain Program* (2009) online: <http://www.epa.gov/airmarkets/progsregs/arp/basic.html> ("The General Accounting Office recently confirmed the benefits of this approach, projecting that the allowance trading system could save as much as $3 billion per year—over 50 percent—compared with a command and control approach typical of previous environmental protection programs.")
[254] See generally James Salzman and J.B. Ruhl, "Currencies and the Commodification of Environmental Law" (2000) 53 Stanford L.J. 607.
[255] Doremus and Hanemann, *supra* note 248 at 803.

broader, more comprehensive regime of systems-based governance mechanisms that would constitute ecological law, it is in many respects a special case.

The *Montreal Protocol*[256] was adopted in 1987, two years after the ozone hole over Antarctica was discovered.[257] The agreement sets forth a mandatory schedule of reductions in signatory countries of the production and consumption of substances that deplete stratospheric ozone, along with a process for conducting periodic scientific assessments of the control measures with a view to adjusting them as the signatories deem necessary.[258] The signatory parties have tightened the initial set of control measures six times, both by decreasing the allowable production and consumption of ozone depleting substances and by bringing additional ozone depleting substances under the Protocol. The parties have agreed through those adjustments to the phaseout of the consumption and production of chlorofluorocarbons [CFCs], halons, other fully halogenated CFCs, carbon tetrachloride, methyl chloroform and methyl bromide, with exceptions for "essential uses" and attenuated control schedules for developing countries.[259] For example, provisions were adopted in 2007 to phase out hydrochlorofluorocarbons [HCFCs], which had served as interim replacements for more destructive substances banned earlier but were nonetheless ozone-depleting.[260]

A potential problem with many international environmental agreements is enforcement and compliance. The *Montreal Protocol* initially left the matter of non-compliance for further elaboration, with a view to adopting an agreement on the

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[256] See *supra* note 90.
[257] UNEP, "Backgrounder: Basic Facts and Data on the Science and Politics of Ozone Protection" (2008) online: <http://ozone.unep.org/Events/ozone_day_2008/press_backgrounder.pdf>.
[258] *Montreal Protocol,* arts. 2, 6, 11.
[259] *Adjustments to the Montreal Protocol agreed by the Second, Fourth, Seventh, Ninth, Eleventh and Nineteenth Meetings of the Parties*; *London Amendment to the Montreal Protocol,* 29 June 1990 (entered into force 10 August 1992); *Copenhagen Amendment to the Montreal Protocol,* 25 November 1992 (entered into force 14 June 1994); *Montreal Amendment to the Montreal Protocol,* 17 September 1997 (entered into force 10 November 1999); *Beijing Amendment to the Montreal Protocol,* 3 December 1999 (entered into force 12 February 2002).
[260] UNEP, Ozone Secretariat, "Report of the Nineteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer" (2007) online: <http://ozone.unep.org/Meeting_Documents/mop/19mop/MOP-19-7E.pdf> at 33-34; Mark W. Roberts, "The Montreal Protocol Must Act to Prevent Global Climate Change While Restoring the Ozone Layer" (2009) 9 Sustainable Dev. L. & Pol'y 33 at 35.

methodology for determining and treating non-compliance at the first meeting of the parties.[261] At the second and fourth meetings of the parties, the parties agreed to an interim[262] and final procedure[263] whereby concerns regarding a party's implementation of its obligations to the *Montreal Protocol* may be brought to the attention of the Secretariat[264] by that party, by another party or parties or by the Secretariat itself. The Secretariat then refers the submission and the allegedly non-compliant party's reply to an Implementation Committee made up of ten parties. The procedure calls for the Implementation Committee to gather information and seek an amicable resolution of the matter and to report on the matter to the full meeting of the parties. The parties can then decide on steps to help bring a non-compliant party into full compliance, taking into account an agreed indicative list of steps that includes providing technical and other assistance, issuing cautions and suspending privileges and rights under the Protocol. Although the *Montreal Protocol* has been faulted for its lack of a rigorous, disuasive enforcement mechanism,[265] its consultative non-compliance procedure has been praised as a relatively effective international procedure for dealing with non-compliance.[266]

By 1999, the *Montreal Protocol* had resulted in an eighty-five percent global

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[261] *Montreal Protocol* Art. 8 ("The Parties, at their first meeting, shall consider and approve procedures and institutional mechanisms for determining non-compliance with the provisions of this Protocol and for treatment of Parties found to be in non-compliance.")
[262] UNEP, Ozone Secretariat, "Report of the Second Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer" (1990), Annex III, online: <http://ozone.unep.org/Meeting_Documents/mop/02mop/MOP-2-3e.pdf> at Annex III, 33-34.
[263] UNEP, Ozone Secretariat, "Report of the Fourth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer" (1992) online: <http://ozone.unep.org/Meeting_Documents/mop/04mop/4mop-15.e.pdf> at 13, Annex IV, Annex V.
[264] *Montreal Protocol* art. 12 (establishing a Secretariat for the protocol).
[265] See Leesteffy Jenkins, "Trade Sanctions: An Effective Enforcement Tool" (1993) 2:4 Rev. of Eur. Community & Intl. Envtl. L. 362 at note 26 and accompanying text. The parties made minor modifications to the non-compliance procedure at the tenth meeting of the parties. See UNEP, Ozone Secretariat, "Report of the Tenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer" (1998) online: <http://ozone.unep.org/Meeting_Documents/mop/10mop/10mop-9.e.pdf> at 23-24.
[266] See e.g. Alan E. Boyle, "Some Reflections on the Relationship of Treaties and Soft Law" (1999) 48 Int'l and Comparative L. Q. 901 at 910-911; O. Yoshida, "Soft Enforcement of Treaties: The Montreal Protocol's Noncompliance Procedure and the Functions of Internal International Institutions" (1999) 10 Colo. J. Int'l Envtl. L. & Pol'y 95 at 99-101, 139-141.

decrease in the production and consumption of ozone depleting substances.[267] By 2007, ozone-depleting substances had declined by ninety-five percent.[268] A 2007 report confirmed earlier findings that "the total combined abundance of [ozone depleting substances] is now declining not only in the lower atmosphere (troposphere), but also in the stratosphere [and that] peak [ozone depleting substances] levels were reached in the stratosphere in the late 1990s."[269] The report indicated that if compliance with the Protocol continued, the levels of ozone in the stratosphere would return to their pre-1980 levels, when no hole in the ozone layer existed, by 2050 at mid-latitudes and a decade or two later at the poles. Because of this apparent reversal of the trend toward depletion of stratospheric ozone, the Rockström group considers stratospheric ozone to be "a good example where concerted human effort and wise decision making seem to have enabled us to stay within a planetary boundary."[270]

While many commentators see the *Montreal Protocol* as a relatively successful international endeavor to address a systemic environmental problem,[271] some also see clear reasons why its success has not been repeated with other global problems like climate change. Peter Victor explains:

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[267] UNEP, Ozone Secretariat, "Report of the Eleventh Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer" (1999) online: <http://ozone.unep.org/Meeting_Documents/mop/11mop/11mop-10.e.pdf> at 2.

[268] Achim Steiner, "20th Anniversary of the Protocol and International Day for the Preservation of the Ozone Layer" (Speech at the Opening of the 19th Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 16 September 2007) online: <http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=518&ArticleID=5667&l=en>. More specifically, developed countries have phased out over 95 percent of ozone depleting substances covered by the Protocol, while developing countries have phased out 50 to 75 percent of those substances. Roberts, *supra* note 260 at 33.

[269] UNEP, Ozone Secretariat, *Synthesis Report of the 2006 Assessments of the Scientific Assessment Panel, the Environmental Effects Assessment Panel and the Technology and Economic Assessment Panel*, UNEP/OzL.Pro.WG.1/27/3 (June 2007) online: <http://ozone.unep.org/Meeting_Documents/oewg/27oewg/OEWG-27-3E.pdf> at 4.

[270] Rockström *et al.*, *supra* note 4 at 15.

[271] See e.g. Sunstein, *supra* note 194 at 73; Roberts, *supra* note 260 at 33; N. Brian Winchester, "Emerging Global Environmental Governance" (2009) 16:1 Ind. J. Global Legal Stud. 7 at 11, 13; Daniel C. Esty, "Revitalizing Global Environmental Governance for Climate Change" (2009) 15 Global Governance 427 at 427; Rockström *et al.*, *supra* note 4 at 15. But see Roberts, *ibid*. at 33, 35 (noting that the Protocol does not cover the serious problem of "banks" of ozone depleting substances in "discarded stockpiles, equipment, and products" or hydrofluorocarbons that are powerful greenhouse gases); Hubert Reeves, *Mal de Terre* (Paris: Éditions du Seuil, 2005) at 54-55 (expressing concern that global warming could impede recovery of the ozone layer).

> Several factors led to this unusually rapid response from the international community to the problem of CFCs once it was discovered. These included the scientific consensus on the chemistry of CFCs in the stratosphere, heightened public awareness, the availability of profitable and less harmful substitute chemicals such as HFCs and HCFCs (which are also potent greenhouse gases), and the small number of producers, making regulations easy to enforce, though a black market in CFCs developed undermining for a time the new regulations.[272]

As Cass Sunstein sees it, in light of these mostly favorable factors, the United States—a key country in the success of the protocol—concluded that "the monetized benefits of the Montreal Protocol dwarfed the monetized costs."[273] The Protocol's relative success has also been attributed to the elaboration of separate tracks for developed and developing countries,[274] and to the creation of a "Multilateral Fund [which] has played a pivotal role in facilitating the transfer of technology and enhancing capacity building and development capabilities [in developing countries]."[275] Although scientific consensus on the role of CFCs and other substances in depleting the stratospheric ozone layer was quite strong, it was not absolute, and the *Montreal Protocol* therefore can be seen as a relatively successful application of the precautionary principle so as to avoid catastrophic systemic effects[276] on human health and the global environment.[277]

The *Montreal Protocol* has been successful in ways that TMDLs, NAAQSs, control of greenhouse gases in the United States and the critical levels and loads approach

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[272] Victor, *supra* note 105 at 76 (citation omitted). See also Winchester, *ibid*. at 11, 13 (noting in addition that the United States, the largest producer of CFCs, was a strong supporter of the Protocol because it had already banned CFCs in aerosols and its manufacturers had developed substitutes for CFCs).

[273] Sunstein, *supra* note 194 at 73. By contrast, Sunstein posits that the United States has come to the opposite conclusion with respect to climate change. See *ibid*. at 73-75.

[274] See Anne Lucia Plein, "A Story Between Success and Challenge: 20th Anniversary of the Montreal Protocol" (2007) N.Z. J. Envtl. L. 67 at 75-76.

[275] Roberts, *supra* note 268 at 34.

[276] UNEP, Environmental Effects Assessment Panel, *Environmental Effects of Ozone Depletion: 2010 Assessment, Interactions of Ozone Depletion and Climate Change* (2010) online: <http://ozone.unep.org/Assessment_Panels/EEAP/EEAP_Executive_Summary_1_Nov_2010.pdf > Executive Summary; UNEP, Environmental Effects Assessment Panel, *Environmental Effects of Ozone Depletion: 2006 Assessment* (2006) online: <http://ozone.unep.org/Assessment_Panels/EEAP/eeap-report2006.pdf>. Both reports discuss impacts of ozone depletion on human health, such as increased skin cancer and cataracts, and on ecosystems, such as contributions to global warming and changes in behavior of a wide variety of organisms.

[277] See Sunstein, *supra* note 194 at 73.

in Europe have not. Specifically, although at least some of those other mechanisms have identified thresholds on the tolerance of receptor systems to the effects of pollutants, they have not yielded effective controls on the industrial and other processes that cause those effects. By contrast, the prevailing view appears to be that the *Montreal Protocol* is on a predictable track to eliminating ozone-depleting substances so as to return the stratospheric ozone layer to its pre-disturbance condition within this century.

D. Imagining Strict Application of System-based Limits Reveals Legal and Socio-economic Reforms Needed to Avoid Catastrophe

What if the system-based limits that TMDLs, NAAQSs, a maximum global temperature increase of two degree Celsius and critical loads under the *LRTAP* represent were strictly respected? In other words, what if they were seen to establish the ecological boundary within which the human enterprise must operate? Whereas Slavoj Zizek proposes immersion in the eventual catastrophe of ignoring ecological limits and working back from that unacceptable future so as to imagine how catastrophe could be avoided,[278] another option is to envision a future in which ecological limits frame the context for human activity.

The ecological side of this vision is axiomatic. The human and ecological systems that these various legal mechanisms are designed to protect are functioning with negligible, or at least systemically acceptable, disturbance due to the pollutants or activities of concern. Waterbodies in the United States are in compliance with all water quality standards, which depending on the designated uses means a quality that is suited (albeit according to a human perspective) for the social-ecological system in which the waterbodies are found. In most cases, this implies a reasonable degree of biological and ecological integrity. The global average temperature increase is less than two degrees warmer relative to the beginning of the industrial era, and so climate is maintained within a safe planetary threshold. Thus, the relatively stable climate conditions of the Holocene still exist, even if a considerable amount of human adaptation is required. The terrestrial and aquatic ecosystems of the eastern United States and Canada and other regions affected by acid rain are headed toward full recovery to their pre-acidification condition,

[278] See *supra* note 42 and accompanying text.

with all the attendant benefits for biodiversity. The ecosystems of Europe are in full recovery from the eutrophication, acidification and other ecosystemic harms that the *LRTAP* was designed to address.

Meanwhile, what has transpired on the social, economic and political side of this vision? To meet ecological limits for mercury in downwind aquatic systems, for greenhouse gas emissions and for sulfur dioxide, fossil fuel fired power plants in the United States either have been replaced by renewable or alternative energy sources or have installed new and effective pollution control technologies such as carbon capture and storage. A new wave of economy-wide energy efficiency measures has swept in. Jobs lost in coal mining have been counterbalanced by gains in "green collar"[279] jobs and expansion of job sharing and other innovative forms of employment. Agricultural sources of air emissions and nonpoint source water pollution, which contributed significantly to exceedances of TMDLs and critical loads under the *LRTAP*, have been brought under control through decreases in fertilizer use and industrial fish, meat and dairy production.

In short, the project of ecological economics and ecological law has brought about answers to the political, economic and social stalemates that have allowed the aggregate ecological costs of the global economy to rise dangerously past ecological thresholds. On realizing that both human and ecological communities fare better in a world where these boundaries are respected, citizens have elected representatives who have been able to overcome past political impasses to the enactment and implementation of legal mechanisms that ensure rigorous respect for ecological limits. Innovative and equitable approaches to labor, energy, transportation, buildings, agriculture and population planning have allowed the economy to adjust to this reality. Rich countries have downsized, poor countries have achieved modest economic growth and all countries are significantly more self-sufficient than in 2010. The assumption that investing in measures that will ensure that ecological boundaries are respected is less economically

[279] See generally Van Jones, *The Green Collar Economy: How One Solution Can Fix Our Two Biggest Problems* (New York: HarperOne, 2008).

efficient than investing in other things with higher rates of economic return,[280] so as to pay for the ecological damage later, has been resigned to the dustbin of history.

We have entered the era of "pay as you go" for environmental harms, where payment takes the form of avoidance, restoration or other measures that prevent use of the Earth's life support capacity faster than in can regenerate. For the examples included here as well as for a comprehensive set of interrelated ecological boundaries, the rule of ecological law has begun to maintain the human and ecological communities of life within a space that allows humans and other life to flourish.

Part III. The Current Global Institutional Architecture Is Not Equipped to Maintain the Human Enterprise Within Ecological Limits

Systems-based legal mechanisms that contain human use of the ecosphere within ecological limits and fulfill a vision of a more ecological, just and peaceful world will need a place to live. The architecture for the rule of ecological law must include an institutional structure consisting of "a set of principles, rules, norms and procedures" along with physical and organizational infrastructure.[281] The institutional challenge is enormous, because the architecture must encompass an integrated system from the global to the local level, addressing complex dynamics of temporal and spatial scale and also shifting the current primacy given to creation of monetary wealth to considerations of the ecological limitations of the economy. The existing global complex of environmental institutions, from the global to the local level, has hardly prevented global ecological threats from worsening, and they seem unlikely to do so without radical reform.[282]

This Part presents an examination of the structural inadequacy of the existing global institutional architecture for maintaining the human enterprise within ecological limits and for promoting conditions for the flourishing of life on Earth. It begins with an overview of these structural failures, which impede establishment of the rule of ecological law. It then presents a seminal example of the ineffectiveness of global arrangements for

[280] See *supra* note 132 and accompanying text.
[281] Maria Ivanova, "UNEP in Global Environmental Governance: Design, Leadership, Location" (2010) 10:1 Global Environmental Politics 30 at 37.
[282] *Ibid.* at 30.

adjusting human affairs to ecological constraints: the United States' approach to trade and the environment in regional or bilateral trade agreements, with a focus on the *North American Agreement on Environmental Cooperation* and the Commission for Environmental Cooperation.

A. Current International and National Environmental Law Regimes and Infrastructure Are Structurally Deficient

Tseming Yang and Robert Percival describe the features of an emerging field of "global" environmental law that transcends traditional understandings of international, domestic and local law.[283] They describe global environmental law as follows:

> Global environmental law is the set of legal principles developed by national, international, and transnational environmental regulatory systems to protect the environment and manage natural resources. As a body of law, it is made up of a distinct set of substantive principles and procedural methods that are specifically important or unique to governance of the environment across the world. It includes: (1) public international environmental law, commonly used to refer to the set of treaties and customary international legal principles governing the relations between nations; (2) national environmental law, which describes the principles used by national governments to regulate the behavior of private individuals, organizations, and subnational governmental entities within their borders; and (3) transnational law, which describes the set of legal principles used to regulate the cross-border relationships between private individuals and organizations.[284]

Prominent in this notion of global environmental law are the precautionary principle and the "polluter pays" principle, along with widespread use of environmental impact assessments and permit systems for polluters, all of which support the central substantive goals of protecting human health and the integrity of ecosystems.[285]

Yang and Percival provide a comprehensive description of the global complex of soft and hard environmental legal regimes, which are implemented through both public and private initiatives.[286] Yet, this emerging global environmental law reflects a kind of schizophrenia in the law as it regards the most pressing global ecological challenges: an

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[283] Tseming Yang and Robert V. Percival, "The Emergence of Global Environmental Law" (2009) 36 Ecology L. Q. 615.
[284] *Ibid.* at 616-617.
[285] *Ibid.* at 623.
[286] *Ibid.* at 623-26 (describing the network of international, national and sub-national environmental laws, as well as the corporate rules and other private initiatives, that influence global environmental law).

increasingly interlinked network of approaches for dealing with some aspects of environmental stress on one hand, and an unrelenting failure to deal with the most momentous, aggregate environmental problems on the other. Yang and Percival's analysis invites an assessment of which features of global environmental law are leading to and which are impeding the development of a global legal architecture that supports effective legal limits on human use of the Earth's ecocapacity. Overall, global environmental law as these authors describe it falls short.

The principal problem is that global environmental law is essentially the handmaiden of growth-driven economic globalization.[287] Yang and Percival present global environmental law as a counterpart to sustained economic growth, which they appear to endorse without contemplating whether such growth is tenable in light of the growing global ecological crisis.[288] Although they describe well the emerging ways in which environmental legal regimes, norms, procedures and policy are transcending traditional notions of state-led international law, they neglect to situate global environmental law within the broader legal and institutional context, with its own emerging trends, that envelopes the increasingly globalized economy. In noting "a growing convergence around a few principal approaches to environmental regulation,"[289] they fail to ask whether those approaches are capable of reining in the enormous drive to unleash financial capital "to mobilize global resources as fodder for industrial metabolism,"[290] with adequate attention to how the aggregate scale of the economy measures up against global ecological limits.

To remove obstacles and find openings for the integration of ecological law, a comprehensive review is necessary of this broader legal infrastructure from the global to the local level. A prime candidate for such review is the global trade regime. Yang and Percival contend that trade liberalization, as reflected for example by the *North American*

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[287] Further discussion of the dominance of trade over environment is presented at pages 72-74 and 79-95, below.
[288] Yang and Percival, *supra* note 283 at 616.
[289] *Ibid.* at 616.
[290] Pelletier, *supra* note 33 at 220.

Free Trade Agreement [*NAFTA*][291] and its side agreements, has promoted legislative reforms that protect the environment.[292] They note that following the adoption of the environmental side agreement to *NAFTA*, which purported to address a range of trade-related environmental concerns,[293]

> post-NAFTA trade liberalization negotiations with other nations, ranging from Jordan to Peru, have led the United States to press for adoption of environmental provisions within those agreements. In other words, trade liberalization can also be used as a tool to spur greater environmental protection.[294]

Yet, the environmental provisions contained in these trade agreements or their environmental side agreements can also be seen as lost opportunities, if the assumption that they increase environmental protection is not rigorously assessed on the post-adoption record, or is called into question based on such review, and they are nonetheless duplicated in one trade agreement after the other. Once in place, they could relieve the pressure to establish stronger, more effective rules. This is in fact what has occurred. The environmental provisions of many recent trade agreements in the Americas are part of an overall global approach that promotes trade to generate growth,[295] with relatively hard legal provisions to protect investments and punish protectionism but only soft mechanisms aimed at protecting the environment.[296] Although modern trade agreements typically give precedence to at least some multilateral environmental agreements in the case of conflicting provisions or interpretations,[297] in general multilateral environmental

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[291] *North American Free Trade Agreement Between the Government of Canada, the Government of Mexico and the Government of the United States,* 17 December 1992, Can T.S. 1994 No. 2, 32 I.L.M. 289 (entered into force 1 January 1994) [*NAFTA*].
[292] Yang and Percival, *supra* note 283 at 643
[293] See *infra* note 342 and accompanying text.
[294] Yang and Percival, *supra* note 283 at 643.
[295] Rees, *supra* note 38 at 251; Pelletier, *supra* note 33 at 224-25.
[296] See pages 88-95, below.
[297] See e.g. *NAFTA* art. 104 (providing that only the *Convention on International Trade in Endangered Species of Wild Fauna and Flora*, done at Washington, March 3, 1973, as amended June 22, 1979; the *Montreal Protocol on Substances that Deplete the Ozone Layer*, done at Montreal, September 16, 1987, as amended June 29, 1990; the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal*, done at Basel, March 22, 1989, on its entry into force for Canada, Mexico and the United States; and two border-related bilateral agreements between the U.S. and Canada and the U.S. and Mexico shall prevail over provisions of the *NAFTA* to the extent of inconsistency).

agreements are relatively weak, unenforceable and grounded in a hierarchy of values that allow political and economic concerns to trump environmental protections.[298]

Under the rule of ecological law, the opposite would be true. Regulation of trade would be oriented at the outset toward driving down the total ecological footprint of trade, using the principles that underlie, for example, the green building movement: minimize demand for energy, water and resources; maximize renewable, low-carbon energy; maximize reuse and recycling of materials; and favor local sourcing over long-range transport of materials unless it does not minimize ecological footprint.[299]

The prevailing international and national regimes of property rights constitute another area where review against structural criteria for maintaining the economy within ecological bounds is warranted.[300] In many respects, property rights serve as the glue that keeps the globalized economic system together as it is currently formulated. The rule of ecological law would call into question longstanding notions of property rights rooted in the Anglo-American legal tradition. On one hand, starting with Garret Hardin's proposal for addressing the Tragedy of the Commons, property rights have been cast as one solution to the overexploitation of some kinds of open access resources.[301] The idea is that "[w]ith property, each individual harvests the rewards of her care and effort in the management of her resources, just as she suffers the losses from her sloth and poor management; those features of property make her vastly more likely to exercise diligence and prudence about the things she owns."[302] At the extreme, property is associated with a paradise of "peaceful, fruitful effort" that drives the "grand bustle of trade and labor [by

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[298] See Pelletier, *supra* note 33 at 221-222 (making this argument generally and giving the *Kyoto Protocol* and the *LRTAP* as examples of governance regimes in which "politically feasible reduction targets achieved through problem shifting end-of-pipe technologies are favoured over precautionary solutions, fundamental changes in production systems, and hard limits on total allowable emissions").
[299] See Commission for Environmental Cooperation, Secretariat Report to Council Under Article 13 of the North American Agreement on Environmental Cooperation, *Green Buildings in North America: Opportunities and Challenges* (Montreal, 2008) [CEC Green Building Report] at 16-19.
[300] See *supra* note 49 and accompanying text.
[301] Garrett Hardin, "The Tragedy of the Commons" (1968) 162 Science 1243 at 1245; Carol M. Rose, "The Several Future of Property: Of Cyberspace and Folk Takes, Emission Trades and Ecosystems" (1998) 83 Minn. L. Rev. 129 at 129.
[302] *Ibid*., at 130-131.

which] we all grow richer."[303] By this view, the more we privatize and commodify, the better stewards we will be—and the richer, too. This is the prevailing view. "From the demise of the authoritarian socialist regimes, we have taken the lesson that modern economies need not the centralization of direct governmental control, but rather the decentralization associated with property and contract."[304]

On the other hand, a property-based approach does not easily apply to public goods like clean air, a safe climate, abundant biodiversity and other environmental values, and in fact can make them worse.[305] The tendency of the property owner to have "difficulty seeing why it is not his natural right to muddy the waters flowing past his door"[306] is at the heart of the growing global ecological crisis. The increasing trend toward monetization of ecosystem services and natural capital exacerbates[307] this problem by greasing the skids for transactions in which property rights can be exchanged. The incremental "muddying" of the global economy's innumerable "waters" by each of the myriad consumers and producers, big and small, individual or corporate, who make up the human enterprise adds up to an aggregate level of ecological degradation—a surpassing of global boundaries—that Yang and Percival's global environmental law is unable to address. Indeed, if one considers the negative environmental externalities of the global economy in the aggregate, the strangeness of the artificial construct by which one species allows itself to assert ownership over land and other interdependent elements of Earth's commonwealth of life becomes starkly evident.[308]

No system of property rights is absolute, and longstanding principles of common law, along with constitutional and positive law, put restrictions on the use of property. For example, the use of property to create nuisances or trespasses may be enjoined or subjected to claims for damages, and the United States Supreme Court has said that

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[303] *Ibid*., at 131.
[304] *Ibid.*, at 130.
[305] Hardin, *supra* note 301 at 1245.
[306] *Ibid*.
[307] See pages 31-34, above.
[308] See Berry, *supra* note 40 at 61; Pelletier, *supra* note 33 at 221 (describing the roots in the Enlightenment and the Age of Reason of the subject-object dualism between humans and "non-human nature," such as "Locke's prescription that a just and efficient social order requires enclosure of the commons and state-guaranteed property rights").

compensable property rights exclude protection from liability for common law infractions and other limitations that inhere in property title.[309] On the other hand, in the American system and others, government restrictions on property rights, including environmental regulations, can trigger constitutional entitlements to just compensation if they deprive the property of all but token economic value.[310] Regulatory measures that harm the value of foreign investments can also trigger investors' claims for compensation under recent United States trade agreements.[311] These rules open avenues for forcing public officials into settlements from public funds,[312] which can chill the willingness to regulate.[313]

In a legal and policy environment in which maintaining economic activity within ecological boundaries is paramount, property rights will likely have to be understood as incorporating an expanded set of responsibilities and regulatory restrictions for which compensation would not be due.[314] This could necessitate a review of constitutional provisions. For example, in the United States, to what extent can constitutional property rights be interpreted so as to limit the right to use property in ways that undermine the shared ecological commonwealth? Can the Commerce Clause[315] of the United States Constitution open the way for a more thorough integration of ecological law into the United States' federalist legal structure, with necessary restrictions on private property? Or, is the United States Constitution incompatible with the rule of ecological law?

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[309] *Palazzolo v. Rhode Island,* 533 U.S. 606 at 629 (2001).
[310] See *Lucas v. South Carolina Coastal Council,* 505 U.S. 1003 at 1015 (1992); *Agins v. City of Tiburon,* 447 U.S. 255 at 261 (1980).
[311] See e.g. *NAFTA* ch. 11; *DR-CAFTA* ch. 10.
[312] See Marcia J. Staff and Christine W. Lewis, "Arbitration Under NAFTA Chapter 11: Past, Present, and Future" (2003) 25 Houston J. of Int'l L. 301 at 319 (discussing Canada's $13 million settlement of Ethyl Corporation's claim that Canada's ban on imports and interprovincial trade of methylcyclopentadienyl manganese tricarbonyl [MMT] violated provisions of *NAFTA* Chapter 11); Douglas M. Kmiec, "At Last, the Supreme Court Solves the Takings Puzzle" (1995) 19 Harvard J. L. & Pub. Pol'y 147 at 151 (noting South Carolina's settlement for $1,575,000 of *Lucas v. South Carolina Coastal Council, supra* note 286, involving a property owner's claims that the state's refusal to allow him to build homes on a barrier island because it would constitute a common law nuisance effected a taking of his property requiring just compensation).
[313] See Staff and Lewis, *ibid.* at 320; J. Peter Byrne, "Ten Arguments for the Abolition of the Regulatory Takings Doctrine" (1995) 22 Ecology L. Q. 89 at 90 ("[Regulatory takings] doctrine protects economic interests in the development of land against otherwise valid enactments of the democratic process, thereby inhibiting experimentation with new environmental initiatives.").
[314] See generally Byrne, *ibid.*
[315] U.S. Const. art. I, § 8, cl. 3.

Another area where reforms of the current institutional infrastructure could help instill the rule of ecological law is environmental impact assessment [EIA]. In the many legal systems that have followed the example of the United States in adopting the EIA requirement in *NEPA*,[316] EIA is one of the broadest links between environmental protection and the broader legal and policy infrastructure. EIA laws and similar impact assessment regimes require analysis of impacts related to resource and energy use, but these laws are by and large procedural only.[317] Moreover, judicially approved notions of foreseeability and concreteness constrain consideration of alternatives to development proposals and of cumulative and indirect impacts.[318] Even with strategic EIA requirements, whereby impacts are evaluated at a broad policy or programmatic level, the full picture can fall through the legal cracks.[319] More often, EIA is undertaken in detail at the project level, so that the cumulative impacts are isolated from the broader perspective. Further, monitoring of impacts following the completion of an EIA is notoriously weak,[320] at least in the United States, where such monitoring is not always mandatory and is rarely conducted[321] and where the Supreme Court has limited the ability to challenge implementation of a decision based on subsequent monitoring.[322] Yet, supported with

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[316] *NEPA* § 102(2)(C), 42 U.S.C. § 4332(2)(C)(2006).
[317] See e.g. *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332 at 350 (1989) (noting that "it is now well settled that NEPA itself does not mandate particular results, but simply prescribes the required process").
[318] See e.g. *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc.,* 435 U.S. 519 at 551-52 (1978)(limiting the scope of alternatives that agencies are required to consider); *Robertson V. Methow Valley Citizens Council, ibid.* at 355 (noting emphasis on "reasonably foreseeable" impacts); *Center for Biological Diversity v. Nat'l Hwy. Safety Admin.,* 538 F.3d 1172 at 1215-17 (9th Cir. 2008)(discussing NEPA requirement to consider "reasonably foreseeable" cumulative impacts).
[319] See *Kleppe v. Sierra Club*, 427 U.S. 390 at 412-15 (1976)(cutting short the ability of environmental plaintiffs to challenge broad programmatic actions that affect the environment).
[320] See Madeline June Kass, "A NEPA Climate Paradox: Taking Greenhouse Gases Into Account in Threshold Significance Determinations" (2009) 42 Ind. L. Rev. 47 at 84 (referring to the lack of a monitoring requirement as NEPA's Achilles' heel).
[321] See 40 C.F.R. § 1505.3 ("Agencies *may* provide for monitoring to assure that their decisions are carried out and should do so in important cases.")(emphasis added). However, the Council on Environmental Quality's *NEPA* regulations require enforcement and monitoring "where applicable" for mitigation measures that are formally adopted in a record of decision that is based on an environmental impact statement. 40 C.F.R. § 1505.2(c).
[322] See *Norton v. Southern Utah Wilderness Alliance,* 542 U.S. 55 at 72-73 (2004)(holding that the *NEPA* process for the adoption of a land use management plan of the Bureau of Land Management ends with the adoption of the plan, precluding *NEPA* challenges to the implementation of the plan).

adequate research and monitoring, and contained with an infrastructure for ecological law that includes substantive limitations that build off of impact assessments, EIA has a role to play in maintaining the human economy within global ecological boundaries.

The legal regime that accords with ecological economics and global ecological boundaries will undoubtedly impose on human activities limitations that do not exist under the current legal regimes in most if not all of the developed world. A system in which ecological restraints envelope the economy requires the collectivity of economic actors to limit their choices so that, taken together, they respect those ecological limits. Yet, in market economies, the freedom to spend on activities and maximize personal wealth, often regardless of their ecological costs, is paramount.[323] The reward that a well-compensated person expects is not just money; it is more specifically what that money can purchase: often, one or more large homes, jet-fueled vacations in far-off places, and a host of other material and energy intensive luxuries. This legally protected consumption, rooted in strong notions of property rights and personal freedom, exacts ecological costs that are collectively shared and often incremental, diffuse and delayed and consequently external to the economic and legal infrastructure. Analyses of the trade flows of material and energy resources indicate that their consumption in high-income countries contributes significantly to biodiversity losses that are most severe in low- and middle-income countries.[324] Our current institutional infrastructure does little to address such ecological stresses.

B. A Seminal Example of Ineffective Institutions: The United States' Outdated Approach to Trade and Environment

International trade, as the foregoing section should make clear, is a particularly appropriate venue for examining the potential for the rule of ecological law to transform the human-Earth relationship. As William Rees has astutely observed, "[a]ll major national governments and mainstream international agencies are united in a vision of global development and poverty alleviation centered on unlimited economic expansion

[323] Rees, *supra* note 38 at 251.
[324] *LPR 2010*, *supra* note 25 at 79. See also Jonathan A. Foley *et al.*, "Our Share of the Planetary Pie" (2007) 104:31 Proceedings of the Nat'l Ac. of Sci. 12585.

fueled by open markets and more liberalized trade."[325] This reliance on free markets and trade derives from a fundamental belief at the heart of neo-classical economics that the capacity of the ecosphere places no constraints on the economy and that natural resources and ecosystem services are infinitely substitutable as the economy expands.[326]

The resulting modern system of globalized trade, in which financial capital flows across borders virtually unimpeded, has become a mad race in which

> balanced trade to the mutual benefit of [trade] partners is no longer the objective. This is because much of the globally competitive scramble for international markets is actually driven by national and corporate debt, the servicing of which greatly reduces internal purchasing power. All nations are thus engaged in a blindly compulsive drive "to maximize exports, minimize imports and *create a trade imbalance*" in order to increase the amount of debt-free money in domestic circulation.[327]

Yet, not all countries can be net exporters, because globally exports must balance imports. The result is a system of trade for trade's sake, replete with unnecessary exchange of goods and services that could be sourced locally—or eliminated—and with lower social and environmental impacts.[328] In the United States (as elsewhere), the predominant concern driving the discourse on trade is that other countries or regions, such as Canada and the European Union, will outcompete the United States by developing trading relationships with potential trading partners, like Colombia and other Latin American countries, before the United States does.[329] As Rees explains,

> [t]he intense competition bids down prices, encourages overproduction and consumption, undermines local/regional firms and economies, and eliminates surpluses needed for sound resource management. Meanwhile, the exploding demand for transportation, much of it nonessential, burns up one third of the world's precious oil supplies and contributes to climate change.[330]

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[325] Rees, *supra* note 38 at 251.
[326] *Ibid.* at 252-253; Douglas A. Kysar, "Law, Environment, and Vision" (2002) 97 Nw. U.L. Rev. 675 at 676-77, 680.
[327] *Ibid.* at 257.
[328] *Ibid.* at 258.
[329] See Sewell Chan, "Obama Plans to Step Up Talks on Free Trade Pacts" *The New York Times* (9 February 2011), online: <http://www.nytimes.com/2011/02/10/business/10trade.html?ref=politics> (reporting that the new chairman of the House Ways and Means Committee was pushing for trade agreements with Colombia and Panama so that the United States will not lose market share to other countries like Canada and the European Union, which are "mov[ing] forward dramatically" on trade with Latin America).
[330] Rees, *supra* note 38 at 258.

Studies of the material and energy flows in the global trading system bear out concerns about the environmental costs of international trade. The total human ecological footprint attributed to international trade is estimated to have risen from eight percent in 1961 to forty percent in 2005.[331] The growing disconnect between where the total biomass appropriated for human ends is harvested or otherwise reduced through land use change or lost productivity and where it is consumed further highlights how global trade contributes to patterns of consumption that diminish the Earth's life support capacity.[332]

Trade policy in the United States is a key driver of this global trade regime. The current objective for the environmental agenda within the Office of the United States Trade Representative is "to leverage trade negotiations and relationships to pursue environmental achievements . . . across a variety of multilateral, regional and bilateral initiatives, including the World Trade Organization (WTO), APEC, free trade agreements (FTAs), trade and investment framework agreements (TIFAs) and commodity trade agreements."[333] The general idea—or rather, leap of faith—behind this agenda is to harness the international market in goods and services to promote environmental improvements.[334] The current basic structure of the legal and institutional arrangements around trade and environment in the United States has not changed significantly since the adoption of the *NAFTA* and its environmental and labor side agreements in 1992 and 1993. This hastily assembled[335] set of mechanisms is outdated in light of the accumulating information regarding the momentum of global ecological impacts from the globalized human economy. The rule of ecological law will require a radically redirected international trade and finance regime.

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[331] *LPR Report 2008*, *supra* note 4 at 30.
[332] See generally Karl-Heinz Erb *et al*., "Embodied HANPP: Mapping the Spatial Disconnect Between Global Biomass Production and Consumption" (2009) 69:2 *Ecological Economics* 328; Foley et al., *supra* note 324.
[333] U.S., Trade Representative. *Environment* (2010), online: <http://www.ustr.gov/trade-topics/environment>.
[334] See e.g. Commission for Environmental Cooperation, *Report of the Executive Director at the Regular Session of Council* (2001), online: <http://www.cec.org/Storage/44/3610_EDREP-E_EN.PDF>. at 2-3.
[335] See Pierre Marc Johnson and André Beaulieu, *The Environment and NAFTA: Understanding and Implementing the New Continental Law* (Washington DC: Island Press, 1996) at 30-34.

The basic formula for incorporating environmental concerns in United States trade agreements is to include environment chapters (or earlier, environmental side agreements) that "include obligations on effective enforcement of laws, non-derogation of environmental protections in encouraging increased trade or investment, domestic procedural protections, and promotion of public participation in environmental matters."[336] This formula is codified in the *Trade Promotion Authority Act of 2002*, which sets forth overall trade negotiating objectives. One overarching objective is to seek obligations "to ensure that trade and environmental policies are mutually supportive and to seek to protect and preserve the environment and enhance the international means of doing so, while optimizing the use of the world's resources."[337] Another is "to seek provisions in trade agreements under which parties to those agreements strive to ensure that they do not weaken or reduce the protections afforded in domestic environmental and labor laws as an encouragement for trade."[338] Of course, another negotiating objective is to "foster economic growth, raise living standards, and promote full employment in the United States and to enhance the global economy."[339]

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[336] U.S., Trade Representative. *Environment* (2010), online: <http://www.ustr.gov/trade-topics/environment>.

[337] *Trade Act of 2002* § 2102(a)(5), 19 U.S.C. § 3802(a)(5) (2006).

[338] *Trade Act of 2002* § 2102(a)(7), 19 U.S.C. § 3802(a)(7) (2006).

[339] *Trade Act of 2002* § 2102(a)(4), 19 U.S.C. § 3802(a)(4) (2006). More specifically, the Act provides as follows:

> (11) LABOR AND THE ENVIRONMENT.—The principal negotiating objectives of the United States with respect to … the environment are—
>
> (A) to ensure that a party to a trade agreement with the United States does not fail to effectively enforce its environmental or labor laws, through a sustained or recurring course of action or inaction, in a manner affecting trade between the United States and that party after entry into force of a trade agreement between those countries;
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> (B) to recognize that parties to a trade agreement retain the right to exercise discretion with respect to investigatory, prosecutorial, regulatory, and compliance matters and to make decisions regarding the allocation of resources to enforcement with respect to other labor or environmental matters determined to have higher priorities, and to recognize that a country is effectively enforcing its laws if a course of action or inaction reflects a reasonable exercise of such discretion, or results from a bona fide decision regarding the allocation of resources, and no retaliation may be authorized based on the exercise of these rights or the right to establish domestic labor standards and levels of environmental protection;
>
> …
>
> (D) to strengthen the capacity of United States trading partners to protect the environment through the promotion of sustainable development;
>
> (E) to reduce or eliminate government practices or policies that unduly threaten

As they relate to the environment, these provisions essentially outline the architecture of the *North American Agreement on Environmental Cooperation* [*NAAEC*],[340] which was adopted in 1993 as a side agreement to the *NAFTA*.[341] The *NAAEC* was intended to address concerns that liberalized trade among Canada, Mexico and the United States would increase environmental impacts due to the scale of increased economic activity, create pollution havens for polluting industries and trigger a "race to the bottom" by which the governments would weaken environmental regulations or enforcement in order to attract economic benefits of trade.[342] At the time of its adoption, promoters of the *NAFTA* called it the most environmental trade agreement to date.[343] The *NAAEC* attempts to respond to environmental concerns by 1) requiring the three *NAFTA* parties to seek to maintain high levels of environmental protection, to effectively enforce their environmental laws and regulations and to ensure access to remedies for environmental harms consistent with due process;[344] 2) establishing a Commission for Environmental Cooperation [CEC] to oversee trinational cooperation to improve the North American environment;[345] 3) promoting transparency and public participation in North American environmental protection;[346] 4) allowing individuals and non-government organizations to file complaints regarding weak environmental enforcement

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sustainable development;

(F) to seek market access, through the elimination of tariffs and nontariff barriers, for United States environmental technologies, goods, and services; and

(G) to ensure that labor, environmental, health, or safety policies and practices of the parties to trade agreements with the United States do not arbitrarily or unjustifiably discriminate against United States exports or serve as disguised barriers to trade.

Trade Act of 2002, Pub. L. 107-210 (6 August 2002), § 2102(b)(11), 116 Stat. 933, 1000; 19 U.S.C. § 3802(b)(11).

[340] 14 September 1993, 32 I.L.M. 1480 (entered into force 1 January 1994)[*NAAEC*].

[341] See Johnson and Beaulieu, *supra* note 335 at 30-34.

[342] See *ibid*. 23-24, 36-37, 40-47, 68, 245-46; Joseph A. McKinney, *Created from NAFTA: The Structure, Function, and Significance of the Treat's Related Institutions* (Armonk, NY: M.E. Sharpe, 2000) at 90.

[343] See Johnson and Beaulieu, *ibid.* at 66; Greg Block, "Trade and Environment in the Western Hemisphere: Expanding the North American Agreement on Environmental Cooperation into the Americas" (2003) 33 Envtl. L. 501 at 503.

[344] *NAAEC* arts. 3 and 5-7.

[345] *NAAEC* art. 8.

[346] See especially *NAAEC* arts. 1(h), 9(4), 10(2)(f), 10(5)(a), 16.

by one of the *NAFTA* governments;[347] and 5) establishing a dispute resolution process allowing one of the countries to complain about a pattern of weak environmental enforcement by another country.[348] A comparison of this array of mechanisms with the *Trade Promotion Authority Act of 2002* makes clear that the trade and environment formula in the United States is virtually unchanged since the adoption of *NAFTA* and the *NAAEC*, despite the instrumental role of globalized trade in the growing ecological crisis.

Is this legal and institutional formula adequate to the task of harnessing global markets in goods, services and financial capital so as to steer the economy toward decreasing the global human ecological footprint and staying within ecological planetary boundaries? Considerable evidence suggests that it is not. The average per capita ecological footprint in North America in 2007 was estimated to be 6.73 global hectares, compared to a global average of 2.7 hectares and global available biocapacity of 1.8 hectares per person.[349] The total ecological footprint is estimated to have increased from 1961 to 2007 by 258 percent in Canada, 306 percent in Mexico and 152 percent in the United States.[350] From 1990 to 2005, emissions of greenhouse gases rose about twenty-five percent in Canada,[351] sixteen percent in the United States[352] and thirty-seven percent in Mexico.[353] The North American environmental agenda under the *NAAEC* is clearly not framed to track and respond vigorously to information regarding the relationship of the individual and collective economies of the *NAFTA* countries to global ecological boundaries.

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[347] *NAAEC* arts. 14 and 15.
[348] *NAAEC* Part V.
[349] *The Ecological Footprint Atlas 2010, supra* note 300 at 18, 66, 74. North America as used in this thesis includes Canada, Mexico and the United States, whereas in *The Ecological Footprint Atlas 2010* and elsewhere it only includes Canada and the United States. The figure of 1.8 hectares of global biocapacity per person reflects the problematic assumption that virtually no biocapacity would be available for other species.
[350] *Ibid.* at 71, 79.
[351] Environment Canada, *2007 CESI Highlights* (2010), online: <http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=847338B1-1&offset=3&toc=show>.
[352] U.S., Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2008*, Doc. DOE/EIA-0573(2008) (Washington: DOE, 2009), online: <http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/0573(2008).pdf> at 1.
[353] John Blodgett and Larry Parker, *Greenhouse Gas Emission Drivers: Population, Economic Development and Growth, and Energy Use* (Washington, DC: Cong. Research Service, 2010) at 7.

The United States government has hinted only obliquely at the possibility of addressing the planetary boundary related to climate change in the context of international trade. Responding to concerns regarding the "carbon leakage" that occurs when production shifts from countries with restrictions on carbon emissions to countries that have less stringent restrictions, such that little or no net reduction in carbon emissions occurs, the United States Trade Representative stated in 2009:

> The [Obama] Administration believes that the best approach to address concerns with carbon leakage is to negotiate a new international climate change agreement in the United Nations that ensures that all the major emitters take long term, significant action to reduce their greenhouse gas emissions. We look forward to working with these countries to negotiate a meaningful global climate agreement and actively avoiding circumstances in which we are simply exporting carbon emissions abroad.[354]

Within the context of the *NAAEC,* the CEC Council has increasingly focused attention on climate change, with an emphasis "on improving the comparability of [North American] greenhouse gas emissions data gathering, methodologies, and inventories, and to build stronger networks of experts and systems to share climate change information"[355]—a far cry from more aggressive regional action to reduce greenhouse gas emissions in Europe,[356] let alone the coordinated global action that would be required to respect the planetary boundary for climate change.

These aspirational declarations and timid actions in the United States and North America have not produced, and cannot produce, needed reductions in greenhouse gas emissions. They remain subservient both to short-term efforts to accelerate economic growth and job creation, using business sectors as the leading voice of national and international public interest, and also to trade as one tool among many to stimulate economic activity, regardless of the ecological consequences.[357] A concrete recent

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[354] Letter from Ronald Kirk, United States Trade Representative, to Congressman Joe Barton, (14 April 2009), online: <http://ictsd.org/downloads/2009/04/kirk-letter-14-04-09.pdf>.
[355] Commission for Environmental Cooperation, *Ministerial Statement of the Seventeenth Regular Session of the CEC Council* (17 August 2010) online: <http://www.cec.org/Page.asp?PageID=122&ContentID=2968&SiteNodeID=219&BL_ExpandID=>.
[356] Greenhouse gas emissions decreased by about six percent in the European Union from 1990 to 2005. Blodgett and Parker, *supra* note 353 at 7.
[357] Cf. Bosselmann, *supra* note 51 at 4 ("Environmental governance is still the poor cousin of economic governance.")

example is the United States' insistence on provisions in its trade agreement with South Korea, concluded in December 2010. The accord exempts American automobiles from South Korea's relatively strict fuel economy standards—global climate change notwithstanding.[358] Nothing in the United States' legal infrastructure for international trade and finance prevented this outcome, which United States automobile manufacturers aggressively pursued.[359]

And yet, this is a stable infrastructure. The Obama Administration and the Congress have done little tweaking of it, and little concrete evidence exists to support the Administration's claims to have "continued and enhanced U.S. efforts to address environmental objectives through multilateral, regional, and bilateral trade initiatives."[360] Evidence to the contrary, like the United States-South Korea trade agreement, is more readily apparent. A more expansive example is the current approach to management of the CEC under the *NAAEC*.

Not only does it fall far short of the international integration of environmental and economic policy in the European Union, but the *NAAEC* also has only limited potential to bring into being a governance architecture that would bring North America into the fold of a limit-based system of global regulations and policy. Among the agreement's objectives are to "foster the protection and improvement of the environment in the territories of the Parties for the well-being of present and future generations[,] promote sustainable development based on cooperation and mutually supportive environmental and economic policies[,] and increase cooperation between the Parties to better conserve,

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[358] See Legal Text Between U.S. Trade Representative Ron Kirk and Korean Trade Minister Kim Joon-Hoon, *Agreed Minutes on regulations pertaining to automotive fuel economy and greenhouse gas emissions* (10 February 2011), online: <http://www.ustr.gov/webfm_send/2555>. See also Brown and Garver, *Right Relationship, supra* note 6 at 100 ("In trade and many other matters, governments virtually always assume that their national interest is identical with the economic goals of the industries or business interests that stand to profit from the trade agreement, because, it is thought, these interests will serve the supreme goal of adding to economic growth, hence a happy government and a contended populace.")

[359] See Dustin Ensinger, "Ford Comes Out Swinging Against FTA With South Korea" *Economy in Crisis* (4 November 2010), online: <http://www.economyincrisis.org/content/ford-comes-out-swinging-against-fta-south-korea>.

[360] U.S., Trade Representative. *Environment* (2010), online: <http://www.ustr.gov/trade-topics/environment>.

protect, and enhance the environment, including wild flora and fauna."[361] More specifically, Article 10(2) of the Agreement equips the CEC Council to "study and make recommendations" on a virtually unlimited range of topics related to the intersection of the environment and the regional economy.

Aside from the merely aspirational nature of these provisions, the agreement is either permissive or effectively unenforceable. The Agreement contains mandates with which the Council or the Parties have either not complied at all, or done so ineffectively or incompletely. For example, Article 10(7) requires the Council to work toward a trinational agreement on transboundary environmental impact assessment, but the Council's efforts to do so effectively ended in 1999 with no agreement.[362] Although the CEC has periodically examined the environmental effects of *NAFTA*, as called for under Article 10(6)(d), the resulting piecemeal information, much of which is valuable and of high quality, has not been rigorously compiled or synthesized, and the Council's compliance with this mandate has flagged in recent years. The failure of *NAFTA* and the *NAAEC* to address the cumulative, aggregate scale effects of a more integrated economy in North America remains one of the most serious flaws in the North American model for trade and environment.[363] The Parties and the Council have also fallen short of the mandate in Article 12 to prepare an annual report that, among other things, should report periodically on the state of the North American environment. The Council has also failed to adopt rules governing Party-to-Party dispute resolution over persistent patterns of weak environmental enforcement, or to prepare rosters of arbitrators for such disputes, as required under Articles 25 and 28. These provisions remain unenforced most likely because the government parties to the *NAAEC* are both the potentially guilty parties and the overseers of compliance.[364]

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[361] *NAAEC* art. 1(a), (b) and (c).
[362] Geoffrey Garver and Aranka Podhora, "Transboundary Environmental Impact Assessment as Part of the North American Agreement on Environmental Cooperation" (2008) 26:4 Impact Assessment and Project Appraisal 253 at 257.
[363] See Block, *supra* note 343 at 522-26.
[364] This inherent conflict of interest has received considerable attention in the context of Articles 14 and 15, but the Council has taken virtually no action to alleviate those concerns. See JPAC, Advice to Council 03-05 (2003) (noting "an emerging perception of Council being in conflict of interest" and recounting public testimony at a JPAC meeting to the effect that "Council is having

These shortcomings, however, pale in comparison to the performance of the *NAAEC* governments with respect to one of the *NAAEC*'s signature innovations, the process for submissions on enforcement matters [SEMs], or citizen submissions, under Articles 14 and 15. Article 14 allows North American persons or non-governmental organizations to file a submission with the independent CEC Secretariat asserting that one of the *NAAEC* parties is failing to effectively enforce its environmental law. If certain criteria are met, the Secretariat can request a response from the Party and, if it is so inclined, recommend to the CEC Council that a detailed investigation be conducted and a "factual record" be prepared. Factual records provide information that allows interested members of the public to assess whether the Party has failed to effectively enforce its environmental laws, but do not make recommendations or subject the Party to penalties or corrective orders.[365] Thus, the process provides a public spotlight on a Party's performance in enforcing its environmental laws that may lead to improvements in enforcement.[366] Proceeding with a factual record requires a vote of at least two of the three Parties, as does publication of the final factual record.[367]

The *NAAEC* Parties, acting individually or as the CEC Council, have steadily and consistently weakened this relatively benign accountability mechanism.[368] The process presents an inherent challenge to the governments, because as written, the *NAAEC* casts them as both targets and overseers of the process.[369] Perhaps not surprisingly, they have

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a hard time differentiating their role—when they are acting as a Council and when they are acting individually as Parties"); Geoffrey Garver, "Tooth Decay" (2008) 25:3 Envtl. Forum 34 at 38 ("Providing the CEC secretariat with greater discretion to define the scope of factual record investigations would address a fundamental concern about the process: the inherent conflict of interest that the NAFTA governments face in being both council members who vote on factual records and also, since the council is composed of the three countries' environmental ministers, targets of individual submissions."); David Markell, "The Role of Spotlighting Procedures in Promoting Citizen Participation, Transparency and Accountability" (2010) 45 Wake Forest L. Rev. 425 at 440.

[365] See Commission for Environmental Cooperation, *Factual Record, Pulp and Paper Submission (SEM-02-003)* (2006), online: <http://www.cec.org/Storage/72/6649_SEM-02-003-FR_en.pdf> at 274.

[366] See David L. Markell, "The CEC Citizen Submission Process: On or Off Course?" in David L. Markell and John H. Knox, eds., *Greening NAFTA: The North American Commission for Environmental Cooperation* (Stanford, CA: Stanford University Press, 2003) 274 at 274.

[367] *NAAEC* arts 15(2) and 15(7).

[368] See generally Garver, *supra* note 364.

[369] See *supra* note 364.

tended to bend the process so as to protect themselves from the rigorous, independent scrutiny that must have been intended.

First, in voting and issuing resolutions on recommendations to prepare factual records, they have established an unreviewable practice of including detailed restrictions on the scope of factual records, often in disregard of the central concerns raised by submitters and the recommendations of the Secretariat.[370] In doing so, the Party that is the subject of the submission and factual records takes the lead in drafting the resolution. The Council's restrictions have avoided review of particularly embarrassing allegations with little rationale[371] and created an incentive for delays in the process by limiting the scope of factual records to the time period ending when the submission was filed.[372] Second, rather than setting a high standard on themselves to provide government-held information that responds to allegations in submissions when the Secretariat asks for a response, they have placed a high burden on submitters to collect facts in support of allegations—for example, to find evidence of the destruction of specific nests of migratory birds during the logging of remote boreal forests in Canada to support allegations of weak enforce of Canadian regulations protecting migratory birds.[373] Third, they have seriously delayed voting on the preparation and publication of factual records.[374] The time they have taken to vote on factual record recommendations has generally increased over time, such that by late 2010 two recommendations had been pending over three years and another over three years.[375] Four of the last five votes on publication of factual records, of a total of fifteen, have taken from five to seven months, even though Article 15(7) of the *NAAEC* states that votes on publication shall normally be within sixty days.

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[370] See especially CEC, Council Resolutions 01-08 (2001)(Oldman River II), 01-10 (2001)(Migratory Birds), 01-11 (2001)(BC Mining), 01-12 (2001)(BC Logging), 03-05 (2003)(Ontario Logging) and 03-16 (2003)(Pulp and Paper). See also Block, *supra* note 343 at 541; Garver, *supra* note 364 at 36-37.

[371] See Ecojustice, Media Release, "Species-at-risk defenders walk away from NAFTA review process" (17 January 2011), online: <http://www.ecojustice.ca/media-centre/press-releases/species-at-risk-defenders-walk-away-from-nafta-review-process>.

[372] See e.g. CEC, Council Resolution 03-16 (2003)(Pulp and Paper); Garver, *supra* note 364 at 36.

[373] See e.g. CEC, Council Resolution 03-05 (2003)(Ontario Logging); Garver, *ibid*. at 36-37.

[374] See Garver, *ibid*. at 38.

[375] See CEC, *Registry of Citizen Submissions,* online: <http://www.cec.org/Page.asp?PageID=751&SiteNodeID=250>.

Citizen submission processes are the main actively used[376] environmental accountability mechanisms that the United States has put into the *NAAEC* and the environment chapters of more recent trade agreements since the early 1990s. In the *NAFTA* context, the CEC Council has seriously limited the potential of the process as a rigorous independent accountability mechanism, effectively breached the careful deal that allowed *NAFTA* to gain political support in the early 1990s and cast serious doubt on the viability of the overall formula for trade and environment in United States trade policy.[377]

The longer the Council and the *NAAEC* Parties persist in falling far short in implementing the *NAAEC* to its full potential, the stronger the case grows to replace the agreement with a more effective means to address the concerns it was meant to address and the growing number of additional concerns that have come increasingly to light since

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[376] State-to-state dispute resolution processes as in *NAAEC* Part V have never been used, and are not likely to be. After more than 15 years, the CEC does not even have model rules required for Part V. See also *infra* note 380.

[377] The Parties' and the Council's performance with respect to the SEM process is described in more detail in Garver, *supra* note 364. The article concludes:

> A truly fair trade regime will require measures to ensure that countries with strong environmental protection and enforcement programs will be able to compete fairly with countries that fall short. Otherwise, the incentive to weaken environmental protections to gain competitive advantage will persist. It is clear that environmental mechanisms in the NAFTA package have not met their promise or potential, and yet they are being duplicated with little analysis or meaningful modification. Unless they are made to work, a different approach is urgently needed.

Ibid. at 39. A recent formal letter of the EPA Assistant Administrator for International and Tribal Affairs to the U.S. National Advisory Committee for matters related to the *NAAEC* gives little hope that the situation with regard to the SEM process at the CEC will improve any time soon. Letter from Michelle DePass, Assistant Administrator, Office of International and Tribal Affairs, EPA, to Karen Chapman, Chair, U.S. National Advisory Committee (14 September 2010) online: <http://www.epa.gov/ocempage/nac/pdf/2010_0914_epa_response_nac.pdf>. The letter, which provides thin excuses for the CEC Council's untimeliness and fails to acknowledge the harm that the Council's delays and other actions have done to the process, is particularly significant because it appears to be the first statement of the Obama Administration of its position on the citizen submission process. Significantly, the letter is at odds with President Clinton's Executive Order No. 12915, 59 Fed. Reg. 25775 (May 13, 1994), which provides that "[t]o the greatest extent practicable, pursuant to [*NAAEC*] Articles 15(1) and 15(2), where the Secretariat of the Commission for Environmental Cooperation ('Secretariat') informs the Council that a factual record is warranted, the United States shall support the preparation of such factual record." The only reasonable interpretation of Executive Order 12915 is that it signals a strongly deferential standard for reviewing Secretariat recommendations to prepare factual records, not the *de novo* review the DePass letter suggests is necessary.

the *NAAEC* was adopted. And, the weaker the case becomes to continue to use the *NAAEC* as the core model on which to base the environmental provisions of post-*NAFTA* agreements, as has already been done in the case of the *Dominican Republic-Central America-United States Free Trade Agreement* [*DR-CAFTA*],[378] the *United States-Peru Trade Promotion Agreement*[379] and pending agreements with Colombia and Panama.

In short, not only is the assembly of mechanisms in the *NAAEC* and its progeny in subsequent trade agreements quite weak relative to the ecological stakes related to international trade in the era of accelerating climate change, biodiversity loss and other global ecological threats, but those mechanisms are not even meeting their limited potential. Neither *NAFTA* and *NAAEC* nor subsequent United States trade agreements seriously envision a harmonized environmental regime in North America. The Party-to-Party dispute resolution on weak enforcement under the *NAAEC* (the so-called environmental teeth of *NAFTA*) involves a byzantine process with exemptions—for reasonable prosecutorial discretion and bona fide allocation of resources to other environmental matters—that make any use of the process highly unlikely.[380] Without a court or other means for effective enforcement, we are left without recourse to the political judgments of the three *NAFTA* partners, reduced to the lowest—that is, the environmentally weakest—common denominator. Three important structural omissions

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[378] 5 August 2004, 43 I.L.M. 514 (entered into force 1 March 2007).

[379] 12 April 2006, -- I.L.M. -- (entered into force 1 February 2009), online: <http://www.ustr.gov/trade-agreements/free-trade-agreements/peru-tpa>.

[380] See Garver, *supra* note 364 at 39:

> Winning would require proof that a government has a recurring course of action or inaction amounting to a failure to effectively enforce environmental law that affects trade regulated by the free trade agreement. However, the accused government could defeat the case by showing that it either reasonably exercised its enforcement discretion or made a bona fide allocation of available resources to environmental matters of higher priority. As a result, the outcome will be much less certain than in a typical trade dispute, with completely different stakes and a greater potential for backfiring. [Further,] every plaintiff in these dispute resolution processes is also a potential defendant in a future case, and therefore has a reduced incentive to develop the strongest possible arguments favoring the plaintiff position. It is hard to imagine a government arguing for an expansive definition of what qualifies as a failure to effectively enforce, or for a limited interpretation of defenses that apply to the reasonable exercise of enforcement discretion and bona fide allocation of resources to higher priorities. In short, in contrast to other trade disputes, dispute resolution under these provisions is a Pandora's box no government is likely to open.

from the *NAFTA* environmental arena are, first, a fully built system of environmental law and policy at the North American level built on principles of subsidiarity and proportionality; second, a system for tracking and responding to the aggregate scale impacts of trade on the environment, using an ecological economics perspective; and third, a truly independent judicial function with real teeth: a North American environmental court or its equivalent.

Overcoming the stagnancy of trade policy of the United States will be difficult in part because of the general difficulty in transforming an institution—in this case, an entire series of trade agreements built around a flawed approach—that has achieved stability, even where the conditions and assumptions under which the institution was established have changed significantly or been shown to be faulty.[381] This phenomenon of maintaining "tragic institutions"[382] is likely exacerbated where pressures in addition to the bureaucratic tendency to maintain budgets and programs are considerable, as is certainly the case with the disdain of the current hegemonic institutions of international trade and finance toward radical measures to contain the global economy within ecological limits.

The approach of the United States to international trade and the environment is a reflection in large measure of the global approach. The key features of the global trade and finance system are its unexamined and increasingly doubtful belief in the power of mobile capital and limited market regulation to lead to social and environmental well-being; its consistent undervaluation of environmental values, biodiversity and ecological integrity; its default, and difficult to overcome, assumption that measures to protect the environment, public health or other public goods are disguised barriers to trade; its blindness to overconsumption and aggregate ecological impacts of economic activity; and its apparent assumption that comparative advantage—a bedrock justification for international trade—remains an important factor in a world with virtually unrestricted movement of capital.[383] In light of the momentum this set of features provides along a path to ecological catastrophe, the assumption that they will ensure that boundaries

[381] See Brigham Daniels, "Emerging Commons and Tragic Institutions" (2007) 37 Envtl. L. 515 at 520-21, 539-41.
[382] *Ibid.*
[383] See generally Rees, *supra* note 38; Pelletier, *supra* note 33.

between ecological security and catastrophe will be respected must be rejected. Rather, all of the elements of the institutional infrastructure that supports the current regime of international trade and finance should face scrutiny as to whether they will respect those boundaries.

As has been noted elsewhere, "[i]nvestment and trade deals present an important opportunity to leverage commitments to long-term environmental stability from the desire to reap the economic benefits of international commerce."[384] However, because long-term stability means avoiding the catastrophic outcomes on the far side of ecological planetary boundaries, it is possible only if the international trade and finance regime becomes entirely subservient to ecological boundaries such as the planetary boundaries and complementary measures outlined in Section I.B., above.

Part IV. Successful Use of Planetary Boundaries for Safe Operating Space in Novel and Adaptive Forms of Governance Will Require the Rule of Ecological Law

The proposal of the Rockström research team of planetary boundaries, as supplemented by complementary measures and ongoing refinements, is powerful because of its potential to provide a comprehensive framework for adaptive legal and policy mechanisms based on a scientific, ecological approach from the global to the local level. The power of this framework resides in its commitment to a system-based approach that depends on the best possible understanding of human-Earth dynamics and feedbacks while acknowledging the impossibility of predicting the often non-linear and chaotic behavior of social-ecological systems. Although, as Rockström and his colleagues acknowledge, the planetary boundaries are a work in progress, and other indicators of global ecological limits are possible, the support a comprehensive and useful approach.

This Part examines how the lessons from the experience of existing mechanisms that rely at least in part on a systems-based approach can be applied in establishing the rule of ecological law based on planetary boundaries or other systems indicators and complementary principles like right relationship. Following a review of the key lessons to be drawn from the experience to date with mechanisms discussed in Part II, ten

[384] Garver, *supra* note 364 at 34.

fundamental features of the rule of ecological law are identified. A presentation of the essential characteristics of the institutional infrastructure in which to house those features of the rule of ecological law follows. These characteristics take into account the shortcomings of existing institutional structures discussed in Part III.

A. Applying Lessons from Existing Mechanisms in Formulating Ecological Law

Dealing with pollution problems in isolation, without a systems approach that reckons with issues of cumulative impacts, scale and the interrelationship between different systems limits, will be insufficient to address the complex global ecological crisis effectively. This is a main shortcoming of environmental laws and regulations in the United States and elsewhere since the 1970s. These pollution control laws are limited by reductionism that misses the forest of broad systemic impact for the trees of smokestacks and sewage pipes, by an over-reliance on cost-benefit analysis and by an enduring allegiance to a reactive, non-precautionary approach.[385] Although those laws and regulations have reduced many of the most patent environmental pollutants, they have not evolved to address effectively the cumulative impacts and scale effects tied to the growing material and energy throughput that has accompanied economic growth.[386] Indeed, "[p]ollution control is actually a very restricted part of environmental reality. Impacts such as climate change, resource shortages and biodiversity losses follow a completely different logic from pollution control. In reality, it is the 'rich and clean' countries that are the biggest cause of such impacts."[387]

The TMDL, NAAQS and critical loads and levels approach under the *LRTAP,* discussed in Part II, above, are perhaps among the most promising of the current crop of environmental mechanisms in that they pay at least some attention to systemic limits. All

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[385] See Percival, *supra* note 109 at 8-9; Heinzerling, *supra* note 111 at 164-69.
[386] See Victor, *supra* note 105 at 204 ("Far too many environmental regulations, standards and guidelines are written in terms of emission rates expressed as kilograms per unit of output or as concentrations in mg/litre or some similar measure. Regulations, standards and guidelines written this way do not prevent total emissions from rising even if the letter of the law is being followed. Whenever a regulated activity increases, say because of increased production, emissions are allowed to rise.")
[387] *Factor Five*, *supra* note 96 at 5.

follow the same basic methodology, and all have elements that link human activity and pollution to life systems. The first step is to determine pollutant loads or levels in ecosystems or ambient air that will protect human health or ecosystem function to a level considered safe or otherwise acceptable. The second step is to adjust emissions reduction requirements so as to move toward those loads or levels, taking into account additional perceived limits as to technical feasibility, economic cost and efficiency, and the time scales for instituting new requirements and realizing anticipated environmental benefits.[388]

The critical load and levels approach is broader than TMDLs, NAAQS or other provisions of the *Clean Water Act* and *Clean Air Act* in that critical loads are more clearly tied to a full range of indicators of ecosystem functioning.[389] Moreover, the Europe-wide context for the critical loads and levels approach makes their application in transboundary contexts more straightforward than is the case for TMDLs, which raise complicated issues when the sources that pollute a water body are in another state or country. Indeed, the sensible argument has been made that the TMDL approach should lead inexorably to an internationally integrated system for dealing with transboundary pollution.[390]

In all of these cases, however, full achievement of the desired loads and levels remains in the indefinite future because of the primacy of technological and economic factors. The weighing of the costs to the environment and to human health, and of future opportunities to address those costs, is undertaken entirely within a neo-classical economic context. Even if some externalities are internalized in the formal or informal cost-benefit analyses that take place, the concept of enclosing the economic sphere within ecological boundaries is entirely out of the equation. Moreover, no weighing at all occurs of the aggregate impact of economic activities against global ecological limits, regionally and locally distributed, that are by definition established on the safe side of the boundary between continuation of the human enterprise and catastrophic decline.

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[388] See, e.g., James Irwin, John Tidblad and Vladimir Kucera, "Air Quality Policy" in John Watt *et al*., eds., *The Effects of Air Pollution on Cultural Heritage* (New York: Springer, 2009) 269 at 278 (discussing air pollution policy in the United Kingdom).
[389] See discussion on pages 43-48, above.
[390] See Mark A. Drumbl, "Environmental Supra-nationalism" (2002) 59 Wash. & Lee L. Rev. 289 at 291-92.

The context and necessity for undertaking such weighing, under the rule of ecological law, is becoming increasingly clear. The current Chair of the International Cooperative Programme on Modeling and Mapping under the *LRTAP* observed in a 2008 study focusing on the emission of ammonia and other nitrogen-based pollutants that

> [t]he successful effects-based emission abatement policy developed in the LRTAP Convention framework should be increasingly linked to biodiversity and climate change policies and targets. In addition, it should include a multi-media and multi-effect research and policy development to reduce uncertainties and develop linked and optimized management and abatement policy responses.[391]

In other words, the ultimate backdrop for a review of international, national or regional pollution control policy regimes is the planetary boundaries (or like indicators of global system limits), and particularly the ones that the Rockström team warns we have already crossed: nitrogen fluxes, climate change and biodiversity. For example, with these boundaries more firmly established as the drivers of policy and regulation, mechanisms like TMDLs and critical loads and thresholds would have more success in bringing under control nonpoint sources that contribute to exceedance of the planetary boundary for the global nitrogen flux, with likely benefits in regard to climate change and biodiversity as well.

The cap-and-trade program for sulfur dioxide emissions from power plants and other sources in the United States illustrates a more fundamental problem. In that example, Congress omitted the exercise of rigorously establishing the critical loads of acidic atmospheric deposition that receptor ecosystems, like the forests and lakes of the Adirondacks, New England and eastern Canada, could withstand.[392] Instead, the legislative debate focused on determining the level of reductions that was politically and economically achievable. Indeed, the approach has been both lauded and criticized as implicitly including a political decision, arrived at through democratic processes, as to the appropriate level of protection of downwind ecosystems, infrastructure and people from acid rain.[393] Although the resulting reductions in sulfur dioxide emissions were

[391] Spranger *et al*., *supra* note 222 at 486.
[392] See page 60, above.
[393] See generally Heinzerling, *supra* note 245 (noting that although advocates of pollution trading schemes emphasize that the ultimate pollution level to be allocated through trading is arrived at

significant, to the modest benefit of downwind terrestrial and aquatic ecosystems, the direct link between emission sources and receptor systems has never been made, as it has in Europe.[394] Thus, the acid rain program in the United States does not contain a mechanism for ongoing emissions reductions designed to attain systemic limits on acidification and, as is essential in an approach based on ecological law, to repair damage that past emissions have caused.

The example of the *Montreal Protocol* demonstrates the possibility of collectively tackling a global systemic environmental problem, with a differentiated system of responsibility for countries at different stages of economic development and well-being and an adherence to the precautionary principle. For those hoping for quick solutions, it also illustrates the relatively long path to reversal of systemic consequences of environmental overload. This record of performance provides lessons for a more generalized approach, particularly in regard to precaution, distribution of responsibilities and supranationality. However, ozone-depleting substances were not as central to the global economy as are the energy sources, the industrial model and the globalized system of trade and finance that underlie other planetary boundaries, and substitutes or prospects for radical changes in efficiency are not as readily apparent or achievable.[395] As a result, the global scientific, social and political consensus to adapt the approach for phasing out ozone depleting substances to other planetary boundaries has not emerged. The rule of ecological law offers a framework for allowing that emergence to happen.

The rule of ecological law also has the potential to address the structural and institutional problems identified in Part III, above, all of which are linked to the primacy of economic growth under a neo-classical economic paradigm. In particular, the current global architecture for ecological governance makes environmental concerns subservient to economic and political ones; supports a system of economic exchange that overprotects property rights and individual freedoms at the expense of the global ecosystem; treats

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through democratic processes, experience with the Acid Rain Program shows that the allocation process favored special interests—big polluters, that is—that had strong influence in Congress).

[394] Somewhat generously, the United States' Acid Rain Program is nonetheless treated as consistent with the critical loads and levels approach under the *LRTAP*. See Shapiro, *supra* note 235 at 216.

[395] See Sunstein, *supra* note 194 at 101-17.

discrete environmental problems in isolation rather than holistically; and promotes consideration of environmental impacts without requiring attention to impacts revealed through mandatory monitoring and assessment following development-oriented decisions.

B. Ten Features of the Rule of Ecological Law

The *Montreal Protocol,* TMDLs, NAAQSs, the United States' acid rain program, Europe's critical loads and levels approach and the nascent regulation of greenhouse gases in the United States all emerged within the framework of contemporary environmental law. Robert Percival has identified four principles underlying environmental law in its contemporary form:[396] 1) the principle that "no one has the right to cause significant harm to others,"[397] 2) the polluter pays principle, 3) the "look-before-you-leap"[398] principles embodied in environmental impact assessment requirements, and 4) the precautionary principle.[399] The context in which these principles apply is one in which environmentalism is seen as concerned, first, with protecting human health from harmful contaminants and, second, with preserving and protecting natural areas and species.[400] Yet, while these objectives imply some limits on human activities, the contemporary environmental law built on them has consistently defaulted to economic and political factors and has not significantly framed those limits around an integrated, systemic understanding of ecosystems and human-Earth dynamics. Nor does it effectively address the aggregate effects of pollution or biodiversity loss. Thus, as Dan Tarlock has observed, Percival's four principles "do not represent a system of 'transformative nature-centered rule' likely to 'tame the drive to exploit and modify all planetary life support systems.'"[401] In other words, contemporary environmental law lacks principles or features that are needed to establish the ecological rule of law.

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[396] Percival, *supra* note 109 at 8.
[397] *Ibid.*
[398] *Ibid*.
[399] Percival notes that not all of these principles have been followed consistently. In the United States, for example, he explains the limited effectiveness of the precautionary principle. *Ibid*. at 15-17.
[400] See Tarlock, *supra* note 114 at 238.
[401] Percival, *supra* note 109 at 8 (quoting Tarlock, A. Dan, "Is There a 'There' There in Environmental Law?" (2004) 19 J. Land Use & Envtl. L. 213 at 253-54)).

Any attempt to list the essential principles of an area of law runs the risk of missing or overstating aspects of the essence of that area of law. Rather than present such a list of principles, this section offers some essential features of the rule of ecological law on the understanding that there may be others. Legal and policy mechanisms for keeping the global economy within safe operating space and allowing for a mutually enhancing human-Earth relationship—ecological law, in essence—should include at least the ten following mutually reinforcing features:

First, the rule of ecological law should recognize that humans are part of the Earth's life systems, not separate from them.[402]

Second, the legal regime must be constrained by ecological considerations necessary to avoid catastrophic ecological outcomes and to promote the flourishing of life, with the socio-economic sphere fully contained within these ecological constraints and ecological restoration mandatory where necessary.[403]

Third, the rule of ecological law must permeate the legal regime in a systemic, integrated way, and not be seen as a specialty area of the law.

Fourth, the legal regime enveloping the global economy should be radically re-focused on reduction of its material and energy throughput to address the current ecological overshoot.

Fifth, the legal and institutional framework of ecological law must be global, but distributed in a fair manner using principles of proportionality and subsidiarity, with protection of the global commons and public goods paramount and constraints on property rights and individual choice as needed to meet ecological limits.

Sixth, the rule of ecological law must ensure fair sharing of resources among present and future generations of humans and other life.

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[402] See Bosselmann, *supra* note 51 at 75.
[403] See Pelletier, *supra* note 33 at 226 (arguing that ecological considerations must take precedence over economic ones in the hierarchy of governance).

Seventh, the rule of ecological law must be binding and supranational, with supremacy over sub-global legal regimes as necessary, and with rights of enforcement for non-state actors.

Eighth, a greatly expanded program of research and monitoring tied to improved understanding and continual adjustment of ecological boundaries and means for respecting them is needed to support the rule of ecological law from the global to the local level.

Ninth, the rule of ecological law requires precaution about crossing planetary boundaries, with both margins of safety to ensure that the boundaries are respected from the global to the local level and complementary measures to allow the Earth's life systems to flourish.

Last, ecological law must be adaptive, in recognition of the non-equilibrium nature of ecosystems and the need to get started on a comprehensive effort to constrain the economy within ecological limits despite uncertainty.

The following sections introduce these features of ecological law in more detail.

1. Humans Are a Part of the Earth's Life Systems

A fundamental critique of the neo-classical economics paradigm relates to its integration of the view that humans stand apart from, and reign over, the environment and non-human species.[404] The most fundamental feature of the rule of ecological law is the view that humans are relational beings in a broad complex of interrelated life systems, and ultimately the cosmos. Thomas Berry puts it this way: "We might begin by recognizing that the life community, the community of all living species, including the human, is the greater reality and the greater value. The primary concern of the human community must be the preservation and enhancement of this comprehensive community, even for the sake of its own survival."[405] The rule of ecological law calls for a revival of

[404] See Berry, *supra* note 40 at 4; Kysar, *supra* note 326 at 675-76 (discussing the instrumental view of nature in contemporary law and economics).
[405] Berry, *ibid*. at 58.

the notions of deep ecology and Leopoldian ethics that ceded to a more instrumentalist view of non-human life and life systems at the birth of contemporary environmental law.[406]

2. Constraints Based on Systemically Derived Ecological Limits

The core principle in ecological economics is that the economy must stay within the Earth's ecological limits in order to avoid the deterioration of the ecological base on which the economy and the flourishing of life on Earth depends.[407] This principle must also be the foundational criterion for the rule of ecological law.[408] The planetary boundaries framework and similar normative concepts, like ecological footprint, are based on this principle, and in suggesting the need for "novel and adaptive governance approaches at global, regional and local levels"[409] based on the boundaries framework, the Rockström team is in essence calling for the development of a comprehensive system of ecological law. The planetary boundaries framework also makes clear that this approach must be systems-based, which means that ecological law must track the interactive dynamics among the boundaries and the feedbacks, thresholds, non-linearity and other characteristics of the global social-ecological system. Further, to respect ecological constraints, ecological restoration must be applied where ecological limits have already been exceeded.[410]

3. Full Integration of the Rule of Ecological Law

Just as ecological economics presents a comprehensive reorientation of economics, the rule of ecological law should develop so as to become fully integrated within the legal and policy infrastructure for the human enterprise.[411] Cast in this way, ecological law is not a specialty area of law as contemporary environmental law is often perceived to be, but rather a transdisciplinary source of juridical concepts and analysis

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[406] See generally Delgado, *supra* note 114.
[407] See Kysar, *supra* note 326 at 679-81.
[408] Cf. Bosselmann, *supra* note 51 at 53 ("[D]evelopment is sustainable if it tends to preserve the integrity and continued existence of ecological systems; it is unsustainable if it tends otherwise.").
[409] Rockström *et al.*, *supra* note 4 at 28.
[410] See Brown and Garver, *Right Relationship, supra* note 6 at 83-84.
[411] See page 16, above; Bosselmann, *supra* note 51 at 4.

that must permeate law and policy.[412] A leading expression of the need to integrate the rule of ecological law in the entire envelope of law and policy is the Earth Charter, which states:

> To move forward we must recognize that in the midst of a magnificent diversity of cultures and life forms we are one human family and one Earth community with a common destiny. We must join together to bring forth a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace. Towards this end, it is imperative that we, the peoples of Earth, declare our responsibility to one another, to the greater community of life, and to future generations.[413]

4. Radical Reduction of Material and Energy Throughput

The global economy has grown at a supercharged rate in the industrial era of the last two centuries. The consequence, which is at the heart of the development of ecological economics, is an urgent problem of the economy's scale, that is, how large it should be "in its physical dimensions . . . relative to the ecosystem that sustains it."[414] The most rigorous analysis that has been conducted indicates that the human enterprise is consuming the Earth's biocapacity faster than it can regenerate and has created a rising ecological debt.[415] In these circumstances, the rule of ecological law requires a radical reduction of the material and energy throughput of the economy and a normative system that views the unnecessary use or wasting of biocapacity as a legal violation.

At the beginning of his book *The Bridge at the Edge of the World,*[416] James Gustave Speth includes a series of sixteen graphs covering the period 1750 to 2000 that he labels "The Great Collision."[417] The first two graphs show the exponential rise during that period in global human population, from about eight hundred million to about six billion, and in global total GDP, from an amount well under one trillion dollars to about forty trillion dollars. Both graphs turn sharply upward around 1950—an indication of exponential growth. The other fourteen graphs show similar patterns for such things as

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[412] See Kysar, *supra* note 326 at 682; David Boyd, *supra* note 52 at 365.
[413] The Earth Charter Initiative, *The Earth Charter* (2000), online: <http://www.earthcharterinaction.org/content/pages/Read-the-Charter.html> Preamble.
[414] Daly and Farley, *supra* note 105 at 12.
[415] See generally *LPR 2010*, *supra* note 25; *supra* notes 23-31 and accompanying text.
[416] Speth, *supra* note 3.
[417] *Ibid*. at Introduction

the damming of rivers, water use, fertilizer consumption, paper consumption, the number of motor vehicles, the concentration of carbon dioxide in the atmosphere, the loss of ozone in the stratosphere, the human addition of nitrogen to coastal ecosystems, the loss of tropical rain forest and woodland and species extinctions. These graphs starkly depict the exponential increase in the throughput of material and energy in the economy that has closely tracked the rise in global GDP and population.[418]

The growing field of sustainability science, which frames the current ecological crisis as a problem of the interaction between society and nature,[419] is providing a set of analytical tools for tracking the throughput of material and energy in the economy.[420] Leading indicators of this "socioeconomic metabolism"[421] confirm the story that the Speth graphs tell. Ecological footprint is a measure of the amount of bioproductive land (usually measured in hectares) that would be needed to produce everything that humans consume and everything they waste on a sustained basis, including the land that would be needed to take up such waste as greenhouse gases in perpetuity.[422] As noted above, the total global human ecological footprint in 2007 was estimated to be fifty percent greater than the available bioproductive land on Earth and rising, a situation that indicates overconsumption of material and energy in the economy.[423]

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[418] See also *Factor Five*, *supra* note 96 at 301 ("The problem is that for the last three centuries the levels of growth in the consumption of resources (particularly oil, coal, water and timber) have steadily increased, in line with levels of economic growth."), 302.
[419] Helmut Haberl *et al.*, "Progress towards sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer" (2004) 21 Land Use Policy 199 at 199-200 (noting that sustainability science "offers a new perspective beyond the simplistic idea that sustainability can be achieved by adding a third, ''environmental'' dimension to the classical policy goals of improving economic performance and social well-being").
[420] See Fridolin Krausmann *et al.*, "Resource flows and land use in Austria 1950–2000: using the MEFA framework to monitor society–nature interaction for sustainability" (2004) 21 Land Use Policy 215 at 216 (explaining that these tools are used for "tracking stocks and flows of substances (e.g., carbon, chlorofluorocarbons, cadmium), materials (e.g., fossil fuels, minerals, biomass) and energy (biomass, fossil fuels, hydropower, nuclear energy, etc.) related to socioeconomic activities").
[421] See Marina Fischer-Kowalski and Christof Amann, "Beyond IPAT and Kuznets Curves: Globalization as a Vital Factor in Analysing the Environmental Impact of Socio-Economic Metabolism" (2001) 23:1 Population and Environment 7 at 12 (defining "social metabolism" as "the sum total of the material and energetic flows into, within, and out of a socio-economic system.")
[422] Meadows, *supra* note 19 at 3.
[423] *LPR 2010, supra* note 22.

Material and energy flow accounting [MEFA] is used to analyze "important aspects of society–nature interaction by tracing socio-economic materials and energy flows and by assessing changes in relevant patterns and processes in ecosystems related to these flows—in other words, the 'colonization' of terrestrial ecosystems."[424] More precisely, MEFA makes it possible to "link data and models used to analyse socio-economic systems (e.g. economic models, social statistics and indicators) to data and models used for natural systems (e.g. biosphere models, climate models, ecosystem models) in a consistent way."[425] An account published in 2009 of global material flow in the twentieth century found that material extraction increased eight-fold, at an exponential rate, from 1900 to 2005, while global GDP rose by a factor of about twenty-three and population by a factor of four.[426]

The Speth graphs and the signals from indicators like ecological footprint and MEFA, along with the conclusion of the Rockström group that three of the planetary boundaries that they propose have been exceeded, point to the need to structure the rule of ecological law so as to achieve a radical reduction of material and energy throughput. "Effective governance of the global environmental commons must . . . proceed from a recognition of the scale of resource extraction and waste production that natural systems can accommodate in perpetuity."[427] A key challenge is to avoid the so-called rebound effect, also known as Jevon's paradox or the Khazzoom-Brookes Postulate.[428] The aforementioned study on global material extraction from 1900 to 2005 makes clear that although "an overall decline in the material intensity of the global economy, or, inversely, the increase in efficiency with which materials (and energy) are used, is a characteristic feature of the period of global industrialisation[, t]hese efficiency gains did not translate in a reduction of the materials and energy used."[429] The rebound effect is the

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[424] Haberl *et al., supra* note 419 at 199-200. The authors use the term "colonization," as opposed to others such as "disturbance," to emphasize the active intervention of humans in natural systems so as to increase their socio-economic utility. *Ibid*.
[425] *Ibid*. at 203.
[426] Fridolin Krausmann *et al*., "Growth in global materials use, GDP and population during the 20th century" (2009) 68 Ecological Economics 2696 at 2698-2701.
[427] *Factor Five, supra* note 96 at 223.
[428] *Ibid.* at 301-307.
[429] Krausmann *et al*., *supra* note 426 at 2702.

phenomenon by which increases in the efficiency of material or energy use result in increases in consumption, which often more than make up for the gains from efficiency.[430] Because increases in efficiency have tended to support growth in population, affluence and consumerism, the rebound effect is a prominent feature of the current legal and socio-economic arrangements in the developed world and much of the developing world.[431]

Many specific features of the current dominant legal and socio-economic architecture contribute to the situation in which overall consumption outpaces gains in the efficiency of material and energy use. For example, approaches to pollution control under environmental legislation in the United States that call for piecemeal implementation of the best available control technology,[432] reasonably available control technology,[433] maximum available control technology[434] and the like to individual pollution sources implicitly favor the economic activity that is causing ecological impact over the human and ecological systems that are harmed. Similarly, Nathan Pelletier criticizes the *LRTAP* regime[435] for implicitly protecting fossil fuel burning by imposing technological requirements that do not question the need for an ever-growing fossil fuel-based economy.

> The implicit assumptions of industrial society which permeate such regimes provide intrinsic advantage to specific actors and ideologies. Economic reliance on fossil fuels in a system premised on growth means that questions of constraint are not entertained. Instead, politically feasible reduction targets achieved through problem shifting end-of-pipe technologies are favoured over precautionary

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[430] See *Factor Five*, *supra* note 96 at 301. The authors of *Factor Five* offer the example of Corporate Average Fuel Economy standards in the United States, which led to a rise in average fuel economy from 18 miles per gallon to 27 miles per gallon after they were introduced in 1978. However, the result was a dramatic increase in the number of miles driven. *Ibid*. at 303-304. See also Robert Nordhaus, *supra* note 191 at 70-71.

[431] See *Factor Five*, *ibid.* at 302; Right Relationship at 80. While the authors of *Factor Five* note some controversy over the extent of the rebound effect, noting that Amory Lovins and others believe the effect is small and will disappear as applications for various technologies reach "saturation points," they identify a broad set of examples of it with regard to energy, water and material use. *Factor Five* at 304-306. They conclude that "the evidence is clearly on the side of the rebound effect, in that efforts to improve efficiency have been fraught with increasing overall levels of consumption." *Ibid*. at 306.

[432] *Clean Air Act* § 169, 42 U.S.C. § 7479 (2006).

[433] *Clean Air Act* § 172(c)(1), 42 U.S.C. § 7502(c)(1) (2006).

[434] *Clean Air Act* § 112(g)(2), 42 U.S.C. § 7412(g)(2) (2006).

[435] See pages 52-57, above.

> solutions, fundamental changes in production systems, and hard limits on total allowable emissions.[436]

The principal mechanisms of contemporary environmental law carry an implicit assumption that stopping or constraining economic activity so as to meet ecological boundaries would be more devastating to the social-ecological system in which it occurs than the ecological harm from the activity would be.

The market cannot be expected to constrain material and energy throughput in the economy on its own. Rather, government standards or policies, which have been necessary historically to protect the environment from free market forces, must drive the uptake of technology that improve resource productivity, such as zero-emissions or carbon neutral technologies.[437] To address the rebound effect, legal and policy mechanisms are also needed for directing the use of the economic gains associated with efficiency to even further reduction of the throughput of material and energy in the economy, so as to maintain sufficient resource stocks and waste processing capacity to avoid running down the Earth's ecological base.[438]

On the side of resource (or natural capital) stocks, ensuring that maximum possible resource productivity and energy efficiency is achieved with respect to economic metabolism would be a good step in the direction of the rule of ecological law.[439] This might be accomplished in a number of ways. For example, a wedge analysis using MEFA methodologies[440] could be performed for different economic sectors, where the total available energy or materials would be determined based on the amount that can be

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[436] Pelletier, *supra* note 33 at 221-222 (citation omitted).
[437] Percival, *supra* note 109 at 30-31.
[438] See Adler, *supra* note 149 at 10313 ("[T]o reconcile population and economic growth with increasingly scarce water resources, the concept of sustainable water use must entail *sufficient* supplies to accomplish necessary and legitimate purposes, using the most efficient means possible."); see also *Factor Five*, *supra* note 96 at 314-31.
[439] Herman Daly warns, however, that "the notion that we can save the 'growth forever' paradigm by dematerializing the economy, or 'decoupling' it from resources, or substituting information for resources, is fantasy. We can surely eat lower on the food chain, but we can't eat recipes!" Daly, *supra* note 38 at 28.
[440] For an impressive example, see Stefan Giljum and Klaus Hubacek, *International trade, material flows and land use: developing a physical trade balance for the European Union,* Interim Report IR-01-159 (Laxenburg, Austria: International Institute for Applied Systems Analysis, 2001).

extracted or made available through reuse and recycling without crossing ecological limits.[441] These capped sectoral amounts could then be distributed with market mechanisms. In essence, this would be a quota system, where resource availability is determined by ecological means, not simply price mechanisms that account for demand based on perceptions of scarcity but not on ecological limits on resource supply or waste assimilation capacity. As Peter Victor explains convincingly, "[t]rends in [resource costs, rents or prices] reflect beliefs about scarcity not necessarily the scarcity itself and it is impossible to tell from the data which it is."[442] Taxing is the other main alternative, where the objective is to adjust the price of resources so that demand stays within ecological limits on supply.[443] William Nordhaus's use of the DICE model[444] to propose a progressively rising tax on fossil fuels to address climate change is an example, but one with a flawed model of climate change impacts, an unconscionable discount rate, a reduction of incommensurable values to dollar values and a complete reliance on a neo-classical theory of economic growth.[445]

On the waste, or pollution, side of efficiency, drastic reductions of the total output of waste products from the economy are needed, either by reducing the amount of waste or pollution per unit of production or by scaling back production altogether. However, improving efficiency alone is not sufficient if overall growth in physical output is such that aggregate pollution and waste loads increase according to the rebound effect. For example, greenhouse gas "intensity," measured as the amount of greenhouses gases per unit of GDP, decreased steadily in the United States from 1990 to 2005, but aggregate

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[441] Cf. generally Stephen Pacala and Robert Socolow, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies" (2004) 305 Science 968 (proposing "stabilization wedges" in which the reductions in greenhouse gases needed to stabilize the level of greenhouse gases in the atmosphere are distributed among wedges representing different economic sectors, such as vehicles, buildings and energy shifts).

[442] Victor, *supra* note 105 at 54. He explains further:

> As a substantial and growing component of production and transportation costs – the environmental costs – are excluded from the calculations, the prices and costs actually paid for resources become less and less useful indicators of scarcity. They can decline while environmental costs are rising, in which case, scarcity will be increasing but we will not see it if we only look at market prices.

Ibid. at 53.

[443] See *Factor Five*, *supra* note 96 at 314-331.

[444] See page 32, above.

[445] See Sterman, *supra* note 114 at 519.

greenhouse gas emissions increased.[446] In Europe, the situation is somewhat better, in that greenhouse gas emissions decreased in the aggregate in this same period, almost certainly because of both improvements in efficiency and the displacing of production to countries outside of Europe.[447]

By way of example, a sector with enormous potential for improved efficiency in terms of both inputs and outputs is buildings, which are responsible for about one third of primary energy consumption and about thirty-five percent of total carbon dioxide emissions in North America.[448] The green building movement focuses on using integrated design to create buildings that have low demands for materials, energy, water and waste processing and that favor reused, renewable, locally sourced and non-toxic material and energy resources to meet those demands. A 2008 report of the North American Commission for Environmental Cooperation concluded that "[a] rapidly increasing market uptake of currently available and emerging advanced energy-saving technologies could result in annual reductions of 1711 megatonnes (MT) of CO2 into the atmosphere in North America by 2030, compared to a business-as-usual approach."[449] This reduction, which is almost as much as the 1756 MT of carbon dioxide attributed to the entire transportation sector in the United States in 2000, would decrease current total carbon dioxide emissions from the building sector in North America by about sixty percent by 2030.[450]

Voluntary rating and certification systems are driving the green building movement, although some cities in North America have begun to impose mandatory green building criteria, often with reference to leading green building rating systems, like the Leadership in Energy and Environmental Design [LEED] system, or their

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[446] See Blodgett and Parker, *supra* note 353 at 7.
[447] *Ibid*. Cf. Giljum and Hubacek, *supra* note 440 at 49 ("[A]nalyses of the physical trade balance of the European Union . . . revealed that the economy of the EU faces a substantial trade deficit in physical terms with all other major world regions (including the non-EU OECD countries) and is heavily depending on resource inputs provided by other countries, especially in Asia, Africa and Latin America. The significant trade deficit in physical terms is mainly caused by the import of large amounts of fossil fuels (around 60 % of all imports) as well as abiotic raw materials and semi-manufactured products (around 20 % of all imports).")
[448] CEC Green Building Report, *supra* note 299 at 4-5.
[449] *Ibid.* at 5.
[450] *Ibid.* at 5, 40-47.

equivalent.[451] However, ratings are for the most part based on the performance of individual projects.[452] Although these assessments are important, individual ratings must be put in the context of the aggregate of material and energy use and waste production from buildings, and policies instituted so as to fairly distribute the right of each individual contributor to the overall impact. The CEC's green building report was a step in this direction, because it framed its analysis around the entire commercial and building sectors in North America.[453] Similar efforts should be applied to a broader range of sectors, and the policy recommendations should be turned as rapidly as possible into hard law requirements and more systematic means of distributing limits on pollutant loads and resource inputs.

The example of the building sector is a reminder that the possible gains from efficiency may be limited because of the rebound effect. Indeed, from the 1950s to the early 2000s, the average single-family home in the United States grew from one hundred square meters to over two hundred square meters, even though average household size decreased from 3.67 members in 1940 to 2.62 in 2002.[454] As a result of the increasing size of houses and floor area per occupant, along with the increased number of appliances, garage space and bathrooms per household, electricity consumption per household increased by thirty-nine percent from 1970 to 2009 despite gains in efficiency.[455] In Canada, household energy use rose nine percent from 1990 to 2005, during which period population increased by seventeen percent and the average size of

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[451] See Jesse W. Abair, "Green Buildings: What It Means to Be 'Green' and the Evolution of Green Building Laws" (2008) 40 Urb. L. 623 at 626-27 (noting green building laws in Austin, Boston, Boulder, Chicago, Dallas, Los Angeles, New York, Oakland, Portland OR, San Francisco, San Diego and Seattle and over 110 other municipalities).
[452] The LEED system has created a category for neighborhood development. See U.S. Green Building Council, *LEED for Neighborhood Development,* online: <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=148>.
[453] See CEC Green Building Report, *supra* note 299.
[454] Alex Wilson and Jessica Boehland, "Small is Beautiful: U.S. House Size, Resource Use, and the Environment" (2005) online: <http://www.greenbiz.com/news/2005/07/12/small-beautiful-us-house-size-resource-use-and-environment>.
[455] Pew Center on Global Climate Change, Residential Building End-Use Efficiency (2009) online: <http://www.pewclimate.org/technology/factsheet/ResidentialBuildingEnd-Use>.

the homes grew by nineteen percent.[456]

Where efficiency gains are insufficient to decrease aggregate use of materials and energy or production of waste, the remaining reduction in the impacts that are pushing the economy past ecological boundaries must come from constraints on production and consumption. This is where the urgent need to reduce the throughput of material and energy resources in the economy, an essential component of the rule of ecological law, confronts perhaps the most difficult dilemma of this age of ecological crisis. Through a net shift toward service sectors, some decrease in the production output of physical goods in the economy may be possible while the economy continues to grow in terms of GDP, but at some point, ecological law requires the economic growth imperative to be called into question.[457] Indeed, a postulate of ecological law is that if economic growth is possible only by transgressing ecological boundaries beyond which lies catastrophic deterioration of the economy's ecological base, then an alternative to the growth paradigm is necessary.[458]

Many ecological economists are convinced that, given the current unprecedented precarious state of the economy in relation to the global ecosphere, efficiency gains in a growing global economy will be insufficient to maintain the economy within an ecologically resilient state. For example, noting the Organisation for Economic Co-operation and Development's goal of a ten-fold decrease in material intensity over a thirty to fifty-year period, Peter Victor has written that

> [f]rom data available for Germany, Japan, the Netherlands and the United States, there is little evidence of this happening simply because of improved technologies or the transition to a service economy, trends that were already in play from 1975 to 1993. If it is to happen, it will have to be driven by a combination of much higher prices for raw materials and deliberate government policies requiring ongoing improvements in efficiency.[459]

Ultimately, however, he concludes that increases in efficiency will not be sufficient

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[456] Government of Canada, Sector Sustainability Tables, "Economic Scan of Canada's Energy Sector" (2007) online: <http://www.tdds-sst.gc.ca/default.asp?lang=En&n=AADC6287-1&offset=3&toc=show>.
[457] See Daly, *supra* note 38 at 28.
[458] See generally Rees, *supra* note 38.
[459] Victor, *supra* note 105 at 56.

to decrease material and energy throughput so as to avoid growing resource scarcity, let alone to avoid the impacts on the waste side of economic processes.[460]

5. Global Rules, Applied Using Principles of Subsidiarity and Proportionality

The foregoing sections indicate that the overall framework of ecological law must be built around ecological limits on the global aggregates of material and energy resources that the economy consumes and the wastes it produces.[461] A central challenge is to develop legal mechanisms for distributing these global limits down to the local level. If implemented on a global level, the principles of subsidiarity and proportionality that form part of the bedrock of the European Union treaties could provide strong structural support for such distribution. This architecture of distribution should also incorporate legal and policy mechanisms for enabling all humans and other living beings to flourish, built on principles of intragenerational, intergenerational and interspecies fairness.[462]

The *Treaty on European Union* [*TEU*][463] and the *Treaty on the Functioning of the European Union* [*TFEU*][464] establish subsidiarity as a core principle of governance in the

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[460] *Ibid.* at 70. See also Pelletier, *supra* note 33 at 223 ("Excessive faith has been placed in the potential 'decoupling' of growth and throughput to mitigate environmental concerns whilst allowing for continued growth. To date, empirical evidence does not support this position … , and even the vaunted dematerialization of the 'information economy' has proven illusive … .")(citations omitted).

[461] Cf. Bosselmann, *supra* note 51 at 4 ("The environment . . . is global by nature and the functions of the Earth's ecological systems are felt everywhere beyond any cultural identity.")

[462] See Brown and Garver, *supra* note 6 at 89-91; Bosselmann, *supra* note 51 at 5, 85-90.

[463] *Consolidated version of the Treaty on European Union,* [2008] O.J. C 115/13, *incorporating changes made by Treaty of Lisbon Amending the Treaty on European Union and the Treaty Establishing the European Community*, 13 December 2007, O.J. [2007] C 306/01 (entered into force 1 December 2009)[*TEU*]. The *TEU* introduces subsidiarity in the preamble, where the Member States resolve "to continue the process of creating an ever closer union among the peoples of Europe, in which decisions are taken as closely as possible to the citizen in accordance with the principle of subsidiarity." *TEU*, Preamble.

[464] *Consolidated version of the Treaty on the Functioning of the European Union,* [2008] O.J. C 115/47, *incorporating changes made by Treaty of Lisbon Amending the Treaty on European Union and the Treaty Establishing the European Community*, 13 December 2007, O.J. [2007] C 306/01 (entered into force 1 December 2009) [*TFEU*]. See art. 69 (calling on National Parliaments to comply with the principle of subsidiarity in submitting proposals and legislative initiatives on cooperation on criminal and policing matters).

European Union.[465] Article 5(3) of the *TEU* states:

> Under the principle of subsidiarity, in areas which do not fall within its exclusive competence, the Union shall act only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States, either at central level or at regional and local level, but can rather, by reason of the scale or effects of the proposed action, be better achieved at Union level.[466]

Subsidiarity is perhaps a reaction to the debate around whether policymaking should be centralized or decentralized, but although it favors policymaking as close as possible to affected citizens, it is agnostic on the question of centralization. Rather, subsidiarity is a principle that favors intervention at the level at which it will be most effective for achieving policy objectives.[467] In the United States, the federalization of environmental law that took place starting in the late 1960s looks like centralization but can be seen as an adjustment based on subsidiarity. As Kirsten Engel explains,

> According to the legislative histories of the Clean Air Act of 1970 and the Federal Water Pollution Control Act of 1972, Congress thought . . . states simply could not be trusted to impose upon industry the costs that would be necessary to adequately protect human health and the environment. To Congress, a history of state reticence to impose controls under prior federal laws demonstrated that states were too afraid that they would lose existing or new industries to other states to impose stringent controls or take an aggressive stance on environmental enforcement. Consequently, if human health and the environment were to receive adequate protection, the job must fall to the federal government which is comparatively immune to such pressures.[468]

The challenge in implementing the principle of subsidiarity is to account for a broad range of cultural, ecological and socio-political contexts, and a concomitant plurality in the way behavior is made to conform to legal limits, in fashioning a predictable and

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[465] See also *ibid*., *Protocol 2 On the Application of the Principles of Subsidiarity and Proportionality*. The Protocol establishes procedures for consultations on draft legislative proposals with regard to subsidiarity and proportionality and requires European Union institutions to justify draft legislative proposals with regard to the principles of subsidiarity and proportionality.

[466] *TEU* art. 5(3). See also Richard E. Saunier and Richard A. Meganck, *Dictionary and Introduction to Global Environmental Governance, Second Edition* (London: Earthscan, 2009) at 259.

[467] See Saunier and Meganck, *ibid.* at 259 ("[S]ubsidiarity assigns priority to the lowest jurisdictional level consistent with effectiveness.")

[468] Engel, *supra* note 94 at 290. The firm grip that business interests appear to have on political institutions in the United States in more recent times suggests that the relative ability of the federal government to resist private sector pressures is nonetheless limited.

consistent global system of the rule of ecological law. Subsidiarity should be implemented in recognition that global (as opposed to international) environmental law and governance is generally conceived to include the participation of "a long list of institutions including governments, businesses, nongovernmental organizations (NGOs), universities, research centers, and foundations [operating] inside and outside of government and across national and institutional boundaries."[469]

Proportionality complements subsidiarity with the notion that governments at all levels must have sufficient capacity and authority to achieve their mandates and objectives. For example, with respect to the European Union, the *TEU* provides that "[u]nder the principle of proportionality, the content and form of Union action shall not exceed what is necessary to achieve the objectives of the Treaties."[470] Although proportionality is sometimes viewed as a principle for limiting government, it is just as appropriately a principle for ensuring that governments are properly enabled to accomplish their work. Thus, rather than speaking in terms of proportionality, the authors of *Right Relationship* put forth the notion that

> [g]overnance systems and procedures at the global, national and subnational levels must have, first, the capacity to establish ecological limits on economic activity and, second, the authority to set and enforce rules that will allow human and nonhuman life and the systems they rely on to flourish for generations to come.[471]

6. Fairness within and among Generations and Species

Subsidiarity and proportionality do not necessarily ensure fairness in the allocation and distribution of the limited shares of life support capacity that human and nonhuman life must share. A central feature of the globally dominant economic and legal paradigm is its protection of market freedoms and property rights with a view to maximizing economic efficiency and maintaining perpetual economic growth, on the assumption that doing so will provide the greatest welfare for the greatest number of

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[469] Saunier and Meganck, *supra* note 466 at 3-4. See also Yang and Percival, *supra* note 283 at 623-26.
[470] *TEU* art. 5(4).
[471] Brown and Garver, *Right Relationship, supra* note 6 at 110.

people.[472] The current economic system operationalizes utilitarian theory that is centered on the individual's pursuit of well-being, which economists assume is expressed entirely through preferences revealed in market transactions.[473] It is reflected in the United States in constitutional notions of liberty and property rights, and in Europe in treaty protection of the free movement of goods, of services, of capital and of people and a core commitment to economic growth.[474] In globalized markets for goods and services, it is reflected in strong protections for individual (including corporate) market actors and preferences for privatization but relatively weak measures to protect the global commons, the poor and species other than humans from market forces.[475] In this system, the main fairness concern is that all humans (but not other species) should have an equal possibility to consume and seek wealth, but fairness is rarely assessed in relation to initial endowments that result from inheritances, luck and actual (as opposed to theoretical) outcomes.[476]

The rule of ecological law would prioritize protecting and allowing access to the global commons—that is, the Earth's capacity to maintain life and allow flourishing—in such a way as to ensure opportunities for flourishing for a diverse community of living beings.[477] Individual humans and artificial entities like corporations would be considered interrelational beings in a shared ecological context, and not as free agents whose quest to maximize abstract monetary wealth that can be converted into consumptive and waste-

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[472] See Daly, *supra* note 38 at 220; Daly and Farley, *supra* note 105 at 3-4; Victor, *supra* note 105 at 18-19, 40-41.
[473] Daly and Farley, *ibid*. at 3; Daly, *ibid*. at 220; Rees, *supra* note 38 at 251 ("You and I are assumed to act as isolated automatons whose sole goal is to maximize our personal consumption through participation in the increasingly global marketplace.")
[474] TEU art. 3(3) ("The Union shall . . . work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment."); TFEU Titles II (free movement of goods) and IV (free movement of persons, services and capital).
[475] See Rees, *supra* note 38 at 257-59.
[476] See Brown and Garver, *Right Relationship, supra* note 6 at 97 ("Much of current income and wealth distribution is shaped and determined by institutions, structures, and endowments that have nothing to do with contribution to current output. Among these are genetic inheritance; social connections; clan or class structures; cultural attitudes toward gender, race, and class; institutional power structures; historical imperialism; slavery; financial speculation; and, finally, age-old custom.").
[477] See Berry, *supra* note 40 at 28.

producing activities is given priority. This notion of relationship within a shared commonwealth of life provides a foundation for distribution of Earth's limited life support capacity.

Herman Daly has presented succinctly a sound principle of distribution—albeit one that should be expand to include species other than just humans—that captures the notion of fairness that should be incorporated into ecological law: "We should strive for sufficient per capita wealth—efficiently maintained and allocated, and equitably distributed—for the maximum number of people that can be sustained over time under these conditions."[478] With this proposal, he rejects the utilitarian notion that we should "convert as much as possible of the matter/energy of the world into ourselves and our artifacts"[479] in favor of striving for sufficient—not maximum—wealth for all. He makes clear that equitable distribution does not require equal wealth for all, but it does imply a limited range of inequality above the level of sufficiency for all.[480] It implies, in other words, that the rule of ecological law should apply the principle that it is possible to be too rich.

With material and energy throughput and waste production in the economy so closely correlated to GDP, a common refrain is that a moral imperative exists to allow economic growth, and hence aggregate material and energy consumption, to rise in developing countries in order to reduce poverty and increase human well being.[481] This is in part a question of distribution. However, the moral imperative framed this way fails to address the moral imperative to avoid a catastrophic change in the global context for the human enterprise and the commonwealth of life. The real moral imperative is to distribute access to the means for flourishing of human and other life in ways that avoid catastrophe, which must include a drastic overall reduction in material and energy throughput and waste. Economic growth may be necessary to address the situation of

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[478] Daly, *supra* note 38 at 220.
[479] *Ibid*. at 219.
[480] *Ibid*. at 220.
[481] See Justin Gillis, "A Scientist, His Work and a Climate Reckoning," *The New York Times* (21 December 2010) online: <http://www.nytimes.com/2010/12/22/science/earth/22carbon.html?pagewanted=5&hp>.

developing countries,[482] but where growth occurs it must happen within global ecological limits. Under the rule of ecological law, the notion of common but differentiated responsibilities that is weakly reflected in international law will most likely require developed countries to contract their consumption in order to ensure ecological integrity and human dignity in less developed countries.[483]

The IPAT framework discussed in Section I.B., above,[484] identifies the fundamental policy arenas for developing innovative ways to meet the challenge of distribution. The use of this framework, adjusted as I=f(PATE) with the addition of a variable E to account for ethical choices, is described in *Right Relationship:*

> Nations . . . will have choices about the weight assigned to the four variables, so long as the total human impact (I) globally remains within their share of the earth's ecological limits. A nation that chooses to permit a large population may have to agree to a lower level of wealth, different technologies, or different practices, and conversely.[485]

This may be extended beyond the nation state level through establishment of a regulatory structure designed to identify the key systems limits for particular economic sectors and activities, so that legal and policy tools can be applied according to a hierarchy that favors the approaches that are most effective for addressing the most serious concern with respect to a particular sector or activity. For example, with respect to the climate change boundary and the energy sector, a priority should be limiting greenhouse gases from coal-fired power plants, either through fuel switching, retirement of plants or carbon capture and storage. These reductions would likely also reduce concerns related to other pollutants such as mercury, fly ash or sulfur dioxide, and to other planetary boundaries like biodiversity and chemical pollution.

7. Supranational, with Rights of Enforcement for Non-state Actors

The principles of subsidiarity and proportionality in Europe are derivative of the supranational authority of many provisions of the *TEU* and *TFEU.* The supremacy of

[482] See Victor, *supra* note 105 at 18.
[483] See Bosselmann, *supra* note 51 at 59-60, 75.
[484] See pages 22-23, above.
[485] Brown and Garver, *Right Relationship, supra* note 6 at 133.

European law in key areas emerged as an essential characteristic of the Treaty of Rome and its progeny, with the European Court of Justice playing a determinative role in establishing areas where European law is supreme.[486] For the rule of ecological law, supranational authority is a necessary complement to subsidiarity and proportionality, because if planetary ecological boundaries require global legal and policy mechanisms, then those mechanisms must be made binding in national and sub-national systems. In other words, they must have supreme authority.

Nathan Pelletier makes a convincing case that the insistence on wholesale preservation of state sovereignty in nearly all, if not all, structures of international environmental governance virtually ensures their ineffectiveness.[487] He argues that "[s]ince the most serious contemporary environmental problems are trans-border and/or global, their resolution requires global-level decision-making that can effectively trump the opposition of recalcitrant states."[488] The lack of strong environmental protection mechanisms and politically tainted decision making and vote taking under the *NAFTA* regime, outlined in Section III.B. above, illustrates the problems associated with overprotection of sovereignty on environmental matters.

Professor Dan Tarlock underscores three main principles of United States environmental law as it has unfolded since the 1960s. He claims that

> the three principal and related objectives of the early environmental movement were to open the courts to NGO suits to challenge the failure of federal and state agencies to consider adequately the environmental consequences of their actions, to federalize environmental protection to the maximum extent possible, and to solve most problems by the application of state-of-the-art- plus technology.[489]

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[486] See *Costa v. ENEL,* C-6/64, [1964] E.C.R. 585 at 593 ("By contrast with ordinary international treaties, the EEC Treaty has created its own legal system which, on the entry into force of the Treaty, became an integral part of the legal systems of the Member States and which their courts are bound to apply. By creating a Community of unlimited duration, having its own institutions, its own personality, its own legal capacity and capacity of representation on the international plane and, more particularly, real powers stemming from a limitation of sovereignty or a transfer of powers from the States to the Community, the Member States have limited their sovereign rights, albeit within limited fields, and have thus created a body of law which binds both their nationals and themselves.")

[487] See Pelletier, *supra* note 33 at 225.

[488] *Ibid.* at 225.

[489] A. Dan Tarlock, "The Future of Environmental 'Rule of Law' Litigation and There Is One" (2001) 19 Pace Envtl. L. Rev. 611 at 611.

Professor Tarlock posits that together, these principles underlay a "rule of law" litigation strategy by which public interest environmental lawyers blended common law rules, administrative and statutory schemes and carefully tailored principles of statutory construction to convince courts that the law created enforceable duties to protect the environment and "judicial intervention was necessary to uphold the rule of law."[490]

Two of Professor Tarlock's principles should equally form the basis of a global system of supranationalecological law. First, just as the environmental movement in the 1960s and 1970s in the United States grew out of realization that the individual States were poorly equipped to manage a legal framework for the nation's increasingly evident environmental problems, the global ecological problems of the current era call for a global system in which individual countries must cede to certain supranational rules. environmental problems related to industrial manufacturing, motor vehicles, energy production, pesticides and the like became increasingly apparent in the 1960s, making clear that federal environmental laws were needed to address the ineffectiveness of state-level controls.[491] This illustrates not only the principle of subsidiarity, but also the conditions that create a need for binding authority at a higher level of government.

Second, a judicial authority or its equivalent is needed to ensure the enforcement and implementation of an ecological regime, as the experience in the United States, Europe and elsewhere has so clearly demonstrated. The most reliable way firmly to establish supranational authority of global rules is with a supranational judicial function, such as the European Court of Justice in Europe, although the principle of supranationality may be met through other means that effectively ensure that behavior conforms to expected supranational norms. These might include such mechanisms as third-party certification systems, eco-labeling requirements or alternative dispute resolution mechanisms. The dispute resolution mechanism of the *Montreal Protocol* may provide an example in this regard,[492] although reliance on this example raises a question of causation (did the mechanism contribute significantly to reductions in ozone-depleting

[490] Tarlock, *supra* note 114 at 241-42.
[491] See *supra* note 25 and accompanying text.
[492] See pages 62-63, above.

substances?) versus correlation (would those reductions have happened anyway?). Other explanations for the relative success of the protocol,[493] as well as some examples of chronic noncompliance,[494] may suggest that it played a limited role.

The experience of Europe illustrates the emergence of supranational authority within an overall context of economic integration. Although protection of the environment was not a core objective when the Treaty of Rome established the European Community, or even mentioned in the Treaty, it emerged, with approval of the European Court of Justice, as implicit in the Community's authority to regulate the functioning of Europe's common market.[495] The federalization of environmental law in the United States under the Commerce Clause of the United States Constitution generally followed the same general logic. The chief barrier in the United States and most other countries outside of Europe to a supranational regime of ecological law is a hypersensitivity to perceived infringements of sovereignty.[496] Importantly, however, the United States and the many countries with whom it has trade accords that include investment chapters akin to *NAFTA* Chapter 11, including Canada, Mexico, Dominican Republic, the Central American countries and Peru, have waived their sovereign immunity to allow private investors to seek binding arbitration on claims that a government has harmed its investment by violating the investment provisions.[497] With such precedents, and with the examples of Europe and the federal system of environmental regulation in the United States, arguments against creation of a supranational regime of ecological law lose considerable force.

The supranational enforcement regime in Europe and the federal system of environmental law in the United States demonstrate the value of giving non-governmental actors the ability to enforce environmental protection laws against the government or

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[493] See pages 63-66, above.
[494] See Victor, *supra* note 105 at 76.
[495] See Ida J. Koppen, "The Role of the European Court of Justice" in Andrew Jordan, ed., *Environmental Policy in the European Union, Second Edition* (Sterling, VA: Earthscan, 2005) 67 at 67, 72-80, 83; Jon Burchell and Simon Lightfoot, *The Greening of the European Union?* (London: Sheffield Academic Press, 2001) at 34-37.
[496] See e.g. Johnson and Beaulieu, *supra* note 335 at 23-24 (discussing the strong role of sovereignty concerns as *NAFTA* and *NAAEC* were being negotiated).
[497] *NAFTA* arts. 1115-38.

private violators. The ability of private citizens in Europe to enforce European law in the national and European courts, and of private citizens in the United States to bring citizen suits or administrative legal actions to enforce environmental laws, has undoubtedly contributed greatly to environmental progress in Europe and the United States.[498]

8. Greatly Expanded Research and Monitoring

The rule of ecological law will depend on a deep scientific understanding of the global ecosystem, its subcomponents, and their relationship with the human sphere. The areas in which greatly expanded research is needed fall into two categories. An adequate system of global governance will require first, more research into the Earth's life systems, their systemic behavior and thresholds, and the impacts of the human enterprise on those systems; and second, ongoing research into the governance structures that are most appropriate for the rule of ecological law.

In the first category, the high degree of uncertainty with respect to the planetary boundaries, even as the Rockström team estimates that three have been transgressed, underscores the need for greatly expanded research and monitoring. For example, as the Rockström team explains:

> There is ample evidence from local to regional scale ecosystems, such as lakes, forests, and coral reefs, that gradual changes in certain key control variables (e.g., in biodiversity, harvesting, soil quality, freshwater flows, and nutrient cycles) can trigger abrupt system state change when critical thresholds have been crossed. More research is urgently needed on the dynamics of thresholds and feedbacks that operate at continental and global scales, especially for slow changing control variables such as land use and cover, water resource use, biodiversity loss and nutrient flows.[499]

With respect to the planetary boundaries generally, "the knowledge gap is disturbing" and "there is an urgent need to identify Earth System thresholds, to analyse risks and uncertainties, and, applying a precautionary principle, to identify planetary boundaries to

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[498] See Ben Boer, "Institutionalising Ecologically Sustainable Development: The Rules of National, State, and Local Governments in Translating Grand Strategy Into Action" (1995) 31 Willamette L. Rev. 307 at 326; Paul Craig & Gráinne de Búrca, *EU Law: Text, Cases, and Materials* (Oxford: Oxford University Press, 2008) at 268-69 (describing ways for European citizens to enforce European law in national and European courts). See generally, Tarlock, *supra* note 493.

[499] Rockström *et al.*, *supra* note 4 at 10.

avoid crossing such undesired thresholds."[500]

The knowledge gap in regard to climate change, for example, remains considerable despite the impressive efforts of the IPCC, although the gaps are insufficient to justify inaction. Corinne Le Quéré recently summarized some of the research and methodological needs as of the late 2000s:

> Some GHG emissions and sinks are difficult to quantify and may not be correctly accounted. This is particularly important for CO2 emissions and sinks from deforestation and forest management, CH4 emissions from wetlands and fires, and N2O emissions from agriculture. Although national anthropogenic emissions of GHG other than CO2 are monitored, full global sources and sinks are not compiled on a year-to-year basis; only their atmospheric concentrations are systematically monitored. Also, GHG emissions directly reported by each country may be inaccurate because of methodological issues, scope of accounting (such as soil carbon, land use, black carbon, shipping and aviation), inconsistent system boundary definitions, and incompleteness in the information base. Finally, there are many countries where inadequate accounting infrastructure can lead to large errors in inventories.[501]

Le Quéré and her colleagues describe a mixed problem of research and monitoring and of data analysis and management. On the research and monitoring side, they assert that "[t]o ensure that reductions in GHG emissions are effective, the full anthropogenic and natural components of the carbon and nitrogen cycles must be quantified and monitored at multiple scales."[502] A prominent example of an area where research and monitoring has been inadequate is the potential for sea level rise due to melting of the Greenland and Antarctic ice sheets,[503] a major area of uncertainty in the IPCC's 2007 climate change assessment.[504] This void of information, exacerbated by the failure to

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[500] *Ibid.* at 28.
[501] Corinne Le Quéré *et al*., "An International Carbon Office to assist policy-based science" (2010) 2 Current Opinion in Environmental Sustainability 297 at 297.
[502] *Ibid*. at 298.
[503] Justin Gillis, "As Glaciers Melt, Scientists Seek New Data on Rising Seas" *The New York Times* (13 November 2010), online: <http://www.nytimes.com/2010/11/14/science/earth/14ice.html?hp> ("While the United States is among the countries at greatest risk, neither it nor any other wealthy country has made tracking and understanding the changes in the ice a strategic national priority.")
[504] IPCC 2007 *Synthesis Report*, *supra* note 11 at 33, 45. Since that time, research on the melting of glaciers and ice sheets has intensified, and this more recent work indicates that "all the models used for the IPCC AR4 underestimated the timing of Arctic ice loss." UNEP, *Climate Change Science Compendium, supra* note 21 at 19.

replace failed ice monitoring satellites, limits the ability to deal with both mitigation of and adaptation to climate change.[505]

The critical levels and loads approach to control of long-range transboundary air pollutants in Europe also illustrates the need for ongoing research and monitoring. Malcolm Cresser, who was involved in developing some critical load estimates, posits that scientists overcame their initial concerns regarding uncertainties and simplifications of complex ecosystem dynamics used in the approach, because they agreed on the need for science-based justifications for reducing the systemic harms that air pollution causes despite uncertainties.[506] However, he also notes that the approach spurred a great deal of research that has strengthened understanding of the relationships between pollutants and their receptor ecosystems, which in turn should, but does not always, lead to improvements in the approach.[507]

Helmut Haberl and his research colleagues point out the need for expanded research before MEFA and related tools for analyzing socio-economic metabolism can be used in policy.

> Both MFA and EFA are, at present, restricted to accounting. Establishing MEFA compatible models that would analyse systemic interrelations between material and energy flows, land use, [human appropriation of net primary production (HANPP)], and many other important variables related to processes within social-ecological systems relevant to sustainability (e.g. net carbon flows into the atmosphere) are still in their infancy. Only such models would allow to establish scenarios and forecasts which are important for policy advice.[508]

A key problem to overcome is the current imbalance between research in support of private interests, propelled by the anticipation of financial profits, and research in support of humanity's common interest, where pooling the resources to fund research must confront competing demands for public money.[509] The urgency of the global

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[505] Gillis, *supra* note 503.
[506] Cresser, *supra* note 210 at 52. See also Spranger *et al*., *supra* note 222 at 486.
[507] Cresser, *ibid*. at 53-54, 59-60.
[508] Haberl *et al*., *supra* note 419 at 205
[509] See Thomas Homer-Dixon, *The Ingenuity Gap: Facing the Economic, Environmental, and Other Challenges of an Increasingly Complex and Unpredictable World* (New York: Vintage Books, 2002) at 259-260. Cf. Berry, *supra* note 40 at 141-42; Victor, *supra* note at 105, 147-48.

ecological crisis compels a reprioritization that ensures that adequate research and monitoring is funded to enable a much better tracking of the situation of humans and our fellow Earth inhabitants with respect to the planetary boundaries.

The second category of research is oriented to the issues of public policy and governance that relate to managing the human-Earth relationship in a manner that respects global ecological boundaries and complementary principles. The Earth System Governance project[510] provides a promising framework for this area of research. Earth system governance is defined in this project as

> the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set up to steer societies toward preventing, mitigating, and adapting to global and local environmental change and, in particular, earth system transformation, within the normative context of sustainable development.[511]

The research plan of the project is framed around five interlinked analytical questions, four crosscutting themes and an initial set of four "flagship activities." The analytical questions concern the architectures of governance, agency, the adaptiveness of Earth systems, accountability and legitimacy of governance systems, and allocation of and access to material and immaterial values.[512] The crosscutting themes that relate to all of the analytical questions are power, knowledge, norms and scale.[513] The flagship activities provide broad contexts within which to examine the analytical questions and crosscutting themes, and the initial set identified for the project are the global water system, the global climate system, food systems and the global economic system.[514] The Earth System Governance Project and similar research efforts have considerable potential to enhance the development of the rule of ecological law.

9. Comprehensive Caution about Breaching Ecological Limits

The need for greatly expanded research and monitoring is due to the considerable

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[510] Earth System Governance Project, online: <http://www.earthsystemgovernance.org/>.
[511] Frank Biermann *et al*., *Earth System Governance: People, Places, and the Planet,* Earth System Governance Report 1, IHDP Report 20 (Bonn: The Earth System Governance Project, 2009) at 4.
[512] *Ibid.* at 15-16.
[513] *Ibid.* at 67.
[514] *Ibid.* at 86-108.

uncertainty that remains regarding the human-Earth relationship and how the human community should manage it. The rule of ecological law requires use of the precautionary principle to guide management of the human-Earth relationship in the face of this uncertainty. In particular, caution is needed to avoid crossing planetary boundaries between safe operating space and catastrophe.

The precautionary principle was recognized internationally as early as 1982 and was included in Principle 15 of the 1992 Rio Declaration, which states that

> in order to protect the environment, the precautionary approach shall be widely applied by States according to their capability. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[515]

Other statements of the precautionary principle avoid the mischief of referring to "cost-effective measures," such as a version adopted at the 1990 Bergen Conference that stated simply that "when confronted with serious or irreversible environmental threats, the absence of absolute scientific certainty should not serve as a pretext for delaying the adoption of measures to prevent environmental degradation."[516] The precautionary principle is explicitly embedded in the bedrock of European Union environmental law. The *Treaty on the Functioning of the European Union* provides that European Union environmental policy "shall be based on the precautionary principle."[517]

Uncertainty, which triggers application of the precautionary principle, is not the same as risk. Decisions based on known risks, where probabilities of different outcomes can be compared in working toward a decision, are different from decisions in which risks are uncertain.[518] The precautionary principle comes into play in the increasing number of situations "in which law has to fill cognitive gaps, since scientific data prove

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[515] UNEP, *Rio Declaration on Environment and Development* (1992), Principle 15.
[516] Saunier and Meganck, *supra* note 466 at 229. For additional versions of the precautionary principle, see Sunstein, *supra* note 194 at 118-119.
[517] *TFEU* art. 191.
[518] Tallacchini, *supra* note 75 at S648; Sunstein, *supra* note 194 at 147. Tallacchini suggests that, in fact, situations in which uncertainty does not exist rarely, if ever, occur, and that the "normal" situation is one in which "facts are uncertain, values in dispute, stakes high, and decisions urgent" and "essential unpredictability" rather than uncertainty drives decisions. Tallacchini, *ibid*. at S649.

uncertain, insufficient or susceptible to sharply diverging interpretations."[519] Thus, application of the precautionary principle under the European Commission's guidance requires a prior scientific evaluation of risks and uncertainties. The Commission distinguishes prudence in regard to uncertainty in risk assessment from application of the precautionary principle, which it casts as relevant only at the risk management stage,[520] "when scientific uncertainty precludes a full assessment of the risk and when decision-makers consider that the chosen level of environmental protection or of human, animal and plant health may be in jeopardy."[521] The precautionary principle can be applied under this guidance to establish a presumption that a product or activity requiring government authorization is hazardous, with the burden on the proponent to prove otherwise, or to allow those concerned about the risks of a product or activity that is not a priori considered hazardous to show the dangers and risks associated with it.[522]

The European Union applies the precautionary principle in conjunction with other core European principles, most prominently the principle of proportionality. Proportionality requires allowable restrictions on the free movement and goods and services to protect human health or the environment to be the least restrictive means necessary to achieve health or environmental safeguards.[523] The European Court of Justice merges the proportionality and precautionary principles as follows:

> It is true that the assessment which a Member State is required to make may reveal a high degree of scientific and practical uncertainty . . . . Such uncertainty, which is inseparable from the concept of precaution, influences the extent of the discretion of the Member State and thus has an impact on the means of applying the proportionality principle. In such circumstances, it must be acknowledged that a Member State may, under the precautionary principle, take protective measures without having to wait for the reality and the seriousness of those risks to be fully demonstrated . . . . However, the assessment of the risk cannot be based on purely hypothetical considerations . . . .[524]

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[519] *Ibid*. at S648.
[520] EU, Commission, "Communication from the Commission on the precautionary principle" (Brussels: EU, 2000) at 12, § 5, and 12, § 5.1.2.
[521] EC Communication on the precautionary principle at 12.
[522] *Ibid*. at 20.
[523] TEU arts. 5, 12, 69; TFEU art. 69, 296 and *Protocol on the Application of the Principles of Subsidiarity and Proportionality*.
[524] *Commission v. France*, C-333/08, [2010] E.C.R. — at ¶ 91 (citations omitted).

Precautionary approaches are resisted in many ways, for example with demands of sound science, exaggerated assertions of uncertainty, and categorical attacks on the use of assumptions and other normal methodological approaches.[525] "Such strategies can be termed 'idealizations' of science insofar as they rely on an unrealistic image of good science as somehow capable of avoiding tentative conclusions, institutional interests, consensual assumptions, and the need for further research."[526] In the United States, Robert Percival attributes the weak application of the precautionary principle, at least in part, to the tension between

> a precautionary approach that seeks to prevent harm to health or the environment by regulating activities science believes contributes [sic] to such harm, and a reactive approach that seeks to forestall precautionary measures until detailed evidence proves that significant harm is occurring that cannot be attributed to other causes.[527]

The result is what he calls "a kind of 'regulatory common law' that endorses precautionary regulation and purports to defer to agency expertise, while insisting that agencies convince reviewing courts that the risks they seek to control are significant and can be appreciably reduced by regulation."[528]

Questions surrounding the application of the precautionary principle in legal and policy contexts often touch on the degree of deference to be given to "science" and its findings. The degree of deference to be given to science, or whether it deserves deference at all, is strongest in a "republic of science" paradigm, in which science is seen as purely objective and supremely equipped to "speak truth to power."[529] In this model, "scientists form a perfect community of peers, self-governed through shared and freely discussed knowledge, without any coercive mechanisms and forms of authority other than knowledge itself."[530] The law bound up with science in this idealized model carries with

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[525] Caudill and Curley, *supra* note 149 at 251.
[526] *Ibid*.
[527] Percival, *supra* note 109 at 10. He finds evidence of the reactive approach, which is grounded in common law traditions that emphasize rigorous standards or causation and individualized harm, in judicial decisions limiting the jurisdictional scope of wetlands under the Clean Water Act, regulatory takings jurisprudence, the U.S. Supreme Court's standing jurisprudence and judicial decisions limiting the EPA's regulatory authority under the Toxic Substances Control Act. *Ibid*. at 12-16.
[528] Percival, *supra* note 109 at 17.
[529] Tallacchini, *supra* note 75 at S646-47.
[530] *Ibid.* at S647.

it the strong assumption of objective truth. In reality, science is never entirely objective, and scientific uncertainty can lead to divergent views among scientists. Context and the discourse of science influence the weight of science in legal and policy settings.[531]

The operation of the precautionary principle gains clarity when it is considered in connection with the possibility of catastrophic harm or irretrievable loss. The concept of planetary boundaries, which are defined in relation to catastrophic systemic changes, incorporates a strongly precautionary approach.[532] The nature of climate change and other systemic disruptions that threaten a fundamental shift in the ecological context of the economy puts the precautionary principle in a particular context.

> [Climate change] is not an isolated externality in an otherwise perfect market system, nor a simple harm with a straightforward remedy. The traditional, often implicit assumption of a higher burden of proof for those who want change than for those who oppose it may be obsolete if the world is in fact headed rapidly for a cliff. *Something* new and different has to be done … .[533]

The emphasis on threats of serious or irreversible environmental harm helps avoid the common criticism that the precautionary principle improperly invoked simply provides cover for a political choice to be cautious about some things but not others. As Cass Sunstein explains:

> Often people, and nations, take undue precautions against worst-case scenarios simply because they disregard the burden and risks of those precautions. But often people, and nations, neglect worst-case scenarios because they are unduly attentive to the burden imposed by precautions. It is important to look at both sides of the ledger.[534]

To avoid a state of paralysis in which the precautionary principle prevents any decisions because of risks on both sides of the ledger, a system is needed for ordering risks and accounting for uncertainty.[535]

Sunstein confirms that in the case of the risk of catastrophic harm, the precautionary principle can properly order public choice among opposing risks in the face of

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[531] See *ibid*.
[532] Rockström *et al.*, *supra* note 4 at 7 and Supplementary Information at 4-7.
[533] Heinzerling and Ackerman, *supra* note 106 at 333.
[534] Sunstein, *supra* note 194 at 7-8.
[535] *Ibid*. at 125-127.

uncertainty. He proposes the following Catastrophic Harm Precautionary Principle:[536]

> In deciding whether to eliminate the worst-case scenario under circumstances of uncertainty, regulators should consider the losses imposed by eliminating that scenario, and the size of the difference between the worst-case scenario under one course of action and the worst-case scenario under alternative courses of action. If the worst-case scenario under one course of action is much worse than the worst-case scenario under another course of action, and if it is not extraordinarily burdensome to take the course of action that eliminates the worst-case scenario, regulators should take that course of action. But if the worst-case scenario under one course of action is not much worse than the worst-case scenario under another course of action, and if it is extraordinarily burdensome to take the course of action that eliminates the worst-case scenario, regulators should not take that course of action.[537]

By so formulating the precautionary principle, Sunstein intends to create space for its application in ways that avoid undervaluation of future benefits of imposing immediate measures to avoid catastrophe (the discounting problem), that account for tradeoffs between different (and sometimes opposing) risks of catastrophe, and that avoid unreasonable risk aversion in the face of uncertainty.[538] As applied to climate change, he explains that this formulation of a precautionary approach might call for elimination of its catastrophic consequences even at the cost of a thirty percent reduction in average living standards, but only if the probability of those consequences rises above some threshold "for extremely significant expenditures in response to a catastrophic risk under conditions of uncertainty."[539]

Similarly, Sunstein introduces what he calls the Irreversible Harm Precautionary Principle, which provides that "[s]pecial steps should be taken to avoid irreversible harms, through precautions that go well beyond those that would be taken if irreversibility were not a problem."[540] Sunstein grounds this version of the precautionary principle in considerations of valuing and preserving options and flexibility that may be irreversibly lost if certain decisions are taken, and of valuing the deferral of decisions that entail irreversible harm if the prospects for reducing uncertainty about the nature and degree of harm are good.[541] "The key point is that uncertainty and irreversibility should lead to a

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[536] He introduces this term at *ibid.* at 119.
[537] *Ibid.* at 167-68.
[538] See *ibid.* at 118-175
[539] *Ibid*. at 171.
[540] *Ibid*. at 177.
[541] *Ibid*. at 180-182.

sequential decision-making process. If better information will emerge, regulators might seek an approach that preserves greater flexibility."[542] However, noting ambiguity in the term "irreversible," Sunstein clarifies that to invoke the Irreversible Harm Precautionary Principle, irreversibility should involve harms that "rise to a certain level of magnitude" and—to account for the possibility that avoiding one irreversible loss may cause other irreversible losses—care should be taken to assess the extent of irreversibility related to alternative choices.[543] For example, some argue that it is better to wait for better information before deciding whether and how to address climate change, given the possibility of irreversible decisions involved in mitigating it—although Sunstein concludes, as this author does, that "we have good reason to believe that the irreversible losses associated with climate change do indeed justify the irreversible losses associated with greater investment in emissions reductions, worldwide."[544]

Another aspect of irreversibility that is relevant to the ecological rule of law is the incommensurability of different things that might be lost or gained in an irreversible decision. As Sunstein explains,

> [w]hen people say that the loss of a pristine area, or of a species, is irreversible, they do not merely mean that the loss is grave and that it takes a lot to provide adequate compensation. They mean that what is lost is incommensurable—that it is qualitatively distinct, and that when we lose it, we lose something unique.[545]

The notion of incommensurability is important to understanding the fundamental problem with the view that the future losses from transgressing planetary boundaries such as climate change or biodiversity loss can be reduced to a monetary value, discounted to present value and compared against the anticipated growth in alternative investments of the money that would have to be spent now to avoid those future losses.[546]

Even limited to catastrophic or irreversible environmental harms, one might try to avoid application of the precautionary principle to avoid ecological catastrophe by characterizing the economic or social implications of being ecologically cautious as

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[542] *Ibid*. at 182.
[543] *Ibid*. at 184-86.
[544] *Ibid*. at 187.
[545] *Ibid*. at 188.
[546] See e.g. William Nordhaus, *supra* note 23 at 15.

equally or more catastrophic. For example, catastrophic loss of employment or negative effects on economic growth have been invoked to resist action to regulate greenhouses gases in the United States—often by lawmakers who are skeptical about the catastrophic nature of climate change and who rely on high discounting of future consequences of climate change.[547] However, these are typically false comparisons of opposing catastrophic consequences, in that they rely on incommensurable forms of catastrophe. The Rockström team's planetary boundaries are defined as frontiers between safe operating space and a catastrophic change in the ecological context for the human enterprise. Catastrophe is part of the definition of the boundaries and therefore cannot be ignored in analyzing them. The economic catastrophes that are typically contrasted with catastrophes associated with the planetary boundaries, in particular climate change catastrophes, ignore the possibility of alternative economic scenarios that might avoid economic catastrophe, such as innovations in access to and distribution of the means of well being.[548] Further, the supposed economic catastrophes resulting from mitigation of climate change must be compared to the projected economic catastrophes of not mitigating climate change.

Despite proposing formulations of the precautionary principle for the special cases of catastrophic harm and irreversible loss, Sunstein offers qualified support for cost-benefit analysis as an alternative.[549] Here, he parts ways with those, like Lisa Heinzerling and Frank Ackerman, who reject cost-benefit analysis in favor of the precautionary principle.[550] Sunstein says that critics of cost-benefit analysis "neglect the possibility that expensive regulation, focused on the elimination of worst-case scenarios, will actually hurt people—and have worst case scenarios of its own" such as significant increases in

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[547] In a 2007 U.S. Senate floor statement, U.S. Senator James Inhofe, relying on William Nordhaus's work with the DICE model, stated that the claim "that it would be cheaper in the long run to immediately enact regulatory policies aimed at controlling the Earth's global temperatures . . . is clearly wrong." Senator James Inhofe, Press Release, "Floor Speech: Inhofe, Boxer Debate Global Warming on Senate Floor" (29 October 2007), online: <http://epw.senate.gov/public/index.cfm?FuseAction=Minority.PressReleases&ContentRecord_id=eddb00e1-802a-23ad-4b39-b70900f52b98&Region_id=&Issue_id=>.
[548] See Victor, *supra* note 105 at 191-224.
[549] Sunstein, *supra* note 194 at 218-38.
[550] *Ibid*. at 218, 221-24, 233-34.

unemployment and poverty.[551] Yet, Sunstein's apparent endorsement of cost-benefit analysis relies too heavily on individual—and, unavoidably, largely uninformed—choice regarding willingness to pay for regulations and autonomy regarding what risks to assume, without reckoning with the free-rider and other collective action problems his analysis implies. Or, the conditions that he would attach regarding those concerns are such that cost-benefit analysis will only rarely be the preferred tool for making decisions.[552] Moreover, he is willing to defer to these arbitrary individual assessments of costs and benefits without fully reconciling the problems of incommensurability of values they entail and without acknowledging the primary degree of caution that is due to uncertainty regarding the risk of systemic ecological catastrophes.[553] In the case of the catastrophic risks associated with the planetary boundaries, the kinds of tradeoffs inherent in cost-benefit analysis are particularly inappropriate.[554]

Under the rule of ecological law, Sunstein's guidelines for applying the precautionary principle when faced with catastrophic harm or irreversible loss lay a possible foundation for managing collective human behavior and activities so as to steer clear of planetary boundaries. However, in applying his rules, it is important to respect the incommensurability of many ecological values with monetary indicators of value, and to apply a strong assumption that many ecosystem services have infinite monetary value and must be protected, preserved and enhanced using non-market mechanisms.

10. Adaptive

Building off the need for expanded research and monitoring and a precautionary approach giving primal importance to global ecological boundaries, the rule of ecological law should take an adaptive approach, for two principal reasons. First, in order to exercise caution about crossing planetary and sub-global ecological boundaries, ecological constraints on the human enterprise must be integrated into the global legal

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[551] *Ibid*. at 218-19
[552] See *ibid.* at 218-243.
[553] See *ibid.* at 224.
[554] See Heinzerling, *supra* note 111 at 168; Frank Ackerman and Lisa Heinzerling, "Pricing the Priceless: Cost Benefit Analysis of Environmental Protection" (2002) U. Penn. L. Rev. 1553 at 1570-72.

and policy structure despite uncertainties, which will persist in some form or another. An adaptive approach allows mechanisms to be put in place to fend off catastrophe and adjusted as research and experience fill gaps in knowledge about Earth systems and about governance of the human-Earth relationship. The adaptiveness called for applies both to the response to evolving scientific understandings and to the mechanisms and institutional arrangements in which to apply them. Second, adaptation is needed in recognition of the non-equilibrium nature of ecosystems.

A key development in the science of ecology in the last few decades has been the switch from an equilibrium view of nature, in which ecosystems were assumed to have an ideal natural state, to a non-equilibrium view, in which ecosystems are now seen as constantly evolving, often in stochastic and non-linear ways.[555] "The non-equilibrium paradigm . . . accepts the principal lessons of ecology, that unregulated, humans can damage ecosystems, and that the magnitude of human intervention is often too great."[556] Much of contemporary environmental law was developed under the equilibrium view of nature. The rule of ecological law, by contrast, must incorporate the now well-accepted non-equilibrium view, and in so doing, incorporate an adaptive approach to legal mechanisms that govern the human-Earth interface. As Dan Tarlock explains, "[a]daptive management . . . is premised on the assumption that management strategies should change in response to new scientific information: all resource management is an on-going experiment."[557] Because the Earth's ecology is in constant flux, this new scientific information includes not only improved general understanding of the global ecosystem, its myriad subsystems and social-ecological interactions, but also specific information on the changes taking place within those systems.

That the global ecosystem and its subcomponents are constantly evolving does not mean, as some have suggested, that human degradation of the Earth's regenerative

[555] See A. Dan Tarlock, "Environmental Law: Ethics or Science" (1996) 7 Duke Envtl. L. & Pol'y F. 193 at 197-199.
[556] *Ibid*. at 202.
[557] *Ibid.* at 205. See also Rockström *et al.*, *supra* note 4 at 28.

capacity is entirely natural and acceptable.[558] Nor does it imply complete management of the Earth's ecology by humans. Rather, human agents may rely on ecology and other sciences to manage the human-Earth relationship with the goal of preserving and enhancing ecological integrity. The rule of ecological law calls for legal mechanisms and policy to manage human behavior in an ongoing, adaptive manner, with an emphasis on "the maintenance of processes that produce undisturbed systems [consistent with] the functional, historical and evolutionary limits of nature."[559]

Law and policy tend to favor finality and certainty,[560] and to resist change,[561] and thus the transition to a system built for adaptation will be difficult. Stable institutions can help solve the tragedy of the commons, but "with a change in circumstances, sensible institutions can morph into tragic institutions."[562] To design institutions that are responsive and adaptive, Brigham Daniels notes the importance of 1) promoting public participation and transparency, 2) preparing the users of commons resources to be flexible and adaptive, 3) integrating management of multiple values rather than single uses of commons resources, 4) allowing trading among commons users within sensible bounds, 5) building mechanisms for internalizing externalities, 6) providing incentives for conserving the commons, 7) giving legal rights to those affected by the use of commons to challenge decisions regarding management of the commons, and 8) buying out

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[558] See Tarlock, *supra* note 555 at 202; Frank Graham, Jr., *Since Silent Spring* (Boston, Houghton Mifflin Co., 1970) at 46-47 (taking issue with the view of a Shell Chemical Company consultant that human use of pesticides may be part of an "ordained path in nature's road of terrestrial development").

[559] Tarlock, *ibid.* at 202.

[560] Professor Tarlock lists res judicata, statutes of limitations, the doctrine of vested rights and the finality of decisions based on valid environmental impact statements as examples of the desire for finality in the law. *Ibid.* at 206.

[561] See generally Daniels, *supra* note 381. Daniels notes that "[w]e see the face of tragic institutions most clearly when incumbent institutions lock out emerging values. Those attempting to protect emerging values can face significant hurdles: collective action, informal norms, established organizations, and institutional remedies." *Ibid*. at 562. An example is "rulemaking ruts," a term Lynn Blais and Wendy Wagner coined to describe rulemaking that becomes resistant to change in light of new scientific information, such as occurs with technology-based standards where the best information on new technologies is in the hands of the regulated industries with the least interest in wanting to incur costs on new technologies that revised rules might require. Lynn E. Blais and Wendy E, Wagner, "Emerging Science, Adaptive Regulation, and the Problem of Rulemaking Ruts" (2008) 86 Tex. L. Rev. 1701 at 1738.

[562] Daniels, *ibid*. at 565.

entrenched interests if necessary.[563] Many of these proposals—which are all rich and complex topics for analysis—resonate with the features set out in the foregoing sections.

C. Institutional Frameworks for the Rule of Ecological Law

The ten features of the rule of ecological law set out in the foregoing sections need some kind of global institutional structure in order to be effective. In response to the ineffectiveness of existing institutional frameworks, for reasons such as those presented in Part III, above,[564] the authors of *Right Relationship* proposed an institutional framework with four principal components: an Earth Reserve to analyze "the earth's life support budgets and their uses in accordance with right relationship with the commonwealth of life,"[565] a Trustees of Earth's Commons to manage trusts so as "to protect the earth's life support systems and to ensure that these systems be used for the flourishing of life's commonwealth,"[566] a Global Federation "to maintain global security and to protect human and non-human rights,"[567] and a Global Court "to prevent the abuse of power of global agencies or their subsidiaries and to hear cases of enforcement of global rules."[568] The functional elements of this institutional framework (as opposed to its specific institutional proposals) help in imagining what the rule of ecological law would involve, even if the break they imply from current global arrangements may seem impossible to overcome.

The proposals in *Right Relationship* align well with the essential set of functions and activities contained in other proposals for institutional frameworks for global environmental governance. For example, Daniel Esty identifies the following core functions for an effective global environmental institution: 1) rulemaking for supranational norms related to issues like climate change, for which decentralized rulemaking is insufficient; 2) dispute resolution; 3) technical support for policy making,

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[563] *Ibid*. at 566-68.
[564] See Brown and Garver, *Right Relationship*, *supra* note 6 at 103-09 (reviewing the main reasons why governance currently is not working at national and international levels).
[565] *Ibid*. at 113.
[566] *Ibid.* at 124.
[567] *Ibid.* at 127.
[568] *Ibid.* at 135.

which would involve a central bureaucracy to "do data collection and analysis, distill current scientific thinking, undertake cost-benefit or economic analyses of policy proposals, support negotiations, and manage dispute settlement efforts;" 4) serving as a clearinghouse for information that tracks key environmental indicators; 5) monitoring compliance with international norms; 6) funding capacity building in countries that need assistance to meet norms; and 7) coordinating global environmental policies with global policies related to trade, health, food and agriculture, and other matters.[569]

The inadequacy of the current global environmental institutions is well documented.[570] The UNEP is generally credited with some important successes, such as facilitating the process that led to adoption of the *Montreal Protocol* and conducting monitoring and scientific assessment,[571] but it is often cited as having failed to establish a leadership role as the central coordinating forum on international environmental matters.[572] Worse, with international coordination of policy on climate change under the UNFCCC relegated to other international entities, UNEP is widely seen as having lost influence in the past two decades.[573]

The relative ineffectiveness of UNEP has given rise to calls for a World Environmental Organization [WEO] or a Global Environmental Organization [GEO].[574] Some advocates of such an organization assert that it is needed to pull together the currently fragmented international environmental regime, for example by uniting the separate secretariats of various multilateral environmental conventions, the United Nations Commission on Sustainable Development and other such entities into a focused single organization.[575] Equipped with adequate authority to establish binding rules, such an organization might also overcome the dominance of the short-term political interests of

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[569] Esty, *supra* note 271 at 430-32.
[570] See Pelletier, *supra* note 33 at 224.
[571] See Ivanova, *supra* note 281 at 36, 38, 42-43, 46; Esty, *supra* note 271 at 427.
[572] See Ivanova, *ibid*. at 36, 42-44, 46; Esty, *ibid*. at 427; Pelletier, *supra* note 33 at 224.
[573] See Ivanova, *ibid.* at 43; Esty, *ibid*. at 427; Konrad von Moltke, *The Organization of the Impossible* (Winnipeg, MB: IISD, 2001) at 2.
[574] See Biermann, Frank. "The Case for a World Environment Organization" (2000) 42:9 Environment 22; Ivanova, *ibid*. at note 4; Esty, *ibid*. at 428; von Moltke, *ibid*. at 1; Winchester, *supra* note 271 at 23; Pelletier, *supra* note 33 at 225.
[575] See e.g. Esty, *supra* note 271.

the leaders of individual States, which hampers the ability to reach international environmental accords.[576]

Others see the prospects for a WEO or GEO as futile, at least unless its creation coincides with significant reform of the international trade and finance institutions, like the World Trade Organization [WTO], the International Monetary Fund [IMF], the World Bank and others. Konrad von Moltke persuasively observes that "[i]t seems strange to propose change in the environmental regimes to deal with a problem that originated in the WTO."[577] The review in Section III.B., above, of the United States' stale and already outdated approach to linking trade and environment regimes, which is largely reflective of the general international approach to those matters, underscores the observation that an adequate global institutional structure for the ecological rule of law must include a radically different global trade and finance system.

One disturbing proposal, which seems to have the support of some ecological economists, imagines a global institutional arrangement in which a key structural component is the economic valuation of ecosystem services in cost-benefit analyses conducted to support government decision making. For example, the World Wide Fund for Nature's *2010 Living Planet Report* asserts that

> we need a proper system for measuring the value of nature. Governments can account for ecosystem services in cost-benefit analyses that guide land use policies and development permits. We must start with the measurement of the economic value of biodiversity and ecosystem services by governments. This would be the first step to providing new additional financing for biodiversity conservation, which in turn would lead to a new impetus for the conservation and restoration of biodiversity and ecosystem services, including roles for local communities and indigenous peoples.[578]

This proposal, while apparently motivated by a desire to protect ecosystems by assigning them monetary value in decision making that currently accords them no value, is a dangerous capitulation to cost-benefit analysis and an inherent rejection of decision making mechanisms that will protect ecosystems on moral, spiritual or other grounds. Monetizing the valuation of ecosystems carries with it an unavoidable notion that

[576] Pelletier, *supra* note 33 at 224.
[577] von Moltke, *supra* note 518 at 5.
[578] *LPR 2010, supra* note 22 at 97.

ecosystems are the property of humans, that they can be substituted by other things that money can buy and that they must pay their way to be protected—all squarely within the neo-classical economic paradigm that has brought the human enterprise so dangerously close to the edge of ecological catastrophe. Under the rule of ecological law, the attempt to monetize ecosystem services warrants deep skepticism, and, except when dealing with market commodities such as food products, timber and the like, alternative methods of decision making should be used.

With respect to climate change, "[n]o institution is mandated to compile, analyse, report and archive information on full GHG cycles, neither at the regional scale nor at the global scale; no institution is mandated to identify precursors of large and/or abrupt changes in the natural carbon reservoirs or to monitor the evolution of key reservoirs."[579] Hence, Corinne Le Quéré and colleagues propose the creation of an International Carbon Office [ICO], whose mandate would be to:

- *Compile, analyse, report and archive statistics and information on the global and regional balance of CO2 and other GHGs.* A comprehensive analysis of GHG balance would help identify anomalies either in the reporting of GHG emissions or in the expected behaviour of natural sources and sinks. It could lead to the development of non-intrusive means of verifying compliance with commitments of GHG reductions. The archiving of raw data and derived products in a form that is easy to access for all interested parties would ensure transparency and encourage external scrutiny.
- *Identify and monitor the most important CO2 sinks and natural reservoirs of carbon.* The ICO would assess and report the size and vulnerabilities of the natural reservoirs, and ensure that the continuous monitoring of the sensitive reservoirs can be adequately implemented by relevant organisations. The ICO would also assist in monitoring of future activities which might attempt to manipulate CO2 sinks at large scales (geo- engineering).
- *Facilitate the development of methods that can help fill the gaps in full GHG accounting, reduce uncertainty in existing estimates, and provide independent verification of reported emissions.*[580]

Thus, the proposed ICO would be created explicitly to ensure, consistent with the UNFCCC framework and in concert with efforts of the IPCC and related institutions, that research and monitoring of greenhouse gas cycles provide information adequate for use in

[579] Le Quéré *et al*., *supra* note 501 at 298.
[580] *Ibid.* at 299.

policy tools aimed at preventing the crossing of critical thresholds in the global climate system. This same basic institutional formula could and should be applied to the entire suite of planetary boundaries.

The failure of international climate change negotiations to reach long-term, binding reductions in greenhouse gas emissions, and in particular the weak outcome at the Copenhagen talks in 2009 and the Cancun talks in 2010, has drawn attention to the role that governance outside the traditional international channels can play. As Frank Biermann explains,

> Copenhagen gave fresh impetus to those research programmes and political projects that focus on the critique of the 'UN system' and try to explore novel ways of global governance that go beyond the current core system of multilateral diplomacy, legally binding intergovernmental agreements, and regular mega-sized political and diplomatic summits.[581]

This expanded notion of governance includes emerging transnational networks involving civil society, the business sector and scientists, as well as public-private and private-private partnerships. Biermann's analysis suggests that a fortified institutional structure for climate change and other planetary boundaries, along the lines of the ICO, will gain legitimacy and effectiveness by engaging these non-state actors.[582] This is undoubtedly true, and cross-sectoral organizations like the Earth Charter Initiative and the International Union of Conservation and Nature may be primed for leadership in promoting this engagement.[583] The challenge is to establish the ten features identified in Section IV.B, above, and others that complement then, as binding elements of such an institutional structure.

To ensure that these various interests remain focused on the paramount objective of maintaining the human enterprise within planetary boundaries, trusts or fiduciaries for the global commons and an effective system for enforcing global limits can play critical roles.[584] The safeguarding of the ecological base of biodiversity and the human enterprise should be treated broadly as a trust responsibility, protected against the destructive forces

[581] Frank Biermann, "Beyond the Intergovernmental Regime: Recent trends in Global Carbon Governance" (2010) 2 Current Op. in Envtl. Sustainability 284 at 287.
[582] *Ibid*. at 285.
[583] See Brown and Garver, *supra* note 6 at 147-48, 161.
[584] *Ibid*. at 124-26.

of the market, private ownership and the price tagging of values that cannot be expressed in monetary terms. Independent trustees or fiduciaries that develop binding or near-binding proposals for engaging stakeholders and managing the human enterprise within ecological boundaries would have the advantage of being removed from political influences, but would likely succeed and be perceived as legitimate only if they emerged through a participatory process. Of course, creating such trusts and identifying qualified fiduciaries is an enormous challenge, and good existing examples are not easily identified.

One possible prototype is the commission established to select military bases for closing in the United States, whose decisions are subject to an up or down vote. In light of a widely recognized need to close military bases, the *Defense Base Realignment and Closure Act of 1990*[585] created a Base Realignment and Closure [BRAC] Commission to identify and make recommendations as to the bases most appropriate for closure in three base closing rounds in the 1990s. The BRAC's recommendations were subject to acceptance or rejection in their entirety, first by the President, who could refuse to forward the recommendations to Congress, and then the Congress.[586] The use of this process allowed the United States government to make a series of decisions that were broadly deemed in the national interest, but politically difficult for local lawmakers whose constituents the decisions affected. The process made it very difficult for local Congressional delegations of the bases recommended for closure to scuttle the closure decisions.

Institutional means for enforcing or otherwise ensuring compliance with binding ecological boundaries on the human enterprise may take different forms. A leading institutional model is the European Union's system of enforcing its directives and regulations through both the European courts and the national courts of its member states. The federal system of environmental regulation in the United States is similar, in that federal environmental requirements are implemented by the states, with enforcement

[585] Pub. L. 101-510, Title 29, Part A, §§ 2901 to 2910, 104 Stat. 1485, 1808-19, as amended (contained 10 U.S.C. § 2687 statutory notes).
[586] For a more detailed summary of the process, see *Citizens Concerned About Jet Noise, Inc. v. Dalton*, 48 F. Supp. 2d 582 at 586 (E.D. Va. 1999).

shared by the federal and state systems. In Europe, this model has led to a fairly lean bureaucracy at the European level compared to the member state bureaucracies with which regulatory and enforcement responsibility is shared. Alternative means of assuring compliance with global norms distributed through institutional models like the European or American ones may have a role to play as well. These might include, for example, third-party certification of performance, as long as the certification system includes certification of compliance with norms and not simply use of a particular set of management practices, and as long as the certification system has a reliable degree of government oversight.

The authors of *Right Relationship* identify the European Union more broadly as a promising if imperfect model for an institutional framework appropriate for the rule of ecological law.[587] The European Union remains a treaty organization, not quite a State, but with the rare ability to impose supranationally binding rules using mostly the instruments and structure of member states. Although it remains firmly committed to a neo-classical model based on perpetual economic growth, Europe also integrates the principles of precaution, subsidiarity and proportionality that are among the features of the rule of ecological law presented in Section IV.B., above. Further, the European structure allows adoption of legal mechanisms to protect the environment at the European level, which bypasses the fears of disguised protectionism that dominate other multilateral arrangements.

With key countries like China and the United States so clearly averse to the supranational authority and other features of the European model, and with the dominant governance institutions at virtually every level, from the global to the local, so clearly unwilling or not ready to embrace the primacy of ecological boundaries over the economic and socio-political spheres, an institutional framework appropriate for the rule of ecological law may be long in coming. When the time is right, however, Europe—where supranationality, subsidiarity and precaution have at least a foothold—may well be the best structural model with which to begin.

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[587] Brown and Garver, *supra* note 6 at 127-28, 153-54.

Conclusion

As Robert Percival has stated, "[e]nvironmental regulation is one of the most important things any society does. It reflects and expresses some of our most fundamental values concerning respect for life, fairness and the kind of world we aspire to leave to generations to come."[588] Yet, our current way of addressing environmental issues from the global to the local level systematically falls short of protecting those values and ensuring that future generations of humans and other life will flourish as we have up to this critical point in history. This failure is rooted in the lack of a system for tracking the aggregate burden of the economy on the global ecosystem and its subcomponents and using that information to keep the human enterprise within global ecological limits, with fair sharing of the Earth's biocapacity among present and future generations of humans and nonhuman species.

In *The Bridge at the Edge of the World,* James Gustave Speth summarizes in a compelling sweep the interlinked problems that have us seemingly locked in this situation:

> To sum up, we live in a world where economic growth is generally seen as both beneficent and necessary—the more, the better; where past growth has brought us to a perilous state environmentally; where we are poised for unprecedented increments in growth; where this growth is proceeding with wildly wrong market signals, including prices that do not incorporate environmental costs or reflect the needs of future generations; where a failed politics has not meaningfully corrected the market's obliviousness to environmental needs; where economies are routinely deploying technology that was created in an environmentally unaware era; where there is no hidden hand or inherent mechanism adequate to correct the destructive tendencies. So, right now, one can only conclude that growth is the enemy of environment. Economy and environment remain in collision.[589]

How, then, can the rule of ecological law take hold within the global community? The answer to this question is extremely elusive at this time. Many people, including many with political influence, are literally banking on keeping the current system going, with entitlements and justice claims locked up in their homes and pensions, and with the expectation that those and other investments will grow in monetary value at the highest

[588] Percival, *supra* note 109 at 17.
[589] Speth, *supra* note 4 at 57.

possible rate over their life times. The consensus of the G20 countries, built on a definition of recovery and global well being that is intrinsically insistent on economic growth, poses an enormous obstacle to the rule of ecological law.

Calls are rising for a kind of benignant environmental authoritarian regime, for example pursuant to a War on Climate Change akin to the War on Terrorism, that will impose the rule of law regardless of democratic will or with the curtailment of some civil rights.[590] However, as others have cautioned,[591] authoritarian regimes historically have a poor track record, and may be prone to quick, technocratic solutions for which the current ecological crisis is not suited. Rash decisions to implement geo-engineering solutions to climate change, for example, could have catastrophic consequences.[592] Further, as James Gustave Speth warns, a "fortress world" in which authoritarianism slowly rises, draconian measures increase and "the well-to-do escape to protected enclaves and wall out the global underclass" is an unattractive solution.[593]

A better course may be to empower a transdisciplinary cohort within the context of participatory democracy,[594] where the cohort is entrusted with a fiduciary capacity to inform the world about "the full extent of our predicament"[595] and make binding or near-binding proposals, along the lines of military base closing commissions in the United States. The experience of the IPCC, which has the potential to serve this role, has been disappointing to date, in that it has not overcome the resistance of "entrenched interests"[596] and tragic institutions. More importantly, the human collective on whose

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[590] See Mark Beeson, "The Coming of Environmental Authoritarianism" (2010) 19:2 Envtl. Politics 276; Nicole Rodgers, "Law and Liberty in the Time of Climate Change" (2009) 4 Public Space: The Journal of Law and Social Justice 1.
[591] See e.g. John S. Dryzek and Hayley Stevenson, "Democracy and Earth System Governance" *Earth System Governance Paper No. 8* (Lund and Amsterdam: Earth System Governance Project, 2010), online: <http://www.earthsystemgovernance.org/publication/dryzek-john-s-democracy-and-earth-system-governance> at 1-2.
[592] See generally Alan Robock, "20 Reasons Why Geoengineering May Be a Bad Idea" (2008) 64:2 Bulletin of the Atomic Scientists 14.
[593] Speth, *supra* note 4 at 43.
[594] Cf. Westra, *supra* note 57 at 16 (urging that "an impartial, highly respected UN body state unequivocally [the] fundamental importance [of biological and ecological integrity] in a public forum" and proposing the World Health Organization as a preferable candidate).
[595] Speth, *supra* note 4 at 234.
[596] *Ibid*. at 235.

behalf the IPCC toils away has not overcome the collection of wants and fears that prevent most individuals, and particularly those in the rich countries of the world, from truly orienting toward profound and transformative change. The rule of ecological law is only possible if this change happens.

Cassandra is speaking to us. We had better break her curse and start listening.

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